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OPHTHALMIC PRACTICE

LEWIS'S PRACTICAL SERIES

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A MANUAL

OF

OPHTHALMIC PRACTICE

BY

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ILLUSTRATIONS.

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PREFACE TO SECOND EDITION.

In the preparation of this edition, an endeavour has been made to bring it thoroughly up to date, and to make it as concise and simple as possible.

The manual is intended entirely for students and general practitioners, it does not pretend to go deeply into the subject, but merely to give as much information as is likely to be useful to those still engaged in their studies, or in general practice.

Much has been rewritten, some additions and omissions have been made. The editing has been done entirely by Mr. A. W. Ormond, by whom most of the new matter has been written, and I have to thank Mr. F. Durham for most valuable assistance in seeing the sheets through the press.

C. H.

52 Brook Street, W.
June, 1903.

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A

MANUAL OF OPHTHALMIC PRACTICE.

CHAPTER I.

Optical and General Outlines.

The following outline of the phenomena of refraction has been in a great measure compiled from Ganot's "Elementary Physics"* from which the diagrams have also been adapted.

Transmission of Light through Transparent Media.

Refraction.—Light is propagated in any given medium in straight lines, but on passing obliquely into another medium of different density these straight lines are refracted or bent at an angle. All rays of light remain straight and divergent unless refracted.

Refraction is the deviation which luminous rays experience when passing obliquely from one medium to another, for instance from air into water; we say *obliquely*, because if the incident ray is perpendicular to the surface separating the two media, it is not deflected but continues its course in a straight line.

* Sixteenth Edition, by A. W. Reinold.

The *incident ray* being represented by SO (fig. 1) the *refracted ray* is OH, the direction which light takes in the second medium, and of the angles SOA and HOB, which these rays form with the "normal"* AB, at right angles to the surface which separates the two media, the first is the *angle of incidence* and the other the *angle of refraction.* According as the refracted ray approaches or deviates from the normal, the second medium is said to be more or less refringent or refracting than the first.

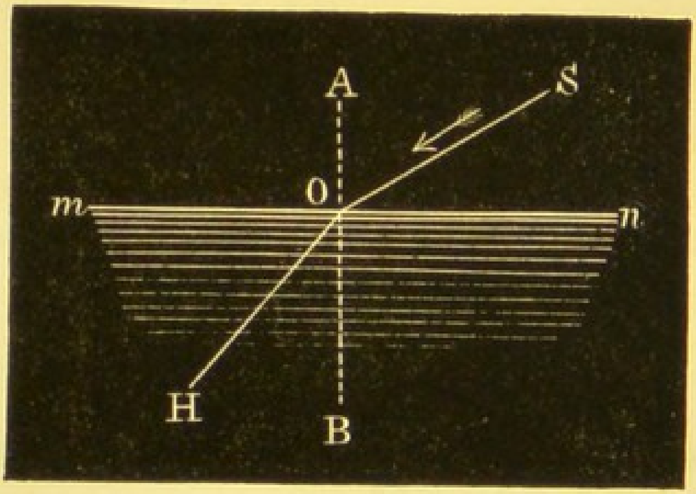


FIG. 1.

Media with parallel surfaces.—When light traverses a medium with parallel surfaces the *emergent* rays are parallel to the incident rays, as shown in figure 2 in which SA is the incident ray, AD the refracted ray, and DB the emergent ray, G and E are the normals to the two surfaces. But when light traverses media the surfaces of which are not parallel, the emergent ray is not parallel to the incident ray; upon this depends the action of prisms and lenses.

* The line perpendicular to the surface separating the two media (AB in diagram).

Prisms.—In optics a prism is any transparent medium comprised between two plane surfaces inclined to each other. The intersection of these two surfaces is the *edge* of the prism, and their inclination is its refracting angle.

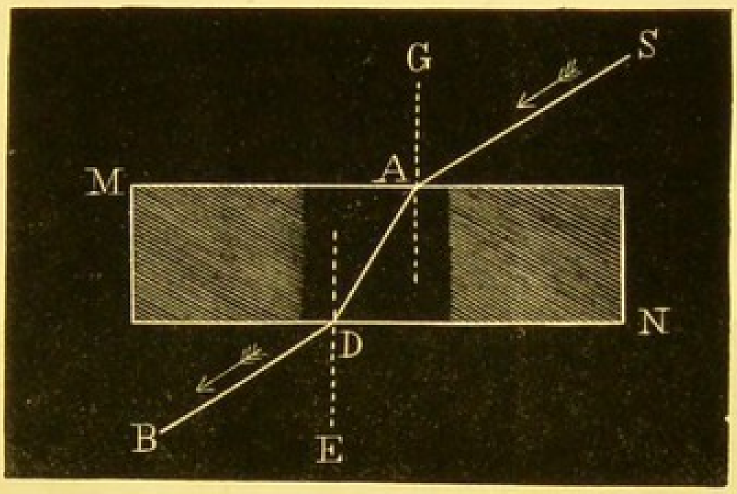


FIG. 2.

Path of rays in prisms.—When the laws of refraction are known the path of rays in a prism is readily determined. Let O (fig. 3) be a luminous point,

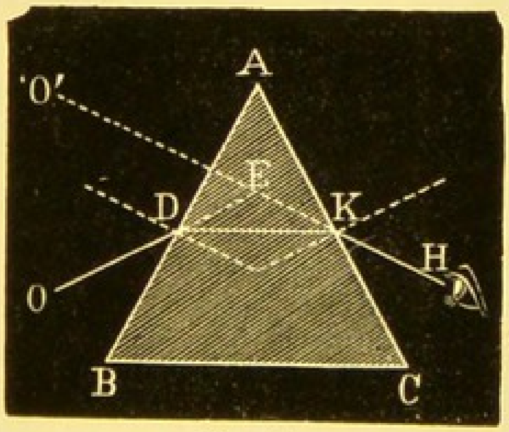


FIG. 3.

ABC, a section of a prism made of glass, of which A is the summit, BC the base, and OD an incident ray. This ray is refracted at D and approaches the normal, because it passes into a more highly refracting medium (see p. 2). At K it experiences a *second* refraction, but it then deviates from the normal, for it passes into air which is less refractive than glass (see also p. 2). The light is thus refracted twice in the same direction, and the eye which receives the emergent ray KH, sees the object O at O′; that is *objects seen through a prism appear displaced towards its edge or summit.* Prisms are numbered by the degree of inclination of their surfaces; we speak of a prism of so many degrees.

Lenses.—We next come to the consideration of

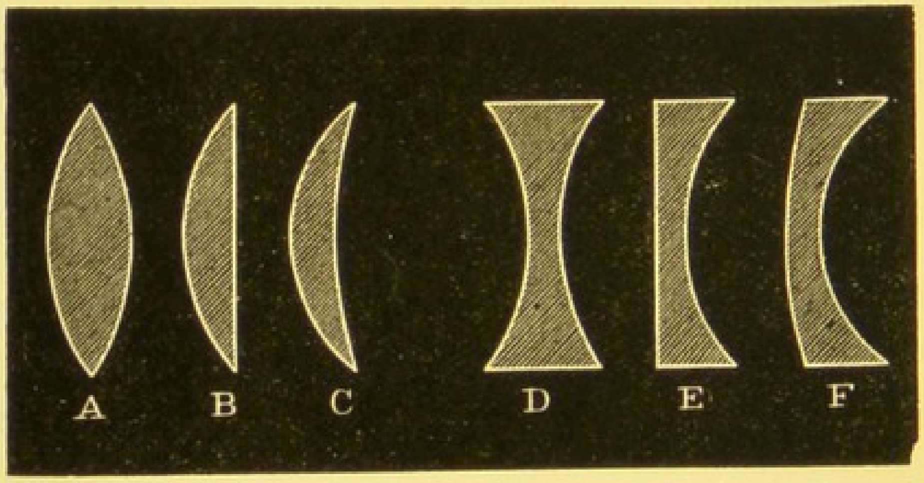


FIG. 4.

lenses. These are transparent media which from the curvature of their surfaces, have the power of refracting luminous rays which traverse them so that they either converge or diverge. According to their curvature, they are either spherical, cylindrical, elliptical or parabolic. We have to consider only spherical and cylindrical lenses. These are usually made of crown or flint glass, of which the latter is the more highly refractive; spectacle lenses are frequently made of what is known among opticians as "pebble" or rock crystal which is harder than glass and does not easily scratch.

Spherical lenses.—The combination of spherical surfaces, either with each other or with a plane surface, gives rise to six kinds of lenses, sections of which are represented in fig. 4. Four are formed by two spherical surfaces, and two by plane and spherical surfaces. A is a *double convex*, B is a *plano-convex*, C is a *converging concavo-convex*, D is a *double concave*, E is a *plano-concave*, F is a *diverging concavo-convex*. The lens C is called the *converging meniscus*, and the lens F the *diverging meniscus*.

The first three, which are thicker at the centre than at the borders, are converging; the others which are thinner in the centre are diverging. In the first group the double convex lens only need be considered, and in the second the double concave, as the properties of each of these lenses apply to all those of the same group. The spherical lenses used in ophthalmic practice are almost always double convex, or double concave, but occasionally a plano-convex, or plano-concave, or a meniscus may be found useful. Objects seen through a convex lens, when held close to the eye, appear to move in the opposite direction to the movement of the lens. With concave lenses objects appear to move in the same direction as the lens is moved.

Centres of curvature and principal axis.—In lenses whose two surfaces are spherical the centres for the surfaces are called *centres of curvature* and the straight line which passes through these two centres is the *principal axis*.

In considering the path of rays through lenses, we may compare them with prisms; the convex ABC may be looked upon as a series of prisms having their summits outwards, the concave DEF as a series with their summits inwards. From this we see that the former ought to condense the rays and the latter to disperse them; for we have already seen that *when a ray of light traverses a prism it is deflected towards its base* (see p. 3).

Foci in double convex lenses.—The focus of a lens is the point where the refracted rays or their prolongations meet. Double convex lenses have what are known as real and virtual foci.

Real foci.—We will first consider the case in which the luminous rays falling on the lens are *parallel to its principal axis* (fig. 5). In this case any incident ray LB,

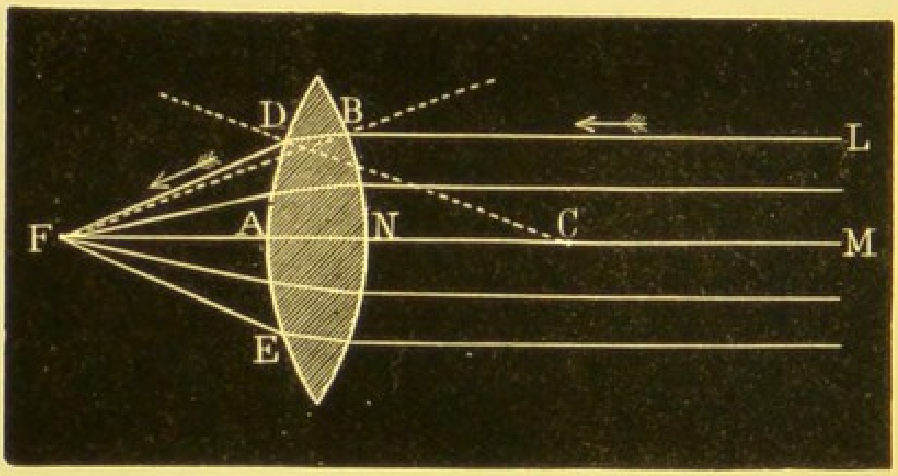


FIG. 5.

in approaching the normal of the point of incidence B and in diverging from the normal at the point of emergence D, is twice refracted towards the axis, which it cuts at the point F. As all rays parallel to the axis are refracted in the same manner, it can be shown that they all pass very nearly through the point F. This point is called the *principal focus*, and the distance FA is the principal *focal distance or focal length of the lens.*

Conjugate foci.—We will now consider the case in which the luminous object is further from the lens than its principal focus, but so near that all incident rays of light form a divergent pencil, as shown (fig. 6). The luminous point being at L, by comparing the path of the diverging ray LB with that of the ray SB parallel to the axis, the former is found to make with the normal an angle, L*Bn*, greater than the angle S*Bn*; the angle of refraction is consequently greater, and after traversing the lens, the ray cuts the axis at a point *l* which is more distant than the principal focus F. As all rays from the point L cut the axis approximately at *l*, this point is what is called the *conjugate focus* of the point L. The term conjugate focus expresses the relation existing

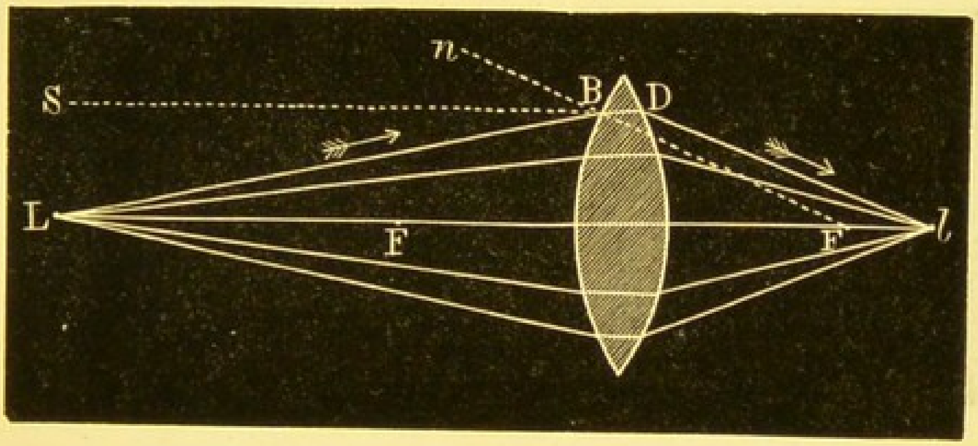


FIG. 6.

between the two points L and *l*, which is of such a nature that if the luminous point be removed to *l*, the focus passes to L.

Accordingly as the object comes nearer the lens, the divergence of the emergent rays increases and the focus *l* becomes more distant; when the luminous point L coincides with the principal focus, the emergent rays on the other side of the lens are parallel to the axis, and there is no focus, or what is the same thing it is infinitely distant.

Virtual foci.—A double convex lens has a virtual focus when the luminous object L is placed between the lens and the principal focus as shown (fig. 7). In this case the incident rays LI make with the normal greater angles than those made by the rays FI from the principal focus F; hence when the former rays emerge they move further from the axis than the latter and form a diverging pencil HK GM. These rays cannot produce a real focus, but their prolongations in the opposite direction meet in some point *l* on the axis, and this point is the virtual focus of the point L.

Foci in double concave lenses.—In double con-

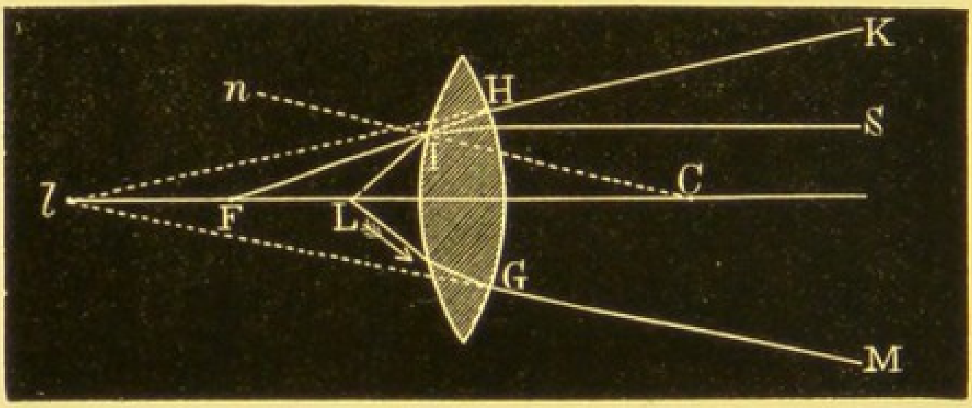


FIG. 7.

cave lenses there are only virtual foci, whatever the distance of the object. In fig. 8 let SI, S′K be any pencil of rays parallel to the axis, any ray SI, is refracted at the point of incidence I and approaches the normal CI. At the point of emergence it is again refracted, but diverges from the normal GC′. So that it is twice refracted in a direction which moves it from the axis CC′. As the same thing takes place for every other ray, S′KMN, it follows that the rays after traversing the lens form a diverging pencil GH, MN. Hence there is no real focus, but the prolongations of these rays in the opposite direction cut one another in a point F, which is the principal virtual focus.

In the case in which the rays proceed from some

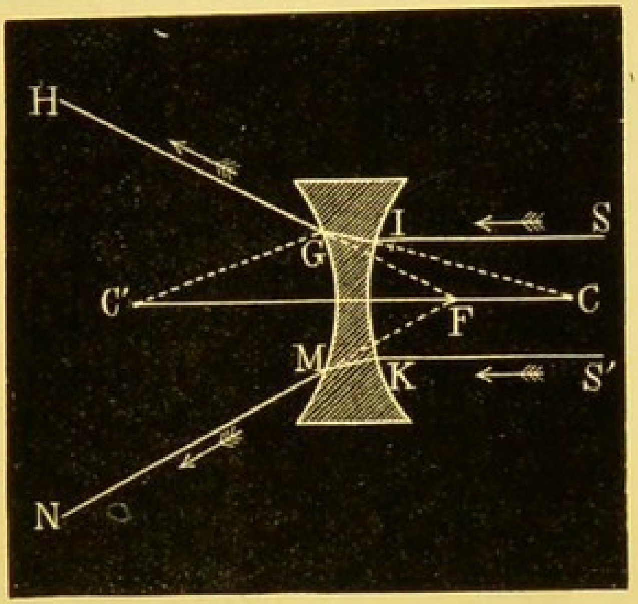


Fig. 8.

point L on the axis, and form a diverging instead of a parallel pencil (fig. 9), it is found that a virtual focus is

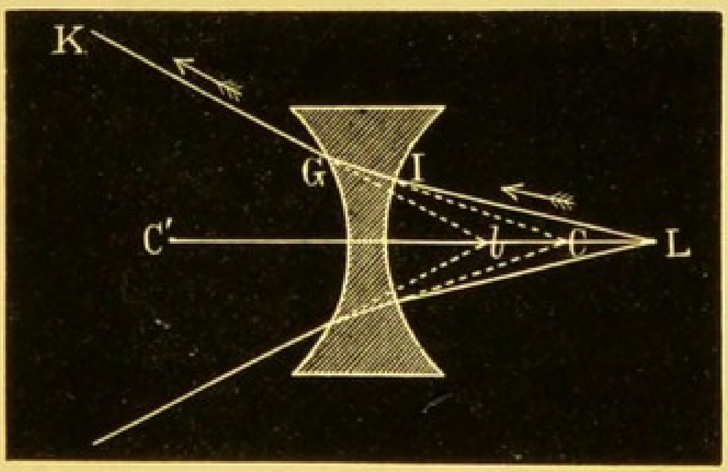


Fig. 9

formed at *l*, which is between the principal focus and the lens and which may be considered the conjugate focus of the point L.

Optical centre and secondary axis.—In every lens there is a point called the *optical centre*, which is situated on the principal axis, and which has the property that any luminous ray passing through this point experiences no angular deviation, that is, that the emergent ray is parallel to the incident ray. The existence of this point may be demonstrated in the following manner:—Let two parallel radii of curvature CA and C′A′ (fig. 10) be drawn to the two surfaces of a double convex lens. As the two plane elements of the lens A and A′ are parallel being perpendicular to two parallel straight lines, it will be granted that the refracted ray KA A′K′ is propa-

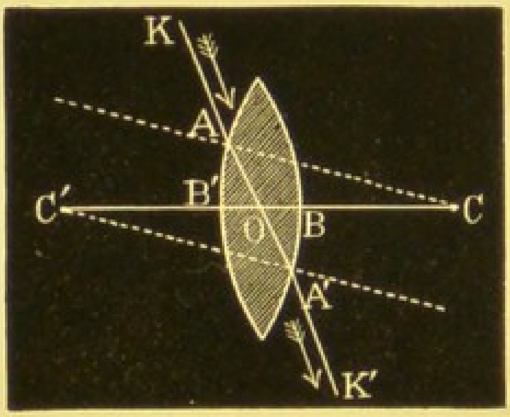


FIG. 10.

gated in a medium with parallel faces. Hence a ray which reaches A at such an inclination that, after refraction it takes the direction A A′, will emerge parallel to its first direction (see fig. 2, p. 3); the point O, at which the straight line cuts the principal axis is, therefore, the optical centre. Every straight line PP′ (fig. 11) which passes through the optical centre without passing through the centres of curvature is a *secondary axis*. From the property of the optical centre, every secondary axis represents a luminous rectilinear ray passing through this point, for from the slight thickness of the lenses it may be assumed that rays passing through the optical centre are in a straight line, that is, that the small deviation which rays experience in passing through a medium with parallel faces may be neglected (see fig. 2, p. 3).

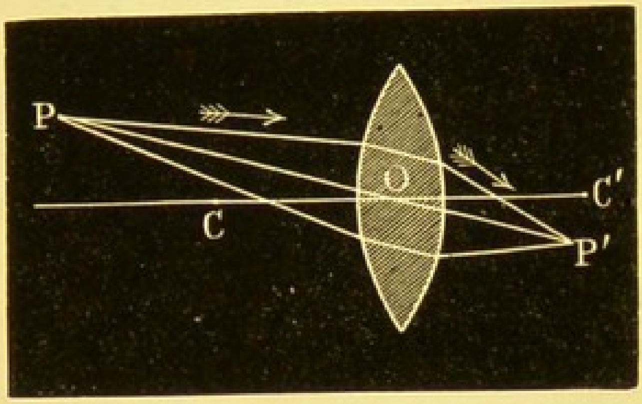


FIG. 11.

Nodal points.—If, however, we take into consideration this deviation, we have to notice what are known as "*Nodal points.*" The anterior nodal point k' (fig. 12) is the point upon the principal axis AA to which the

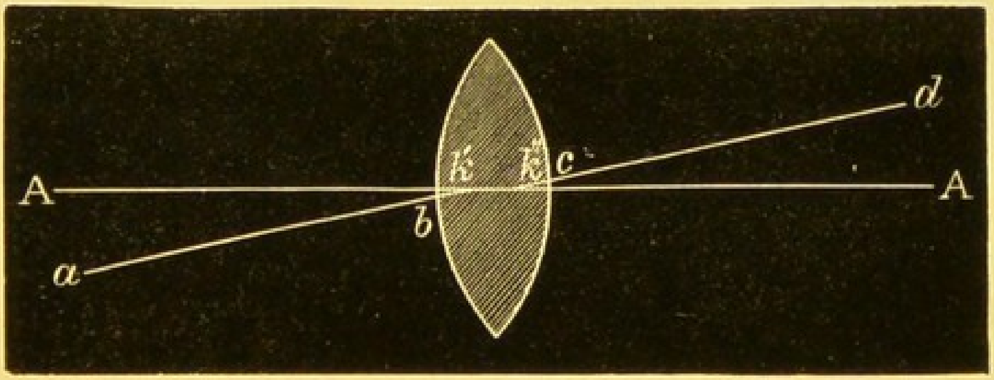


FIG. 12.

ray *ab* appears to be directed before refraction; the posterior nodal point k'' is the point from which the emergent ray *cd* appears to proceed; the direction of the emergent ray is, however, parallel to that of the incident ray.

So long as the secondary axes make only small angles with the principal axis, all that has been said about the principal axis is applicable to them; that is, that rays of light emitted from a point P (fig. 11) on the secondary axis PP′, nearly coincide in the same point of this axis P′ and accordingly as the distance from the point P to the lens is greater or less than the principal focal distance, the focus will be either conjugate or virtual.

Formation of images in double convex lenses.—In lenses the image of an object is the collection of the foci of each of its points; hence the images furnished by lenses are real or virtual in the

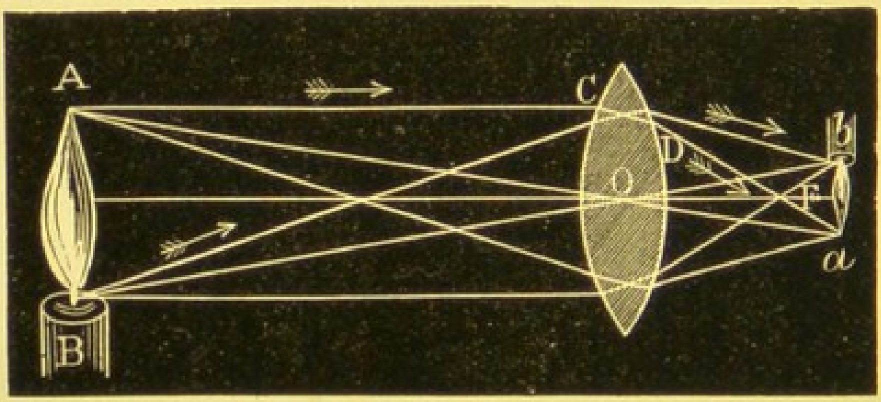


FIG. 13.

same cases as their foci, and their construction resolves itself into determining a series of points.

Real image.—Let AB (fig. 13) be placed beyond the principal focus. If a secondary axis A*a* be drawn from the outside point A, any ray AC from this point will be twice refracted at C and D, and both times in the same direction, approaching the secondary axis which it cuts at *a*. From what has just been said (p. 7), the other rays from the point A, will coincide in the point *a*, which is accordingly the conjugate focus of the point A. If the secondary axis be drawn from the point B, it will be seen in like manner, that the rays from this point coincide in the point *b*, and as the points between A and B have their foci between *a* and *b*, a *real* image of AB will be formed at *ab*, which is inverted and smaller than the object AB.

Virtual image.—There is another case in which the object AB (fig. 14) is placed between the lens and its principal focus. If a secondary axis, O*a*, be drawn through the point A, every ray AC after having been twice refracted, diverges in emerging from this axis, since the point A is at a less distance than the principal

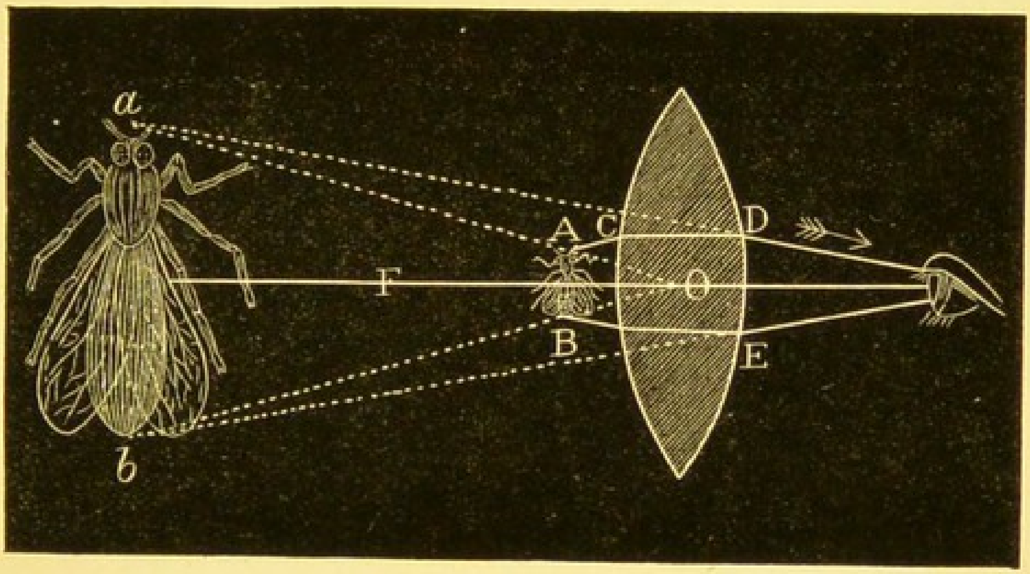


FIG. 14.

focus (see fig. 7, p. 8). This ray continued in the opposite direction will cut the axis O*a* in the point *a*, which is the virtual focus of the point A. Tracing the secondary axis of the point B, it will be found in the same manner that the virtual focus of this point is formed at *b*. There is, therefore, an image of AB at *ab*. This is a virtual image, it is in its right position, and is larger than the object.

Formation of images in double concave lenses.—Double concave lenses give only virtual foci, whatever the distance of the object. Let AB (fig. 15) be an object placed in front of such a lens. If the secondary axis AO be drawn from the point A, all rays, AC, AI, from this point are twice refracted in the same direction, diverging from the axis AO; so that the eye receiving the emergent rays DE and GH, supposes them to proceed from the point where their continuations cut the secondary axis AO, in the point *a*.

In like manner drawing a secondary axis from the point B, the rays from this point form a pencil of diverging rays, the directions of which prolonged, coin-

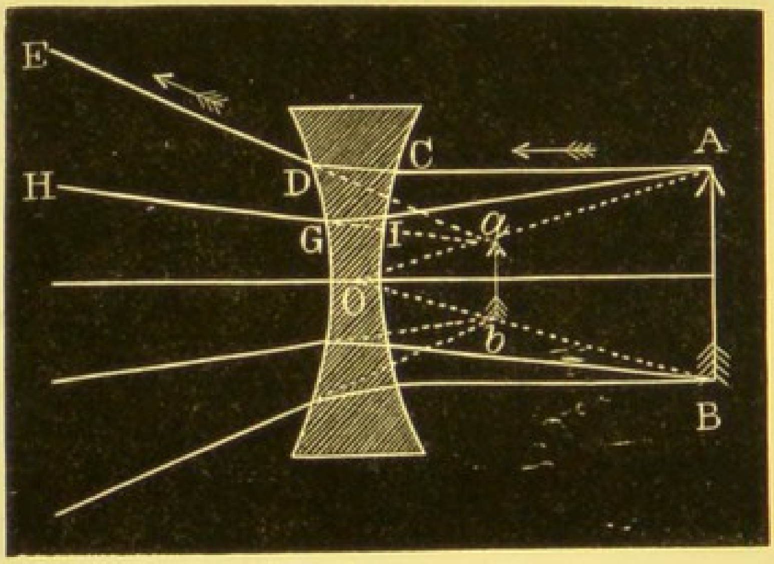


FIG. 15.

cide in the point *b*, on the secondary axis BO. Hence the eye sees at *ab* a virtual image of AB which is in its right position, and is smaller than the object.

CYLINDRICAL LENS.

A cylindrical lens, convex or concave, is ground upon a cylindrical surface and differs from a spherical in having what is known as an axis, in the direction of which there is no curvature; so that all rays of light passing through such a lens in the direction of its axis undergo no refraction, or at least only such as is experienced by rays passing through media with parallel surfaces (see fig. 2, p. 2). All other rays passing through the lens are refracted; those in planes making small angles with the axis but little, those in planes making larger angles with the axis more, those in a plane at right angles to the axis most of all; so that we see the most powerful action of a cylindrical lens is in a direction at *right angles* to its axis. The direction of the refracted rays is either convergent or divergent according as the lens is convex or concave. *Spherical lenses refract rays of light, passing through them equally in all directions. Cylindrical lenses mainly at right angles to their axes.* Refraction becomes less as the axis is approached, when the axis is reached no refraction takes place, whereas a sphere refracts all rays equally excepting those passing through its optical centre.

We can ascertain the convex or concave curvature, as well as the axis of a cylindrical lens by holding the lens close to the eye and watching through it the apparent movement of objects seen through it, when it is moved rapidly from side to side. If convex, objects will appear to move in an opposite direction to the movements of the lens. If concave, in the same direction, and in one meridian no movement at all will be seen, since this is the axis, and no refraction takes place in the axis of a cylindrical lens.

Reflection.—When rays of light strike polished surfaces, such as mirrors, the surface of the cornea, &c., some of the rays rebound and again traverse the medium through which they came, the angle of reflection being equal to the angle of incidence. This phenomenon is known as reflection. We estimate the degree of polish of any surface by the brilliancy of the reflection produced, and this fact is taken advantage of in all investigations of the cornea, the anterior surface of which is highly polished, and when normal, yields a very brilliant reflection. Any impairment of this reflection denotes an abnormal condition of its surface.

Polished surfaces may be plane, concave or convex. The mirror of an ophthalmoscope is concave, some instruments having in addition a plane mirror. Plane mirrors form virtual images only, whereas a concave mirror forms a real inverted image of the source of light if it be beyond the focal length of the mirror. The only part of the phenomenon of reflection we need consider now, is the way in which an image is formed by the ophthalmoscope mirror. A real inverted image is formed provided the object be beyond the focal length of the mirror which is usually 20 cm.

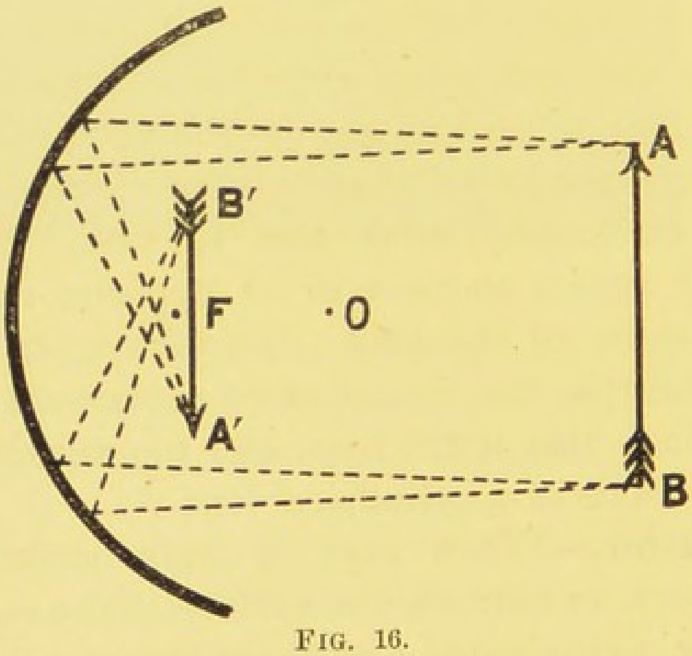


FIG. 16.

Let AB be the object, the rays from A will be formed at A′ and those from B at B′. Hence an inverted image will be formed in front of the mirror and can be received upon a screen. This image is therefore real and inverted.

Refraction of the Eye.

The eye may be compared to a photographic camera, consisting as it does of a dark chamber having an opening in front (the pupil), a lens through which the light passes, a sensitive plate (the retina) on to which the rays of light are focussed and an iris diaphragm which acts as a "stop" to regulate the amount of light entering the globe. But whereas in a camera accurate focussing of the picture is brought about by moving the position of the sensitive plate, this mechanism for focussing is not possible in the eye.

The normal eye is arranged so that parallel rays of light are brought to a focus exactly on the retina, consequently such an eye enjoys a distant landscape without any effort of accommodation.

In the eye there are three refractive surfaces; the front of the cornea, the front of the lens and the front of the vitreous; we may consider these combined dioptric media as one biconvex lens, at the principal focus of which, in the normally shaped or *emmetropic* eye when its accommodation is relaxed the retina is situated; *i.e.*, the emmetropic eye with accommodative rest is adapted for parallel rays.

How then can divergent rays be brought to a focus on the retina? By increasing the refractive power of the media. This takes place in the eye, an addition to the refractive power of the lens being brought about by an increase of its curvature and thickness. By these means divergent rays are accurately focussed. The eye has no power to focus converging rays of light, they must be rendered parallel or divergent, previous to entering the eye. Clinically, we find that the retina may be situated either in front, or behind the focus of the dioptric system. If it is situated in front the globe is too short (hypermetropia) if behind the globe is too long (myopia). Consequently the hypermetropic eye must increase the refractive power of its media to focus correctly, and the myope only sees objects close to him, the light rays from which enter the eye in a divergent way. Further the normal eye in order to see objects close to it, has to increase its refractive power (*vide* Accommodation).

If we imagine the retina as being the source of light, the rays leaving a hypermetropic eye are divergent; those leaving an emmetropic eye, parallel, and the myopic, convergent.

Not only is the posterior wall of the eye a sensitive plate, but it is also a reflecting surface, and if we look through the central hole of the mirror of an ophthalmoscope into the eye, from a distance of two or three feet, we see a bright red reflection. The condition of this reflection is of great importance when examining the eye, since the rays of light forming this red reflex, pass through the dioptric media, and are influenced in such a way that the refraction of the eye may be diagnosed by it alone (Retinoscopic Test).

In a darkened room, by means of your ophthalmoscope mirror, throw the light of a candle flame through a convex lens, so that you obtain on the wall an erect image of the flame surrounded by a deep shade. Now move the mirror so that it faces a little to the right and then to the left and notice that the image of the lamp on the wall has moved first to the left and then to the right, viz., in the opposite direction to that taken by the mirror. This is exactly similar to the condition existing when the light from an ophthalmoscope is thrown into the eye, the convex lens being in that case the dioptric media of the eye. Consequently you have on the retina an erect image of the source of light which moves in the opposite direction to the way the mirror is moved, if the mirror looks up the image is lowered and if down the image is raised. Of course the image on the retina cannot be seen, since the sclerotic and choroid coats are opaque. The only means of ascertaining the condition is by looking through the central hole of the ophthalmoscope at the illumined pupil, and then we find one of two things, the red reflex on moving the light away from the pupil disappears either by a shadow which moves with, or by a shadow moving against the direction of the mirror. On these facts depend the utility of the "shadow test" or "retinoscopic test" now so extensively used in estimating refractions.

The explanation is simple.

We are, remember, using the retina as a reflecting surface, consequently the retina may be considered as the source of light. The rays of light leaving the hypermetropic eye are divergent, consequently we see a virtual, erect, image moving in the same way as the image is moving on the retina, that is against the mirror. In the myopic eye we have rays which on leaving the eye are convergent, therefore they meet at the principal focus of the eye and cross, so the reflection then moves in the opposite way to the image on the retina, that is, with the mirror.

Visual line and visual angle.—The former signifies an imaginary line drawn from the yellow spot to the centre of the object looked at; the latter is the angle formed by two secondary axes drawn from what is known as the optical or more correctly the posterior nodal point of the eye (a point situated a little behind the crystalline lens) to the extremities of the object looked at. The visual line does not correspond with the optic axis, but cuts the cornea rather below and internal to its centre, and forms with the optic axis, an angle which varies in size according to the shape of the eyeball.

Conditions of normal vision.—In order that an object may be seen distinctly, the following optical conditions must be fulfilled. A well defined inverted image must be formed on the yellow spot. The image must have a certain size, the minimum corresponding to a visual angle of one minute ($\frac{1}{60}$ degree).

Certain terms are applied to the eyeball in order to designate different parts and divide it into regions. Thus, a point at the summit of the cornea is known as the anterior pole of the eyeball, a corresponding one at the most remote part of the fundus between the yellow spot and optic disc as the posterior pole; an imaginary line passing through the two as the axis of the globe or optic axis; another imaginary line passing around the globe midway between the two poles is known as the equator, and the portion in front of the equator is known as the anterior hemisphere, that behind as the posterior hemisphere of the globe.

We also divide the eyeball in an antero-posterior direction by imaginary lines, on its surface passing through the poles and corresponding to the axis called meridians; it is obvious that any number of such lines may be drawn, but for practical purposes it is only necessary to distinguish two; a horizontal meridian dividing the globe into superior and inferior halves, and a vertical meridian dividing it into equal lateral portions. The narrow zone nearest the cornea is known as the sclero-corneal junction or margin, and a wider band next it corresponding to the ciliary body internally is called the ciliary region. The ciliary body extends for a distance of about 6 mm. from the corneo-

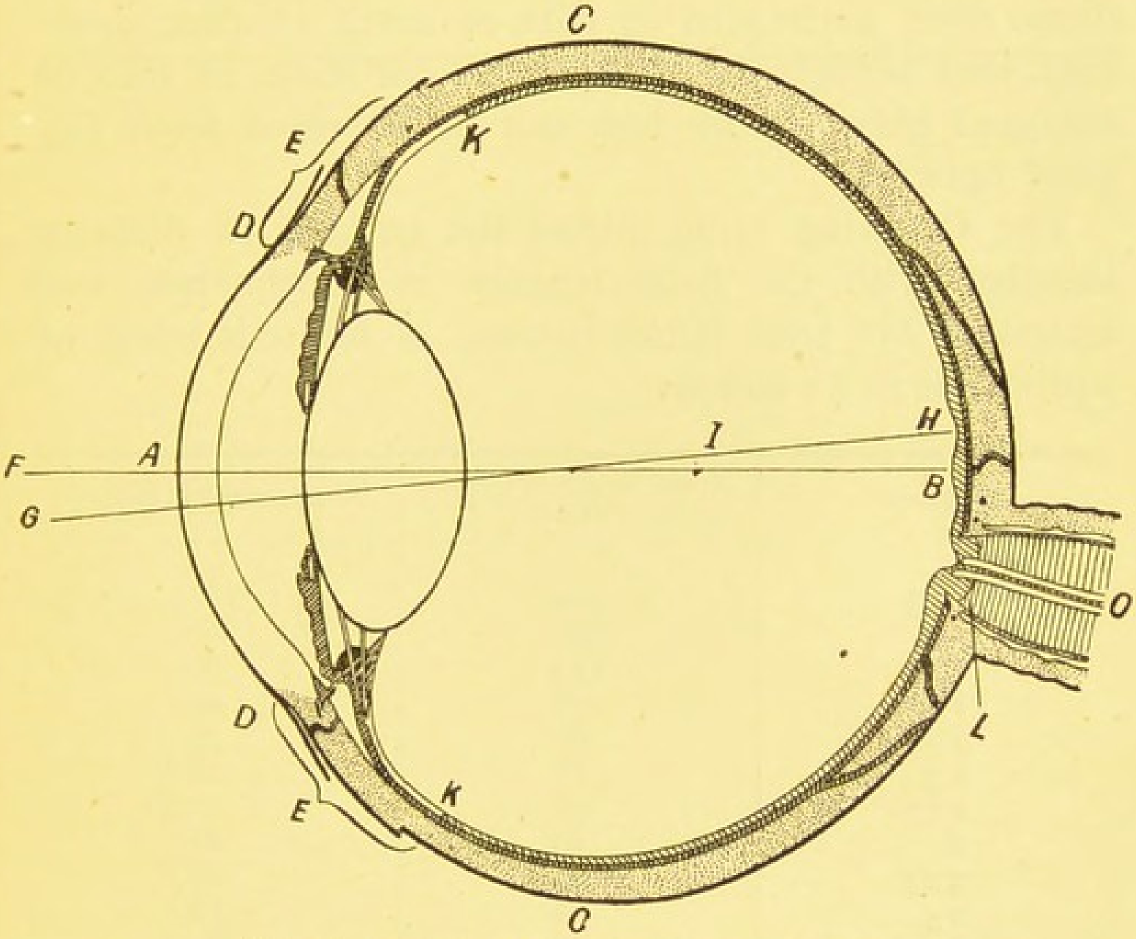


FIG. 17.—HORIZONTAL SECTION OF RIGHT EYE.

A. Anterior pole. *B*. Posterior pole. *C*. Equator. *D*. Sclero-corneal junction. *E*. Ciliary region. *FB*. Optic axis. *GH*. Visual axis. *H*. Macula lutea. *I*. Centre of rotation. *K*. Ora serrata. *L*. Lamina cribrosa. *O*. Optic nerve.

scleral margin. We also distinguish the "centre of rotation" a point situated on the optic axis about two-thirds of its length from the cornea.

Trial glasses.—The trial glasses, which are now very generally in use, are arranged according to what is known as the "metrical system." The unit in this system is a lens of one metre focal length; it is called a "diopter" (=D). A lens of two diopters is double the strength of that of one diopter, and has a focal length of half a metre (fifty centimetres) and so on. The box of trial glasses contains convex and concave spherical and cylindrical lenses, (the sign + signifies a convex lens, the sign − a concave lens), a set of prisms, opaque discs, discs perforated by slits or small circular openings, lens holders or trial frames, and discs or slips of coloured glass. The box can be obtained from any good optician.

The following table shows the number in diopters together with the focal lengths in centimetres and inches of the trial lenses in use. A metre is taken as equivalent to 40 inches.

Diopters.	Focal length in Centimetres.	Focal length in inches.
·25	400	160
·5	200	80
·75	133	60
1	100	40
1·25	80	32
1·5	66	26·6
1·75	57	22·8
2	50	20
2·25	44	18
2·5	40	16
2·75	36	14·5
3	33	13·3
3·5	28	11
4	25	10
4·5	22	9
5	20	8
5·5	18	7·3
6	16	6·6
7	14	5·7
8	12	5
9	11	4·4
10	10	4
11	9	3·6
12	8·3	3·3

Diopters.	Focal length in Centimetres.	Focal length in inches.
13	7·6	3
14	7·1	2·8
15	6·6	2·6
16	6·2	2·5
17	5·9	2·3
18	5·5	2·2
20	5	2

CHAPTER II.

Examination of the Eyeball and its Appendages.

The examination of the eyeball and its appendages will be considered under four heads :—

1. By the unaided eye.
2. By lateral illumination.
3. By the ophthalmoscope.
   (*a*) Direct; (*b*) Indirect examination.
4. By manipulation.

The acuteness of vision, field of vision, range of accommodation, colour sense, movements of the eyeball, and its refraction, have also to be tested.

I. Examination by the unaided Eye.

Not any of our features gives so much character to our appearance as our eyes. If we watch the patient entering the room we can often learn many facts about him before he has told us anything of his troubles.

An inclination of the head to one side, or an unusual carriage of the head suggests that in order to obviate diplopia, to centralise his field of vision, or to overcome some defect, this position of the head is maintained. Notice if he walks towards you as if he saw well and distinctly, or if he knocks against obstacles in his path ; also whether both eyes look at you together, and are directed towards you when the patient looks at you ?

In order to examine the outer surface of the eyelids, ocular conjunctiva, cornea, anterior portion of sclerotic, aqueous chamber, iris, and lachrymal apparatus, it is necessary to place the patient before a window and direct him at first to close the eyes, then to open them widely and look by turns in different directions. The reflection of the window from the cornea should be carefully watched, as the eye is moved; if any slight opacity or irregularity be present the image will be lost or become broken or distorted in some portions.

To examine the palpebral conjunctiva, it is necessary to evert the upper lid and draw the lower lid downwards. Eversion of the upper lid can be accomplished thus:—The surgeon, standing in front of the patient, should direct him to look downwards and close the eyes; he should then place the forefinger of one hand upon the lid at the attached or upper border of the tarsal cartilage, and make gentle pressure downwards and backwards, so as to make the free edge of the lid stand away from the globe; then place his thumb beneath the margin of the lid and make a slight upward movement, at the same time continuing the pressure with the finger; by this means the lid will be made to turn upon itself and become everted. The lid may also be everted by pressing a probe horizontally upon its outer surface and drawing its margin upwards by the lashes, at the same time making pressure downwards with the probe.

To examine the conjunctiva covering the lower lid, all that is necessary is to place the finger upon its margin and draw it strongly downwards, when its conjunctival surface will become exposed.

Normal Appearances.

The outer surface of the eyelids is covered by soft delicate skin, which is thrown into folds on every contraction of the orbicularis muscle; their free margins are of considerable thickness, and accurately fit one to the other, so that when the lids are together the conjunctival sac is a closed cavity, except for the two small openings of the canaliculi leading to the lachrymal sac. From the outer edge of this free margin project the lashes in two or three rows, those of the upper lid being thicker and longer than those of the lower. The lashes extend along the whole outer edge of each lid, but are much fewer and more delicate in that portion extending from the tear punctum to the inner canthus. The inner edge of each margin is occupied by the orifices of the Meibomian glands, which are seen as a close set of yellowish points, and extending from them the glands themselves can be seen as a row of closely set yellowish lines beneath the palpebral conjunctiva.

The ocular conjunctiva is smooth, moist, shining, and transparent, allowing the white sclerotic to show plainly through it. A few small vessels may be seen running from the outer and inner canthi towards the cornea. The caruncle and semilunar fold occupy the space immediately external to the inner canthus, the former appearing as a small reddish-grey projection, the latter as a well defined pinkish fold. The palpebral conjunctiva is also smooth, moist, shining, and transparent, and appears yellowish in colour, from the tarsal cartilage, to which it is closely and evenly united, showing through it. The portion of conjunctiva reflected from the lids to the globe (Fornix) appears somewhat thickened and wrinkled, and is slightly more vascular than the ocular and palpebral portions.

Certain parts of the conjunctiva require to be specially examined; next the thickened margin of the lid, in the fornix or about the caruncle are the most frequent situations for the lodgment of a foreign body. The portion covering the attached border of the tarsal cartilage of the upper lid should also be noticed, as it is here that granular ophthalmia manifests itself most plainly.

The cornea is smooth, shining, and perfectly transparent throughout, except in the case of old persons in whom a bluish-white rim (arcus senilis)* is often seen occupying more or less of the structure somewhat within its margin; no bloodvessels are seen on its surface or in its substance. The anterior portion of the sclerotic is pearly-white or of a pale blue tint and shining. It is plainly visible, through the transparent conjunctiva covering it; some fine vascular twigs are seen passing forwards from the equator to a point about $\frac{1}{8}$ inch from the corneal margin, where they end abruptly.

It is necessary that the bloodvessels seen upon the anterior surface of the eyeball should be carefully noticed, for although but insignificant in health, they become greatly enlarged, and their visible number enormously increased in inflammation; their position and size are important aids in the differential diagnosis of inflammation of the eyeball. The diagram (fig. 18) shows the vascular system of the anterior portion of the eyeball.

In disease three different sets of vessels become congested.

1. The vessels supplying the conjunctiva only (posterior conjunctival vessels) (figs. 18, 19).

* The same condition occasionally occurs in quite young people.

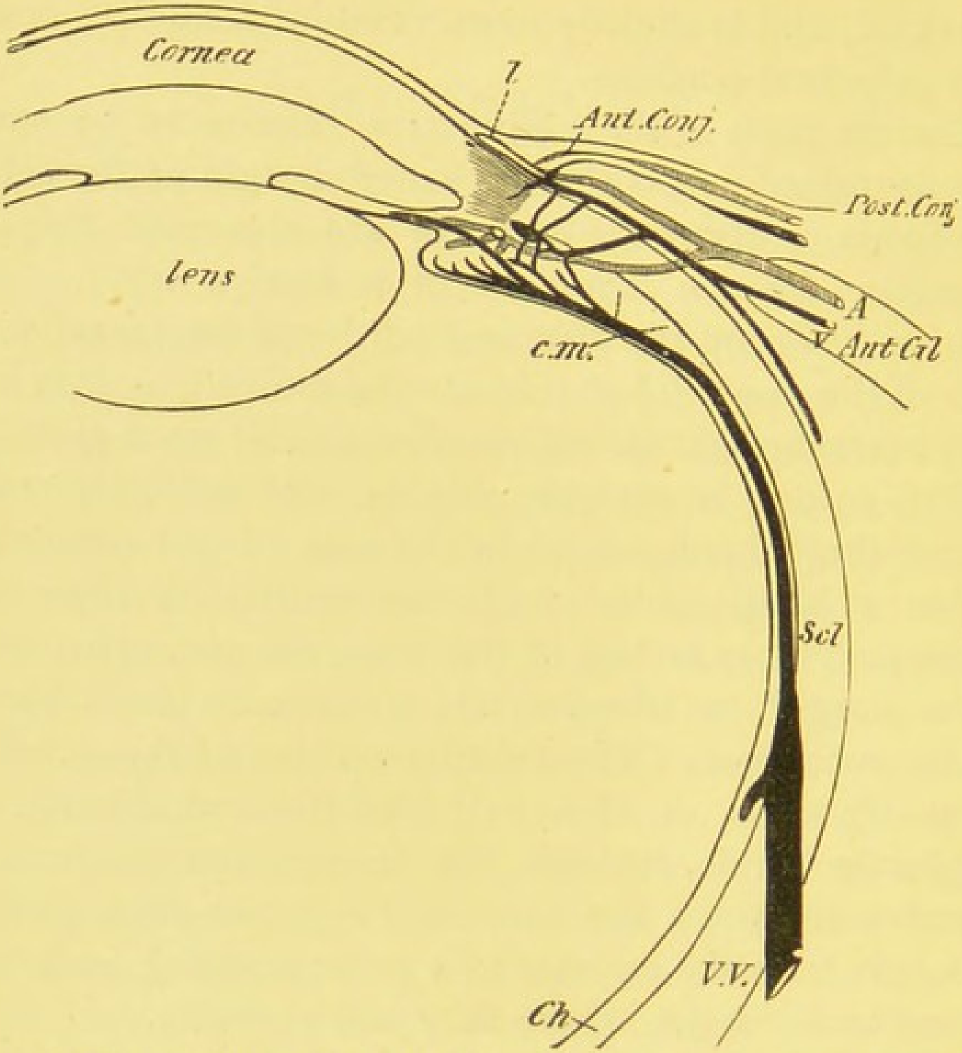


FIG. 18.—Vessels of the front of the eyeball. *c.m.* Ciliary muscle. *Ch.* Choroid. *Scl.* Sclerotic. *V.V.* Vena vorticosa. *l.* Marginal loop plexus of cornea. *Ant.* and *Post. Conj.* Anterior and posterior conjunctival vessels. *Ant. Cil. A.* and *V.* Anterior ciliary arteries and veins. (Simplified and altered from Leber). (After Nettleship).*

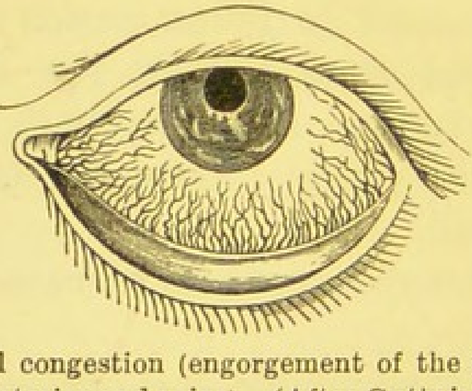


FIG. 19.—Conjunctival congestion (engorgement of the posterior conjunctival arteries and veins). (After Guthrie).

* The figs. 18, 19, 20, 21, are taken from Nettleship, "Student's Guide to Diseases of the Eye."

2. The anterior ciliary vessels lying in the episcleral tissue beneath the conjunctiva, the perforating branches of which are the vessels already mentioned as seen in health, terminating abruptly at a short distance from the corneal margin (figs. 18, 20). Their non-perforating branches (figs. 18, 21) lie in the episcleral tissue, and extend up to the corneal margin. In health they are invisible, but when distended they form a pink zone of fine straight vessels around the cornea *circumcorneal zone* or *ciliary injection*.

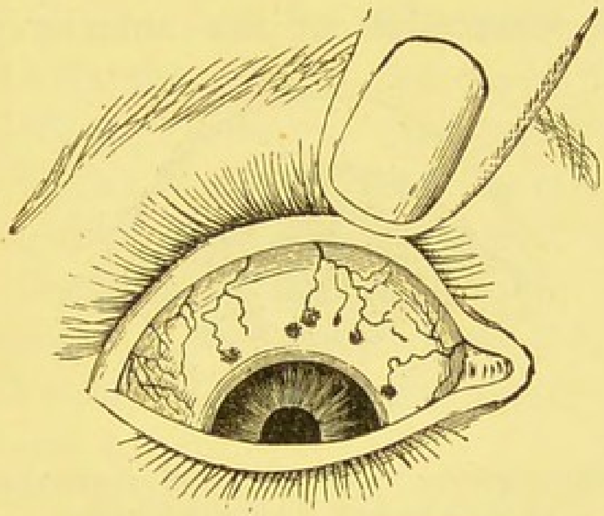


FIG. 20.—Congestion of the perforating branches of the anterior ciliary arteries. (Dalrymple).

3. The vessels of the corneal margin *and* anterior portion of conjunctiva (the anterior conjunctival vessels and their loop plexus on the corneal margin, fig. 18). These are branches of the anterior ciliary vessels and join with the post-conjunctival vessels.

A bright red network of vessels which move with the conjunctiva, when it is slid over the globe, most distinct towards the equator and least so near the cornea, (fig. 19) shows congestion of the posterior conjunctival vessels, and indicates inflammation of the conjunctiva (ophthalmia). A pink zone around the cornea, made up of straight vessels radiating from the cornea and not moving with the conjunctiva, shows congestion of the anterior ciliary vessels (fig. 21) and means iritis or corneitis. Congestion in the same zone deeply seated, of a lilac tint, and rather patchy, indicates inflammation of the ciliary body (cyclitis). A dusky red patch on one side of the eyeball, rather external to the ciliary region, means inflammation of the episcleral tissue (episcleritis). A superficially situated bright red zone of vessels around the cornea, often encroaching on it, shows congestion of the anterior conjunctival

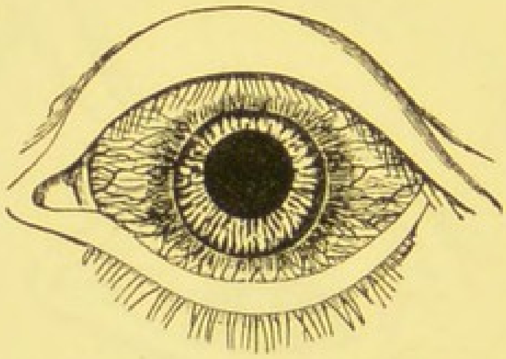


FIG. 21.—"Ciliary congestion" (engorgement of episcleral twigs of anterior ciliary arteries). (After Dalrymple).

vessels and their loop plexus (fig. 18) and indicates severe superficial inflammation or ulceration of the cornea.

Distension of the vessels seen in health to terminate near the corneal margin (perforating branches of anterior ciliary arteries, figs. 18, 20, and their accompanying veins) with a scanty zone of dusky colour around the cornea as a rule indicates glaucoma.

The aqueous chamber is filled by the aqueous humour, which is transparent, colourless, and of such quantity as to preserve the proper curvature of the cornea, without causing tension, or allowing of laxity, and to keep it separated from the iris by a considerable interval. Its depth varies, and the recognition of this fact is sometimes difficult. If the observer has good binocular vision the estimation of the third dimension should offer but little difficulty; but if not, then he should look at the eye from the side and notice whether the iris is hanging in an almost vertical plane, or convex forward or backward. If convex forward the anterior chamber is shallower, and if backwards deeper than normal. The patient should be looking straight forward and as far away as possible.

The iris varies in colour in different individuals and occasionally in the two eyes of the same person; it is often irregularly pigmented so that parts of it in the same eye are lighter or darker than the remainder. Its surface is slightly ridged and furrowed especially in a radiating direction around the pupil; these points should be carefully noticed as loss of distinctness and a certain uniformity of surface, are among the earliest symptoms of inflammation.

The pupil lies somewhat to the inner side of the centre of the iris. Its mobility, size in ordinary daylight, and shape have to be noticed. The two pupils must be examined separately and together. The simplest and also the best way of examining the pupil is to direct the patient to look out at the window, and then alternately shade and uncover the eye with the hand or some opaque object. In health, if one eye alone is shaded, its pupil will dilate considerably when shaded, and contract quickly on exposure to light—direct reflex action; during the trial, the pupil of the other eye will act, but to a less extent—indirect reflex action. The pupil also contracts when the eye is accommodated for its near point, *i.e.*, when an object about five or six inches away is looked at, and dilates again when the accommodation is relaxed and a distant object regarded. This associated action, however, is not so great as the reflex action; but it must be remembered when examining the reflex action, as some patients persist in accommodating for the hand when the eye is shaded and consequently the pupil contracts nearly as much when the eye is covered as when it is exposed to light.

The movements of the pupils vary in different individuals, and become more sluggish as age advances. The usual size of the pupil also varies considerably; it is larger in myopia, than in emmetropia and hypermetropia, also in delicate anæmic persons than in the healthy and robust; it is smaller in old persons than in the young. It should be quite round in health, and of a perfectly black colour since not any of the light entering the globe returns to the eye of the observer. The pupil is only grey or milky in appearance when some more or less opaque screen, due to opacities in the lens or anterior portion of the vitreous, interposes at the anterior part of the eye, and so causes some reflection to take place.

The direct reflex action of the pupils is lost in blind eyes, if, however, one eye sees well, the indirect reflex action is present in the other eye, even if quite blind, provided the nerve supply of the iris is healthy. The pupil will not act in cases of recent iritis or of extensive old iritic adhesions, in cases where the structure of the iris has become much altered by disease, and in cases of paralysis of its nerves. In cases of locomotor ataxy and some other spinal affections with no failure of sight, the reflex action of the pupils is lost, though they act well during accommodation—associated action; this condition is often described as the "Argyll Robertson pupil." The action of the iris is destroyed or greatly restricted by mydriatics and myotics.

The examination of the lachrymal apparatus gives chiefly negative results; the position of the tear puncta closely in contact with the ocular conjunctiva must be noticed, pressure with the finger over the lachrymal sac causes no escape of fluid through the puncta, neither can the lachrymal gland be felt or seen in a normal condition of the parts.

II. Examination by Lateral or Focal Illumination.

All the parts mentioned above are more plainly seen by lateral illumination than by the unaided eye; minute foreign bodies, slight opacities of the cornea, &c., which might be overlooked in the previous examination are discovered, and in addition the whole of the lens and the anterior portion of the vitreous can more satisfactorily be looked into.

The examination should be conducted as follows:—The patient should be seated in a dark room (the pupil previously dilated with atropine or homatropine if necessary) and a lamp placed at about two feet distance on the left, and rather in front of his face. The surgeon standing nearly in front, or rather to the patient's right side, and facing him, should then take in his right hand a biconvex lens of about two and a half inches focal length,* and with it concentrate the light from the lamp on the surface of the cornea; with a little manœuvring he will find that he can throw the light through the pupil to a considerable depth into the eye,

* A lens of two and a half inches focal length is about equal to one of fifteen diopters in the metrical system.

as shown by the continuous and broken lines in the diagram fig. 22. The lens should be held at right angles to the direction of the light rays coming from the source of light, and a little further from the cornea than its focal length. The patient should be told to look in various directions, so that all parts of the anterior portion of the eye may be examined.

Lateral illumination gives chiefly negative results. The lens in health is perfectly transparent, and in youth is nearly colourless, but some bluish lines showing its division into different segments can be recognised by careful examination. As age advances, these lines become more marked, and the whole lens appears of a

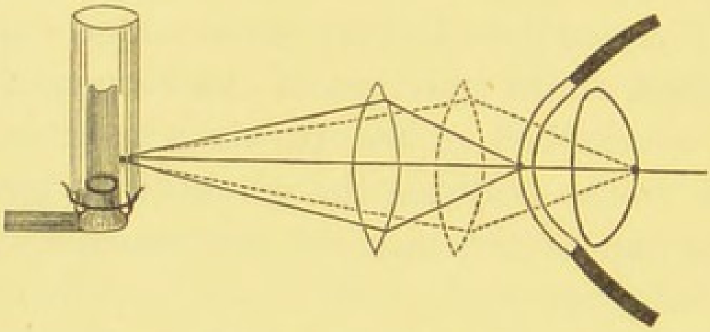


FIG. 22.—Lateral illumination.

bluish-grey colour, though its transparency is still unaffected.

Beyond the lens all appears dark, but any hæmorrhage occupying the anterior part of the vitreous, or a tumour coming forwards from the deeper parts of the fundus and extending to the back of the lens, or growing from the ciliary region would be discovered.

It should be noticed in the examination by lateral illumination that opacities of the cornea, &c., always appear with greatest distinctness on the side which is furthest from the light. A second lens may also be used to magnify the parts illuminated by means of the first.

III. Examination by the Ophthalmoscope.

Description of the instrument.—The ophthalmoscope consists essentially of a mirror of silvered glass or polished metal, having a central opening, with certain accessory portions in the shape of convex lenses of different foci, used as objective lenses. The ophthalmoscope since its introduction has undergone innumerable modifications, both in principle and detail; the number of different instruments being nearly, or quite, as great as that of ophthalmic surgeons.

The most convenient form of ophthalmoscope is Morton's modification of Couper's instrument (*vide* fig. 23). This has two concave mirrors, a large one for indirect examination, and a small one set obliquely for direct examination. The advantage of the oblique mirror is, that the observer can hold the instrument perfectly straight and has not to tilt the mirror in order to direct the light on to the pupillary area, and he obtains a much brighter and more concentrated light. The two mirrors are set in a frame which revolves around a pivot at its centre. In the case forming the body of the instrument is an endless chain of small rings, into which are fitted lenses of strengths ranging from +·5 to +12 and from −·5 to −20.

The chain is moved around by means of a toothed wheel worked by the index finger of the observer and this simple arrangement augmented by another disc placed at the top of the instrument gives a range of lenses from +·5 to +32 and from −·5 to −50. Another advantage of this instrument is its length, the handle being sufficiently long and far from the sight hole to allow the hand holding the instrument to remain below the patient's chin when using the direct method, and the mechanism for moving the correcting lens is also below the level of the nose, consequently the lenses can be moved without removing the gaze from the fundus.

A less expensive and smaller instrument is made, the endless chain being replaced by a circular disc in which lenses are set. This instrument has also an oblique

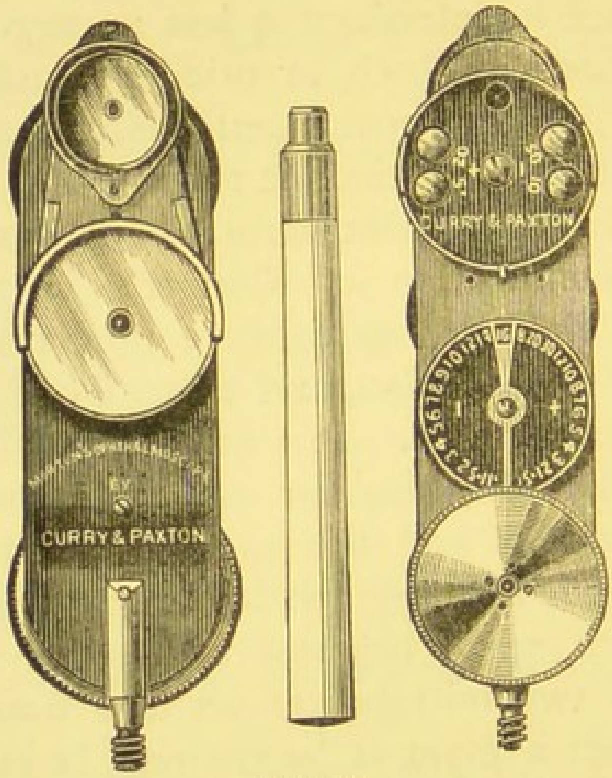


FIG. 23.

mirror and is suitable for any ordinary medical ophthalmoscopic examination (*vide* fig. 24).

