Sclero-corneal trephining in the operative treatment of glaucoma / by Robert Henry Elliot.

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THE OPERATIVE TREATMENT OF GLAUCOMA

R. H. ELLIOT

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BY

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To E. C. I. E.,

TO WHOM THE AUTHOR OWES SO MUCH

To PRIESTLEY SMITH, M.Sc., M.B., B.Ch., F.R.C.S., Etc.

KINDLY CRITIC, AND GENEROUS HELPER, WHOSE LIFE-LONG WORK IN CONNECTION WITH GLAUCOMA PROBLEMS HAS MADE THE WORLD HIS DEBTOR, THIS

BOOK IS DEDICATED

BY HIS VERY SINCERE ADMIRER

PREFACE.

The present time may be spoken of in ophthalmological history as The Glaucoma Age. The magnificent work of past decades, associated with the honoured names of Priestley Smith, Lagrange, de Wecker and many other workers, has suddenly reached fruition. The underlying principle is to be expressed in the one word "Sclerectomy."

The methods proposed to carry out the common object are very various, and time alone will show which of them is the best.

To me trephining seems the ideal procedure, and though I clearly recognise that my judgment may not be, I should almost say cannot be, unprejudiced, I desire to lay my case fully and freely before the Medical Profession.

At that bar we must all be tried, and I for one have no doubt that the ultimate verdict, even though delayed, will be the just and right one, be it what it may.

Medical men have written to me from many parts of the British Isles, from our Colonies, from America and from Europe to ask questions about the procedure I have recommended for the operative treatment of glaucoma. Most of their questions have been fully answered in past articles I have written or read during the last four years. I felt that it was necessary therefore to collect all that could be said on the subject of trephining within the covers of a single volume, so that all who would could read it.

I have endeavoured to acknowledge much of the kind aid I have received, but I should be remiss if I failed to specially remember a few of my helpers.

To Mr. Sydney Stephenson I owe more than I can easily express, but in that respect I am on equal terms with a large

body of ophthalmologists throughout the English-speaking world, to whom the arrival of the monthly *Ophthalmoscope* is a looked-for event.

To my staff, whose untiring and devoted work has made possible any work I may have done, I am deeply indebted. Lieutenant Craggs has been invaluable in the after-treatment of the patients; Assistant Surgeon Taylor has assisted me in many ways, and not least by the aid of his excellent photographs. Sub-Assistant Surgeon Ranganatha Row has made the writing of the book possible by the untiring and excellent work he has put into it in his capacity of Surgical Registrar of the Government Ophthalmic Hospital, Madras.

To Majors Kirkpatrick and Hime I am under much obligation for their assistance in the revision of the proofs, and for many valuable suggestions.

I have to acknowledge the courtesy of the Editor of *The Ophthalmoscope*, of Messrs. Arnold & Sons, and of Messrs. Jno. Weiss & Sons in lending me the blocks of illustrations which were in their possession.

I have left till last, though far from least, my acknowledgments to Mr. Sydney Stephenson, to Dr. A. J. Ballantyne, and to Dr. Temple Smith for so kindly allowing me to include their very able articles in chapters ii and xii of the book.

ROBERT HENRY ELLIOT.

SHAWFIELD,
EGMORE,
MADRAS,
INDIA,
1913.

PREFACE TO THE SECOND EDITION.

Before "Sclero-Corneal Trephining" had been eight months in print, the publishers were asking for a second edition. My visit to the United States, at the very kind invitation of the American Academy of Ophthalmology and Oto-Laryngology, made it impossible for me to commence the task for some months. Nor was this the only cause of delay, for the year (1913) of the book's first publication proved an exceptionally full one for its writer. In it, I had the honour of taking part in a number of very interesting discussions on the subject of glaucoma. These included (1) The Glaucoma Discussion in London at the International Congress of Medicine (August, 1913), of which I was one of the openers, my distinguished colleagues being Professors Priestley Smith and Lagrange; (2) The Congress of the American Academy of Ophthalmology and Oto-Laryngology (October, 1913), before which, by their kind invitation, I delivered the Anniversary Oration on Trephining; (3) The Symposium on Glaucoma, held by the Chicago Ophthalmological Society (November, 1913), in which Professors Weeks, de Schweinitz, and Jackson also took part as my fellow guests of the Society, and (4) The Oxford Congress of Ophthalmology (1913). Besides these, there have been a number of other occasions on which it has been my privilege to meet the members of various ophthalmological societies, and to take part in their deliberations on the subject of the treatment of glaucoma. In the short space of two months I had the pleasant but arduous task of performing the operation of sclero-corneal trephining on 135 eyes, in 28 hospitals, in 14 of the large towns of the United States of America; and I have also had the opportunity of demonstrating my *technique* in a number of hospitals in England.

In addition to this, I have carefully studied the very numerous recent additions to the literature of glaucoma. Some idea of the task involved may be gathered from the fact that trephining alone has claimed about five hundred references during the past three years.

The consequence of all this has been that the issue of a second edition has practically involved the re-writing of the book, and no pains have been spared to bring the treatment of the subject up to date.

The work of others has been drawn on very freely, and to the many who have written to me from Europe, America, Canada, Australia, New Zealand, Egypt, and the East, I tender my grateful acknowledgments, and I regret that it is not in my power to here express to each one individually my deep sense of indebtedness. I can only hope that they and others will still further help me in the future. I very greatly appreciate their assistance.

By special request of many of my American friends, I have greatly expanded Chapter V, giving very minute details of the *technique* of the procedure which I have advocated. Chapter VI has been brought well abreast of the times, the opinions and practice of others being given freely, and it is hoped impartially. Chapter XI has, thanks to Captain Gray's kindness, and to Mr. Ranganatha Row's work, been completely revised; enabling the reader to judge of the results of over four years of trephining in Madras. Chapter XII is new, and puts forward the experience and statistics of a number of well-known ophthalmologists. Chapter XV is the 'lumber-room' of the book, but it is hoped that many will consider that the 'lumber' it contains is not without value. Chapters III, IV, VII, VIII and IX have also been largely added to, or recast. A number of new illustrations have been added.

Captain W. C. Gray, I.M.S., who, since I left India, has been acting as Superintendent of the Government Ophthalmic Hospital, Madras, has been most kind in helping me in many ways, and not least in furnishing me with statistical and other information. To his head assistant, Lieut. Craggs, to Mr. Taylor, and to his whole staff, I am indebted very deeply, but

I must not omit to specially mention the excellent work done for me by the surgical registrar, Mr. Ranganatha Row, whose painstaking study of case-sheets has added so much to the value of the rewritten chapter on our Madras results.

I am indebted to the Editors of *The British Medical Journal*, *The Lancet*, and *The Ophthalmoscope*, for permission to reproduce articles which have appeared in their columns, and to the last-named gentleman for much other assistance.

In conclusion, I wish to take yet another opportunity of adding my meed of homage to that which Professor Lagrange has already so justly earned from the profession throughout the world, by the great work he has done. He it is who gave us "sclerectomy"; this conception has been the foundation stone of all our progress in the treatment of glaucoma; it has materialised the dream of von Graefe, and has converted the longing foresight of that great German into the practical triumphs of the surgery of to-day. In minor matters of *technique* I may have to disagree with Professor Lagrange, but he has no more sincere admirer, and no one who more fully recognises the greatness of his achievement than

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CHAPTER I.

INTRODUCTORY.

The idea of substituting trephining for sclerectomy as performed by the older methods, had been present in the writer's mind for a long time before he ventured to put it into execution. An enormous amount of glaucoma is met with in Southern India, mostly in a chronic or sub-acute form, and the results yielded by iridectomy were such as to leave much to be desired. When Lagrange and Herbert brought their new operations before the profession, the Madras Hospital was one of the first to give these a full and free trial. To the writer the soundness of the new operations appealed so strongly that he ventured to bring the matter before the local branch of the British Medical Association in the year 1906, and he then expressed the opinion that the day of von Graefe's operation was over, and that its sun had set after nearly fifty years of undisputed supremacy. The members present were greatly taken aback, and it was suggested that too hopeful, if not too premature, a view had been taken of the case. Time, however, declared its verdict in favour of the new methods, and, little by little, iridectomy was abandoned in favour of one form or another of sclerectomy. The after-results in the cases that returned to the Madras Hospital gave us great encouragement. During this transition period another interesting observation was frequently made. All cases which had undergone iridectomy for glaucoma were carefully examined on their return to hospital, and in a large number of these, in which good vision had been retained, a filtering scar was found to be present, whilst in the failures no such evidence of filtration existed.

We had therefore reached the conclusion that Herbert and Lagrange had established their two contentions, *viz.*, (1) that it is possible to form a permanent filtering cicatrix between the anterior chamber and the sub-conjunctival space, and (2) that the establishment of such a condition permanently reduces a raised intra-ocular tension. To Lagrange's operation and to Herbert's earlier method, there were however very distinct objections. It is not easy to graduate the amount of sclera to

be removed by the former method, especially as the scleral section has to be made on an opened, and, often, on a congested eye, nor is the operation free from the dangers of serious vitreous accident, and of intra-ocular hæmorrhage. Every moment of this procedure is fraught with anxiety, and at the late stage at which operation is so frequently called for in Madras, disaster is at times unavoidable. Herbert's original operation was tricky and difficult, although when correctly performed it yielded excellent results.

