AN ADDITIONAL METHOD

TO

DETERMINE THE DEGREE OF AMETROPIA.

In the American Journal of the Medical Sciences for January, 1870, will be found a description of a test for ametropia, based on the experiment of Scheiner. It was there shown that whenever the visual axis is too long or too short, a point of light, used as a test object, will appear double to the eye of an observer when it is examined through two small perforations in an opaque screen.

A short experience with the disk clinically, or with ametropia artificially produced, convinces one that the degree of ametropia influences the apparent distance apart of the double lights, and that if that distance could be computed with accuracy, the degree of ametropia could be diagnosticated, and a correcting lens selected without a prolonged empirical examination.

After a sufficiently full demonstration of the laws of refraction as applied to the human eye, and an exhaustive analysis of its refracting surfaces of different curvature and its media of varied density, Donders gives his authority, in addition to that of Helmholtz, for the adoption, for purposes of calculation, of the simplified diagrammatic eye of Listing, which consists, as is well known, of a single refracting surface of 5 mm. radius in curvature, and a medium whose index of refraction is 1.333, whose posterior focus is 20 mm., and its anterior focus 15 mm. from its refracting surface.

From a comprehension of these cardinal points, it becomes possible to trace, in this simple eye, the course of any given ray of light; to find the points of conjugate foci; to ascertain the dimensions of retinal images, or of circles of diffusion which fall upon the retina in ametropia; and these values thus found may be considered equal to those which would exist under the same circumstances in the human eye, with its complicated apparatus, composed of two complete dioptric systems.

with two perforations in it, each .5 mm. in diameter, and placed 4 mm. apart, through which, in the overlapping space between the two holes, as described in a previous paper, he searches for the double images. Myopia or hypermetropia may be determined by placing over one of the holes a piece of ruby glass, when one of the images will become red, and be found on the same side with the hole covered in myopia, but crossed and on the opposite side in hypermetropia, a result which is explained by the well-known law of projection.

Having ascertained the presence and kind of ametropia, the red glass is removed, and the distance apart of the two images is measured by means of another small flame or light held in the hand of the surgeon, which is brought into the patient's field of vision whilst he looks at the first mentioned fixed light. The second flame is moved in a line with the double images until the patient is able to say that one of the moving flames coincides with or overlaps one of the fixed ones, and that but three instead of four flames are perceived; and when this is accomplished, this distance of the fixed from the moving flame is ascertained by an ordinary rule or measure. Several other methods have been employed with success, and the ingenuity of each surgeon will enable him to overcome any difficulties he may encounter in these manipulative details.

The brief notes of a few cases will illustrate the use of this method.

Mrs. G., placed 5 mm. from a point of light (a gas-burner turned low), saw two lights through a disk, whose apertures were apart 4 mm., and the one colored red stood on the side of the hole covered with red glass, thus demonstrating myopia. A candle lighted and held by the surgeon was now brought near to the gaslight, and it also appeared double, but it could be distinguished from the gas by its motion and its larger flame. It was moved back and forth until the left-hand flame of the candle overlapped the right-hand one of the gas-burner; and, when this was accomplished, the distance from gas-burner to candle was measured with a common rule, and found to be five inches, or 121 mm. Then 121 : 5000 :: 4 : 165, which, reduced to English inches by dividing by 25.5, or to French inches by dividing by 27, gives 6.5 in English inches as the distance of convergence of the rays from the nodal point. The myopia was then found to be corrected perfectly by a $-\frac{1}{6}$ placed $\frac{1}{2}$ from the nodal point.

In a case of aphakia, after a successful operation for cataract, the distance between the double lights was found to be 10 inches, or 250 mm.; and $\frac{5000 \times 4}{250} = 80$ mm., or 3.2 inches. This case required for its correction a $+\frac{1}{3.5}$, $\frac{1}{2}''$ from the nodal point, showing that the hypermetropia $= \frac{1}{3}$.