Method of using the ophthalmoscope.—There are two methods of using this instrument. The first, which requires more practice, with the ophthalmoscope alone, without the aid of a biconvex object lens, is called the direct method of examination, or examination of the *erect image*.

The second, which is easier, is called the indirect method, or examination of the *inverted image;* in it both the ophthalmoscope and a biconvex lens are used.

Direct ophthalmoscopic examination.—In this method a virtual erect image situated behind the eye is seen. The examination is conducted in the following manner:—

The patient being seated in a dark room, a gas, or

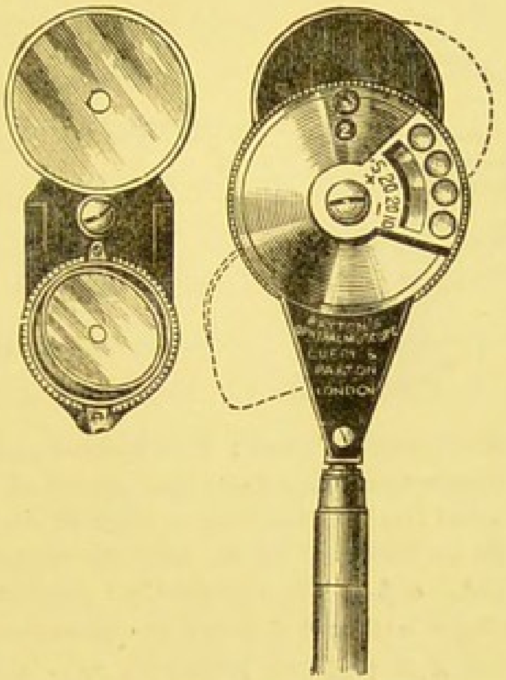


FIG. 24.

electric light should be placed at the side corresponding to the examined eye, on a level with it, but so situated as to leave the cornea in shade; he should then be directed to look forwards and a little upwards, at some distant object, and to keep the eyes as steady as possible.

Supposing the right eye to be examined, the light should be placed at the patient's right side; the observer, standing in front, a distance of eighteen inches or two feet separating his eye from that under examination, should take the ophthalmoscope in his right hand, look through the sight hole with the right eye, and reflect the light from the lamp through the pupil of the patient's right eye by means of the oblique mirror. If the examination be conducted properly, the pupil will appear of a bright red colour. The observer should then look for the optic disc, which is situated rather to the inner side of the axis of the eyeball, and which he will recog-

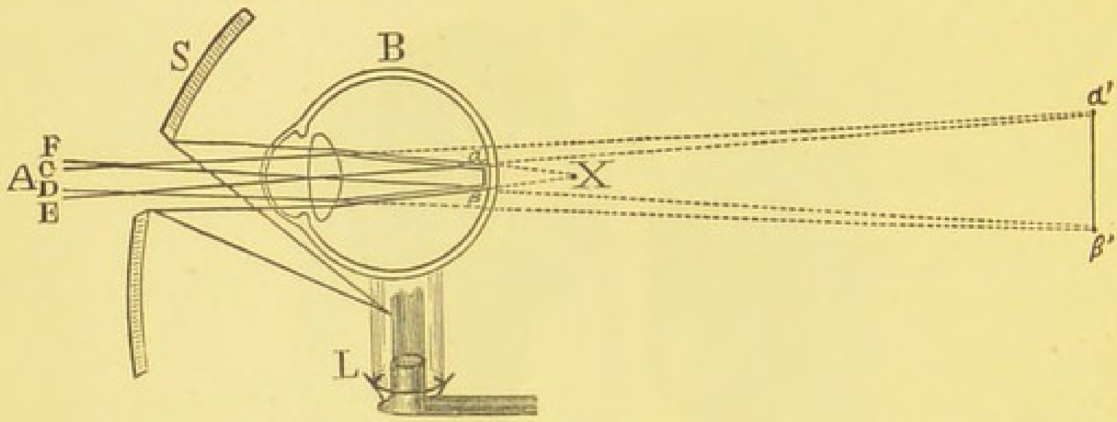


FIG. 25.—A, position of observer's eye; B, observed eye; S, the mirror; L, the light. The thick continuous lines show the course of rays from the light to the mirror and reflected from it, forming a slightly divergent pencil, which would after refraction be focussed at X, and consequently illuminates the fundus with diffuse light. α β is the illuminated portion of the fundus (object); the continuous lines α E and β F are the secondary axes drawn to the extremities of the object α β, and two returning rays α C, β D, which after refraction diverge from their respective secondary axes; but their continuations in the opposite direction meet the secondary axes as shown by the broken lines, in the points α' β', which are the virtual foci of the points α β, and between which the magnified, erect, virtual, image of α β is formed and seen by the eye placed at A.

The foregoing explanation is correct only when the illuminated portion of the fundus (object) lies somewhat within the principal focus of the "dioptric system," in other words when the eye is hypermetropic.

If the object be situated *exactly* at the principal focus of the dioptric system the rays represented by the lines, α C, and β D, will, after emerging from the eye, be parallel to the respective secondary axes, α E and β F, and if prolonged in the opposite direction will continue parallel to and nowhere meet the same axes.

Theoretically, therefore, no image of the object α β is formed; or what comes to the same thing it is formed at "infinity"; nevertheless a distinct, virtual, erect and highly magnified image of α β can be easily seen, provided the observed eye be approached within two inches.

nize from the alteration in colour of the pupil, which will turn from red to white, or pinkish white. Having obtained the peculiar reflection of the optic disc, the observer (taking care to relax his own accommodation) should approach the eye until an interval of only two inches separates his cornea from that of the examined eye. Some difficulty will be experienced in keeping the eye illuminated, increasing as the distance between the observed and the observer becomes less; this, however, will be overcome by practice. When the observed eye has been approached to within a distance of two to three inches (supposing both the examining and examined eye to be emmetropic), a distinct erect and greatly magnified image of the parts occupying the fundus of the latter will be obtained; most observers, however, find the image sharpened in outline and detail by using a weak *concave* lens behind the sight hole of the ophthalmoscope. Should either the observer or patient be myopic, it will be necessary, in order to examine the erect image, to place behind the sight hole of the ophthalmoscope a concave lens, which neutralises the existing ametropia, because if the patient be myopic the returning rays are convergent and cannot be focussed on the retina of an observer whose eyes are emmetropic until rendered parallel, or of one who is myopic, whether the patient be myopic or not, until rendered sufficiently divergent.

The examination of the erect image, although requiring considerably more practice than that of the inverted, should never be neglected, as it gives much more satisfactory evidence of minute changes in the fundus oculi, all the parts being seen highly magnified (about 14½ times). It gives, however, a less extensive field of vision, on account of the size of the objects, which only allows small portions of them to be seen through the pupil at one time.

The optic disc, retinal vessels, and other parts occupying the fundus, should be examined by looking in different directions through the pupil; the observed eye being kept steadily fixed during the examination upon some distant and suitably situated object.

The right eye having been examined, the lamp should be placed on the patient's left side, and the manœuvre repeated; the observer using the left hand and left eye, instead of the right hand and right eye.

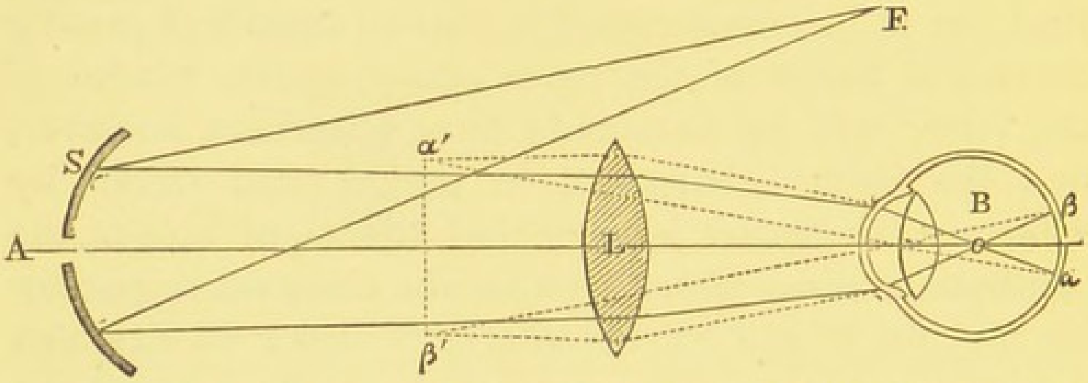


FIG. 26.—From Carter's translation of "Zander on the Ophthalmoscope"; A, observer's, B, observed eye; F, the light; S, the mirror; L, the biconvex lens; α β, some portion of the retina, or the disc; α' β', its inverted aerial image formed between the mirror and biconvex lens.

The condition of refraction of the eye can be diagnosed by the direct method of examination. (See p. 69).

Indirect ophthalmoscopic examination.—In this method of examination a "real" inverted (see fig. 13, p. 12) aerial image of the fundus oculi is formed by the interposition of a biconvex lens between the observer and the observed eye.

The position of the patient and observer should be the same as for the direct examination; the same lamp also can be used, but should be placed rather further back and may be kept on the same side during the examination of either eye. The patient should look at some distant object so situated that the axis of the observed eye is turned somewhat inwards; this brings the optic disc (which lies somewhat to the inner side of the optic axis) opposite the ophthalmoscope, when its peculiar bright reflection will be at once observed. The ophthalmoscope should be held in the same manner and the light reflected through the pupil as detailed above, but the large mirror, not the small one is used for this method, the red reflection having been obtained, the observer must not approach the eye, nearer than about 24 to 30 inches.

The biconvex lens should then be held in front of the observed eye at a distance about equal to its own focal length from the cornea, and steadied by the observer resting his ring and little fingers on the patient's brow (*vide* fig. 26). By this means an inverted image of the optic disc and vessels of the retina is immediately seen, which, although apparently within the eye, is in reality formed in the air between the observer and the biconvex lens, and (in emmetropia) at a distance from the latter corresponding to its focal length.

If the image of the disc appear indistinct, the observer may be sure that his own eye is not accommodated for the distance at which the image is situated, which is, in reality, shorter by some inches than it appears to be. Should this be the case, the observer must increase the tension of his accommodation, or withdraw somewhat further from the observed eye.

A better method, however, than either of the foregoing, is to employ habitually, behind the sight hole of the ophthalmoscope, a convex ocular lens of about ten or twelve inches* focal length. If this is done, a clear

* Four or three diopters.

and well defined image will always be obtained without tension of accommodation, provided precautions are taken that the distance between the observer's eye and the image is *not greater than the focal length of the convex ocular lens.*

The disc and parts immediately surrounding having been examined, the patient should be directed to look straight forward, so as to bring the region of the yellow spot opposite the ophthalmoscope; this having been carefully examined, the eye should be turned upwards, downwards, to the right and left, so that all parts of the fundus may be examined in turn.

In the indirect method of examination the observer should use his right eye, and hold the ophthalmoscope in his right hand and the biconvex lens in his left in examination of the right eye, and *vice versâ* in examination of the left.

Difficulties of Ophthalmoscopic Examination.

The use of the ophthalmoscope is not so easily learned as might at first appear probable, proficiency is only arrived at by long and patient practice, and the beginner will be frequently much disheartened at his want of success. Some of the difficulties are only to be overcome by practice, others are easily remedied. Reflections of the mirror from the two surfaces of the object lens often prove very troublesome; the inconvenience arising from this source is obviated by holding the lens somewhat obliquely, when the two images will recede from each other and leave a clear space between them. Reflection from the surface of the cornea may be troublesome, but can usually be overcome by a little manœuvring. Contraction of the pupil is also a frequent obstacle to the beginner, but can be removed by dilatation with atropine; for this purpose a solution of one grain to one ounce of water should be dropped into the eye about half an hour before the examination is made; or the patient may be ordered to use a solution of one-eighth grain to one ounce of water two or three times on the day preceding it. A solution of hydrobromate of homatropine may be used for the same purpose, its effects pass off sooner than those of atropine. When experience has been gained, however, mydriatics can be dispensed with, except in some few cases, or in those where it is necessary to make a very complete examination by lateral illumination.

If the patient looks at a distant object the accommodation is relaxed, and sufficient increase in the pupillary area will generally take place.*

Every ophthalmoscopic examination should be conducted on a certain definite system.

First, examine the condition of the refractive media by lateral illumination.

Next, the red reflex, the condition of refraction of the eye, and the state of the vitreous chamber should be ascertained by the direct method of examination. (See p. 37).

Thirdly, a general survey of the fundus oculi should be made by the indirect method.

Fourthly, any abnormalities which have been discovered by the indirect examination should be fully and carefully studied in detail by the direct method.

If this systematic plan of examination be carefully

* It is a common practice to direct the patient to look at the little finger of the hand with which the observer holds the ophthalmoscope. This is a mistake as the patient immediately accommodates for the finger and his pupil contracts.

carried out few mistakes will be made, and no abnormality of importance is likely to be overlooked.

The red reflex is due to the reflection of the light from the capillary layer of the choroid. Its brilliancy depends on the transparency of the media in front of the vascular layer and also on the refraction of the eye. Opacities in the cornea, lens, vitreous humour, &c., will interfere with, or even extinguish it altogether and high errors of refraction also diminish its brilliancy. To examine its condition, the large concave mirror of the ophthalmoscope should be used, the observer should stand at a distance of about two feet from the patient, and looking through the sight hole of the ophthalmoscope direct the light from the lamp placed above and behind the patient's head, on to the pupillary area. If the media are clear and the refraction about emmetropic, the reflex should be of a bright red colour, but opacities of the media will either make it a dull red, or the opacities themselves appear as black marks in the illumined area. The patient should be directed to look up, down, to the right, to the left, and the brilliancy of one part with another should be compared. Very valuable information can be obtained from this procedure, the position and extent of the defect being observed before passing to the much more difficult task of focussing the fundus.

The position of any opacity with regard to the plane of the iris can be recognized by a very simple method also. Move your position to the right, left, up and down, and notice whether the opacity moves in the same or in an opposite direction. If the opacity moves with the observer then the opacity is behind the plane of the iris, but if against then the opacity is in front. Should the opacity be on the same plane as the iris no movement will be apparent.

We are dealing here with the phenomenon known as "Parallax," an apparent displacement of an object due to a change in the observer's position. We view the apparent movement of the opacity in relation to the plane of the iris. If we imagine three opacities, on the cornea, anterior and posterior surfaces of the lens (*vide* fig. 27), and all three on the median axis, then an ob-

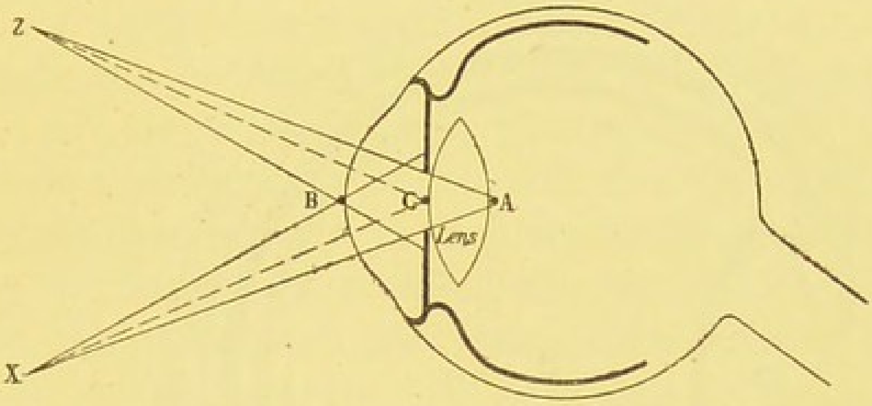


FIG. 27.—Diagram to illustrate the apparent movement of opacities situated in front, behind, and on the same plane as the iris.

The observer moving from X to Z an opacity at B, will appear to move in the opposite direction, an opacity at A will appear to move in the same direction, and one at C will have no apparent movement at all.

server at X will see the corneal opacity projected against the upper part of the iris, and on moving to Z the object will appear to travel downwards, being projected against the lower part of the iris. On the other hand the opacity on the posterior surface of the lens will appear to move with the observer and that on the anterior surface, being on the same plane as the iris will not appear to move at all.

NORMAL APPEARANCE OF PARTS SEEN BY THE OPHTHALMOSCOPE.

The refractive media (cornea, aqueous humour, lens, and vitreous), as stated under Lateral Illumination, are perfectly transparent.

The retina is either quite transparent and colourless, or in dark eyes may appear as a faintly grey cloud, covering the choroid; its position is marked by that of its blood vessels. The bright red reflection previously mentioned is due to the blood in the choroid. In addition to the causes already mentioned the depth in colour of the reflection varies with the amount of

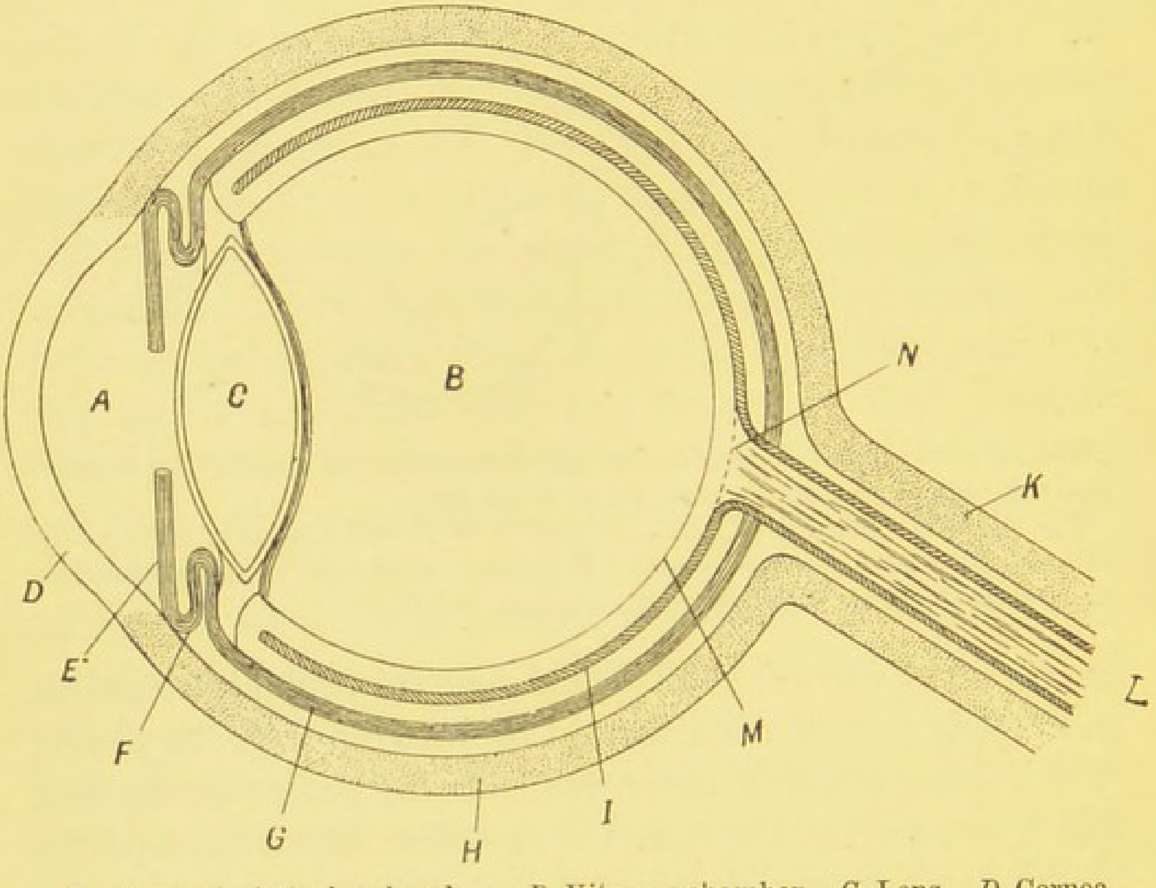


FIG. 28.—*A*. Anterior chamber. *B*. Vitreous chamber. *C*. Lens. *D*. Cornea. *E*. Iris. *F*. Ciliary processes. *G*. Choroid. *H*. Sclerotic. *I*. Retina. *K*. Optic nerve sheath. *L*. Optic nerve. *M*. Hyaloid membrane. *N*. Optic disc.

pigmentation of this vascular tunic—in blue or grey eyes it is light red, in dark ones of a much deeper tint, and in the negro appears to be dusky blue or slate colour. The parts of the fundus oculi requiring special attention are the optic disc and parts immediately surrounding it, and the region of the yellow spot.

The disc appears at first sight to be of an uniform pale pink colour, but on closer examination different portions are found to present different shades.

Its centre is pale, or even white; around this is a zone of pink, bounded by a border of lighter colour, sometimes partly edged by pigment. The pale appearance of the central portion of the disc is caused by the connective tissue which surrounds the blood vessels in this situation. The succeeding pink zone consists entirely of nerve fibres and delicate capillaries. The outer pale border edged by pigment is formed by the margins of the sclerotic and choroidal rings, which do not accurately cover each other, the choroidal ring being somewhat greater in diameter than the sclerotic opening, the margin of which, being left uncovered by pigment, shines through the transparent nerve fibres, whilst the retinal pigment may not reach to the limits of the choroidal ring, and this then shows as a pigmented area around usually only one part of the scleral ring (*vide* fig. 36, A and B).

Both the white central portion and the scleral ring are in some cases so distinctly marked, that the appearance produced might be taken by an inexperienced observer as evidence of disease, but both conditions are perfectly consistent with health. From the pale central portion of the disc proceed the retinal blood vessels; these appear upon its surface usually at the same point, but may emerge separately or in groups of two or three, or a branch may appear coming from beneath the choroid at the margin of the disc.

As a rule about eight vessels are seen, upon or close to the disc, four of these being arteries, with a corresponding number of veins; two of each pass upwards, and a like number downwards, to be distributed over the retina. Their names sufficiently indicate their distribution. Superior and inferior temporal artery and veins; and superior and inferior nasal artery and vein. The lateral branches are comparatively insignificant, and are given off from the principal trunks, either upon the nerve surface or in the retina near its margin.

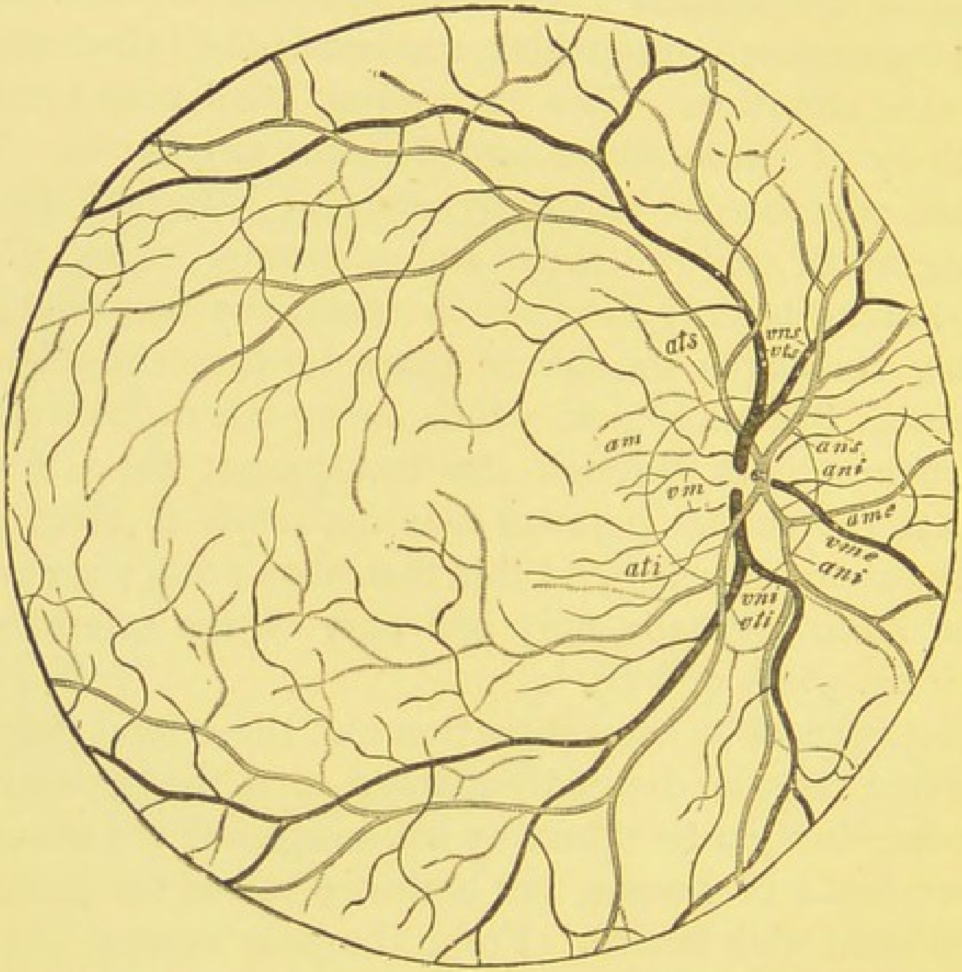


FIG. 29.—*ans*, Art. nas. sup.; *ani*, Art. nas. inf.; *ats*, *ati*, A. temp. sup. and inf.; *vns*, *vni*, Ven. nas. sup. and inf.; *vts*, *vti*, Ven. temp. sup. and inf.; *ame*, *vme*, Art. and ven. median; *am*, *vm*, Art. and ven. macularis. (Græfe and Sæmisch).

The veins are distinguished from the arteries by being of greater calibre, the proportion being about three to two. There is also a difference in colour between the two, the veins being the darker; the arteries are marked by a double contour, and their central portion is much lighter than their borders.

Occasionally a dark spot is noticed in one of the vessels at its origin or termination in the disc. This might be taken for a clot, but the appearance is caused by a peculiar arrangement of the vessel, which at this point is seen, as it were, on end and foreshortened.

Spontaneous pulsation of some of the retinal *veins* may also be observed; the occurrence of *venous* pulsation is, however, perfectly consistent with health, and has no pathological import.

In any eye, pulsation, both arterial and venous, can be produced by pressure upon the globe, but should it occur spontaneously in the *arteries*, it shows increase of tension, and has the gravest significance (see Glaucoma). Arterial pulsation may, however, occur spontaneously in cases of aortic regurgitation, but so far as the eye is concerned need cause no anxiety.

Anomalies of Optic Disc, &c., Consistent with Health.

Certain phenomena are not unfrequently observed with the ophthalmoscope, which, although contrary to the condition usually met with, are perfectly consistent with a healthy state of the parts.

The appearances caused by the connective tissue surrounding the central vessels, the occurrence of pulsation, unusual distribution, and existence of dark spots together with abnormal distinctness of the sclerotic ring, have been already mentioned.

Other anomalies are:—

1. **Variations in depth of colour of the disc.** —Due regard must be had to the colour of the surrounding fundus in forming an opinion as to whether

the tint in any particular case is so much deepened or lessened as to constitute a diseased condition.

In light eyes the disc appears much redder than in dark, the apparent difference being due more to contrast with the surrounding parts than to actual change in colour.

Slight deviations are only to be determined by careful examination and long experience.

2. **Excavation of the optic disc.**—Not unfrequently a sloping or even abrupt depression is met with occupying the centre of the disc, but usually extending somewhat further towards the yellow spot than in other directions. The whole nerve surface, however, is never included in the cup; the vessels do not bend under its edge, their calibre is not altered, neither is spontaneous arterial pulsation observed, as may be the case in the excavation of glaucoma (see Glaucoma).

3. **Persistence of the hyaloid artery.**—Occasionally a small whitish cord may be seen extending from the centre of the disc to the back of the lens; it is the remains of a vessel which, during fœtal life, nourished the latter structure.

4. **Shot silk appearance.**—A peculiar glistening watery appearance of the retina, most marked along the borders of the larger blood vessels, designated "shot silk appearance," which describes it perfectly, occurs sometimes, most frequently in children. A very similar appearance may be caused by the patient's hair intervening between the mirror and the lamp and causing the light to be reflected in an irregular manner.

5. **Senile changes.**—As age advances, the refractive media become less transparent, the retina grows somewhat hazy and the disc appears whiter than in youth.

6. **An appearance of white whisp-like patches,** "opaque nerve fibres," extending from some part of the margin of the disc over the surrounding fundus. These patches have irregular jagged borders, and are often of considerable size; the retinal vessels pass through and are obscured by them, and occasionally white threads are continued for some distance along the sides of the vessels.

The patches are caused by the opaque nerve sheaths which should end at the lamina cribrosa, being continued beyond this point into the transparent retina; they are congenital, and do not interfere with vision, although the "blind spot" may be found enlarged.

7. **The choroidal vessels** are at times (especially in light eyes) very plainly visible, appearing as an irregular network of pale pink bands, which anastomose, and are broader and flatter in appearance than the retinal ones and have no central light streak.

The region of the yellow spot presents in health no very marked ophthalmoscopic signs, but requires special notice, as it is frequently the seat of pathological lesions. In the normal condition it is marked by the absence of blood vessels, which appear to avoid this part of the retina passing above and below it; some deepening in colour, and occasionally an indistinct, dark, transversely oval figure, in some cases having a bright centre, or surrounded by a shining, but rather ill defined ring, can be detected.

IV. Examination by Manipulation.

The method of examination, *by manipulation*, consists in ascertaining the tension of the globe by digital pressure. Many students find a difficulty in this manipulation, but careful attention to details will remove many fallacies in the way of arriving at a correct opinion as to the tension of the eye. The globe, although situated in the bony orbit, by no means fills it, and is surrounded in its major part by soft yielding tissues, consequently we must take care that we are not palpating the orbital contents instead of the globe. The sclerotic coat varies in thickness, being thickest at the posterior part close to the optic nerve and thinnest at its equator, and also the cornea is harder and more resisting than the sclerotic. Another difficulty is, that we have to feel the tension of the globe through the eyelid, and consequently any swelling or œdema of the lid will render a correct estimation more difficult. Direct the patient, with his head a little thrown back, to look down at his hand placed in front of him on a level with his watch chain. The equator of the globe can then be reached by the finger tips. The upper lid being smooth and not screwed up, place the tip of one index finger on the globe, and steady it against the floor of the orbit and with the tip of the other index finger gently fluctuate. The pressure should be made in a direction downwards and backwards so as to compress the globe against the floor of the orbit. If fluctuation is easily obtained the tension is subnormal, if not obtained, or obtained with difficulty, the eye is hard. Always compare the two eyes, any variation of tension is pathological.

In health the eyeball is firm, tense, and semifluctuating; in disease the tension may deviate in the direction of increase or decrease. The degree of tension may be expressed as follows:—If normal as Tn, if above par as T+1, T+2, T+3, according to the amount of increase; if below par as T – 1, T – 2, T – 3. If a doubt exist as T + ? or T – ? according as the doubt is on the side of increase or decrease.

ACUTENESS OF VISION (V).

Visual acuity or keenness varies in different races and is affected by occupation, age, &c. Savages and races accustomed to gazing at very distant objects develop keener distant vision than those confined to rooms by sedentary habits. The acuteness of vision is considerably modified by age, being above the standard in youth and often much below it in old age. The failure in the latter is due to natural senile changes, as loss of transparency of the media or degenerative changes in the nervous structures concerned in vision. Such changes can hardly be looked upon as morbid, and we should expect to find them in old people.

When we speak of the acuteness of vision we refer to the perceptive and conductive power of the nervous structures concerned in sight. The optical conditions necessary for normal vision have been given above.

In order to ascertain the acuteness of vision, we use "test types," which are letters made of certain definite proportions, and which can be recognised by a standard eye at certain distances.

The test types of Dr. Snellen are those most generally used. It has been estimated that the smallest object that can be seen, subtends an angle of one minute on the retina. If smaller than this, it is not seen. Snellen of Utrecht arranged a series of letters, the component strokes of each being one-fifth the thickness of the whole letter. At varying distances according to their size, these letters subtend an angle of five minutes, therefore each part of a letter subtends an angle of one. The top letter marked 60, if viewed from a distance of 60 metres, subtends an angle of five minutes, and each of its component lines an angle of one minute. So also, the letters of the last line marked 6, at a distance of 6 metres subtend an angle of five minutes. Consequently the big letter at the top of the list would appear the same size to an observer at 60 metres away as the letters of the last line would at a distance of 6. The usual arrangement of the letters is 60, 36, 24, 18, 12, 9, 6.

The reading types in use in England are those of Jaeger of Vienna, and are simply specimens of printer's types arranged one under another on a card, and not on any scientific principle. Snellen has arranged also reading types on the same lines as his distance types, but they are not in common use in England.

In any case in which we find abnormal want of sight we may always attribute the failure to some of the following causes:—opacity of the media, anomalies of refraction or accommodation, or those affections of the retina, choroid, optic nerve, and brain, which were formerly classed together under the names "amblyopia" and "amaurosis."

Field of Vision.

By the field of vision we understand the area over which objects can be distinguished, whilst the eye is kept fixed on some one point. The limits of the field of vision are marked by the most eccentrically placed points which can still be distinguished, the direction of the visual line being unaltered.

A patient may have full visual acuteness and yet not have sufficient sight to go about with safely. Our visual acuity depends on the condition of the macula which occupies but a small area of the retina, the rest of the retina being used for the orientation, or assigning of objects to their proper position around us. We may liken a man with only central vision, that is vision at the macula, to one looking through a long tube, who sees only what is in front of the end of the tube, and nothing around him.

The extent of the visual field may be roughly measured by one of the two following methods:—

1. Having placed our patient in a convenient position, we stand opposite to him, at a distance of about two feet, and supposing his left eye to be examined, direct him to look steadily at our own right eye, which is opposite to his left, the patient's right eye and our own left being kept closed. We then move the hand in various directions in the peripheral parts of the field, and notice if its movements are perceived by the patient at the same distance from the centre as by our own presumably healthy retina. We must take care that the hand is moved in a vertical plane, situated midway between our own eye and that of the patient, and not nearer one than the other; and also see that the patient keeps his eye fixed.

Supposing that the eye under examination distinguishes all movements of the hand at the same distance from the centre as our own, we decide that the field of vision is normal; but if a falling off is noticed in any particular direction, we infer that the sensibility of the corresponding portion of retina is impaired.

It must be remembered that each part of the visual field corresponds to a part of the retina opposite to and not on the same side as the object seen—*e.g.*, suppose that the movements of the hand are not perceived in the outer half of the field, the inner half of the retina is defective, and *vice versâ*.

It must also be borne in mind that the height of the bridge of the nose has a considerable influence in limiting the inner half of the visual field.

The above method for estimating the size of the field of vision is a rough but practical one.

2. More scientific and accurate information is obtained by using one of the numerous forms of perimeters—that of McHardy being the most used on account of several ingenious contrivances for registering the field automatically.

It consists of a vulcanite quadrant which can be rotated into any position, and on which a carrier, with the test object, moves. As the carrier moves, a pointer moves simultaneously in such a way that the position of the test object can be pricked on to the chart spread out on a circular cork pad behind. Printed charts are supplied with the instrument on which is marked, the normal field of vision, for comparison with that obtained from the patient.

Both carrier and pointer are worked by a revolving handle.

The patient is seated with his back to the light and with his chin resting on the support. The eye not under examination is covered with a shade; the other should be on a level with and facing the small white spot placed at the central end of the quadrant, which marks the pivot around which the quadrant moves. "Keep your eye fixed on this central white spot, and tell me as soon as you see another spot coming into view from any direction," are the instructions to the patient.

The operator then starts with the quadrant placed horizontally, the test object, which should be moved as slowly and silently as possible, being at the far end.

If the temporal portion of the field is taken first, the

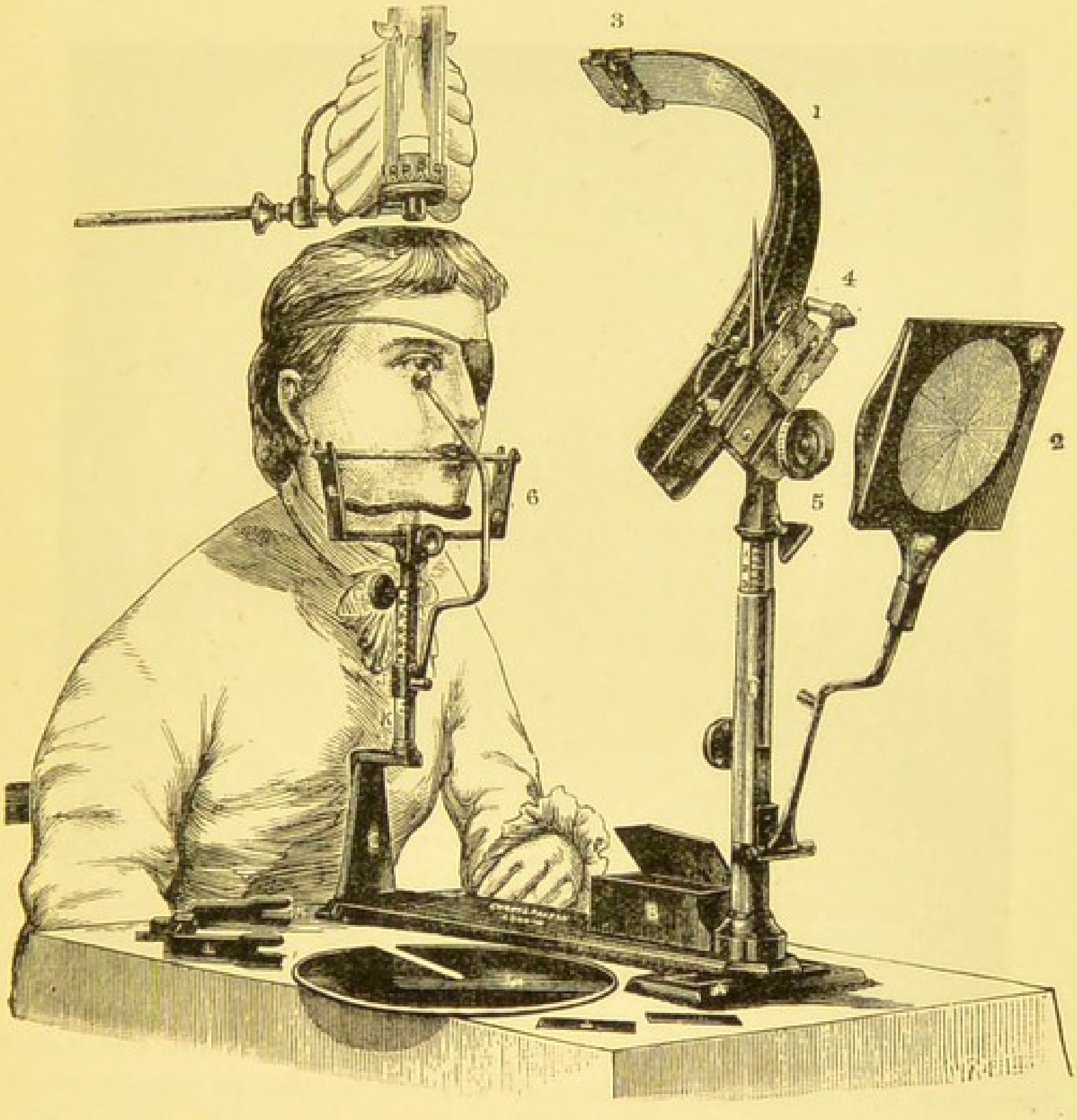


FIG. 30.—McHardy's Perimeter. 1. Vulcanite quadrant. 2. Chart holder. 3. Carrier. 4. Pointer. 5. Revolving handle. 6. Chin rest.

patient will recognize something white almost as soon as the object is moved, whilst on the nasal side the test object nearly reaches the centre of the quadrant before it is seen. The field should be taken in all parts and not less than a dozen points mapped out, where the white test object is first seen.

If colours are used they must be recognized as colours, that is, red as red, blue as blue, not merely as something moving.

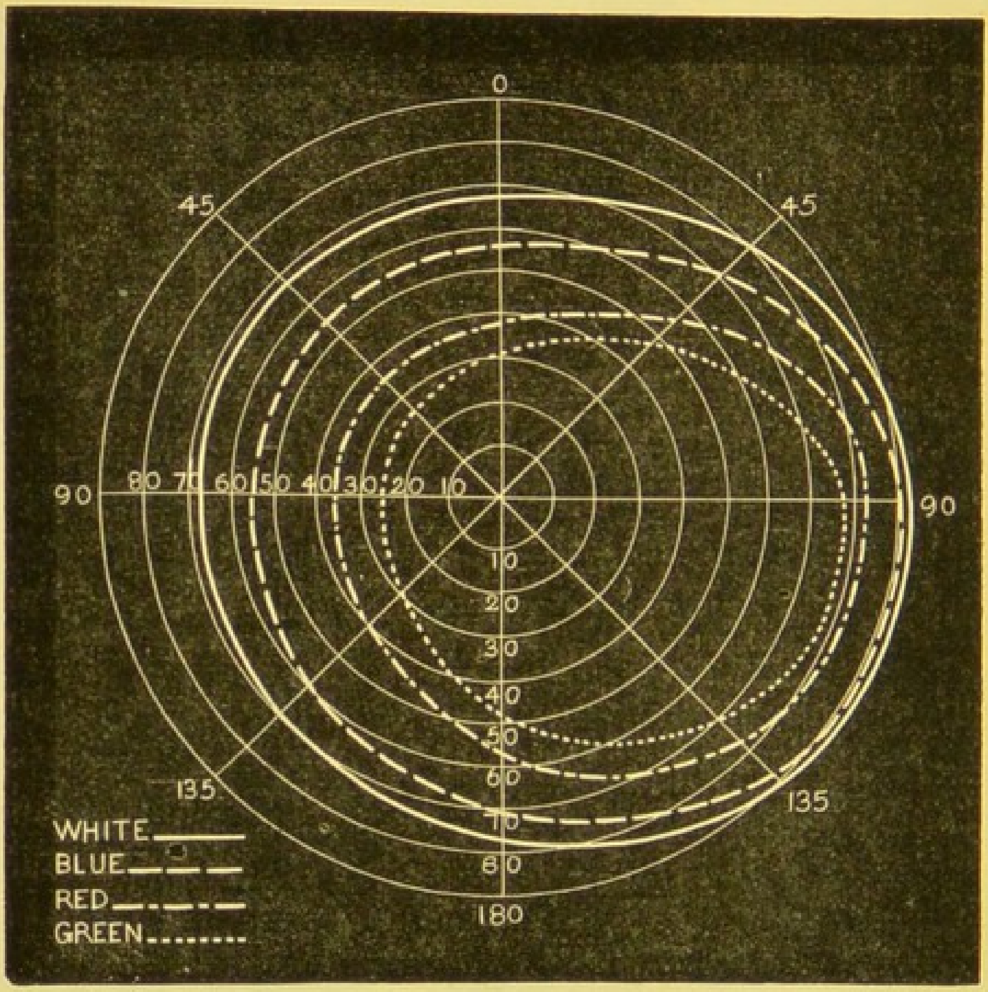


FIG. 31.—Field of vision of right eye. The continuous, broken and dotted lines show the outer limits of the field over which different colours can be recognized (Landolt).

Since we depend entirely on subjective evidence in these cases, the intelligence of the patient is of great moment to the observer, and his attention must be aroused in order to make him take an intelligent interest in the examination.

The condition of the light in the room during the test, the size of the object and colour, must be noted on the chart. The chart must be accurately centred on the pin in the middle of the cork disc and that drawn for the right eye used, when the right field of vision is being examined, and *vice versâ*.

The field extends from the central or fixation point outwards, 90° or more, in other directions it is limited by the height of the bridge of the nose, prominence of orbital margins, and depth of the eyeballs in the orbits, and extends for about 65° to 75° from the fixation point. The extent of field is different for different colours, white is the largest, then comes blue, next red, and last green (see fig. 31).

Contraction of the visual field, or gaps in its area (scotomata) are very constant accompaniments of retinal or choroidal changes; contraction is also one of the earliest symptoms of glaucoma, and occurs as a physiological condition with advancing age.

Charts corresponding to fig. 31, but without the lines indicating the field for different colours, are printed for the purpose of making a record of the field. The straight lines show the angle at which the arc is placed, the circular lines the angle from the visual line directed to the central dot.

Accommodation (A).

By accommodation is meant the power which the eye possesses of altering the condition of its refractive media, so as to form upon the retina images of near objects, the rays of light from which are divergent. Near objects are, by accommodation, rendered as distinct as images of distant ones, the rays of light from which are parallel, or nearly so.

The power of accommodation depends upon the elasticity of the crystalline lens, the curvature of which can be increased to a considerable extent; this alteration of curvature is brought about by the action of a ring of involuntary muscular fibres, situated between the sclerotic and choroid, just external to the greater circumference of the iris, known as the *ciliary muscle.* The manner in which the ciliary muscle acts upon the lens is as yet a disputed point, one theory being that the lens is maintained in a flattened condition by tension of its suspensory ligament so long as the eye is adjusted for a distant object, but that upon accommodating it for a near one the ligament is relaxed by contraction of the muscle, and the curvature of the lens (more especially that of its anterior surface) increased by virtue of its own elasticity. The other theory is that the ciliary muscle compresses the lens in some manner, and so alters its curvature.

Range of Accommodation.

By the range of accommodation, we mean the strength of the lens, which we suppose the crystalline adds to itself when we look from the furthest to the nearest point of distinct vision. Thus, an eye which sees clearly at infinite distance when its accommodation is relaxed, and at 16 centimetres with greatest tension of accommodation, has a range or "amplitude" of accommodation equal to a lens of $\frac{100}{16} = 6$ D, the focal length of which is 16 centimetres (see p. 22). We test the range of accommodation by ascertaining the furthest point of distinct vision —*punctum remotum* = *r*—and then finding the nearest point at which small print can be read—*punctum proximum* $= p$. The latter recedes from the eye as age advances, and consequently the range of accommodation decreases.

Accommodation is accompanied by convergence of the optic axes and by contraction of the pupil.

With convergence of the visual lines to a given point, accommodation for that point takes place, so that when the eye is fixed on an object at one metre distance, the angle of convergence is one metre angle, and the accommodation equal to one diopter. At half a metre distance: 2 metre angles and 2 diopters of accommodation. Hence with x metre angles of convergence we have x diopters of accommodation and $\frac{1}{x}$ metres distance.

This relationship of convergence and accommodation only holds good for emmetropia.

The Colour Sense.

The colour sense is best tested by ascertaining the power of distinguishing various colours without naming them. The best test objects are skeins of wool of various colours. A set of these has been introduced by Professor Holmgren, by whose name they are known. The examination is made by spreading the whole set of skeins in a good light and directing the person examined to pick out and place together all that appear to him alike. Holmgren takes a pure pale green and directs the patient to pick out from the pile of skeins on the table all skeins of the same colour. Since no two skeins in the pile are of the same shade the person examined must pick out some of a lighter and some of a darker shade, but all must have green in them; if he shows hesitation or picks out fawns, drabs, greys, browns, or any other of the confusion colours, his colour vision is defective. If the patient be colour blind he will place together dissimilar colours, and will have no appreciation of different shades; at the end of the examination the skeins will be in a hopeless confusion.

Persons with acquired colour blindness from atrophy of the optic nerve may arrange the same colours together, but if asked to name them will probably make mistakes. In congenital colour blindness the confusion test without naming is sufficient.

Movements of the Eyeball.

The eyeball moves around a point which, as stated at p. 21, is situated on the axis about two-thirds of its length from the summit of the cornea. To ascertain that the movements are normal we need only take a pen or other object, and move it in front of the eyes, upwards and downwards, and to the right and left. If both eyes follow the movements accurately, the muscular apparatus is in proper working order.

Muscæ Volitantes.

Beads, threads, flies, films, or webs floating before the eyes are often complained of, more especially in myopia. They are always seen most distinctly in bright light, or when looking upon a white surface as up at white clouds, or down at the pavement. They are known as muscæ volitantes, and are due to mucus in the cornea, or very slight imperfections in the transparent media. If they cannot be seen with the ophthalmoscope their presence is of no importance; patients are often anxious about them, but may be assured that they will do no harm.

CHAPTER III.

Errors of Refraction.

Definition.—By refraction of the eye we understand the power which the refractive media (cornea, humours, and lens) possess by virtue of their curvatures and densities of bringing together *parallel* rays of light, and forming them into an image at a certain spot (known as the principal focus of the refractive or dioptric system) *without the employment of any adjusting power* (see also p. 59).

The refraction is said to be *normal* or *abnormal* according to the position of the retina with regard to the principal focus of the dioptric system. The former condition is known as *emmetropia*, the latter as *ametropia*, the terms, normal and abnormal, being seldom applied.

Emmetropia (E).—The emmetropic eye (fig. 32*a*) is of such a shape that when its accommodation is relaxed (see also p. 17 and 59) the retina is situated at the principal focus of the *dioptric system*, in which position a distinct inverted image of any object, *the rays of light proceeding from which are parallel*, is formed upon the layer of rods and cones.

Ametropia.—The ametropic eye differs from the emmetropic in two opposite directions; the deviations are known as *anomalies of refraction*. In the first and (in this country)* most commonly met with anomaly the

* It is generally believed amongst English, and is also reported by continental ophthalmologists, that in this country hypermetropia is

retina lies in front of the principal focus of the dioptric system; that is to say, the axis of the eyeball is too short from before backwards, and when the accommodation is at rest, images of objects, the rays of light proceeding from which are parallel, are formed behind the retina instead of in its substance. This anomaly is known as *hypermetropia*, or far sight (see fig. 32*b*).

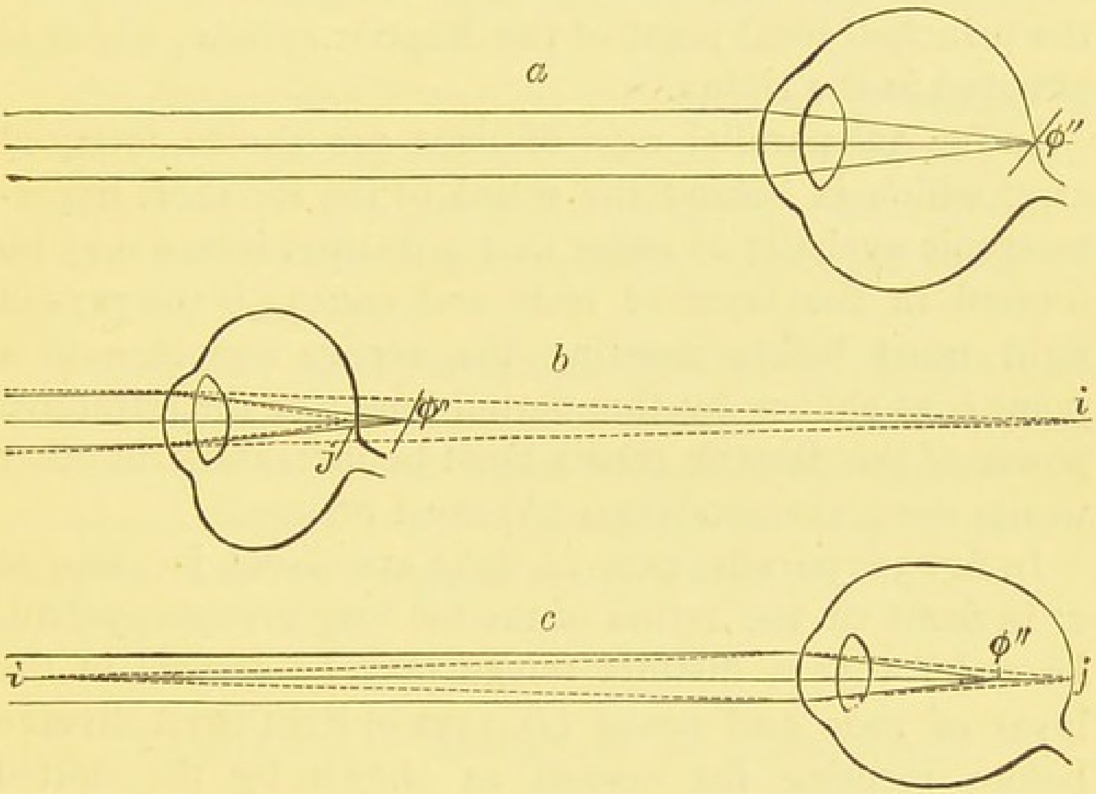


FIG. 32.—From Donders' *Accommodation and Refraction of the Eye*. *a*. Emmetropia; *b*. Hypermetropia; *c*. Myopia.

In the second anomaly we have an opposite state of things; the axis of the eyeball from before backwards

of more frequent occurrence than myopia. It appears to me that the reverse may be the case, for we are rarely in hospital practice consulted about slight myopia, as it gives no inconvenience. On the other hand, a very slight degree of hypermetropia may incapacitate the sempstress, skilled mechanic, or clerk, so that whereas we get all degrees of hypermetropia, we are only applied to in the higher degrees of myopia.

is too long, consequently the retina comes to lie behind the principal focus of the dioptric system, and the image of an object, the rays of light coming from which are parallel, is formed in front of it. This anomaly is known as *myopia*, or short sight (see fig. 32*c*).

Fig. 32*a* shows the emmetropic eye, a pencil of parallel rays of light is represented meeting the anterior surface of the cornea, and after refraction focussed at ϕ'' the principal focal point of the dioptric system, which is situated in the retina.

In fig. 32*b* parallel rays of light are shown focussed at ϕ'' which is behind the retina of the too short hypermetropic eyeball; in order that a distinct image may be formed in the layer of rods and cones (*j*) the rays of light must before meeting the cornea converge to a point *i*, as shown by the dotted lines; or the refractive power of the dioptric media must be increased; in other words the accommodation (A) must be used.

In fig. 32*c* parallel rays of light are shown focussed at ϕ'' in front of the retina of the too long myopic eyeball. In order that a distinct image may be formed in the layer of rods and cones (*j*), rays of light must diverge before meeting the cornea as shown by the dotted lines.

Astigmatism.—Regular astigmatism signifies a difference in refraction in different meridians of the same eye. It depends upon a want of symmetry of the cornea, the curvature of which is greater in one meridian than in others.

The meridian of greatest curvature is that which has the shortest radius of curvature and the sharpest curve. The meridian of least curvature is that which has the longest radius of curvature and the flattest curve.

The meridians of greatest and least curvature are called *principal meridians* and are always at right angles to each other.

A familiar instance of regular astigmatism is supplied by the back of an ordinary spoon. The misshapen appearance of the reflection of the face when seen on the back of a bright spoon is well known to all, and is caused by the curvature of its surface being much sharper from side to side than in the long axis of the spoon bowl.

The phenomena of regular astigmatism are caused by a similar condition of the curvature of the cornea ; but in the case of the spoon the image is reflected, whilst in that of the astigmatic cornea the misshapen image on the retina is refracted.

Irregular astigmatism signifies a difference in refraction in different parts of one or several meridians of the eye. It depends upon irregularity in corneal curvature or defects in the crystalline lens. No treatment is of any avail in irregular astigmatism.

DIAGNOSIS OF ANOMALIES OF REFRACTION.

The diagnosis of anomalies of refraction, and of astigmatism, can be made by trial with lenses, by direct and indirect ophthalmoscopic examination, and by keratoscopy (*vide* infra).

Trial with lenses.—In order to diagnose and also to measure the "degree" of anomalies of refraction and astigmatism by trial with lenses, we must be provided with the box of trial lenses described at p. 21, and a set of Snellen's types,* p. 53. Having placed the

* For the sake of brevity we denote Snellen's types as S, Jaeger's as J.

patient at a distance of 6 metres from a set of Snellen's test types, try how many of the letters each eye, separately, can read. If all or most of the letters can be read, hold before the eye under examination a weak convex lens + ·25 D. If vision is *as good* with this lens as without, or if sight is improved by it, hypermetropia is certainly present.

If only a few or none of the letters can be made out

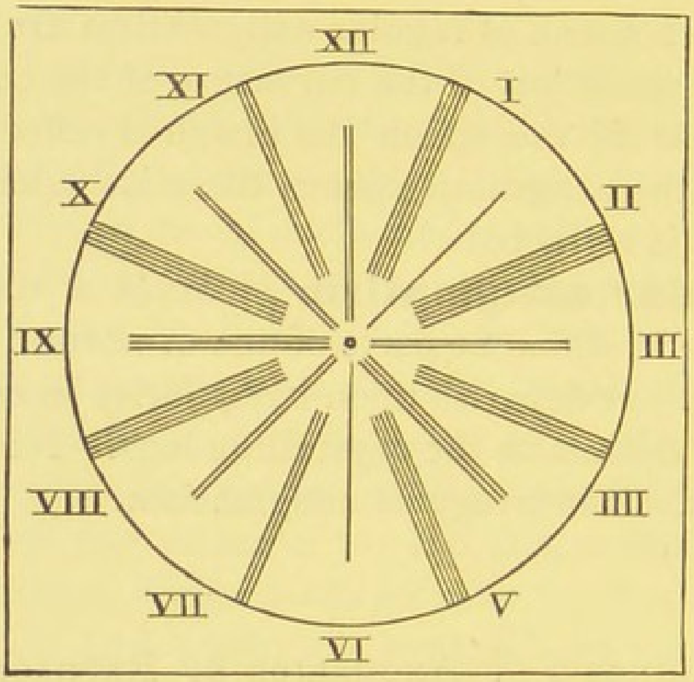


FIG. 33.—Purves' Clock Face diminished about ⅓. The disc carrying the lines revolves upon a central axis, so that any bundle of lines can be placed in any position ; we judge of the patient's ability to see the lines by his counting the separate strokes in each bundle. If he learns the number in one bundle, and counts without seeing them, we soon catch him by altering the position of the bundles.

the eye is probably myopic, and this diagnosis is confirmed if the small types, J 1, can be read near the eye, and if distant vision is *improved* by a concave lens. If the trial gives no satisfactory result, vision being below the normal standard, both for near and distant letters, and capable of improvement to a limited extent only, by convex or concave lenses, and more letters are seen than are read correctly, B being mistaken for E, O for D, C for G, &c., some form of astigmatism is probably present. Before testing for it, however, it is well to examine by oblique illumination and with the ophthalmoscope, to make sure that the want of sight is not due to opacity of the media, or disease at the fundus of the eye.

The existence of astigmatism is rendered certain by finding that some of the lines on Snellen's fan or on the clock face (fig. 33) placed at 5 or 6 metres can be seen more distinctly than others without any lens; or that by the aid of lenses some of the lines come into view whilst others still remain indistinct, or that those lines which were distinct before are rendered indistinct, the indistinct ones being seen still less distinctly.

Diagnosis by the Ophthalmoscope.

Direct method.—As stated under examination of the erect image, no details of the fundus become plainly visible in emmetropia until the observed eye has been approached to within a distance of two inches or less; if, on the contrary, a blood vessel, portion of the optic disc, or other object situated at the level of the retina, is *plainly* seen, whilst the observer is still separated from the observed eye by some considerable interval, ametropia certainly exists. The question now arises—What is the form of anomaly of refraction present?

This question is answered by ascertaining whether the object seen is viewed in an erect or inverted position: if the former, hypermetropia, if the latter, myopia is present.

The position of the image may be ascertained by either of the following methods :—First, having plainly distinguished some object, a blood vessel for instance, steadily approach the observed eye, taking care the while to direct the light properly, and to keep the object in view. If, as the observed eye is approached, the object retains its distinctness, or becomes even more plainly visible, the image is an erect one; the retina is situated in front of the principal focus of the dioptric system, and the eye is hypermetropic. If, on the contrary, as the observed eye is approached, the object becomes gradually indistinct, and at length fades entirely from view, the image is an inverted one; the retina lies behind the principal focus of the dioptric system, and the eye is myopic.

In the second method, having obtained a *distinct* image of some object occupying the fundus, we move our head from side to side, the observed eye being meanwhile fixed. Should the object seen move in the same direction as our head, the image is an erect one, and the eye is hypermetropic, if in the contrary direction, the image is inverted, and the eye is myopic.

If vessels running in one direction are seen either in an erect or inverted image at a distance from the eye, whilst those at right angles to them are seen only when the eye has been approached quite near; or if at a distance some vessels are seen in an erect image, whilst others are seen inverted, regular astigmatism is present. If the vessels or disc appear distorted or broken, or appear to have an irregular wave-like or whirling movement when the observer's head is moved from side to side, there is irregular astigmatism.

Indirect method.—The state of refraction and the presence of astigmatism can be diagnosed by indirect ophthalmoscopic examination, by noticing the behaviour of the image of the optic disc when the distance of the biconvex object lens from the eye is altered. If on withdrawing the lens from the eye the image of the disc becomes smaller, the eye is hypermetropic, if on the contrary it becomes larger, the eye is myopic ; if the image becomes oval at the same time that it grows smaller, there is hypermetropic astigmatism ; if it becomes oval and larger, there is myopic astigmatism.

In the emmetropic eye no alteration in size of the disc image takes place on withdrawal of the object lens.

Keratoscopy (or retinoscopy).—This method of examination depends for its results upon the bending or refraction by the dioptric media, of the rays of light reflected from the capillary layer of the choroid. These rays leave the eye in a divergent, parallel, or convergent manner (*vide* Chap. I., p. 19). The examination is conducted as follows:—The patient whose pupil is well dilated by a solution of atropine or homatropine, being seated, with a lamp or other light above and a little behind the head so that the face is in shadow, is directed to look at the mirror in the observer's hand (in order to obtain the refraction at the macula), and if a squint be present the eye not under examination should be covered with an obturator. The observer should stand or sit at a distance of about a metre and a quarter (one yard and a half). A pair of spectacle frames, a box of lenses ranging from ·25 to 20 D, and an ophthalmoscope complete the outfit.

The light reflected from the mirror should be then thrown on to the pupillary area, and if the observer looks through the sight hole of the instrument he will see the red reflection from the capillary layer of the choroid. If the light be moved from the pupil the red reflex is lost and the pupillary area appears to be black.

Notice whether the red reflex disappeared, by a shadow which started from the opposite side or by a shadow travelling in the same direction as the light: did in other words the red reflex disappear by means of a shadow moving with or against the direction of the mirror?

Since, as has been previously explained (Chap. I.), the image on the fundus oculi moves against the direction of the mirror, all rays of light leaving the eye in a parallel or divergent manner remain unchanged, only those that are convergent meet and cross in front of the eyes of the observer, hence all hypermetropic and emmetropic eyes give a shadow moving against, and all myopic eyes give a shadow moving with, the direction of the mirror. It must be remembered, however, that the observer is seated at a distance of a little more than one metre, hence all converging rays of light coming to a focus at a distance of more than one and a quarter metres appear to have a shadow *against*, since they do not cross in front of the observer, but behind him.

The rule then is this: when using an ophthalmoscope mirror, hypermetropia, emmetropia, and low degrees of myopia of less than one diopter give plus shadows, that is, shadows going against the direction of the mirror, and myopia gives minus shadows, *i.e.*, shadows going in the same direction as the mirror.

Ascertain whether the shadows are travelling in the same direction in the vertical and horizontal meridians. Both may travel against, both may travel with, and on the other hand one may travel with and one against.

Sometimes the shadows are not vertical and horizontal, but oblique, one being directed downwards and outwards, the other downwards and inwards.

If the shadows are *against*, then place plus spherical lenses in the spectacle frames until you obtain a distinct shadow moving with, the direction of the mirror. You have by means of the lenses rendered the eye myopic, and after making certain allowances, to be explained afterwards, you have the measure of the patient's hypermetropia. The same applies to myopia, only use minus or concave spherical lenses until the shadow turns and moves against the mirror, the myopic eye having been made hypermetropic by the use of minus spherical lenses.

You will often meet with cases in which the shadows in one meridian are changed by a spherical lens and not in the meridian at right angles to it. In that case correct the lower meridian, and having noted the glass, insert higher lenses until the meridian at right angles is corrected. There is astigmatism present.

If from the first the shadows in one meridian are plus shadows and in the meridian at right angles minus, then you are dealing with a case of mixed astigmatism, correct first one meridian with plus lenses and afterwards the myopic meridian with minus lenses.

If the edge of the shadow is obliquely placed, astigmatism is present.

If both meridians are corrected by the same spherical lens no astigmatism is present, but if not, the strength of the cylinder required to correct the astigmatism is equal to the difference between the lens correcting the meridians, and its axis must go in the meridian of least error or ametropia.

If the pupils are wide and the patient directed to gaze in the distance the retinoscopic test may be carried out without a mydriatic, but then the refraction at the disc is taken and not that at the macula, so that an approximate estimate only can be made.

Having estimated the refraction of the eye we now test the visual acuity, in order to ascertain the glass with which the patient *sees* best.

We find that the addition of a — 1 D is necessary to the retinoscopic results made at a distance of rather more than one metre because the eye must have been rendered myopic, to one diopter, in all cases of hypermetropia, in order to enable the ray of light to cross at a distance of one metre, and the shadows will cross in myopia although something less than 1 D still remains uncorrected.

The custom is to record a retinoscopic test by means of a cross, the arms of the cross being placed in the directions corresponding to the principal axes of the eye and always at right angles to one another.

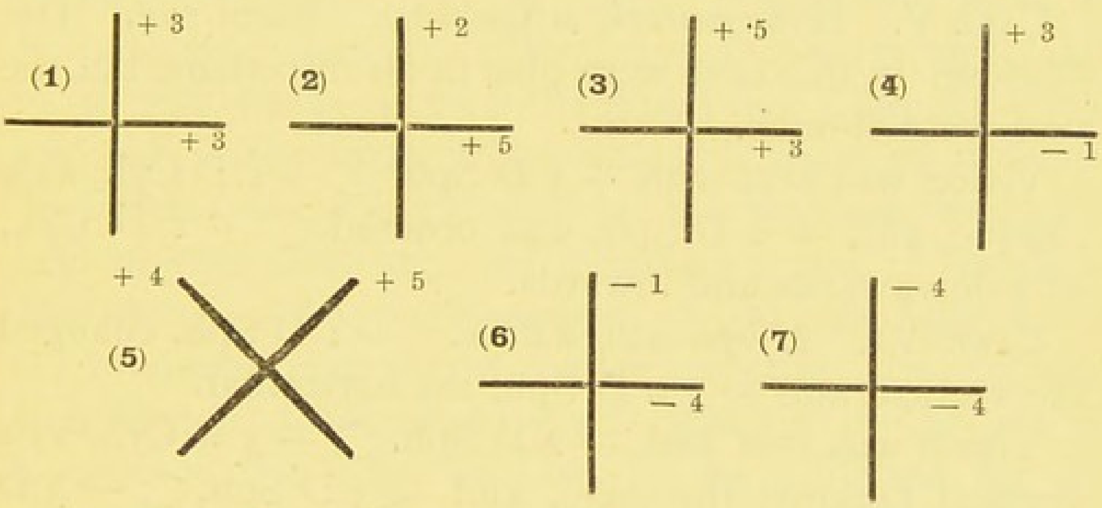
It is not correct to suppose that because the shadows are obliquely placed that the axes of the cylinder must also be placed obliquely. Obliquity of shadows denotes astigmatism, not necessarily the axes of the cylinder. If the shadow is oblique the operator should move the light in the same meridian as the shadows, that is, at right angles to its edge.