The essential feature of the new operations was the removal of a portion of the outer tunic of the eye, and the establishment thereby of drainage from the interior of the eye into the sub-conjunctival space. So far, we were obviously on firm ground, but our methods of accomplishing our object left all too much to be desired. Whilst mentally balancing this position, it occurred to the writer, at the close of 1907, that the key to the difficulty might be found in the use of the trephine. At once there surged up a number of difficulties: would a trephine hole be permanent? would there be room to apply a trephine? would it be an easy or a difficult operation? would unexpected complications attend it? what size of blade should be used? These and many other questions presented themselves to the author's mind, whilst those surgeons whose opinions were asked, looked askance at the suggested procedure, which did not recommend itself in the least to them. To break ground on a new method, with a patient's eye at stake, is always a serious matter for any surgeon; and yet in spite of discouragements, the idea returned insistently, that trephining was sound in principle and should be given a trial. This was the position at the beginning of 1908, and a determination to put the matter to a crucial test had been all but reached, when unexpected circumstances compelled the writer to leave India on very short notice. Whilst at home on leave, he had the opportunity, rarely given to an ophthalmologist in the East, of discussing this question with confrères, and he returned to India determined to try trephining as soon as opportunity offered. The first chance was on August 2nd, 1909. The operation proved to be an extremely easy one, and two more were performed the same morning. From that time on, several eyes have been trephined weekly in Madras, the number rising to double figures on many occasions, so that when the writer left India, he had the carefully recorded notes of about 900 cases to draw on: since then he has had the opportunity in America and in Europe of adding more than another 150 cases. Experience has only served to strengthen the opinion that the method is as easy of execution as it is sound in principle.

It is no part of the present purpose to contrast the writer's operation with that of others. This has been ably done by Dr. Temple Smith, whose paper is reproduced in Chapter XIII of this book and it is also dealt with in Chapter XIV. But he desires at this point to state clearly the objects which he has kept consistently before him from the very first. The light of experience, and the valuable advice which he has ungrudgingly received from all parts of the world, have enabled him, in important details, to modify the *technique* of his operation; the essential feature of the procedure has, however, never altered. His object has been to tap the anterior chamber and to drain it permanently into the sub-conjunctival space. In doing so, he has endeavoured consistently to reduce to a minimum the amount of trauma inflicted upon the eye. Iridectomy enters into the procedure exactly as it does into that of the combined operation for cataract. In other words it is a necessary evil. Fortunately however, as we shall see later, the evil can, in this operation, be reduced to a practically negligible quantity. Every effort has been made to avoid any interference with the ciliary body. Cyclodialysis, so far from having been courted, has been sedulously shunned. It is for these reasons that the site of the trephining has crept forward till the operation is now a sclero-corneal, or almost a corneo-scleral procedure. In searching for a title to describe the operation, none seems more suitable than that of "Sclero-Corneal Trephining for the relief of Glaucoma."

CHAPTER II.

HISTORICAL.

The History of Trephining in the Surgical Treatment of Glaucoma is of sufficient interest to justify a chapter being devoted to it. Fortunately this side of the question has recently been very fully and ably dealt with by Mr. Sydney Stephenson and by Dr. Arthur J. Ballantyne in the pages of *The Ophthalmoscope*. No apology is needed for reproducing these articles at length, but the author desires to acknowledge his indebtedness to both these writers for the permission to thus make use of their work.

THE TREPHINE IN THE TREATMENT OF GLAUCOMA.

BY

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THE use of the trephine in the surgical treatment of glaucoma has recently been advocated by Dr. Freeland Fergus[1] and Major R. H. Elliot[2] respectively. The method, however, is by no means new, although the precise application of the method may perhaps be so.

Writing thirty-four years ago, the late Dr. D. Argyll Robertson[3] described what he called "A New Operation for Glaucoma." He drilled a hole, about 1/12th of an inch in diameter, through the upper part of the sclera at or about the junction of the ciliary processes with the choroid. In his last two cases Robertson turned up a flap of conjunctiva with a

* *The Ophthalmoscope*, Feb. 1910.

cataract knife before applying the trephine, and afterwards replaced it over the aperture. Finding that Bowman's trephine was not in all respects well adapted for perforating the sclera, he introduced certain modifications in the instrument. For example, he added to the original trephine a collar of German silver roughened on its outer surface, so as to afford a good hold for the surgeon's fingers; and, furthermore, he modified the cutting end of the trephine, so as to enable perforation of the sclera to be more readily effected, and also to prevent the instrument from passing too deeply into the interior of the eye.

By these means Robertson had operated on four patients, and he believed that in the operation he described we possessed "an effectual means of reducing increased intra-ocular tension."*

At the International Medical Congress at Madrid (section of ophthalmology) Dr. Blanco,[4] of Madrid, advocated the removal from all blind and painful eyes of a circle, 4 mm. to 5 mm. in diameter, of sclera, choroid, and retina.

A proposal to revive the operation of trephining the sclera in glaucoma, meanwhile condemned by certain writers and looked on askance by others, was brought up by Dr. Konrad Fröhlich[5] twenty-eight years after Argyll Robertson had described the operation. A triangular flap of conjunctiva, 10 mm. to 12 mm. long, having been reflected from the lower-outer part of the eyeball, a disc of sclera was removed with von Hippel's trephine, provided with a 5 mm. crown. The choroid and the retina were not touched. On completion of the operation, the conjunctival flap was replaced, and kept in position by means of several sutures. Fröhlich treated by these means five painful eyes blinded by glaucoma, and all made an uncomplicated recovery (with a single exception) in from ten to fourteen days. The failure appears to have been due to the fact that the trephine was inadvertently pushed through all the membranes, whereby profuse extra- and intra-ocular hæmorrhage was brought about. In case of failure, Fröhlich advocated evisceration of the eyeball.

As to the more recent suggestions, those of Fergus[1] and of Elliot,[2] they differ from one another somewhat as regards details, and collectively, again, they also differ from the methods advocated by Robertson, Blanco, and Fröhlich.

Whereas Robertson, Blanco, and Fröhlich removed a disc from the sclera immediately posterior to the ciliary body, both

*It should be noted that Argyll Robertson advocated his operation only under special circumstances—as, for example, when iridectomy could not be performed or when it had failed.

Fergus and Elliot advocate a more anterior position. All the writers named reflect a flap of conjunctiva prior to trephining the sclera.

When we come to examine a little more closely the proposals of Fergus and Elliot, we find a considerable difference in the operations they advocate.

Fergus,[1] after dissecting a large conjunctival flap up to the sclero-corneal margin, removes with the trephine a piece of sclera as near to the cornea as possible. The point of an iris repositor is then passed from the scleral opening into the anterior chamber. The last step is to replace the conjunctival flap, and to stitch it into position. Although Fergus regards his operation as a mere modification of the sclerectomy devised by Lagrange,[6] yet it obviously bears an even closer resemblance to Heine's cyclodialysis, in which the ligamentum pectinatum is broken through by means of a spatula, an incision having first been made through the denuded sclera at a distance of about 5 mm. from the limbus. By this operation, as everybody knows, Heine endeavoured to establish a permanent communication between the anterior chamber and the supra-choroidal space.

Elliot,[2] after reflecting a flap of conjunctiva, applied the crown of a small trephine (2 mm.) as close to the limbus as possible, and aims at allowing the instrument to cut its way into the anterior chamber. The surgeon may then leave the disc of sclera in place, or remove it altogether. Iridectomy may or may not be combined with the trephining. Elliot aims at establishing a permanent filtering cicatrix between the anterior chamber and the subconjunctival space. Of fifty patients treated in this way in none did the operation fail to relieve tension. Elliot claims that by his operation even a tyro can accomplish all that Herbert and Lagrange aim at in their operations, the *technique* of which is more difficult.

Both Fröhlich and Fergus lay some stress upon the fact that the sclera can be trephined without general narcosis, as by chloroform.

REFERENCES.

(1) **Fergus, Freeland.**—*Brit. Med. Jour.*, October 2nd, 1909.

(2) **Elliot, R. H.**—*The Ophthalmoscope*, December, 1909.

(3) **Robertson, D. Argyll.**—*Royal London Ophthalmic Hospital Reports*, Vol. VIII, Part 3, May, 1876.

(4) **Blanco.**—*Klin. Monatsbl. für Augenheilkunde*, Bd. XLI, Heft ii, S. 150, 1903.

(5) **Fröhlich.**—*Klin. Monatsbl. für Augenheilkunde*, Mai, 1904. Abstracted in *The Ophthalmoscope*, 1905, p. 462.

(6) **Lagrange.**—*The Ophthalmoscope*, September, 1907.

THE NEWER OPERATIONS FOR GLAUCOMA

BY

ARTHUR J. BALLANTYNE, M.D.*

SURGEON TO THE GLASGOW EYE INFIRMARY.

There are few more interesting chapters in the recent literature of ophthalmology than those which record the efforts of surgeons to devise an operation that will be both easy of performance and devoid of serious risk, and will at the same time offer reasonable prospects of improvement or cure in chronic glaucoma.

Since its introduction by von Graefe, half a century ago, iridectomy has held the field practically undisputed, and any attempt to displace it from its position of security was at first looked at askance. It is admitted on all hands that the results of iridectomy in acute glaucoma leave little to be desired. In chronic congestive or inflammatory glaucoma its beneficial effects have been scarcely less notable, but it is almost universally recognised that in chronic simple glaucoma iridectomy has not been by any means so successful as in the other forms of the disease. A growing dissatisfaction with the relative futility of iridectomy in this condition has led to the introduction, from time to time, of alternative operations, but although each has had its body of supporters, none has yet been received as the last word in the surgical treatment of chronic glaucoma.