A case of hypermetropic astigmatism in a person able to give concise replies, and who could fully relax his accommodation, gave the following results. With the holes so placed as to analyze one meridian, the distance apart was $4'' = 101$ mm.; and in the meridian at right angles to first, 4.5, or 115 mm. Let x be the degree of ametropia, and we have the formula: $x = \frac{5000 \times 4}{101} = 196$, or 7.7 in., which indicates that the rays diverge from this meridian as though they arose from a point 7.7'' behind its nodal point, and that a convex $\frac{1}{8.2}$ would suffice for its correction.

After atropia an $\frac{1}{8}$ was found sufficient, combined with a cylinder of $\frac{1}{50}$, to overcome the greater ametropia of the other meridian.

It will be found convenient to use the English measures for these calculations, and to reduce Listing's eye and the other quantities to the following values:

Radius,	5 mm.	= 0.2	English	inch.
Anterior focus,	15 "	= 0.6	"	"
Posterior "	20 "	= 0.8	"	"

The distance apart of apertures in the screen, 4 mm. = 0.16.

The distance from observer to test-light, 5 metres = 200 inches nearly, or $16\frac{2}{3}$ feet.

The rule, then, would be to multiply the distance from the eye examined to the test-object by the arc of the small angle, and divide the result by the distance apart of the two lights, as ascertained by measurement.

Mr. W. suffers from a high degree of myopia, using $-\frac{1}{4.5}$, which does not fully correct it. The distance apart of the images was 8 inches. Then $\frac{200 \times 0.16}{8} = \frac{32.00}{8} = 4$. With $-\frac{1}{3.5}$ the double lights were perfectly fused together, and his myopia corrected.

Mr. M., with the disk so placed that a line uniting the holes was horizontal, saw the points of light apart $4\frac{3}{4}$ inches, and in the vertical meridian they were 3″ apart. $\frac{200 \times 0.16}{4.75} = 6.7''$. $\frac{200 \times 0.16}{3} = \frac{32.00}{3} = 10\frac{2}{3}$. In these meridians the points of light were brought together respectively by $-\frac{1}{6}$ and $-\frac{1}{10}$, and the myopic astigmatism was fully corrected by a sphero-cylindroid lens, $-\frac{1}{10} \bigcirc \frac{1}{16}$ cy.

Mr. D., myopic astigmatism; the images apart in one meridian 5 inches, in the other $1\frac{1}{2}$. $\frac{200 \times 0.16}{5} = \frac{32.00}{5} = 6\frac{2}{5}$. $\frac{200 \times 0.16}{1.5} = 20$. A glass $-\frac{1}{3.5}$ corrected the greatest, and $-\frac{1}{20}$ the least myopic meridian, and a spherical and cylindrical of $-\frac{1}{20} \bigcirc \frac{1}{8}$ cy was ordered.

It will be observed that, by the English measure, the formula is so simple that it can most readily be remembered, viz., 200×0.16, divided by the distance between the lights; and that a separation apart of $1'' = \frac{1}{32}$ of ametropia. I have constructed a table, which will save the slight trouble of making even this short calculation.

Distance of Images apart.	Degree of Ametropia.	Distance of Images apart.	Degree of Ametropia.
$\frac{1}{2}''$	$\frac{1}{64}$	5″	$\frac{1}{6.5}$
1	$\frac{1}{32}$	6	$\frac{1}{5.3}$
$1\frac{1}{2}$	$\frac{1}{20}$	7	$\frac{1}{4.5}$
2	$\frac{1}{16}$	8	$\frac{1}{4}$
3	$\frac{1}{10}$	9	$\frac{1}{3.5}$
4	$\frac{1}{8}$	10	$\frac{1}{3.2}$

In selecting a glass for the higher degrees of ametropia, its distance from the nodal point must be considered, and a lens chosen for myopia $\frac{1}{2}''$ stronger, and for hypermetropia $\frac{1}{2}''$ weaker, than that which would be required after a calculation by the present method.