If the patient is under atropine, and the ciliary muscle completely paralysed, another addition of — 1 D must be made when the glasses are ordered, because the lens is not so flat, even when the ciliary muscle is at rest as when it is fully under the influence of atropine, the ciliary muscle having a certain tone about it which it loses after the prolonged use of atropine. If homatropine only has been used, and one or two drops at the most instilled, the glasses with which the patient sees best may be ordered.

If instead of an ophthalmoscope mirror, that is a concave mirror we use a plane mirror, the shadows which go against the direction of the mirror are minus, and those that go with the direction of the mirror are plus. This is due to the fact that the rays of light cross once less, than with the concave mirror, otherwise the procedure is exactly similar with a plane mirror.

Illustrative Cases.

The patients have all had atropine drops instilled for several days.



Case I. *Simple hypermetropia.* A + 3 D Sph. changed the plus shadows to minus ones in both principal meridians. Patient read $\frac{6}{6}$ with +2 D Sph. and was ordered + 1 D Sph. for near work.

Case II. *Hypermetropic astigmatism.* + 2 D Sph. changed the vertical meridian and + 5 D Sph. the horizontal.

Vision was best with + 1 D Sph. $\bigcirc$* + 3 D Cyl., axis

* $\bigcirc$ = combined with.

vertical. + 3 D Cyl., axis vertical, was ordered for constant wear.

CASE III. *Mixed astigmatism.* The vertical meridian was changed by a + ·5 D Sph., and the horizontal by + 3 D Sph.

Vision was best with — ·5 D Sph. $\bigcirc$ + 2·5 D Cyl., and — 1·5 D Sph. $\bigcirc$ + 2·5 D Cyl., axis vertical, was ordered.

CASE IV. *Mixed astigmatism.* The vertical meridian was changed by + 3 D Sph. The horizontal meridian shewed minus shadows which were changed by – 1·0 D Sph.

Vision was keenest with + 2 D Sph. $\bigcirc$ —4 D Cyl., axis vertical, and + 1 D Sph. $\bigcirc$ — 4 D Cyl., axis vertical, was ordered.

CASE V. *Hypermetropic astigmatism.* Right eye. The shadows in this case were plus in all directions, but the axes were oblique.

Vision was best with + 3 D Sph. $\bigcirc$ + 1 D Cyl., axis oblique, and + 2 D Sph. was ordered $\bigcirc$ + 1 D Cyl., axis downwards and inwards.

CASE VI. *Myopic astigmatism.* — 1 D Sph. changed the vertical and — 4·0 D Sph. the horizontal.

Vision was best with —2 D Sph. $\bigcirc$ —3 D Cyl., axis vertical (against the rule), and — 3 D Sph. $\bigcirc$ — 3 D Cyl., was ordered for constant wear.

CASE VII. *Myopia.* Shadows were changed by — 4 D Sph. and $\frac{6}{9}$ read with — 5 D Sph. —6 D Sph. was ordered, for distance.

CHAPTER IV.

Hypermetropia (H).

The hypermetropic eye is, as already stated, too short, from before backwards, the retina lies in front of the principal focus of the dioptric system (see fig. 32*b*)—provided no accommodative change takes place in the system—and a blurred indistinct image of objects is formed upon it. It is obvious that as the distance of the object from the eye decreases, and the rays of light proceeding from it become more and more divergent, the focus will tend to go still further behind the retina (see Chap. I., p. 7), and the image upon it becomes still more ill defined. In order that the hypermetropic eye may see even distant objects distinctly, the refractive power of its dioptric system must be increased, or rays of light must be rendered convergent before meeting the cornea. The first of these conditions is fulfilled by the act of accommodation; the second can be provided for by placing a convex lens in front of the eye.

As already shown, the emmetropic eye (fig. 32*a*) has no need of accommodation so long as rays of light entering it are parallel, but requires it for diverging rays only.

The hypermetropic eye must, however, accommodate for parallel rays, and must increase its accommodation as the distance of the object becomes less and the rays of light more divergent.

If the power of the ciliary muscle is sufficient, the hypermetropic eye will see both distant and near objects distinctly, and it is obvious that this result will depend upon the amount of shortening of the antero-posterior axis of the eyeball (degree of H), and also on the range of accommodation (see p. 60). From the foregoing it follows that the disturbance of vision caused by hypermetropia is manifested chiefly when the eyes are adjusted for their near point, as in reading, &c., that it is greater in direct proportion to the degree of hypermetropia, and that the symptoms become more urgent in all degrees as age advances, and the range of accommodation decreases.

Symptoms of hypermetropia.—The symptoms of hypermetropia are due to insufficiency of the accommodation (accommodative asthenopia). If the degree of hypermetropia is slight or moderate and the accommodation good no inconvenience is experienced in seeing either distant or near objects. But if the degree of hypermetropia is high, or if accommodation has become weakened by local disease or ill health, or failed with advancing age, the sufferer will complain that he can no longer see near objects distinctly for any length of time; he will probably state that he can read for a limited period only, that then the print becomes indistinct, the letters appearing to run together, but that if he closes his eyes for a time or rubs them he can continue to read again for a few minutes.

Watering and pain in the eyes are sometimes complained of; severe headache, in some cases frontal, in others occipital or extending down the neck, brought on by using the eyes for any kind of near work is a not uncommon symptom; in moderate degrees of hypermetropia the symptoms do not appear till between the ages of thirty and forty, when the power of accommodation has naturally declined. They may first make their appearance after long periods of study as in working for examinations, in persons suffering from exhausting diseases, or in women after prolonged lactation. Children, as a rule, only manifest symptoms when hypermetropia is of rather high degree; they often blink a good deal, their eyes water and they suffer from headache. In the higher degrees of hypermetropia "muscæ volitantes" are often complained of, and they are usually described as being black specks floating in front of the eyes. Their presence is often annoying to the patient, but they need cause no anxiety.

Results of hypermetropia.—The most marked result of hypermetropia is convergent strabismus (see Part 2, Chap. III.).

Hypermetropic children frequently suffer from repeated attacks of phlyctenular ophthalmia; older persons from red slightly swollen eyelids, chronic conjunctivitis and epiphora, the results of congestion caused by constant strain of accommodation. Meibomian cysts and styes, if of frequent occurrence, may also be due to the same cause. The refraction should always be carefully tested in all cases of slight, chronic, or recurring inflammation of any of the ocular structures. Headache has been already mentioned, it is common in hypermetropes of all ages, and the eyes should be carefully examined in all cases of persistent head pain. All forms of astigmatism and the higher degrees of myopia may also lead to like results.

In all the foregoing conditions relief can alone be given by properly selected lenses; lotions, ointments, or constitutional treatment, being all useless without their aid.

Diagnosis, measurement of degree, treatment of hypermetropia.—The diagnosis of hypermetropia has been already given. The fact that a patient can see as well at a distance with a plus glass as without it proves the existence of hypermetropia. The total amount of hypermetropia does not increase, but the relation between latent and manifest varies. The amount of hypermetropia, which we ascertain by trial with lenses, we distinguish as *manifest* hypermetropia (Hm). The hypermetropia still remaining, but masked by accommodation, is known as *latent* hypermetropia (Hl), and becomes manifest on artificial paralysis of the accommodative apparatus by means of atropine or other mydriatic. Latent hypermetropia (Hl) decreases with age and manifest hypermetropia (Hm) increases but Hl + Hm remains constant. If a child has six diopters of hypermetropia under atropine then Hm + Hl = 6. Through life the proportion will vary and will be found at different times to be Hl = 4, Hm = 2; Hl = 3, Hm = 3; Hl = 2, Hm = 4; and so on until the whole hypermetropia becomes manifest. The fundus in hypermetropia shows certain characteristics. The vessels are seen with a plus glass, when examined by the direct method. The edges of the disc sometimes appear slightly blurred and streaky, and if the patient has asthenopic symptoms may be red, so that a hypermetropic fundus has been sometimes mistaken by beginners for an early stage of neuritis. This is especially to be remembered in examining children. We can measure the degree of hypermetropia in the same manner that we can ascertain its existence—by lenses, by direct ophthalmoscopic examination, and by keratoscopy.

Measurement by lenses.—We conduct the measurement with lenses as follows:—Having placed our patient at a distance of 6 m. from the board containing letters from 6 to 60, or at a distance corresponding to lower numbers if we have not 6 m. at our disposal, we cover one eye and proceed to test the other. If we find that the eye under examination reads 6 at 6 m., and that the same acuteness of vision is still maintained on the addition of a weak convex lens, we try a stronger and still stronger lens, continuing the trial until we have found the *strongest* lens with which the same letters can still be made out. We can express the degree of hypermetropia by the number of diopters of this lens, *e.g.*, if the eye reads 6 at 6 m. and can still make out the letters when a convex lens of 2 D is held in front of it, the degree of hypermetropia may be expressed as H = 2 D.

But the eye under examination may not read letters of 6 at 6 m. either with or without a convex lens, but only those of 9 or 12 or larger. Should this be the case, there may be some impairment of sensibility of the retina, opacity of the media, or the hypermetropia may be complicated by astigmatism. Nevertheless, the degree of hypermetropia may still be expressed by the number of diopters of the strongest convex lens with which the greatest acuteness of vision is maintained.

Measurement by direct ophthalmoscopic examination.—If we wish to measure the degree of hypermetropia by means of the ophthalmoscope, we must be provided with one of the many forms of refraction ophthalmoscopes. Having ascertained the existence of hypermetropia, we direct the patient to look at some distant object, and thus relax his accommodation as much as possible; then approaching the observed eye, till our own cornea is separated from it by an interval of only two inches (taking care to relax our own accommodation), revolve the disc or chain containing convex lenses, placed at the back of the ophthalmoscope until we have ascertained the *strongest* lens through which a *distinct* view of the fundus is obtained.

The number of D of this lens expresses the degree of hypermetropia; for instance, if it be found that a clear view of the fundus is obtained when + 1·5 D is placed behind the sight hole of the ophthalmoscope, and that a *stronger* lens renders the image indistinct, H 1·5 D is present.

If the observer is not emmetropic, he must place that lens which corrects his ametropia in front of his eye. Or having ascertained the strongest + lens with which he sees clearly must subtract his own H or add his own M, *e.g.*, if the observer have H of 1 D and the patient H 2 D, it will be found that the fundus of the observed eye can be clearly seen through a lens of + 3 D, this, however, will be 1 D more than the lens required to correct H in the observed eye. If the observer have M 1 D and the observed eye H 2 D, the fundus will be clearly seen through no stronger lens than + 1 D, and 1 D must be added for the observer's M.

Rays of light emerging from the hypermetropic eye are divergent, and the strongest lens with which an emmetropic eye with accommodation relaxed can make out clearly the details of its fundus, is that which gives them a parallel direction, and renders the hypermetropic eye artificially emmetropic.

Measurement by keratoscopy.—The position of patient and observer should be as described at p. 71. A trial frame should be placed on the patient's face, and the observer having determined that the movement of the shadow is opposite to that of the rotation of the mirror, should place a convex lens of 1 D in the clip before the eye under examination; if on rotation of the mirror the shadow still passes against its movement a stronger lens must be substituted, and so on, the trial being continued until a lens has been found which makes the shadow move in the same direction as the rotation of the mirror. As stated at p. 72, the movement of the shadow in M of less than 1 D is against the movement of the mirror; consequently the lens which in a case of H reverses the movement of the shadow is too strong and renders the eye slightly myopic, and a lens of about 1 D less strength is that which corrects the H. Thus if a lens of 3 D reverses the movement of the shadow, the lens required to correct the H will be one of 3 D — 1 D = 2 D.

Treatment.—In the treatment of H our object is to render rays of light convergent before they reach the cornea, so that they may be brought to a focus on the retina by the refractive power, without accommodation.

If the patient is in bad health, he must be treated on general medical principles. He should be directed to *wear glasses for all near work*, and these should be the *strongest* with which letters of D 6 can be read at six metres; or if no glasses enable the patient to read D 6 at six metres, the *strongest* with which distant vision is most acute. He should also be recommended to rest the eyes for a time, and especially avoid working with insufficient light. If after having used the glasses for a week or a fortnight the patient experiences the same difficulty in doing near work, stronger ones must be ordered.

In ascertaining the degree of H by means of convex glasses, and in a less degree by the other methods, only part of the existing defect becomes apparent, the remainder being masked by accommodation, which the patient is unable entirely to relax.

In most cases of hypermetropia it will be found sufficient to neutralise the manifest portion; but should the symptoms return persistently, in spite of the strength of the glasses being increased, the accommodation must be thoroughly paralysed by a strong solution of sulphate of atropine (4 grains to 1 ounce), and glasses ordered which correct the whole of the H, both manifest and latent.

In the higher degrees of H (above 3 or 4 D) it may be necessary to give glasses for distance as well as for near work; but the necessity for them depends upon the nature of the patient's occupation, and also his convenience. It must also be borne in mind that as soon as a person takes to convex glasses for distance, he begins to get dependent on them and his vision without them becomes worse, which may in some cases be a serious drawback.

Myopia and Astigmatism.

Myopia (M).

In myopia the antero-posterior axis of the eyeball being too long, the retina is placed too far from the dioptric system and only those rays of light which are more or less divergent are brought to a focus on it, parallel or nearly parallel rays being focussed in front of it (fig. 32*c*). Consequently, only near objects (the rays of light from which are divergent) are plainly seen; distant objects (the rays coming from which are parallel) are either not seen at all, or only very indistinctly.

In order that the myopic eye may see clearly distant objects, it is necessary to open out the parallel rays and make them so divergent that after refraction by the dioptric media they are accurately focussed in the retina.

Symptoms of myopia.—The patient complains of being near-sighted. If test types are given him to read, he will hold them close to his eyes, but if the myopia is uncomplicated he will read the smallest type provided the book is brought close enough. In some cases of high degree of hypermetropia and astigmatism, especially in young persons and in cases of dull sight, the types may be brought very near the eyes, but the smallest will not be read; the reason is that at no distance is vision distinct, but that when the object is held close, its image on the retina is larger, and a better idea is gained of it even though its distinctness is less. If told to look at a distance, the myopic person will screw up his eyelids so as to narrow the palpebral aperture, and will only be able to make out objects indistinctly, or not at all. Myopic patients often complain of spots floating before the eyes (muscæ volitantes, p. 62). If suffering from a high degree of myopia (above 4 D) and unprovided with glasses, myopes are often round shouldered and stoop; they have a way of peering into things which is quite characteristic.

The age at which the symptoms of myopia first manifest themselves varies with its degree. It is rare to see quite young children short-sighted, but in the higher degrees symptoms may appear at about the age of four or five years; in the more moderate degrees the defect is noticed from about the age of nine to twelve, and in the slight degrees but little complaint is made until puberty or adult life has been reached; indeed some people go through life without ever discovering that they are short-sighted; such are the "wonderful old people" who—as we are told—can read the smallest print to almost any age without the aid of glasses, the too great length of the antero-posterior axis of the globe in their case making up for the failure of accommodation and refractive power which in emmetropic persons causes presbyopia.

Myopia is progressive and increases up to the age of twenty-five or thereabout; the increase depends upon the amount to which the eyes are used for near work, the quality of the work, the conditions under which it is done, and the treatment adopted.

The conditions which favour the development as well as the increase of myopia are use of the eyes on small objects or bad print, with insufficient illumination; prolonged use for near work of any kind; unsuitable positions, especially those which bring the eyes and the object too near each other (even though the illumination be sufficient), as when a child is seated on a low stool or form at a high desk, or the reverse.

In some cases of incipient cataract myopia makes its appearance; and is caused either by swelling of the crystalline lens or by increase in its index of refraction. That it is not caused by lengthening of the antero-posterior axis of the eyeball is shown by the fact that after extraction of the cataract the eye requires the same lenses for far and near work as an emmetropic eye.

Results.—Divergent strabismus is often the result of myopia. Muscular asthenopia frequently occurs in the higher degrees of myopia; the farthest point of distinct vision (*r*) being very near the eyes, great strain of the internal recti is required in order to maintain binocular vision; the result is fatigue, giving rise to the symptoms mentioned in Part 2, Chapter III., article "Divergent Strabismus." As in hypermetropia, headache is often complained of, but is not due, as in the former defect, to overstrain of the ciliary muscle—accommodative asthenopia—but to overstrain of the internal recti; it is in fact but a part of muscular asthenopia. In myopia, as in hypermetropia, we often meet with slight chronic inflammations of the conjunctiva and lids, slight tinea being the most common form.

Certain morbid changes in the choroid accompany or result from myopia, chiefly of an atrophic nature, and

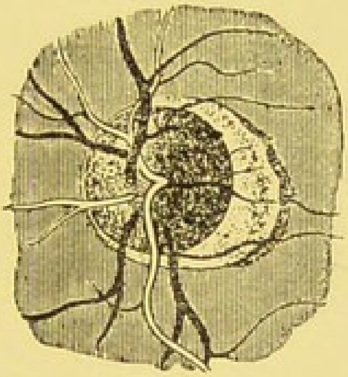


FIG. 34.—Myopic crescent or small posterior staphyloma (Wecker and Jaeger). (After Nettleship).

they present very marked ophthalmoscopic appearances. The most commonly observed change is the occurrence of a white or dirty white more or less crescentic figure bordering the optic disc at its outer margin —*posterior staphyloma* (fig. 34). The boundary of the white figure, away from the disc, may have almost any form of outline; in some cases it is clean cut and well defined, in others it is indistinct, and appears to shade gradually into the adjoining healthy structures. Again, the figure may be seen as an irregular white patch, varying considerably in size, extending further in some directions than in others. In slight cases only a small white rim may be seen bordering the outer margin of the disc, in others, a very considerable atrophic patch will be found, and in some instances the white figure has a somewhat circular form surrounding the whole disc with a band, the breadth of which is usually greatest next to the outer side (fig. 35). This *posterior staphyloma* is brought about by a yielding of the ocular tunics to intra-ocular pressure. The yielding is probably always preceded by inflammatory softening; as it progresses the choroid becomes separ-

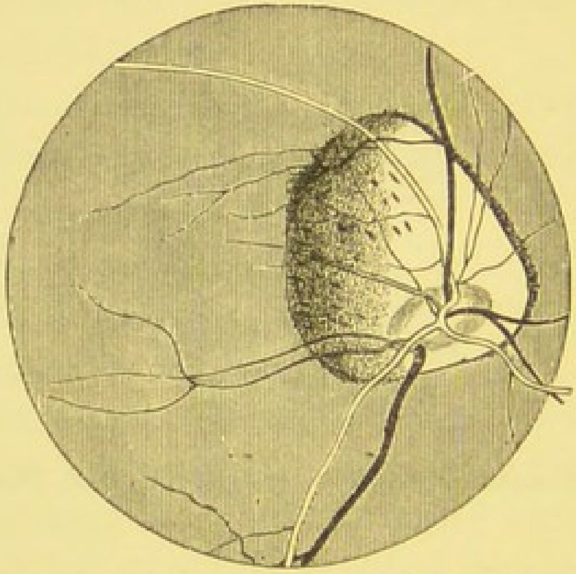
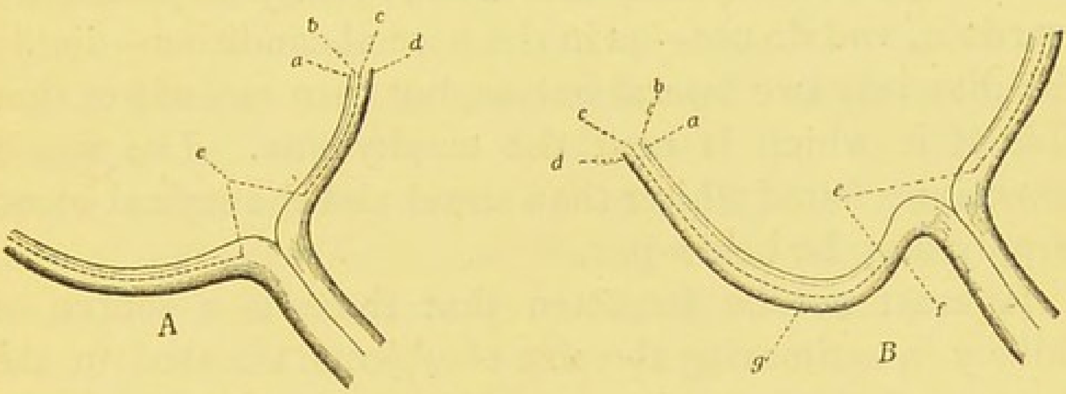


FIG. 35.—Large annular posterior staphyloma (Liebreich). (After Nettleship).

ated from the margin of the disc and disintegration and atrophy follow. The white appearance of the figure is due to the light from the ophthalmoscope being reflected from the sclerotic, left uncovered by yielding of the choroid, which usually covers the sclerotic as far as the edge of the disc. The white crescent seen at the outer margin of the disc in cases of myopia is due in part no doubt to the choroid coat failing to cover the increased area of sclerotic at this point, and the crescent is evidence of the existence of a staphyloma or bulging, due to yielding of the sclerotic on the outer side of the optic nerve, on the posterior pole of the eye.

The diagram inserted below will explain its formation.

A staphyloma of greater or less extent exists in nearly all myopic eyes, but occasionally it is so ill-defined or so small as to be overlooked. The depth and extent of the staphyloma bear a distinct ratio to the degree of myopia; in low degrees it is small, in high degrees large, and in all it is prone to progress, and with it the degree of



a. Retina.
b. Retinal pigment.
c. Choroid.
d. Sclera.
e. End of choroid.
f. Exposed sclera.
g. Staphyloma.

FIG. 36.—Diagrams to illustrate the formation of the scleral and choroidal rings around the normal disc and the myopic crescent. A, is a diagrammatic section of a normal eye, and B, of a myopic eye with a bulged or staphylomatous condition on the outer side of the optic disc.

myopia to increase. The edge of the staphyloma away from the disc should always be carefully examined; if it is well-defined and clean cut the myopia is probably stationary, but if ill-defined and ragged and the choroid next it reddened or blood stained, the myopia is on the increase and every precaution must be taken to arrest it.

In some cases of posterior staphyloma the disc seems altered in form, appearing oval, and, as it were, fined off towards the white figure. This change in the disc is not real, but apparent, and is caused by its being situated on the sloping side of the staphyloma, so that its inner border lies nearer the observer than its outer, its transverse diameter consequently appearing shortened.

The retina is moreover dragged in a fold over the inner surface of the disc by the stretching which it undergoes on the outer side over the staphyloma. As a consequence the retinal vessels undergo a change in direction, and are seen to curve in passing over the white figure; they may also seem wholly displaced towards it, and do not—as in the normal condition—divide the disc into two lateral halves, but turn entirely to that side of it which is next the staphyloma. The disc is sometimes found whiter than usual and the retinal blood supply may be below par.

It must not be forgotten that there is a source of fallacy in estimating the size of objects situated in the fundus of the myopic eye. When examined with the ophthalmoscope by the indirect method, the objects seen always appear much smaller than in emmetropic or hypermetropic eyes. This depends on refraction and might lead to an erroneous diagnosis with regard to the retinal blood supply.

Besides the changes which take place about the optic disc the choroid is frequently much thinned throughout, the pigment being destroyed and the large vessels forming its outer layer exposed to view. Atrophic patches, having more or less circular and well-defined or irregular, ill-defined, borders, together with dark patches and dots of pigment, are frequently seen scattered about the fundus without any particular arrangement. Atrophic changes are sometimes seen in the region of the yellow spot, in the form of irregular white patches, or of radiating lines looking as if the choroid was stretched and cracking, and we sometimes see a nearly circular dark spot of pigment occupying the position of the spot itself. These changes about the yellow spot are most serious as central vision is much impaired or destroyed by them.

The term malignant myopia is applied to cases in which the choroidal changes are extensive.

Other morbid changes resulting from or accompanying myopia are morbid fluidity of the vitreous, free movement of vitreous opacities which are frequently present, detachment of retina, and secondary cataract.

Diagnosis, measurement of degree and treatment.—We have already seen (pp. 85 and 86), how to diagnose the existence of myopia; its degree, like that of hypermetropia, can be measured by trial with lenses, by ophthalmoscopic examination, and by keratoscopy, but its treatment is not quite so simple.

Measurement of degree of myopia by lenses should be conducted thus:—We place the patient complaining of near sight at a distance of 6 m. from Snellen's card, on which are the letters from 6 to 60, and ask him to try to read them with each eye separately. If he is suffering from at all a high degree of myopia, he will not be able to distinguish any of the letters; if, however, some of them can be made out, concave glasses beginning with a weak one about 1 D may be immediately tried; but if none can be read, we place the book of small types in the patient's hand, and note carefully the distance at which he reads type 0·5 or 0·6 Snellen, or 1 or 2 Jaeger. We shall generally find that the concave lens, the negative focal length of which corresponds to the greatest distance at which the eye reads distinctly, or a lens a little stronger or weaker than this, will neutralise the myopia. For instance, if in reading the patient holds the types at 20 centimetres it will be found that a concave lens of 20 centimetres negative focus, *i.e.*, a lens of 5 D will be the one which will improve distant vision most. Having ascertained the distance at which small type can be read, we direct the patient to look again towards the Snellen types and hold concave lenses (beginning with that, the focal length of which corresponds to the distance at which small type is read) in front of the eye under examination, until we have ascertained the *weakest* with which the small letters can be read at 6 m.; the degree of myopia may then be expressed by the number of diopters of this concave lens. For instance, if it is found that a concave lens of 4 D is the weakest with which letters of 6 can be read at 6 m., the degree of myopia is expressed as 4 D; if, however, letters of 6 cannot be read at 6 m., but only 12, 18, 36, or even 60, the degree of myopia may still be expressed by the number of diopters of the *weakest* concave lens with which *the greatest possible acuteness of vision* is maintained.

In many cases of myopia, especially those of high degree (above 6 D), we find that the acuteness of vision has very much diminished; the failure of sight is due in most cases to some of the morbid changes already described.

Measurement of degree of myopia by the ophthalmoscope.—In order to ascertain the degree of myopia by the ophthalmoscope, a refraction instrument (as in hypermetropia) must be used; but as the retina is situated behind the focus of the *dioptric system*, an image of it is necessarily formed at some point (conjugate focus) in front of this system and outside the eye.

Consequently, the rays of light emerging from the myopic eye are not parallel as in emmetropia, or divergent as in hypermetropia, but are converging to a point situated further from or nearer to the eye, according to the degree of myopia.

Now, the emmetropic eye cannot accommodate itself for convergent rays of light; consequently, if the observed eye is looked at from a distance less than that of the point to which the emergent rays converge, no image will be formed upon the observer's retina. But if the eye is examined from a point situated at a distance somewhat greater than that to which the emergent rays are directed, an inverted aërial image is plainly seen, which is lost as the observer approaches near the point at which the image is formed.

An approximate estimate of the degree of myopia may be made by noticing the distance from the observed eye at which this disappearance of the inverted image takes place, as the observer, if emmetropic and not yet presbyopic, can approach to within about 15 cm. of it, and still see it clearly; for instance, if it is found that the inverted image disappears at a distance of 30 cm., we may conjecture that it is in reality situated at about 15 cm. from the observed eye, and that a myopia of $\frac{100}{15}$ about 6·5 D exists.*

The more accurate plan of measurement—having ascertained the existence of an inverted aerial image, and therefore of myopia—is to take no notice of its distance from the eye, but commence the examination at

* 15 cm. is the focal length of a lens of 6·5 D. We arrive at the number of D of any lens of which we know the focal length in cm. by dividing 100 by the focal length whatever it may happen to be. If we wish to know the focal length of any number of D, we divide 100 by that number.

once, a distance of only two inches separating our own cornea from that of the observed eye, revolve the disc containing the concave lenses fixed behind the sight hole of the ophthalmoscope, until we have found the *weakest lens*, which so opens out the convergent rays as to allow a distinct erect image of the parts occupying the fundus of the examined eye to be seen. The number of diopters of this lens will represent the degree of myopia. The observer's eye if not emmetropic must be rendered so, or an addition made if hypermetropic, a deduction if myopic. Thus, if hypermetropic he will under-estimate the myopia by the amount of his own hypermetropia, if myopic, he will over estimate the myopia by the amount of myopia in his own eye.

Measurement by keratoscopy.—We proceed exactly as in the measurement of hypermetropia, but having ascertained that the movement of the shadow is with the rotation of the mirror, we place concave lenses in the trial frame until the weakest has been found, which makes the shadow move against the mirror. As stated at p. 72, the movement of the shadow is against the mirror in hypermetropia, emmetropia and slight myopia. Consequently the concave lens which just makes the shadow move against the mirror, does not quite correct the myopia, but leaves about 1 D, so that by keratoscopy we under-estimate the degree of myopia by that amount, and must add 1 D if we wish to express the whole myopia present. Thus, if a lens of -3 D is the weakest which makes the shadow move against the mirror, the myopia present is not 3 D, but 3 D$+$1 D$=$4 D.

Treatment.—In the treatment of myopia our object is to so open out parallel rays of light that they fall divergent upon the cornea, and so appear to come from a near object. Slight degrees of myopia do not give rise to much inconvenience, the patient being able to read or work at a fair distance, and no treatment is *necessary*; it is only when looking at a distant object that the defect of vision is noticed.

If much inconvenience is experienced from the limitation of distant vision, a pair of glasses may be ordered, and these should be *the weakest concave lenses* with which the greatest acuteness of vision can be maintained; they need only be used when looking at a distance. Higher degrees of myopia, where the farthest point of distinct vision is situated only at a few inches from the eye, always require attention from the great tendency of the myopia to increase, and with it the choroidal changes mentioned above. The treatment consists in the use of suitable spectacles, and the avoidance of all conditions likely to cause congestion of the eyeballs.

In the selection of glasses we must be guided by the circumstances of the case and the age of the patient. In children with good accommodation, and myopia not exceeding 5 D, the degree of myopia should be carefully ascertained, and glasses which accurately neutralize it, ordered to be used for all purposes. Occasionally it will be found that the glasses make the eyes ache when used for a considerable time for near work; but this is only caused by the unaccustomed exercise of accommodation, and will usually pass off if the use of the glasses is persevered in, and near work done for a short time only, until the eyes become used to the extra strain. Should the symptoms, however, continue, or increase after a fair trial, the glasses must be replaced by weaker ones, which should be worn for some weeks, after which those which fully correct the myopia may be again tried (*vide* p. 114).

In myopia above 5 D, or in persons with less degrees, who have reached puberty without wearing glasses, an absolute correction cannot be borne, and can only do harm if tried. In these cases, having first carefully ascertained the degree of myopia, we must order glasses which neutralize about two-thirds of it. These should be used for all purposes for some weeks, at the end of which time stronger ones may be given; the strength being gradually increased until the whole, or nearly the whole, of the myopia has been corrected.

In many cases it will be found useful to order a pair of spectacles which enable the patient to do near work at a fair distance (50 cm.); and to give spectacles or a double eyeglass, with lenses which accurately neutralize the myopia, to be used for looking at distant objects only.

In some cases of myopia the degree will be found to be greater in one eye than in the other. If there is no considerable difference, a different glass may be ordered for each; but if the defect in one eye is considerably in excess of that in the other, no good will result from different glasses, and we should give for both eyes those lenses which suit the less myopic one, their selection being governed by the rules already laid down.

Congestion of the eyeballs often occurs in myopia and is brought about by the conditions already mentioned. To obviate it certain precautions should be taken. Myopes can see with less illumination than hypermetropes, or even emmetropes, and are often very fond of reading or working in twilight, or by the light of a fire, but they should never be allowed to read or work by a bad light. Attention must also be paid to position; they should not be allowed to read lying down, or to stoop over their books or work. Stooping can be avoided by using a desk or rest, which raises the book to a suitable height, or by holding the book up to the eyes, in myopia of 3 to 5 D; in myopia above 5 D by the use of glasses.

A considerable factor in causing increase of myopia is the compression of the eyeballs caused by the internal recti muscles when convergence is excessive, as in the higher degrees of myopia (8 to 10 or 12 D); this can be avoided by the use of glasses which correct sufficient of the myopia to allow the patient to see clearly at 22 cm. (8 inches) or rather further from the eyes.

In the very high degrees of myopia (16 to 20 D) occasionally met with, the patient had better not use glasses, but content himself with seeing what he can, without; he should read but little, and if employed on any work should do it, if possible, by feeling as if entirely blind. Highly myopic eyes are very unsound, and if used much upon near objects, are liable to become quite blind, from detachment of the retina, choroidal hæmorrhage, or other cause.

Recently the treatment of high degrees of myopia by means of needling the lens has been revived. After absorption of the lens the emmetropic eye becomes hypermetropic to the extent of about +12; so in high degrees of myopia the result of removing the lens is to greatly diminish the myopia. In well selected cases the results have been good, but cases where much choroidal change has occurred are not suitable. If the myopia amounts to 16 or 20 D, and the fundus is healthy, a good result may be obtained, the patient having to wear glasses for near work only. It is worthy of notice that in myopia of 20 D, the patient after removal of the lens requires no glass for distant vision at all, only a glass for reading.

Not unfrequently in the course of myopia there arise what are known as *symptoms of irritation;* these are flashes of light, fiery sparks and circles, photophobia, a sense of fulness, and sometimes pains in the eyeballs.

Whenever symptoms of irritation occur, they must be looked upon as of considerable import, and require careful management; their occurrence usually means increase of the myopia.

If glasses are being worn, their use must be discontinued; all work should be abstained from; the patient, when indoors, should be kept in a subdued light, and when in the open air, blue or smoked protectors should be worn. In extreme cases an entirely dark room must be prescribed, all excitement must be avoided, and alcoholic and hot drinks abstained from. Cold douches should be used to the eyes and forehead; and in many cases great benefit will be derived from the abstraction of blood from the temples, either by the application of natural leeches or of the artificial leech—the latter, however, being preferable. The treatment must be persevered in until the symptoms have entirely subsided, and great care must be subsequently taken to avoid a recurrence.

The existence of "muscæ volitantes," unless there be opacity of the media visible by the ophthalmoscope, need give rise to no uneasiness.

We must bear in mind when prescribing glasses for myopia, to be careful never to order them too strong.

Presbyopia (*old sight*) though not an anomaly of refraction, may appropriately be considered here, as its treatment is optical, and it is influenced by the condition of refraction.

Presbyopia depends on changes in the crystalline lens, by which it is rendered harder and its elasticity impaired. As a consequence its curvature can only be altered to a limited extent by the action of the ciliary muscle, and the amplitude or range of accommodation is correspondingly diminished.

Persons generally begin to experience the effects of presbyopia from the age of forty-five to fifty. The nearest point of distinct vision, which year by year has been receding from the eyes, now becomes inconveniently far off, so that small print can only be read with difficulty, or not at all; distant vision, however, still remains acute.

It has been arbitrarily decided that a person shall be considered presbyopic as soon as his nearest point of distinct vision is at twenty-two centimetres or further from the eyes, and the degree of presbyopia is expresssd by the number of D which it is necessary to give the eye in order to bring its near point up to this distance; or, in other words, to give it a refractive power equal to 4·5 D, which is the power the crystalline lens must add to itself in order to see distinctly at twenty-two centimetres. Thus, a person aged forty-five can only see distinctly at twenty-eight centimetres, that is, he can only add to his crystalline a lens equal to 3·5 D. In order to enable him to see distinctly at twenty-two centimetres we must give a lens which makes up the difference between 3·5 D and 4·5 D, *i.e.*, 1 D. A person of forty-five, therefore, requires a convex lens of 1 D to remedy his presbyopia; the number of this lens also expresses the degree of presbyopia.

It has been determined by observation that presbyopia increases by one diopter for every period of five years from 40 to 60; sometimes by one diopter and sometimes by a half only, for each similar period from 60 to 80.

The following table shows the lens required at each period of five years by the emmetropic eye. Should hypermetropia exist its degree must be ascertained and added to the number given in the table. The degree of myopia, on the contrary, must be subtracted:—

Age.	Diopters.	Age.	Diopters.
40	0	65	4·5
45	1	70	5·5
50	2	75	6
55	3	80	7
60	4		

Should our patient require to see at some particular distance, the numbers in the table need not be adhered to; he may be allowed to select those lenses which he thinks suit best. As a matter of fact we often find that the glasses given in the table are too strong, especially in hypermetropic persons who have become presbyopic before taking to glasses. Such persons have long been accustomed to strain their accommodation to the utmost, and will not thank us for giving them glasses which neutralize the whole of their hypermetropia as well as their presbyopia. We shall give much greater satisfaction by ordering glasses which, a little more than neutralize the hypermetropia, and so give help without being an absolute correction.

Astigmatism (As).

A certain amount of regular astigmatism is present in the cornea of the emmetropic eye. Its maximum of curvature (that which has the shortest radius, and consequently the shortest focal length) is in the vertical meridian; its minimum of curvature (that which has the longest radius, and consequently the longest focal length) in the horizontal meridian. The cornea then, as a rule, has its greatest curvature in the same meridian as an egg lying on its side; and when the greatest curvature is horizontal, as when the egg is standing on its end the astigmatism is said to be against the rule. The rule is for plus cylinders to be vertical or nearly so, and minus cylinders to be horizontal or near the horizontal. If the degree of asymmetry is so slight as to give rise to no impairment of vision, it is known as *normal astigmatism*, or *astigmatism of the normal eye*. But if, on the contrary, defective vision is produced by the asymmetry, it is known as *abnormal astigmatism*.

The existence of normal astigmatism can be very easily demonstrated. If we draw two fine lines on paper, crossing each other at right angles, and look at them in such a position that they shall correspond to the vertical and horizontal corneal meridians, a distance will be found for every emmetropic eye at which the vertical line can be seen more distinctly than the horizontal, and *vice versâ*.

The question at once arises, why should this difference exist? To answer it, we must understand the conditions necessary, in order to see a vertical or horizontal line distinctly.

To see a vertical line distinctly, it is requisite that rays of light proceeding from it in a *horizontal direction*, and therefore passing through the horizontal meridian of the cornea, should be brought to a focus in the retina.

To see a horizontal line distinctly, it is necessary that rays of light proceeding from it in a *vertical direction* and therefore passing through the vertical meridian of the cornea, be brought to a focus in the retina. As a consequence of this, vertical lines may be considered as belonging to the *horizontal* corneal meridian, and horizontal lines to the *vertical meridian*.

As has been already stated, the curvature of the cornea has the shortest radius and shortest focal length in its vertical meridian, the longest in its horizontal; consequently it will be found that a fine horizontal line can be *distinctly* seen at a shorter distance than a fine vertical line, a fine vertical line at a somewhat greater distance than a horizontal.

By practising the simple experiment just mentioned, any individual whose eyes are emmetropic can prove to himself the existence of normal astigmatism. What has been said with regard to vertical and horizontal lines applies with equal force to those drawn in any direction. In order to see any line distinctly, rays of light passing through that meridian of the cornea which is at right angles to it must be brought to a focus in the retina. This rule should be borne in mind when working out astigmatism with test lines.

Abnormal astigmatism.—In abnormal astigmatism we find that most frequently the greatest curvature (that which has the shortest radius) of the cornea is in, or approaches, the vertical meridian; and the least curvature in, or approaching, the horizontal meridian. The two principal meridians—those of the greatest and least curvature—always stand at right angles to each other.

There are five forms of abnormal astigmatism:—in two, one principal meridian of the cornea is normal, that at right angles to it deviating in the direction of too great or too slight a curvature, the first constituting *simple myopic astigmatism*, the second *simple hypermetropic astigmatism*. In the third form the whole eye has a myopic refraction, but the curvature of the cornea, in one principal meridian is in excess, and consequently the myopia in that meridian increased. This condition is known as *compound myopic astigmatism*. In the fourth the whole eye has a hypermetropic refraction, but the curvature of the cornea in one principal meridian is diminished, and consequently the hypermetropia in that meridian increased. This condition is known as *compound hypermetropic astigmatism*. In the fifth form the curvature of one principal meridian is too great, causing myopia in that meridian; the curvature of the meridian at right angles to it being too slight, and giving rise to hypermetropia. This condition is known as *mixed astigmatism*.

Symptoms.—The symptoms of astigmatism are similar to those of ametropia, but do not point so plainly to the variety present. Thus the patient will complain, in all forms, of difficulty in reading or doing near work; and whether the defect be myopic, hypermetropic, simple, compound, or mixed, will hold the book or work too near the eyes; he will moreover very likely tell us that he does not see well at any distance, but that near work troubles him most. Pain in the eyes and *headache* brought on or aggravated by looking intently at any object, but more especially at near ones are frequent complaints.

The age at which astigmatism gives evidence of its existence depends upon its degree. If of high degree, 4 to 5 or 6 D, difficulties arise as soon as the child's education is commenced; lower degrees, 1, 2 or 3 D, manifest themselves during school life, whilst the low degrees ·25, ·50, ·75 D may give no trouble at all, or are only discovered after presbyopia has commenced at from 45 to 50 years of age. On the other hand, quite low degrees may give much trouble to young adults who are rather hyperæsthetic and make much use of their eyes either in close study or some kind of fine work.

Astigmatic people of all ages will generally complain that glasses, which they have probably selected for themselves, do not help them; or that they give some assistance at first, but do not enable them to read or work for any length of time. This is markedly the case in those who have become presbyopic; they will probably have procured weak convex lenses, known as "clearers," and having found them of not much assistance will have changed them for stronger ones with a like result. When a patient above forty-five presents himself saying that he cannot get glasses to suit him for reading we may predict with certainty that he suffers from a low degree of astigmatism.

We must also remember that in low degrees of hypermetropic astigmatism, distant vision may be normal; so that the fact that a person's $V = \frac{6}{6}$ and that no manifest hypermetropia (Hm) can be found, does not preclude the existence of slight hypermetropic astigmatism, which must be carefully sought for in all cases of discomfort in reading or working which is not removed by the use of convex spherical lenses.

The diagnosis of astigmatism has been already given; like hypermetropia and myopia its degree can be measured by lenses, by direct ophthalmoscopic examination, and by keratoscopy. Much trouble will be saved if, before attempting to measure the degree of astigmatism by any method, a solution of sulphate of atropine,* gr. iv. to ℥j., be dropped into the eyes three times a day for two or three days, so as to thoroughly paralyse the accommodation. When accommodation is at rest, especially in cases of hypermetropic astigmatism, the difficulty in ascertaining the degree of astigmatism is much lessened, and a more correct result is obtained than when accommodation is active.

The result obtained, however, when the eye is tested under the influence of a mydriatic, though more correct and more scientifically arrived at, is not always so satisfactory to the patient; and as a matter of practical experience it will be found that patients much prefer to use glasses which correct the astigmatism found when accommodation is active, than those which neutralize that found when accommodation is paralysed. Consequently, in spite of the extra trouble and without regard to the scientific aspect of the proceeding, it is best to work out the majority of cases without the aid of mydriatics, leaving their use for those cases only in which no satisfactory result can be obtained without their employment.

Measurement by Lenses.

Astigmatism is most correctly measured by means of keratoscopy, and in many cases a satisfactory result can only be obtained by its means, and in cases of mixed astigmatism where neither plus nor minus glasses give a satisfactory result, the media being clear, and the fundus

* A solution of hydrobromate of homatropine does nearly as well as that of sulphate of atropine; its effects pass off sooner, and the patient is saved the inconvenience caused by a week or fortnight's inability to accommodate for his near point.

healthy, time and trouble will be saved by resorting to keratoscopy at once.

At the same time a very considerable number of cases possessing low degrees of astigmatism, either myopic or hypermetropic, can be worked out without keratoscopy; and provided the examiner is careful, and the patient attentive, the liability to error is not great, especially in hypermetropic astigmatism.

Having discovered the highest plus or the lowest minus spherical lens with which the patient reads most of the letters on Snellen's board, take a plus cylinder in hypermetropia and a minus cylinder in myopia of a strength of about ·75 D, and holding it at first with its axis vertical, and then with its axis horizontal, ascertain if the patient can see more of the test types with it in one position than another, also before coming to any decision, place the cylinder with its axis obliquely downwards and outwards, and then downwards and inwards.

In other words ascertain if a cylindrical glass placed with its axis in any particular direction will improve the visual acuity. The patient has astigmatism if he sees decidedly better with a cylinder having its axis in one particular direction; conversely, when the axis is placed at right angles to this direction vision will be at its worst with that cylinder.

If the patient has no astigmatism then the visual acuity will be diminished in whatever direction the cylinder is placed, and the patient will not be able to decide in which axis the cylinder should be placed. Suspect astigmatism if the patient prefers the cylinder in one meridian to all others. Having ascertained the position where vision is most acute, place higher or lower cylinders in that meridian, and so find the strength of the cylinder with which vision is brought to the greatest acuteness.

If a good result is not obtained retinoscopy should be resorted to with or without a mydriatic, preferably with homatropine.

Measurement by Keratoscopy.

Having ascertained the direction of the shadow, we proceed in exactly the same manner as in the measurement of hypermetropia and myopia. We shall, however, find that on placing before the examined eye lenses either —convex or concave—of greater and greater strength, one is arrived at which causes the shadow to move in a direction opposite to its previous movement, in one meridian; whilst in the meridian at right angles the movement of the shadow is the same as before the addition of the lens. The strength of this lens subject to the subtraction of 1 D in a case of hypermetropia, and the addition of 1 D in a case of myopia, see p. 71, gives the degree of hypermetropia or myopia in the meridian in which the direction of the shadow is altered. Let us suppose that in a vertical direction the movement of the shadow is against the rotation of the mirror, and is reversed by a convex lens of 2 D, then on subtracting 1 D for the over-estimation which always occurs, we have vertical hypermetropia of 1 D. We then put stronger lenses before the eye until one has been found which reverses the movement of the shadow in a horizontal direction, suppose this to be a lens of 4 D on subtracting 1 D for over-estimation, we have horizontal hypermetropia of 3 D. The difference between 3 D and 1 D expresses the degree of astigmatism; thus, we have in the case supposed, hypermetropia 1 D, hypermetropic astigmatism 2 D; the case is one of compound hypermetropic astigmatism. Again, suppose that the direction of movement of the shadow in the vertical direction is the same as the rotation of the mirror, that the addition of a concave lens of 2 D makes it move against the rotation of the mirror; then, on adding 1 D for under-estimation, we have myopia 3 D in the vertical meridian. In the horizontal direction a concave lens of 1 D makes the shadow move against the mirror, then on adding 1 D for under-estimation we have myopia 2 D in the horizontal meridian. The difference between 2 D and 3 D expresses the degree of astigmatism, and we have myopia 2 D with myopic astigmatism of 1 D. The case is one of compound myopic astigmatism. In a case of mixed astigmatism it will be found that in one direction, the vertical for instance, the movement of the shadow is the same as the rotation of the mirror, whilst in the horizontal direction the movement is against the rotation of the mirror; that the addition of a concave lens will cause the shadow to move against the rotation of the mirror in the vertical direction, and the addition of a convex lens will cause the shadow to move in the same direction as the rotation of the mirror in the horizontal direction; then, on making the necessary addition of 1 D to the concave lens, and subtraction of 1 D from the convex lens, we shall arrive at the degree of myopia in the vertical meridian and the degree of hypermetropia in the horizontal meridian; and the sum of the two will give the degree of astigmatism. Suppose that −2 D reverses the movement of the shadow in the vertical direction, we have myopia 3 D in the vertical meridian; and that + 2 D reverses the movement in the horizontal direction, we have hypermetropia 1 D in the horizontal meridian, and there is mixed astigmatism of 3 D + 1 D = 4 D.

In a case of simple hypermetropic astigmatism the shadow moves against the rotation of the mirror in all directions; the addition of a convex lens of 1 D does not affect its movement; the addition of + 1·25 D causes the shadow to move in the same direction as the rotation of the mirror in the emmetropic meridian (myopia above 1 D having been produced), though it still moves against the rotation of the mirror in the direction of the hypermetropic meridian. If stronger lenses are added, one will be found which causes the shadow to move in the same direction as the rotation of the mirror; the strength of this lens subject to the subtraction of 1 D for over-estimation gives the degree of hypermetropia in the hypermetropic meridian. Suppose that a lens of + 3 D is that which first causes the shadow to move in the same direction as the rotation of the mirror, we have hypermetropia 3 D − 1 D = 2 D, *i.e.*, simple hypermetropic astigmatism 2 D.

In a case of simple myopic astigmatism above 1 D, the shadow moves in the same direction as the rotation of the mirror in the myopic meridian. In the emmetropic meridian the shadow moves against the rotation of the mirror. On the addition of concave lenses, one is at length found which causes the shadow to move against the rotation of the mirror in the myopic meridian as well as in the emmetropic, the strength of this lens with the addition of 1 D for under-estimation, gives the degree of myopia in the myopic meridian.

Suppose that a lens of 1 D is that which first makes the shadow move against the rotation of the mirror; we have myopia in the corresponding meridian, not of 1 D, but 1 D + 1 D = 2 D, or simple myopic astigmatism of 2 D.

Treatment.—The treatment of astigmatism consists in prescribing glasses which neutralize the defect. The optician should be furnished with the number of D of the required simple cylindrical lens in the case of simple astigmatism; and with the number of D of the required spherical and cylindrical lenses in the case of compound astigmatism. These are combined in one lens, of which one surface is ground to the required spherical curvature, and the opposite surface to the required cylindrical curvature; such a combination is known as a spherico-cylindrical lens. In the case of mixed astigmatism, a bicylindrical lens—that is, a lens having one surface ground with a concave cylindrical curvature, the other with the requisite convex cylindrical curvature, the axes of the two at right angles to each other—may be ordered; or what is preferable, a lens having on one surface a convex spherical curvature may have its opposite surface ground with a concave cylindrical curvature, the strength of this, of course, being increased in proportion as the convex spherical surface increases the myopia in the meridian on which it (the cylindrical lens) is alone intended to act. For instance, in a case where myopia of 2 D exists in the vertical meridian, and hypermetropia 2 D in the horizontal, a lens one surface of which has a spherical convex curvature of 2 D may be used; but this, of course, increases the myopia in the vertical meridian by 2 D; consequently the other surface of the glass must be ground with a concave cylindrical curve of 2 D + 2 D or 4 D, so as to neutralize the myopia already existing, and that produced by the spherical convex curvature.

In some cases of mixed astigmatism it may be requisite to give glasses which enable the patient to see at a certain definite distance. Thus, in the case supposed above, with M 2 D in the vertical meridian and H 2 D in the horizontal, it might be desirable to bring the farthest point of distinct vision to 50 cm. (20 inches) this can be done by converting the 2 D of H into 2 D of M.

Now, a convex cylindrical lens of 2 D neutralizes the hypermetropia, and renders the eye emmetropic in the meridian on which it acts. To induce a myopia of 2 D, in this meridian, the curvature of the cylindrical lens must be increased by 2 D; consequently we shall have a convex cylindrical lens of 2 D + 2 D, that is 4 D; therefore, to make the hypermetropic meridian of 2 D, myopic 2 D, a convex cylindrical lens of 4 D is required; and as M 2 D already existed in the vertical meridian we have by the addition of convex 4 D cylindrical converted mixed astigmatism into simple M of 2 D.

Patients suffering from astigmatism of whatever form should be strongly advised never to read or work without glasses. Their use for looking at distant objects is more a convenience than a necessity, and in the lower degrees (below 1 D) may be omitted, but never in the higher. In cases of compound myopic astigmatism care must be taken that the spherical curvature is not too strong in the glasses which are used for reading; in fact the choice must be guided by the same rules as in simple myopia. The astigmatism should, however, always be fully corrected. In cases where the myopia in the least myopic meridian is not above 2·50 or 3 D, the astigmatism only should be corrected, the eye still being left with simple myopia of low degree. In cases where the myopia in the least myopic meridian is above 3 D a part of the myopia should be corrected; it is a good rule to order glasses which enable the patient to see clearly at about 55 cm. (twenty-two inches).

In cases of simple myopic astigmatism up to 1·50 D, especially in persons advanced in life, it is well to order for reading a convex cylindrical lens of the same strength as the concave cylindrical lens which corrects the astigmatism; but with its axis placed in a direction at right angles to that of the correcting concave lens, so that it acts on the emmetropic meridian and produces a myopia equal to that in the myopic meridian; in fact reduces the case to one of simple myopia of low degree.

Thus, if we find myopia 1·50 in the vertical meridian, and emmetropia in the horizontal, instead of giving a concave cylinder 1·50 D axis horizontal, leave the myopic meridian alone and order a convex cylindrical lens 1·50 D axis vertical.

Glasses may be ordered for distance which correct the whole of the myopia as well as the astigmatism except when the myopia is of very high degree (above 10 D) in which case it is well to leave about 1 D or 2 D of myopia still uncorrected.

In compound hypermetropic astigmatism the whole of the Hm, or if necessary, both Hm and Hl as well as the As should be neutralized, and the glasses will do equally well for distance or near work; but if the patient has become presbyopic, the spherical curvature will have to be increased for reading (see p. 99). When cases of astigmatism have been worked out under atropine, and when the power of accommodation returns, concave glasses may not be quite strong enough whilst convex are rather too strong; a little perseverance will usually overcome the difficulty, if not, the concave curvature may be slightly increased or the convex slightly reduced.

The Ordering of Glasses.

Some advice on this subject has already been given to the reader under the head of treatment.

Should the glasses be worn constantly? Why does the surgeon order sometimes less and sometimes more than the full correction?

The advice to the patient and the strength of the lenses ordered depends on the kind and degree of error present, whether the patient has ever worn glasses before, the age of the patient, the trouble about which he complains, his occupation and pursuits, the condition of his accommodation and convergence, and also the condition of the extrinsic muscles of the eye.

A small degree of hypermetropia or astigmatism necessitates the use of glasses for near work only. A low degree of myopia requires to be corrected for distance only. High degrees of error of all kinds require some assistance constantly, and in these cases the astigmatism present should be fully and continuously corrected.

Children should be accurately corrected in order to save the eyes from any unnecessary strain which might lead to strabismus, and also to assist in the development of the visual acuity. Patients in the presbyopic stage require glasses for near work differing from those for distance. When a presbyope has to wear glasses for distance it is convenient to order bifocal lenses, in which the correction for reading is obtained by cementing a convex sphere on to the lower part of the distance glasses. A myopic patient over puberty who has never worn glasses before will not be able to wear his full correction constantly.

The ciliary muscle of myopes is ill-developed owing to their having a distinct point of clear vision near to them, which allows them to read without much accommodative effort, if, now we give them full correction we place them in the same position as an emmetrope who has to use about four diopters of accommodation to read with, an amount which the myope will not be able to produce without difficulty.

To ascertain whether a myope will accept his full correction give him Jaeger's types, and without any glasses ask him to read No. 1. After he has read two or three lines place his correction in front of his eyes, if he can still read on without altering the position of the book you may order full correction, if not he will require weaker glasses for near work.

If the patient is quite satisfied with his distant vision and only has difficulty with his near work he will not wear glasses for distance unless you strongly insist; do not do so unless it is absolutely necessary.

Headaches due to uncorrected errors of refraction require glasses to be worn constantly until the headaches quite disappear.

Patients engaged in out-of-door pursuits, with vision sufficiently good to carry on those pursuits, should not wear glasses constantly. We must remember that patients sometimes complain that having worn glasses constantly for a time they find that on leaving them off they are not able to do as much, or see as well, as before wearing glasses, and so accuse the surgeon of spoiling their sight.

Practically the vision of ametropes is always much better than we should, on theoretical grounds, imagine it to be, owing to the patient interpreting indistinct objects, by means of associations, previous knowledge, and probabilities.

If the accommodation is weak, strong plus lenses and weaker minus lenses will be required.

If convergence is weak the converse holds good since accommodation and convergence act together. Increasing the accommodative effort produces an increase of convergence and *vice versâ*. The presence of a latent squint, and the condition of the extrinsic muscles of the eye is tested best by means of Graefe's dot and line. On a sheet of paper draw a vertical straight line with a dot in the middle, and give it to the patient to hold, take a square prism, and holding the base downwards, ask the patient to state what he sees when the prism is held in front of one eye. He should see *two* dots, one above the other on *one* line. Should he see two lines and two dots he has some want of balance of the extrinsic muscles of the eye, that is a squint, divergent or convergent. If it is divergent we treat the patient as if he had a weak power of convergence, and order lower plus spheres or higher minus, if convergent then an excess of convergence exists, and higher plus and lower minus glasses are ordered.

Never allow a cylinder to be worn by a patient unless the frames are made in such a manner that the axis is kept constantly in its correct position.

Often hypermetropes will accept higher plus glasses when allowed to use both eyes together, and myopes will see as much with lower minus spheres when both eyes are being used, so it is a good practical rule to order the highest plus spheres for hypermetropes and the lowest minus spheres for myopes, with which, using both eyes, they see most of Snellen's types.

If the convergence is good in cases of hypermetropia, or hypermetropic astigmatism, and the patient complains of difficulty with near work only, the surgeon may order + ·5 D spherical, added to the highest sphere that the patient accepts for distant vision, the glasses being used only for near work.

CHAPTER V.

Diseases and Injuries of the Eyeball and its Appendages.

Many of the more important affections of the eyeball and parts adjacent can only be remedied by operation; the present section includes those forms of disease and injury which with a few exceptions (*e.g.*, glaucoma), require only medical treatment.

Affections of the Ocular Muscles, External and Internal.

Affections of the ocular muscles may be divided into those of the external muscles, recti and obliqui, and those of the internal muscles, muscles of the iris and the ciliary muscle.

We have already considered the relationship of the external muscles to refraction and wearing of glasses in a previous chapter, but sometimes the want of balance of the muscles of the eyes lead to a train of symptoms referable to the muscular deficiency rather than to a refractive error.

Muscular asthenopia signifies weakness of some of the external ocular muscles. For all practical purposes it is sufficient to consider the disease as affecting the internal recti, but at the same time we may remember that it is possible to get symptoms of asthenopia from imperfect action of the external, or even of the superior or inferior recti or the oblique muscles.

The symptoms of muscular asthenopia always manifest themselves when reading or doing near work; they are, pain in the eyes, headache, indistinct vision with a tendency to diplopia. We are told that the page of the book seems to widen out, the print to become misty, and the lines mixed up; or inability to do near work for any length of time, without these symptoms appearing, is complained of.

If we tell the patient to fix some small object—the end of a pen or pencil—and then move it nearer the eyes, they become unsteady, and soon one or other diverges, double images resulting. The images are crossed, that of the right eye being to the left of that of the left eye, and *vice versâ*. If we cover one eye and direct the patient to fix an object situated at about ten inches with the other, we shall find that the covered eye diverges, and on removing the hand he will see double, the diplopia may be only momentary; by an effort the deviated eye can be made to fix the object, and we shall see it move inwards; but after looking steadfastly for a short time one or other eye will diverge.

Muscular asthenopia occurs in all conditions of refraction, but is perhaps most frequently met with in myopia.

The treatment of muscular asthenopia depends on the condition of refraction. In myopia the difficulty arises from the far point *r* being very near the eyes, and much convergence being necessary to make the visual lines meet at the required distance. All that is necessary is to give a pair of glasses which remove *r* to a distance at which convergence is easy. For example, if myopia 8 D is present, *r* lies at five inches* from the eye, at which distance it may be impossible to maintain convergence. If we order — 6 D to be used for reading, we reduce myopia to 2 D (8 D — 6 D = 2 D), and remove *r* to about twenty inches from the eyes, at which distance convergence is easy (see also p. 22).

In emmetropia and hypermetropia the symptoms are due—not as in myopia—to the necessity for excessive convergence, but to real weakness or insufficiency of the internal recti, rendering them incapable of maintaining convergence to the distance at which ordinary print can be read. Such cases are remedied by optical means. Our aim is to make rays of light appear to come from a point situated at a greater distance from the eyes than the object looked at, and so lessen the amount of convergence required. This can be done by the use of prisms, or lenses arranged so as to have a prismatic action.

The action of a prism is to displace objects seen through it towards its summit (see p. 4). Consequently if we place in front of the eyes a pair of prisms with their summits or edges outwards, any object looked at through them is displaced outwards and can be seen distinctly with convergence to a point further from the eyes than that at which the object is situated ; the distance is greater as the angle of the prism is larger. A very convenient way of finding the strength of the prism required is to place before the patient's eyes, at a distance of ten inches, a straight vertical line with a round black dot in its centre (*vide* p. 115). He will probably see the line and the dot single. Then place before

* In myopia the furthest point of distinct vision lies at the negative focal length of the lens which corrects it. The negative focal length of a lens of 8 D is five inches, of a lens of 2 D twenty inches.

one eye a prism of 5°, apex upwards, two dots at once appear; if no insufficiency is present they will both appear to be situated on the same line, if muscular insufficiency is present, the upper dot—that belonging to the eye covered by the prism—will be seen situated on a separate line at the side of the lower dot, crossed diplopia is produced. If we take a weak prism and place it before the eye already covered by the first prism, but with its apex outwards instead of upwards, we shall find the upper dots come more nearly over the lower; we try stronger prisms until we arrive at one which makes the dots stand directly over each other. This prism will quite correct the muscular insufficiency, and greatly assist the weak internal recti. It is not necessary to test both eyes; the prism found as above gives all the correction necessary for the two, and we divide it between them. Thus suppose a prism of 6° held apex outwards causes the dots to stand directly one over the other on a continuous line, we order a prism of 3° apex outwards for each eye; these are placed in an ordinary spectacle frame and used for reading, &c. In a case of emmetropia this is all that is needed; if hypermetropia is present, or if the patient has become presbyopic, the required convex curvature must be ground on one surface of the prisms as found above; or the convex lenses which correct the hypermetropia or presbyopia may be "decentrated" inwards, *i.e.*, the optical centre of each lens instead of being in the middle of the ring of the spectacle frame is put close to its inner edge—only half a lens is used—by which means in addition to its action as a convex lens, it has that of a diverging prism.

In a large number of cases we find these muscular deficiencies associated with errors of refraction and when the refractive error is corrected the patient has no further difficulty. Sometimes complaint only is made when owing to some exhausting illness, or at the end of a fatiguing day's work, the patient is either weak or tired. In those cases where general debility is present the tincture of nux vomica is useful, taken in 5-minim doses, and the general health must be improved.

In very severe cases tenotomy has sometimes to be resorted to before relief can be obtained.

Paralysis of External Ocular Muscles.

The external rectus (sixth nerve), the superior oblique (fourth nerve), may be paralysed separately; the internal, inferior, and superior recti, and the inferior oblique (third nerve) as a group, or separately, or the whole of the muscles may be palsied together (ophthalmoplegia externa).

The symptoms of paralysis of a single external ocular muscle, or group of muscles, are double vision (diplopia), with more or less marked deviation of the eye in some direction and want of mobility in others.

The direction of deviation and the relative position of the two images will tell us which muscle or muscles are affected. The projection of the false image is always in the opposite direction to that of the deviation of the eye; thus, with deviation of the eye inwards from paralysis of the external rectus the image is projected outwards, and we get what is known as "homonymous diplopia." With deviation of the eye outwards, the image is projected inwards and stands on the further side of the image of the properly directed eye, producing "crossed diplopia."

In the following descriptions the right eye is always supposed to be one affected :—

Paralysis of right external rectus.—The eye deviates inwards, the patient goes about with his head rotated to the right, and looks to the left ; if he puts his

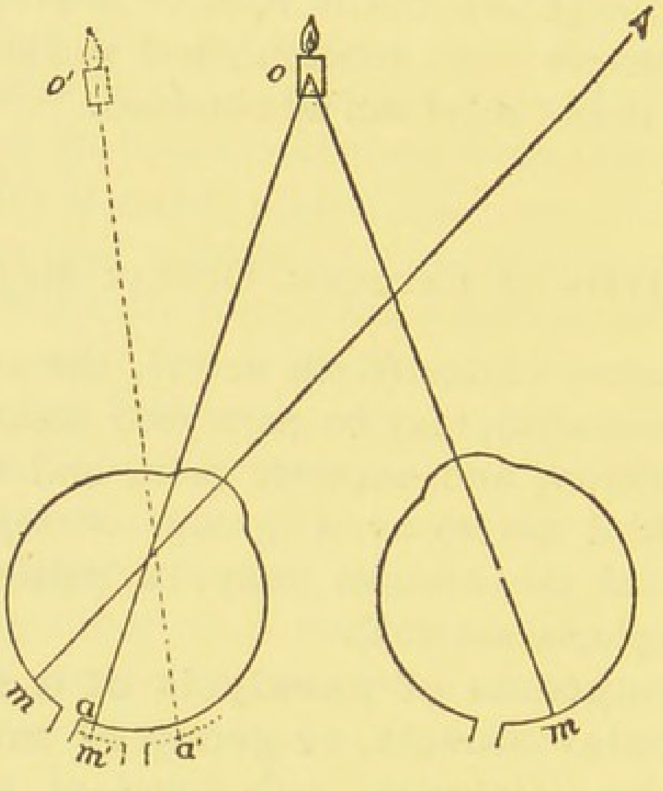


FIG. 37.—Diagram to illustrate the occurrence of homonymous diplopia in convergent squint.

The left eye is turned in towards the nose. The normal position of the macula is represented by the dotted lines. The whole eye being rotated the macula occupies a position outside the normal, and the image of the candle falls on the inner side of the displaced macula and is projected to the outer or temporal side.

In divergent squint the opposite condition is produced, the image of the candle flame falls on the outer side and is projected to the inner or nasal side. (From Swanzy's "Diseases of the Eye").

head straight, two images at once appear, and we notice a marked convergent squint of the right eye ; if an attempt is made to follow an object moved from left to right the images get further and further apart as the object is moved further to the right, homonymous diplopia is present. If we hold a piece of coloured glass before one eye we shall find that the image on that side is coloured,

Paralysis of the superior oblique.—In paralysis of the superior oblique the deviation of the eye is not so noticeable, but is in a direction upwards and inwards. This is caused by the unbalanced action of the inferior rectus, which, unless counteracted by the superior oblique, drags the lower end of the vertical corneal meridian inwards and rotates its upper end outwards. Double vision when looking downwards is the chief symptom. The images are homonymous; the false one is at rather a lower level and rather nearer to the patient than the true one, towards which it is inclined at the top. Paralysis of the superior oblique gives rise to great inconvenience; it causes uncertainty in walking, especially in going down stairs, and interferes with almost all occupations. As soon as the patient looks above the horizontal meridian the false image disappears.