Whatever may be the true pathogenesis of the condition, the working hypothesis on which all efforts at treatment are based is that there exists some abnormal relationship between the intra-ocular pressure, on the one hand, and the resistance of the ocular tunics, on the other. We are compelled therefore to seek means whereby the tension of the eye may be permanently reduced by facilitating the outflow of the intra-ocular fluids. The authors of the newer glaucoma operations claim that they do establish this permanent reduction of the ocular tension, and if their claim is found to be justified, these operations will mark a distinct and valuable advance in ophthalmic surgery.

Readers of *The Ophthalmoscope* have been kept in touch with the literature of this subject, through its abstracts, reviews and original articles, which, however, are now distributed over a period of four years. The present Review, undertaken in view of the expected discussion at the forthcoming Oxford Ophthalmological Congress, is presented in the hope that it may give the reader some idea of the chief points round which

* *The Ophthalmoscope*, July, 1910.

discussion may be expected to centre. It will be convenient in the first place, at the risk of repeating what has already been published here and elsewhere, to classify and briefly to describe the operations which we are to consider. Thereafter we may ask and attempt to find an answer to some questions bearing upon their utility and safety.

Sclerotomies.

The writings of Lagrange, Herbert and their followers, have made us familiar with the conception of the "filtering cicatrix," but lest we should imagine that the idea originated with these writers, it is well to recall the fact that von Graefe, de Wecker and others were quite familiar with the idea of the filtering cicatrix. It was, indeed, de Wecker who coined the phrase. In the discussions which centred round the *modus operandi* of iridectomy in glaucoma, de Wecker held that to explain the apparent success of iridectomy where the iris was atrophic one was forced to conclude that the effect depended on the scleral incision, which was followed by a "*cicatrice à filtration.*" When it came to be suspected that in chronic simple glaucoma iridectomy was useless or even harmful, de Wecker felt that an alternative operation was desirable, and in 1867 proposed sclerotomy, the cicatrix of which facilitated the filtration of aqueous, and consequently secured a permanent reduction of intra-ocular pressure. Not only did de Wecker aim at the production of a filtering scar, but he also insisted that the sclerotomy wound must be free from incarceration of iris.[1]

Since its introduction, sclerotomy, in some form, has, next to iridectomy itself, been the operation most largely practised in simple chronic glaucoma. It has been accepted as a safe procedure, although repetition of the operation on the same eye is frequently required owing to the want of permanence of the results. Dianoux[2] has recently reaffirmed its value, but recommends that it be followed up by massage of the eye, to prevent first intention healing, and to cause the formation of a permeable cicatrix. He is supported by Wicherkiewicz,[3] who recommends the same measure after iridectomy.

The operation of sclerotomy has assumed many forms in the hands of different operators. The two classical methods are those of de Wecker and Quaglino, the former being probably the more popular.

If one may judge by the absence of any expression of disapproval of the newer operations from the supporters of sclerotomy, one is led to the conclusion that in chronic glaucoma sclerotomy, after forty years, has, like iridectomy, failed to give

the satisfaction that it seemed to promise. But the belief that it *ought* to be possible to produce deliberately a corneo-scleral wound which will lead to a permanently filtering cicatrix, has never been altogether lost, and was the motive which inspired the newer operations, which will be considered under the heading of sclerectomies.

In addition to the classical sclerotomies of de Wecker and others, one or two more recent forms may be alluded to.

Querenghi's operation of sclero-choriotomy[4,5] consists in paracentesis of the posterior chamber with a perfectly linear Graefe knife, making puncture and counter-puncture immediately behind the insertion of the iris. The author believes that glaucoma is due to a hydropsia of the peri-choroidal space, and that his operation overcomes this by establishing a communication between the perichoroidal space and the aqueous chambers.

Bjerrum's operation[6] is recommended for simple glaucoma if myotics fail. With a narrow Graefe knife he makes an incision, the puncture and counter-puncture being placed at the limbus and the knife being made to cut out obliquely, so that it emerges through the sclera from 3 mm. to 6 mm. from the upper or lower edge of the cornea. The incision is rendered subconjunctival by making the conjunctival puncture and counter-puncture some distance from the limbus.

Among the sclerotomies should also be included the procedure tried by more than one operator in the past, and recently revived by Herbert,[7] namely, the infolding of a slip of conjunctiva between the lips of a corneo-scleral wound, with a view to the establishment of a filtering cicatrix.

Still another form of sclerotomy is the *subconjunctival paracentesis* operation introduced by Herbert two years ago.[8] Having subconjunctivally passed a narrow Graefe knife into the anterior chamber, in such a way that it makes a short incision parallel to the corneal margin, and 1 mm. from it, he carries the knife from each end of this incision a short distance inwards towards the cornea. In this way he isolates a rectangular tongue of sclero-corneal tissue, the partial shrinkage and displacement of which are said to lead to the formation of a filtering cicatrix. More recently[9] he has been making a broader tongue, placing it at the upper limbus, and combining it, in some cases, with an iridectomy.

Abadie's Operation.—In an article which appeared in the *Archives d'Ophtalmologie* for May, 1910, and a translation of which will be found in the present number* of

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* July, 1909.

The Ophthalmoscope (p. 501), Abadie describes the new operation of " Ciliarotomy."

Abadie has always disputed the claims of Lagrange, chiefly on theoretical grounds. He holds that filtration through the cicatrix is not the cause of the reduction of tension after iridectomy or sclerectomy, that a very small iridectomy is as efficacious as a large one, and that the effect is really attributable to division of the nervous circle of the iris.

Believing that in certain cases glaucoma is due to irritation of the nerve plexus in the ciliary zone, he hopes to produce an " anti-glaucomatous " action in such cases by division of the nervous circle. This he does by first dissecting up the conjunctiva and then with a Richter's triangular knife making a 7 mm. to 8 mm. incision through the ocular tunics in a meridional direction immediately behind the root of the iris. The conjunctiva is sutured in place over the wound.

The operation has given Abadie excellent results in relief of pain, reduction of tension, and improvement of vision, in cases of absolute glaucoma and glaucomatous degeneration.

Cyclodialysis.

Heine, of Breslau, introduced this operation to the Ophthalmological Congress at Heidelberg in 1905.[10] With a straight lance knife he makes an incision in the sclera parallel to the corneal margin and 5 mm. or 6 mm. outside of it. A small spatula is then passed through the wound and between the sclera and uveal tract into the anterior chamber, breaking through the ligamentum pectinatum.

The operation is based largely on the suggestion of Axenfeld, that the choroidal detachment which Fuchs had observed after operation for cataract, occurred also in glaucoma iridectomies, and was responsible for the good results of these operations. Heine believed it possible to set up, by means of his operation, a communication between the anterior chamber and the suprachoroidal space.

The abundance of references to this operation in the literature of the last few years [11] [12] [13] [14] [15] [16] shows that it has excited a good deal of attention. Operations vary considerably as to the safety and trustworthiness of the operation as a means of relieving pain and tension, and as to the permanence of its results. The interest manifested in Heine's operation has no doubt been somewhat lessened by the advent of the " filtering cicatrix " operation, but cyclodialysis has again appeared as an integral part of Fergus's sclerectomy with the trephine, to be referred to at a later stage.

Operations involving incarceration of the iris in the wound.

The operations comprised in this group resemble the most recent procedures of Lagrange and his followers in their aim of ultimately establishing a permanently permeable cicatrix, but the former differ from the latter in that they seek to attain their object by means which are deliberately avoided by the advocates of the iris-free filtering scar.

The authors of the incarceration operations base their proposals on the following three facts :—(1) that in such an operation as extraction of cataract the entanglement of iris in the wound frequently leads to the formation of a cystoid, or, at least, a fistulous, scar, and that the eye in consequence remains permanently soft, with evidence of leakage of aqueous fluid into the subconjunctival tissue ; (2) that in iridectomies done for acute glaucoma the best and most permanent results are found in cases where the iris has become entangled between the lips of the wound ; and (3) that the risk of infection of a prolapsed or incarcerated iris is greatly less in the cases where the latter is covered with conjunctiva. If the beneficial effect of iridectomy in many cases is due, not to the iridectomy but to an accidental inclusion of iris, why not, they ask, set out to produce such an inclusion in a regulated and deliberate manner, adding the conjunctival covering to avoid risk of infection ?

In June, 1903, Major H. Herbert[7] communicated the results of no fewer than 130 operations for the production of a *subconjunctival prolapse of the iris* in primary glaucoma. In thirteen the iris was left uncut, in five an iridotomy was added, and in all the others iridectomy was performed. He found that the relief of tension was certain and permanent, although in some cases the reduction was not immediate but was established only after the use of massage and myotics for periods up to two or three months. The effect on vision was found to be more favourable than could be looked for in the same class of cases from iridectomy, and this was most notable in cases with advanced failure of vision, for in early simple glaucoma the post-operative astigmatism was apt to disturb the good central vision. He also held that the risk of late infection was very small, and that early serious complications were less frequent than in similar cases operated on by large iridectomies. In 1908, Herbert[17] was still convinced of the value and safety of the operation.