Having satisfied ourselves that an ametropia does exist in any given case, and that the visual axis is too long or too short, we can measure the axis with precision by using the Listing eye for comparison. We know that when an object is placed so near the eye as to give divergent instead of parallel rays, its image must fall behind the position of the posterior focus. These points of emission and convergence are the conjugate foci, and are found by the formula $f' f'' = F' F''$; f' being the distance of the object from the anterior focus, and f'' the distance of the image from the posterior focus; F' and F'' being the known quantities of the anterior and posterior foci. The proportion is $f' : F' :: F'' : f''$; hence $f'' = \frac{F' \; F''}{f'}$.

In the case of Mrs. G., we found a myopia of $\frac{1}{6.5}$, and we know that an object distant $6\frac{1}{2}$ inches from her nodal point has its image on her retina. Should we desire to ascertain how much her visual axis is too long, assuming with the best authorities that it should be normally 22.23 mm., we subtract from 6.5 = 165 mm. the distance from nodal point to anterior focus = 20 mm., and we have $f' = 145$; to find $f' = \frac{F' \; F''}{f'}$ we say $f'' = \frac{20 \times 15}{145} = 2.07$. The retina is 2.07 mm. distant from its proper position, and her axis is therefore $22.23 + 2.07 = 24.30$ mm. in length.

The same formula is used for hypermetropia; but as the distance from the nodal point to the object is negative, f' is found by adding the distance of the point of convergence behind the eye to the distance from the nodal point to F'', and with hypermetropia of $\frac{1}{6.5} = 165$ mm. $f' = 165 + 20 = 185$, $f'' = \frac{20 \times 15}{185} = 1.6$. Subtract this quantity from 22.23, and we have the length of axis which gives rise to this degree of hypermetropia = 20.63.

An instrument for making these examinations has been constructed for me by Mr. Zentmayer, which consists of four disks of sheet-brass $1\frac{1}{3}$ inches in diameter, attached together by a pivot passing through a small projecting handle upon each disk.

No. 1 has in its centre a single perforation, 1 mm: in diameter.

No. 2 has 12 perforations, $\frac{1}{2}$ mm. apart.

No. 3 has 2 perforations, 3 mm. apart.

No. 4 has 2 perforations, 4 mm. apart, those in the last three disks being all $\frac{1}{2}$ mm. in diameter.

It is known that when an ametropic eye regards a distant point of light, a circle of diffusion must fall upon its retina; and that by the exclusion of peripheral rays, by means of a small perforation in an opaque screen, definition may be so much improved as to enable the point of light to be distinctly seen. A rapid to and fro motion of the screen will bring other portions of the diffused circle on the retina under the influence of the diaphragm, and the test-light will, to the observer, appear to dance in accord with these motions. Screen No. 1 is used for this purpose.

The entire circle of diffusion may be influenced by a series of perforations by the use of disk No. 2, through which the test-light will appear to the observer multiplied.

No. 3 has fixed in a groove a small slip of ruby-colored glass, which may at will be pushed over one of its holes, and thus color one of the double images of the test-light red. Myopia is distinguished from hypermetropia in this manner, and this disk is used when the point of light is employed instead of the ordinary test-types, and a glass is empirically sought for which will fuse the two images and correct the ametropia. The overlapping space is larger than in disk No. 4, the double images are more easily found, and the examination of dispensary patients or children is made with precision and rapidity.

Disk No. 4 is employed for the calculation of ametropia in the manner and by the formula above described.

Note.—An ametropia $=\frac{1}{32}$ is indicated when the two points of light appear to be 1 inch apart.

A band of light, passing through a slit in a screen $\frac{1}{10}$ inch in width, presents an angle of nearly two minutes at 16 feet—an angle of 1 minute being chosen by Snellen as the standard for normal acuteness of vision.

It follows that if this band should appear twice as wide, by becoming double, but not separated, it would indicate the tenth part of $\frac{1}{32}$, or an ametropia of $\frac{1}{320}$.