Paralysis of superior, internal, and inferior recti, inferior oblique, and levator palpebræ.—The upper lid droops and covers the eyeball; on raising it the eye is seen to turn outwards, diplopia occurs, the two images being side by side; if a piece of coloured glass is placed in front of the deviating eye the image to the left becomes coloured (crossed diplopia). In some cases the accommodation is paralysed and the pupil is dilated and fixed, in others no change is observable; in the cases in which the pupil is dilated the instillation of atropine causes further dilatation.

If an attempt is made to look inwards or downwards a distinct rotation of the cornea on an antero-posterior axis (unbalanced action of superior oblique) is noticed. If the sound eye is closed and the lid of the affected one raised, and the patient directed to walk, he flounders about in the most ludicrous fashion, the deviated eye giving him an erroneous impression of the position of the floor and objects in the room.

Paralysis of separate muscles of this group may be met with, but is of extremely rare occurrence.

Paralysis of all the external ocular muscles (ophthalmoplegia externa).—The upper lid is more or less drooped, the eye looks straight forward and has no movement in any direction.

Examination.—In order to investigate a case of recently occurring diplopia in an adult, the observer will obtain most conclusive and accurate evidence by means of an examination of the relationship of the images of the two eyes. For this purpose a candle and a darkened room are necessary.

Stand in front of the patient at a distance of 2 to 3 yards, and ascertain by moving the flame up and down, to right and left, in which part of the field the diplopia is noticed. By that means we discover whether the muscles raising or lowering the eyes, or those turning the globes to the right or left are in fault.

Next, to ascertain which eye is affected, place the candle in the position of greatest diplopia and ascertain to which eye the most displaced image belongs. The eye to which the most displaced image belongs is the eye at fault.

Having ascertained which eye and which group of muscles are affected we now have to separate the obliques from the recti (sup. and inf.). To do this we must remember that the action of the recti and obliques is a double one, they draw the eye not only up or down, but also to the right or to the left, and their vertical action will be greatest when the globe lies in the same plane as the muscle.

Hence the law that the rectus is affected if the maximum vertical diplopia lies on the same side as the affected eye, and the obliques if on the opposite side, since the tendons of the recti always point to the side to which the muscle belongs.

The right superior and inferior rectus pointing to the right, and the left superior and inferior rectus pointing to the left.

The obliques point away from it. The right obliques pointing to the left, and the left obliques pointing to the right. The tendon of the superior oblique being considered as if it took origin from the pulley.

If the student wishes further information on this subject he is referred to Mr. Maddox's book from which the following directions are taken :—

1. Find which group is affected :—Superductors, subductors, dextroductors, laevoductors.

2. Which eye ? The eye seeing the most displaced image.

3. Rectus or oblique ? Rectus if the maximum vertical diplopia is on the side of the paralysed eye. Oblique if on the side of the sound eye.

Paralysis of Internal Ocular Muscles.

The three internal muscles are the sphincter of the pupil, dilator of the pupil and ciliary muscle. The sphincter of the pupil and ciliary muscle are supplied by the third nerve through the ciliary ganglion ; the dilator of the pupil by the sympathetic, either through the ciliary ganglion or by branches which do not pass through it.

Paralysis may effect the iris alone.—The dilator may be paralysed (paralytic myosis) in which case the pupil will be moderately contracted, being about the same size as the other in good light; in very bright light it will contract a little, but when shaded will not dilate to anything like the same extent as the other. Consequently in dull light the affected pupil is much smaller than that of the sound eye. Accommodation is not affected. This condition of pupil is common as a physiological change in old age, but it then affects both eyes equally. When it occurs in one only it may be caused by paralysis of the cervical sympathetic; it is met with in cases of thoracic aneurism causing severe compression of the sympathetic trunk. The reverse condition, dilatation from spasm of the dilator, due to irritation of the sympathetic in the neck or thorax may occur. The sphincter alone may be paralysed (paralytic mydriasis); in this case the pupil is moderately dilated, and its action both reflex and associated entirely absent. Complete paralysis of the iris both dilator and sphincter may occur *(iridoplegia)*. The pupil is of medium size, quite uninfluenced by variations of light, but may act during accommodation (associated action).

The ciliary muscle alone may be paralysed *(cycloplegia)*. The range of accommodation is nil, the eye remaining adjusted for its far point, but the activity of the pupil is unaffected. This condition is not unfrequently met with after diphtheria, but the paralysis is more often partial (paresis) than complete. When we speak of paralysis of accommodation we refer to nervous cases, and do not include the diminished effect of accommodation consequent on presbyopia.

The ciliary muscle and sphincter of the pupil may be paralysed as seen in cases of complete paralysis of the third nerve; the pupil is moderately dilated and fixed, and accommodation lost.

Paralysis of all internal muscles (ophthalmoplegia interna).—All three internal muscles may be paralysed; the pupil is of medium size, the movements of the iris—both reflex and associated—are abolished, and accommodation is lost.

Causes of ocular paralysis.—If we exclude cases of orbital tumour, which are evident enough, and of which ocular paralysis is only one of many well marked symptoms, we have left a very large majority of cases of paralysis of the external ocular muscles, or external and internal combined, in which there is nothing in the condition of the eyeball, or orbit to guide us to the seat of disease. Meningitis, morbid growths, or periostitis about the base of the skull are often the cause of ocular paralysis, and occasionally aneurism of the carotid in the cavernous sinus, fracture of the base of the skull, and cerebral hæmorrhage; but in all these cases the paralysis is seldom confined to one nerve.

Gumma of the trunk of a nerve is probably the commonest cause of single paralysis. Some cases are referred to cold and considered similar to the peripheral paralysis of the facial from the same cause; about this point, however, there is room for considerable doubt. Paralysis of one nerve, usually of short duration, is met with in the early stages of locomotor ataxy, often occurring and passing off before any other symptom develops. Ophthalmoplegia externa comes on very slowly, taking many months for its full development; it indicates sclerosing changes in the nervous centres, generally of syphilitic origin.

The causes of internal paralysis are but little understood, syphilis or gout is often at the root of the evil, but the exact local lesions in the present state of our knowledge must remain doubtful.

Treatment of ocular paralysis.—The treatment may be summed up in a very few words. Iodide of potassium and mercury should be given internally, and blisters applied to the temples or behind the ears, with galvanism to the affected muscles.

With the exception of ophthalmoplegia externa or interna, the prognosis is good in recent cases of ocular paralysis; but in those of many months standing little improvement will result from treatment.

Nystagmus signifies a peculiar, involuntary, quivering motion of one or both eyes, dependent on rapid contraction of antagonistic pairs of muscles. The disease is usually developed in infancy, and is then associated with considerable impairment of vision arising from congenital cataract, opacity of the cornea after ophthalmia neonatorum, atrophy of choroid, &c. Nystagmus occurs in some nervous disorders as locomotor ataxy, and also in persons who work in cramped or unnatural positions in bad light, as those employed in mines, when it is described as "miner's nystagmus."

Treatment.—Nothing can be done to remedy nystagmus in the two first classes of cases; but miner's nystagmus may be entirely cured by removing the patient from his work and by the administration of tonics.

Spasm of accommodation.—In many cases of anomaly of refraction and astigmatism a tonic or intermittent contraction of the ciliary muscle is present, it often masks a considerable amount of hypermetropia and may at times make the hypermetropic eye appear to be myopic. If it exists with myopia the degree of short sight is increased.

Symptoms.—Severe and constant pain in the eyeballs and forehead, increased on any attempt to use the eyes, associated with some anomaly of refraction (generally hypermetropia), and inability to see either near or distant objects distinctly. These symptoms are modified or entirely removed by the use of a mydriatic.

Treatment.—Paralyse the accommodation by the use of atropine (gr. iv. of sulphate to ℥j. of water) or other mydriatic, and accurately neutralize any anomaly of refraction.

CHAPTER VI.

The Eyelids and Conjunctiva.

Congenital anomalies.—Absence of the eyelids; a failure of closure of the fœtal fissure, leaving a cleft in one or both lids (coloboma); ptosis, complete or partial; development of a third lid; pigment spots, moles, nævi, and warty growths, have all been occasionally met with.

Ulcers.—Simple ulcers, primary venereal sores (chancres), tertiary syphilitic and cancerous ulceration, are sometimes met with. The first three require to be treated on general medical principles; the last by operation, if the disease has not proceeded too far.

Phthiriasis.—The pediculus pubis (crab louse) is sometimes found amongst the eyelashes close to the margin of the lids. The edges of the lids appear to be covered with scabs and crusts somewhat resembling tinea; on close examination the insects themselves will be discovered adhering closely to the margin of the lids, their eggs being attached to the lashes near their bases.

Treatment.—Clip the lashes and use daily some kind of mercurial preparation, none being better than the white precipitate ointment.

Paralysis of the orbicularis muscle occurs in some cases of facial paralysis; there is an inability to close the eye, the lower lid falling away from the globe. Lachrymal secretion collects at the inner canthus, and constant watering of the eye results, consequent on the displacement of the lower tear punctum and want of the proper movements of the lids.

Treatment.—General medical treatment should be adopted.

Spasm of the orbicularis muscle may occur from long continued intolerance of light, consequent on affections of the cornea.

Treatment must be directed against the corneal affection (see Diseases of the Cornea).

Spontaneous twitching, more especially of the lower lid, popularly known as "live blood," is met with in some cases of hypermetropia, or in persons whose digestion is out of order; it is very probably due to muscular twitching.

Treatment.—Correction of existing hypermetropia, instillation of atropine, and attention to the general health.

Acute inflammation of the eyelids may occur during or after acute diseases (measles, scarlatina, &c.), in the course of erysipelas, as the result of injuries, or in connection with severe inflammation of neighbouring parts, *e.g.*, purulent ophthalmia. The swelling and redness are usually considerable, and the eye cannot be opened; the inflammation generally ends in resolution, but may (especially if it result from measles, scarlatina, &c.), go on to the formation of abscess, or even to sloughing of the skin.

Treatment.—Locally, fomentations with hot boracic lotion; if an abscess forms it should be opened—preferably through the conjunctiva.

The patient's general health should also be attended to.

Stye (hordeolum) is a small red and painful swelling situated on the outer surface of the lid near its margin, and consists in a circumscribed inflammation, dependent on an infection of the follicles of the cilia or lashes by micro-organisms. Styes generally occur in weakly, delicate persons; several may appear simultaneously, or there may be a succession of them; they give rise to considerable irritation, and are often extremely painful. The inflammation usually goes on to suppuration.

Treatment.—Fomentations, poultices, the administration of tonics, and good living. Suppuration may sometimes be prevented by rubbing the red oxide of mercury ointment into the swellings as soon as they appear. Pulling out a lash in the centre of the stye may sometimes shorten its duration; but when pus has formed, the little tumours should be opened. If attacks are frequent, the refraction should be tested, in this, and all chronic inflammations of the lids and conjunctiva.

The probable reason why an uncorrected error of refraction is a predisposing cause of so many conjunctival troubles, is that the ciliary muscle being so constantly in action, a chronic hyperæmia of the front of the eye is brought about. Secondarily an increased secretion of the numerous and various glands connected with the conjunctiva results, leading to inflammation of the lid margins, styes, Meibomian cysts, &c.

Tinea (ophthalmia tarsi blepharitis). Patients suffering from slight tinea present themselves with scurf attached to the margins of the lids; in the more severe forms with yellowish-brown, dry, and closely adhering crusts. The lashes are often scanty, many of them having fallen out.

On removing the crusts the margin of the lid will be found ulcerated, fissured and easily bleeding. The disease consists in inflammation and ulceration in and about the follicles of the lashes; it runs a very chronic course, often lasting for years in spite of remedies. It occurs most commonly in delicate children and young adults. In old cases the margins of the lids are much thickened, giving rise to redness and eversion of the lower lids, with displacement of the tear puncta, and consequent watering of the eye. This condition is known as "lippitudo."

Treatment.—Slight cases can generally be cured by the use of a lotion containing 10 grains of boracic acid to 1 ounce of water, applied three or four times a day, and of mild nitrate of mercury ointment (one part of the ordinary nitrate of mercury ointment to eleven of lard),* smeared along the margins of the lids night and morning.

The patient should be directed to remove all the crusts by bathing with warm boracic lotion or a weak alkaline solution† before applying the ointment. Iron or cod-liver oil, or the two combined, should be given internally in delicate subjects.

More severe cases should be treated by pulling out the lashes and removing the scabs with forceps, and then applying solid nitrate of silver to the raw surface.

In cases where the lower tear punctum has become everted the punctum and canaliculus must be slit up. (See Part 2, Chapter II.). This condition is often kept up owing to a weak state of health. The removal of adenoids and enlarged tonsils have in some chronic

* The ointments employed in the ophthalmic department at Guy's Hospital are now almost invariably prepared with vaseline instead of lard.

† Sodium bicarbonate	7 grains
Borax	7 "
Sodium chloride	7 "
Warm water	2 ounces.

cases effected a cure. The refraction should always be investigated.

Injuries.—Wounds of the eyelids, however extensive or ragged, after having been thoroughly cleansed, should be brought accurately together; they will usually heal readily enough. Should there be any loss of substance, an endeavour must be made to prevent contraction of the resulting cicatrix causing distortion of the lids.

Ecchymosis of the lids (black eye) frequently occurs as the result of blows, and may be caused by leech-bites or operations, and occasionally as the result of strain as in whooping cough.

Treatment.—Most cases may be left alone, but if it is desirable to get quickly rid of the effused blood, a cold poultice made of equal parts of the scraped root of black bryony and bread crumbs should be applied. The poultice should be kept on as long as the patient can bear it. The application is often accompanied by a good deal of stinging pain.

Emphysema of the lids sometimes occurs from rupture of the mucous membrane of the nose, air being forced into the cellular tissue of the eyelids on sneezing or blowing the nose. Gentle pressure with cotton wool and a bandage, and avoidance of violent expiratory movements, sneezing, &c., is the only treatment required.

The lachrymal apparatus.—The principal affections of the tear passages, &c., will be described in Part II.

The Conjunctiva.

Ophthalmia.—This term includes all the different forms of inflammation of the conjunctiva. Certain characters are common to all: these are more or less vascularity of the membrane, uneasiness and stiffness of the lids, pain of a smarting character, some kind of discharge, and gumming together of the lids during sleep.

Inflammation of the conjunctiva has to be distinguished from inflammation of the sclerotic or sub-conjunctival fascia, and from the injection of these structures which is present in many of the inflammations of deeper parts of the globe. The distinction can be made by paying attention to the position of the vessels and the character of the pain. For position of vessels see Chapter II., pp. 27, 28. Adrenalin, a preparation made from the supra-renal glands, is sometimes used to diminish the congestion of the conjunctival vessels, owing to its local action as a vaso-constrictor.

The pain in inflammation of the conjunctiva is of a smarting character; while in inflammations of deeper parts it is dull and aching, and often very severe.

Treatment.—Inflammations of the conjunctiva are as a rule best treated by weak astringent applications.

Any of the following formulæ may be employed:—

Boracic Acid Lotion.

Boracic acid, gr. x. to xv.; water, or rose-water, ℥j.

Useful in all forms of ophthalmia and in sloughy ulceration of the cornea.

Strong Alum Lotion with Boracic Acid.

Alum, gr. x.; boracic acid, gr. x. to xx.; water, ℥j.

Useful in cases of purulent ophthalmia.

Alum Lotion.

Alum, gr. iv. to vj.; water, ℥j.

Lotio Iodi.

Tr. Iodine, ♏v.; water ℥j.

Formalin Lotion.

Formalin (40 per cent.), 1; water, 2000.

Hyd. Perchlor. Lotion.

Mercuric chloride, 1; distilled water, 5000.

Chinosol Lotion.

Chinosol, 1; water, 2000.

Chloride of Zinc Drops.

Chloride of zinc, gr. ij.; water, ℥j.

Most useful in cases of chronic ophthalmia.

Sulphate of Copper Drops.

Sulphate of copper, gr. ij.; water, ℥j.

Sulphate of Zinc Drops.

Sulphate of zinc, gr. ij.; water, ℥j.

Nitrate of Silver Drops. (Not to be used if any corneal ulceration exists).

Nitrate of silver, gr. j.; water, ℥j.

Atropine and Astringent Solution.

Sulphate of atropine, gr. ½ to gr. ij.; sulphate or chloride of zinc, gr. ij.; water, ℥j.

Useful in cases where iritis or keratitis occurs in the course of ophthalmia.

Any of these remedies may be given to the patient to use himself; they should be applied from three to six times a day, or oftener, and the patient should be directed to wash away all discharge before using any of them, and to take care that the lotion goes well between the lids, and is brought thoroughly into contact with the conjunctiva. All the lotions should be mixed with an equal quantity of warm water before being used. The "drops" mentioned above are most valuable in chronic cases.

Some kind of ointment (boracic, spermaceti, mild nitrate of mercury, &c.) should also be ordered to be smeared on the margins of the lids at night, to prevent their becoming gummed together during sleep.

The condition of the patient's general health should also be attended to.

Other applications, which should be used by the surgeon himself, are:—

The mitigated nitrate of silver stick (consisting of nitrate of potash and nitrate of silver, in the proportion of three parts of the former to one of the latter); *green stone, lapis divinus* (consisting of equal parts of alum, nitrate of potash, and sulphate of copper, with a small quantity of camphor), and *solid nitrate of silver.* In order to apply any of these the patient should be seated in a chair, and the surgeon should evert the lids and lightly rub the conjunctival surface with either. If a preparation of nitrate of silver be employed, the conjunctiva should be washed with salt and water immediately after the application.

Varieties of Ophthalmia.

Catarrhal ophthalmia.—The conjunctiva, both ocular and palpebral, is highly injected, red and some times swollen; there may be small extravasations of blood in the former, and there is a thick yellow, tenacious discharge.

One or both eyes may be affected, the disease usually commences in one and spreads to the other in the course of two or three days.

Ætiology.—Catarrhal conjunctivitis is due to the presence of various micro-organisms in the conjunctival sac (staphylococci, streptococci, bacilli, &c.).

In health, various pathogenic organisms can often be found in the lower fornix of the conjunctiva; consequently we must consider the ætiology of catarrhal ophthalmia to consist of a predisposing, as well as of an exciting cause, in many cases. The latter is usually some slight traumatism, irritation from dust, noxious gases, cold, errors of refraction, general debility, &c. These reduce the resisting power of the tissues, and so enable the organisms to grow.

Treatment.—In the early stages (before there is any amount of discharge) some soothing application (weak, warm antiseptic lotions) should be employed; later on, an astringent, boracic acid and alum lotion, or alum lotion alone, should be used three times a day, and some mild nitrate of mercury or spermaceti ointment smeared on the edges of the lids at bedtime, to prevent their becoming gummed together during sleep.

The patient (or, in the case of a child, those who have the care of it), should be warned of the contagious nature of the disease, and no sponges, towels, &c., which he is in the habit of using, should be used by other people. Among the poorer classes it is very common to see a whole family suffering from catarrhal ophthalmia.

Muco-purulent ophthalmia.—A troublesome form of conjunctival inflammation accompanied by flakes of muco-pus floating in tears, swelling and redness of the eyelids, and often intolerance of light, is frequently met with in children recovering from measles, scarlatina, &c. The patients are often extremely feverish and irritable. The Koch-Weeks bacillus is often found in these cases, and sometimes the pneumococcus of

Fraenkel produces cases clinically indistinguishable from those due to the Kock-Weeks bacillus.

Treatment.—A few drops of a solution of sulphate of atropine (gr. iv. to ℥j.) should be dropped into the eyes by the surgeon himself, once or twice a week, if there is much photophobia; a large shade to cover both eyes should be ordered; hyd. perchlor. lotion used three to six times a day or oftener; yellow oxide of mercury ointment put within the lids at night; the bowels freely opened by a powder of calomel and rhubarb, or other aperient, repeated on alternate nights for a week, and directions given as to the child's feeding. When the bowels have been well cleared out iron or other tonic should be prescribed.

Chronic ophthalmia is usually a sequel of some more acute form; the palpebral conjunctiva is reddened, and the ocular conjunctiva presents patches of slightly increased vascularity, but no general redness, as in catarrhal ophthalmia; the lids are often somewhat thickened, and the caruncle and semilunar fold swollen. There is slight mucous discharge, which forms dry crusts on the margins of the lids, and at the inner canthus; overflow of tears may occur from obstruction or displacement of the tear puncta.

Treatment.—The same as that of catarrhal ophthalmia. The lotions may be used at their full strength, and the guttæ mentioned above are all useful in chronic cases. The disease may continue for almost any time, and when one remedy appears to have lost its effect, another should be tried.

In all obstinate cases the probable existence of some anomaly of refraction must be remembered and looked for. Lotions will do no good so long as hypermetropia or astigmatism remains uncorrected. If other causes are not obvious, sometimes a misdirected lash is to be found. Constantly working in a smoky, or badly ventilated room, also predisposes to chronic conjunctival troubles.

Phlyctenular ophthalmia, usually met with in children and young adults, especially females, is characterised by the existence of small pinkish elevations on the conjunctiva, most commonly near the margin of the cornea; each little elevation has a wisp of blood-vessels leading to it if near the corneal margin, and is surrounded by a zone of vascularity if situated in any other part of the conjunctiva. There is some watering of the eye and slight mucous discharge.

Patients are frequently met with who suffer from repeated attacks of phlyctenular ophthalmia; in such, some anomaly of refraction is nearly always present.

Treatment.—In treating phlyctenular ophthalmia our object is to set up a certain amount of irritation of the conjunctiva, by which the phlyctenulæ will be destroyed. This can be attained by dusting calomel into the eye daily, or by ordering a small quantity of an ointment containing 1 grain of yellow oxide of mercury to ʒj. of vaseline, to be applied to the inner surface of the lower lid at bedtime. Either of these remedies will soon cause the phlyctenulæ to disappear. Tonics should be given if required. The refraction must always be carefully tested in all obstinate or recurrent cases. The disease, as affecting the conjunctiva covering the cornea, will be spoken of under diseases of that structure (*vide* pp. 156, 157).

Granular ophthalmia — Trachoma — Egyptian ophthalmia.—This disease occurs at all ages, and is very common amongst the lower classes, especially of the Jews and Irish; it is highly contagious.

Granular ophthalmia is often very prevalent where large numbers of persons are crowded together in workhouses, parish schools, barracks, &c. It would appear that in those who have lived for a considerable time under unfavourable hygienic conditions, a peculiar granular state of the palpebral conjunctiva becomes developed. Persons thus affected are said to be predisposed to granular ophthalmia. During an acute attack the patient suffers from photophobia, lachrymation, and a feeling of heat and uneasiness in the eyes. On everting the upper lid the conjunctival surface is seen to be rough, the unevenness being due to small rounded nodules, sometimes of a pinkish colour, sometimes almost gelatinous in appearance, most marked at the retrotarsal fold, and varying in number, distribution, and arrangement with each case; these are the so-called "sago grain" bodies. On examining the upper part of the cornea we find vessels invading this usually evascular structure (conjunctival vessels) passing over the limbus just beneath the anterior epithelium.

This condition which is due to the constant irritation of the cornea by the rough surface of the lid is really a new formation consisting of vascular tissue, rich in cells, similar to the infiltrated trachomatous conjunctiva of the lids, and is called pannus trachomatosus.

After an acute attack has subsided the conjunctiva may remain chronically inflamed, the patient being troubled more by the sequelæ of the disease than by the disease itself, and an acute attack may supervene on the chronic condition at any time.

The long history, the nationality of the patient, the position of the trachoma bodies, the upper lid being the only one, or the one most, affected, the presence of pannus, its resistance to treatment, all assist in determining the diagnosis when any doubt exists. Follicular conjunctivitis with which trachoma is sometimes confounded, has the conjunctiva of the lower lid affected most, pannus is absent, and the inflammatory symptoms much slighter and more amenable to treatment, although the follicles themselves persist for a long time.

In old cases, and especially in those that have been treated by strong caustics, the conjunctiva may be found converted into a mass of rough hard cicatrices, and its secreting power destroyed, the condition known as "*xerophthalmia*" being developed. A condition resembling xerophthalmia and closely allied to, if not identical with it, is described as "essential shrinking of the conjunctiva" and is said to be preceded by an eruption of pemphigus upon the conjunctival surface.

Granulations in active granular ophthalmia are always found most developed on the conjunctiva covering the attached border of the tarsal cartilage of the upper lid. Their appearance is more or less altered by treatment; they are accompanied by thick yellow discharge, and there may be more or less severe intolerance of light.

Sequelæ of granular ophthalmia.—The cornea may become more or less opaque and vascular, especially at its upper part, where the "pannus" exists. This is caused by constant irritation of the cornea by the rough surface of the lid. Corneal ulceration and iritis may also occur.

The conjunctiva may be destroyed to a greater or less degree, extensive cicatrices being formed, which, by their contraction, cause shrinking of the membrane and distortion of the lids, with entropion and narrowing of the palpebral aperture. The hair bulbs may become displaced, causing the eyelashes to be misdirected (*trichiasis*) (see Part 2., Chapter II.). The results of granular ophthalmia are frequently aggravated by unskilful treatment.

Treatment.—In treating granular ophthalmia our object is to destroy the granulations, with as little damage as possible to the conjunctiva itself.

The use of strong caustics must be carefully avoided, as they cause too much destruction of tissue, followed by the formation of contracting cicatrices.

Slight cases can be cured in a short time by the application of mitigated nitrate of silver stick twice a week, or oftener, and the use of sulphate of copper drops from three to six times a day.

Special roller forceps are made to squeeze out the trachoma bodies and so remove them, and are most useful in the cases where these are large and fleshy.

An anæsthetic should be given, the upper lid everted and the blades of the forceps, with the folded conjunctiva between them, firmly pressed together and drawn along the whole length of the everted lid.

More severe cases will remain under treatment for months or years, and will tax the surgeon's ingenuity and patience to the utmost, but if persevered with will improve greatly and may ultimately recover. If the ophthalmia is of recent date the granulations should be touched every day with the mitigated nitrate of silver stick, and sulphate of copper drops used from three to six times daily.

In chronic cases the green stone should be used instead of the nitrate of silver stick.

The application of calomel powder or quinine to the granulations has also been found useful in some cases.

In cases where there is much photophobia with pain, or if the cornea is ulcerated, or iritis present, hot sedative fomentations should be employed five or six times a day, and solution of atropine gr. j. to ℥ j., dropped into the eye three times a day, until the more acute symptoms have passed off, when the caustic treatment can be commenced.

When the cornea is completely opaque and fleshy looking, inoculation with pus from a case of purulent ophthalmia may be tried, but only in extreme cases, otherwise we may do more harm than good by causing sloughing of the cornea; should but one eye be affected, care must be taken to prevent the other becoming inoculated.

In some cases of old standing granular ophthalmia where the granulations are rough and pale, and there is considerable pannus, much good may be done by setting up purulent ophthalmia by the application of an infusion of the seeds of *Abrus precatorius*—jequirity seeds—commonly known as crab's eyes. The infusion should be prepared thus:—

Jequirity seeds, free from husks, gr. 70
Distilled water, ℥ iij.

Soak bruised seeds in the water for two hours, then pound up and re-soak in the same water for 22 hours, and filter.

The infusion should be applied by everting the lids and brushing it freely over them and well into the fornix with a camel-hair brush.

The effect produced is, that within five or six hours sharp conjunctivitis sets in, followed in six hours more by the formation of a membrane over the conjunctiva, both ocular and palpebral, with pain, swelling, photophobia, watering and abundant muco-purulent discharge. The inflammation remains at its height for about twelve hours, and then begins to subside, it can be reproduced by a further application of the infusion. If the desired effect is not produced by one application, as many more may be made as necessary.

Pannus as a rule requires no special treatment, and if not very dense, disappears as the granulations are cured, but in cases where it is dense and does not disappear with the granulations, improvement may follow the operation of peritomy (*i.e.*, incising the conjunctival and episcleral tissue around the cornea at the corneo-scleral margin), or deep cauterization around the corneal margin with the actual cautery.

Purulent ophthalmia. — Purulent ophthalmia may be met with, as "ophthalmia neonatorum" in children, soon after birth, or in older persons. In the former case it is caused by contact of contagious vaginal secretions, by want of cleanliness and care, or a combination of the two; in the latter by contact with some form of specific pus, or by constant irritation of the already inflamed conjunctiva. It is highly contagious.

The worst form of the disease, whether occurring in infants or older persons, is that caused by inoculation with the gonococcus "gonorrhœal ophthalmia," when the virus is most virulent.

"Ophthalmia neonatorum" makes its appearance a few days after birth; the eyelids are found red or bluish-red and swollen; the eyes can only be opened with difficulty, and on attempting to separate the lids, thick yellow purulent discharge escapes from between their edges; both eyes are almost always affected.

Purulent ophthalmia in older persons may affect one or both eyes; it commences with intolerance of light, lachrymation, and injection of the conjunctiva, shortly followed by marked œdema of the lids with a thin blood stained discharge, the œdema being so great that the lids cannot be opened. In about twelve to twenty-four hours its real nature becomes apparent by thick yellow discharge from between the swollen, red, and sometimes everted lids. The conjunctiva is bright scarlet, traversed by large distended blood vessels, and much swollen, especially the ocular portion (*chemosis*) which may overlap the cornea, and protrude in folds between the lids; there is pain and intolerance of light; and there may be much general depression, especially if the attack has lasted long. The great danger to be feared in purulent ophthalmia is implication of the cornea, which may be partially or entirely destroyed by suppuration or sloughing. The patient may be suffering from gonorrhœa.

Treatment.—In all cases the patients themselves or their parents should be warned of the contagious and serious nature of the disease, and if one eye only be affected, the greatest care should be taken to protect the other. This may be done in children by careful bandaging of the unaffected eye; in grown up persons by the application over the sound eye of what is known as a "Buller's shield," *i.e.*, a watch glass fixed in the centre of a piece of thin indiarubber sheeting, cut to the required size and secured by strapping. If possible, a good view of the cornea should be obtained, as its condition materially influences the prognosis with regard to sight. The examination should be made with care, as the cornea may be damaged whilst making it.

In ophthalmia neonatorum the treatment required is to wash out the eyes every hour or half-hour with boracic acid or other antiseptic lotion until the discharge is lessened; the lotion need only be used thus frequently for twelve hours out of twenty-four (from 8 a.m. to 8 p.m.), the child being allowed to sleep at night; as the discharge gets less the lotion may be used less frequently. When there is much discharge the conjunctiva of the lids should be painted with a solution of silver nitrate (gr. v. to ℥j.) once a day. Some simple ointment should be applied to the margin of the lids once or twice a day to keep them from sticking together. The greatest attention must be paid to cleanliness.

Slight cases of purulent ophthalmia in older persons may be treated in the same manner, but the more severe forms (especially the gonorrhœal) require much more energetic measures.

The treatment should be both local and constitutional.

Local treatment.—When the patient is first seen the lids should be everted, and the whole conjunctiva, brushed over with a stick of solid nitrate of silver, or painted with a solution of forty to sixty grains of the salt to ℥j. of water; the application should be repeated in the course of two or three days if no improvement has taken place. Nitrate of silver may be applied so long as the discharge is free and copious. Its action is due probably to the formation of a superficial coagulum which entangles in it the specific organisms, the whole being thrown off as a slough.

Boracic acid lotion, gr. x. ad ℥j.,
Permanganate of potash, 1 to 2000,
Chinosol, 1 to 2000,
Formalin (40 per cent.) 1 to 2000,
Lotio hyd. perchlor., 1 to 5000,

are some useful lotions to use. The patient should be kept lying in a subdued light, and a bag of ice, or lint kept wetted with ice water, applied over the closed lids; the ice or lint should be removed and the eyes washed out every hour or half-hour with some astringent or antiseptic lotion, the greatest cleanliness being observed. Another and extremely efficacious plan of treatment is, having thoroughly cleansed the eye from discharge, to fill the conjunctival sac, with an ointment of Hyd. ox. flav., gr. xvi., Acid. borici, gr. x., Atropine sulph., gr. ij., cocaine hydrochlor., gr. x., vaseline, ℥j. The ointment may be applied with a brush, syringe, or quill; it does not matter how, so long as the conjunctiva is thoroughly coated with it. The eye should then be covered with a piece of lint smeared with the ointment and lightly bandaged. A fresh cleansing and application of the ointment is required every four hours or oftener according to the amount of discharge. As soon as the swelling has subsided, and the discharge become sensibly lessened, the ointment may be discontinued and washing with boracic acid lotion substituted. Whatever form of local treatment is adopted the great point is *never to allow discharge to collect.*

Should there be much pain, and the patient strong, blood may be taken from the temples by leeches or the application of the artificial leech, but, as before stated, most patients suffering from severe purulent ophthalmia are much depressed, and will not bear depletion. If there is great swelling, pressure on the cornea may be lessened by freely dividing the outer canthus, with a strong pair of scissors or scalpel.

Constitutional treatment.—A good purge should be given, followed by the free administration of tonics, especially iron and quinine, with good living, and a fair amount of stimulants.

If perforation of the cornea threatens or has taken place, the eye should be kept firmly bandaged, so as to prevent as much as possible any escape of the contents of the globe.

Diphtheritic ophthalmia.—This form of ophthalmia is but rarely met with in London; it affects persons of all ages. At first sight the case appears to be one of severe purulent ophthalmia; its chief characteristic, however, is a solid infiltration of the substance of the conjunctiva, with or without the formation of diphtheritic membranes on its surface. The affected eye is frequently lost from implication of the cornea. The sound eye should be guarded by a bandage or Buller's shield. The disease is best treated by injections of diphtheria antitoxine. Antiseptic applications, in the form of lotions, &c., and iodoform powder or ointment, should be used; attention being also paid to the patient's general health.

Membranous ophthalmia is more commonly met with than the foregoing. It looks at first sight like a case of moderately severe purulent ophthalmia, but on closer examination the characteristic yellowish membrane will be found adhering closely to the palpebral conjunctiva, from which it can be separated, leaving an abraded and bleeding surface. Membranous ophthalmia differs from true diphtheritic ophthalmia by the absence of the solid infiltration.

The treatment is the same as that of catarrhal ophthalmia. Strong perchloride of mercury lotion, 1 to 2000, or 3000, is especially useful in this condition.

Ulcers.—Simple ulceration of the conjunctiva is rare, syphilitic sores are occasionally met with, cancerous ulceration is mentioned in Part 2, Chapter II.

Injuries.—Wounds of the conjunctiva usually heal readily enough, requiring only simple treatment.

Burns are usually caused by contact with lime or hot metals; the damage done may be only slight, or the whole conjunctiva and cornea may be converted into a dead white slough.

Treatment.—The conjunctiva should be carefully examined, and all foreign bodies and portions of sloughy tissue removed; should the injury have been caused by lime, the surface of the conjunctiva must be carefully cleansed with a weak solution of acetic acid or simple warm water. Some oil should be placed between the lids, and the eye bound up with wet boric lint and a bandage. If any symptoms of iritis appear, a solution of atropine should be dropped into the eye from three to six times a day. Should there be much discharge, boracic acid or other astringent lotion may be used. Should there be much pain a two to four per cent. solution of hydrochlorate of cocaine should be dropped into the eye five or six times a day.

When the sloughs have separated, care must be taken to prevent adhesions between the raw surfaces left, by passing a probe between the lids and eyeball once or twice a day, and directing the patient to draw the lid away from the globe frequently.

Foreign bodies.—Small pieces of coal, iron, &c., are sometimes found embedded in the conjunctiva, and must be removed. The addition of one drop of a solution of cocaine (gr. v. to ℥j.) greatly facilitating the removal.

Hæmorrhage into the substance of the conjunctiva or beneath it may occur spontaneously, or from injury; no treatment is necessary; the patient may be assured that no harm will come of it, and that the blood will disappear in the course of a week or longer.

CHAPTER VII.

The Cornea, Sclerotic, Episcleral Tissue, and Lens.

The Cornea.

Inflammation of the cornea (corneitis or keratitis). The cornea in health is transparent and its surface perfectly smooth and polished.

A body may have a surface which is smooth and polished but may not be transparent (porcelain), or the surface may be polished but not smooth, the substance remaining transparent (films of French gelatine), or lastly the surface may be smooth but not polished or transparent (ground glass).

Morbid changes in the cornea manifest themselves by an interference with its transparency, smoothness, or polish. We judge of the transparency of the cornea by the distinctness of the tissues seen through it (iris). Its smoothness and polish by the regularity and brilliancy of the reflection from its surface.

The epithelial layer of the conjunctiva is continued over the cornea as its most superficial layer, and is really the direct continuation of the conjunctiva. The polish of the cornea depends on the perfect regularity of the cells forming this layer. Beneath it is a homogeneous membrane—Bowman's membrane, separating the epithelium from the parenchyma of the cornea which is mainly composed of interlacing fibres of connective tissue.

The two deepest layers are Descemet's membrane and the endothelial layer lining the anterior chamber.

The cornea is evascular, being nourished by means of lymph coursing through lymph spaces and canals.

It is supplied by the fifth nerve, and unlike the conjunctiva is very sensitive.

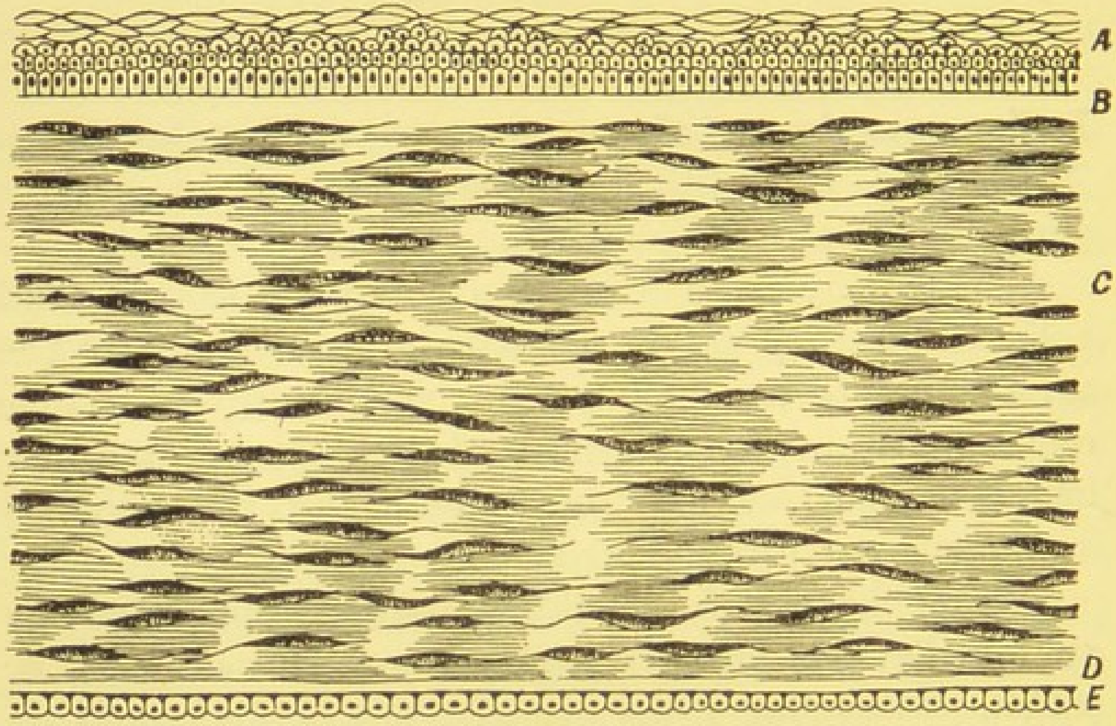


FIG. 38.—Diagram of Cornea. *A*. Anterior epithelium. *B*. Bowman's membrane. *C*. Corneal tissue proper. *D*. Descemet's membrane. *E*. Endothelium lining anterior chamber.

Inflammation of the cornea is known as keratitis or corneitis. Keratitis may be superficial or deep; it may lead to destruction of tissue, in which case, should repair take place ordinary scar tissue will replace the lost substance, a permanent opacity remaining; or on the other hand, if no loss of tissue takes place, the inflammatory products are absorbed and the cornea regains its usual transparency.

The distinction between a superficial inflammation due to an ulcer &c., and a deep parenchymatous change is clinically decided by the appearance of the reflection from the source of light used to examine the eye, be it window, gas, or candle flame. If the reflection is blurred and indistinct the change is deep, the surface of the cornea being smooth, but its polish lost. If the reflection is distorted, broken, and irregular, then the change is superficial, the surface of the cornea being affected.

An opaque cornea, having a smooth and polished appearance, is in a condition of complete repair, after a loss of substance, that is, it is a healed cicatrix. Transparent corneæ, with irregular but polished surfaces, are found in cases of clean ulcers, where repair is taking place, but scarring has not yet started.

The surface of the cornea may be irregular, due, not to a loss of substance, but to a raising of the surface, as in cases of vesicles, phlyctens, foreign bodies, &c.

It cannot be too earnestly insisted upon, that the student should in all cases examine critically the reflection from the surface of the cornea.

Symptoms.—Keratitis is characterized by watering of the eye, impairment of vision, intolerance of light, and pain, at times severe, at others insignificant; on examination, more or less of the cornea will be found cloudy or quite opaque, and blood vessels may be seen in its substance or on its surface.

It is of importance to notice the course and position of the blood vessels in any case where the cornea has become vascular. Should the vessels lie altogether in the cornea, commencing near its margin, and passing for a variable distance in its substance, the case is probably one of interstitial keratitis; but should the vessels be continuous with those of the conjunctiva, pass over the margin of the cornea, and lie superficially on its surface, the vascularity is probably due to mechanical irritation from granular lids or inverted lashes.

It is very necessary that the difference between these two forms of vascularity should be recognized, as their treatment varies widely.

In the former case the treatment of keratitis, to be presently described, should be adopted; in the latter, treatment must be directed against the cause of the vascularity (granular lids, &c.).

Keratitis may be due to local or constitutional causes, or secondary to inflammation of the tissues around.

Interstitial or parenchymatous keratitis (corneo-iritis, syphilitic keratitis, diffuse keratitis).

Interstitial keratitis occurs in persons who are affected by hereditary syphilis; it is frequently, but by no means invariably, associated with changes in the teeth, pegged canines, notched incisors, or dome-shaped first molars; flattened nose, fissures around the angles of the mouth, or other manifestations of congenital syphilis. In some cases injury seems to be the exciting cause of this form of keratitis. Interstitial keratitis is an affection of the structures developed in conjunction with the uveal or middle tunic of the eye, that is to say, the deep parts of the cornea, iris, ciliary body and choroid. The student should remember this, because in many cases, and those the most serious, the implication of the iris, ciliary body and choroid, stamp this disease as more than merely a corneal affection and in all severe cases the ciliary body and the choroid participate in the inflammation.

It usually makes its appearance between the fifth and eighteenth years, but has been known to appear as late as the thirtieth; it always affects both eyes, either simultaneously or at short intervals; it runs a very chronic course and is most intractable, a severe attack often lasting from twelve to eighteen months. Relapses are frequent, and occasionally recurrences occur. The prognosis with regard to vision is good in most cases, although the course of the disease is long.

Symptoms.—Interstitial keratitis presents all the symptoms of inflammation of the cornea in a marked degree. The opacity is peculiar and is caused by infiltration of the substance of the cornea with small cells mainly aggregated at its deep part, the more superficial layers being quite free.

At first the cornea becomes spotted at its centre, but the spots soon run together, forming a greyish haze; opacity then commences at the upper and lower corneal margins, and gradually spreads, until the whole structure resembles somewhat a piece of ground glass, apparently blood-stained in parts, from the development of innumerable minute blood vessels. There is always a well marked band of ciliary injection. Interstitial keratitis is not unfrequently complicated by iritis, hence the name "corneo-iritis," and in severe cases with cyclitis, as evidenced by alterations in tension and deposits at the back of the cornea. The implication of the choroid cannot be ascertained until the cornea has cleared.

The opacity having reached a certain point, may remain stationary for months, but at length clearing commences, and the cornea regains more or less of its normal transparency, recovery always taking place to a much greater extent than would be at first expected. When the cornea has sufficiently cleared to allow an examination of the fundus to be made, spots of atrophy and masses of pigment in the choroid are frequently seen, showing that "choroiditis disseminata" has existed along with the corneitis. In some few cases the eye becomes enlarged, its anterior portion bulging forwards; the ciliary region becomes stretched and thinned and appears dusky in colour, and the tension of the globe is increased. In other cases the eye becomes soft and eventually shrinks. The subjects of interstitial keratitis often become quite deaf from chronic interstitial inflammation of the labyrinth affecting the terminations of the eighth nerve, often coming on suddenly and associated with giddiness. The affection is always bilateral, one ear being often more affected than the other. This usually occurs between the ages of 10 and 20 years.

Treatment.—The patient or his friends should be warned that the disease will affect the eyes for a long time, and if only one is affected, that the other will probably suffer sooner or later. Antisyphilitic remedies, mercury and iodide of potassium in one of the numerous forms suitable for administration should be ordered. The pupils should be dilated and kept dilated with atropine. The best possible hygienic conditions should be obtained for the patient. If much pain is complained of, heat and leeches to the temple are useful. In the retrogressive cases, local application of mercury in the form of the Ung. hyd. ox. flav., or calomel powdered into the conjunctiva assists in absorbing the opacity.

Phlyctenular keratitis (phlyctenular, strumous, vascular corneitis; strumous ophthalmia, fascicular keratitis).

Phlyctenular keratitis is met with in children and young adults; it often follows measles, scarlatina, and other acute diseases; it is frequently accompanied by eczematous eruptions on the eyelids, about the nostrils and angles of the mouth, and on the head. Among the poor ill-nourished children of our large cities we find ample scope for studying this disease. The children, with enlarged tonsils, adenoids, swollen glands of the neck, otorrhœa, rhinitis, thick lips displaying many of the characteristics formerly summed up by the word "strumous," are frequently the victims of this disease.

Phlyctenular trouble is really conjunctival and always starts in that membrane (*vide* p. 140). When, however, that part of the conjunctiva which covers the cornea is affected the top of the phlycten becomes rubbed off, and a small ulcer forms. This becomes secondarily affected by some organism present in the conjunctival sac, and ulceration of the corneal tissue takes place, as a result of the infective process. This ulceration spreads superficially, as a rule, and may cause serious damage to the sight, since the ulcerative process heals by means of cicatricial tissue.

Symptoms.—In most cases there is profuse lachrymation, accompanied by great intolerance of light; the lids may be swollen, covered with eczematous eruption, and tightly screwed up, so as to cause the greatest difficulty in examination.

There is more or less injection of the ciliary region (ciliary redness). Upon the surface of the cornea may be found (1) small greyish elevations (phlyctenulæ); (2) phlyctenulæ in a state of suppuration (pustules); (3) small ulcers left on discharge of the contents of the latter. Any of these are usually found in greatest quantity round the margin of the cornea, but its whole surface may be found dotted over with phlyctenulæ, pustules, or ulcers; or examples of all three may be met with in the same eye. There is more or less haziness and vascularity surrounding the affected portions of cornea, and in some cases there is thick mucous or muco-purulent discharge in addition to the lachrymation.

Fascicular keratitis is a somewhat rare form of the disease characterised by the existence of a fasciculus of vessels running on to the cornea from its margin, the fasciculus terminating in a small ulcer, phlyctenule, or small inflamed patch of cornea.

Prognosis.—As regards the attack the prognosis is good, treatment usually alleviating these cases rapidly. Unfortunately, recurrences are common, and being unable to go to school, the patient's progress is retarded. Moreover, the cicatrices cause serious and permanent damage to the sight in many cases.

Treatment.—To be successful constitutional treatment must be employed. Change of air, open air occupation, plenty of good wholesome food, and improved hygienic conditions, must be prescribed. Ext. malt, cod-liver oil, iron, &c., are useful aids. Locally, mercury in the form of calomel powdered into the eye, or in the form of the Ung. hyd. ox. flav., should be used. If much photophobia exists atropine also should be prescribed, a large shade over both eyes, and warm lotion to bathe the eyes, considerably relieve this distressing symptom.

Ulcers of the cornea present a great variety of forms and are sometimes described as marginal or central, according to their position. They may be transparent or opaque, healing, indolent, vascular, or sloughing. The depth to which the corneal tissue is destroyed varies from slight abrasion of its surface to destruction of its whole thickness, causing perforation.

The area of the cornea which is destroyed also varies from a small point to its whole surface.

Ulceration of the cornea is constantly met with in cases of debility, from whatever cause arising. It is very common in patients recovering from acute diseases, as measles, scarlatina, and more especially small-pox, not from the formation of pustules or eruption on the cornea but from impaired nutrition.

A common cause of corneal ulcer is some slight traumatism, a speck of dust, scratch, &c., producing an abrasion of the corneal epithelium which becomes infected, either at the time of the infliction of the injury, or subsequently by pyogenic organisms. In other cases the inflammatory condition starts deeply in the corneal tissue itself, and is then due to some focus of irritation probably micro-organic, in the substance of the cornea.

Soon the point of irritation is surrounded by small cells, the infiltration appearing as an opacity below the surface of the cornea. Usually it spreads to the surface and the cells are discharged, leaving an irregular ulcer with an infiltrated base. If healing takes place the base of the ulcer clears and the whole becomes transparent, "clean or healing ulcer." Subsequently the loss of tissue is replaced by scar tissue and the cornea again becomes opaque, a cicatrix remaining as evidence of previous ulceration. Sometimes an infiltration may be absorbed and leave no trace, but if a loss of corneal tissue has taken place then scar tissue will replace it.

It is sometimes a matter of difficulty to say whether the opacity of a cornea is recent or old. In all cases of old healed cicatrices the surface is polished; loss of polish indicates a recent affection.

Symptoms.—A patient presents himself suffering from severe intolerance of light, watering of the eye, and smarting pain. On examination any kind of ulceration may be found (one variety has been mentioned under phlyctenular keratitis). There may be one or more small **transparent ulcers,** which can only be seen in certain lights, and are very likely to be overlooked. These appear like small abrasions of the epithelium ; sometimes the greater part of the surface of the cornea is found to be affected either by several small transparent ulcers or one large one. This form of ulceration is most commonly met with in adults of irritable, nervous temperament. A small single central ulcer is very common in children.

Opaque ulcers are visible enough ; they may be of any size ; generally only one, but occasionally two or three are seen in the same eye. At times they appear to be spreading, when the edges are smooth, grey and infiltrated, and the surface of the ulcer rough and opaque or cloudy ; at others are indolent. Again they may be healing, when their edges are clean cut, as if a piece of the cornea had been punched out by some sharp instrument. The ulcer is often deeply excavated, and the surface appears glassy.

Sloughing ulcer is more or less opaque, spreads rapidly both in area and depth, and if the process is not soon arrested the cornea will be perforated, and a prolapse of the iris of greater or less extent (according to the size of the perforation) take place. If the opening is large the lens or some of the vitreous may escape.

In the greater number of cases of perforation of the cornea the iris is pushed forwards, fills the opening, and becomes adherent to its margins, forming an "anterior synechia ;" but a considerable prolapse may take place, forming a projection or bulge from the surface of the cornea (staphyloma).

Marginal or crescentic ulcer (ulcus corneæ serpens) is a somewhat peculiar form of corneal ulceration; it is met with in persons of middle age, generally females, is very intractable, and very likely to recur and relapse. This form of ulceration is accompanied by very severe pain, great intolerance of light, and very profuse lachrymation. On examination a crescentic patch of ulceration is found skirting generally the upper margin of the cornea; the ulcer is deep, its margin clean cut, and its surface glassy looking.

The ulceration spreads rapidly up to a certain point —remains stationary for a time, and then commences to heal slowly, the healing process being frequently interrupted by relapses.

The ulcerative process may involve both the upper, lower and lateral segments of the cornea, but never passes beyond its centre.

Treatment.—The treatment of ordinary ulcers of the cornea is very similar to that of the phlyctenular variety (*vide* p. 158). Iritis is frequently present, and in the large majority of cases the use of atropine is indicated. In cases of callous ulcers, the instillation of solutions of sulphate of eserine (gr. j.-iv. to ℥j. of water), three times a day or oftener, will be found beneficial. The yellow oxide of mercury ointment combined with atropine should be used in the small central ulcer of children as well as in the phlyctenular ulcers. Slight cauterization of the edges and surface of the ulcer with a point at dull red heat does much good in obstinate cases of sloughy or serpiginous ulceration, or in those associated with hypopyon. In all cases the eye should be kept carefully bandaged, if there is no large amount of discharge, which if kept in would irritate the cornea further. The lotions used should

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invariably be hot, and any of the previously mentioned antiseptic lotions may be used mixed with hot water.

The treatment of all inflammatory conditions of the eye is advantageously started by free purgation and subsequently administering tonics, as Vinum ferri, Liq. ferri dial., Tr. ferri perchlor., quinine, &c.

Iridectomy should be performed in any case in which perforation is imminent. The operation reduces tension and gives time for the damaged tissue to recover itself. In no case of keratitis or corneal ulceration must the patient be confined to dark rooms or kept indoors.

Suppurative keratitis is due to infection of the cornea by pyogenic organisms, and is usually the result of sharp blows, as flicks from twigs, &c., or is caused by the irritation of foreign bodies, as the husks of corn; it may also occur after operations for cataract, and sometimes arises spontaneously in badly nourished persons, especially those suffering from chronic muco-purulent discharge from the lachrymal sac.

Symptoms.—Those of keratitis—severe pain being, as a rule, one of the most marked; some part of the cornea will be found occupied by a collection of pus, or the pus may have gravitated down between the layers of the cornea to its lower margin, forming a collection much resembling hypopyon, and known as "onyx." The iris may be inflamed and suppurating, causing a collection of pus to form at the lower part of the anterior chamber, a condition known as hypopyon. Hypopyon is due to the suppurative iritis present in these cases and not to the direct discharge of pus into the anterior chamber from the purulent cornea. Suppurative corneitis is met with in cases of *neuro-paralytic ophthalmia*, a peculiar form of inflammation, associated with paralysis of the ophthalmic division of the fifth nerve, and consequent anæsthesia of the parts supplied by it.

Instead of a collection of pus, some part of the cornea may be found occupied by a dead white slough, or a large ulcerated and sloughing surface.

Frontal herpes.—Corneitis with ulceration, often associated with severe iritis, occurs in conjunction with swelling of the eyelids and conjunctivitis in cases of frontal herpes and is not unfrequently mistaken for erysipelas. In some cases perforation of the cornea occurs and irreparable damage is done, or the eye may be entirely lost from the combined effects of corneal and iritic inflammation.

Treatment.—In keratitis with suppuration warm applications will be found most beneficial; the eye should be well bathed with warm belladonna lotion or decoction of poppies several times a day, and bound up firmly with lint, soaked in one or the other. Dry heat is often of great use. This can be best applied by means of a metal coil (Leiter's) made for the purpose, through which a stream of hot water passes. A piece of lint should be laid over the closed lids and the coil bandaged over it. The application may be continued for fifteen or twenty minutes several times a day. If the coil cannot be obtained, dry heat may be applied by the use of large pads of cotton-wool heated before a fire. The eye may be kept bandaged with pads of wool, instead of lint, soaked in the sedative solutions. If pain is a prominent symptom it may be greatly relieved by the application of heat and also by taking blood from the temples. Should a large area of the cornea become infiltrated with pus, a free incision should be made by transfixing with a cataract knife, and cutting out obliquely through the centre of the infiltrated portion. An antiseptic ointment of iodoform or mercury should be used two or three times daily, a small quantity being placed within the lids.

In cases of keratitis, especially of the phlyctenular form, where there is obstinate intolerance of light, and the disease constantly relapses or recurs, in spite of other treatment, a blister should be placed on the skin of the temple on one or both sides. In some cases the spasmodic contraction of the orbicularis may be kept up by the irritation of small fissures at the outer canthus; in such, a free division of the junction of the lids and orbicularis by cutting through the outer canthus will often effect a speedy cure.

The inhalation of chloroform is also said to act beneficially in some cases.

If in a case of suppuration or sloughing, perforation of the cornea appears imminent or tension becomes increased, iridectomy should be performed (see Part 2).

Opacities of the cornea are the result of inflammation, ulceration, or injury.

They are met with of all densities and sizes; thin cloudy opacities are known as "nebulæ," dense white ones as "leucomata." A dense white opacity, involving the whole cornea, is called a "total leucoma;" an opacity of the same description occupying a part only, a "partial leucoma." Should a corneal opacity have been caused by a perforating ulcer or wound of the cornea, an "anterior synechia" will probably be found associated with it and it is then called an "adherent leucoma."

False pterygium.—*Fleshy opacities* are sometimes met with near the margin of the cornea, and continuous with the conjunctiva. They are composed of granulation tissue, and are frequently the result of burns.

Transverse calcareous bands stretching across the centre of the cornea are sometimes met with in blind eyes, or eyes with very defective sight, and occupy that part of the cornea which is exposed between the lids. It is possible to scrape the calcareous matter away, but the opacity will probably return.

Treatment.—Corneal opacities have always a tendency to disappear, especially in children. Their removal may be aided by the use of slightly irritating applications, which set up a certain amount of increased vascularity, and thus aid absorption. The remedies generally employed are drops of sulphate of copper; turpentine, pure, or mixed in various proportions with olive oil; calomel powder, or the yellow oxide of mercury ointment. Any of these may be used for some considerable time. Should no improvement have taken place at the end of twelve months, and the opacity be so situated as to interfere with vision, an artificial pupil must be made, and if the opacity is disfiguring it should be tattooed (see Part 2). The fleshy opacities may be removed by operation, but are very liable to reappear in their former site.

Injuries.—Abrasions may be caused by scratches from thorns, ends of straw, finger nails, &c. They give rise to severe pain, much intolerance of light, and watering of the eye. The extent is best recognized by staining the cornea, bare of epithelium, with an alkaline solution of fluorescein. This dye stains the denuded area a green colour, and the more recent the injury the better marked will be the staining.

Foreign bodies sometimes lodge on the cornea and remain fixed, causing severe pain and annoyance to the patient whenever the lid moves over it. These should be searched for in a bright light and with a corneal magnifier; no attempt being made to remove them until the corneal surface has been treated with a solution of cocaine (grs. v. or x. ad. ℥j.). The surgeon should try to lift the particle from its bed by means of a sharp needle, and to disturb the epithelium as little as possible.

Treatment.—The eye should be kept carefully bandaged. An antiseptic ointment, such as iodoform, should be used till the abrasion has healed, and the conjunctival sac washed out frequently with a warm antiseptic lotion.

Penetrating wounds of the cornea may be simple or complicated. The most frequent complications being prolapse of the iris, injury to the lens or vitreous chamber and infection of the eye by pathogenic organisms.

Treatment.—Simple penetrating wounds should be treated in the same way as abrasions (*vide* supra).

When the iris is prolapsed it must be returned, and if possible retained in position. If it cannot be returned a careful iridectomy including the prolapse must be performed. In cases where the lens has been wounded or iritis set up, solution of sulphate of atropine—gr. $\frac{1}{2}$-j. to ℥j. of water—should be dropped into the eye from three to six or eight times a day, and the eye should be carefully bandaged with lint soaked in belladonna lotion. (See also Injuries of Iris).

Should the lens swell and cause pain and increase of tension, it must be removed without delay, or iridectomy must be performed.

Iridectomy may have to be performed at some future time for optical reasons, or to obviate the irritation caused by dragging on an anterior synechia. Traumatic cataract may also require to be treated subsequently.

In cases where septic material has been introduced into the globe, a bad prognosis must be given. The humours of the eye forming excellent media for the growth of organisms and sympathetic trouble, or panophthalmitis is to be feared.

Burns of the cornea by lime, hot metals, &c., usually occur in conjunction with like injuries of the conjunctiva; they usually leave behind them opacities of greater or less extent and density, according to the severity of the injury, or may cause sloughing and destruction of the whole or greater part of the cornea.

Treatment, the same as that of burns of the conjunctiva.

The Episcleral Tissue.

Episcleritis is an inflammation of some of the tissues of the eyeball situated between the insertions of the lateral recti muscles and the cornea. Though its name implies inflammation of the episcleral tissue alone, the adjacent sclerotic as well as the conjunctiva is usually affected. The disease is not common; it is characterized by the presence of a rather dusky red swollen patch covered by engorged conjunctival vessels and situated about the insertion of an internal or external rectus muscle.

The patches often disappear from one portion of the globe, and appear again at another; the inflammation is chronic in its course, but subsides after a time, leaving some discoloration of the affected part; it is very liable to recur.

It occasionally follows operations for strabismus.

Treatment.—Sedative applications, as decoction of poppy heads or belladonna fomentation should be used three or four times a day, and if there is much conjunctival vascularity or any mucous discharge, some astringent, as boracic acid lotion should also be employed.

Any constitutional treatment that may appear called for should be adopted. In some cases tonics do most good; others again are greatly benefited by a course of mercury or iodide of potassium.

The Sclerotic.

Staphyloma.—A bulge of the sclerotic may occur from softening of its structure by inflammatory changes, which usually commence in the choroid.

Staphyloma may be met with in the ciliary region (ciliary staphyloma), about the equator (equatorial staphyloma), or near the optic nerve (posterior staphyloma). Little can be done in the way of treatment.

Gummata are occasionally seen upon the sclerotic; they occur as vascular, well-defined bosses, either singly or in groups of two or three. Their diagnosis is not easy; they are likely to be confounded with sarcoma or patches of episcleritis. From the former they can be distinguished by their course, which is, though slowly, towards recovery, from the latter by being more abruptly defined and raised above the surface of the globe.

They are generally associated with syphilitic history, and often with other manifestations of syphilis. They require vigorous antisyphilitic treatment.

Sclero-keratitis is an extremely chronic relapsing form of inflammation of the ciliary portion of the sclerotic and episcleral tissue, and adjacent cornea. It is characterised by deep violet, patchy congestion and swelling of the ciliary region, and irregular patchy opacity of the corresponding portions of cornea. As the disease progresses, iritis is set up, accompanied by much pain and intolerance of light. In some cases the tension of the globe is increased. After some weeks or months the inflammation subsides, but sooner or later relapses; eventually—perhaps after a year or more—recovery takes place, but the cornea is left more or less opaque and the sclerotic stained and bulged in places. The disease occurs in young adults, most frequently women. The patients are generally unhealthy delicate people; they may be tuberculous or syphilitic, and have often a gouty family history.

Treatment.—Locally, nothing does so much good as the instillation of eserine drops, but if iritis exist atropine must be substituted. Sedative fomentations or the application of dry heat, with leeches to the temples should be employed to relieve pain. The eye should be protected from light by a shade, bandage or protectors. If the globe becomes hard and remains so in spite of the use of eserine, iridectomy should be performed.

Iodide of potassium with perchloride of mercury combined with tonics, or tonics alone should be administered according to circumstances. Calomel baths, or mercurial inunctions combined with vapour baths are very useful in severe cases.

Hydrophthalmos (buphthalmos, congenital glaucoma) is a gradual enlargement of the cornea, anterior portion of the sclerotic and iris, with deepening of the anterior chamber, and increased tension of the eyeball. Cupping and atrophy of the optic nerve often occur, and spontaneous hæmorrhage into the anterior chamber or vitreous, followed by disorganization and subsequent shrinking of the globe may take place. The disease which is sometimes described as infantile or congenital glaucoma is present at birth or commences soon after. It is often if not always preceded by iritis. Eserine may do good. Operative treatment is not advisable; either sclerotomy or iridectomy being followed by intra-ocular hæmorrhage.

Injuries.—The sclerotic may be wounded by sharp instruments, or ruptured by blows; in the latter case the lesion usually takes place in the ciliary region, near the upper margin of the cornea.

The sclerotic (as also the cornea) may be pierced by a shot, chip of metal, or other small foreign body, which may be lodged within the globe or have passed clean through it.

Treatment.—The treatment of injuries of the sclerotic depends much upon the extent and nature of the damage done.

Small incised wounds will usually heal readily enough if the eye is kept carefully bandaged. Larger wounds require to be closed by a suture which need only be passed through the conjunctiva.

Blows often cause complete disorganization of the globe, the aqueous and vitreous chambers being filled with blood, and hæmorrhage may take place between the sclerotic and choroid, although no rupture of the external tunic has occurred.

Such cases must be carefully watched, and the eye kept bandaged with lint soaked in belladonna lotion. If the eye becomes painful or begins to shrink it must be excised.

In cases of extensive incised wounds, large ruptures, or wounds associated with lodgment of a foreign body within the globe, extirpation of the eyeball will probably have to be performed.

CHAPTER VIII.

The Crystalline Lens.

Congenital anomalies.—Variations in shape, absence of the whole (aphakia) or part of the lens, and displacements, are met with as congenital defects.

Injuries.—Opacity of the lens (traumatic cataract) may be caused either by penetrating wounds of the cornea or simply by concussion.

Dislocation of the lens.—As the result of blows upon the eyeball, the lens may become partially or entirely displaced; it may still retain its transparency, but often becomes more or less opaque.

Displacement of the lens may take place upwards, downwards, or laterally; forwards into the anterior chamber, backwards into the vitreous, or it may be entirely extruded from the globe through a wound in the sclerotic, and be absent entirely or lie beneath the conjunctiva. In the three first positions the displacement is only partial and the margin of the lens can be seen by oblique illumination occupying some part of the pupil.

In displacement forwards the pupil will be found dilated, irregular in shape, and fixed; oblique illumination will show the lens lying partially or entirely in the anterior chamber.

In displacement backwards the iris will be tremulous, the pupil sluggish, and the anterior chamber deepened. Direct ophthalmoscopic examination will probably detect the lens lying in the ciliary region at the lower part of the eye.

In displacement beneath the conjunctiva the lens forms a small rounded tumour somewhere near the corneal margin most frequently at its upper part.

Treatment.—If the lens is displaced partially, or into the anterior chamber and still retains its transparency, it may be left alone. But should it become opaque it must be removed by extraction, or an artificial pupil may be made in such a position as to allow of light entering the eye by the side of the opaque lens. If the lens sets up irritation it must be extracted with a scoop, or sharp hook, iridectomy being performed at the same time, if it has not already been done (see Extraction, Part 2, Chap. V.) some vitreous will probably be lost during the operation.

A transparent lens may remain for years in the anterior chamber, and, with the exception of impairment of vision, give rise to no inconvenience. If its capsule has been ruptured, however, it will become opaque and if not extracted will be removed by absorption. A lens displaced into the vitreous chamber will very probably act as a foreign body and set up glaucomatous changes, in which case it should be removed at all risks; but if it causes no irritation it is best left alone.