In the *Annales d'Oculistique* for 1907, Holth[18] advocated a somewhat similar procedure. He varies his operation somewhat in regard to the form and position of the incision, and

the method of producing the incarceration ; but in most cases he makes either a flap incision at the limbus, with a linear knife, covering it with a conjunctival flap, or a 6 mm. incision 1 mm. outside the corneal border with a keratome, which is first made to pierce the conjunctiva 8 mm. to 10 mm. from the limbus, so as to render the corneo-scleral wound subconjunctival. An iridectomy or iridotomy is done before the iris is drawn into the wound. Holth reported that he had done the operation 41 times, in 85 per cent. of which he had obtained persistent conjunctival œdema with normal tension. In a later paper[19] he published the results of a further series of 87 operations with 86 per cent. of filtering cicatrices. He had had no bad results and had not lost an eye. Some of the cases were found still satisfactory on subsequent examinations six months to two years later ; but the author seems to have felt that the results were a little uncertain, and he turned his attention later to the production of a filtering cicatrix by means of sclerectomy. Borthen[20] has done fifty operations for establishing a subconjunctival prolapse without previous iridectomy. In no case of simple or absolute glaucoma did he fail to obtain the desired results. Maher, in the discussion following a contribution by Lawson,[21] stated that he had performed a similar operation combined with iridectomy, and in ten or twelve years had lost only one eye from iridocyclitis. He thought the benefits outweighed the risks of inflammation or of sympathetic disease.

The fear of disaster from infection of the eye, or from sympathetic ophthalmitis of the fellow eye in these operations which we have just been considering, and the difficulty of regulating the effect produced, supply two good reasons why we should carefully weigh the claim made on behalf of the next group of operations, some of which are stated to be free from both of these drawbacks.

Sclerectomies.

Quite a number of these operations are now on trial, but first in point of time come those of Lagrange and Herbert.

Lagrange's Operation. — In May, 1906, Lagrange brought forward his operation, the details of which have been made familiar through a now fairly large number of papers from the pen of Lagrange and others (bibliography 22 to 38). He is of the opinion that in iridectomy the removal of iris *per se* is not answerable for the success of the operation. He says that in operations for glaucoma, hypertension interferes with the co-aptation of the

wound. The cicatrix allows a certain amount of filtration, and this phenomenon explains the success of the iridectomy. In chronic glaucoma with low tension operation is valueless because the wound does not give place to a filtering cicatrix. The conditions are strictly comparable to those in the normal eye, in which no form of scleral incision is able to produce a permeable scar (Schoeler[39]). Again, he recognises that a filtering cicatrix can be produced by sclerotomy and in iridectomy, if the iris is involved in the wound, but he sets out to produce an "iris-free filtering cicatrix" and this he claims to have succeeded in accomplishing. His operation he now calls that of "Sclerecto-iridectomy," the sclerectomy being the essential part of the operation, the iridectomy only conditional.

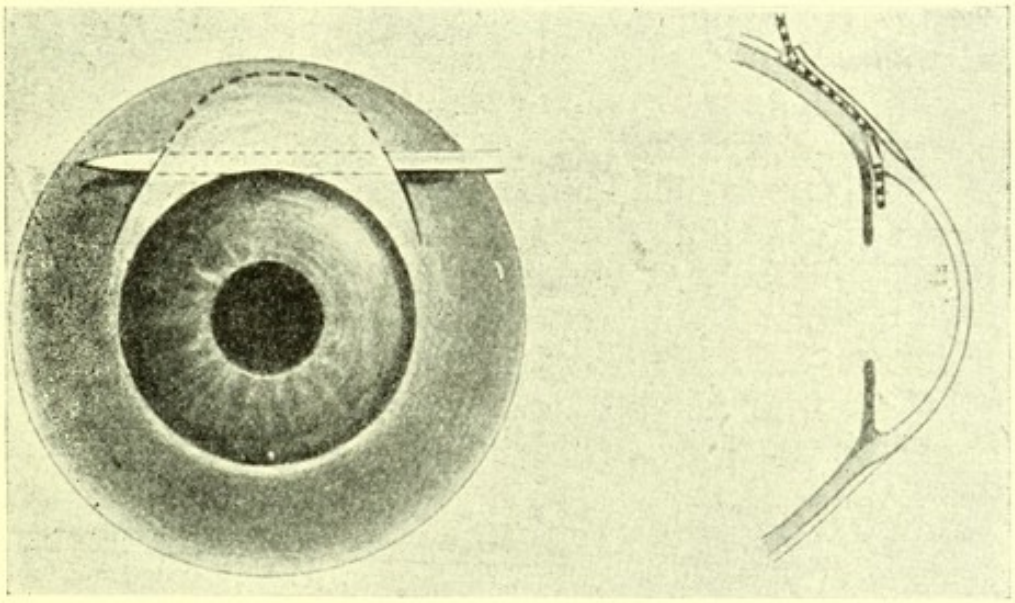

FIG. 1.—Section of the Sclera and Conjunctiva.

The accompanying diagrams (Figures 1 to 4) will help to explain the steps of the operation. Using a narrow Graefe knife, a small corneo-scleral flap is made at the upper part. Puncture and counter puncture are made 1 mm. outside the corneal margin, and the blade is carried upwards, parallel to the iris and as close to it as possible, the first object being to sever the scleral insertion of the ciliary muscle. The plane of the knife blade is then changed, so that it emerges from the sclera 2 mm. or 3 mm. from the limbus and thus bevels the posterior lip of the incision. The incision is completed with a large conjunctival flap (Fig. 1). This flap having been turned down, the corneal lip of the wound is

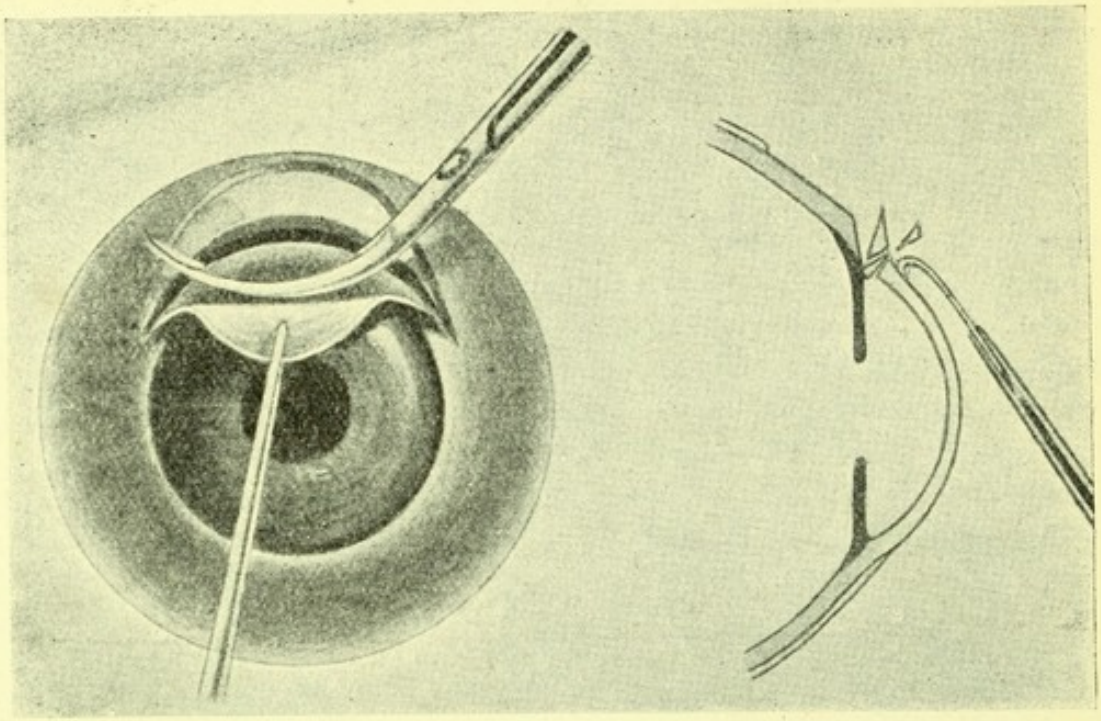

FIG. 2. - Resection of the Sclerotic.

removed by the scissors (Fig. 2). If iridectomy is considered desirable, it is done at this stage (Fig. 3), and the replacement of the conjunctival flap completes the operation. Iridectomy,

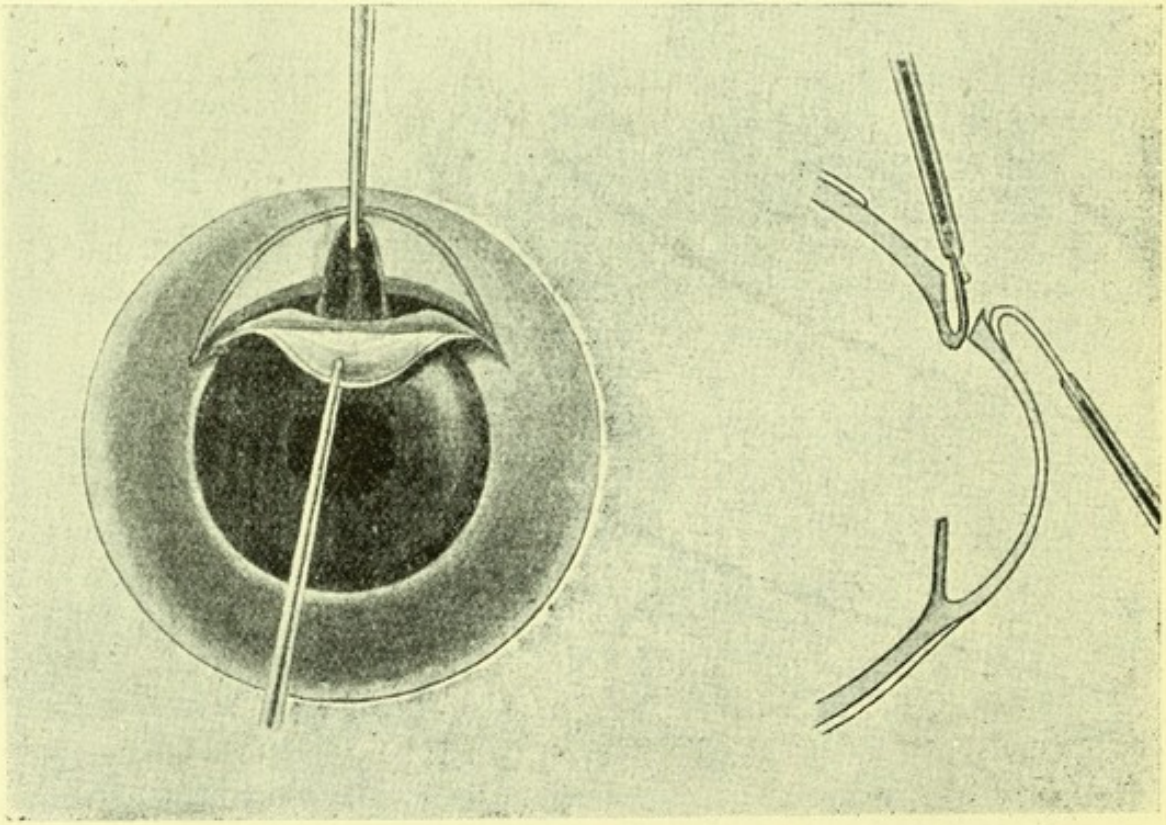

FIG. 3.—The Making of the Iridectomy.