A lens displaced beneath the conjunctiva may be left alone or removed at discretion.

Cataract.—By cataract we understand an opacity of the lens. The name is a very old one, the result of a mediæval idea that vision was lost because an opaque fluid fell over the sight, as water falling over rocks is called a cataract.

The cause of cataract is, in possibly all cases, certainly in many, the direct action of fluids on the lens.

If the lens capsule is ruptured the lens is brought into direct contact with the aqueous humour, and within a short time turns opaque. In traumatic cataracts the lens capsule has been ruptured by the injury. In senile cataracts fissures are formed in the substance of the lens which contain minute particles of fluid, and so bring about the cataractous condition.

The lens is surrounded by a capsule which is of a different physical and chemical character to the lens material proper, so that in health the lens never comes in contact with the aqueous humour.

Cataracts may be divided into primary and secondary. Primary cataracts develop irrespective of any lesion in the neighbouring tissues, and may be progressive or non-progressive, partial or complete. Secondary cataracts are developed in connection with disease in the surrounding tissues. Progressive cataracts are those in which the opacity increases and generally become complete. Non-progressive cataracts are incomplete, some transparent lens material remaining.

Congenital cataracts.—These are seen at birth, are of a bluish white colour, complete, and may be associated with some other congenital defect in the eye.

Lamellar cataracts.—These are found in children, complaining of defective vision for distance and reading, at a later period of life. Glasses may help, but full vision is not obtained.

On dilating the pupil, the red reflex is diminished in brilliancy at the centre, and a more or less circular opaque disc situated on a red ground is seen. As a rule the opacity is quite well-defined, but in some cases a few spicules may be seen extending into the transparent portion of the lens, "riders." Lamellar cataract rarely increases in area, but the opacity may become more dense as the child grows up. This condition is due to the fact that certain lamellæ of the lens have developed in them vacuoles and fissures filled with a granular material, the change occupying mainly the part of the lens between the nucleus and the cortex.

We may find in these patients other evidence of defect of the epiblastic structures, as defect of the enamel of the teeth, sometimes evidence of rickets.

The cause of the disease is probably due to the fact that the patient has passed through a period of ill-health or general malnutrition at an early period of life, and the epiblastic structures laid down during that period are defective.

The treatment of these cases depends on the vision present. If the patient can read small print and has a third of normal vision for distance ($\frac{6}{18}$) it is best to leave the case alone, if the vision is not equal to this, then the lens should be needled (*vide* Part II.), but of course, that being so, all power of accommodation will be lost, and glasses will be required for constant use. Often an iridectomy will enable the patient to reach the required standard of vision.

Anterior polar cataracts.—These are really opacities deposited on the surface of the lens and not opacities of the lens itself.

The inflammatory exudation resulting from a perforating corneal ulcer, or an ulcer which has not perforated during early childhood, becomes organised and remains as a small, pyramidal, chalky-white mass, about the size of a pin's head at the anterior pole of the lens. These cataracts are not usually difficult to diagnose, and give rise to no inconvenience.

Senile cataracts.—This is the most numerous and important class of cataracts, and is not usually found before the age of 50.

Symptoms.—Failure of sight for distance and reading; specks like flies, webs, or haze, in front of the eyes; acuteness of vision, varying according to the amount of light present; monocular diplopia or polyopia.

The patient sees better in a dull light if the opacity is central, and in a bright light if the opacity is peripheral, owing to alterations in the size of the pupil. The prismatic effect of the opaque striæ often give rise to the diplopic or polyopic symptoms, but these disappear as the lens becomes more uniformly opaque.

Senile cataracts may be found in one of four stages:—

1. The early or incipient stage, in which some of the red reflex remains.

2. The stage in which the whole lens is swollen and the anterior chamber consequently shallow.

3. The mature stage.

4. The hypermature stage.

Signs of maturity.—The whole lens is opaque; no bright glistening sectors are present; vision is reduced to perception and projection of light, *i.e.*, the patient cannot only perceive light, but can tell the direction from whence it comes; the anterior chamber is of normal depth; no iritic shadow is present.

This last point is important as it enables us to say whether the anterior cortical portion of the lens is opaque. If the lens is opaque quite to the anterior surface, the iris will cover its own shadow, if however this is not so, then a shadow will be formed between the iris and the opaque screen somewhere deeper in the lens.

The hypermature cataract has a calcareous capsule, a soft semifluid cortex, and a hard nucleus, which sometimes is found at the lower part of the capsule. The extraction of such a lens is more difficult than one in the mature stage.

The following conditions should be investigated before the extraction of the lens is undertaken :—The cataract should be mature. The patient must have perception of light, and must also be able to say accurately from whence the light comes, in all parts of the field, *i.e.*, projection of light. If not, some disease at the back of the eye should be suspected. On no account must there be any conjunctival discharge or lachrymal obstruction. A cough must be cured before operation, and the patient should be free from all mental worry and depression.

Nuclear cataracts occur in persons who have passed the middle period of life, and are characterized by the presence of a hard yellowish central portion or nucleus of varying size and density; the nucleus is surrounded by more or less soft cortical substance, and is occasionally of a greenish or almost black colour, giving rise to what is known as "green" or "black" cataract.

Secondary cataracts.—These are caused by changes in the lens secondary to inflammation, syphilitic or otherwise, of the choroid or ciliary body, and are often associated with changes in the vitreous.

A posterior polar cataract, although commencing at the posterior pole, progresses slowly, and sometimes after covering its posterior surface, attacks the anterior surface of the lens, the whole eventually becoming opaque, and a nucleus of greater or less size and density being formed.

Posterior polar cataracts may, however, be non-progressive, but are usually associated with some disease of the deeper structures of the eye.

Traumatic cataracts.—When the lens capsule is ruptured either accidently or purposely, as in the operation of needling, the aqueous humour comes in direct contact with the lens material and causes it to turn opaque, swell and gradually dissolve away, leaving behind only the lens capsule and the epithelium on its anterior surface.

Diagnosis of cataract.—The existence of cataract is easily ascertained by oblique illumination, and by the position of opacities diminishing or obliterating the red reflex.

Treatment.—(*Vide* Part 2, Chapter V.).

Webs.—The lens is removed from its capsule, which is left behind together with a small amount of the cortex of the cataractous lens. The cells of the anterior layer of the lens, may, and sometimes do, proliferate after the removal of the cataract, and form opaque webs in the pupil which interfere with the passage of light through the media. These webs are troublesome, and if dense must be cut or torn across, before the patient can see sufficiently to read.

CHAPTER IX.

THE IRIS AND CHOROID.

CONGENITAL ANOMALIES.

Coloboma.—A cleft condition of the iris or choroid dependent on failure of closure of the fœtal fissure, is known as a congenital "coloboma." In the iris it occurs as a deficiency of the lower segment, appearing as if iridectomy had been performed downwards; in some rare cases the cleft is above. In the choroid it is seen (on examination by the ophthalmoscope) as a brilliant white figure, commencing at, or below, the optic disc, and continuing downwards and forwards for a variable distance towards the ciliary processes, through which, in extreme cases, the cleft extends and is even continuous with a similar deficiency of the iris.

Central deficiency.—In some cases a central nearly circular hole is met with in the choroid as a congenital defect.

In the **albino** the pigment of the iris and choroid is absent to a greater or less extent, and with the ophthalmoscope the fundus of the eye appears of a yellowish-white colour, and the blood vessels of the choroid are distinctly seen.

Irideremia, or congenital absence of the iris, is occasionally observed.

Persistency of the pupillary membrane.—Small portions of the membrane, which at a period of fœtal life covered the anterior surface of the lens, occasionally remain, and are seen as one or more fine threads, somewhat resembling cobwebs, passing across the pupillary area, and attached at either end to the anterior surface of the iris, near the margin of the pupil. The thread is often double at one end and single at the other.

Anomalies of colour.—The irides in the two eyes may be different colours; thus the colour in one eye may be brown, whilst that of its fellow is blue, or differences in colour may occur in different parts of the same iris.

Tremulous Iris, Tumours.

Tremulous iris (iridodonesis) signifies a tremulous condition of the iris, which shakes about as the eye is moved. This condition is met with when the iris has lost the support of the crystalline lens, either through dislocation, absence, or other cause.

Tumours seldom originate in the iris itself, but its structure often becomes implicated by growths commencing in deeper parts of the globe (see Tumours of Eyeball). Instances, however, of malignant growths, dermoid and simple cysts, and of the cysticercus, have been met with in the iris.

Inflammation of the Iris (Iritis).

Causes.—The causes of iritis are local and constitutional; most cases, however, are the latter.

Local.—Secondary to inflammation in its neighbourhood, as irritation from foreign bodies in the conjunctival sac or cornea; friction of the cornea by granular lids or inverted lashes; corneal ulcers, severe conjunctival troubles, cyclitis, &c.; traumatism, as injuries to the iris itself by operations, or accidents, with or without the lodgment of foreign bodies in its substance or on its surface; pressure by a swollen crystalline lens, and perforation of the cornea; sympathetic, when iritis is set up, owing to injury of the other eye.

Constitutional.—Certain specific diseases, as syphilis, rheumatism, gonorrhœa, tubercle, diabetes, and in association with infectious diseases, &c. Of the constitutional causes syphilis accounts for more than 50 per cent. of the cases. In the acquired form of syphilis, iritis occurs as a secondary symptom and also as a late tertiary; in the congenital form during the first three months, and also about the 18th to 20th years.

The student must not be satisfied with a history of vague rheumatic pains, but should elicit a history of acute or subacute rheumatism. Gonorrhœa is probably a more frequent cause than is generally recognised and is often associated with fluid in the knee or ankle joint, gleety discharge from the urethra, and includes many, possibly all, those cases commonly called gouty.

Symptoms.—These may be divided into those due to increased vascularity and those dependent on exudative changes.

Pain, photophobia, lachrymation, circumcorneal injection, are the earliest symptoms of this as well as of several other ocular inflammatory troubles. The pupil is small, contrary to the condition in glaucoma, and reacts sluggishly or not at all, both to light, and to atropine. The iris is blurred and indistinct; the aqueous humour turbid.

Symptoms due to exudative changes are deposits of lymph on the iris, especially on its posterior surface, fixing it to the anterior surface of the lens capsule; deposits of lymph in the pupil, which may lead to serious diminution of the visual acuity, and in severe cases the exudation may be so great that the solid portion sinking to the lower parts of the anterior chamber forms there an hypopyon. Sometimes if a small vessel gives way, blood may collect at the bottom of the anterior chamber, forming hyphæma. Pain is very variable, being more marked in rheumatic than in syphilitic cases. The adhesions formed by the iris to the back of the cornea are called "anterior synechiæ," those fixing the iris to the lens capsule "posterior synechiæ."

Severe iritis is almost invariably complicated with cyclitis.

An uncomplicated attack lasts from two to three weeks or longer, and usually ends in resolution, the iris quite recovering its normal condition, but a few adhesions may form between the iris and lens capsule (posterior synechiæ). In all forms of iritis, however, the inflammation may run on to the formation of a considerable quantity of new material or into suppuration. When suppuration takes place, the iritis is sometimes described as a separate variety "suppurative iritis."

Rheumatic iritis occurs in persons who are subject to attacks of rheumatism. An attack of this form of inflammation presents all the more constant symptoms of iritis, and has one character peculiar to itself, viz., its tendency to recur, some patients having had as many as twenty or more separate attacks; in some cases the attacks observe a remarkable periodicity, recurring regularly at the same time of year. The inflammation sometimes appears in one eye, sometimes in the other, or perhaps in both, at short intervals, rarely simultaneously, the second eye becoming affected long before the first has begun to recover. Rheumatic iritis is frequently accompanied by more or less haziness of the cornea and aqueous humour. In some cases very severe pain of a dull aching character is experienced in the eyeball, forehead, side of nose, and temple; in others the attack is most insidious, the patient's attention not being attracted until a considerable amount of new material has been thrown out, extensive adhesions formed, the sight of one eye much impaired, and the inflammatory action extended to the other.

All persons who have "posterior synechiæ" are not subject to recurrent attacks; in all probability, those who have repeated attacks, have some constitutional taint which renders their irides liable to inflame upon slight provocation. The most severe form of recurrent iritis is that associated with gonorrhœal rheumatism and is sometimes described as gonorrhœal iritis. Very fine posterior synechiæ and a gelatinous exudation characterize this variety at times, but usually it is not possible to say what the cause is from the clinical appearance.

Syphilitic iritis is, perhaps, the most common of all the forms.

A typical case presents all the constant symptoms of iritis in a very marked degree, the zone of ciliary redness being extremely well-defined. There may be, besides, certain peculiar nodular excrescences, of a dirty yellow colour (known as lymph nodules), situated on the surface of the iris or at its pupillary margin, and at times extending into the pupil, which may be completely blocked by them. These excrescences are syphilitic condylomata, and their existence renders the diagnosis of syphilitic iritis certain; they are, however, only occasionally present, and in the greater number of cases met with, the surgeon will have to take into consideration the patient's previous history, ascertain the existence of other signs of syphilis, and make his diagnosis accordingly.

Syphilitic iritis occurs most frequently between the ages of eighteen and forty, but is occasionally met with as a manifestation of congenital syphilis in infants, and often in cases of interstitial keratitis.

Results of iritis.—In many cases, especially if early and properly treated, perfect recovery takes place; in others, permanent signs of inflammation are left. The morbid changes more commonly met with are:—

(1) **Complete adhesion of the pupillary margin** to the lens capsule, and on account of the pressure of fluid behind, the iris may become bulged forwards, forming the so-called "Bombé" iris. The iris itself may be found atrophied, rigid, or rotten, and very prone to bleed on the slightest wound. These latter conditions become most apparent when operating upon its structure. On attempting to perform iridectomy, considerable difficulty will be experienced in removing a portion of the iris, which may be so tough that none of it can be torn away, or so rotten that only the portion included between the blades of the forceps is removed; or hæmorrhage may take place to such an extent as to prevent the completion of the operation.

(2) **Adhesions to neighbouring parts (synechiæ)** those most commonly met with being between the iris and lens capsule (posterior synechiæ).

Posterior synechiæ are generally situated at the pupillary margin, and vary in extent from a few adherent tags of this part only, to complete adhesion of the whole posterior surface of the iris to the lens capsule, this latter condition being known as "total posterior synechiæ." When the pupillary margin is entirely bound down to the lens capsule, and no communication exists between the two divisions of the anterior chamber, the pupil is said to be "excluded."

Adhesion of the iris to the cornea (anterior synechiæ) —should this occur at all as the result of iritis—will be found about its greater circumference.

(3) **Blocking of the pupil** by inflammatory material (occlusion), or by opacities upon the lens capsule, caused by adhesion of "uvea" detached from the posterior surface of the iris.

(4) **Capsular cataract.**—Dense inflammatory deposits in or beneath the lens capsule, or involving the superficial fibres of the lens itself (capsular cataract), may also be met with.

Treatment.—In treating iritis we must take care, *firstly*, to dilate the pupil; *secondly*, to relieve pain; *thirdly*, to employ any constitutional treatment that may appear called for.

In order to dilate the pupil, a few drops of a strong solution (gr. iv. to ℥j.) of sulphate of atropine should be placed between the eyelids by the surgeon himself at each visit, and a weaker solution (gr. ¼ to gr. j. to ℥j.) should be used by the patient from four to eight or twelve times a day. If the case is treated at the commencement, more or less dilatation of the pupil will usually take place; but should the iris have become infiltrated with inflammatory matter, and adhesions formed, little or no effect will be produced; the atropine should, however, be persevered with.

Some patients are extremely intolerant of atropine;

in such, it produces swelling and inflammation of the eyelids and face of an erysipelatous appearance, known as "atropism."

If atropism occurs a substitute must be found for the atropine. Daturine, hyoscyamine, duboisine,* homatropine,† or other mydriatics, in solutions of gr. i. to iv. to ℥j., may be tried, or the atropine may be used in the form of an ointment, gr. $\frac{1}{4}$ of sulphate of atropine to ʒj. of vaseline. In one case it was found, after all else had failed, that mixing gr. j. of carbolic acid in ℥j. of atropine solution prevented atropism. Boracic acid may also be used for the same purpose.

In cases of iritis with suppuration, the eye should be fomented frequently with hot belladonna lotion, and kept bound up with lint soaked in the lotion.

In cases accompanied by much pain, blood should be taken from the temples by leeches or the artificial leech. Atropine may give rise to pain by causing dragging upon adhesions, and should be used with caution in cases where its application is attended by much suffering, especially if it has no effect on the pupil. The eyes should be protected from light by a green shade or protectors until the inflammation has subsided. The hot coil is often of great use, both in suppurative and painful iritis.

Of *constitutional remedies* there is none so useful in the treatment of iritis as *mercury*. The drug should be given in some form or other, so as to speedily affect the system, in all cases where inflammatory products are plentifully produced, whether the inflammation be of

* Duboisine must be used with caution as poisonous effects have followed its application in even weak solutions.

† The sulphates of daturine, hyoscyamine, and duboisine, and the hydrobromate of homatropine are the salts most frequently used.

syphilitic origin or not. A pill containing gr. ij. of pil. hydrarg. and gr. $\frac{1}{4}$ of pulv. opii may be taken three times a day, and is a very convenient and effectual mode of administration. Mercurial inunction, combined with Turkish baths, or calomel vapour baths, or hypodermic injection of perchloride of mercury, may be employed if preferred.

If the iritis occurs in debilitated states of the system, or the inflammation goes on to suppuration, tonics, as iron or quinine, should be prescribed, and a plentiful supply of good food given. Should there be much pain opium must be given, and it is well to prescribe the drug in conjunction with extract of belladonna or hyoscyamus. In rheumatic iritis, salicylate of soda, in doses of gr. xv. to xxx. combined with gr. ij. of quinine, three times a day, often does much good.

The treatment by Turkish baths and mercurial inunctions is most valuable in many inflammatory conditions of the eye. It is best carried out as follows:—The patient should remain in a Turkish bath (any of the portable ones answer the purpose admirably) long enough to produce free perspiration. The perspiration should be wiped off and ʒj. of Ung. hydrarg. rubbed thoroughly into any part of the body—axilla, flanks, inner side of thigh, or anywhere where the skin is soft, a fresh place being selected for each rubbing.

The baths and rubbings should be given three or four times a week up to the number of twenty-one, and then discontinued for a few weeks, to be repeated if necessary.

The results of iritis, should they seriously interfere with vision, require the performance of iridectomy or some one of the operations for artificial pupil. Iridectomy should also be performed in cases of recurrent iritis. The removal of a portion of iris in some manner—probably by preventing dragging on adhesions —has an effect in preventing recurrence.

Traumatic iritis.—The iris may be cut, torn, or bruised; prolapsed through, or adherent to, the cornea, in cases of penetrating wounds of that structure (see Wounds of the Cornea); or it may be separated from its insertion to a greater or less extent by concussion, without external wound. Any of these injuries are liable to set up iritis, which may possibly be followed by suppuration.

Treatment.—In all recent cases of injury where the iris has become prolapsed, or is adherent to a wound in the cornea, an attempt must be made with a curette or small spatula, to return it to its proper position. Then, if the wound is near the centre of the cornea, atropine should be freely used and the eye bandaged with lint soaked in belladonna lotion. But if the wound is near the corneal margin, eserine should be employed, and the eye bandaged with sal alembroth or iodoform gauze. The object in each case is to draw the iris as much away from the wound as possible; in the first by dilating, in the second by contracting the pupil. In the case of a wound near the corneal margin, eserine should be discontinued as soon as the wound has healed, and atropine substituted, so as to dilate the pupil and prevent the occurrence of synechia, should iritis supervene. It is worse than useless to attempt to return prolapsed iris more than thirty-six hours after an injury, as it will be found firmly adherent to the edges of the wound. In extensive wounds also, as when the cornea is cut clean across or starred, it is of little use to attempt to return the iris, as it will again prolapse as quickly as replaced. In such cases and where from any cause the prolapsed iris cannot be returned, iridectomy including the prolapse should be performed. In injuries not associated with corneal wound and prolapse, or adhesion, the injured eye should be kept carefully bandaged with lint soaked in belladonna lotion, and if much pain is complained of, or inflammatory symptoms arise, blood should be freely taken from the corresponding temple, either by leeches or the artificial leech, and hot fomentations or the hot coil applied.

As in iritis from other causes, the pupil may become blocked, or extensive synechiæ form, requiring operative interference at some later period (see Operations on Iris).

The Ciliary Body.

The ciliary body consists of two parts, the ciliary muscle and the ciliary processes (*vide* fig. 39). The muscle (E, F) is used in accommodation; the processes (D), consisting of vascular tissue, and having numerous small glands in their structure, secrete the main portion of the fluid which traverses the anterior portion of the eye (*vide* fig. 40). Consequently an inflammation of this structure produces symptoms which are referable to these two conditions. A failure of accommodation in the early stages and in slight cases, evidenced by difficulty with all near work, reading, sewing, &c., is a frequent symptom, and an alteration of the tension of the eye, either an increase or a decrease, must also be referred to an interference with the function of the ciliary body. The most characteristic symptom is keratitis punctata.

As the result of the inflammation, a number of cells and inflammatory débris are thrown from the ciliary body and conveyed by the current of fluid from the posterior to the anterior portion of the anterior chamber. These cells adhere together and form little masses which tend to sink to the bottom of the aqueous chamber, the larger

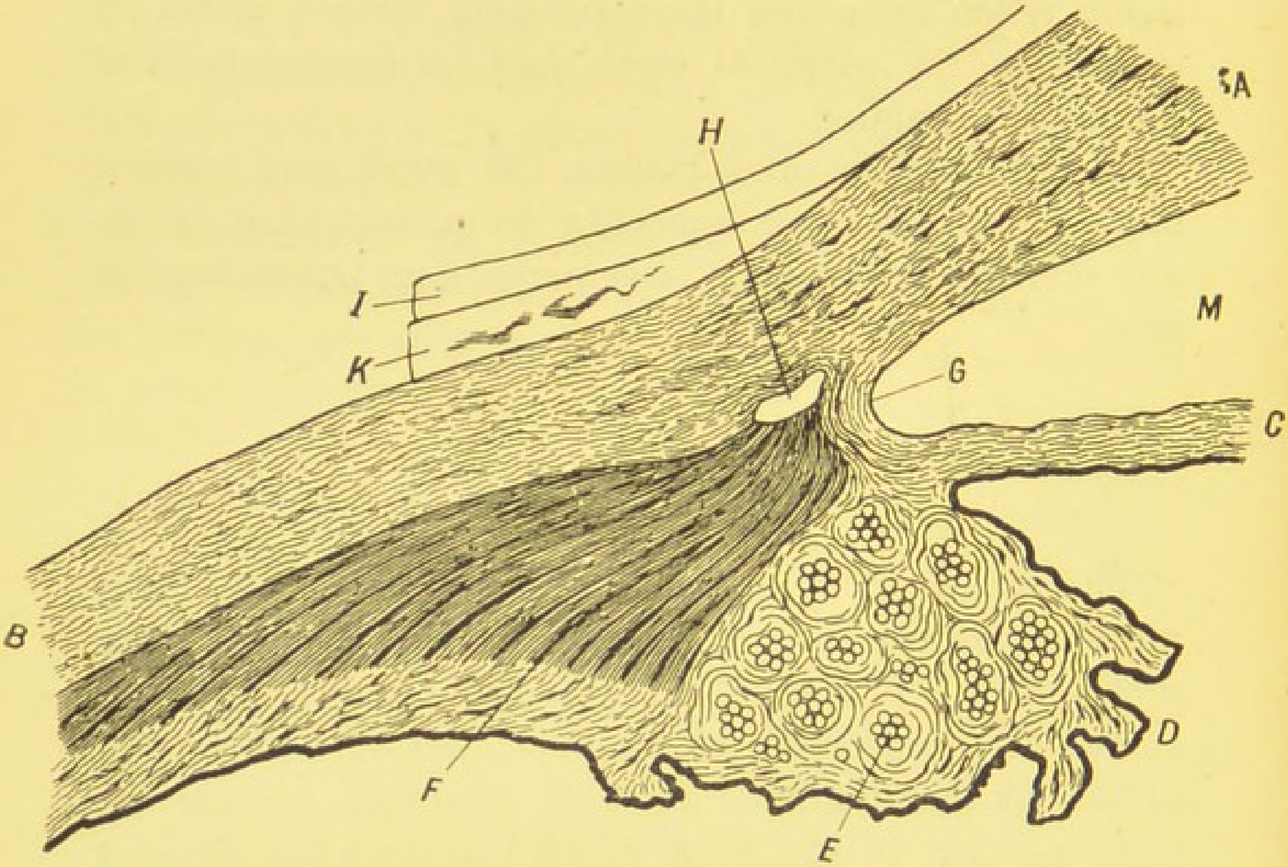


FIG. 39.—Diagrammatic Section of Ciliary Body.

A. Cornea. *B*. Sclera. *C*. Iris. *D*. Ciliary process. *E*. Circular fibres of ciliary muscle. *F*. Longitudinal fibres of ciliary muscle. *G*. Filtration angle. *H*. Canal of Schlemm. *I*. Anterior epithelium and conjunctiva. *K*. Sub-conjunctival tissue. *M*. Anterior chamber.

and heavier ones being lower down. Owing to the movements of the globe, a number of these sticky particles adhere to the posterior surface of the cornea and so form the clinical picture of keratitis punctata, which is a triangular-shaped haze, situated at the lower and deep part of the cornea, and when viewed with a magnifying lens is seen to consist of numerous small separate dots—the larger ones being at the base of the triangle, which is always at the lower part of the cornea.

Cyclitis.—Inflammation of the ciliary portion of the choroid (ciliary body), in typical cases, is characterized by dusky red swelling of portions or the whole of the ciliary region, pain in the eyeball aggravated by pressure in the ciliary region, some inflammatory opacity in the vitreous and alterations of tension of the eyeball, and keratitis punctata. It is very frequently associated with slight or even severe iritis (irido-cyclitis).

Cyclitis may be caused by injury, or may depend on any of the causes producing iritis. In the former case the inflammation is often of a plastic nature. In many cases, more especially those of syphilitic origin, complete recovery takes place, more or less dark staining of the ciliary region being left. In some cases, more especially those associated with iritis, great increase of tension occurs, "secondary glaucoma" being set up. In other cases softening and shrinking of the globe follows on atrophy of the ciliary body. Suppuration may also take place.

Wounds of the ciliary region should always be looked upon as much more serious than those of other parts of the eyeball, from their tendency to set up plastic cyclitis, ultimately destroy the eye, and place its fellow in danger from sympathetic ophthalmia.

Treatment.—Instillation of eserine (gr. ij. to ℥ j.) or if there be iritis, without increased tension, of atropine. If increased tension exists, eserine must be used even though there be severe iritis. If the tension persists in spite of eserine, iridectomy should be performed. Iodide of potassium and perchloride of mercury should be given internally, or mercurial inunctions resorted to, if the case is syphilitic, or indeed in any case arising spontaneously.

In traumatic cases no constitutional treatment is required, but the same local treatment should be adopted and the eye kept carefully covered with a black bandage placed over a pad of lint so as to exclude all light. If there is much pain the same treatment should be adopted as in painful iritis or corneitis.

Diseases of Choroid.

Hyperæmia.—Increased vascularity of the choroid is not unfrequently met with, more especially in myopic persons; it should be suspected if a feeling of fulness and tension of the eyes, accompanied by watering and intolerance of light, is complained of.

On examination with the ophthalmoscope increased redness of the choroid (especially of that portion nearest the outer side of the optic disc) and some enlargement of the choroidal vessels can be made out; these changes will, however, very probably be overlooked by an inexperienced observer.

Treatment.—The eyes should be kept carefully at rest, protected from light, cold douches employed, and all positions (as stooping or hanging the head) which cause congestion of the eyeballs, carefully avoided; blood may be taken from the temples, and if glasses have been worn their use must be discontinued. When the more acute symptoms have passed off any anomaly of refraction must be carefully neutralized by suitable lenses.

Inflammation of the choroid, "choroiditis,"

and its sequel, choroidal atrophy, are most commonly caused by syphilis, either congenital or acquired. A chronic form of choroiditis affecting the whole of the choroid, or only its central part, "central choroiditis," is met with in persons past the middle of life; choroiditis also occurs in myopia of high degree; associated with iritis, "choroido-iritis," and in sympathetic ophthalmia.

Symptoms.—The diagnosis of choroiditis can only be made by ophthalmoscopic examination. Pain, intolerance of light, impairment of vision, fulness of veins emerging from the sclerotic in the ciliary region, ciliary redness, dilatation and sluggishness of the pupil, are symptoms often met with in choroiditis, but are by no means constant or characteristic.

The changes seen with the ophthalmoscope are, in the early stage, greyish or yellowish spots or patches of exudation surrounded by more or less redness. If the disease has lasted any length of time atrophic areas will be found mixed up with the exudation. The exudation may occur in one or more large patches, or be distributed over the choroid in the form of spots, "choroiditis disseminata." We know that the morbid changes seen, are in the choroid, if the retinal vessels pass in front, without being obscured by them.

The retina is, however, frequently involved in the inflammatory process, in which case the vessels may be obscured, and it is difficult to tell where the inflammation has commenced, and which structure is most affected. Experience, however, teaches that large yellowish or greyish ill-defined opaque patches, or dirty yellow scattered spots, belong to the choroid; whilst in inflammation of the retina the opacity is more milky or opalescent if in patches; glistening and bright if in spots.

The optic disc is often affected if choroiditis exists in its vicinity. It becomes somewhat swollen, and looks dirty and opaque; the retinal vessels become thinner than normal, and the disc may pass into atrophy. In some cases where the ocular tension is increased the disc becomes cupped and eventually atrophied.

A typical case of syphilitic choroiditis is characterized by the presence in the choroid of yellowish nodules similar to those seen in syphilitic iritis; but, as in the latter disease, typical cases are only occasionally met with, and we must be guided by the same rules in making a diagnosis. The ophthalmoscopic appearances in choroiditis caused by congenital and acquired syphilis are similar.

Choroiditis disseminata is syphilitic; the atrophic changes left by it are seen as white or dirty white spots, showing holes in the choroid, through which the sclerotic is seen more or less distinctly, and dark spots consisting of accumulation of pigment. An irregular pigment-bounded ring of atrophy extending round the discoloured optic disc is met with in some cases of old syphilitic choroiditis.

Opacity in the vitreous occurs in choroiditis, more frequently in the syphilitic form. Displacement of the retina may take place from effusion between it and the choroid. Opacity of the lens commencing at its posterior pole, "posterior polar cataract," may occur, and gradually extend over the posterior surface of the lens finally involving the whole of it and forming a variety of soft or cortical cataract. Cataract occurring in early adult life is commonly of this nature (*vide* p. 177).

The chronic form of choroiditis, or as we generally see it, of atrophy of the choroid attacking the eyes of persons past the middle of life comes on without apparent cause. The ophthalmoscope in some cases shows a peculiar mottled or marbled appearance of the fundus, an exaggeration of the condition mentioned at p. 51 as occurring in normal eyes; it is caused by abnormal distinctness of the choroidal vessels due to wasting of the pigment. In some instances instead of the mottling, a striped appearance is produced, and in other cases the pigment appears to be entirely worn away over areas of varying extent and the sclerotic shows plainly through.

In "central choroiditis" a hæmorrhage is probably the cause, and at first we may make out the effused blood, often, however, shrouded by inflammatory exudation. As time goes on the blood and inflammatory products become absorbed and a more or less circular patch of atrophy remains occupying the centre of the fundus. Choroiditis almost always attacks both eyes; not always in the same degree, the disease being often far advanced in one eye when just commencing in the other. Its effect on vision depends on the amount and part of choroid affected; considerable change may take place in the peripheral parts, without much affection of vision, but a very small patch of exudation in the region of the yellow spot, as in central choroiditis, causes great impairment. In some cases, however, remarkably good vision may be preserved, though the choroid appears to be riddled with holes (atrophy), and presents more or less marked signs of recent inflammation; and in such the amount of vision depends upon the extent to which the retina is involved in the inflammatory or atrophic process. Cases of acute choroiditis are not often seen. The reason of this is, that unless the patches are large or placed at or near the macula they lead to little disturbance of vision, and are not noticed by the patient. Also choroiditis is frequently associated with keratitis and irido-cyclitis, conditions which prevent a clear view of the fundus being obtained.

Chronic cases are by no means rare in ophthalmic practice.

For changes in the choroid in myopia see pp. 87, 89.

Treatment.—The treatment of choroiditis should be very similar to that of iritis. A course of Turkish baths, followed by mercurial inunction, is much to be recommended in the more acute cases ; in chronic cases a long course of perchloride of mercury should be tried. Iridectomy does good in some cases in which there is increase of tension of the globe. For the atrophic changes no treatment is of any avail.

Injuries.—The choroid may be injured by foreign bodies entering the eyeball, or ruptured by violence, without perforation of the tunics.

In the former case (more especially if a foreign body is lodged in the structure of the choroid) inflammation is very liable to follow, the eyeball being eventually lost by suppuration or shrinking. A rupture of the choroid from external violence is generally situated near the margin of the optic disc, is attended with more or less hæmorrhage, which fills the rent with blood, and may cause considerable displacement of the retina.

Seen with the ophthalmoscope soon after the receipt of the injury, a rupture of the choroid appears as a more or less elongated blood clot ; later the blood becomes absorbed and a white linear or curved figure is left, from the white sclerotic showing through the rent in the choroid and the organization of the blood clot. This form of injury is not often followed by destructive inflammation. The damage to sight depends upon the size and position of the rupture, and whether detachment of the retina is caused or not.

Treatment.—A simple rupture of the choroid should be treated by giving rest to the eye by bandaging and the instillation of atropine; and by blistering behind the ear or on the temple. In injuries associated with wound of the sclerotic, cornea or iris, the treatment recommended for injuries of these structures should be adopted.

Bone upon the choroid.—Deposits of bone are not unfrequently met with upon the inner surface of the choroid in eyes that have been blind and shrunken for years.

Tubercle in the choroid.—In cases of general tuberculosis deposits of tubercle have occasionally been met with in the choroid, and when seen by the ophthalmoscope, appear as small white dots scattered about the fundus, raised above the level of the surrounding tissues and having indefinite hazy outlines.

Diseases of the Vitreous Humour.

The vitreous can be thoroughly examined by direct ophthalmoscopic examination.

Disease of the vitreous is always associated with disease of the retina, choroid, or ciliary body.

The vitreous humour being evascular and almost structureless, does not undergo any acute inflammatory change. The changes in the vitreous are secondary to morbid conditions of the tissues immediately surrounding it, and are of a degenerative nature. Its consistence may be altered so that it becomes more fluid than normal, and it may shrink in bulk, in which case it will probably drag away the retina from its attachments. The changes which can be seen in the vitreous whilst the eye remains in the orbit, are loss of transparency caused by opacities of various size and shape, moving freely or slowly, or in rare instances fixed. An idea may be formed of the consistence of the vitreous by noticing the rapidity of the movement of any particles seen floating in it; if their movements are rapid the vitreous is fluid, but if they move sluggishly it is of denser consistence.

Sometimes fine dust-like opacities are discovered in the vitreous when examined with a high magnifying lens. This condition is probably syphilitic, and vigorous antisyphilitic treatment generally affects a cure.

It is sometimes associated with keratitis punctata, shewing that the ciliary body is affected.

Much more common is a degeneration of the vitreous, secondary to choroiditis, cyclitis, or retinitis. The ophthalmoscope shows more or less diffuse haze, mingled with which, are large shreds or webs.

The treatment is as that of choroiditis, retinitis, &c. (see Diseases of Choroid, Retina, and Ciliary Body).

Opacities in the vitreous may be large dense masses, so large as barely to admit of any normal reflex from the fundus, muddy clouds stirred up from below on movement of the globe, membranes dense or gauzy, beads, shreds, or threads, glistening scales, or numerous sandy dots, so numerous as to give the idea of general opalescence. Opacities in the vitreous are easily detected by direct ophthalmoscopic examination at a distance of 12″ to 18″, but if the eye is approached quite near they will not be seen so clearly as they lie too near the back of the lens. If the patient is directed to move his eye up and down quickly two or three times and then look straight in front of him, the opacities will be seen to pass across the illuminated fundus as dark figures on a red ground, showing that their movements are independent of those of the eyeball which is not the case with opacities situated in the cornea, lens or retina. In some cases only one or two small opacities exist and are found with difficulty and then lost again. Opacities near the outer surface of the vitreous are often attached to the retina or optic disc—more commonly the latter—they appear ill-defined and hazy and have no movement, they are single and are often first detected by indirect ophthalmoscopic examination as a circumscribed haze covering some part of the optic disc or its neighbourhood. By careful direct examination from different distances, aided if necessary by convex lenses behind the sight hole of the ophthalmoscope, such an opacity can be accurately defined.

In sympathetic ophthalmia, as already stated, opacities appear in the vitreous.

In some cases though no definite opacity can be made out by the most careful examination, a diffuse haziness of the vitreous occurs, which blurs the outlines of the disc and retinal vessels, or indeed obscures them entirely, though a bright red reflex is returned from the fundus. The same appearance may be caused by diffuse corneal or lenticular haze, but in either case oblique illumination will show its position, whilst, if the opacity is in the vitreous, this method of examination will give only negative results. Crystals of cholesterine sometimes form in the vitreous, they are the glistening opacities already mentioned. They may be very numerous and when the eye is moved appear like a number of dancing golden spangles or minute stars; the appearance is called *sparkling synchysis*, and may occur in eyes the vision of which is quite normal. Opacities from blood or lymph close to the back of the lens may be seen in their natural colour by oblique illumination.

Disease of the vitreous occurs in the higher degrees of myopia; the humour becomes fluid and opacities form in it which may be the result of former hæmorrhage.

A foreign body, small piece of iron for instance, may sometimes lodge in the vitreous and be visible. Bleeding into the vitreous may be caused by severe blows on the eye; the hæmorrhage may be so abundant as to entirely darken the interior of the eye and if near the back of the lens may—as already stated—be seen by oblique illumination. If only in small quantity and situated deep in the eye it is seen with the ophthalmoscope as a dark ragged cloud stirring up from below when the eye is moved and settling slowly down again.

Penetrating wounds of the eyeball cause hæmorrhage into the vitreous which may be followed later on by the formation of lymph or pus, giving a greenish-yellow colour when the eye is examined by oblique illumination or by daylight. In some cases of exudative iridocyclitis the vitreous becomes infiltrated with pus, giving rise to a condition simulating a neoplasm (pseudoglioma). The exudate gives a yellowish reflex, even at a distance "amaurotic cat's eye."

Spontaneous hæmorrhage.—Hæmorrhage into the vitreous may take place spontaneously, usually to only a small extent; the blood becomes absorbed to a greater or less extent in the course of time, but very commonly some permanent opacity remains. In some rare cases, however, repeated attacks of hæmorrhage take place so that after a time the chamber becomes filled with blood. This may occur in two classes of cases. 1. In women about the climacteric. 2. In young adult males subject to bleeding from the nose and constipation. The sight of one or both eyes may be entirely destroyed, secondary cataract may form, the tension of the globe diminish, detachment of the retina take place and even shrinking of the eyeball follow.

The treatment of hæmorrhage into the vitreous depends on its cause. If traumatic, the eye should be kept bandaged, the pupil dilated with atropine, the patient kept at rest, on low diet without stimulants, and absorption promoted by the use of frequent blisters to the temple or behind the ear.

In the idiopathic form, the eyes must be kept at rest, and guarded from bright light by protectors; the patient should go about quietly, avoid straining; attention should be paid to the general health; uterine trouble should be treated if it exists. In the case of hæmorrhage associated with obstinate constipation some means should be taken to ensure a pretty free daily action of the bowels, by no means an easy task.

Cysticercus is occasionally seen in the vitreous.

CHAPTER X.

Sympathetic Ophthalmia—Sympathetic Irritation—Sympathetic Amblyopia.

Sympathetic ophthalmia is the name applied to a peculiar form of inflammation of all the ocular structures, but more especially of the ciliary body and iris, coming on in the second or sympathising eye in consequence of morbid changes which have previously existed or are still in operation in the originally injured or exciting eye.

The most common causes of sympathetic ophthalmia are injuries of one eye, *especially wounds implicating the ciliary region*, or associated with *lodgment* of a foreign body in the interior of the globe. In such cases the wounded eye instead of recovering within a few weeks of the receipt of an injury, remains inflamed and irritable, and the inflammatory symptoms show no signs of abating, but rather increase, and may become affected by keratitis punctata and irido-cyclitis of a markedly adhesive character; pain more or less severe is complained of, and there is some intolerance of light; sight is rapidly reduced to perception of light, extensive synechiæ form, and the tension of the globe may increase. If we examine with the ophthalmoscope before the media have become too opaque we shall find opacity in the vitreous and optic neuritis, with perhaps retinal hæmorrhage.

The disease may stop here, the eye being left with the iris more or less altered in structure, and numerous posterior synechiæ formed; or with the pupil blocked by inflammatory exudation, its margin being entirely adherent round the whole of its circumference (occluded and excluded), whilst the remainder of the iris bulges forward to the posterior surface of the cornea almost obliterating the anterior chamber (Bombé iris); or the whole posterior surface of the iris may be adherent to the lens capsule, and the lens itself become opaque. If the inflammation continues, the tension of the eyeball gradually diminishes and the globe shrinks, owing to the ciliary body becoming atrophied. The whole process occupies many months and the course of the inflammation is often interrupted by remissions, during which we may have some hope that recovery will take place; to be again followed by fresh outbreaks. At any time during the foregoing changes in the injured eye, even in their earliest stage, failure of accommodation may be noticed in the sound one, a slight blush of the sclerotic making its appearance, and the eye becoming irritable and painful, a similar inflammation is set up in it, leading to like results. In some cases, however, the inflammation is of a milder type and confined to the iris (sympathetic iritis), and the eye may recover with only a few posterior synechiæ. As a rule sympathetic ophthalmia need not be feared till three weeks or a month after the injury, but in some rare cases it has commenced as early as six days. Sympathetic ophthalmia has not been so frequently seen since antiseptics were introduced, and in fact we may look upon its existence as rare.

Treatment.—Where sympathetic ophthalmia has been once established, in all probability irreparable damage will be done; the great point to bear in mind is to prevent its occurrence by *timely extirpation of the damaged globe* (see Extirpation of the Eyeball). If the disease has become fairly established, little benefit can be expected to result from such extirpation, as the morbid changes will probably continue in the sympathetically inflamed globe, in spite of the removal of that primarily affected, indeed when the inflammation has quieted down the exciting eye may turn out to be the less damaged of the two. The operation should, however, be performed, if the disease has not passed beyond the initial stage in the sympathizing eye.

The sympathetically affected eyeball, or, if excision has not been performed, both eyes should be kept carefully bandaged with lint soaked in belladonna lotion and atropine freely used; all light must be carefully excluded by using a black bandage and keeping the patient in a darkened room. Pain must be relieved by the same methods as in cases of iritis. Any constitutional treatment that may appear necessary should be employed, and when the inflammatory symptoms have *entirely* subsided iridectomy should be performed. This operation often exerts a very beneficial influence upon the nutrition of the globe as well as making a way for rays of light to reach the retina (see Iridectomy), and should be repeated a second or even a third time should the new pupil become (as is very likely to be the case) occluded by inflammatory exudations; the great point to bear in mind is never to be in a hurry to operate, at least twelve months should be allowed to elapse after the last signs of inflammation have disappeared.

Should suppurative inflammation be set up in one eye, sympathetic changes need not be feared in the other; it is only in the adhesive form of irido-cyclitis that sympathetic ophthalmia is likely to occur.

Sympathetic Irritation and Sympathetic Amblyopia.

Sympathetic irritation.—It not unfrequently happens that soon after the receipt of an injury to one eye its fellow becomes slightly painful, intolerant of light and irritable. These conditions may remain unchanged week after week and eventually subside. They make up what is known as sympathetic irritation.

When sympathetic irritation occurs we must always watch the *injured* eye carefully, and if signs of choroido-iritis or keratitis punctata appear, it should be immediately excised. If no such symptoms occur, however, its removal is not necessary.

Sympathetic amblyopia.—It sometimes happens that when one eye has been lost from injury or disease and is constantly inflamed and painful, the sight of the other becomes much impaired without any visible change taking place in its structure. This condition is known as "sympathetic amblyopia," and is generally cured by removing the blind and painful eye.

CHAPTER XI.

Glaucoma.

By glaucoma we understand "a series of morbid changes of the eyeball; the most prominent of which, and apparently the one which causes all the others, being an increase of tension in the globe" (Bader). Glaucoma is said to be *simple* when the increase of tension progresses slowly and continuously without inflammatory outbreaks. Acute or chronic when attended by attacks of inflammation.

If the aqueous is allowed to flow out of the anterior chamber through a small incised wound, and the wound subsequently closed, within a short time the anterior chamber is again filled.

It has been experimentally proved that a current of fluid is constantly passing from the ciliary body, through the posterior part of the anterior chamber and the pupil, into the anterior part of the anterior chamber, leaving the eye through a series of small fissures placed at the angle where the cornea joins the iris (filtration angle) and so communicates with the general vascular system (*vide* fig. 40). This circulation may not be the only one in the eye, but as far as is known it is the most important one.

Glaucoma may be caused by one of two conditions, either the inflow is excessive or the outflow impeded, either a condition of hypersecretion exists or owing to a blocking of the filtration angle, the fluid is unable to leave the eye.

In a large number of cases the filtration angle is found to be narrowed or obliterated because the periphery of the iris has been pushed forwards.

For further information on the theories as to the causes of glaucoma the student is referred to larger textbooks.

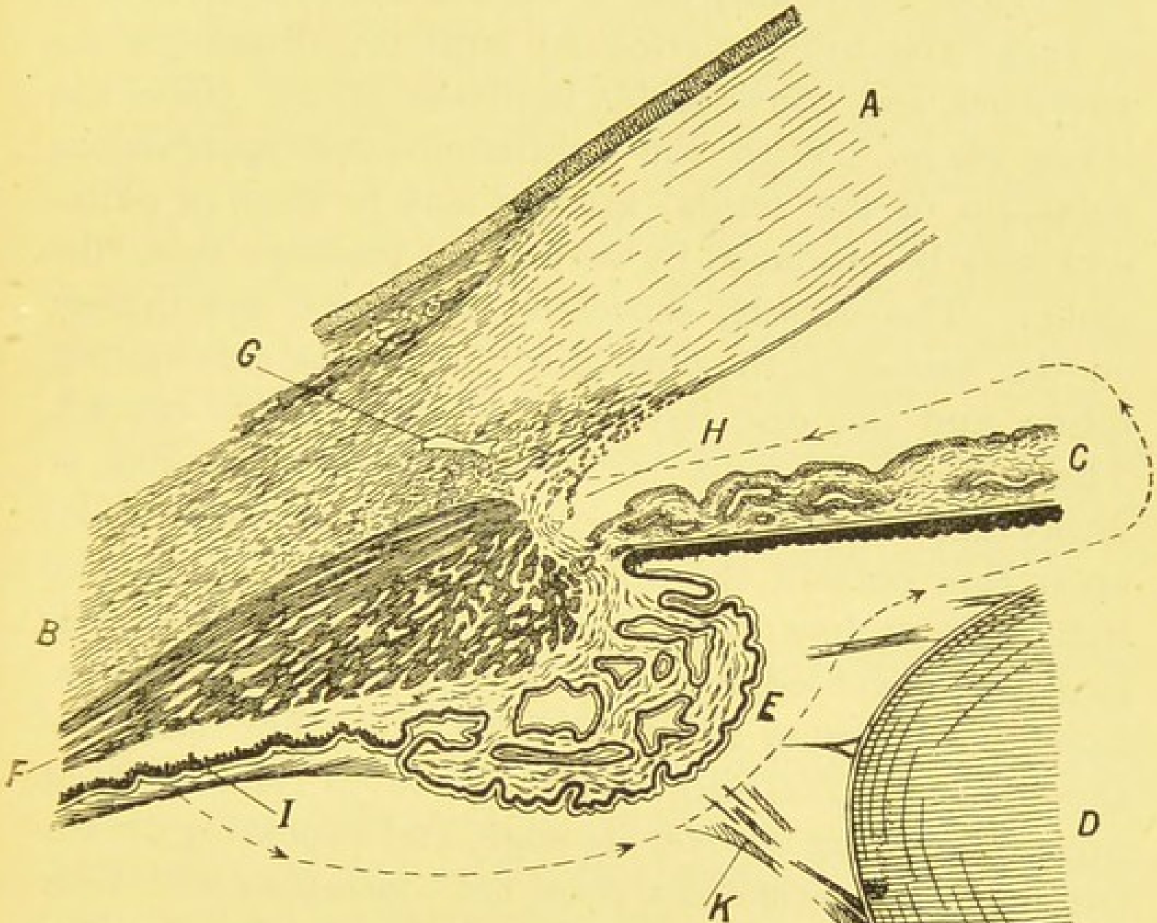


FIG. 40.—Section at corneo-scleral margin.

A. Cornea. *B*. Sclera. *C*. Iris. *D*. Lens. *E*. Ciliary body. *F*. Ciliary muscle. *G*. Canal of Schlemm. *H*. Filtration angle. *I*. Secreting glands. *K*. Suspensory ligament. Dotted line indicates course of circulation of aqueous fluid.

Simple glaucoma presents no inflammatory symptoms its onset being most insidious. It is characterized by gradual decrease of acuteness of vision, with narrowing of the visual field, especially on the nasal side, impairment of the power of accommodation, causing rather rapid increase of presbyopia, sluggishness in movements of the iris, some dilatation of the pupil, and some apparent haziness of the crystalline lens. Increase of tension is probably one of the earliest symptoms, but is very liable to be overlooked until the disease is far advanced and considerable hardness of the globe has taken place. With the ophthalmoscope spontaneous pulsation of the retinal arteries may be seen, or pulsation may be produced by very slight pressure upon the globe. The vessels, especially the veins, are thinner on the surface of the optic disc than in the surrounding retina, and the disc itself may be more or less cupped. The cup of glaucoma is characterised by a bluish or dusky appearance of the greater portion of the disc; upon this portion the vessels appear very small and indistinct, or they may be quite invisible; the whole disc is usually involved, and not, as in physiological excavations, the centre or outer quadrant only. The margin of the disc is white, and the large tortuous retinal vessels are seen curling up over its edge, and appearing on the surface of the retina at a point not continuous with their course upon the nerve surface. Cupping of the disc requires long continued pressure for its production; it does not occur in the early stage of any form of glaucoma and its presence shows that sight is greatly and permanently damaged, if not entirely lost. Small hæmorrhages may also be met with upon the retina.

Chronic glaucoma, the form most commonly met with, is characterized by the occurrence of slight inflammatory attacks, associated with temporary increase of dimness of vision and more or less pain in and around the eyeball. On examination the field of vision will be found to be limited, the tension of the globe increased, and if the patient presents himself during an inflammatory attack, circumcorneal injection will be present (*vide* fig. 41 *A*), the episcleral vessels enlarged, the pupil somewhat dilated, the movements of the iris sluggish, and the cornea steamy.

The loss of vision, in cases of chronic glaucoma, is attended by somewhat peculiar symptoms. Patients complain that their sight is always somewhat misty, that there is an appearance of a bright halo around a candle or other flame, that they see colours resembling a rainbow, and often of great beauty; and occasionally flashes of light and fiery circles, these latter symptoms are, however, common to all forms of retinal irritation. Vision is always worse during the inflammatory attacks and recovers to a certain extent during the remission, never, however, returning to the same condition as before the attack.

The ophthalmoscope shows changes similar to those mentioned under simple glaucoma.

Acute glaucoma usually commences suddenly with well-marked inflammatory symptoms. The patient will state that he was seized (frequently during the night) with sudden severe pain in the eye; the pain will be described as affecting, not only the eyeball, but the whole of the corresponding side of the head, and he will have found that the sight of the painful eye is much impaired or entirely lost. On examination the eyelids will be found reddened and swollen, the conjunctiva chemosed, and the circumcorneal vessels, as well as those situated more deeply in the subconjunctival tissue, enlarged (*vide* fig. 41). There will be profuse lachrymation, and often much intolerance of light; the aqueous humour will very probably be somewhat turbid. The pupil will be moderately dilated, somewhat irregular and fixed, and the tension of the globe greatly increased.

The attack is often accompanied by severe headache

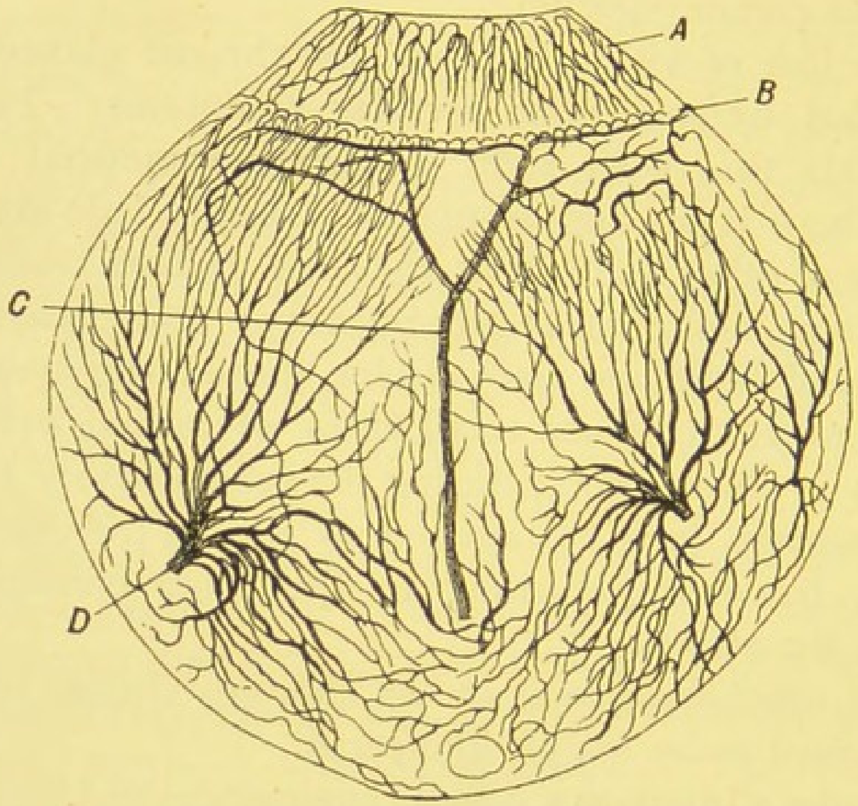


FIG. 41.—Diagram of vessels chiefly affected in glaucoma.

A. Non-perforating branches of anterior ciliary vessels. These are pink or bright red in acute inflammatory glaucoma, and are dark and congested in chronic glaucoma.

B. Ciliary zone, where the branches of the anterior ciliary vessels perforate. (*Vide* Figs. 18 and 20).

C. Episcleral vein.

D. Venæ vorticosæ, about five in number, which pierce the sclerotic in a very oblique manner, a little way behind the equator.

Owing to the increased intra-ocular tension the discharge of the choroidal venous blood by these channels is prevented, the episcleral veins taking on their function.

and gastric disturbance; indeed, in some cases, so marked have been these symptoms, that the ocular condition has been overlooked and the patient treated for a bilious attack.

On examination with the ophthalmoscope some of the appearances mentioned under simple glaucoma may be found, but the media will probably be so hazy as to obscure the parts behind, a dull red reflection being all that can be made out.

The acute symptoms may pass off in the course of a few days or weeks, leaving the eye more or less permanently damaged. Similar attacks may recur, but more frequently the disease relapses into a chronic state.

Absolute glaucoma.—Sooner or later, in any form of glaucoma, if relief is not given, the condition known as *absolute glaucoma* is established. The eyeball becomes stony hard, the pupil widely dilated and fixed, the cornea hazy and anæsthetic, the iris and aqueous humour discoloured, the anterior chamber shallow, and the lens more or less opaque. A few dilated vessels (perforating branches of the anterior ciliary), figs. 20 and 41 (pp. 29 and 210), are seen issuing from the globe in the ciliary region, the blood from the choroidal veins being unable to discharge itself through the venæ vorticosæ (*vide* Fig. 41 *D*), the sclerotic may be somewhat bulged in places and bluish in colour, and the conjunctiva is extremely rotten, tearing on any attempt to seize it with forceps. On examination with the ophthalmoscope all appears dark behind the pupil, or a dull red reflection may be returned from the interior, but no details of the fundus can be made out. All perception of light is lost.

Glaucoma fulminans.—A form of acute glaucoma rarely met with, characterised by the suddenness of its onset and extreme violence of its symptoms is known as "glaucoma fulminans." The eye attacked may be entirely and irremediably blinded in the course of a few hours.

Diagnosis.—Glaucoma is essentially a disease of the latter half of life, occurring most frequently in women between the ages of forty and sixty, but rarely in young adults, or children. Glaucoma almost always affects both eyes, not, however, simultaneously, but at more or less considerable intervals. The tendency to glaucoma is no doubt increased by uncorrected anomalies of refraction; an attack is often brought on by fatigue, as in a woman worn out by long nursing and sleepless nights.

In some cases of acute glaucoma, and almost invariably in chronic glaucoma, the onset of the disease is preceded by *premonitory* symptoms.

These are, as in simple glaucoma, rapidly increasing presbyopia and slight increase of tension of the globe, sluggishness and dilatation of the pupil, some apparent haziness of the lens, and narrowing of the visual field.

Besides these we may find some congestion of the vessels referred to above emerging from the sclerotic in the ciliary region. There may be periodic attacks of dimness of vision, objects appearing as if veiled by a greyish or yellow mist (London fog); in the later stages we may have a halo around a flame, or the appearance of a rainbow, and at times attacks of pain in and about the eyeball.

In order to diagnose glaucoma we must be well acquainted with the method of ascertaining the tension of the globe, and also with the use of the ophthalmoscope (see Examination of Eyeball, &c.).

We must also remember that the injurious effects of pressure are evidenced earliest in the peripheral portions of the retina, and should therefore very carefully examine the condition of the *visual field* in all suspected cases (see Examination of Field of Vision). Instances are frequently met with in which great contraction of the visual field has taken place, although central vision is still acute.

Another symptom which should lead us to suspect glaucoma is the *rapid increase of presbyopia.* Patients affected by the simple or chronic forms of the disease are constantly changing their glasses, as they find that those which at first appear to suit become useless in the course of a few months.

Apparent haziness of the crystalline lens is a symptom requiring special attention; otherwise the surgeon may fall into the fatal error of mistaking chronic or simple glaucoma for cataract, and allow the disease to continue until sight is irrevocably lost. In such cases ophthalmoscopic examination will show that there is little or no real opacity of the lens, and this, aided by a careful examination of the tension of the globe and the state of the visual field, will prevent so disastrous a mistake. This condition of the lens is more marked in dark eyes than light, and especially in those which are highly myopic.

Besides the foregoing we not unfrequently meet with what is known as "secondary glaucoma," *i.e.*, glaucoma coming on in the course of some other disease, as corneitis, ulceration of cornea, iritis, choroiditis, &c. Glaucoma occurring in young persons is usually secondary. Glaucoma following injury is spoken of as "traumatic glaucoma." Glaucoma associated with large and numerous retinal hæmorrhages is described as "hæmorrhagic glaucoma;" it is one of the worst forms of the disease and the most rebellious to treatment.

Treatment.—Glaucoma can only be remedied by operation, and it is our duty to explain to the patient the nature of his case and to urge upon him most strongly the *necessity* for operative interference.

Patients suffering from glaucoma often evince the greatest unwillingness to undergo an operation; this unwillingness is explained by the fact that during the *remissions* of the disease little or no inconvenience is experienced, and, moreover, even at the time that an attack of inflammation is present the sufferer will be encouraged by the hope that the symptoms will pass off (as, they in all probability have done in previous attacks) leaving the eye but little damaged. Nevertheless we must always bear in mind *that an operation, to be successful, must be performed early*, and we must not be satisfied until we have convinced our patient of this. Most patients will readily submit to an operation when one eye has been lost and the disease has commenced in the other.

Several operations have been practised for the relief of glaucoma, but iridectomy and sclerotomy are those which give the best results. Iridectomy or sclerotomy, to be effectual, should be performed as early as possible. In simple glaucoma operative interference is anything but satisfactory; the most favourable result is, that the disease may be arrested at the stage at which it has arrived, but no gain of sight is to be expected. We must also bear in mind the possibility of the eye going quite to the bad after an operation. On the whole an operation in simple glaucoma should not be rashly undertaken. The course of the disease is very slow, and if our patient is advanced in years we may well leave him alone, hoping that his sight may last as long as he does. If, however, he has a prospect of living for many years, we have no alternative but to advise him to take his chance of an operation, and having decided to perform one, to do it with as little delay as possible.

The operative treatment of inflammatory, especially of acute, glaucoma is much more satisfactory; as a rule, however, no good is likely to result from an operation in cases where vision has been reduced to bare perception of light; but in glaucoma fulminans much improvement may take place even though all perception of light has been lost for some days.

In performing iridectomy for glaucoma we must take care to remove the iris well down to its insertion and to excise a good broad piece (see Iridectomy); merely cutting away a portion of the iris near the margin of the pupil does no good. The object which an operator aims at in performing iridectomy for glaucoma is to re-establish the closed filtration angle, hence a large piece of iris must be removed, including its most peripheral portion, otherwise it is useless, and the tension is not permanently relieved. The operation is easy enough in cases of acute glaucoma, but in those of old standing, where the structures are rotten or the pupils so widely dilated that the iris has become a thin rim at the periphery of the anterior chamber, it is anything but simple. In such cases sclerotomy is to be preferred to iridectomy.

In cases of glaucoma where for any reason an operation does not seem advisable we must do our best to give relief by medical treatment. The means which will be found most useful are the instillation of solutions of sulphate of eserine (gr. $\frac{1}{4}$ to iv. to water ℥ j.), application of very hot sedative fomentations, administration of opium, and the local abstraction of blood by leeches or the artificial leech, with perfect rest of the eyes.

Atropine *should never be used* in glaucoma, as it causes increase of tension of the eyeball. Eserine, however, has a contrary effect and is often of great benefit.

CHAPTER XII.

The Retina and Optic Nerve.

Diseases of the retina and optic nerve can be diagnosed by the ophthalmoscope alone. Before the introduction of this instrument all cases of want of sight arising without cause apparent to the unaided eye were collected together under the names of "Amblyopia" and "Amaurosis." To the former were referred all cases where vision was much impaired, but not entirely lost; to the latter cases in which no perception of light remained. But now that the ophthalmoscope has come generally into use, making the interior of the eyeball as accessible to our sight as the exterior, we have come to refer "amblyopia" and "amaurosis" to their proper causes, and the terms have fallen into comparative disuse. For instance, if in a case of want of sight we find on ophthalmoscopic examination that there is haziness of the vitreous, inflammation of the retina, or choroid, &c., we do not say, as formerly, that the patient is amblyopic, but that he is suffering from disease of the vitreous, retinitis, choroiditis, &c. Again, in cases of total blindness the ophthalmoscope will probably detect atrophy of the optic nerve, and instead of saying that the patient is "amaurotic," we say that he is suffering from optic nerve atrophy. The terms "amblyopia" and "amaurosis" may, however, still be used in some cases to be presently described, where there is partial or complete loss of sight, with an apparently healthy condition of the ocular structures.

Hyperæmia of the retina occurs from over-strain of the eyes, in doing near work (especially in hypermetropic or astigmatic eyes), or from constantly looking at bright light; the disease is not uncommon amongst engine drivers and others who work over a blazing fire.

Symptoms.—The symptoms are dimness of vision, and a feeling of fulness and discomfort about the eyes. In hypermetropic or astigmatic individuals there will be the usual complaints of pain in the eyes, headache and inability to read or work for any length of time. The ophthalmoscope shows redness of the optic disc, engorgement and twisting of the retinal vessels, both arteries and veins, with increase in the visible number of each. This form of hyperæmia may be described as active, another form affecting only the veins, which are found enlarged, tortuous, and sometimes varicose, depending on interference with venous circulation being looked upon as passive hyperæmia.

Hyperæmia of the retina, especially the active form, is not easily recognised, as the limits between health and disease fade almost imperceptibly into each other, and considerable experience is required in order to judge with certainty where one ends and the other begins.

Treatment.—Active hyperæmia must be treated by insuring perfect rest to the eyes. To this end all near work must be prohibited, the accommodation must be paralysed by using a solution of sulphate of atropine, (gr. ij. to iv. to ℥ j.) three times a day or oftener; the eyes must be shielded from light by protective spectacles or shades. Leeches or the artificial leech should be applied to the temples from time to time, and purgatives given if necessary.

After subsidence of the hyperæmia any anomaly of refraction must be carefully neutralized, the eyes being well under the influence of a mydriatic during the examination.

Passive hyperæmia is generally an indication of some more serious disease and demands no direct treatment (see Ischæmia).

Inflammation of the Retina—Retinitis.

Causes.—Retinitis most frequently depends on some constitutional condition, as albuminuria, diabetes, gout, or syphilis; it may also arise from embolism of the vessels of the retina, hæmorrhage into its substance, or from cerebral disease; from tumours or entozoa within the globe, exposure to sudden flashes of bright light, or wounds of the eyeball. It may also be secondary to choroiditis, iritis, or cyclitis, and is a part of sympathetic ophthalmia.

Symptoms.—Retinitis is characterized by hyperæmia of the retina, associated with more or less dense and extensive opacity of its structure, either diffuse or in spots or patches, and frequently with extravasations of blood in its substance.

Disturbance of vision may be a prominent symptom, or the patient may hardly be aware that anything is amiss with his eyes. The degree of impairment of vision depends upon the situation and extent of the inflamed portion of the retina; for instance, a small patch of inflammatory exudation in the region of the yellow spot will cause much loss of sight, whereas a considerable amount of opacity situated peripherally will give rise to scarcely any symptoms.

Pain, photophobia, coloured vision, and flashes of light, are symptoms occasionally met with in inflammation of the retina.

Acute retinitis is rarely met with, and if it should occur would hardly be recognized, as the inflammatory exudation would be transparent, and, therefore, invisible ; consequently, the only appearance revealed by the ophthalmoscope would be enlargement and tortuosity of the retinal vessels.

The forms of retinitis which give rise to striking ophthalmoscopic appearances are essentially of a chronic nature, and are frequently associated with inflammatory changes in the choroid and optic disc.

Retinitis may affect one or both eyes, those forms which are of constitutional origin usually affecting both, though not always in the same degree.

The ophthalmoscope shows :—1. Hæmorrhages of variable size. 2. Spots of pigment. 3. A more or less general turbidity of the retina, varying from a scarcely perceptible cloudiness (giving the idea that the structure is opalescent and visible instead of entirely transparent) to an uniform greyish-white or mottled opacity, which covers the choroid like a veil ; conceals the outline of the optic disc and in parts covers the gorged, dark coloured, and tortuous retinal veins, and the normal or nearly normal arteries. 4. A number of opaque glistening white spots either quite discrete or running together and forming patches, seen chiefly in the region of the yellow spot, around which the opacities are often arranged in a radiating manner. 5. A number of small irregular yellowish patches scattered about the central part of the retina, but without any particular relation to it.

Varieties of Retinitis.

[Note.—The student is advised to read the following paragraphs, in conjunction with one of the numerous atlases published. The references given in the letterpress are to the "Atlas of Ophthalmoscopy," by Professor Haab of Zurich (13*s*.), a copy of which, if the student has not one, is generally to be found in the Medical Libraries].

Hæmorrhagic retinitis (Haab, fig. 33, *a* and *b*).—This is generally due to thrombosis of the central retinal vein, or one of its main divisions. The optic nerve is reddened, somewhat swollen, its outline obliterated. The transparency of the retina so much affected that the course of the retinal vessels upon its surface and in its substance cannot be traced; the retinal veins are turgid and tortuous in their course, presenting alternately breaks and dark portions, according as they lie deeply in the engorged blood-stained retina, or more superficially near its inner surface. The retinal arteries are nearly normal or too thin.

The principal characteristic of the disease is the occurrence of extensive hæmorrhage, most marked around the optic disc, and fading away gradually into the surrounding parts. The blood extravasations have a peculiar striated appearance, and radiate, spoke-like, from the optic disc as a centre. In some cases the retina immediately surrounding the disc is uniformly infiltrated with blood, the bright red colour thus produced gradually shading off externally into the spoke-like appearance above mentioned.

As time goes on the extravasated blood undergoes changes, becoming brown in colour, and is eventually partially or entirely absorbed. The disease is said to be of gouty origin; as a rule one eye only is affected.

Retinitis pigmentosa (Haab, figs. 37, 38 and 45, *c* and *d*) is a peculiar form of degeneration of the retina, met with most frequently in the offspring of blood relations; the sufferers are often deaf and dumb, and may be idiotic; several members of the same family are often affected.

The most marked symptoms of the disease are *night blindness and gradual narrowing of the visual field without glaucomatous symptoms.* The ophthalmoscope reveals the most striking changes; the retina, especially about its peripheral parts, is dotted more or less thickly with black pigment spots; these spots appear somewhat like a multitude of small black spiders with many legs; they have also been likened to bone corpuscles. The spots of pigment appear to follow the course of the blood-vessels of the retina, and, as before stated, are collected most thickly in the peripheral parts.

The blood-vessels themselves are much diminished in size and visible number, and the optic disc is markedly anæmic, and of a peculiar waxy appearance; cataract not unfrequently occurs.

Albuminuric retinitis (Haab, figs. 25, *a* and *b*, 26, *a*, *b* and *c*, 27, 28, 29) is a form of retinitis met with in Bright's disease. The changes which take place in the retina are inflammation with effusion and hæmorrhages, followed by fatty and fibrinous degeneration of its structure, and subsequent atrophy.

The ophthalmoscope shows, in the early stages of the disease, retinal hyperæmia (more especially venous) with increased vascularity and redness of the optic disc. Next the retina becomes cloudy (more especially around the optic disc, the outline of which becomes obscured), and hæmorrhages in the form of streaks and spots occur in various parts of its structure.

The cloudiness goes on increasing, and obscures the smaller vessels; later in different parts of the fundus, but mostly in a ring situated at a little distance from the margin of the disc, appear glistening white spots and patches ; and still later the disc itself becomes grey and opaque.

Whilst the above changes are going on in other parts of the retina, characteristic appearances may be developed in the region of the yellow spot. A number of small white glistening spots, which do not at first coalesce so as to form a patch but remain distinct, make their appearance. These glistening spots are arranged in a radiated position around the macula as a centre, and somewhat resemble a constellation; the appearance is quite characteristic, and once seen is not likely to be forgotten. As the disease advances the spots may run together into elongated patches.

As the opacity of the retina increases, the vessels become more and more obscured, so that when the disease has reached its height, only a few large venous trunks are still visible. Fresh hæmorrhages may occur at any time, and cover over and obscure the opaque portions of retina. After a time a retrograde process sets in, the hæmorrhages and peculiar opacity slowly disappear, the retina being at length left in a state of atrophy. Detachment of the retina may occur. In many cases the changes in the yellow spot region accompanied by a few small blood spots scattered about in other parts are the only appearances noticed, and little or no change takes place for months or even years.

Albuminuric retinitis is usually associated with granular kidney; it is dependent on the blood-vascular disease (arterio-capillary fibrosis, Gull and Sutton), of which the kidney affection is only a part. The retinitis often appears before any sign of kidney mischief sufficient to attract the patient's attention is manifested, and it is the ophthalmic surgeon who first discovers the nature of the case. The urine need not be albuminous, but there is always evidence of increased arterial tension. It is important to remember that, although as just stated, the patient's attention may not have been directed to his kidneys previous to his visit to an ophthalmic surgeon, that retinitis comes on late in the course of albuminuria and that its appearance has the gravest significance.

Leukæmic retinitis (Haab, fig. 60*a*).—A peculiar form of retinitis, somewhat resembling the albuminuric, has been described as occurring in connection with leucocythæmia.

Leukæmic retinitis is marked by pallor of the optic disc, a peculiar rose colour of the retinal vessels, hæmorrhages, some opacity of the retina around the optic discs, and white glistening spots similar to those met with in albuminuric retinitis, which, however, are situated in the peripheral parts of the retina.

Embolism of the central retinal artery (Haab figs. 32 and 34).—A form of retinitis associated with plugging of the central artery comes on suddenly without apparent cause, with complete loss of sight. Ophthalmoscopic examination shows some pallor of the optic disc and diminution in calibre of the vessels emerging from it, but the most marked change is seen in the region of the yellow spot.

The retina around the spot is white or greyish-white and opaque, and numerous blood-vessels, not visible under ordinary conditions, arranged in a radiating manner round the spot, come plainly into view; the macula itself is seen as a bright red spot which might be taken for a hæmorrhage by a careless observer.

The bright red appearance of the macula arises from the anatomical arrangement of the parts; the retina in this situation, being thin and firmly bound down to the parts beneath, does not become infiltrated with inflammatory exudation, and consequently the normal red colour of the fundus appears in striking contrast to the surrounding opaque retina. Hæmorrhages may occur. Atrophy of the optic disc follows within three months.

Syphilitic retinitis (Haab, fig. 16) is frequently associated with choroiditis. There are no ophthalmoscopic signs which will enable us to say with certainty that the changes seen are of syphilitic origin, in making a diagnosis other signs of syphilis must be taken into consideration. As in choroiditis there is often opacity of the vitreous.

The opacity of the retina is generally diffuse, but may be confined to the zone immediately surrounding the optic disc, or to the region of the yellow spot. The opacity varies from a slight smoky haze to dense white or yellowish-white.

The optic disc at first hyperæmic becomes hazy, the retinal vessels over full and tortuous. In favourable cases the opacity clears and the retina returns to more or less its normal condition; in unfavourable ones atrophy of the retina and choroid results.

Syphilitic retinitis may occur in either congenital or acquired syphilis, in the latter it is one of the secondary symptoms usually setting in from six to eighteen months after the primary disease, its course is extremely chronic and is often broken by relapses.

Diseases of the retinal vessels giving rise to plugging of small arterial branches and consequent loss of sight in the portion of retina supplied by them, is not uncommon in tertiary syphilis. The symptoms are loss of parts of the visual field; the ophthalmoscopic signs are not well marked. Recovery usually takes place under antisyphilitic treatment.

Treatment.—In all cases of retinitis both eyes should be kept thoroughly at rest, by prohibiting all near work, paralyzing the accommodation with atropine, and shielding the eyes from the stimulus of too bright light by neutral tint or smoke coloured protectors. Everything that is likely to cause disturbance of the ocular circulation, as stooping positions, excitement, stimulants, too rapid variations of temperature, &c., should be carefully avoided.

Blood may be taken from the temples by leeches, or, preferably, by the artificial leech; blisters to the temples or behind the ears may be used. In syphilitic retinitis mercury does good; it should be given so as quickly to affect the system, either by the mouth, by inunction, or in the form of calomel vapour baths. In long-standing cases, however, small doses of bichloride of mercury, taken regularly for some months, may be beneficial.

The other forms of retinitis are of only secondary importance to the disease with which they are associated, and against which treatment must be directed (see causes of Retinitis). No treatment is of much avail in retinitis pigmentosa.

Atrophy of the retina may be the sequel of inflammatory changes. Its principal characteristic seen with the ophthalmoscope is a condition of bloodlessness, in some cases associated with opacity of the retina, and frequently with atrophic changes in the choroid. Bloodlessness shows itself in a diminution of the number, and also of the calibre of the retinal blood-vessels, more especially of the arteries, some of which may appear pervious to red blood corpuscles in part of their course only, their continuations being marked by a yellowish-white cord. Opacities, if they occur, are of a greyish-white colour, and situated for the most part around the optic disc.

The disc itself is frequently extremely anæmic or atrophied. (For treatment of atrophy of the retina, see Atrophy of the Optic Disc).

Hæmorrhage into the retina (Haab, fig. 35).—Besides the form of hæmorrhage described as occurring in retinitis, bleeding may take place into the structure of the retina, from rupture of a retinal blood-vessel without previous inflammatory change. The hæmorrhage is usually considerable, and will be seen as an irregular patch of blood, situated somewhere in the course of the ruptured vessel, and often surrounded by exudation. The patients are often young women, and the bleeding occurs at a menstrual period. Large D-shaped hæmorrhages, situated on the outer side of the optic disc and between the retina and hyaloid membrane, are occasionally seen (Haab, fig. 35), they are generally described as sub-hyaloid hæmorrhages.

The extravasated blood becomes gradually absorbed, but usually leaves behind it some indications of its previous existence.

Treatment.—Rest of the eyes and protection from bright light, counter-irritation and mild purges.

Detachment of the retina (Haab, figs. 55 *c*, 56, 57, 58) is associated with the effusion of serous fluid, or blood, or the presence of a growth between it and the choroid. It almost always occurs in connection with disease of the choroid, ciliary body or vitreous.

A blow on the eyeball or head may be the immediate cause of displacement, or it may occur spontaneously. Myopic eyes are more liable to suffer from retinal displacement than those which are emmetropic or hypermetropic.

Detachment of the retina occurs usually at its lower part, but may vary in extent from detachment of a small fold to total separation of the whole retina from the choroid, the only points of attachment left, being at the optic disc and ora serrata.

Symptoms.—The symptoms of retinal displacement are sudden or rapid failure of sight, or the patient complains that a sudden mistiness came on and gradually increased; we shall probably be told that vision is better when first waking in the morning and becomes worse as the day wears on. An examination of the visual field will show a deficiency of some part, generally the upper, corresponding to the lower part of the retina; the patient will very probably say "I can see your chin and mouth, but cannot see your eyes," or make some such statement.

Detachment of the retina is best examined by direct ophthalmoscopic examination, the appearances depend much on its duration. At first the retina retains its transparency, and an abnormal condition of the retinal vessels may be seen, some of which appear to move slightly, look dark instead of bright red, smaller than usual, and are evidently out of place. As time goes on the detached portion of retina becomes opaque and appears as a dark grey, slightly movable fold, or cloud, over which the dark retinal vessels can be traced. Displacement of the retina may be associated with opacities in the vitreous.

A hæmorrhage or inflammatory deposit may be mistaken for a retinal detachment. A correct diagnosis can always be made by noticing the retinal vessels; if they can be traced over the grey cloud it is certainly a detached retina.

The treatment of detached retina is unsatisfactory. An attempt should be made to procure absorption of the effused fluid by the administration of such drugs as iodide of potassium and mercury, and by the application of blisters to the temple or behind the ear. In all cases complete rest should be given to the eyes, so as to prevent as much as possible further detachment.

Perfect rest in the recumbent posture, the hypodermic injection of nitrate of pilocarpine so as to cause profuse sweating and salivation; trephining or puncture of the sclerotic, so as to let out the subretinal fluid, have all been tried, but without any very satisfactory result. A quite recent detachment may subside with or without treatment, but one of long standing remains stationary or gets worse.

Inflammation of the optic disc (optic neuritis, neuro-retinitis).—The ophthalmoscope shows a reddish-grey turbidity of the disc and the surrounding zone of retina, accompanied by swelling. The retinal veins are engorged, but their visible number is not increased; the arteries are thinner than usual, and all the vessels are more or less shrouded and concealed from view in the opaque portion of retina and upon the nerve surface. Numerous small hæmorrhages may occur upon and around the disc.

Papillitis (choked disc) (Haab, figs. 13, 15, 17).—Simple congestion has been (and still is by some) looked upon as distinct from optic neuritis, the difference, however, is one of degree only. The ophthalmoscope shows great swelling and an intense red colour of the disc, its outline being entirely lost; there is, however, but slight swelling or opacity of the surrounding retina; small hæmorrhages are frequently seen on the nerve surface. The retinal veins are enormously distended, their course extremely tortuous, and they may be varicose; their visible number is also considerably increased. The arteries are usually smaller than normal; none of the vessels are shrouded or concealed from view, as in neuritis.

In many cases of neuritis sight is unaffected; in others vision is much impaired or reduced to perception of light only.

Optic neuritis may be looked upon as indicative of irritation of the nerves in some part of their course, as would occur in meningitis; or of obstruction to the venous circulation resulting from pressure directly on the main trunks, as in cerebral tumour, or from any form of disease which causes *overcrowding* of the contents of the cranium. Neuritis is usually bilateral. Should it occur in one eye only it is probably due to some local disease, as tumour in the orbit, orbital cellulitis or periostitis.

Treatment.—Optic neuritis is of only secondary importance to the disease which gives rise to it; it is of much greater interest to the physician than to the oculist, as its existence enables him to diagnose cerebral lesions with great certainty. The cerebral lesion is, however, often syphilitic, and it may be laid down as a rule, seldom to be departed from, that optic neuritis calls for the administration of iodide of potassium, or mercury in full doses, by the mouth or by inunction.

Atrophy of the optic nerve (Haab, figs. 19, 20, 21, 22) may be the result of preceding neuritis, when it is called "consecutive atrophy," or may commence and slowly progress without inflammatory change, "simple atrophy." It may also come on after injury to the head, the history being that after a blow the sight of one eye was lost. At first the ophthalmoscope shows no change, but in about two or three months complete atrophy of the disc sets in. The cause is damage to the optic nerve behind the eyeball.

With the ophthalmoscope the atrophic optic disc is seen to be white or bluish-white in colour, frequently its margin appears irregular, and it may be cupped. The atrophic cup varies from the glaucomatous in not having steep sides, so that the vessels do not appear broken in their course as in the latter affection. The cupping of the disc in atrophy has been likened to a saucer, that in glaucoma to a flask. Optic atrophy cannot be certainly diagnosed by the ophthalmoscope alone, the visual acuity and the colour vision must be tested. The condition of the vessels upon the disc varies at different periods during the course of the disease. In "simple atrophy" the vessels are not altered until late, they are then smaller than usual. In "secondary atrophy" in the early stages the veins are engorged, later the arteries and veins become small and are often reduced to mere threads. Atrophy of the retina frequently accompanies atrophy of the optic disc.

In cases of atrophy of the optic nerves vision is always much impaired; some patients with extremely white discs can count fingers, distinguish large letters, or even read ordinary print, but in the majority of cases vision is reduced to bare perception of light. The colour sense is impaired, green and red being lost first.

Treatment.—The treatment of atrophy of the optic nerves, especially if associated with a similar condition of the retina, is most unsatisfactory, and, indeed, almost hopeless. Should a certain amount of vision still remain, and no change have taken place for many months, we may safely assure our patient that he will retain what sight he has. The drugs which have been principally used are iron, either alone or in combination with nux vomica, strychnia taken by the mouth or injected hypodermically, phosphorus, quinine, or other tonics, and opium in gradually increasing doses. Galvanism has also been employed.

CHAPTER XIII.

Amblyopia and Functional Disturbances of Sight.

Amblyopia, or blunt sight, is the name given to a condition existing in one or both eyes, in which, whilst impaired vision exists, the eye shows no defect, by the ordinary means of examination, sufficient to account for its presence.

It is most frequently found in association with concomitant squint.

When examined externally or ophthalmoscopically the amblyopic eye is apparently healthy. In the majority of cases one eye alone is involved, the other eye having full visual acuteness. If there is a difference of refraction in the two eyes, the higher error of refraction exists in the amblyopic eye.

A lens may improve the vision, but the improvement is never more than partial.

The condition is possibly due to varying causes acting in the first months of life and rendering the image in one eye less perfect than is the other, and on this account the patient is led to regard the image formed on one retina only.

Colour vision is often unaffected, and although exceptions are found, the field of vision is generally complete; sometimes, however, scotomata, central or peripheral, may be demonstrated.

The presence of indirect vision renders the eye of great service to the possessor, even although the visual acuity may be less than one-sixtieth of the normal standard.

On questioning the patient, if he is old enough and sufficiently intelligent to understand, one is told that objects appear unreal, shadowy, blurred, or sometimes unsteady, as if they were vibrating.

The degree of amblyopia is not proportional by any means either to the length of time that the squint has lasted, or to the degree of error of refraction present.

The effect upon the squinting and amblyopic eye of covering the sound non-squinting eye, for a prolonged period may be nil, or, on the other hand, may lead to a slow but real improvement, but not, however, to complete restoration of full acuteness of vision. Such an improvement is doubtless due to certain additional factors influencing the vision of the amblyopic eye. Since the eye has not been used for fixation, binocular vision (*vide* Squint, Part II.) being defective or absent, no effort to focus objects accurately has been made; and further, the object looked at having been seen indistinctly, we should expect a certain awkwardness to exist on first employing functions which have been for a longer or shorter time in abeyance—a sort of left-handed condition noticed in right-handed people, when owing to some injury the right hand is placed *hors de combat.* The improvement noticed in squinting eyes, on covering the sound eye for long periods is probably due to this awkwardness being gradually overcome.

If the amblyopia of the squinting eye were due to the effect of the suppression of the image of that eye we should expect the prolonged covering of an eye would lead to defective visual acuteness, and that in those cases where the eye has been bandaged for a long time, or owing to persistent blepharospasm the lids have been kept closed, that a permanent defect of vision would ensue, but this is only found to be the case where the affection existed before full and complete development of the visual acuity had taken place. In adults this is not the case, since cases of cataract developing during childhood obtain full vision after operation where the cataracts have existed for several years.

On the other hand one can quite understand that any interference with the passage of light to the retina may have an effect on the proper development of the macula, but this interference must exist at birth or very shortly after; visual acuity at the macula being once normally and completely developed is not permanently depressed by the exclusion of light.

Amblyopia in one eye may result from the formation of a defective retinal image. Corneal nebulæ, congenital cataract, high degrees of hypermetropia and astigmatism are the chief causes. In the majority of cases the retina is normal, but not properly educated; in others it is probably imperfectly developed.

Amblyopia from hæmorrhage.—In some cases of frequently recurring hæmorrhage extending over a long period as the bleeding from piles, or menorrhagia, serious impairment of vision may take place. The ophthalmoscope shows no change, or at most some pallor of the discs. Arrest of the hæmorrhage will cure the amblyopia.

Traumatic amblyopia.—Blows upon the eyeball sometimes cause amblyopia or amaurosis. The pupil is dilated, all reflex abolished, and all perception of light may be lost. The ophthalmoscope shows no change. Recovery of sight usually takes place after a time; no treatment beyond giving rest to the eye is required.

Hysterical amblyopia.—In some cases of hemi-anæsthesia, partial loss of sight or complete blindness (amaurosis) with dilatation and immobility of the pupil of the eye on the affected side occurs. Complete or partial loss of sight, in some cases associated with colour blindness in one eye, may also be met with in cases where no hemianæsthesia exists. In both classes of cases ophthalmoscopic examination shows all the ocular structures to be healthy, but often some anomaly of refraction is revealed. With the rare exception of these cases of hemianæsthesia the reflex action of the pupil both direct and indirect is normal.

In another class of cases irritative symptoms occur; there is photophobia with spasmodic closure of the lids; lachrymation and spasm of accommodation. Examination reveals no corneal or other disease; one or both eyes may be affected, and the symptoms often follow some slight injury to the eye. The sufferers are usually young females (not children), but occasionally well-marked cases occur in boys about puberty. The prognosis is good.

Treatment.—The amblyopic eye should be practised by covering the sound eye and attempting to read for half an hour, two or three times a day, with the defective one (*vide* Squint, Part II.). The treatment in all cases of hysterical amblyopia or amaurosis should be to demonstrate clearly and firmly to the patient that there is nothing the matter with the eyes; all sympathy should be withheld, and a little judicious bullying practised. In cases where one eye only is affected the sound one should be tied up and the patient made to use that which is supposed to be blind. If any anomaly of refraction exist it should be corrected. The administration of drugs only tends to keep up the delusion.

Hemiopia or Hemianopsia signifies loss of one-half of the visual field; both eyes are usually affected, and as a rule the lateral halves of the field suffer. In the majority of cases the right or left lateral half of each field is lost, in some cases the temporal half, or the upper half of each field is lost.

Loss of the right half of each field indicates loss of function of the left half of each retina, and is probably caused by disease of the left optic tract. Loss of the two temporal halves indicates loss of function of the nasal half of each retina, and may depend on disease of the anterior part of the chiasma. Permanent hemiopia is consequently a symptom of some lesion in the central nervous system. Hemiopia may be transient, some persons appear to suffer from it as a kind of migraine; the attack coming on rather rapidly, arriving at its height and then gradually disappearing, the whole lasting about half an hour and leaving behind it a general feeling of discomfort. Sometimes the edges of the dark portion of the field are bounded by a bright zigzag line. Transient hemiopia is probably purely functional and is often associated with gastric disturbance.

Closely allied to the foregoing is a transient loss of sight of one eye; the symptoms are identical with those of transient hemiopia, with the difference that the whole field is lost, there being no perception of light for some minutes. In one case, which was examined ophthalmoscopically during an attack, the retinal vessels, both arteries and veins, were found to be engorged with blood, and returned to the normal condition as vision was restored. In all these cases any anomaly of refraction should be carefully neutralized.

Permanent hemiopia may last for any time without change visible to the ophthalmoscope, in some cases, however, atrophy of the disc is present.

Asthenopia.—In a certain class of cases there occurs weakness with inability to use the eyes, in spite of careful correction of anomalies of refraction if they exist. These cases may be all included under the head of asthenopia, accommodative or muscular (*vide* p. 117).

The sufferers may be male or female, but are most frequently women about the time of the menopause. If males they may be of any age, and are nervous hypochondriacal fidgety creatures. The following is a good instance of the class of patient:—A gentleman about fifty, apparently in robust health, but according to his own account always ailing, was more particularly troubled about his eyes. He could not use them for any length of time, could not sleep in a room where it was possible for the least light to enter; his own bedroom had every crevice stopped, and nothing would induce him to sleep out of it. He went about wearing the darkest smoke coloured protectors and said he could not bear to be without them. His vision was normal, the only discoverable defect was ·25 D of hypermetropic astigmatism. He was ordered + ·25 cyl. light smoke to go about in and persuaded that he could do perfectly well without the nearly black protectors, and was given + 1·25 D sph. + ·25 cyl. for reading. For months he complained that he could not bear the light, and could not read or write. He was persistently advised to go on using the glasses, and no change was made in spite of his assurance that he was getting rapidly worse. After about eighteen months he entirely recovered.

Treatment.—The treatment must be careful correction of anomalies of refraction and presbyopia. If the internal recti muscles are weakened, assistance must be given by the use of prisms or decentrated lenses. Glasses will not, however, give immediate relief.

The patients should have thorough rest for a time and then be encouraged to exercise the eyes, without straining or fatiguing them ; thus if reading or working can be continued for fifteen or twenty minutes without discomfort, the patient should be instructed to read or work for a rather less period and then to rest for a few minutes before continuing. By degrees the eyes may be used for longer and longer periods, but never long enough to cause fatigue, until any reasonable amount of work or reading can be done without difficulty. Care must be taken that all work is done in good light, and when artificial light is used it must be bright and steady. The patient should be encouraged to forget the eyes, to take plenty of out-door exercise and do all that is possible to keep up the general health. Ovarian, uterine, and digestive troubles should be treated, and men should be warned against sexual excess.

Retrobulbar neuritis may be acute or chronic. *Acute retrobulbar neuritis* is supposed to depend on an inflammation of the nerve, behind the globe.

Symptoms.—A rapid failure of sight in one eye, accompanied by pain on moving the eye or on pressing it back into the orbit.

The sight fails first in the centre of the field, and a central scotoma of varying size can generally be made out. The pupil generally is a little dilated, and reacts only slowly to light. The ophthalmoscopic signs in the early stages are absent, but later evidence of neuritis appears, unless the process is arrested before the disc is involved. The sufferers are generally young adults. The failure of sight is often attributed to exposure to cold, it may be due to inflammation passing along the periosteum, and affecting the optic nerve at its entrance, but the commoner causes are syphilis, influenza, diabetes, scarlet fever, and other exanthemata. The prognosis must be guarded, but recovery usually takes place. In other cases central scotomata remain.

Treatment.—If a cause can be ascertained, treat this, if not, free sweating, mercurial inunction, and rest to the eye, should be tried.

Chronic retrobulbar neuritis.—Excess in the use of some substances, as tobacco; over-doses of some drugs, as quinine; the prolonged exposure to the fumes of some chemical substance, bisulphide of carbon, chloride of sulphur, and also the poison of malaria may cause chronic retrobulbar neuritis. Tobacco amblyopia is the only one which need be specially described in a work of the present scope.

Tobacco amblyopia is characterized by a slowly progressive blunting of sight in both eyes, amounting in a few months to inability to read letters less than J. 20 at a few inches. In the early stage beyond the failure of sight there are no local symptoms, and ophthalmoscopic signs, if they exist, are not sufficiently pronounced to be of any value.

The defect of vision is limited in most cases to the central part of the retina; what is known as central " scotoma " (an area over which vision is lost or greatly diminished) being developed. The patient complains of failure of sight for distance as well as for reading. Glasses do not improve the vision. He usually sees best in a dull light and often has difficulty in recognising coins, mistaking half a sovereign for a sixpence, or a penny for a half a crown.

The scotoma may be "relative" or "absolute." If relative the colours lost are green first and then red. If absolute the patient complains of a mist in front of his eyes.

The persons affected are almost invariably men; they are generally from forty to fifty-five years of age, have smoked or chewed, or done both to excess ($\frac{1}{2}$ oz. or more of strong tobacco per diem) for some years, and have often drunk hard and lived dissipated lives as well. These last, however, are not necessary to the development of the disease, indeed some authorities affirm that drink rather retards it. Such is not the usual experience.

Treatment.—The treatment is simple to prescribe but not so easy for the patient to carry out. He must give up tobacco in every form, and generally mend his ways. It is our duty to point out in the strongest terms that blindness will result if tobacco is continued. Strychnine in some form should be given. The prognosis is good if no visible change has taken place in the disc, and even in some cases of marked pallor recovery may take place.

Functional Disturbances of Sight.

Functional disturbances are numerous and their nature is ill-understood.

Micropsia and megalopsia.—Objects appear too small or too large. When not caused by altered conditions of accommodation and convergence, these disturbances may be due to misplacement of the rods and cones of the retina from inflammatory exudation, or to some affection of the nerves causing them to act discordantly.

Metamorphosia.—In which objects appear distorted, may be caused by an oblique position of some groups of rods and cones, consequent on inflammatory exudation, retinal detachment or progressive posterior staphyloma.

Colour-blindness (achromatopsia) may be congenital or acquired. If acquired, it depends on disease of the optic nerve, or may be a part of hysterical amblyopia. Congenital colour-blindness is usually discovered accidentally, or when systematic investigation is made as in examining signalmen, sailors, &c.

Researches made in this country, on the Continent, and in America, show that from three to five per cent. of the male population are more or less colour-blind; this fact should be borne in mind by all who have the examination of railway servants and others whose duty it is to distinguish coloured signal lights.

Colour-blindness is rarely complete, but the perception of certain colours is much limited or absent. Thus red and green may be confounded together, but yellow and blue can be distinguished from each other and from red and green; or yellow and blue may be indistinguishable from each other, but red and green can be recognised. Red-green blindness is the commonest form of achromatopsia.

The methods of testing the colour sense are numerous, but the confusion test given at p. 61 is perhaps as good as any, and is very simple. Tests which require colours to be named are not good, as many people who can quite well distinguish colours, and even pick out slightly differing shades of the same colour, do not know what to call them.

Coloured vision.—Objects appear red, green, yellow, &c., their real colour being changed. In some cases of jaundice objects appear yellow, from circulation of the colouring matter of bile through the transparent parts of the eye. In poisoning by santonin, yellow or violet vision, the former in bright light, the latter in dull light, may occur.

Blue or leaden vision occurs after cataract extraction; patients complain that the hand, for instance, looks like a dead hand. It is said to be caused by the presence of lens substance in the pupil; it passes off in time. Coloured vision is complained of in some cases of high degree of hypermetropia and in astigmatism; it probably depends on diffusion of light in the dioptric media, due to imperfect accommodation.

Night blindness.—A person suffering from night blindness is unable to see in dull light, the loss of sight being much greater than can be accounted for by the diminution of light, whilst in daylight or bright artificial light his sight is normal. Its cause is constant exposure to very bright and dazzling light either direct or reflected, and also to prolonged periods of malnutrition, due to limited or improper food, prolonged fasting, scurvy, &c.; thus sailors who are exposed in the tropics for many hours a day to direct sunlight and light reflected from the water are liable to suffer. Soldiers may also be affected when exercising for many hours a day under a burning sun, especially upon white soil. It is due probably to exhaustion of the retina, which requires a stronger stimulus than usual to make it react. Night blindness is also a prominent symptom in retinitis pigmentosa.

Snow blindness or ice blindness is of the same nature, but in addition to the want of sight there is conjunctival congestion, photophobia and pain, and in some cases conjunctival ecchymosis.

Muscæ volitantes appear as small dots, filaments, or webs, generally transparent, but at times quite dark or even black; they move about in the visual field and do not interfere with vision; they are, however, a source of considerable discomfort and sometimes of anxiety to nervous patients. They are always seen most distinctly in bright light and upon a light surface as when looking at white clouds or white paper, or the pavement in walking.

Muscæ are due to minute changes in the transparent media or films of mucus on the cornea; they are most common in myopic eyes; if they cannot be seen with the ophthalmoscope their presence is of no importance, and patients may be assured that they will do no harm.

Malingering.—Patients sometimes wilfully feign blindness of one or both eyes, but are easily detected. If one eye only is affected its pupil acts freely both directly and indirectly; if we put a prism base up or down in front of either eye, the sound one for choice, double images appear, and the patient believing them to be caused by the glass mentions them at once. If a prism is not at hand, double vision can be produced by pressing on the sound eye with the finger so as to make it deviate in any direction. If atropine is applied to the sound eye, when it has fully dilated the pupil and paralyzed the accommodation, the patient will read small print easily which of course must be done by the supposed blind eye. This test and that of the action of the pupil will be of no use if the patient has used a mydriatic to his supposed blind eye.

If both eyes are affected we shall soon find out the imposture by watching the patient; he will move about without running against objects, his pupils will act freely: if spoken to suddenly, or if a light be unexpectedly thrown upon the eyes he will give some sign that he sees.

The treatment of functional diseases of the retina, so far as treatment is of any avail, consists in the removal of the cause. Constitutional diseases should be treated, anomalies of refraction corrected, and the surroundings of the patient altered.

PART II.

OPERATIONS.

CHAPTER I.

Position of Patient and Operator, Administration of Anæsthetics, Use of Cocaine, &c.

All the minor operations, such as slitting the canaliculi, passing probes down the nasal duct, opening tarsal cysts, &c., can best be performed when the patient is seated in a chair, and the operator stands behind him; the patient's head, over which a towel has first been thrown, resting against the operator's chest (see fig. 42).

The more important operations, as extraction of cataract, iridectomy, squint, &c., should be performed whilst the patient is lying on a hard couch, his head resting on a bolster covered by a towel, thrown forward over the forehead; the operator should sit or stand behind (see fig. 43). In whichever position an operation is to be performed, the chair or table should be placed in front of a large window so as to insure a good light, and care be taken to prevent assistants and others from interposing their heads or bodies between the patient's face and the source of light. It will be found whilst operating that, with the exception of occasional pronation and supination, there is little occasion to use the arms, which should be kept with the elbows near the sides, the wrists resting on the patient's head or face, in a position which allows of free movements of the hands and fingers.

Every ophthalmic surgeon should learn to use his fingers, cultivate his sense of touch, and, if possible, become ambidextrous.

It will be found that incisions can be best made by holding the knife lightly between the thumb and first two fingers of whichever hand is most conveniently situated.

FIG. 42.—Position for minor operations. (Sitting).

FIG. 43.—Position for major operations. (Lying).

(*From* Bryant).

In all operations, incisions commencing at, or situated entirely on, the outer aspect of the globe, should be made with the hand corresponding to that side, the opposite hand being employed upon the inner side. That is to say, if the right eye is operated on, the right hand should be used to make an incision at its outer side, the left at its inner, and *vice versâ*.

Incisions above or below may be made with either hand; scissors should also be used with whichever hand is most favourably situated.

In one operation, that for internal strabismus, the positions of patient and operator are somewhat different from those already described, the operator standing at the side of the couch in front and to the right of the patient, instead of behind his head.

The scissors may be used with the right hand for both eyes, but in operating on the left the hands will have to be crossed.

Before performing any operation the operator should look carefully to the condition of the instruments he is about to use. Knives should be passed through a piece of thin leather tightly stretched on a small metal cylinder, and care taken to ascertain that they have good points and that there are no notches in the blades.

Scissors should be carefully examined and tried; it should be seen that forceps close properly, and are free from rust or dirt; silk for sutures should be black, as fine and strong as possible, and free from flaws or kinks. Inattention to these details may very possibly mar the success of an operation.

Preparation of the patient for a major operation (cataract extraction).—It is advisable that the patient should have a purge the previous day, and precautions taken against the necessity of any straining at stool, or violent action of the bowels after the operation has been performed. The conjunctival sac should be washed out two or three times the previous day with warm boracic acid lotion (gr. x. ad ℥ j.) or hyd. perchlor. lotion (1-10,000).

Any conjunctival inflammation or discharge from the lachrymal sac will necessitate postponement of the operation until such conditions are cured.

It must be remembered that owing to the nature of the parts operated on, the severe antiseptic measures employed in general surgery are quite inadmissible here, and also unnecessary owing to the excellent blood supply of the eye and its appendages, together with the fact that the fingers (the most cogent source of infection in general surgery) never touch the wound. The skin of the lids and parts around should be thoroughly washed with soap and warm water, and a weak compress of carbolic lotion (1-100) applied to the side of the face to be operated on.

Immediately before the operation the conjunctival sac should be thoroughly flushed out with warm boracic lotion, or sterilized water, care being taken that the fornices of the conjunctiva are thoroughly cleansed and the inner canthus has no speck of dust, &c., lodged there.

The sutures and all the instruments, except the knives, should be boiled and placed in formalin lotion (1-3000). The knives sharp and bright will be sterilized best by allowing boiling water to flow over them and cooled by passing them through some antiseptic lotion immediately before use. The knives used are extremely delicate and require the greatest possible care. They should never be left long in lotions and should be thoroughly dried immediately after use.

The head and forehead as far as the brows should be covered with a towel, and the speculum having been inserted, the whole face is covered with a square of gauze wrung out in carbolic lotion (1-60), a hole being made in its centre, the diameter of which is equal to the distance between the blades of the speculum.

After the operation the eyes are tied up with a pad made of sal alembroth gauze and wool, or any other antiseptic dressing.

Administration of anæsthetics.—The operator will find that he has much more command over the eye when the patient is under the influence of an anæsthetic than when consciousness remains, but *the anæsthesia must be profound;* a partially anæsthetic condition is worse than no anæsthesia at all, on account of the straining which is sure to take place. In operations for squint or in those where only a small incision is made as in iridectomy for artificial pupil, however, profound anæsthesia is not necessary.

General anæsthetics are less frequently used now for eye operations than formerly, being replaced by the local application of the better and purer preparations of cocaine, eucaine, or holocaine.

In some cases, however, cocaine or other local anæsthetics are useless. In all cases of acute inflammatory trouble, great increase of tension, and for the division of anterior synechiæ, they are of little use. An anæsthetic is given in glaucoma with advantage in most cases, and in inflammatory cases of necessity. It is interesting to note that patients suffering from glaucoma invariably take chloroform well.

In those cases where inflammation is present, and there is great increase of blood to the parts, cocaine is so rapidly absorbed that its effect is only transitory. In cases of marked increase of tension, on the other hand, the absorption is so slight that no anæsthetic effect is obtained. Owing to the increase of hæmorrhage occasioned by the use of the drug, when an iritic adhesion has been severed, the cut iris again adheres, owing to the blood clot becoming organized.

Cocaine is now extensively used as a local anæsthetic and is of great value in ophthalmic practice. The salt which has been found most useful is the hydrochlorate. A solution of 2½ per cent. (or stronger if desired) dropped into the eye causes anæsthesia of the conjunctiva and cornea in the course of a few minutes. Blanching of the conjunctiva, retraction of the upper lid, some dilatation of the pupil and weakening of the accommodation also occur. A solution of adrenalin chloride (1-10,000) is used in combination with cocaine or other local anæsthetic, with the view of preventing hæmorrhage.

The operations in which cocaine is useful, are those affecting only *the conjunctiva and cornea.* It has little or no effect upon the deeper parts, consequently it is of little use in iridectomy and opening tarsal cysts beyond the first incision, the removal of the iris or scooping out of the cyst causing nearly as much pain as if no application had been made; neither does it entirely deaden pain in slitting the canaliculi or passing lachrymal probes, or in division of the tendon in squint operations. But for removal of foreign bodies from the cornea, or sutures from the conjunctiva, all operations on the conjunctiva, corneal incisions as for extraction of cataract *without iridectomy*, and needle operations, cocaine is invaluable.

Cocaine is also useful where the cornea is abraded from injury or is the seat of painful ulceration, and in cases where there is difficulty in examining an eye from pain or intolerance of light.

The method of using it is simple; the solution should be dropped into the eye three times or oftener during five minutes immediately before the operation is commenced, the effect lasts from ten to fifteen minutes; if sensation begins to return before the operation is finished, more of the solution should be applied.

Disagreeable symptoms have been brought about by its use, but the cases are few. Great care should be taken that the solution is fresh, and none should be used which has become turbid from the formation of fungus.

After-treatment.—Operations on the tear passages, tarsal cysts and strabismus, require little or no after-treatment; the parts need only to be washed twice or three times a day with tepid boric acid lotion.

Wounds of the globe made in operations, as a rule, heal rapidly, union having frequently taken place at the end of twelve hours.

Sponges should never be used for cleaning the conjunctival sac, &c.; small pledgets of absorbent cotton wool which have been soaked in boric lotion answer every purpose.

The great danger after operations on the globe is the occurrence of inflammation.

Inflammation, once set up, may subside quickly, leaving no trace behind it; it may continue until more or less irreparable damage has been done, or may run on to suppuration of portions or the whole of the globe; the cornea is more liable to this change than any other structure.

The symptoms of inflammation usually appear within the two days immediately succeeding an operation, and little fear need be entertained for the safety of the eyeball if all has gone well for a week.

Occasionally, after cataract extraction, eyes have been lost through inflammation, or suppuration, commencing at a later period, but these cases are rare, and probably it will be found that some damage had been done to the eye shortly before the symptoms appeared.

The treatment of inflammatory changes consists in the local abstraction of blood from the temple by leeches, or the application of the artificial leech; the use of fomentations of boric acid, poppy heads, or belladonna constantly applied, or the application of the hot coil (see Diseases of Cornea); together with the administration of opium in full doses, either alone or combined with mercury. The treatment must, of course, be varied according to the condition of the patient; should he be weakly and anæmic, we should be careful about blood-letting, and prescribe instead quinine and iron, with good living and a fair amount of stimulants.

The local abstraction of blood, however, acts most beneficially in relieving pain, and should therefore be employed in cases where pain is a prominent symptom, even though the patient does not appear to have much blood to lose. Strong healthy patients should be leeched freely, and kept on light diet.

During the treatment the eye must be kept carefully closed and bandaged, except during the time that fomentations are being applied. Moderate pressure by carefully applied pads of lint and cotton wool, secured by a few turns of flannel bandage, is said to exert considerable influence in cases where the cornea is threatened by suppuration; it should have a fair trial, if pressure can be borne.

If the inflammation goes on to suppuration of the whole globe the case must be treated in the same manner as abscess in any other part (see Ophthalmitis).

Application of the artificial leech.—This instrument consists of a small sharp steel cylinder (worked by a spring arrangement), with which a circular incision can be made through the skin of the temple, and a hollow glass cylinder, which can be placed over the wound, and the air in its interior exhausted by a piston worked by a screw; as the air is removed the blood flows up to fill the vacuum. Care must be taken not to work the screw too quickly, but only to move the piston at the same rate as the blood flows; and the edge of the cylinder must not be allowed to compress the skin against the parts beneath, otherwise the flow of blood will be impeded. The skin should be well greased, and hair which may be in the way removed before the application of the cylinder.

CHAPTER II.

The Eyelids, Lachrymal Apparatus, and Conjunctiva.

Tumours.—Various small growths are met with on or about the eyelids needing operation.

Molluscum contagiosum occurs as a small yellowish-white projection, having a depressed and often blackened centre, on some part of the skin of the lids; there may be only one or many of these little growths. They can be easily removed by thrusting a knife through them, and then squeezing out the contents between the thumb nails.

Dermoid cysts are not unfrequently met with situated deeply beneath the skin and the muscle, often near the outer angle of the orbit. They are congenital, filled with sebaceous matter, and often contain hair. They must be carefully dissected out, much more trouble being experienced in so doing than would be at first suspected, and they will in all probability be opened during removal. These little tumours will be found attached deeply to the periosteum, and may have caused a depression in the bone.

Warts are not unfrequently met with about the eyelids; they should be cut off with scissors.

Tarsal or Meibomian cyst occurs as a dusky red or colourless projection from the outer surface of the lid; its position is marked on the conjunctival surface by a bluish spot, from which a granulation is occasionally seen growing. The cyst is formed by obstruction of the duct of a Meibomian gland and retention of its secretion; it is sometimes in a suppurating condition.

The lid should be everted, the cyst freely opened from the conjunctival surface with a small knife, by means of which an incision at right angles to the margin of the lid is made, and its contents squeezed or scooped out; it must be thoroughly emptied, or it will, in all probability, re-form.

The cavity left on removal of the contents of the cyst will always fill with blood, and shortly after the operation the tumour will be as large or larger than before; the patient must be warned of this.

The swelling will most probably disappear in the course of from four to six weeks; if it remains longer the operation should be repeated.

A tarsal cyst sometimes degenerates into a hard fibrous little mass, feeling somewhat like a shot beneath the skin, known as a *chalazion;* this should be dissected out through an incision in the skin of the lid, which should afterwards be closed by a fine suture.

Xanthelasma is often met with as a small slightly raised yellow patch or patches on some part of the skin of the eyelids; its most frequent site is the surface of the upper lid near the inner canthus. The little patch may be excised if it is a source of anxiety to the patient. In some cases the patches increase until they form a continuous ring around the eye. Patients affected by xanthelasma are often very subject to bilious attacks and there appears to be some relation between the skin affection and hepatic trouble.

Simple serous cysts occur about the margins of the lids; they are about the size of small peas, and nearly transparent. A portion of the cyst wall should be cut out with scissors.

Trichiasis signifies a faulty direction of the eye-lashes (generally those of the upper lid) which turn inwards and irritate the cornea; it is usually caused by contraction of the conjunctiva, (following granular ophthalmia or its unskilful treatment), producing displacement of the hair follicles.

Only a few lashes or the whole row may be inverted. If only a few of the lashes turn inwards, it is sufficient to pull them out with forceps made for the purpose and known as cilium forceps, whenever they become troublesome. In pulling out lashes care must be taken to draw them out straight and not to pull them to one side and so break them off; two or three may be pulled out together and when the bulk have been removed those remaining should be carefully picked out one by one. If a considerable number or the whole row are inverted, their roots should be removed by the following operation:—The patient being in the usual position (see fig. 43, p. 246), the lid should be secured by a compressorium forceps (figs. 44, 45), by which means it is steadied and hæmorrhage prevented; care must be taken not to screw the instrument up too tightly, or sloughing of the lid may follow. The lid being well secured, the operator should make an incision through the skin, about two lines from the free margin of the lid and parallel with it, of such a length as to correspond to the lashes which are misplaced; the incision should be carried down to the outer surface of the tarsal cartilage; a second incision should then be made of the same length as the first, in the margin of the lid, and so conducted as to split the lid and separate the skin and hair bulbs from the subjacent structures;

the ends of the two incisions should then be joined by two short cuts, and the portion of skin included, with the hair bulbs dissected off the tarsal cartilage. The raw surface should be wiped with a sponge, and any black dots denoting the presence of hair bulbs carefully removed.

The compressorium forceps should then be unscrewed, when free hæmorrhage will take place. The eye must

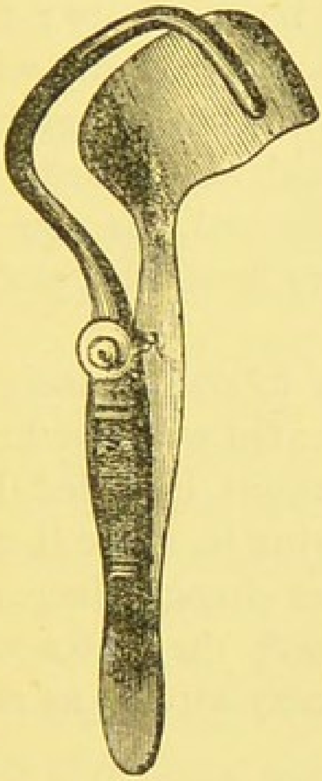


FIG. 44.—Compressorium forceps.

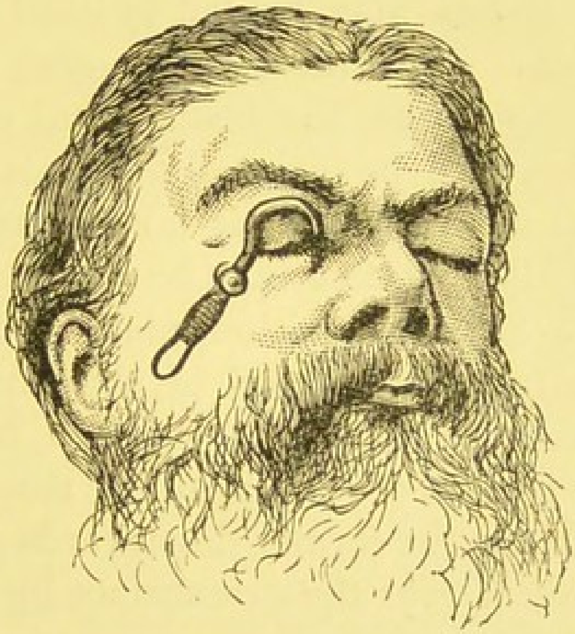


FIG. 45.—Compressorium forceps applied.

(*From* Bryant).

be covered by an antiseptic dressing secured by a bandage.

The whole row of lashes may be transplanted as follows:—The lid being secured by the compressorium forceps, an incision should be made through skin and orbicularis muscle along the whole length of the lid, parallel to and about two lines from its margin; a second lunated incision joining the extremities of the first and including a portion of the surface of the lid about two lines in width should then be made, and the portion of skin and muscle marked out by the two incisions dissected off the tarsal cartilage and removed. The next step in the operation is to separate the portion of lid carrying the lashes, from the tarsal cartilage leaving it attached only by its extremities, then slide it up over the surface of the lid and fix it in the gap already prepared by as many sutures as may be necessary; the raw surface left by separating the portion of lid with the lashes may be left to itself and will heal by granulation. An antiseptic dressing should be applied. If the operation has been skilfully performed, the row of lashes will be directed forwards away from the globe, after cicatrization has taken place.

This operation may be modified as follows:—Instead of a lunated incision, make one parallel with the first, separate the portion of skin and muscle included between the two, and instead of removing it, make it and the portion of lid containing the lashes change places by drawing the former downwards beneath the latter and fixing it over the raw surface by as many sutures as may be necessary.

Entropion signifies a rolling inwards of the whole lid, the whole row of lashes being completely turned towards the eyeball. It is most frequently met with in the lower lid, more especially in old people with a superabundance of loose skin about the face, and is often the cause of much trouble and annoyance, as well as of danger to the eye, after cataract extraction.

The inversion is caused by spasmodic contraction of the orbicularis muscle or by distortion and thickening of the tarsal cartilage after granular ophthalmia.

Entropion caused by contraction of the orbicularis is easily remedied as follows:—The patient, lying on a couch (see fig. 43, p. 246), the operator should seize with forceps the skin of the lid at a point near one or other canthus, about two lines from its margin, and then with scissors remove a portion, in breadth corresponding to about half the surface of the lid, and extending along its whole length; he should then seize and remove the orbicularis muscle to a corresponding extent. No suture need be used; the eye should be bound up with lint wetted with boracic lotion and a bandage. The subsequent healing of the wound and contraction of the cicatrix will remedy the inversion.

Entropion depending on distortion and thickening of the tarsal cartilage is usually met with in the upper lid. It can be remedied by removal of a wedge-shaped piece of cartilage, including the more thickened portion, by the following operation:—The patient, being in the usual position (see fig. 43, p. 246), and the lid fixed by a compressorium forceps, an incision is made along the whole length of the lid, through the skin only, parallel to the border, about 2 mm. from the edge (*vide* fig. 46). A second incision, having a slight elliptical curve, joins this at each extremity and includes about 2 mm. of the skin, so that a long piece of skin is removed from the upper lid. The fibres of the orbicularis muscle are removed to a corresponding extent, and the cartilage exposed at the bottom of the wound. A wedge-shaped strip is cut from the latter by means of a Beer's knife, which makes two oblique incisions meeting at the deep surface of the lid, but not penetrating the conjunctiva.

The operation is completed by a few sutures inserted in the following way:—A fine curved needle, threaded with a silk suture, is passed through the cartilage above the wedge-shaped groove and brought out on its upper cut surface (*vide* fig. 47), then passed through the skin to which the lashes are attached, at the lower margin of

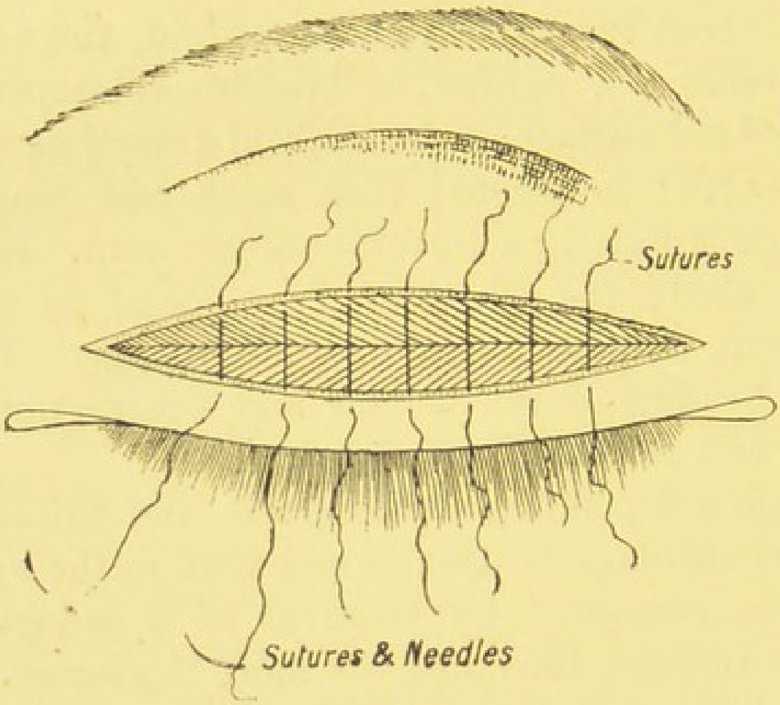
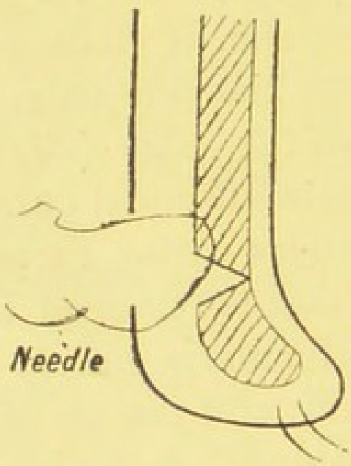


FIG. 46.



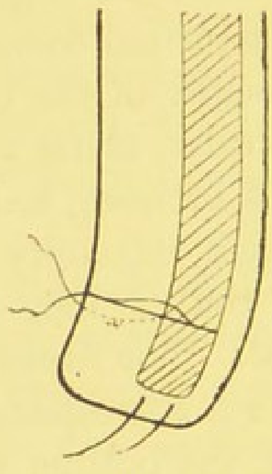


FIG. 47. Method of passing suture.

FIG. 48. Condition at the end of the operation.

Diagrams to illustrate operation for entropion.

the lid, and the ends of the sutures drawn together (*vide* fig. 48).

After the operation the margin of the lid should appear rightly directed.

The former of these two operations is usually performed upon the lower lid, the latter upon the upper lid, as stated above.

Ectropion signifies an everted condition of the lid; the extent of eversion varies in different cases, from slight falling away of the margin of the lid from the globe to eversion of the whole extent of the lid and adjoining fornix of the conjunctiva.

The slighter forms are caused by distension of the lid from inflammatory swelling or from general laxity of tissue as seen in old people, and are easily remedied by slightly narrowing the palpebral aperture, by paring the edges of the lids near the outer canthus, and bringing the raw surfaces together by a suture, when firm union will take place between the two.

Ectropion is also frequently seen in the more severe forms of ophthalmia, or in cases of severe intolerance of light, and is specially liable to occur when an attempt is made to open a firmly closed eye. In these cases the eversion requires no special treatment, but disappears as the affection causing it is recovered from.

The more extreme forms are caused by the contraction of cicatrices arising from burns, wounds, or inflammatory changes about the orbit, and by paralysis of the facial nerve, the subsequent atrophy of the orbicularis and the subcutaneous tissue allowing the lid to fall away from the globe.

No definite rules can be laid down with regard to the treatment of these cases. The surgeon must be guided by the conditions as they present themselves, and do the best he can.

In any case, if the tarsal cartilage is left entire, it should be carefully dissected away from its abnormal attachments and replaced as nearly as possible in its proper position, and kept there by paring its margin and that of the opposite lid, and uniting the two by sutures so that extensive and firm union may take place between them. Then if there is any healthy skin adjoining, a flap should be dissected up and made to cover the raw surface left by freeing the cartilage ; or a V or curved incision may be made in a suitable position and the tissues shifted as required ; in all cases any fresh raw surfaces made should be covered by skin. The lids must not be opened until all contraction of the original cicatrix, or of cicatrices made in operating, is at an end, the time allowed should not be less than six months, and it is better to leave the eye closed for considerably too long a period than to open it a day too soon.

Formation of a new eyelid.—In some cases of burn, or severe ulceration more or less complete destruction of the eyelids takes place. To remedy this defect, a flap of skin, which is left attached by a pedicle to a neighbouring part, may be dissected up, placed in the gap, and there secured by means of sutures, care being always taken that the piece of skin is considerably larger than the surface it is intended to cover. Before removing the skin, search must be made in any portion of the eyelid that may be left for the tarsal cartilage, and if this is found it must be carefully dissected out and preserved, its natural form being as much as possible restored ; it should be fixed in its proper position by uniting its margin to that of the opposite lid. Even if no flap of skin is applied over it, it will in time become covered with cuticle, and form a very effectual covering to the eyeball.

Symblepharon signifies adhesion of the conjunctiva of the eyelid to that of the globe. It is usually caused by burns with lime or hot metal, and may occur to any extent, varying from a thin band of union to fusion of the greater part or whole of both lids with the globe.

This condition requires to be remedied by operation. Where only a thin band of adhesion exists it should be first carefully secured by a suture passed through the extremity nearest the eyeball and then divided between the eyeball and the suture, and drawn into the fornix by passing the suture through the lid and securing it to a small roll of strapping, placed upon the cutaneous surface. By this means the raw surface left by removal of the band from the globe is brought into contact with healthy conjunctiva and granulates over, healing without forming adhesions.

If more than one band exist, each should be dealt with separately.

Cases of more extensive adhesion give rise to the utmost difficulty in treatment, and the operations performed for their relief have been attended with only indifferent success. One plan of treatment recommended was to dissect away the adhesion and interpose a shell of glass between the raw surfaces, but as healing invariably commenced at a point remote from the free margin of the lid, the shell was gradually pushed out and the adhesion re-established.

The insertion of pieces of wire deeply beneath the adhesion, and leaving them in until the walls of the canal made by them had healed, the remainder of the adhesion being then divided with scissors, was followed by no more satisfactory results.

Some few years ago, an operation was introduced by Mr. P. Teale, of Leeds, which has been attended with the best success. The operation has for its object the separation of the raw surfaces by a piece of conjunctiva, taken from some other part of the eyeball. The following is an extract from the account of the operation given by Mr. Teale in the *Transactions of the Fourth Ophthalmic Congress*, 1872. "The patient being under the influence of an anæsthetic, the eye is freed from its attachment to the lid; next, a band of semi-circular form is marked out, with a sharp knife, upon the sound ocular conjunctiva; the band commences at one end of the gap left by liberation of the lid, and passes round the sound side of the cornea, terminating at the opposite extremity of the gap.

"Four stitches are then inserted, two on each edge of the flap thus formed. The flap is next separated on its *under surface*, whilst its extremities are left continuous with the conjunctiva; it is then drawn across the surface of the cornea, and fixed, raw surface downwards, into the gap formed by the liberation of the eyeball from the lid; it is secured in its new position by the sutures already alluded to, aided by as many others as may appear necessary."

Mr. Teale states that "the operation is most tedious," and that he rarely completes it within the hour.

Anchyloblepharon signifies an adhesion of the lids to each other. The adhesions must be divided with scissors, and the skin and conjunctiva united so as to cover the raw surfaces; but if this cannot be done, reunion may be prevented by passing a probe between the lids daily.

Narrowing of the palpebral aperture (Blepharophymosis) is usually a result of granular ophthalmia, and is accompanied by entropion, displaced tear puncta, and consequent watering of the eye. It requires to be remedied by operation, which can be thus performed :—The lids being kept widely open and on the stretch by a wire speculum (fig. 49), an incision should be made with strong scissors through the outer canthus. A flap of conjunctiva, of somewhat conical shape, should then be marked out on the surface of the eyeball, the flap freely dissected from the subjacent structures, but left attached at its base, which is towards the cornea, and then fixed by sutures in the incision made by the scissors, in such a manner as to keep the raw edges separated by a mucous surface.

Tarsorraphy.—It is sometimes necessary to narrow or close entirely the palpebral aperture. This operation, known as tarsorraphy, can be performed as follows:—The lid being held with forceps, a portion of *the inner edge*

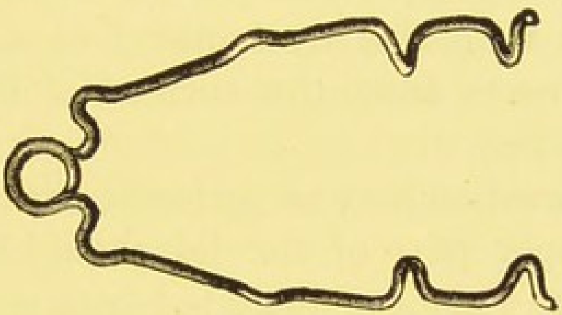


FIG. 49.—Wire speculum. (*From* Bryant).

of its margin should be removed with a small iridectomy knife, care being taken not to cut away any of the outer edge containing the lashes, nor to wound the tear puncta or canaliculi. The opposite lid should then be treated in the same manner, and the raw edges brought together by sutures; firm union will soon take place between them. The lower lid should be operated on first to avoid the difficulty which would be caused by blood running over it from above if the upper lid had already been done.

Ptosis signifies a drooping of the upper eyelid to a greater or less extent, with inability to raise it. Ptosis occurs with divergent strabismus and more or less impairment of the mobility of the eyeball, in cases of paralysis of the third nerve, and is generally, but not invariably, accompanied by dilatation and fixity of the pupil (see p. 123). It is also met with as a congenital defect, and sometimes occurs after severe inflammation of the lid, or from protracted intolerance of light, with constant spasmodic action of the orbicularis muscle. Women past the middle period of life, with a superabundance of loose skin about the face, are also subject to a form of partial ptosis.

Treatment.—In ptosis from paralysis of the third nerve, treatment must be directed against the cause of the paralysis, no operation being advisable; other forms can be remedied by removal of some skin and orbicularis muscle from the surface of the lid, or by means of sutures.

The first operation may be performed as follows:—The skin at the upper part of the lid should be pinched up with forceps, the amount included between their blades being such as to raise the margin of the lid well above the upper border of the pupil. Then with scissors a strip of skin of the required width should be removed, along the whole extent of the lid, parallel to its margin; and the orbicularis muscle should be cleanly dissected off the tarsal cartilage to about the same extent, the wound closed by one or two fine sutures, and the eye bound up with an antiseptic pad.

The wound will heal in the course of a few days, and the shortening caused by the removal of the skin and muscle, and subsequent cicatrization (possibly aided by the entanglement of some fibres of the occipito-frontalis in the scar) should keep the lid in the desired position.

In the second operation, a curved needle, carrying a piece of stout non-sterilized silk, should be entered at a point on the surface of the lid about two millimetres above the centre of its margin, passed beneath the skin and orbicularis muscle for about six millimetres, then brought out and entered again about four millimetres higher up, emerging just beneath the eyebrow.

Two similar sutures should be inserted in exactly the same manner, at points equidistant from the first and the inner and outer canthus respectively.

The upper and lower ends of each suture should then be tied sufficiently tight to raise the margins of the lid well above the pupil, but not enough to prevent it being closed over the cornea at will. No dressing is required. The sutures must be left in for about three weeks and should set up a certain amount of suppuration, the result of which will be cicatrization and contraction of the tissues in their course, so as to place the lid to some extent under the control of the occipito-frontalis muscle, by which it can be raised.

In cases of congenital ptosis we often find movement of the eyes upwards greatly impaired, probably the superior rectus is badly developed or altogether absent.

The Lachrymal Apparatus.

The lachrymal organs consist of a secreting gland and a system of conduits, by means of which the secretion is conveyed over the anterior surface of the globe to the nose. The lachrymal secretion consists of about 99 per cent. of water and 1 per cent. solids, sodium chloride being the chief constituent. Its function is to keep the anterior surface of the eye moist, and in the usual healthy condition, the secretion is not more than sufficient to supply the moisture lost by evaporation, very little reaching the nose, but when owing to some emotion or irritation the secretion is much increased, the lachrymal secretion reaches the nose in greater quantity.

The lachrymal gland is tucked away beneath the upper and outer margin of the orbit, and the secretion is conveyed to the conjunctival sac through a large number of small ducts which open at the upper *cul-de-sac.*

The secretion is pressed by the movement of the lids from the outer to the inner side of the conjunctival sac, when any surplus of fluid leaves the sac through the puncta lachrymalia. These puncta which are really the openings of the lachrymal canaliculi, are placed at the top of little eminences, situated on the free margins of the lids at the inner extremity of the tarsal cartilage. From these elevations the canaliculi pass vertically and then turning at right angles enter the lachrymal sac, situated at the inner canthus behind the internal palpebral ligament. The lachrymal sac rests in a groove formed by the lachrymal bone, and extends downwards to the lachrymal duct which is contained in a bony canal directed downwards, outwards, and backwards, and opens in the nasal fossa under the inferior turbinated bone.

The lachrymal gland is occasionally enlarged from chronic inflammation, or the seat of malignant or other growths, and may require extirpation through an incision in the skin over the most prominent portion of the swelling.

A cyst is sometimes met with caused by obstruction of one of the ducts of the gland and accumulation of secretion. The disease is known as *dacryops.*

Its treatment consists in establishing an opening into it from the surface of the conjunctiva; this is easily done by passing a curved needle armed with silk from beneath the upper lid through the wall of the cyst into its cavity, and out again at a convenient distance; the silk should then be drawn through, and the portion of cyst wall included between the entrance and exit of the needle firmly ligatured; the ligature will slough out and

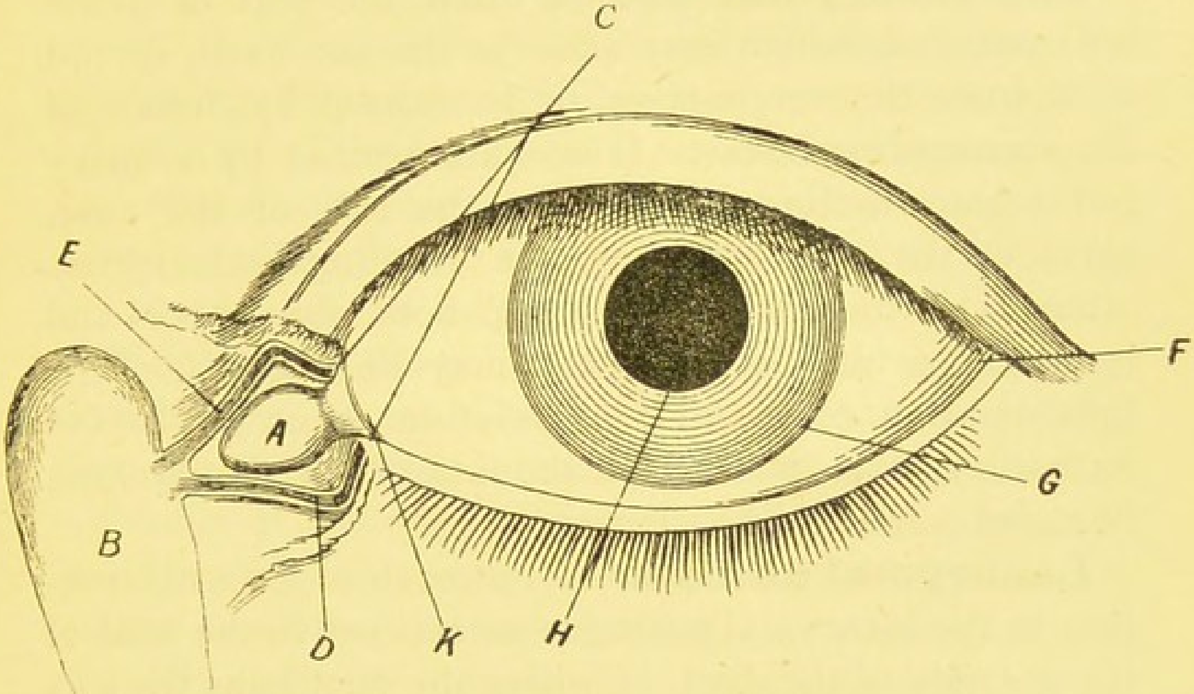


FIG. 50.—Diagram of the Lachrymal Apparatus. *A*. Caruncle. *B*. Lachrymal sac. *C*. Opening of canaliculi at margin of lids. *D*. Lower canaliculus. *E*. Upper canaliculus. *F*. Outer canthus. *G*. Corneo-scleral margin. *H*. Pupil. *K*. Inner canthus.

leave a permanent opening, causing no inconvenience. If the cyst be opened through the skin it may leave a troublesome fistula.