although done in all the earlier operations, is not considered essential. It should always be done where for any reason, such as hypertension, prolapse is feared. No iris must be left between the lips of the wound. The result of the operation is shown in Fig. 4.

From his extensive experience of the operation, Lagrange has reached the following conclusions. — The results of sclerectomy vary according to the degree of hypertension of the eye operated on. Three varieties of cicatrix are distinguishable according to the amount of sclera excised: (1) that in which there is mere thinning of the sclera owing to the excised portion not reaching the posterior surface of the cornea (conjunctiva smoothly covers the cicatrix); (2) that

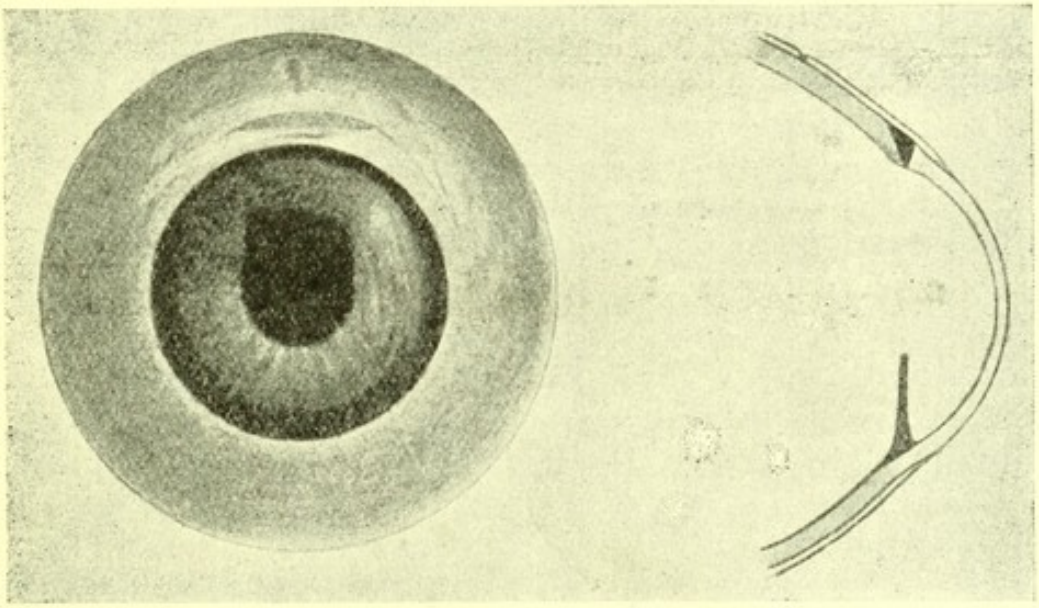

FIG. 4.—The Result of the Operation.

represented by a subconjunctival fistulette, due to excision of the whole thickness of the sclera, in an eye with moderate tension (the conjunctiva lies smoothly over the cicatrix); (3) the fistulous cicatrix with an ampulliform elevation of the overlying conjunctiva, resulting from excision of the whole thickness of the sclera in an eye the seat of high tension. In cases of high tension, even a simple sclerotomy will allow ample filtration, owing to the gaping of the wound, while in cases without elevation of the tension, sclerotomy will be quite ineffectual. He therefore proposes the following rules of procedure:—(*a*) If tension is normal to +1 do sclerectomy without iridectomy, the amount of sclera excised being inversely proportional to the degree of hypertension. (*b*) If tension is +1 to +3 do sclerecto-iridectomy, the iridectomy

being added to avoid entanglement of the iris. He does not recommend his operation for acute glaucoma. It is especially adapted for cases of chronic simple glaucoma.

Herbert's Operation.—Next in point of time comes Major H. Herbert's[40] operation of "wedge-isolation."

In the argument which precedes his description of the operation he speaks of permeable cicatrices as belonging to three groups, the cystoid, the fistulous, and the filtering. By the filtering as opposed to the fistulous cicatrix he appears to mean a cicatrix in which only microscopic channels exist to allow the percolation of fluid. While Lagrange started from the observations that in an eye the seat of high tension, sclerotomy is succeeded by a gaping wound which allows of permanent filtration, and that no kind of scleral incision can permit permanent filtration in an eye with normal tension, Herbert takes as his starting-point the clinical fact that cataract extractions with a large conjunctival flap return after long periods, with a more or less gaping wound, and œdema of the overlying subconjunctival tissue from filtration of aqueous. This he takes as his type of *filtering* cicatrix, and he describes it as "the condition which has been long desired, but never attained with any approach to regularity in the treatment of glaucoma." From such observations he argues that the iris-free filtering cicatrix is a practical entity, and he aims at its production in glaucoma.

Herbert's first device to secure delayed union and consequent filtration was his "jagged incision" operation—a form of sclerotomy—dating from April, 1906. In this operation he made one or both lips of a small corneo-scleral incision as jagged and uneven as possible by means of sawing movements of the narrow Graefe knife. With experience of sixty cases, he obtained results which were excellent, on the whole, but somewhat uncertain. He also used the operation of Lagrange, both in its original form and combined with the jagged incision, but he soon abandoned these procedures in favour of his "wedge-isolation" operation, first carried out in December, 1906. In this operation the intention is to cut out a wedge, or rather a prism-shaped piece of corneo-sclera, the long axis of which shall be tangential to the corneal margin, its base attached to the under surface of the conjunctiva and its edge towards the posterior surface of the cornea. The isolated wedge is raised a little from its bed by the escaping fluid, and as it has now to depend for its nutrition on the conjunctiva to which it is attached, it shrinks sufficiently to provide for filtration from the anterior chamber to the subconjunctival tissue, but not enough to cause an actual

fistula. The operation is claimed to permit of the establishment of different degrees of filtration; it is safe; and if it fail to produce the desired result, it does not prejudice the subsequent performance of the usual operations.

It is difficult to follow this operation from verbal description alone, but perhaps the following summary of the steps, with the assistance of the accompanying diagrams, may make it more or less clear.—A very narrow Graefe knife is used. (1) Proceeding as if the intention were to make a shallow corneo-scleral flap, puncture and counter-puncture are made close to

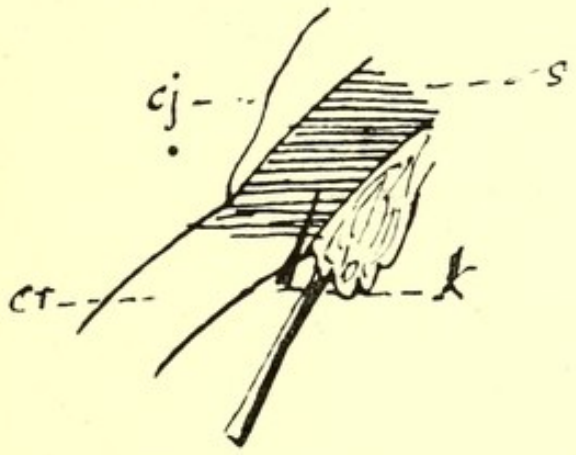

FIG. 5.—Position of the knife blade in making the first incision.

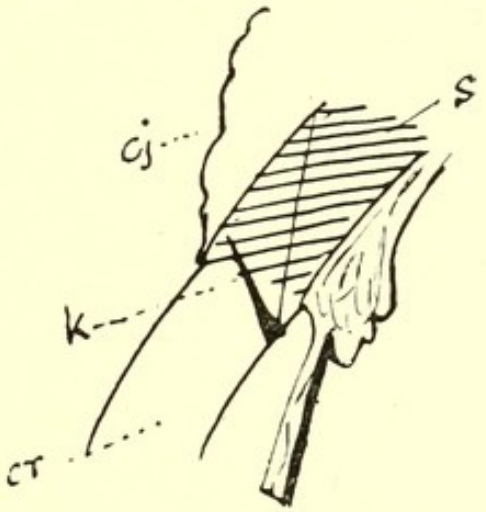

FIG. 6.—Position of the knife blade in making the second incision. The thin line shows the position of the first incision which has been partly made.

the margin of the cornea, the knife point having previously passed through the conjunctiva a little distance above the point of entrance. The upward cut is made with the knife blade bevelled a little backwards, and at this stage the bridge of sclera is left undivided (Fig 5). (2) The knife is brought down again and its edge turned forward. A forward cut is made perpendicular to the scleral surface, care being taken not to cut through the conjunctiva (Fig. 6). This incision makes the lower boundary of the wedge of tissue. (3) The knife is drawn backwards, and rotated upwards to lie in the original incision, which is continued upwards until the knife edge emerges through the sclera, a millimetre or so from the corneal margin. This completes the isolation of the wedge. The blade of the knife is now turned upwards and backwards to form a long conjunctival flap, which, however, is left attached at its upper extremity. A small basal iridectomy is advisable in order to prevent prolapse.