The tear puncta and canaliculi.—The tear puncta in the normal condition lie in contact with the ocular conjunctiva; they may be either everted, as seen in old and neglected cases of tinea, or rolled somewhat inwards, and are sometimes entirely obliterated, either by disease or injury, burns of the eyelids being the most common cause.

The canaliculi may also be strictured, or more or less obstructed in any part of their course, by concretions. These conditions are accompanied by troublesome watering of the eye, "epiphora." They can be remedied by slitting the tear puncta and canaliculi, or removing the concretions.

The lachrymal sac is often the seat of acute inflammation, which may arise in the sac itself, spread to it from the conjunctiva, or be caused by disease of the surrounding bones. It is characterized by a dusky red tense swelling, situated at the side of the nose, close to the inner canthus, the swelling and redness often extending outwards along both the upper and lower lids; one or both sacs may be affected. The inflammation may end in resolution or go on to the formation of an abscess; in the latter case, the swelling becomes soft and fluctuating.

Lachrymal abscess.—As a result of some obstruction to the lachrymal passages, sometimes in the nose at the opening of the duct, or where the duct joins the sac, the lachrymal sac swells and becomes distended with tears, mucus, &c. This material becomes infected with pyogenic organisms, and as a result of some small ulcer or rupture of the mucous membrane, some of this septic material is introduced into the cellular tissue around the sac, and an acute inflammation is set up, which leads to suppuration, forming a lachrymal abscess.

Treatment.—At first, hot fomentations and compresses must be applied, and attention paid to the general health; if an abscess forms, the pus must be let out by a free incision through the skin. If an abscess of the lachrymal sac is allowed to burst a fistulous opening will very probably be left, but if a free opening is made as soon as the formation of pus is suspected, the wound heals readily.

Distension of the lachrymal sac (mucocele).—The lachrymal sac not unfrequently becomes distended, forming a tumour of varying size beneath the internal palpebral ligament (tendo oculi); pressure on the tumour causes the escape, through the tear puncta, of a transparent, somewhat tenacious fluid, consisting of mucus and tears, in some cases thickened from the admixture of pus cells. Distension of the sac is caused by stricture of the lachrymal duct and consequent accumulation of secretion; it is accompanied by more or less watering of the eye, and may be remedied by relieving the stricture of the duct.

Discharge from the lachrymal sac (blennorrhœa).—A muco-purulent or purulent discharge from the sac is often met with, following inflammation, especially if disease of the adjacent bone exists. It may be treated:—1. By insuring a free exit for the discharge by slitting the canaliculus, and passing a large probe down the lachrymal duct. 2. By washing out the sac. 3. By obliteration of the sac.

Stricture of the nasal duct may be met with in any part of its course; the obstruction, however, is most frequently found at its junction with the lachrymal sac. Occasionally the duct is found almost obliterated by dense bony deposit.

Fistula of the lachrymal sac occurs as a small, sometimes scarcely perceptible opening, situated at some point over the sac; it is caused by the bursting of an abscess of the sac and is generally associated with obstruction of the lachrymal duct. If the passage is re-established, the fistula will probably close.

Operations on the tear passages.—The operation of slitting the tear puncta and canaliculi may be performed thus:—The patient should be seated in a chair, the operator standing behind him (see fig. 42, p. 246). Supposing the lower punctum and canaliculus on the right side to be operated on, the small and ring fingers of the left hand should be placed upon the patient's face, near the outer canthus, the lids drawn tight, with these two fingers, and kept so; then a small grooved director (fig. 51) should be taken in the right hand and passed at first vertically to the margin of the lid, through the tear punctum; its handle then depressed, and its point passed horizontally along the canaliculus into the sac. To ascertain that the point of the director is in the sac, the tension of the lids must be relaxed and

FIG. 51.—Grooved director for slitting canaliculus.

the director pushed gently onwards; if there is any puckering at the inner canthus when the director is thus pushed, its point has not entered the sac, and a further attempt must be made; if no puckering occur the lids should be brought again into a state of tension, and the handle of the director transferred to the thumb and forefinger of the left hand; a cataract or any small knife that will cut should then be taken in the right hand, and run along the groove of the director well into the sac, the knife and director being then withdrawn together; the upper lid must be kept out of the way by one of the fingers of the right hand. The operation can be performed on the left side in the same manner, with the exception that the hands are reversed.

The upper punctum and canaliculus sometimes require to be slit; this operation is not quite so simple as that on the lower lid, but is performed in much the same way. In lieu of the grooved director and knife, a small probe-pointed canaliculus knife may be employed; it should be passed through the tear punctum and canaliculus in the same manner as the director, and when its point has entered the sac the handle should be raised into a vertical position and the blade will cut its way out.

The patient must be seen at intervals of two or three days for a week, or longer, after the operation, and a probe passed along the incision to prevent its closing.

Probing the lachrymal duct.—For the treatment of stricture of the lachrymal duct a set of silver

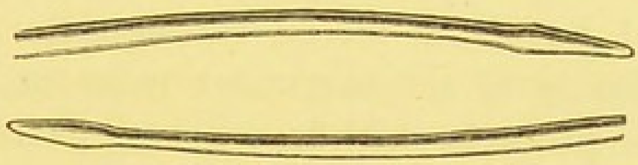


FIG. 52.—Lachrymal duct probe.

probes (Bowman's) are used: there are three probes in a set, the two extremities of each being of different thicknesses, so that there are six sizes, No. 1 being the smallest, No. 6 the largest. The best form are those which have bulbous conical ends (fig. 52), the original ones were straight, with slightly pointed extremities.

To pass a probe down the lachrymal duct, the canaliculus should be first slit, or, what is better, should have been slit at some previous time. The surgeon should stand behind the patient in the same position as for performing the last operation; and the lids being made tense in the same manner, the probe should be passed along the slit canaliculus until the point is well within the sac, as shown by the absence of puckering at the inner canthus on relaxation of the tension of the lids; the other end should then be raised along the margin of the orbit until the probe has attained a vertical direction, care being taken, while so doing, to keep the end which is in the sac pressed firmly against its inner side; the probe, having been brought into a nearly vertical position, should be pushed gently but firmly downwards and slightly backwards and outwards in the direction of the duct; when it has been passed as far as it will go it should be slightly withdrawn, so as to raise its end off the floor of the nose. If the probe has been properly passed down the duct its upper part will remain firmly in contact with the margin of the orbit, but if it moves freely about, the probe is not in the duct, but has been forced through its wall. This little accident is of no particular moment, and needs only that the probe be withdrawn and passed afresh in the right direction.

If the end of the probe is not well within the sac before an attempt is made to pass it down the duct, it may slip backwards into the orbit, or forwards and downwards in the cellular tissue of the cheek. A probe having been satisfactorily passed, should be left in for about twenty minutes, and the operation should be repeated about twice a week. The treatment of stricture of the lachrymal duct is, on the whole, unsatisfactory, probing causes much pain, and must be continued for some time. It is well always to commence with the largest probe (No. 6), and try a smaller one if this cannot be passed.

Washing out the lachrymal sac.—For washing out the lachrymal sac a syringe fitted with a long nozzle is required. The nozzle of the syringe, which has been filled with fluid (water, boric lotion, a weak solution of nitrate of silver, chloride of zinc, formalin, or other weak antiseptic solution), should then be passed along the previously slit canaliculus into the sac and the fluid injected; the patient's head must be bent forwards during the injection, or the fluid will run back along the floor of the nose into the pharynx.

Obliteration of the lachrymal sac.—In some cases of obstinate discharge from the sac, especially if dependent on diseased bone, the discharge may be stopped, and the patient made more comfortable by destroying the sac entirely; of course, more or less watering of the eye will remain after the operation, but this is preferable to the annoyance of a constant purulent discharge.

Obliteration of the sac may be attempted in any of the four following ways. A free incision having been made into it, and the blood carefully sponged out, its lining membrane may be destroyed:—(1) by filling its cavity with a thick paste of chloride of zinc and starch, in equal parts, enclosed in a small piece of lint; (2) by the application of nitrate of silver; (3) by the galvanic or other cautery, or, (4) by a complete dissection of the sac, removing it entirely. By any of these procedures adhesive inflammation is set up, more or less obliteration of the sac following.

Operations for obliteration of the lachrymal sac by the first three methods, are by no means always successful and may have to be repeated, perhaps more than once, before a satisfactory result is obtained.

The Conjunctiva.

But few operations are performed on the conjunctiva alone, it is of course cut in some of the operations on the eyelids and in that for strabismus, and some others.

Warts are occasionally found on some part of the membrane, and should be removed with scissors.

Pterygium is a peculiar, somewhat triangular growth, the base of which is situated in the ocular conjunctiva generally near the inner canthus, the apex encroaching more or less upon the margin of the cornea, or passing for a considerable distance upon its surface. The growth is of a reddish colour and variable density ; it consists of hypertrophied connective tissue.

Pterygium is not common in this country, and when met with is usually found in sailors and others who have been in the East. Should it give rise to any inconvenience or threaten to impair vision it must be removed by operation.

The patient should lie on the couch, the lids be opened by a wire speculum, the growth seized with toothed forceps and with a cataract knife dissected up from the surface of the cornea. An incision should then be made in the conjunctiva parallel with the margin of the cornea, and the apex of the growth fixed by a suture in the wound. The eye should be kept bound up for a few days with an antiseptic pad.

If a pterygium is simply cut off it will, in all probability, grow again, but if transplanted it will shrivel up, and disappear without giving further trouble. A cicatrix always remains upon the cornea after removal of pterygium, so that it should never be allowed to grow over the pupil.

Pinguiculæ are small yellowish growths situated beneath the conjunctiva, generally near the outer and inner margins of the cornea ; they are surrounded by a few large blood-vessels, and are occasionally the source of constant irritation, causing the eyes to be blood-shot and uncomfortable. A pinguicula can be removed, if desired, by making an incision over it, turning back the conjunctiva, then seizing the little growth with forceps, and dissecting it away from the parts beneath. The growth having been removed, the conjunctiva should be closed over the wound by a suture, and the eye kept bandaged for two or three days after the operation.

Lipoma is met with as a tumour projecting beneath the upper lid, near the fornix, and often between the superior and external recti muscles ; it resembles a third lid, and is congenital. If the tumour gives any trouble it must be removed by operation, thus :—The patient lying on the couch, the lids should be kept as widely open as possible by a wire speculum, an incision made with a cataract knife through the conjunctiva over the tumour, and its most projecting portion seized with toothed forceps and removed with scissors ; care must be taken not to drag upon the growth, as it is continuous with the fat in the cavity of the orbit, a great portion of which might be pulled out. As much of the tumour as is thought necessary having been removed, the conjunctiva should be closed over it with sutures, and the eye bound up.

Nævus occasionally occurs in the conjunctiva ; it may be removed by the knife, or destroyed by the galvanic or other cautery, in the latter case due precautions must be taken to guard the eyeball from injury during the operation, and to prevent as much as possible the evils arising from subsequent cicatrization.

Pigmented growths are occasionally met with in the conjunctiva, generally near the corneal margin; they are light brown in colour and flattened, causing but little or no thickening, and can be easily removed with a knife or scissors.

Cancerous ulcers may also be met with; they must be thoroughly extirpated, the eyeball being excised, if necessary.

Cysts containing a clear serous fluid are occasionally met with in the conjunctiva they must be punctured, when they at once subside; they sometimes re-form, in which case a portion of the cyst-wall must be excised, or a fine seton passed through it.

Cysticercus is occasionally met with in the conjunctiva as a bluish pelucid cyst, generally situated in the fold between the eyeball and lower lid, and should be treated by incision of the cyst.

CHAPTER III.

External Muscles of the Eyeball.

Strabismus or squint.—By strabismus or squint is meant that condition of the eyes in which the visual axis of one eye deviates from that of the other, the axes not meeting at the object looked at.

Squints may be divided into two main classes—paralytic and concomitant. It is with the concomitant alone that we are now dealing.

A squint is said to be concomitant when the angle of deviation of one visual axis from that of the other remains the same in every position of the eyes; when no paralysis is present, there is no limitation of movement, and the primary and secondary deviations are equal.

Concomitant squints occur early in life, generally between the second and the fifth years, but no age limit can be fixed to their appearing, except to say that squints in children are most frequently concomitant. The cause of one muscle over-acting is due to the increased innervation of this muscle, since concomitant squints disappear under complete anæsthesia.

To examine a case of squint place the patient in front, and direct him to look straight at you. One eye only is directed towards you, called the "fixing" eye, and the other deviates. Now cover the fixing eye and notice that the deviating eye moves in order to look at you. If you look behind the screen covering the "fixing" eye you will notice that it deviates as much as the squinting eye did at first. This is what is meant when one states that the primary and secondary deviations are, in concomitant squints, equal. If the secondary deviation, that is the deviation noticed when the fixing eye is covered, is greater than the primary deviation, then the squint is not concomitant but paralytic.

Notice if the patient always looks at you with the same eye, or whether he sometimes uses the right and at others the left. If he always uses one eye, that eye has better vision than the other, if he alternates, both eyes have nearly equal vision. The vision in one eye may be so bad that the patient cannot fix an object with it at all.

The fact that no paralysis exists can best be shown by making the patient follow an object which is moved to the right, and to the left, and noticing whether the cornea can be moved as far as the canthus in every direction.

The vision and refraction of each eye separately should be ascertained, and in order to accomplish this atropine drops should be used for all children. In a large number of cases of concomitant squint, an error of refraction, often considerable, is discovered, and also the refraction of one eye frequently differs from that of the other. The wearing of glasses in those cases of strabismus where any great error of refraction exists is imperative, at least for a time.

A point of importance with regard to the prognosis is, whether the patient has binocular vision, that is to say, whether each eye takes part in forming the image which is received by the brain. The image which is seen should be neither the image of the right nor left eye, but an image made up of the two. If the patient complains of diplopia, of course binocular vision is present, but diplopia is rare amongst children with squint.

To ascertain if binocular vision exists, take a square prism and hold it with the apex upwards or downwards, and direct the patient to look at a candle flame placed two or three yards in front of him, he should see two if he has binocular vision, and is sufficiently old to appreciate what is required of him.

Undoubtedly in a large number of squints binocular vision is either very imperfect or absent. By imperfect I mean that by displacing the image of one eye above that of the other diplopia is not obtained or obtained with difficulty. Often further efforts must be made to separate the images, as by putting a red glass in front of one eye and keeping the prism moving in front of the other before the two images can be recognized. If the visual acuity of one eye is much below that of the other, binocular vision will, of course, be bad, but one finds in certain cases defective binocular vision with good visual acuity in each eye. By means of this binocular or stereoscopic vision (as well as by other means) we appreciate the third dimension. If, then, this power in a certain case is not present there is a very much lessened stimulus for the two eyes to work together in a sort of double harness, but each will work irrespective of the other, and it is quite clear that no diplopia will be complained of.

Further, in the treatment of squint, the presence or absence of binocular vision materially affects the prognosis. If present, the chance of good recovery is infinitely greater than if absent. We also find, in some cases, that binocular vision is not present over the whole field, but only over a very small portion, and this area may, by proper means, be considerably extended. Binocular vision may be possible at a distance, but owing to the presence of a divergent squint, associated with defective convergence, is not obtained, on approximating the object looked at, and *vice versâ*. This condition may be entirely absent, possibly due to a congenital defect.

It has been pointed out in a previous Chapter that a squinting eye is often amblyopic.

The existence of some degree of amblyopia in one eye, together with some want of association between convergence and accommodation is undoubtedly the cause of most of the cases of concomitant squint.

In the normal condition of an emmetropic eye a certain amount of accommodation entails a certain amount of convergence, and we generally say that an emmetrope accommodating one diopter converges one metre angle, two diopters two metre angles, x diopters x metre angles; consequently a hypermetrope cannot conform to this condition but accommodates in excess of his convergence, or converges in excess of the proximity of the object looked at. Hence one of two things must happen. The accommodation being used to bring the object into focus clearly, the visual axes of the two eyes do not meet at the object, but between the object and the observer, and the image of the object falling on non-corresponding points of the two retinæ, diplopia or double vision ensues. The other alternative is single but misty vision. In myopia the converse is the case, the accommodation being weak or unnecessary. Convergence is in excess and an effort to relax the convergence produces a tendency to divergence and eventually divergent squint. Although it is unsafe to argue that the relation of convergence to accommodation is the same in ametropia as in emmetropia, still this theory of Donders' is no doubt true in a large number of cases but it is not sufficiently explicit.

A choice has therefore to be made between misty sight and double sight, that is to say, if the visual axes fall on the object the image will be out of focus ; if, on the other hand, the object be focussed accurately double vision must ensue.

The condition of the eyes will decide which of these alternatives will be adopted. If, owing to any cause, such as a high degree of ametropia, opacity of the refractive media, or other cause, clearness of vision is impossible, then no squint will develop, the patient giving up clear vision in order to preserve single vision ; on the other hand, if the object can be seen clearly, then clear vision is preferred and the diplopia overcome, according to Donders, by an active suppression of the image in the squinting eye.

We undoubtedly have power to neglect the image in one eye. In gazing through a telescope, or an ophthalmoscope, or better still a microscope, with both eyes open, many people have the power of entirely neglecting the retinal picture in one eye. The images are of course absolutely different, and no effort is made to fuse them. By an effort, rendered easier by moving the microscope slide, we can perceive one image only.

We do not apprehend all we see, that is to say, a very small part of the image which falls on the retina is appreciated, consequently it does not seem a matter of very great surprise, that in order to avoid a most annoying and muddling diplopia, a child should learn to entirely neglect the image falling on one retina.

But now arises an interesting question, Can this suppression of an image in consciousness lead to such a condition of amblyopia that the patient cannot, even by an effort, with the good eye covered, command good vision? If the amblyopia were due solely or mainly to an active suppression, then the patient would be able to command full vision again.

We are in reality dealing with an amblyopia which depends for its existence upon some cause apart from the squint, and existing previous to the squint, so that the amblyopia is the cause of the squint, rather than the squint the cause of the amblyopia.

Strabismus must not be looked upon as a special form of disease; it is in by far the greater number of cases, as explained above, associated with some anomaly of refraction of which it is only a symptom; other conditions which may induce strabismus will be subsequently considered.

Two forms of squint are commonly met with. 1. Convergent. 2. Divergent. Other rare forms are superior and inferior strabismus; these will receive no further notice.

Convergent strabismus is the most common of all, and hypermetropia or hypermetropic astigmatism is usually present.

Divergent squint is frequently associated with myopia.

Squint may disappear spontaneously, especially if present at birth, and consequently the parents are often told that the child will "grow out of it," no greater mistake can be made, as it is much more likely to grow into it.

The hypermetropic individual must always accommodate when looking at even a distant object; and as the object is brought nearer, the tension of accommodation must be correspondingly increased. Now, the greater the degree of convergence the more strongly is the accommodation brought into play; consequently there is an ever increasing tendency on the part of the hypermetropic individual to converge too much, in order to bring his accommodation into the highest possible state of tension. If the visual lines converge to a point nearer the eyes than the object looked at, convergent strabismus at once results, and no doubt double images sometimes appear which the patients are too young to notice; very soon, however, one eye comes more into use than the other, and its visual line is habitually directed to the object looked at, whilst that of its fellow is directed to a point nearer the eyes "habitual squint." Or the visual lines may be alternately directed to the object "alternating squint." We speak of the eye, the visual line of which is properly directed as the "fixing eye," of that of which the visual line is improperly directed as the "deviating eye." In some cases the deviation is not always present, but only occasionally, when it is called "periodic squint."

The question next arises, Why do not all hypermetropic individuals squint? The reason is that if both eyes are of the same refraction, and have equal acuteness of sight, there is always such a desire to maintain binocular vision that the visual lines will remain directed to the same point, even though the eyes are not accurately accommodated for that point, the individual being content with ill-defined retinal images rather than sacrifice binocular vision by increasing his convergence.

But if vision of one eye is less acute than that of the other, or if there is a difference of refraction between the two, the desire for binocular vision is lost, or its value very much lessened, and the necessity for a well-defined image on one retina is immediately felt, the accommodation is put fully on the stretch, and with it the degree of convergence becomes excessive.

Treatment.—Slight cases of convergent strabismus, especially if the deviation is not constantly present, but only occasionally (periodic squint), may be cured by the constant use of glasses which accurately neutralize the existing hypermetropia.

In more severe cases division of the internal rectus tendon in one or both eyes is necessary. Glasses should be ordered as soon as the child is old enough to wear them, and should be worn constantly. We often meet with cases in which the visual lines remain properly directed as long as the glasses are worn, but squint immediately occurs when they are removed. In such the necessity for wearing glasses for distance may be obviated by tenotomy, and if the patient wishes to go about without them the operation should be performed; if, on the contrary, he is content to wear his glasses constantly, no operation is requisite.

It is often difficult to decide whether only one or both eyes should be operated on.

If it is found that one eye squints habitually and to no great extent, the other being always used for fixing an object, division of the internal rectus of that eye which habitually deviates only is necessary.

If each eye deviates alternately (alternating strabismus), and to no great extent, division of one internal rectus may be sufficient; but if six months after the operation the squint still continues, tenotomy of the internal rectus of the other eye should be performed.

If one eye squints considerably and habitually, or if the deviation, though alternating, is excessive, the internal rectus in both eyes must be divided. In any case, if there is a doubt as to whether one or both eyes should be operated on, it is well to be on the safe side, and do only one at a time.

Operations for convergent strabismus.—There are two principal methods of operating for convergent strabismus.

1. The operator should stand on the right side of the patient, placed in the usual position (fig. 43, p. 246), and the eyelids being kept well open with a wire speculum, should seize the conjunctiva and subconjunctival fascia with the toothed forceps (fig. 53) at a point about midway between the margin of the cornea and semilunar fold, and just below the inferior margin of the tendon of the internal rectus muscle. An incision should then be made with strabismus scissors (fig. 55) through the conjunctiva and subconjunctival fascia, well down to the sclerotic, and the strabismus hook (fig. 54) passed through the opening and inserted between the tendon and the eyeball. If properly introduced the hook will be brought up short at the insertion of the tendon into the sclerotic when it is pulled forwards; it should be held firmly in position, the scissors passed through the opening, one blade following the hook between the tendon and the eyeball, the other being kept outside the tendon, which is thus included between the two blades, and the tendon should then be divided by one or two sharp strokes with the scissors.

The scissors may now be withdrawn, and the hook pulled forwards; if the latter meets with no resistance, but passes freely up to the corneal margin, the operation has been successfully performed; to make sure of this, however, the hook should be withdrawn, the action for hooking the tendon repeated, and any fibres that may have escaped division cut through.

On the division of the tendon the muscle retracts, the retraction being limited by the subconjunctival fascia with which it is intimately connected. If the eye is not properly directed after simple division of the tendon, a greater effect may be produced by further freely severing the subconjunctival fascia.

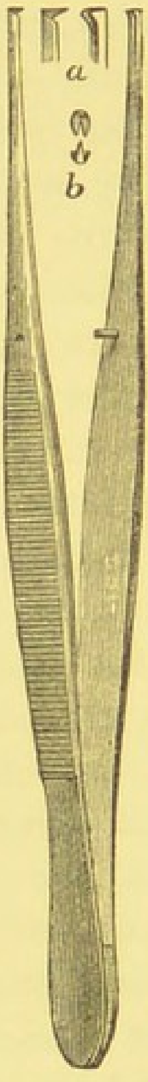


FIG. 53.—Toothed and fixing forceps. *a*, their points shown in side view; *b*, front view.

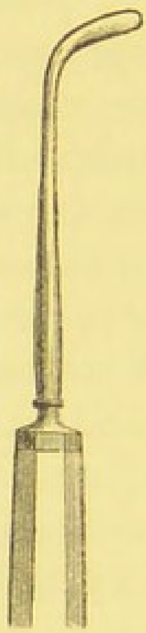


FIG. 54.
Strabismus hook.

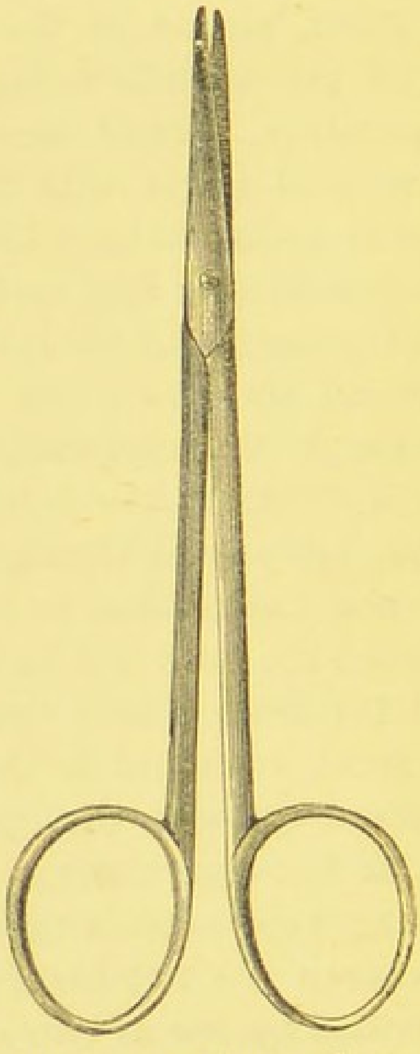


FIG. 55.—Strabismus scissors.

2. In the second operation, the position of the patient and surgeon should be the same, and the lids be kept open with the wire speculum, as in the one already described.

An incision should be made with scissors through the conjunctiva and subconjunctival fascia, over the insertion of the tendon, instead of below its inferior margin; the tendon is then picked up with the strabismus hook, and divided close to the sclerotic. The wound in the conjunctiva should be afterwards closed with a fine suture. Both these operations may be performed from above instead of below, at the discretion of the operator.

No after-treatment is required for strabismus operations; the patient may go about as usual and simply keep the eyes clean. When the eyes have quite recovered from the effects of the operation, if there should be any return of the squint, the degree of hypermetropia must be carefully ascertained, and glasses which thoroughly neutralize it ordered to be used for all purposes. In most cases this will be found sufficient; but if, after the glasses have been perseveringly worn for some months, no effect is produced the operation should be repeated in the other eye.

Use of anæsthetics in operations for convergent strabismus.—Whether anæsthetics should be employed or not in squint operations appears to be a matter of opinion; some oculists never employing them, others again rarely operating without. It is preferable to use an anæsthetic, taking care, however, that a full effect is not produced, and if there is any doubt as to whether one or both eyes are to be operated on, it is best to do one and leave the other for a future occasion; if an anæsthetic is given to such an extent as to exert its fullest influence, and produce thorough muscular relaxation, an erroneous idea of the effect of the operation is likely to be formed, and on the return of consciousness the squint may remain as obvious as ever. Cocaine deadens but does not entirely remove the pain of a tenotomy; a few drops should be injected beneath the conjunctiva—after it has become anæsthetic —just over the insertion of the tendon.

Other conditions than hypermetropia which may produce convergent strabismus are:—

1. Disease of the brain.

2. Paralysis of the external rectus muscle.

3. Inflammatory or other changes in the internal rectus muscle itself, resulting in shortening.

In the first two of these no operation is advisable, the third may sometimes be remedied by operative interference.

Divergent strabismus, as already stated, is often the result of myopia; it is usually consequent on high degrees of the anomaly, and is brought about as follows:—The highly myopic individual requires to bring objects very near the eyes to see them distinctly, consequently a high degree of convergence is necessary to keep both visual lines directed to the same point, and not only has a high degree of convergence to be maintained, but in myopia the length of the eyeball, and the consequent impairment of its mobility place the internal recti at a disadvantage. Consequently, the internal rectus of one eye sooner or later becomes wearied and gives in, and the eye deviates outwards, binocular vision being sacrificed.

Treatment.—Many cases of divergent strabismus may be remedied by the use of concave glasses, which enable the individual to see distinctly at a distance up to which convergence of the visual lines can be maintained without undue strain of the internal recti muscles.

If in spite of the use of glasses the divergence continues, it must be remedied by operation. In cases where the eye only deviates outwards, after an object has been looked at for some considerable time, subconjunctival division of the external rectus of the deviating eye or of both may suffice for a cure; but in cases where one or both eyes diverge constantly, and the visual lines can only be made to meet in one point by a great effort, or not at all, the operation of "readjustment" must be performed.

Readjustment of muscle.—This operation can be performed as follows:—The patient should be placed in the usual position (fig. 43, p. 246) and thoroughly anæsthetised if a child, and cocainized if an adult. The operator standing behind should fix the lids open with a wire speculum, and with strabismus scissors make an incision through the conjunctiva and subconjunctival fascia, below the insertion of the external rectus, hook up the tendon and divide it subconjunctivally close to the sclerotic.

Next an incision should be made through the conjunctiva, about midway between the insertion of the internal rectus and inner margin of the cornea, of such a length as to reach about 3 mm. above and a like distance below the margins of its tendon. The conjunctiva should then be dissected back to a point about one-third of the distance between the insertion of the muscle and the inner canthus. The conjunctival flap so formed, should be cut away in order to avoid wrinkling of the tissues subsequently, but leave the subconjunctival tissue, through which an opening should be made below the tendon, and a strabismus hook passed behind it and the fascia opened upon its point on the other side and the tendon hooked up. Next one blade of Prince's readjustment forceps should be passed under the tendon beside the hook, and the forceps closed so as fix the muscle firmly: the muscle should then be divided close to the sclerotic and the strabismus hook withdrawn.

A curved needle, armed with a fine silk suture, should then be passed through the tendon from within outwards, at a point as far back as possible without passing it through the semilunar fold, the suture drawn through and passed again in the same direction so as to enclose the muscle and fascia in a loop, and so obtain a good firm hold. The needle should now be passed beneath the cut edge of conjunctiva next the cornea through the fascia and a few fibres of sclerotic, and brought out about 2 mm. from the corneal margin. Next a similar suture should be passed in the same way through the other border of the tendon and then through the conjunctiva, subconjunctival tissue, and sclerotic, and a piece of the tendon with the fascia, as far back as possible, without interfering with the hold of the sutures, cut away. One suture should be tied, and as the knot is tightened the eyeball rolled well inwards by an assistant holding the conjunctiva with the forceps close to the outer margin of the cornea. The second suture should then be tightened, any redundant tissue removed, and the ends of the sutures cut oft short. The usual dressing may then be applied.

If the operation has been properly performed a decided convergence should be produced. The dressing should be kept on for a week, at the end of which time the sutures should be removed and a shade worn until all symptoms of irritation have passed away. It is not necessary to divide the external rectus before advancing the internal, but should the effect not be sufficient its division may be required at a later period.

If the operator should require to advance the tendon of the external rectus, the steps of the operation are similar.

Divergent strabismus is met with in cases of paralysis of the third nerve, it may also occur in emmetropic eyes if the sight of one has become much impaired and binocular vision no longer possible, and it may be caused by a too free division of the tissues in the operation for convergent squint. In the first of these cases no operation is advisable, in the second, no improvement of sight is to be expected from re-adjustment, but the operation may be performed simply to remedy disfigurement. In the third, re-adjustment should be performed.

CHAPTER IV.

The Cornea, Sclerotic, and Iris.

The affections of the cornea which require an operation upon the structure itself are six:—1. Sloughing serpiginous and dendritic ulcers. 2. Conical cornea. 3. Corneal opacity. 4. Staphyloma. 5. Lodgment of foreign bodies. 6. New growths.

Paracentesis, or tapping the anterior chamber.—This operation is sometimes performed in cases of sloughing ulcer, or suppuration, threatening perforation, and in cases of increased tension of the eye secondary to irido-cyclitis. By the timely evacuation of the contents of the aqueous chamber, a large rupture of the corneal tissue, with its accompanying evils, may in many cases be avoided.

Tapping the anterior chamber may be done thus:—The patient being in the usual position (fig. 43, p. 246), and the eye under the influence of cocaine, the operator should stand behind, and fix the lids open by a wire speculum or by the fingers; a broad needle should then be passed through the cornea at some convenient part of its margin. When the point of the needle has fairly entered the anterior chamber, its handle should be depressed so that the needle enters the anterior chamber, and is pushed on parallel with the iris. The point must never be allowed to pass deeply for fear of wounding the lens. When the broad part of the needle has entered the anterior chamber it should be withdrawn, and the lower edge of the small wound thus made should be gently depressed, thus opening the valve-like incision. The aqueous humour will run out, a small quantity, however, should always be left so as to keep the iris from the corneal incision.

Iridectomy, however, is to be preferred to paracentesis in most cases.

Conical cornea (staphyloma corneæ pellucidum), as the name implies, signifies an alteration in the curvature of the cornea, of such a nature that it assumes the form of a cone. The origin of the affection cannot clearly be traced.

The most prominent symptom is gradually increasing myopia, which cannot be remedied by concave lenses. On looking at the cornea in profile, its conical form is very evident; but when seen from the front its centre appears as if occupied by a drop of water.

On examination with the ophthalmoscope, by the direct method, the apex of the cone which may, however, be the seat of some opacity, appears brightly illuminated; around this bright portion is a dark ring, which changes its position as the light is thrown from different points, corresponding to the sides of the cone, this being again surrounded by an area giving a bright reflection, and corresponding to a portion of the cornea which retains more or less its normal curvature.

Objects occupying the fundus of the eye are seen through the apex and sides of the cone near its base, in an inverted position, as in myopia, whilst we obtain a more or less distinct erect image of the same, through that portion of cornea which still retains its normal curvature. The retinal vessels appear to have a whirl-like motion as the point of view is changed from side to side. This appearance is quite characteristic, and once seen is not likely to be forgotten.

Treatment.—Conical cornea can only be remedied by operative interference; two methods of operating are practised, the object of each being to flatten the cone, and restore to the cornea its natural curvature.

In one operation an elliptical portion including the whole thickness of the cornea is removed from the apex of the cone. The operation can be performed thus (for the position of patient and operator see fig. 43, p. 246):—Cocaine may be used or an anæsthetic given, the lids should be held open by a wire speculum, and the eye-ball fixed by seizing with the toothed forceps, the conjunctiva and subconjunctival fascia, at some point near the corneal margin. A straight cataract extraction knife (fig. 62*c*) should then be thrust through the cone from side to side, a small flap formed by cutting out either upwards or downwards, and the flap so made seized with iris forceps and removed with knife or scissors.

In this operation the anterior chamber is opened, or the cornea collapses as soon as the first incision is made. Care must be taken that the portion removed includes the most prominent part of the cone, and that the opening left is exactly opposite the pupil.

After the operation, the speculum must be very carefully removed, the lids gently closed, both eyes secured by strapping and bandaged in the usual way; the eyes must on no account be opened for a fortnight, by which time the opening in the cornea should have filled up and the anterior chamber been restored. If healing has taken place, the sound eye may be left uncovered except by a shade, that which has been operated on remaining bandaged for a longer period, but if the wound has not closed, both eyes should be kept bandaged until it has firmly healed.

The margin of the pupil is not unfrequently caught up in the incision, an anterior synechia resulting.

The operation described gives the most satisfactory results, the curvature of the cornea being greatly improved, and a corresponding amount of vision regained.

In the second operation, a superficial portion only is removed from the apex of the cone with a small trephine, a raw surface being left, which by its subsequent cicatrisation and contraction causes considerable flattening of the cone. Or a cicatrix may be formed by using instead of the trephine, a small pointed galvanic or other cautery; the whole apex of the cone should be seared, and a small perforation made in its centre. Whichever method is used cocaine is the only anæsthetic required. In the first of these two methods only the eye that has been operated on need be bandaged; in the second both should be tied up till the anterior chamber has reformed, when the sound eye may remain uncovered, the other eye being kept covered for a week or more longer.

Tattooing the cornea is called for in cases of dense white opacity (leucoma), causing disfigurement. The operation can be performed as follows:—

For position of patient and operator see fig. 43, p. 246. Cocaine having being applied the operator should place the wire speculum between the lids, fix the globe with the toothed forceps, paint some Indian ink upon the opacity, and prick it thoroughly in with a bunch of needles fixed in a handle; the ink should be sponged away from time to time in order to allow the operator to see what progress he has made.

The opacity having been thoroughly tinted, the speculum should be removed, no bandage need be applied, no after-treatment is necessary, and very little irritation follows. If after the lapse of a week or ten days the opacity does not appear sufficiently blackened, the operation may be repeated.

If the ink is allowed to get into the wound made in the conjunctiva by the toothed forceps, a black mark will be left; care should therefore be taken to fix the globe at a point to which the ink cannot run. Should the anterior chamber be opened, the operation must be discontinued, or the lens may be wounded.

Staphyloma, first so-called from its supposed resembance to a grape, has now come to mean a bulge on any part of the eyeball. On the cornea it is caused either by yielding of its structure, or more commonly by prolapse of iris through a perforation in it, the prolapsed portion being firmly coated over with inflammatory material. Staphyloma is said to be "total" where the whole of the cornea is affected, "partial" when some portion of it retains its normal curvature. Total staphyloma should be removed by abscission (*vide* Chap. VI.), or the eyeball eviscerated or excised. Partial staphyloma may subside on the performance of iridectomy, or can be removed as follows:—The position of patient and operator should be as at fig. 43, p. 246, and cocaine applied or an anæsthetic administered. The lids being kept open by the wire speculum, a curved needle armed with fine silk should be passed through the base of the staphyloma, an elliptical portion of which should then be removed with a straight cataract knife, the silk should then be drawn through and tied, thus bringing the edges of the gap made by the removal of the elliptical portion together, and the eye bandaged in the usual way. The suture may be removed in the course of three or four days.

Foreign bodies.—Small fragments of metal, chips of stone, thorns, &c., are not unfrequently found lodged in the cornea. To remove them, the position of patient and operator should be as fig. 42, p. 246. Cocaine having been applied, the lids should be kept open by the fore and ring fingers of one hand, and the globe steadied by gently pressing upon it with the second finger, the foreign body should then be carefully lifted from its bed with the point of a knife or small spud held lightly in the other hand. Foreign bodies, especially thorns, are sometimes so firmly and deeply embedded, that they require to be cut out. In such cases it is best to administer an anæsthetic, and a moderately broad bladed knife should be passed through the cornea so as to go behind the foreign body and prevent it dropping into the anterior chamber during its removal.

New growths may be met with springing from the cornea.

A dermoid tumour is a small white flattened elevation usually situated near the corneal margin, encroaching on both cornea and sclerotic; it lies beneath the corneal epithelium and conjunctiva, and appears to extend pretty deeply into both cornea and sclerotic; the growth is present at birth, but usually increases somewhat as the child grows up. It may give rise to astigmatism by causing distortion of the cornea.

The growth may be single or there may be two or three little tumours. They are composed of connective tissue, and occasionally small hairs grow upon them.

Should the little growths give rise to inconvenience, they can be shaved off level with the cornea, but as a rule they cannot be entirely removed.

Round and spindle-celled sarcomata have also been met with growing from the cornea. Such cases usually call for extirpation of the eyeball.

The Sclerotic.

Sclerotomy as already stated is one of the operations for the treatment of glaucoma. In performing the operation, the position of operator and patient should be as in fig. 43, p. 246. The instruments required are a straight cataract knife (fig. 62*c*), speculum, and fixing forceps. An anæsthetic having been given, the lids should be held open with the speculum, and the eyeball fixed with the forceps. The knife should be entered on the outer side of the globe as far back in the sclerotic as is consistent with entering the anterior chamber quite at its periphery, pushed across the chamber, and brought out at a corresponding point on the inner side. The transfixion having been finished, the incisions should be enlarged to about double the width of the knife blade, which should then be withdrawn, its point being carried round the margin of the anterior chamber so as to notch the parts bounding it, and thoroughly open it, but not cut through the sclerotic. The division of the sclerotic may be made either upwards or downwards; the points of puncture and counter-puncture being situated midway between the horizontal meridian of the cornea and its upper margin in the former case, midway between its horizontal meridian and lower margin in the latter.

The Iris.

Iridectomy or excision of a portion of the iris is an operation which has a very wide range of usefulness and is very frequently required. It is called for in all cases in which it is desirable to influence the tension or nutrition of the eyeball; it is a part of one of the small flap operations for cataract, and in a somewhat modified form is one of the methods of making an artificial pupil, and is useful in some other cases.

Iridectomy is performed (1) to influence tension:—

(*a*) In sloughing ulcers, or suppuration of the cornea, accompanied by pain, and threatening perforation, whether the tension is increased or not. In such cases iridectomy gives almost instant relief to the most severe pain, and will in all probability save the cornea from rupture.

(*b*) In injuries of the eyeball in which the wounded lens has become opaque and swollen, and is pressing on surrounding parts, causing severe pain and increase of tension, thus threatening the integrity of some of the delicate structures of the globe. In such cases, not only does iridectomy diminish tension and relieve pain, but also gives room for any further swelling of the lens.

(*c*) In staphyloma of the cornea iridectomy often causes complete subsidence of the projection.

(*d*) In glaucoma a timely and well performed iridectomy causes instant and lasting diminution of tension and places the eye in comparative safety; the operation should be performed on any eye that can distinguish *bright* light, and in any case, whether there be perception of light or not, to relieve pain; in acute glaucoma it must be tried even if all perception has been lost for some days.

(2) To influence nutrition, iridectomy should be performed in chronic choroido-iritis, recurrent iritis, and in cases of exclusion of the pupil where there is no com-

munication between the anterior and posterior divisions of the aqueous chamber.

(3) Associated with operations for cataract, iridectomy should be performed previous to a needle operation if much swelling of the lens is anticipated; or it may be required after the needle has been used if pain or increase of tension occurs.

(4) Iridectomy for artificial pupil is mentioned at another page.

(5) Other conditions in which iridectomy may be required are:—

(*a*) Displacement of the retina.

(*b*) As an aid to the removal of foreign bodies from the globe.

(*c*) Some peculiar conditions of intra-ocular circulation.

Operation of Iridectomy.

Instruments.—A wire speculum (fig. 49), a straight or bent iridectomy knife or keratome (fig. 56), a pair of toothed forceps (fig. 53), a pair of iris forceps (fig. 57), iris scissors (fig. 58), and a curette (fig. 62*a*). For the position of patient and surgeon see fig. 43, p. 246. The patient should be brought fully under the influence of an anæsthetic, the lids kept widely open by the wire speculum, and the eyeball fixed by seizing the conjunctiva and subconjunctival fascia near the corneal margin with the toothed forceps; then, with a straight or bent iridectomy knife of medium size, an incision should be made in the sclerotic, in such a position that the knife enters the anterior chamber quite at its peripheral part, and close to the anterior surface of the iris.

The knife, having entered the anterior chamber, should be pushed steadily on (care being taken to keep its point well forwards towards the cornea, so as not to wound the lens) until the point is opposite the centre of the pupil. The point should then be turned to one side, so as to be out of the pupillary area, and the knife

FIG. 56.
A keratome.

FIG. 57.
Iris forceps.

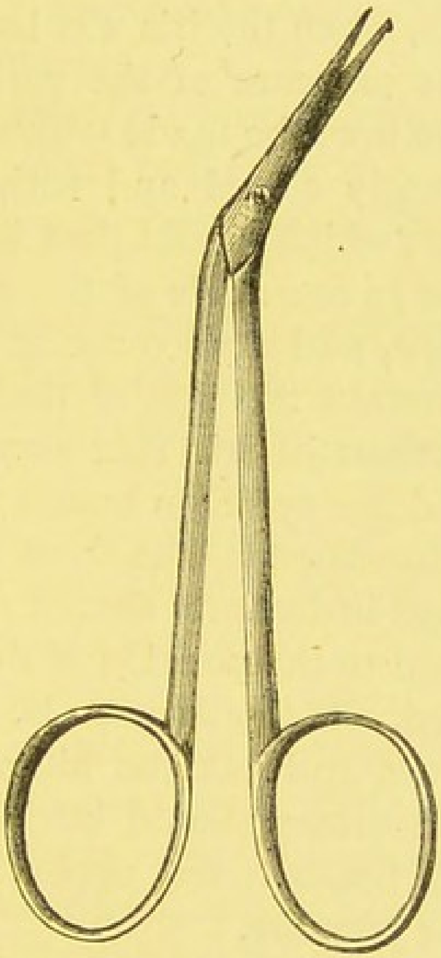


FIG. 58.
Iris scissors.

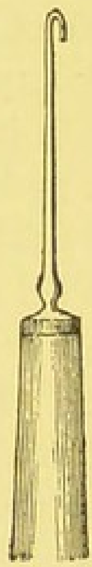


FIG. 59.
Iris hook.

slowly and gently withdrawn, the hold of the forceps being let go at the same time. The incision thus made should be of such a length as to correspond to about one-fourth of the circumference of the iris.

The next step in the operation is the removal of a portion of the iris. If, as is not unfrequently the case, the iris has become prolapsed, it needs only to be seized with the forceps, and a piece of the desired size removed with the scissors. If the iris does not protrude, the iris forceps should be introduced shut, through the wound in the sclerotic, and pushed on until the extremities of their blades are opposite the nearest portion of the pupillary margin; they should then be allowed to open of themselves, when the iris will be pushed between the blades by the pressure of the parts behind; no backward pressure must be made with the forceps, but they should be gently closed and withdrawn, carrying the iris with them, which should then be cut across with the scissors, close to one angle of the wound, drawn over to the other angle, and a piece cut off; the curette should be passed between the lips of the wound so as to push back any portions of iris that may have become entangled in it, and the eye then bound up with an antiseptic pad and a bandage. The form of the pupil after a well performed iridectomy should resemble fig. 61 D.

With regard to the position of the portion of the iris to be removed. If the surgeon be a skilful and experienced operator, and has the aid of a competent assistant, the iridectomy should be done upwards, so as to place the gap beneath the upper lid, and thus conceal it as much as possible.

To perform iridectomy upwards, a keratome knife should be used, and the incision made in the sclerotic above the upper margin of the cornea, an assistant should then draw the eyeball downwards by means of a suture passed through the conjunctiva immediately below the cornea, the iris forceps should be inserted, and the portion of iris removed as previously directed.

An inexperienced operator will find it much easier to remove the portion of iris from its outer and lower segment. In this case a straight iridectomy knife can be used, and no assistant is required. The result is rather an ugly gap, the disadvantage of which, however, is quite counterbalanced by the ease and safety with which the operation can be performed.

Accidents which may happen during the operation of iridectomy, and difficulties which may be encountered.—The accidents which may occur are:—

(1) Wound of the lens from insufficient care in keeping the point of the knife well forward. This accident will, in all probability be followed by the formation of traumatic cataract.

(2) Escape of vitreous humour, is very likely to occur in hard eyes, if the knife be too quickly withdrawn, or if undue pressure is exerted on the globe with the fixing forceps.

(3) The iris may be torn away from its insertion at a point opposite to the incision, if undue traction be exercised upon it with the iris forceps.

Difficulties.—The iris may be found so rigid that it cannot be seized with the forceps, or so rotten that only very small portions can be brought away; sometimes it bleeds profusely when touched, filling the anterior chamber with blood, and considerably hindering the operation.

Artificial pupil.—The operation for artificial pupil is performed to open a new path for rays of light to the retina, the natural passage being obstructed.

It is indicated in the following cases:—(1) In central opacity of the cornea, with or without anterior synechiæ. (2) In closure of the pupil. (3) In central opacity of the lens or its capsule.

The artificial pupil must be small, as nearly central and as well-defined as possible. Care must be taken to make it behind that portion of the cornea which is most transparent and least altered in curvature, the best situation being ascertained by oblique illumination. The new pupil must not be made directly upwards, or it will be covered by the upper lid.

An artificial pupil can be made in any of the following ways:—(1) By incision of the iris (*vide* fig. 61 A). (2) By tearing it away from its insertion. (3) By excision of a portion (iridectomy for artificial pupil), (*vide* fig. 61 B).

In operations for artificial pupil the position of patient and surgeon should be the same as in iridectomy, and an anæsthetic should be administered.

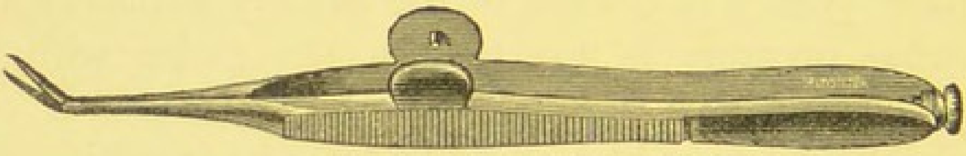


FIG. 60.—Wecker's scissors. (*From* Bryant).

1. *(a) Incision.*—This operation is called for in cases of complete closure of the pupil, following removal of the lens, either by operation or injury, but is not advisable unless the lens is absent. In these cases the iris may be found changed into a tense, unyielding membrane, which cannot be seized with forceps.

The operation of incision may be performed either by thrusting a straight cataract knife through the cornea near its margin, and then incising the iris, so as to cut across its radial fibres, or an incision having been made with an iridectomy knife in the sclero-corneal margin, a pair of Wecker's scissors, fig. 60, (having one sharp and one blunt-pointed blade) may be introduced through the wound, the sharp pointed blade thrust through the iris at its nearest point and passed behind it, the other carried along its anterior surface, and the iris then cut fairly across from one side to the other.

Whichever plan of incision is adopted, the vitreous humour pushes forward into the wound, and keeps its edges widely separated, a pupil resembling fig. 61 A being formed.

There are two other methods of making an artificial pupil by incision known as single and double iridotomy.

For the positions of patient and surgeon in performing either of these operations, see fig. 43, p. 246.

(*b*) *Single iridotomy* should be thus performed :—The eyelids being kept open with the wire speculum, and the eyeball fixed by seizing the conjunctiva and subcon-

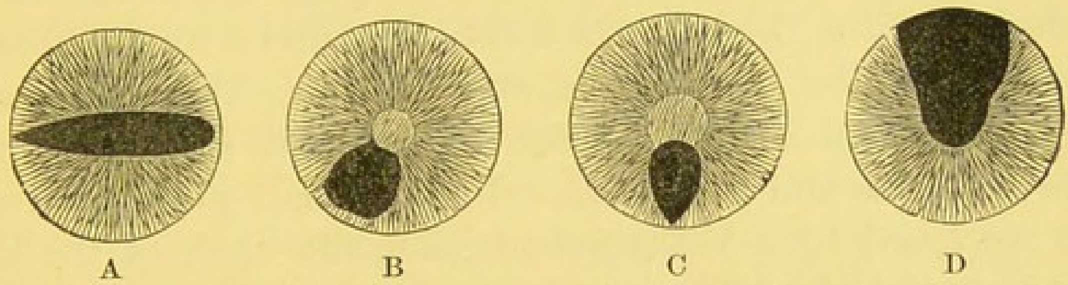


FIG. 61.—A. Pupil after incisions. B. Pupil after excision. C. Pupil made by using iris hook. D. Iridectomy for glaucoma, &c. (*From* Bryant).

junctival fascia, close to the margin of the cornea at its inner side, an incision should be made with an iridectomy knife in the cornea, about midway between its margin and the pupil, and opposite to the point of fixation with the forceps. The scissors (Wecker's, fig. 60) must be then introduced closed through the wound into the anterior chamber, the blades opened, the blunt one passed through the pupil behind the iris, the other on its anterior surface, and the sphincter of the pupil be divided with one sharp cut. The scissors should then be withdrawn, any prolapse of iris that follows replaced with the curette, a drop of atropine placed between the lids, and the eye lightly bandaged.

This operation is applicable in cases where the lens is present, its centre being opaque, and its peripheral portion clear.

(c) Double iridotomy is applicable in cases of closed pupil after cataract extraction. An incision should be made with an iridectomy knife through the upper part of the cornea, the knife carried through the iris and along its posterior surface so as to make a fair sized wound in it, and the incision being finished, the knife should be carefully withdrawn; very possibly, some vitreous humour will follow it.

The next step in the operation is to pass Wecker's scissors closed, through the wound in the cornea into the anterior chamber, open them, pass one blade behind the iris, the other in front of it, make an incision in a direction downwards and inwards, then change the direction of the scissor blades and make a cut downwards and outwards. Thus a small piece of iris is enclosed by a V-shaped incision, the apex of the V being upwards. The small portion of iris contracts up, and a somewhat triangular pupil is left. The eye should be bound up as usual.

(2) *Tearing away the iris from its insertion* (*Iridodialysis*).—An incision having been made through the cornea on the side opposite to that on which the iris is to be removed, a pair of iris forceps should be passed through the wound, and across the anterior chamber, the iris seized close to its greater circumference, and torn away from its insertion; the instrument should then be carefully withdrawn and the eye bound up. If necessary, the whole iris may be removed in this way. This operation is applicable in cases of dense central corneal opacity (leucoma), in which some transparent cornea is left at the margin.

(3) *Excision—Iridectomy for artificial pupil.*—An incision should be made of the requisite size, through some part of the sclero-corneal margin, the iris forceps introduced through the wound, the ends of their blades passed fairly up to the margin of the pupil, the iris seized and drawn out through the wound, and a small portion removed with scissors. The curette should then be passed between the lips of the wound so as to push back any portion of iris that may have become entangled in it; a pupil resembling fig. 61 B should be formed.

Instead of the iris forceps an iris hook (fig. 59) may be used to withdraw the iris from the anterior chamber. A very small incision having been made in the cornea, just within the sclero-corneal junction, the iris hook should be introduced so that the hook lies flat on the surface of the iris; it should be pushed on until the end of the hook is opposite the nearest margin of the pupil, the point of the hook then turned downwards so as to catch the pupillary margin and gently withdrawn carrying the iris with it; when the hook is about to emerge from the wound, it must be rotated so as to turn its loop parallel to the lips of the incision. As soon as the hook has been brought outside the wound, it must be held quite steady, and the piece of iris it carries cut off by a snip of the iris scissors. The curette should then be passed between the lips of the wound to push back the iris which may be engaged in it; the eye should then be bandaged in the usual way. If the operation has been properly conducted, a pupil resembling fig. 61C will be the result.

CHAPTER V.

The Crystalline Lens.

Forms of Cataract.

There are two principal forms of cataract.

(1) *The cortical or soft cataract.*

(2) *The nuclear or hard cataract.*

In the first form the cortical substance of the lens is primarily affected, the nucleus afterwards becoming opaque. the whole being soft, or even fluid.

In the second, the nucleus of the lens becomes hard, yellowish, and opaque; the cortical substance, though some opaque striæ often appear in it about the periphery of the lens, does not entirely lose its transparency until afterwards.

Cortical cataract is met with as an idiopathic disease in childhood and early adult life, and as the result of injury at all ages.

There are several varieties of cortical cataract.

(a) Zonular or lamellar cataract, a disc-shaped opacity occupying the centre of the lens.

(b) Ordinary congenital cataract is a bluish-white opacity of the whole lens.

(c) Traumatic cataract is an opacity of the lens often accompanied by swelling, and caused by rupture of its capsule from injury, and the subsequent action of the aqueous humour upon its substance.

(d) Posterior polar cataract, an opacity commencing at the posterior pole of the lens.

(e) Entirely fluid or diffluent cataract, caused by changes in the lens, secondary to inflammation, syphilitic or otherwise, of the choroid or ciliary body, and often associated with changes in the vitreous. Posterior polar cataract, although commencing at the posterior pole progresses slowly, and after covering its posterior surface at length attacks the anterior surface of the lens, the whole eventually becoming opaque, and a nucleus of greater or less size and density being formed.

The variety of cataract met with in diabetes is composed principally of soft material, but if the patient is advanced in years, there is usually a hard nucleus.

Nuclear cataract occurs in persons who have passed the middle period of life, and is characterized by the presence of a hard yellowish central portion or nucleus of varying size and density; the nucleus is surrounded by more or less soft cortical substance, and is occasionally of a greenish, or almost black colour, giving rise to what is known as *green* or *black cataract*.

Diagnosis of cataract.—The existence of cataract is easily ascertained by oblique illumination, the pupil having been dilated with atropine or other mydriatic previous to making the examination.

Treatment.—The treatment of cataract is entirely operative, no kind of medication being of the least use.

The object of the operation is to open a path for rays of light to pass to the retina. This can be attained in one of two ways, the method adopted depending on the kind of opacity present.

(1) In cases (as lamellar cataract) where the bulk of the lens is clear, the opacity being situated in the axis of the normal pupil, very useful vision is procured by

making an artificial pupil, opposite a transparent portion of the lens (see fig. 61 C).

(2) When the whole lens is opaque, its entire removal must be accomplished.

Two varieties of operation are performed to secure the removal of the whole lens :—

(1) The operation for solution or absorption.

(2) Extraction.

Forms of cataract to which each operation is applicable.—As a broad rule, cataract occurring in persons below twenty is of the soft or cortical form, and should be removed by solution or extraction through a very small flap section ; cataract occurring in persons above thirty (except traumatic cataract) is of the hard or nuclear form, and must always be removed by extraction.

In the intermediate decade a doubt may arise as to what is the best plan of procedure ; in such a case the surgeon must be guided by the general appearance of the cataract, if it appears bluish in colour, and somewhat swollen, it is probably soft and should be removed by solution or extraction through a small section. If there is a distinct yellow reflex from its centre, denoting the presence of a hard nucleus, it should be removed by extraction. It must also be borne in mind that loss of time is a very serious consideration with most patients, consequently preference should always be given to that operation which will allow them to resume their occupations as early as possible.

Solution, though perhaps somewhat safer than extraction, is always a tedious process, and the more so the older the patient, consequently preference should be given to extraction in all cases where the condition of the patient's sight is such as to prevent him following his occupation, even though there is no appearance of a hard nucleus. In cases where the cataract is evidently soft, and one eye retains useful vision, solution is to be preferred to extraction, as the patient can continue at his work during the time that absorption is going on.

Before performing any operation for cataract care should be taken to ascertain that the eye has good perception and projection of light, indicating that the retina is in a normal condition, otherwise no improvement in vision will result from removal of the lens. Before performing extraction it should be ascertained whether or no the cataract is mature. If the lens is entirely opaque, the opacity fills the pupil and is level with its margin. If it is only partially opaque, the opacity will be evidently at a level posterior to the plane of the pupil, though some opaque striæ may be in front of the chief opacity. Oblique illumination causes a dark semicircle to appear upon the opacity at the side from which the light is thrown; it is the shadow of the iris bounding that part of the margin of the pupil. If any red reflex is returned from the fundus when examined with the ophthalmoscope, the cataract is very far from ripe.

Immature cataract should if possible be left alone, but when both eyes are affected, and the patient has no useful vision, extraction in one eye should be performed.

If cataract occurs in one eye only, the other being unaffected, it is best left alone, but in young persons it may be removed as its appearance may interfere with their success in life.

Operations for Removal of Cataract.

Solution.—In the operation for solution the capsule of the lens is opened, and its substance thus allowed to be acted upon by the aqueous humour, by which it is broken up and softened, absorption finally taking place.

The operation should be performed as follows (for the positions of patient and operator see fig. 43, p. 246):— A mixture of cocaine and atropine should be applied so as to cause anæsthesia and dilate the pupil, or the pupil may be dilated before the operation, cocaine alone being used at the time; the operator, keeping the eyelids separated by the fore and ring fingers of one hand, and steadying the globe by pressing the second finger gently upon it, should take a cataract needle in the other hand and pass it obliquely through the cornea at such a distance from its centre that any resulting cicatrix will not interfere with vision; the needle should then be pushed on across the anterior chamber into the area of the pupil, its point then depressed and three or four incisions made in the lens-capsule, so as to divide it freely. Care must be taken to use the needle very gently, and not to pass it too deeply into the lens, otherwise the suspensory ligament may be torn and the lens displaced.

The capsule having been freely divided, the needle should be carefully withdrawn and a drop of solution of atropine placed between the lids; the only after-treatment required is the constant use of atropine, so as to keep the pupil widely dilated. If the operator prefers, the lids may be kept open with a speculum and the globe fixed with forceps, instead of by the operator's fingers.

If the eye is examined in the course of a few days white flocculent lens matter will be seen protruding through the opening in the capsule into the anterior chamber, showing that the lens is swelling and undergoing solution.

It will probably be necessary to repeat the operation in about a month or six weeks, and possibly on one or two subsequent occasions, before the whole lens is absorbed. The process of absorption will occupy five months or longer; capsular obstructions are frequently left. Care must be taken not to do too much at one sitting, or the lens will swell rapidly and press upon the surrounding parts, giving rise to severe pain, iritis, cyclitis, and secondary glaucoma.

Should too rapid swelling occur, the lens must be evacuated by extraction through a very small flap section, or a small incision made with a keratome in the cornea near its margin. It is not necessary to remove the whole lens, but only as much as will run out easily when the knife with which the incision is made is turned across the wound, or a curette introduced between its lips and gentle pressure made on the margin of the cornea opposite. The operation must be repeated if swelling of the remainder of the lens takes place.

Extraction of cataract.—The object of operations for extraction of cataract is the removal of the lens through an incision either altogether in the cornea, the sclero-corneal margin, or partly in the sclero-corneal margin and partly in the cornea; the incision being either simple or associated with excision of a portion of iris.

Extraction can be performed by one of the following methods:—(1) Small flap without iridectomy, (2) small flap with iridectomy, (3) by means of a traction instrument, (4) by suction, and (5) extraction through a very small flap section. In the first method no iris is removed; in the second, iridectomy should be performed either at the time of removal of the lens or some weeks or months previously. In the fourth and fifth, iridectomy is not necessary unless the iris prolapses through the wound and will not remain in the anterior chamber if returned.

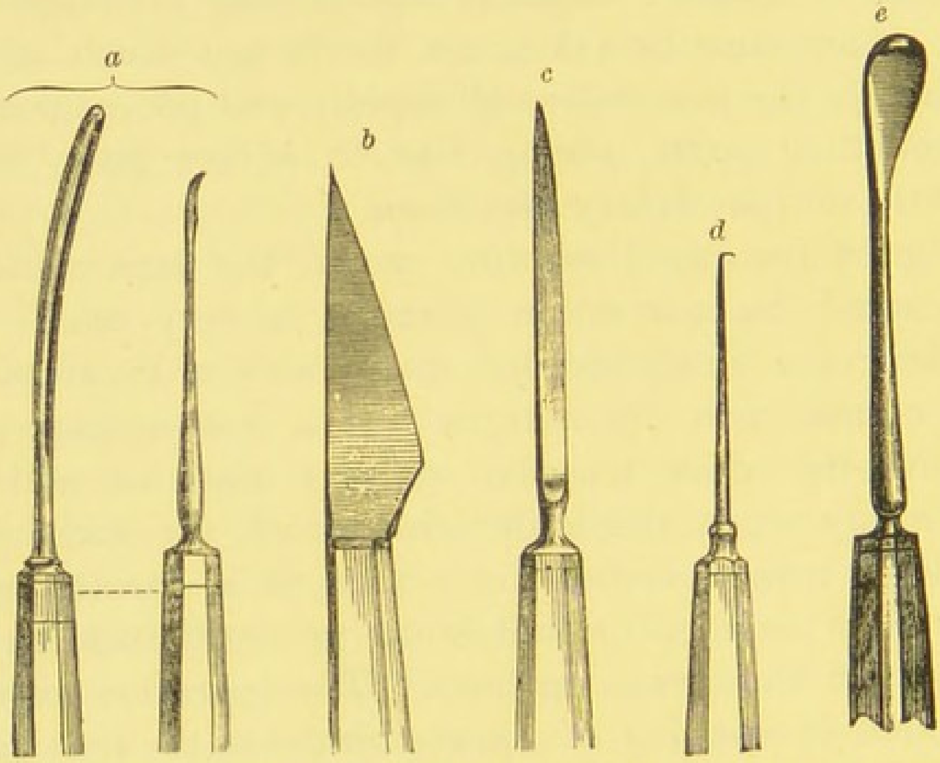


FIG. 62.—Instruments for extraction of cataract. *a*. Curette and pricker. *b*. Triangular cataract knife. *c*. Straight cataract knife (Graefe's). *d*. Sharp hook. *e*. Scoop. (*From* Bryant).

Formerly it was the practice of most ophthalmic surgeons to extract all forms of cataract through an incision associated with iridectomy, performed either at the time of extraction or some weeks or months before. The lens will escape much more readily through a moderately large iridectomy than through the pupil, and the practice was no doubt correct in the days of general anæsthetics, where accidents were likely to happen from the patient not being kept fully under the influence of the anæsthetic, from vomiting or from some unfavourable or alarming symptom arising, necessitating the rapid completion of the operation; but since cocaine or other local anæsthetics have come into almost universal use the operator can take whatever time he likes over his operation, and the necessity for the removal of a portion of the iris no longer exists, except in those cases where, owing to the presence of synechiæ, or other cause the pupil will not dilate, or where there is increased tension.

Some surgeons, however, still make the performance of an iridectomy their rule.

A traction instrument should be used in any case where great difficulty is encountered, or where escape of vitreous has taken place before the lens has been extracted. The methods (4) and (5) are applicable to quite soft or fluid cataract only.

Extraction of cataract can be performed under cocaine in all patients possessing ordinary fortitude; but nervous, fidgety subjects should be brought fully under the influence of an anæsthetic. If cocaine is used, and an iridectomy is to be performed, a small quantity of the solution should be introduced into the anterior chamber by passing the curette through the wound and allowing the solution to run along its groove; in a few minutes the iris will become deadened, and iridectomy can be painlessly performed; cocaine applied to the conjunctiva alone does not deaden the iris.

Small flap, without iridectomy (fig. 63).—The instruments required are a Graefe's cataract knife, a sharp hook and curette (fig. 62 *c*, *d*, *a*).

For the position of patient and surgeon see fig. 43, p. 246.

No speculum is used, a fine suture is passed through the conjunctiva immediately below the corneal margin, the patient is directed to look downwards, and the eye-ball held in the desired position by an assistant pressing a finger upon the suture on the patient's cheek.

The operator holds the upper lid out of the way with the forefinger of the hand not using the knife (left for right eye, right for left eye), and steadies the globe by pressing the middle finger of the same hand upon it near the inner canthus.

The incision is made by passing the Graefe's knife through the sclero-corneal margin on the outer side, at a point (puncture) situated about the junction of the

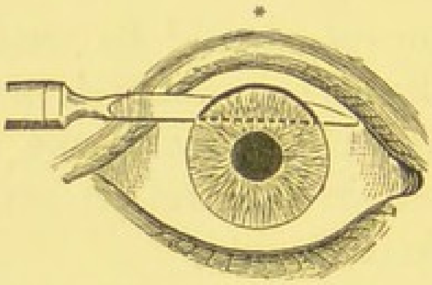


FIG. 68.—Small flap incision for extraction of cataract.

upper and middle thirds of the cornea, into, and across the anterior chamber, out at a corresponding point on the inner side (counter-puncture), and then cutting by a sawing movement through the corneo-scleral margin upwards, the incision being finished by turning the edge of the knife slightly forwards and cutting out rather within the corneal margin.

In entering the knife and passing it across the anterior chamber, care should be taken to keep its surfaces parallel with the iris until the incision is about to be finished; if the knife is rotated in any way after the anterior chamber has been opened, the aqueous humour will escape,

* The flap is shown rather too small.

and the blade become entangled in the iris. As soon as the incision is completed the assistant should let the suture go.

The capsule should next be lacerated by scratching it with a sharp hook, and the lens removed by gently pressing on the eyeball at the lower margin of the cornea aided by gentle counter-pressure near the opposite margin. The pressure can best be made with the thumb of one hand, and the forefinger of the other, placed upon the surface of the partially closed lids. If any difficulty is experienced in pressing out the lens with the fingers, the curette should be pressed at first upon the cornea near its lower margin, and as soon as the wound begins to gape, should be made to gently stroke the cornea in the direction of the incision, and follow the lens in its exit until its equator has passed out, when the remainder will usually follow without further pressure. Should the lens stick, its delivery may be hastened by fixing the hook into it and drawing it gently out.

The bulk of the cataract having been removed, care must be taken to get away any soft cortical substance or fragments of lens that may be left. The soft matter can be removed by gently rubbing the cornea through the lid with the finger, first in a rotatory direction from the circumference towards the centre, so as to press any cortex that may be concealed behind the iris into the pupil, then in the direction of the incision; small hard fragments should be drawn out by the curette, or a small scoop. The whole of the cataract having been removed, the iris, which will in all probability have somewhat prolapsed, should be replaced by gently rubbing the upper lid upon the cornea, or with the curette, and the suture removed, the patient allowed to look about, and the eye well exposed to light to make the pupil contract. In some cases the pupil will not dilate sufficiently to allow of the escape of the lens, in such, no prolonged effort should be made, but the eye be fixed by the suture as already described, and iridectomy performed, the operator keeping the upper lid out of the way by the third finger of the hand that holds the iridectomy forceps. Both eyes should be carefully bandaged.

Small flap with iridectomy can be performed exactly as described in the previous operation, where it is found necessary to perform iridectomy; or the lids being kept open by the wire speculum, the eyeball fixed by seizing the conjunctiva with the toothed forceps, or by a suture inserted just below the cornea, a flap section should be made in exactly the same way as detailed above.

If iridectomy has not been previously performed, the globe should be drawn down and fixed by the suture, and a piece of the iris corresponding in width to a moderately dilated pupil should be excised from the upper segment (see Iridectomy).

The next step is to lacerate the capsule. The operator should fix the eye, and draw it gently downwards with the toothed forceps, then introduce the sharp hook through the incision, freely lacerate the capsule, remove the cataract by making gentle pressure with the curette upon the eyeball, near the lower margin of the cornea, the globe being steadied and held in position by fixing the conjunctiva with the toothed forceps, or by suture.

The nucleus and bulk of the cataract having escaped, the curette should be passed gently over the surface of the cornea from all directions towards the incision, so as to press out any cortical substance that may be left, and if any blood or portions of lens remain in the incision they must be carefully removed, so as to insure perfect coaptation of its margins; the speculum should then be removed, and both eyes bandaged in the usual way.

The section, both in this and in the previous operation, may be made either upwards or downwards, and the point of transfixion should be so arranged that the flap should consist of about one-third of the upper or lower part of the cornea.

The same objections apply to extraction downwards with iridectomy as to iridectomy in the same direction, but the results obtained are equally good as from upward sections and the ease with which the operation can be performed quite counter-balances any objections which may be made on the score of disfigurement.

Extraction of cataract by a traction instrument.—Cataract can be removed by a traction instrument, through a flap section preferably associated with iridectomy.

Cocaine having been applied or a general anæsthetic given, the eyelids should be kept open with the speculum, and the globe fixed with the toothed forceps, while the section is made and during the subsequent removal of the lens.

The traction instrument employed is either a scoop or a sharp hook (fig. 62 *c*, *d*).

Removal of cataract by the scoop (scoop extraction).—Scoop extraction can be accomplished thus:—The section having been made, as described above, and iridectomy performed, the convex surface of the scoop should be pressed gently upon the more peripheral margin of the incision, so as to cause it to gape somewhat; the instrument should then be passed with the utmost gentleness through the incision, beneath the margin of the lens, along its posterior surface and beyond its posterior pole, until the lens lies well in its concavity, and it should then be carefully withdrawn, carrying the cataract with it, the removal being assisted by gentle pressure on the exterior of the globe. In this operation the lens is removed in its capsule.

A wire loop designed by Dr. Bell Taylor may be used instead of, and in the same manner as, the scoop to which it is to be preferred.

Removal of cataract with the sharp hook (sharp hook extraction).—The hook should be passed well behind the lens in the same manner as the scoop, fixed into its posterior surface, and then carefully withdrawn, carrying the lens with it. Two sharp hooks may be used instead of one, and should be fixed into the lens at different points, so as to prevent it rolling round (as sometimes happens when only one hook is used), instead of passing in the desired direction.

After removal of the lens by either method both eyes should be bound up in the usual way.

Suction.—The removal of the cataract by suction is a proceeding highly recommended and often practised by some surgeons. As far as my own practice is concerned I have long given the operation up. It is said to be useful in cases where the lens has become nearly or entirely fluid, as occurs in many instances of traumatic cataract, or after a needle operation has been performed. Such cases are, however, best treated by extraction through a very small flap section.

The instruments required are a wire speculum, toothed forceps, broad needle, and suction tube (figs. 64, 65). Before operating the pupil should be well dilated with atropine. (For position of patient and surgeon see fig. 43, p. 246).

The eye must be cocainised or the patient placed under the influence of an anæsthetic. The lids should be kept open by the wire speculum, the eyeball fixed by the toothed forceps, and a small incision made in the cornea with the broad needle, about midway between its summit and margin, in any convenient position.

FIG. 64.—Needle for making incision in suction operation. (*From* Bryant).

The operator should then place the mouth-piece of the suction tube in his mouth, pass its nozzle through the incision and behind the softened lens, and, by sucking gently, remove as much lens matter as will come away easily. No force must be used, and if any portion of the lens is too hard to pass easily into the tube it may

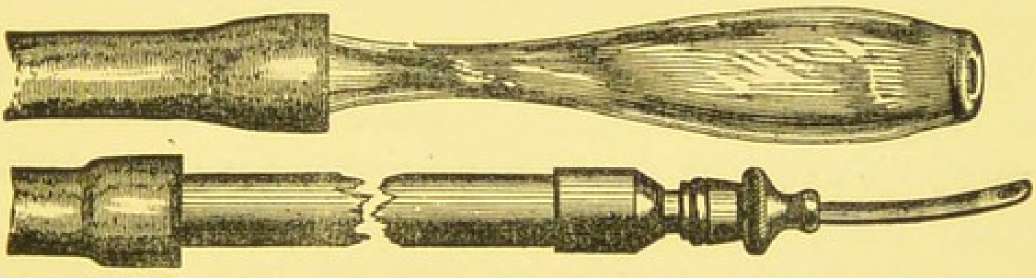


FIG. 65.—Suction tube. The mouth-piece and nozzle are here shown, they are connected by about 18 inches of rubber tubing. (*From* Bryant).

be left to become absorbed or be dealt with on a future occasion. When as much lens as will easily come away has been extracted the suction tube should be removed, the speculum taken out, a drop of solution of atropine placed between the lids, and the eyes bandaged in the usual way. The bandage should be continued, and the pupil kept dilated with atropine, until all irritation has subsided.

Extraction through a very small flap section.—A flap rather more than half the size of that shown at fig. 63, should be made in the same manner as described under small flap extraction. Slight pressure on the globe close to the corneal margin at a point opposite the section, aided, if necessary, by the curette placed between the lips of the incision, will readily effect the escape of any soft lens, and the necessity for introducing the suction tube and the danger of too hard sucking are avoided. Iridectomy should be performed if the iris prolapse and will not remain in its proper position when returned. Eserine should be dropped into the eye immediately after the operation so as to draw the iris away from the wound, and the eye bandaged. As soon as union has taken place (in about 24 to 36 hours) atropine and vaseline should be smeared on the lids and on a piece of lint covering them so as to dilate the pupil and prevent adhesions taking place if iritis supervenes.

Before proceeding to remove the lens by either of the two last methods, the capsule if not previously ruptured should be freely torn up with the sharp hook. In any case, if the soft lens matter does not readily escape, thoroughly stirring up with the hook will much facilitate matters.

Accidents during Extraction of Cataract.

Premature escape of aqueous humour.—If care is not taken in making the section the aqueous humour may escape too soon, and the movements of the knife be hampered by the iris being pushed forwards. Should this happen, the knife must be carefully withdrawn and the section completed with scissors, and if the iris has been badly wounded, iridectomy should be performed.

Bleeding into the anterior chamber.—In some cases hæmorrhage from the cut iris or conjunctiva takes place to such an extent as to fill the anterior chamber with blood and hide the cataract entirely from view.

If the blood does not flow out easily on placing the curette between the lips of the incision and making gentle pressure on the cornea the operation should be discontinued, the eye bound up and left till the blood has become absorbed, unless the lens capsule has been lacerated, in which case the lens *must be removed at all risks*, or it will swell, press upon surrounding parts, set up inflammatory action, cause increase of tension of the globe, and very probably lead to destruction of the eye.

Prolapse of vitreous humour.—If undue pressure is exerted on the globe during extraction the suspensory ligament of the lens gives way and a prolapse of vitreous follows. Should the prolapse of vitreous occur before the escape of the lens, the cataract should be removed as quickly and gently as possible by the aid of a traction instrument.

Prolapse of vitreous is more likely to occur if the humour is abnormally fluid. The accident may give rise to no bad results, but is sometimes followed by a form of chronic choroiditis which ultimately destroys the eye. If a very large escape of vitreous occurs the eyeball will collapse, or it may become filled with blood, in either case it should be excised without delay.

If vitreous has been lost great care must be taken that none remains between the lips of the incision ; perfect coaptation having been secured the eye must be firmly bandaged so as to keep the lids immovable, and prevent further prolapse.

Displacement of the cataract.—In some cases, on an attempt being made to press out the lens, the suspensory ligament gives way, and the cataract, instead of coming forwards into the anterior chamber passes behind the iris or sinks backwards into the vitreous chamber; it should, if possible, be removed by the scoop, loop, or sharp hook. If left within the globe it will probably act as a foreign body, set up inflammation, and destroy the eye.

After-Treatment of Extraction of Cataract.

As soon as the extraction is completed, whatever form of operation has been performed, the eye should be thoroughly cleansed by allowing a stream of two per cent. boric acid lotion to flow freely over it from small swabs of absorbent cotton-wool (no sponges should ever be employed). Any blood or mucus being carefully wiped off with the swab; all superfluous moisture should be soaked up and the eyelids carefully dried with wool.

Both eyes should then be covered with a pad of sal alembroth gauze and wool, Gamgee tissue, or any other antiseptic dressing. A single pad should be used for both eyes, a notch being made in the centre for the nose. The pad should be secured by one of the bandages, which have been designed for the purpose. I always use what is known as a Dunnage bandage, consisting of a piece of soft cotton bandage long enough to reach from a point about midway between the outer canthus and the external auditory meatus on one side, to a corresponding point on the other, to the ends of which are attached loops of tape sufficiently large to go round the ears, strings of tape being again looped to these long enough to go easily round the head. The bandage should be laid smoothly over the dressing, the loops comfortably fitted round the ears, supposing that the ears are in the right place which is not always the case, for they are often too low down, when the loops instead of going round them have to be used as a single string and passed above. The strings should next be brought round on to the forehead, drawn as tight as is comfortable to the patient, and tied in a knot above the brows. When the bandage has been secured the lower edge of the dressing should be raised in order to see that the eye is closed. Not unfrequently, the eye being still under the influence of cocaine, may be open under the dressing without the patient being aware of it, the anæsthetised cornea may sustain some loss of epithelium and consequent superficial ulceration from rubbing against the gauze or other dressing.

When the dressing has been finished the patient should be put to bed, where he should remain for four days.

On the day following the operation, the eye should be examined by simply raising the dressing ; if there is no dried discharge sticking to the lids, and the patient feels comfortable, the dressing may be left for another twenty-four hours ; but if the lids are covered by dry secretions and there is a flow of mucus, or other discharge from between them, and discomfort is complained of, the dressing should be removed and both eyes carefully and thoroughly bathed, with warm boric acid lotion. If it has not been found necessary to remove the dressing on the first day it should be removed on the second and each succeeding day, and the eyelids thoroughly cleansed as already described.

If the lids remain in a normal condition, we may rest assured that all is going on well; and opening the eye too early can do no good and may do a great deal of harm. On no account should the eye be examined until the end of the first week.

At the end of a week the eye may be opened and its condition ascertained. Should the section be healed, the anterior chamber re-established, and no signs of inflammatory action present, the sound eye can be safely left uncovered, the one that has been operated on being kept bandaged with an antiseptic pad, and a large green shade worn over both. At the end of three weeks the bandage may be removed from the eye on which extraction has been performed, but the shade or protectors should be worn until all undue vascularity has subsided.

At the end of about two months (if there is no intolerance of light or irritability of the eye) glasses should be ordered, two pairs being given; one for going about, and one for reading; convex 13 D will usually be found nost suitable for the former purpose, convex 16 D for the latter. Should the patient have been myopic or hypermetropic before the operation, glasses weaker or stronger than these will be required. In many cases a rather high degree of astigmatism may be found, caused by flattening of the cornea, as a result of the cicatrization at the wound. A + cylindrical glass of about 1·5 or 2, placed with its axis parallel to the wound, generally corrects this astigmatism.

This is the usual course of cases of extraction of cataract; all do not, however, go on so favourably.

A day or two after the operation the patient may complain of severe pain in the eyeball, temple, and brow, and on removing the dressings the lids may be found puffy and red, or perhaps much swollen.

These symptoms always indicate inflammation of some of the ocular structures. Slight puffiness without pain, and with slight mucous or muco-purulent discharge, means only conjunctivitis, need occasion no anxiety, and only requires bathing with hot boric acid lotion once a day. Redness and swelling of the margin and surface of the lid, mean iritis; leeches (three to six) should be applied to the temple, and small doses of mercury (gr. ij. of pil. hydrarg., gr. $\frac{1}{2}$ of pulv. opii, three times a day) should be given; the eyelids should be well smeared with vaseline containing gr. viij. of sulphate of atropine to ℥j., and lint well covered with the same should be bandaged over the eye instead of the antiseptic pads. Iritis will probably proceed to a favourable termination, but may cause partial or complete blocking of the pupil. In some cases irido-cyclitis or irido-choroiditis may be set up and eventually destroy the eye.

Great swelling of the lids (the hollow between the margin of the orbit and lids being filled up) means that suppuration has commenced in the cornea, or that a suppurative inflammation of all structures of the eye except the sclerotic (panophthalmitis) has been set up.

The suppuration commences at the incision, may destroy a portion of the cornea next it, and then stop leaving the greater part of the cornea clear. It may destroy the cornea entirely, or go on to panophthalmitis; in both these latter cases the eye as a visual organ is lost, but it may quiet down and keep more or less its natural curvature, or shrink. An eye lost after cataract extraction, from whatever cause, must always be looked upon as an eye lost from injury, and must be excised if symptoms of irritation occur in its fellow, or that too may be destroyed by sympathetic ophthalmitis.

Suppurative inflammation is best treated by fomentations, sedatives to relieve pain, good diet, and a moderate amount of stimulants. When panophthalmitis is fairly set up, a crucial incision should be made through the cornea or its remains, and hot boric fomentations applied.

A not uncommon cause of pain and irritation after cataract extraction, is the occurrence of entropion of the lower eyelid; this must be remedied by operation (see Operations on the Eyelids).

Causes of unsatisfactory results of cataract operations.—The success of an operation for removal of cataract may be marred by partial or complete closure of the pupil following iritis, by obstruction of its area with opaque lens capsule, or capsule thickened by inflammatory products, by opacity in the vitreous, or by a chronic form of keratitis causing more or less permanent corneal opacity.

Closure of the pupil can be remedied by iridectomy; in bad cases the operation may require to be repeated, and we should never give up hope of restoring some sight, *provided the perception of light remains.*

Capsular obstructions can usually be torn through with cataract needles. Any needle operation can be performed with the eye under the influence of cocaine. If only a thin film of capsule is present it can easily be torn through in the following manner:—The pupil having been dilated as much as possible with atropine, the lids held open with a wire speculum, the eye fixed with the toothed forceps, a cataract needle should be passed through the cornea near its margin at any convenient point, and pushed on across the anterior chamber to the middle of the pupil. If two or three cuts are made in the opaque capsule, the vitreous will push through the rent and keep open a clear pupil; some more atropine should be dropped into the eye and a bandage applied for a few days. It may be necessary to repeat the operation.

Denser opacities cannot be dealt with quite so easily. They can, however, be torn asunder with two needles:—One needle having been introduced as described, and pushed through the opaque membrane, should be held steadily in position, a second needle should then be passed from the opposite side of the cornea, and pushed through the capsule close to the first; the needle points should then be separated, when a rent will probably be made. If a satisfactory pupil is not obtained by simply separating the needles, one may be rotated round the other so as to roll up the capsule, the two should then be separated as widely as possible. Care must be taken not to push the needles deeply into the vitreous, or stir it up too freely.

After the operation, atropine should be instilled, and the eye bound up.

Very dense membranes cannot be torn by needles. They may be cut across with scissors (see Iridotomy), or in very bad cases removed with forceps.

The greatest caution must always be exercised in meddling with opaque capsule. Simple needle operations rarely do harm if ordinary gentleness is used, but forcible tearing and especially attempting the removal of capsule with forceps are liable to be followed by secondary glaucoma, severe iritis or cyclitis, or even by panophthalmitis.

Nothing can be done to remedy vitreous opacities; they are sometimes associated with a retinal detachment. Keratitis should be treated by sedative fomentations and atropine, and any constitutional treatment that may appear indicated adopted; it is often of gouty origin; its course is extremely chronic, and it is very rebellious to treatment.

CHAPTER VI.

Extirpation of the Eyeball—Abscission and Evisceration.

Removal of the eyeball is called for under the following conditions:—

1. In all cases of injury causing complete disorganisation, with collapse of the globe and escape of its contents.

2. In cases where one eye, having been damaged by injury or disease to such an extent as to render it *practically useless* (more especially if the presence of a foreign body be suspected), becomes irritable or painful, and the sound eye appears threatened by sympathetic ophthalmia.

3. In cases where an eye lost from injury or disease, and *quite blind*, is a source of annoyance, even though the other eye be not threatened.

4. In cases where the globe has become the seat of malignant disease.

5. In some cases, even when the eye is sound, to render possible the removal of an orbital tumour.

Extirpation of the eyeball should be thus performed (for position of patient and operator see fig. 43, p. 246). The instruments required are a wire speculum, toothed forceps, a pair of blunt pointed scissors, curved on the flat (fig. 66) and a strabismus hook. The patient being thoroughly under the influence of an anæsthetic, the operator should place the wire speculum between the lids, then by the aid of the forceps and scissors, cut through the conjunctiva all round the cornea as close to its margin as possible; he should then, with the strabismus hook, take up the four recti muscles, one after the other, and divide them with the scissors, either the external or internal rectus being cut at a little distance from the globe, so as to afford a hold for the forceps in the subsequent steps of the operation, and the other three muscles as close to it as possible.

The muscles having been divided, the hook should be made to sweep round the globe, so as to be sure that nothing is left uncut. By pressing the speculum backwards the eyeball will become dislocated in front of the

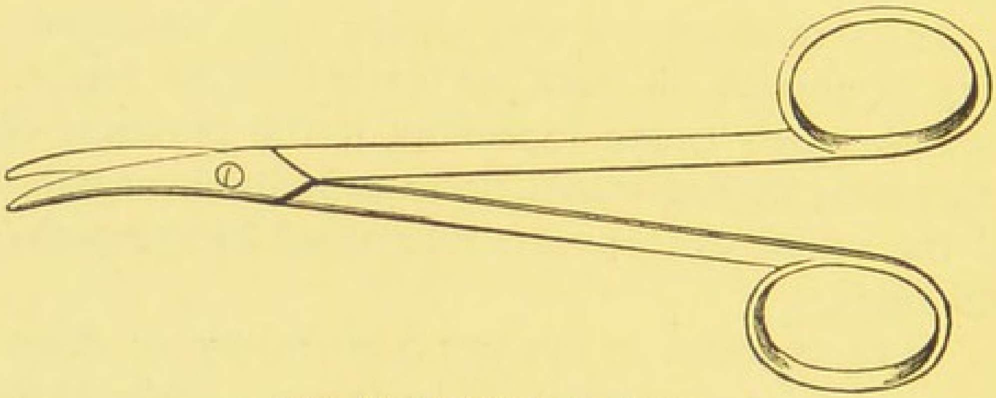


FIG. 66.—Extirpation scissors.

lids; it should then be steadied by holding the piece of muscle purposely left, with the forceps, the scissors should be passed behind it at the inner side, until their points are found to be in contact with the optic nerve, then slightly withdrawn, opened widely, pressed forwards again, and the nerve divided by a single cut.

As soon as the nerve has been cut through, the eyeball will be almost free, being held only by the oblique muscles, which should be divided close to the sclerotic. Should there be free hæmorrhage the speculum may be left between the lids, a piece of lint soaked in boric lotion, pressed firmly into the orbit, and secured by a turn of bandage ; when all bleeding has ceased the lint should be removed with the speculum, and two small pads of wet lint and a bandage applied. Should the hæmorrhage be but slight, two or three small pads of lint, wet with boric acid lotion, should be laid over the closed lids, and secured by a bandage in the same manner as in other operations on the eye. The patient may get up and go about as usual on the day after the operation. The dressing should be applied fresh every day for a week, after that a shade should be worn till an artificial eye can be inserted. In about a month or six weeks an artificial eye may be ordered.

Fitting an artificial eye.—The fitting of an artificial eye may be left to the eye maker. As a rule the tissues of the orbit should be allowed to heal firmly, which will have taken place in the time specified (a month or six weeks), but cases sometimes occur in which it is necessary that an artificial eye should be inserted very much sooner, and it is well to remember that it is possible, though not advisable, to excise the eyeball, and replace it by an artificial one as soon as the bleeding has stopped. Thus, a person may be so circumstanced that he or she is obliged to have an eye removed, which although sightly, does not see, and has to appear before the world again very shortly with no sign of mutilation.

The usual practice is to insert an eye which is too small at first, and in the course of a few days replace it by a larger one, which should be worn for a short time longer, and then be replaced by one as large as can be comfortably worn. The surgeon should always see his patient after the artificial eye maker has done with him, and if not satisfied with the result should send him back for another eye to be made. The artificial eye should be removed at night and thoroughly cleaned, and replaced in the morning.

To insert the artificial eye, draw down the lower lid, push the eye beneath the upper lid till its lower edge is well within the border of the lower lid, then let the lower lid return to its natural position. To remove it, draw down the lower lid until the edge of the eye becomes exposed, then with the finger-nail, a hair-pin, small spud made for the purpose, or any suitable article that may be at hand, lift the edge of the eye over the margin of the lid and allow it to slide out on to the cheek.

It is well to carry out these manipulations over a bed or sofa, as the eye is very likely to be let fall, and will break if it comes in contact with any hard substance.

An artificial eye wears out in from twelve to eighteen months.

Abscission.

Abscission is the removal of the portion of the eyeball (including the ciliary region) situated in front of the attachments of the recti muscles, these being left intact. The object of this operation is to leave a movable stump, on which an artificial eye can rest and be moved in harmony with the movements of the sound one.

Abscission is indicated in staphyloma occupying the whole or greater part of the situation of the cornea, the remainder of the globe retaining its normal curvature.

The operation should be thus performed (for position of patient and operator see fig. 43, p. 246). The instruments required are a wire speculum, toothed forceps, strabismus scissors, a triangular cataract knife, a curved needle and silk. The patient being thoroughly under the influence of an anæsthetic, the wire speculum should be placed between the lids, the conjunctiva divided all round close to the corneal margin (as for extirpation) and dissected back nearly as far as the insertion of the recti muscles.

Then with the curved needle a single suture should be passed through the edge of the divided conjunctiva at five or six different points, so as to surround the wound in it in much the same manner as the string surrounds the mouth of an ordinary bag, and the ends of the silk left hanging on the patient's face.

The staphyloma, the whole of the ciliary body and sclerotic corresponding to it, should then be removed by transfixing the globe with the triangular knife, just in front of the insertions of the internal and external recti muscles, cutting out upwards in front of the insertion of the superior rectus and the removal completed by cutting downwards just in front of the insertion of the inferior rectus.

The silk should then be drawn up and tied, by which means the conjunctiva will be made to cover the wound in the globe, and an antiseptic pad and a bandage applied. Some reaction often follows abscission, and a good deal of swelling of the lids and conjunctiva may occur. The patient should be kept in bed for two or three days, fresh dressings should be applied daily for a week, after which a shade only is required.

As soon as the parts have firmly healed (in the course of six weeks or two months) an artificial eye may be worn.

Abscission should be performed in preference to excision of the globe in children; the presence of the stump left prevents to a great extent the shrinking, or non-development of the orbit, which would occur if the eyeball were removed entirely. In older persons excision is generally to be preferred, as the stump left after abscission is liable to become troublesome, and in the very old is prone to suppurate.

EVISCERATION.

Abscission is rapidly being, and I think should be entirely, replaced by "evisceration" of the globe, an operation which will also probably take the place of excision in a large number of cases, possibly in all except those of malignant disease.

Evisceration is performed as follows:—The position of patient and operator should be as at fig. 43, p. 246. The instruments required are a needle armed with silk, fixing forceps, speculum, triangular cataract knife, excision scissors, a piece of india rubber tubing about four feet long to act as a siphon, and a vessel containing a solution of boric acid (gr. x. to ℥ j.).

The patient having been anæsthetised, the conjunctiva should be divided all round, close to the cornea, as for excision. The cornea should then be separated from the sclerotic by cutting all round the sclero-corneal junction with the triangular knife; the iris, ciliary body, and choroid, with the retina and vitreous enclosed, should then be removed by passing the excision scissors carefully between the choroid and sclerotic all round the interior of the globe, the sclerotic being meanwhile held by the cut margin with the fixing forceps. These parts may often be removed as a whole; if the choroid tears, any portions left should be brushed out with pieces of cotton-wool held in another pair of forceps; this must be done carefully as the object of the operation is to remove the whole of the contents of the eyeball, leaving nothing but the sclerotic. As soon as the evisceration has been completed, a stream of boric acid solution should be directed from the india rubber tube into the cavity of the sclerotic, and kept up until the bleeding, which is rather profuse, has materially lessened or stopped; two quarts or more of the solution may be required. Whilst the washing out is going on, a continuous suture should be passed through the cut edge of the conjunctiva in the same manner as described for abscission, and when sufficient of the solution has been used, the suture should be drawn tight, and the two ends tied together. A large pad of sal alembroth gauze and wool should be laid lightly over the closed lids, and secured by a turn of bandage round the forehead, no pressure being applied over the lids, so as to allow free exit for any blood and discharge there may be, and fresh dressings should be applied daily. Some swelling of the conjunctiva follows, and in some cases, a good deal of febrile disturbance, the temperature rising to 101° or 102° for a night or two after the operation. The patient should be kept in bed for two days or longer if necessary, and then allowed to get up and go about. The parts will have soundly healed in about a fortnight, and an artificial eye may be worn six weeks or two months after the operation. The result is a more or less movable stump on which the artificial eye rests, and with which it moves to a considerable extent.

CHAPTER VII.

Proptosis or Protrusion of the Eyeball—Affections of the Orbit—Panophthalmitis—Tumours of the Eyeball—Removal of Foreign Bodies from the Interior of the Globe.

Proptosis.

Causes:—1. Inflammation within the orbit, with or without the formation of abscess.

2. Hæmorrhage into the orbit.

3. Vascular protrusion.

4. Exophthalmic goitre.

5. Tumours within the orbit:—(*a*) Nodes; (*b*) exostoses; (*c*) sarcomata; (*d*) cysts; (*e*) nævi; (*f*) distension of frontal and possibly of ethmoidal or sphenoidal sinuses; (*g*) tumours commencing in the antrum or other parts of superior maxilla, or the base of the skull, and encroaching on the orbit.

6. Enlargement of eyeball itself from:—(*a*) Growths, malignant or simple; (*b*) inflammation and suppuration of the whole eyeball (panophthalmitis).

7. Paralysis or stretching of its muscles, allowing the eyeball to drop forwards.

Symptoms.—The most prominent is, of course, the protrusion; if this is considerable it is seen at once, but if only slight there may be a difficulty in deciding whether there is protrusion or not. To make sure, place your patient in a low chair, direct him to look forwards and slightly upwards, stand behind him and look down upon the top of his head, then move gently forward, or draw the patient's head back; if either eye is at all in advance of the other, the cornea of that eye will come into view before that of the eye which is in its correct position.

Diplopia, may be complained of, if the sight of each eye is fairly good.

The ophthalmoscope will, in many cases, show retinal congestion, chiefly venous; and in some, severe optic neuritis. The ill-effects of the abnormal condition are seen both in the eyeball itself and in the eyelids. Should the protrusion be so great that the lids cannot be closed over the globe, the cornea will be left unprotected and become opaque, vascular and ulcerated, or it may suppurate or slough. If the protrusion continues for long, the lids become distended and flaccid, their movements much impaired, and the tear puncta may become displaced, giving rise to troublesome watering of the eye.

Treatment.—The proptosis itself, if extreme, must be treated without delay and without reference to its cause. Care must be taken to protect the cornea from injurious exposure by drawing the lids over it, and keeping them closed by a compress and bandage; if this is not sufficient, the edges of the lids near the outer canthus must be pared, united by sutures and allowed to heal firmly together so as to narrow the palpebral aperture and allow the lids to be closed over the cornea by their own efforts.

The position of the abscess, tumour, or other cause of the proptosis should be considered next. In many cases this is obvious, because an abscess may be pointing, fluctuation easily detected, or a tumour felt; in exophthalmic goitre the nature of the disease is evident, and in vascular protrusion the pulsation is marked; but there still remain a large number of cases in which the position of the growth, collection of fluid, or other cause, must be judged of by other means. The direction of the protrusion should be noticed; if it is straight forward, the cause is probably directly behind the eye; if the globe is pushed at all to one or other side, or up or down, the cause is on the side opposite to that towards which the eye is displaced. The movement of the eyeball should be noticed. It is important to make out whether the disease is within the cone formed by the recti muscles or external to it; if it is in the former position, there will be very great impairment of movement from direct interference with the action of the muscles, whereas a very much greater amount of protrusion may occur with little impairment of mobility if the disease is situated outside the muscle cone. A correct diagnosis of its position is necessary when determining where to make an incision for the evacuation of pus or removal of a growth.

The causes of proptosis may now be considered in detail.

1. **Inflammation within the orbit** affecting the soft tissues, the periosteum or bone, may cause protrusion of the eyeball by the swelling produced, and may end in resolution, the parts returning to their natural condition, or chronic thickening may result, causing more or less permanent protrusion and impaired mobility of the eyeball, or an abscess may form, and in the case of periostitis or ostitis, caries or necrosis of the bony wall may supervene.

Symptoms.—Inflammation within the orbit is accompanied by more or less febrile disturbance, pain of a throbbing character much increased by pressure, swelling of the lids and conjunctiva, more or less prominence and impaired mobility of the eyeball, intolerance of light and watering of the eye; it may be the result of cold, injuries, or general diseases—as erysipelas or purulent infection, from whatever cause arising, and (in the case of ostitis or periostitis) of syphilis, or may come on in debilitated states of the system after acute diseases (scarlet fever, measles, &c.), or from over lactation. It is not easy to distinguish between inflammation of the periosteum and bone.

2. **Hæmorrhage into the orbit,** sufficient to cause proptosis, may occur from spontaneous rupture of a blood-vessel, from fracture of its walls (sub-conjunctival ecchymosis being often a prominent symptom in fracture of the base of the skull, extending through the roof of the orbit), or from foreign bodies, such as the point of a stick, or some sharp instrument entering the orbit. A case in which the eye was protruded so as to come in front of the lids from effusion of blood, was caused by a piece of glass entering the orbit. The patient had gone to look out of window, and not noticing that it was shut, put his head through the glass. All efforts to return the eyeball failed, and it had to be excised.

Hæmorrhage, sufficient to cause displacement of the eyeball, has sometimes occurred from the operation for strabismus. It may occur in children with whooping cough, a vessel being ruptured during a fit of coughing.

Symptoms.—Spontaneous rupture of a vessel should be suspected if the proptosis has come on rather rapidly, without apparent cause, or after some strain. When the hæmorrhage arises from injury the cause is more obvious.

3. **Vascular protrusion of the eyeball.**—**Symptoms.**—The patient complains of noise in the head and feeling of tension, singing in the ears, pain in the orbit and eyeball, all of which are aggravated by stooping or exertion, but are nevertheless most annoying at night. These symptoms are accompanied by more or less protrusion and impaired mobility of the eyeball, dimness of vision, much congestion, principally venous, of the eyelids (especially marked in a large vein extending along the lower eyelid from the inner canthus, which becomes very prominent and pulsates vigorously) and chemosis of the conjunctiva. The ophthalmoscope shows venous congestion and rarely pulsation in the retinal arteries. Pulsation can be felt in any part of the orbit and is communicated to the eyeball; it can be controlled by pressure on one or other carotid, generally that on the same side as the proptosis, but in some cases on the opposite side, or only by compression of both, and a bruit may be heard on auscultation over any part of the head, but most distinctly on the brow or other parts immediately adjoining the orbit.

In most cases the symptoms commence at a varying time after an injury to the head, or occur spontaneously and suddenly.

Causes.—Formerly the protrusion was supposed to be caused by aneurism by anastomosis, or, as it is now called, angioma. This must be a rare condition. In the majority of cases the cause is a traumatic aneurism of the carotid in the cavernous sinus, or of the ophthalmic artery close to its origin, or an aneurismal varix; in the few cases where a post-mortem was made, one or other of these conditions was found, and in one of the cases described below, the cause, with little doubt, was a communication between a small artery and vein.

Cases.—In a boy under my care, protrusion of both eyes occurred about ten days after a severe blow on the top of the head from a fall of coal in a mine; both eyes were protruded to about an equal extent, pulsation could be seen and felt, there was a loud bruit, but no very great amount of discomfort was complained of. Pressure on both carotids was required to stop the pulsation. Fracture of the base was diagnosed, extending across both cavernous sinuses with rupture of one or both carotids. The patient declined to have any treatment and left the hospital.

Another case was that of a woman, æt. 42. No very satisfactory history could be got out of her; but she said that for six months she had been getting deaf in her left ear and had a ticking sound in her head. Two months before she had noticed that the left eye was becoming prominent, and that for a month the prominence was increased by coughing, stooping, or straining. She acknowledged having had an ulcerated throat, but gave no other history of syphilis.

On admission, the left eye was pushed forward as if by a tumour behind it, the conjunctiva vascular and œdematous, the upper lid puffy and swollen; stooping or coughing caused the eye to protrude more; there were no noises in the head except the ticking already mentioned. The congestion of the conjunctiva was chiefly venous, and the movements of the eyeball were but little impaired. There was a semi-elastic swelling (dilated vein) in the lower eyelid, which pulsated strongly; pulsation could also be felt in the upper eyelid near the inner canthus, but nowhere else. Both pupils were of the same size, but the left was sluggish in action. There was venous congestion of the retina, and a loud systolic bruit could be heard all over the head, but most distinctly over the centre of the left parietal bone and the closed eyelids of the left eye, which ceased immediately on compression of the left common carotid. No enlargement of the thyroid was noticed.

The left common carotid was ligatured. Immediately the ligature was tightened the left side of the face became blanched and all the symptoms disappeared.

Four days after the operation the patient became hemiplegic on the right side, but eventually recovered, and the vascular protrusion was entirely cured.

The following case is probably unique, and is almost certainly an instance of aneurismal varix of a small artery and vein, and shows how vascular protrusion can arise from such a cause.

A patient who, some months before, had been struck by a piece of glass from a bursting soda-water bottle, just external to the internal angular process of the frontal bone on the left side, sustained a good sized wound of the eyelid which caused sharp hæmorrhage at the time and subsequently stopped by pressure. Much swelling and ecchymosis of the lids followed. The wound healed and the swelling and ecchymosis disappeared; all appeared to be going well, but shortly before being seen by me the eyeball began to protrude, and much congestion of the eyeballs and conjunctiva was noticed. When seen by me there was considerable venous congestion of the eyelids and conjunctiva (no chemosis), with marked protrusion of the eyeball in a direction somewhat outwards; there was no diplopia. A small pulsating tumour could be felt near the inner angle of the orbit; a marked thrill was communicated to the eyeball, which could be felt on placing the fingers on the closed lids; a buzzing in the head was complained of, aggravated by stooping, and a small linear cicatrix marked the seat of the original injury. There was much dilatation and tortuosity of the retinal veins, but no pulsation, either arterial or venous, could be detected. There was no impairment of vision.

Pressure on the left carotid at once stopped the pulsation and caused considerable decrease of the venous congestion. Aneurismal varix was diagnosed. Perfect rest and pressure applied directly to the part were tried for some months without result. The surgeon under whose care the patient was, at length cut down on the pulsating tumour and tied several moderate sized vessels which appeared to communicate with it. The wound healed without difficulty. A year later all the symptoms had disappeared; the eye was in its normal position, and the only sign of the former trouble remaining was a small linear cicatrix in the upper eyelid and slight thickening in the position previously occupied by the pulsating tumour.

4. **Exophthalmic goitre** is characterized by protrusion, as a rule, of both eyeballs, but occasionally in the early stages of only one, a peculiar retracted condition of the upper eyelids, and impaired mobility of both upper and lower lids, diminished sensibility of the cornea and conjunctiva, accompanied by rapid pulse, disturbance of the heart's action and systolic murmurs in the heart and great blood-vessels of the neck, breathlessness and enlargement of the thyroid. The patients are, with few exceptions, young women.

If the protrusion is extreme the eyes must be protected by the means already mentioned, and the case treated from a medical standpoint.

5. **Tumours within the orbit.**—In proptosis from tumours within the orbit, the one symptom common to all, whatever their nature, and that which first attracts the patient's attention, is the protrusion: the differential diagnosis is not easy.

A *node* within the orbit should be suspected if the proptosis is accompanied by pain and associated with nodes on the orbital margin or other bones in an obviously syphilitic patient.

Exostoses may be of two kinds, either hard ivory-like masses or soft brittle growths of an open cancellated structure; they should be suspected if the protrusion has been very slowly produced. Certainty in diagnosis can only be arrived at when they have become large enough to be felt by the side of the eyeball.

Sarcoma should be suspected if the patient is past middle life and the protrusion has increased continuously and with moderate rapidity. If the growth has increased sufficiently to be felt it will be found to be firm, to a certain extent yielding, but not fluctuating.

Tumours, most frequently sarcomata, commencing in the antrum or other part of the superior maxilla, may perforate its orbital plate and cause proptosis; their diagnosis presents no difficulty.

If proptosis is caused by a tumour growing from the base of the skull, there is in addition to the displacement of the eyeball distinct evidence of the growth in the pharynx or posterior nares.

Cysts, if they are large enough to be felt, are elastic and fluctuating.

Nævi deep in the orbit would be almost impossible to diagnose, but as a rule they come forward and involve the eyelids or conjunctiva, to which they give a dusky bluish tinge and soft doughy feel.

If in any case the cause of protrusion is doubtful and it is important to make a diagnosis, an exploratory puncture or incision will often clear up any doubt there may be. In making the exploration, care should be taken to make the puncture or incision over the point at which the eyeball is most pushed away from the orbital wall, and to guide the instrument towards the apex of the orbit, and not to push it through the bone.

In the following case had an exploratory incision been made the first time the patient was seen the nature of the case would have been diagnosed early and the sight probably saved. The patient, a man of 60, gave a history of proptosis which had commenced four years before, without apparent cause; he came for advice because the proptosis had increased rather rapidly during the last two or three months. The left eye was protruded forwards and outwards, and its movements much impaired. A firm, non-fluctuating growth could be felt between the outer and lower orbital margin and eyeball; the pupil was active, and the eye could distinguish large objects; the disc was somewhat swollen, and the retina immediately surrounding it hazy; the retinal veins were dilated. The patient was not seen again for six months, when the proptosis, which had been considerably less for some months, had increased; the eye was blind, the retinal veins much engorged. The disc was atrophied. A firm growth could be felt much more distinctly than before in the same position. Two months later, there was a rounded fluctuating projection below the outer canthus; this was punctured with a grooved needle, and a small quantity of purulent fluid escaped. An incision was made, and more purulent fluid, followed by broken down tissue, a large quantity of small transparent cysts, and some blood-stained fluid escaped, after which the eyeball returned to its natural position. The cysts turned out to be hydatids. The case was one of hydatid of the orbit, which was not diagnosed until it began to cure itself by suppuration.

Distension of the frontal sinus forms a hard tumour, often with a fluctuating central portion surrounded by rough bony edges, at the inner angle of the orbit. The fluctuating centre is caused by the absorption of the bone allowing the fluid contents of the sinus to bulge beneath the skin; the eye is pushed outwards and slightly downwards. There may be double vision, but no impairment of movements.

The tumour generally follows—but at a long interval—a blow across the upper part of the bridge of the nose, the sequence of events being fracture of bone with closure of the infundibulum and retention of secretion, by which the sinus becomes distended. An incision into the tumour gives exit to a large amount of stringy yellowish mucus; a probe can be passed through the incision into the sinus of the affected side and across the middle line into that of the opposite side. Tumours of the superior maxilla and base of the skull, invading the orbit, have already been mentioned (*vide* p. 348).

6. **Enlargement of the eyeball itself.**

(*a*). **Proptosis from growths commencing in the eyeball itself** is usually caused by growths which have commenced within the eyeball, filled its cavity and caused enlargement and some prominence. Later on the growth perforates or grows through the sclerotic and invades the tissues of the orbit, much proptosis resulting, but in the early stages protrusion is not a symptom, and the condition is generally recognized before proptosis occurs (*vide* p. 359).

(*b*). **Proptosis from panophthalmitis** is usually the result of injuries, especially of those complicated by the lodgment of a foreign body within the globe; it sometimes follows operations for cataract, and is occasionally met with during erysipelas, pyæmia, scarlet fever, &c., and sometimes in women after confinement, especially if the strength is lowered by over-lactation. The disease may begin in any of the structures of the eyeball except the sclerotic. Should it commence in the cornea and iris, the former will become cloudy, and soon an abscess will form in its substance, the iris likewise becoming discoloured and covered with pus. The suppuration may stop short here, the cornea and iris being alone destroyed, and the eyeball left with some perception of light (see Suppuration of Cornea and Iris). Should the disease, however, commence in the deeper structures of the eyeball, rapid impairment of vision will take place, all perception of light being lost in perhaps a few hours.

If the pupil is clear, pus may be seen behind it, but in most cases all appears dark; the movements of the eyeball are much impaired, and the lids and conjunctiva considerably swollen. As the disease advances the eyeball becomes enlarged and protruded and its tension is increased, and if left to itself it will rupture and discharge its contents, much to the patient's relief. The globe afterwards shrinks to a small button-like stump. Pain is very severe in many cases, but occasionally is altogether wanting. Suppuration of the eyeball rarely sets up sympathetic changes in the other eye.

7. **Proptosis from paralysis of the ocular muscles** occurs in the disease known as ophthalmoplegia externa. The eye projects straight forward, is moderately proptosed and immovable.

Proptosis from stretching of the ocular muscles follows on long continued protrusion from some one of the other causes already mentioned, after the original cause has been removed.

Treatment.—*Inflammation within the orbit* should be treated by rest, a good purge, and by sedatives if there is much pain; hot boric fomentations frequently used and a hot boric compress applied over the eye in the intervals. If the patient is strong and plethoric, half a dozen or more leeches should be applied to the temple.

As soon as pus can be detected, or if its presence is suspected, the patient should be placed under an anæsthetic, an incision should be made through the skin over the spot where the eye is most pushed away from the orbital margin, and if the abscess is pointing this will at once give exit to the pus. If no pus escapes, a grooved director should be pushed into the orbit in various directions, but care must be taken to use no violence. If still no pus escapes it must be left alone for the time; but if pus makes its appearance, a pair of dressing forceps should be passed along the groove in the director, and as soon as they have entered the abscess cavity, opened moderately wide, and drawn out still open; by this means a good opening will be left, and little risk of damaging important structures will ensue; then a gauze drain should be passed quite to the bottom of the abscess and a hot boric compress applied over all. The compress should be changed as often as may be necessary. If in the course of a few days the discharge has not stopped, the orbit should be carefully examined with a probe, when probably bare bone will be found. The case will be one that has begun as periostitis or ostitis, and a sinus will remain which will go on discharging until the diseased bone is removed.

Hæmorrhage into the orbit requires no further treatment than rest, and slight pressure with a pad and bandage.

Vascular protrusion of the eyeball, in some cases, will recover if treated by complete rest, light pressure with pad and bandage applied over the closed lids, low diet, purgatives, and vascular sedatives, such as tartrated antimony. Others get well spontaneously.

In the case of a lady, what was described as a "crack inside the head," followed by noises, pulsation, bruit, and proptosis, occurred during labour. Treatment was advised, but the patient became very ill from other causes, and nothing was done; some months later all symptoms of vascular protrusion had disappeared, and the patient was in her usual health.

If the above treatment is not sufficient, digital pressure should be tried on whichever carotid stops the pulsation, but the patient must be placed under the influence of an anæsthetic, as pressure in the neck cannot otherwise be borne long enough to be of any use.

All other means failing, the case should be left alone, or that carotid should be ligatured, pressure on which has been found to stop the pulsation. In the case, the notes of which are given above, the results of ligature were entirely successful.

In any case similar to the second one mentioned (the aneurismal varix), the same treatment as was employed in it should be adopted.

Exophthalmic goitre has already been dealt with, so far as it concerns the ophthalmic surgeon.

Tumours of the orbit should be treated in their earlier stages on the supposition that the proptosis may be due to some cause such as a periosteal node which can be absorbed; to this end mercury, or iodide of potassium, should be given in as large doses as can be borne. These remedies failing, the tumour must be removed by operation. It should be first ascertained whether the tumour is situated within the cone formed by the recti muscles, or external to it. The means by which a correct diagnosis can be formed have already been mentioned. If the tumour is in the former position, it is probably attached to the eyeball or optic nerve and cannot be removed without removal of the eyeball, enucleation of which, together with the growth, will be required. But if it is in the latter position, its removal may be effected without damage to the globe.

The position at which the eyeball is most pushed away from the orbital wall, or if the tumour can be felt, its most prominent part should be noted, and an incision made through the skin in either of these situations, the tumour carefully cut down upon, and then, if possible, separated from its attachments with the fingers without the use of any instrument; a sarcoma, cyst, or nævus, can generally be removed by this means alone, aided, perhaps, with a little cutting with blunt-pointed scissors. A spongy exostosis, after it has been well separated from the soft tissues, can be wrenched or twisted out with bone forceps; in so doing the cavity of the nose, or cranium is sometimes opened, as these growths often extend as far outside the orbit as into its cavity, it is, however, somewhat disconcerting to find blood being blown into one's face on each expiration, or to see the dura mater pulsating at the bottom of the wound after removal of the growth. Opening the nasal cavity is of no consequence whatever, and exposure of the dura mater need be followed by no untoward results provided the wound can be kept aseptic. The hard ivory exostosis is very difficult to remove; if it gives rise to but little inconvenience it is best left alone. If its removal appears necessary it can be cut away with gouge, or chisel and mallet, after having been well cleared of its soft parts, but it is surprising to find how very hard it is and how difficult to cut. Drilling through the base of the tumour in as many places as appear necessary with a dental engine and drill, and then breaking off the partially separated mass with forceps, is much the most rapid and easy method of dealing with these cases.

After removal of any orbital tumour, if the eyeball has been left intact, care must be taken to protect it from damage by uniting the lids over it as was described when speaking of the treatment of proptosis.

Tumours of the superior maxilla invading the orbit should be treated by removal of the whole or part of that bone, an operation which belongs rather to the domain of general surgery than ophthalmology, and the same remark applies to tumours commencing about the base of the skull.

A method of removing tumours of the orbit which are not connected with the eyeball, and by which but small risk is run of damaging the globe, has lately been introduced (Kronlein's operation).

The operation is performed as follows:—

An incision should be made commencing at the junction of the outer third, with the middle third of the upper margin of the orbit, around its outer angle, and terminating at a point on the lower margin corresponding to that of commencement on the upper; the incision should be carried down to the bone; next, the outer lip of the incision must be taken up and the skin and orbicularis dissected away, so as to thoroughly expose the outer margin of the orbit and a small portion of the bone in the temporal fossa; then the inner lip should be taken up and the parts separated, including the periosteum, from the margin and outer wall of the orbit, and the whole, pushed with the orbital contents, inwards; the thick margin of the orbit should be sawn through at two points, one just below the external angular process of the frontal bone, and the other just opposite to the upper edge of the zygoma; and then, with a pair of cutting forceps, the bone of the outer wall of the orbit must be divided, commencing at the saw cuts and inclining the incisions towards each other, so as to remove a good sized V-shaped piece of bone, the point of the V being towards the temporal fossa, and the base at the orbital margin; the piece of bone should be pushed backwards, together with any soft parts attached to it, into the temporal fossa, and held in this position whilst the contents of the orbit are drawn over the opposite side; the orbit, right back to its apex, can then be thoroughly explored, and a tumour growing from its walls can be handled and removed without any very great difficulty, and without injury to the eyeball.

After removal of the tumour, the V-shaped piece of bone should be replaced, the periosteum reapplied to its orbital surface, and the skin wound closed with sutures. If necessary, the lids must be closed over the eyeball, their edges pared, and united with sutures.

Distension of the frontal sinus can be cured by drainage. An incision should be made through the soft parts over the tumour; if the bone is already perforated, thick yellowish mucus will at once escape, and the sinus will be opened; if not, the bone should be cut away and the sinus washed out; a little finger should be passed up the corresponding nostril and a director pushed from the opening in the sinus into the superior meatus of the nose until it comes in contact with the finger; an eyed probe (to which a drainage tube has been attached by a piece of strong silk) should next be passed along the groove of the director until it, too, touches the finger; then the director withdrawn and the probe pushed on, guiding it by the finger in the nose until it emerges at the nostril; the probe, followed by the silk and drainage tube, must be pulled through, the silk and probe cut off, and the tube left; it should be fixed to the forehead by a piece of strapping.

The sinus must be washed out every two or three days during the first fortnight, and then left alone. The drainage must be kept going for three or four months, the tube being changed as often as may be necessary; at the end of that time it should be removed, and the skin wound will heal readily, a permanent opening from the sinus into the nose being left.

Panophthalmitis.—The treatment depends upon the cause of the disease, and whether one or both eyes are affected. Should the inflammation depend upon the lodgment of a foreign body, this should be removed without any reference to its position or the state of vision; if the eye has still good perception of light it will certainly be destroyed if nothing is done, and whatever difficulties the surgeon may encounter he cannot possibly make matters worse, and he should not hesitate an instant, or he will lose his chance of preserving any sight that may be left.

Any foreign body having been removed, the surgeon's next care should be to relieve pain, and if possible check inflammation.

These indications are best carried out by the applications of leeches (if the patient is strong, and can bear blood-letting), by opium internally, and by the constant use of sedative fomentations, the best being Fotus Belladonnæ (made by dissolving a drachm of extract of belladonna in a pint of warm water), mixed with an equal quantity of Fotus Papaveris (made by boiling an ounce of poppy heads in a pint of water); a piece of rag or lint soaked in this mixture as hot as it can be borne should be kept constantly applied to the affected eye. Boric compresses may also be employed. Most patients will require the administration of a fair amount of stimulant, good food, with iron and quinine.

When suppuration has been fairly established, and all perception of light lost, the eyeball must be treated as an ordinary abscess, and the pus let out by incision.

If suppuration occurs in both eyes, as is sometimes the case when it arises from idiopathic causes, especially pyæmia, treatment must be directed towards the relief of pain. If the patient escapes with life he will certainly be blind.

Suppurating eyeballs should not be enucleated.

Paralysis of the muscles allowing the eyeball to assume undue prominence is almost invariably due to late syphilis and must be treated accordingly; but in this, and in proptosis due to stretching and laxity, care must be taken by uniting the margins of the lids at the outer canthus to prevent injurious exposure of the cornea.

Tumours of the Eyeball.

1. Glioma.
2. Sarcomata, melanotic, round, and spindle-celled.
3. Carcinoma.
4. Tubercular deposit.
5. Pseudo-glioma.

Glioma commences in the retina; it presents the following appearance:—The patient is always a child, rarely over seven years old, generally healthy looking, and presenting no signs of cachexia; attention has been drawn to the eye from a peculiar glistening appearance of the pupil (cat's eye). On examination the surgeon will notice the peculiar reflection through the pupil, which is generally somewhat dilated but movable in the earlier stages. Examination, both by means of the ophthalmoscope and by lateral illumination, will show a light greenish-yellow coloured growth projecting into the vitreous chamber, either as a single prominence or in nodules; the growth will gradually increase, its surface become covered with blood vessels, the retina be displaced, and sight soon entirely lost.

As the disease progresses the tension of the globe increases, the pupil becomes widely dilated and fixed, the iris pushed forwards nearly in contact with the cornea, and the lens opaque, preventing a view of the interior of the eye; the whole globe now gradually enlarges, with more or less protrusion, frequent inflammatory attacks occur, the sclerotic becomes thinned, and at last, if the growth is allowed to remain, a slough forms near the centre of the cornea, which ruptures, and a fungoid bleeding mass protrudes.

The increase of the growth now becomes much more rapid, and it may grow to a considerable size in a short time.

As soon as the growth is exposed to the air it commences to discharge thin sanious pus and blood, and becomes more or less coated with a dirty yellow scab. The eyelids become inflamed and swollen, sharp attacks of hæmorrhage may take place, the general health suffers, and the patient dies from exhaustion or from extension of the disease to the brain.

Glioma in its earlier stages is likely to be confounded with tubercular deposit within the eyeball, or inflammatory effusions into the vitreous following retinitis, or cyclitis, usually associated with a detached retina and known as "pseudo"-glioma, but it is not likely to be thus mistaken after perforation has occurred.

Sarcomata, as a rule, affect persons past middle life, but may be met with in young children.

Melanotic sarcoma is characterised by the development in it of black pigment cells which give it a dark colour. The other forms are of a yellowish or greyish hue. Sarcomata grow from either the interior or exterior of the eyeball, but most commonly commence in the choroid. The appearance of the tumour varies with the stage of growth at which it has arrived. It may be detected quite early on ophthalmoscopic examination, which will show either a flat raised mass, deep in the fundus, or one or more nodules projecting inwards from the ciliary region, the colour of the growth will show whether it is a melanotic or round celled sarcoma; the former is easily distinguished, but there may be difficulty in diagnosing between an inflammatory deposit and the two other forms.

The existence of bloodvessels on the surface of the mass should suggest that it is malignant.

Later the eyeball becomes filled with growth, then the fundus reflex is lost and a dark or grey mass will be seen behind the lens (should it still be transparent), and the eyeball will be tense and bulged in places and more or less protruded.

Later the growth spreads beyond the limits of the globe and a large fungoid mass of a dirty greyish or brownish colour, having a foul surface covered in parts with dark scabs, in others discharging thin unhealthy matter occasionally mixed with blood, will be seen protruding between the swollen and distended lids. On closer examination the eyeball (as such) will be found nearly destroyed, portions of the sclerotic alone remaining in their proper position. The movements of the globe are much impaired, or altogether wanting, the growth having implicated the whole of the tissues of the orbit in one malignant mass.

The constitutional disturbance in these cases is often severe, especially when the disease is far advanced.

Carcinoma is rarely met with, but secondary deposits in the eye, or orbit, are not very uncommon in carcinoma mammæ and cancer of the bones in young people.

Tubercular deposit.—The appearance of this deposit within the eyeball closely resembles that met with in the early stages of glioma. The patients are usually children. The deposit is in the choroid; there is the peculiar glistening appearance of the pupil noticed in glioma, and blood vessels may be seen upon the surface of the growth; the retina is more or less displaced by fluid between it and the choroid, and floats in the vitreous chamber. The growth goes on increasing, the pupil becomes dilated, and its mobility destroyed; the lens becomes opaque, the sclerotic thinned, the whole eyeball somewhat enlarged, and suppuration may occur; supposing the disease to have gone on to this point, there is nothing by which it can be distinguished from glioma.

After this the difference becomes manifest; the growth, instead of increasing, destroying the cornea, and projecting from the eyeball, commences to shrink, and with it the eyeball, which becomes soft, and is at length reduced to a small irregular mass. The growth of tubercular deposit may become arrested at any time, and the shrinking of the eyeball commence; in this, again, it differs from glioma.

Pseudo-glioma.—Appearances somewhat similar to glioma, and scarcely to be diagnosed from it, are also produced by inflammatory deposit in the vitreous; the disease has received the name of "pseudo-glioma." It is possible to distinguish the two by the fact that in glioma the anterior chamber is in the early stages of good depth; in pseudo-glioma it exists only at the periphery. Moreover, in pseudo-glioma there are often evident signs of past iritis, and the tension of the globe is sub-normal. There is often a history of some febrile attack, accompanied by inflammation of the eye, and we are sometimes told that patients are subject to, or have had, fits (*vide* p. 200).

Treatment.—The treatment of these growths depends much on the extent to which the tissues of the orbit are implicated, and the state of the patient's health.

If the tumour is confined to the eyeball, simple enucleation of the globe will be sufficient. The majority of such cases are due to malignant sarcomata, so care should be taken to cut the optic nerve right back at the apex of the orbit.

If, as is often the case, the tumour has perforated or grown through the sclerotic, but remains fairly circumscribed, so that there is a reasonable hope of removing the whole, and the patient is in such a state of health as to preclude the likelihood of similar deposits, in other parts, extirpation of the eyeball with all the tissues surrounding it, as far as possible, should be performed, and when the hæmorrhage, which will be pretty free, has been stopped, the orbit should be lined with strips of lint on which has been spread a paste of equal parts of zinc chloride and starch ; the eyelids, if they have not been removed, should be closed over the wound, and a pad and bandage applied. In the course of forty-eight hours, or thereabouts, the whole of the soft tissues left in the orbit will be converted into a slough, to which the lint is adherent, and will separate in due course, leaving the bony walls bare; these will subsequently granulate over and heal. But should the orbit be so filled by cancerous deposit that there appears to be little hope of removing the whole growth, more especially if the patient is in a cachectic condition, no operation should be thought of, and the surgeon must content himself with palliative treatment, as opiates to relieve pain, and attention to the general health.

In cases of tuberculous deposit the eye should be removed, unless improvement takes place rapidly under proper treatment. It should be remembered that the eye may be the only focus, and a general infection may result from it.

In pseudo-glioma, if the diagnosis is well-established, the eye should be left alone.

Removal of Foreign Bodies from the interior of the Globe.

Foreign bodies in the anterior chamber can be removed with iris forceps; if fixed in the iris a portion of iris should be removed with the foreign body. If lodged in the lens, the lens should be extracted with the scoop or loop (see p. 321 and fig. 62 *e*). From the vitreous a

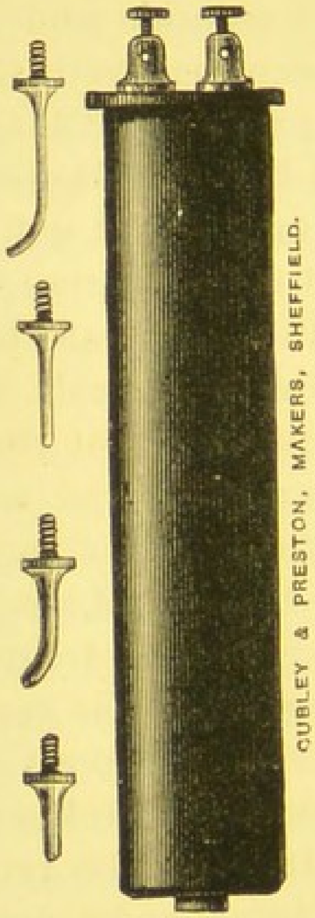


FIG. 66.

foreign body may be removed with forceps made for the purpose, but the operation is extremely difficult and the result will probably be a failure.

Chips of iron or steel can be removed from any part of the interior of the globe by the electro-magnet.

Mr. Simeon Snell, of Sheffield, has had wide experience in the removal of foreign bodies by this means. The following is his description of his instrument (fig. 66) and its mode of use.

"The electro-magnet, as depicted in the engraving, is connected at one end to a battery; for this purpose a quart bichromate battery is convenient. At the other extremity the soft iron case is tapped to receive various terminals, curved or straight, short or long, &c., as any particular case may require. It has been used successfully in the inventor's and also in other hands, for the removal of chips of steel or iron from all parts of the eye, as well as from the orbit. To be employed with the greatest chance of success and of recovering vision, it should be used as soon as possible after the accident; and this remark has particular reference to foreign bodies in the vitreous, in which region, it may be added, some of its most striking successes have been obtained, At the same time, in some instances after the fragment of steel or iron has been located for a considerable time, the value of the electro-magnet has been equally shown.

"In recent cases the point of the electro-magnet may be inserted through the still unclosed wound; in other instances the original wound may be re-opened, or a fresh one made, and then a situation the most suitable for reaching the foreign body should be selected. For fragments in the vitreous, the sclerotic should be incised away from the ciliary region and towards the equator, the direction being meridional. After the magnet has been used the conjunctiva should be united by a suture over the deeper wound.

"As an aid in diagnosis the electro-magnet has proved, also, of great service. A foreign body of doubtful nature has revealed its character by being seen to move on the approach of the magnet, and in the case of a foreign body situated for long in the vitreous, its free mobility on bringing the electro-magnet in contact with the globe, afforded valuable information as to the possibility of its removal."

The Haab Magnet is of very great service in cases of foreign bodies in the globe, but it is too complicated and expensive for use, except in large hospitals. It consists of a very powerful magnet, having a small detachable point which can be removed and boiled. The cornea is cocainized, and the patient brought close to the instrument, the cornea touching the sterilized point. A gradually increasing current is then allowed to pass through the magnet. If a piece of steel is present, the patient will experience some pain, and the anterior portion of the eye will be seen to be drawn forward. As the current increases the resistance of the steel is overcome, and it is drawn into the anterior chamber, from which it may be removed after incision.

The presence of a foreign body may often be discovered by means of a skiagram, and in doubtful cases this aid should never be omitted.

APPENDIX.

Rules for Testing the Refraction of Out-Patients.

Test each eye separately.

Ascertain the visual acuity without glasses. Test for hypermetropia first.

If the patient can see $\frac{6}{6}$, ascertain whether he can see as well, or better, with a convex lens.

Find the highest convex spherical lens with which the patient can see as well, or better. This is the measure of the manifest hypermetropia possessed by the patient.

To test for astigmatism (hypermetropic):—Take a + 1 D cylindrical lens. Ascertain if the patient can see any difference when the cylinder is held vertically, to when it is held horizontally or obliquely. If the patient shews a marked preference for one position over another, then astigmatism is present.

Ascertain the highest + cylinder, placed in the preferred meridian, with which vision is as good or better.

Will the patient see as well, or better, with a + sphere added. If so the highest + sphere should be used, with which vision is as good, or better.

To test for myopia :—

In myopia, vision is defective for seeing in the distance, but the patient can read the smallest print, and a + glass makes vision worse.

Ascertain if the patient can see $\frac{6}{6}$ with a concave lens, if so, what is the weakest lens with which the patient sees $\frac{6}{6}$.

If the patient cannot see $\frac{6}{6}$ with any lens, then, what is the weakest lens with which vision is rendered most acute?

The weakest concave lens, yielding the greatest visual acuteness, is the measure of the patient's myopia.

To test for myopic astigmatism :—

Take a minus cylinder. Ascertain if the patient can see any difference when the cylinder is placed vertically, horizontally, or obliquely.

If the patient shows marked preference for one position over another, then astigmatism is present.

Ascertain the lowest minus cylinder placed in the prefered meridian, with which vision is as good, or better.

Is vision improved with a minus sphere? if so, what is the lowest minus sphere with which vision is improved.

If $\frac{6}{6}$ is not obtained with any sphere, or combination of sphere and cylinder, then examine the cornea, lens, and fundus. If these are normal, steps should be taken to ascertain the refraction by means of retinoscopy (*vide* p. 71).

Before instilling homatropine or atropine, carefully estimate the tension of the eye, as on no account should a mydriatic be used if there is a rise of tension.

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