The widespread interest which these operations have excited has led other operators to introduce modifications, which, while carrying out the ideas of Lagrange, might be simpler of performance and freer from risk than his operation. The first of these modifications was proposed by Holth.[19]

Sclerectomy with punch-forceps.—This operation dates from May, 1909, and it will be found fully abstracted and illustrated in *The Ophthalmoscope* of November, 1909 (p. 774). The first step of the operation, the formation of a corneo-scleral flap, may be carried out either by a Graefe knife or with the keratome. In the former case the conjunctival flap is cut in completing the section, in the latter the keratome is made to enter the conjunctiva some distance above the scleral puncture. Iridectomy follows, and then the anterior lip of the wound is partly cut away by means of punch-forceps, which are a modification of Vacher's (Fig. 8) or de Lapersonne's irido-capsulectomy punch-forceps.

Brooksbank James's Operation.—In the discussion on Lawson's contribution[21] Brooksbank James referred to a modification of the Lagrange operation practised by him in six cases. A description of his method has more recently appeared in the *Transactions of the Ophthalmological Society* (Vol. XXX, Fasc. I, 1910). He dissects down a flap of conjunctiva and then with a Beer's knife makes an incision into the anterior chamber from without inwards, 1 mm. from the limbus. After an iridectomy, a portion of sclera from the lip of the wound is removed by scissors or punch forceps, preferably the latter.

Sclerectomy with the Trephine.—The latest additions to the list are the two operations in which the trephine is used to remove a segment of the corneo-sclera. These are the operations respectively of Fergus and of Elliot. Both of these operations are based on that of Lagrange, and as the reader may gather from the Review on the Use of the Trephine, published by Sydney Stephenson in *The Ophthalmoscope* for February, 1910, they have a much closer affinity to Lagrange's operation than to the older operations of Argyll Robertson, Fröhlich, etc., in which the trephine was formerly employed.

Fergus's Operation.—Fergus has employed this operation since January, 1909, and he demonstrated it before the Ophthalmological Congress at Oxford and the Ophthalmological Section of the British Medical Association at Belfast in July of the same year. The only published account of it was contained in an abstract of the latter contribution in the *British Medical Journal*[41] until the author took occasion to describe the genesis and the nature of the operation in *The Ophthalmoscope* of February, 1910.[42]

The *technique* of the operation is simple.—A conjunctival flap is dissected up towards the cornea and laid over the corneal surface, while with the trephine (Bowman's), a small disc of sclera is removed, a millimetre or two from the apparent corneal margin. At first the operation was completed at this stage by replacing the conjunctival flap, but Fergus soon introduced a modification which now forms an essential part of his operation, namely, the passage of an iris repositor from the trephine hole into the anterior chamber, keeping it in close contact with the sclera and cornea. The conjunctiva is then replaced, and stitched in position.

Elliot's Operation.—About the time that the above operation was on trial, Major Elliot, in Madras, had independently conceived the idea of utilizing the trephine in a similar way. He first used the trephine in August, 1909, and by the time of his first communication,* he had operated on 50 eyes.

Elliot also raises by dissection a flap of conjunctiva with its base at the corneal margin. His trephine opening is made as far forward as possible, so as to enter the angle of the anterior chamber. The disc of sclero-cornea is removed, iridectomy is done, if necessary to prevent incarceration in the wound, and the conjunctiva replaced. It is unnecessary to describe the operation in any greater detail, as it will be found fully discussed in the article by Elliot himself, which appears in the present* issue of *The Ophthalmoscope* (p. 482). Elliot found that in his first 50 cases tension was relieved in every one. While these two operations have features in common, it is obvious, as stated by Sydney Stephenson (*loc. cit.*), that they have marked points of difference. Elliot's operation is as nearly as possible the operation of Lagrange, making allowance for the use of the trephine instead of the scissors, since the opening forms a communication between the angle of the anterior chamber and the subconjunctival tissue, this object being attained by keeping the trephine as far forward as possible. The iridectomy is added, not as an integral part of the operation, but merely to avoid the risks of prolapse.

Fergus's operation, on the other hand, involves an opening up of the suprachoroidal space, to which is added a cyclodialysis. It is true that Lagrange, in stating the aims of his operation, speaks of cutting through the scleral attachment of the ciliary muscle and opening up a communication between the anterior chamber and the suprachoroidal space, but the successful accomplishment of this incision must be difficult, and it may be shown in the future that in most cases the

*July, 1910.

incision is purely into the anterior chamber. In any case Lagrange in his later papers seems to lay most of the emphasis on the formation of a fistulous track between the anterior chamber and the subconjunctival tissue-spaces. Fergus's operation, therefore, would seem to have a nearer relation to the cyclodialysis of Heine, substituting a trephine opening for a scleral incision with the keratome.

Verhoeff's Operation—Verhoeff's contribution to the subject[44] is the substitution of a special instrument—the "sclerectome" for the trephine. As its inventor says: "it combines the actions of a punch and a trephine." An incision 2-3 mm. long having been made parallel with, about half a millimetre from the corneal margin, the instrument is passed through the wound, and having been carried to one end of the incision it is made to cut out a small clean round hole, the diameter of which is one millimetre. A small buttonhole is made in the iris. The operation, like the others, is carried out under a conjunctival flap.

Bettremieux's Operation.—This operation appeared in 1907[46] under the title of "simple anterior sclerectomy." The author sets out from a different standpoint from that of the other operators. He states[47] that he has been impressed by the following facts: (1) that glaucoma has been caused experimentally by the cautery applied round the cornea, or by tying the anterior vessels, or, accidentally, by burns at the corneo-scleral junction, *i.e.*, by conditions which block the intra-ocular blood circulation; (2) that Exner explains the action of iridectomy in glaucoma on the ground that the arteries and veins in the iris are made to communicate directly with each other; and that this restores the normal circulatory conditions. Taking this as his basis, he operates as follows: The sclerotic having been exposed, with a needle slightly curved at its end, he traverses tangentially to the corneal margin, the outer layers of the sclera, which he then excises with a thin and narrow Graefe knife. This produces what he calls a "filtering zone," but later he lays all the emphasis on the setting up of an anastomosis between the deep scleral and more superficial subconjunctival vessels, which restores the normal *blood* circulation of the eye. If Bettremieux's own conception of the operation be the correct one, it probably ought not to be included in the group of operations aiming at the production of a filtering cicatrix.

Lagrange, in speaking of his own operation, warns the reader against confusing it with the simple anterior sclerectomy of Bettremieux, by which, he declares, a filtering scar cannot be produced.

Remarks.

Having thus briefly considered each of the newer operations, we are now in a position to ask, and, if possible, to answer some questions which must, sooner or later, be satisfactorily disposed of if these operations are to attain to a permanent place in ophthalmic surgery.

We have first to put to ourselves the question, "Is there such a thing as a filtering cicatrix?"

It is usually admitted that the cystoid scar which occurs after a certain number of cataract extractions and glaucoma iridectomies, is evidence of a permanent fistulisation of the eye, and it has been repeatedly acknowledged by experienced surgeons that the most successful glaucoma iridectomies are often those in which iris has become entangled in the wound. No one proposes to attempt to form a cystoid cicatrix in its extreme form, but Holth's iridencleisis and Herbert's subconjunctival prolapse aim at the inclusion of iris in the wound, and we may take it that the claim of these operators to set up permanent drainage of the anterior chamber is fairly well established, the opposition to their operations being based on their alleged dangers and the difficulty of regulating the amount of the effect produced.

That filtration of fluid occurs through a simple, iris-free, corneo-scleral wound before cicatrisation is complete is hardly questioned, and it is not denied that for a limited period after healing is apparently complete, the cicatrix may be in some degree permeable. Moreover, one would have thought from a perusal of the papers of de Wecker and Lagrange, and their followers, that it might be accepted as an axiom, that the *possibility* of a permanently filtering cicatrix was an established fact. All of them have agreed in assuming that the filtering cicatrix occurred accidentally, and that it was but natural to aim at the deliberate production of a condition which was believed to be beneficial in certain cases. At this very point, however, the filtering cicatrix operations are met by the opposition of Thomas Henderson,[48] who denies the *possibility* of a permanent filtering cicatrix. It cannot be said, however, that he has substantiated the truth of his opinion. It is proverbially difficult to prove a negative, and we now have to set against such statements of what *can* happen, the statements of others as to what *has* happened.

We have already seen that Herbert devised his operation in the belief that the filtering scar is a "practical entity," basing his belief on the observation of filtering cicatrices accidentally produced in the extraction of cataract (compare Elliot's third

case quoted below). This belief he continues to uphold, and as clinical evidence of the existence of filtration, he submits these two points: (1) that there is true œdema over the scar, evidenced by pitting on pressure with a probe, and an unusually translucent appearance of the conjunctiva; and (2) that this œdema is increased by pressure on the globe, or if not already in evidence, is produced by the same method. He is equally convinced[41] of the possibility of producing a permanent filtering cicatrix by his operation of modified subconjunctival paracentesis. Five out of six cases which he was able to observe at periods up to two years after the operation, gave reduced tension and filtering cicatrices.

Elliot[43] expresses himself as quite convinced of the reality of the permanently filtering iris-free cicatrix. The cases on which he bases his opinion include one seen twelve weeks after the Lagrange operation, one three-and-a-half years after iridectomy, another seven-and-a-half years after iridectomy, and, lastly, one ten years after a combined extraction of cataract. In all of them the existence of filtration through the cicatrix was proved by the presence of œdema as described by Herbert (*vide supra*).

Verhoeff[44] says it is certain that it is possible to establish permanent drainage by this means.

All the doubts cast on the reality of the filtering cicatrix as a result of the sclerectomies of Lagrange, Herbert, and others, will apply with double force to the simpler operation of sclerotomy, as practised by de Wecker and his successors with the same end in view. In this case the opponents would have the support of Schoeler,[39] who satisfied himself by animal experiments that no kind of scleral section can produce permanent filtration, and what applies to the normal eye will apply equally to the case of chronic simple glaucoma with normal tension. de Wecker himself recognised the fact that in chronic simple glaucoma the cicatrix consolidates and the effect diminishes, hence the repetition of sclerotomy, so often advised to prolong its effect, and the employment of massage of the eyeball, as an adjuvant to delay the unavoidable closure of the filtration channels. Lagrange, while holding that the good results of iridectomy in glaucoma with elevated tension were due to the sclerectomy rather than to the iridectomy, saw that the case of chronic simple glaucoma without tension was simply that of the normal eye, and it was this very fact that led him to devise his sclerectomy operation in the hope of producing a gap which could be permanently occupied, not by an increasingly dense tissue, but by a more or less fistulous cicatrix.

So much for the clinical evidence for the existence as a recognisable entity of the filtering cicatrix. We may take it that from the clinical point of view this evidence is almost, if not quite, conclusive, and meanwhile we may accept as a sign of the presence of filtration, the conjunctival œdema as described by Herbert and Elliot.

FIG. 7.

Let us now turn to the histological aspect of the question. The clinical results are the ultimate standard by which these operations will be judged; but having claimed to produce a filtering cicatrix, it lies with the authors to prove that such a thing exists. One imagines that it will be confessed, even by the advocates of the filtering cicatrix operations, that the histological evidence in their favour is still somewhat scanty and unsatisfactory, nor is this surprising, considering the short period during which the operations have been on trial.

Lagrange, in one of his earlier papers,[28] speaks of his hope of examining microscopically eyes operated on by his method and the eyes of dogs submitted to his operation, but so far very little of this material is available for our purpose.

Demicheri[36] had occasion to examine an eye enucleated fourteen days after the Lagrange operation on a subject with hæmorrhagic glaucoma. He found between the lips of the wound, from within outwards, a small knot of atrophied iris, a mass of cellular tissue, and a quantity of loose vascular œdematous tissue containing cystic cavities and numerous pigmented cells apparently washed into it from the iris by a stream of fluid. From his examination of the wound he felt sure that there had been a true filtration of fluid through it from the anterior chamber to the subconjunctival connective tissue. He found no trace of communication between the anterior chamber and the supra-choroidal space. At the extremities of the incision there was incarcerationof the iris. He inclines to think that a true scleral fistula, as conceived by Lagrange, does not persist for long, and that the tissue may ultimately become so dense as to put a stop to all filtration. Lagrange[29] disowns Demicheri's case on two grounds; that it is not an example of his operation if iris is entangled in the

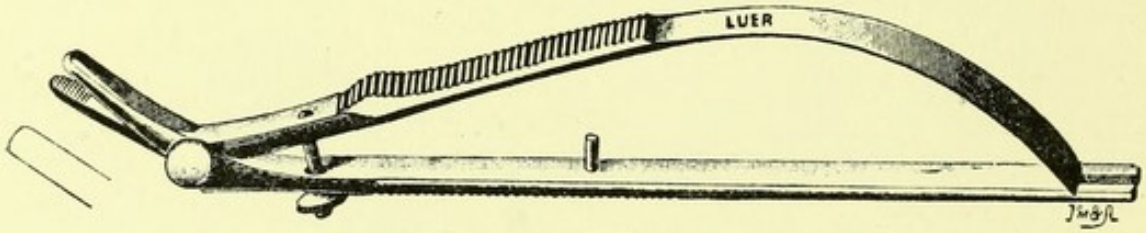

Fig. 8.—Punch-forceps.

wound, and that he does not perform his operation in acute glaucoma. Early in last year Lagrange made an important contribution to the histological aspect of sclerectomy by publishing illustrations of sections from the eye of a dog submitted to his operation eleven months earlier (Fig. 7). During the eleven months the eye had remained quiet and with normal tension. Microscopic examination showed beneath the conjunctiva larger and smaller cavities communicating with each other and with the anterior chamber. Further, the anterior chamber could be seen to communicate also with the supra-choroidal space. The walls of the spaces were neither thickened nor covered with epithelium.

Weekers and Heuvelmans[52] claim to have established the truth of Lagrange's statement, that such a fistula can be produced, by their microscopic examination of the eyes of a rabbit operated on five months before according to the method of Lagrange.

Holth[19] accompanied his description of his operation of sclerectomy with punch-forceps, with a photomicrograph of

the wound six weeks after the operation (Fig. 9). It shows fistulisation. This case had presented normal tension, and marked improvement in visual acuity and field.

I am not aware of any references in the literature to the microscopic examination of eyes after the operations of Herbert, Elliot, Fergus, Verhoeff, or Bettremieux.

The material at our disposal being so scanty, the question that naturally arises as to the nature of the filtering cicatrix

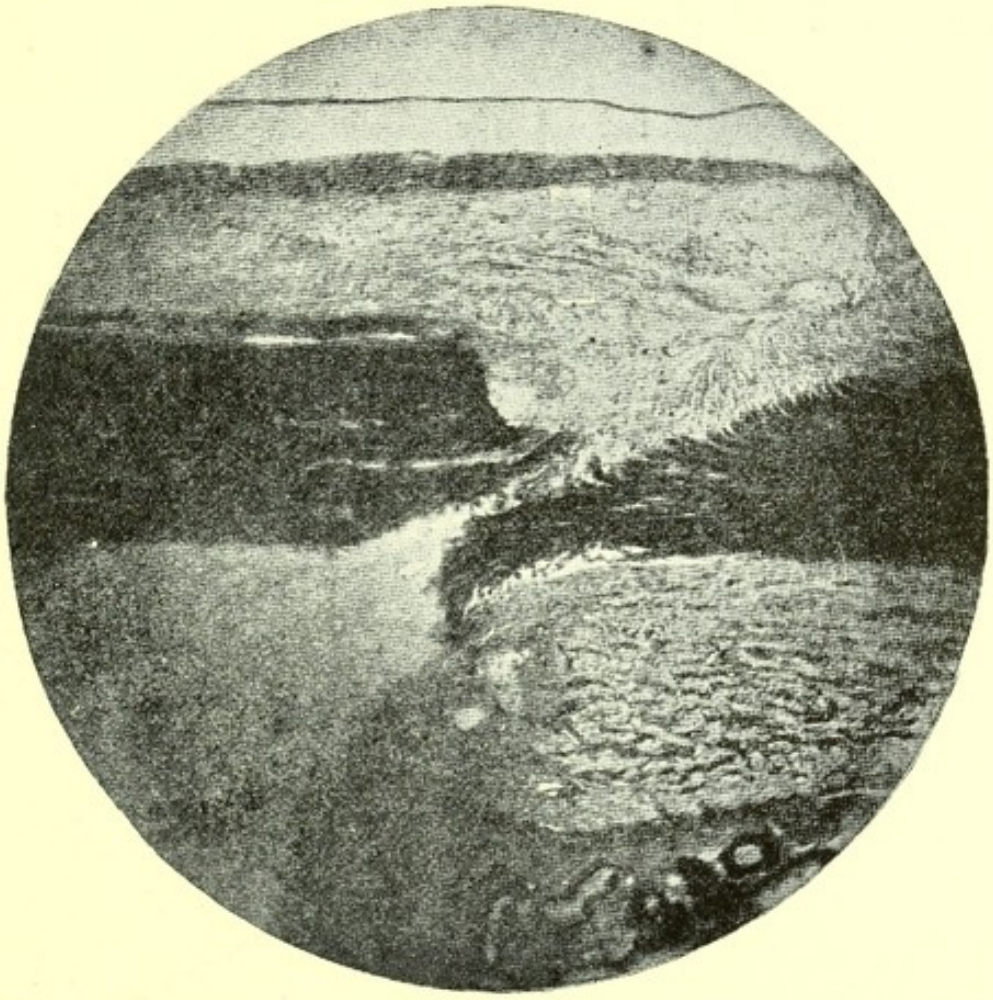

Fig. 9.—Sagittal section through the cicatrix of a sclerectomy of the anterior lip with the punch-forceps six weeks after the operation. The patient died from pulmonary embolism following a fracture of the femur.

and how it acts, cannot yet receive a satisfactory answer. In the communications describing the aims of the various operations and the methods employed to attain them, it will be found that each author has set out with a conception of some kind concerning the conditions that will obtain in the cicatrix after complete consolidation has been reached. Thus, Lagrange said his aim was to make his incision cut through the scleral attachment of the ciliary muscle, and he believed that it brought the perichoroidal lymph spaces and the chambers of the eye into communication with the subconjunctival cellular

tissue. To fulfil this ideal, he aims at making his incision as far back as possible so long as it lies in front of the iris. Morax, in the discussion which followed Lagrange's communication,[27] while acknowledging the good results obtained by the operation, doubted the possibility of producing the exact incision spoken of, namely the division of the scleral attachment of the ciliary muscle. Given an open angle in the anterior chamber the *possibility* of making the incision described is undeniable, and figure 7 seems to be an example of a successful attempt; but we are probably safe in saying that the great majority of so-called Lagrange operations will comprise a section which gives the root of the iris a fairly wide berth. Lagrange himself has recently seemed to lay more stress on the communication between the anterior chamber and the subconjunctival spaces.

An attempt was also made by Herbert to classify the possible forms of permeable cicatrices into filtering, fistulous, and cystoid. The distinction between the first two was that in the first the channels of communication were many and of microscopic size, while in the second we had a single fistula recognisable as a dark point lying under a "filtration area" of the conjunctiva. Lagrange speaks in one place of the orifice becoming transformed into a tiny fistula, and in another of the attempt to produce a cicatrix with microscopical apertures. In all his communications he makes "fistulisation" the keynote of his operation, but he seems to indicate a cicatrix permeated with microscopic channels. It will be remembered that Demicheri, on the strength of the microscopic examination of an eye after sclerectomy, doubted the persistence of a true scleral fistula. Weekers and Heuvelmans[52] in speaking of the conditions of success in this operation, say the whole thickness of the sclera must be excised if a permanent fistula is to be obtained; but against this we may put the section from Holth's case, in which only a part of the scleral flap was excised, while filtration was reported to have been present.

Herbert, from the outset, has looked for the formation of a *filtering* scar. He conceives of a shrinkage and displacement of the isolated corneo-scleral wedge sufficient to provide for filtration, but not sufficient to cause a fistula.

In the photomicrograph of Holth's case already referred to (Fig. 9), the gap between the lips of the wound was filled by a loose connective tissue derived from the subconjunctiva, but this perhaps should not be taken as an indication of the ultimate state of the cicatrix, as only six weeks had elapsed since the operation.

Fergus and Elliot put forward no theory as to the nature of the cicatrix produced by their respective operations, and no

results of histological examination of eyes submitted to scleral trephining are yet available. Verhoeff apparently looks for the formation of a single fistulous opening as the result of the clean-cut circular wound produced by his instrument. He says it is impossible to produce a filtering cicatrix, but that we can establish a subconjunctival fistula.

Such evidence as we possess, then, regarding the histological characters of the cicatrix points to its persistence as a loosely-built tissue derived from the subconjunctival or other neighbouring tissues, and permeated with fine channels which form a possible path for the aqueous fluid, and, on the whole, we may take it that there is both clinical and histological proof that the filtering cicatrix is a reality.

To come now to the question of permanence, we must wait longer before we can feel assured of the permanence of the filtration. Lagrange's sclerecto-iridectomy* is only four years old, Herbert's wedge-isolation operation three and a half years, Bettremieux's about three years, Holth's sclerectomy with the punch-forceps two years, Fergus's eighteen months, Elliot's ten months, and Verhoeff's seven months.

It is not possible to separate clearly the results obtained by most writers into those relating to filtration, to tension, and to vision. We meet too often with vague references to "good results," and similar phrases. We give, without comment, the following figures:

Lagrange, in July, 1907,[26] said he had already recorded the results of 27 cases watched for more than six months. Three had no benefit, and four had been lost sight of. Of the twenty good results twelve had improved vision, and in eight vision was maintained. He adds six other cases, in all of which the results were good. In 1908[2] he reported six cases in which sclerectomy had been done without iridectomy. In one the operation was too recent for comment. Four of the others, seen from three to six months after the operation, had maintained improvement in visual acuity and visual field with persistence of filtration. The case operated on by Lagrange at the Ophthalmological Congress at Oxford, in July, 1907, was reported by Doyne[35] six months later with distinct improvement in vision and extent of visual field.

Weeks, in the discussion on Lawson's communication,[21] said he had done Lagrange's operation thirty or forty times, but the anticipation of permanent lowering of tension had not been entirely realised. Rochon-Duvigneaud[33] reports a case in which he obtained a good result. Tension remained *minus*, and the cupping of the disc disappeared.

* July, 1910.

In July, 1908, Herbert had operated on sixty-three cases, about one-third of which had then been under observation for more than six months. He showed a few cases illustrating the good results following both of his operations. At a recent meeting of the Ophthalmological Society[51] he said he had now the results of six out of eight eyes on which he had done his sub-conjunctival paracentesis in two years. One of the six was a failure from attachment of the iris to the wound. The others all had reduction of tension to normal by filtering cicatrices, but sometimes it took several months for tension to reach the normal level.

For the other operations the following particulars are available:—Bettremieux[53] reports a case of simple chronic glaucoma with poor sight and retention of the outer part of the field only. The patient recovered central vision and still retained it five months later. Holth,[19] between June, 1908, and May, 1909, had done his sclerectomy with punch-forceps 30 times. In the first 10 he punched the posterior lip of the wound and the results were not permanent. In the last 20 he removed sclera from the anterior lip and always produced a fistulous cicatrix. There are no specific dates given for subsequent examinations.

No figures are available as to the number of times Fergus's operation has been performed, or with regard to the results.

Elliot's paper,[45] printed in this issue* of *The Ophthalmoscope*, deals with 128 operations. The communication is of interest, not only on account of the large amount of material dealt with, but also because of the detailed manner in which the results are recorded. A special interest attaches to the table giving the most important facts regarding fifteen cases which have been seen again at intervals ranging from one to nine months after the operation. In Elliot's opinion filtration has been maintained in all except one which was doubtful. It will be seen that the tension in practically all the cases was, at the latest examination, lower than before the operation, and slightly higher than immediately after it. It should also be borne in mind that these are tonometer records. Time alone will show whether this position of the tension represents the ultimate condition of the eye, or whether it indicates a tendency to return to the state prior to the operation. Nine months is perhaps too soon to give a definite answer. It is also of interest to note that vision was in many improved, in others stationary, while it was diminished in one case only.

There must be a large amount of material now available on

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* July, 1910.

which conclusions might be founded as to the permanence of the results of these operations. Many of the reports are rendered somewhat valueless for our present purpose through absence of necessary particulars. It is much to be desired that operators who have the opportunity to examine cases some time after operation would publish details as to the state of the tension, visual acuity under correction, and field of vision, both before and after operation, as well as particulars as to the appearance of the cicatrix at intervals. Only by the accumulation of such details can the question of the value of these operations be settled.

To refer briefly to the related operations, it may be taken as accepted that filtration of fluid does not occur through the scars in which iris is included, and it will be equally freely admitted that a similar scar results from the subconjunctival prolapse of Herbert, and the iridencleisis of Holth.

We have seen that Bettremieux does not insist on the filtering nature of the scar in his operation. I am not aware of any histological proof of the existence of the mechanism by which he tries to reduce ocular tension.

There is no microscopical evidence of the justice of Querenghi's claim to set up a communication between the aqueous chambers and the suprachoroidal space. This idea supplies also the *raison d'être* of Heine's operation of cyclodialysis. Doubts have been cast on the permanent existence of the communication between the anterior chamber and the suprachoroidal space by Weekers,[15] Krauss,[16] and Joudin,[12] who have found in microscopic examination of eyes after cyclodialysis, no such communication, but the ciliary body tightly bound down by cicatricial tissue or impacted in the wound.

In the next place we have to ask ourselves whether the amount of the effect produced by the various operations can be regulated. Lagrange and Herbert are the only authors who attempt to answer this question. Lagrange, as we have seen, shortly after introducing his operation, laid down certain rules to guide the operator in the choice of a procedure for eyes under different degrees of tension. Herbert claimed, as one of the advantages of his wedge-isolation operation, that it could be manipulated to allow of more or less filtration. Elliot is still in doubt as to the size of trephine opening which will meet the mean between too large an aperture, with softening of the globe, and too small an opening, with early blockage of the wound.

Lastly, though first in importance, we are faced by the question, do these operations lead to benefit or to cure, especially in chronic simple glaucoma in which iridectomy has failed to give full satisfaction ?

A consideration of the results already quoted leaves the impression that the claims of the various authors have all been more or less substantiated, and that a sphere of usefulness, still to be more accurately defined, exists for each of them. There have, indeed, been surprisingly few attempts to deny their beneficial results. Henderson, in disputing the contentions of Lagrange, did not deny the good results obtained by his operation, but held that they were attributable to the accompanying iridectomy. Lagrange did not consider the iridectomy an essential part of his operation, and he took up Henderson's challenge by performing his sclerectomy without iridectomy. The good results of four such operations have already been alluded to. Quite as convincing as this demonstration of Lagrange's was that of Valude,[34] who on one patient performed iridectomy in the better eye and sclerecto-iridectomy on the other. The latter improved as regards tension and vision, while the other retained high tension and failing vision. Sclerectomy was then done on this eye and resulted in improved vision. But while Valude has given his support to the operation of Lagrange, he states that the problem of glaucoma is not solved by establishing a filtering cicatrix. In one case, where an ideal filtering scar had been obtained, vision continued to deteriorate, and he thinks the operation should not be done until the vision begins to fail in spite of myotics.

We have not yet the knowledge which would enable us to gauge the respective merits of these operations. An operation which lends itself to lucid description will naturally be more widely adopted than one the explanation of which is difficult. Herbert's wedge isolation operation has no doubt suffered some neglect on this account. Elliot, who has had the advantage of learning it from Herbert himself, says it is "a tricky and difficult operation."

Simplicity and absence of difficult *technique* will also be factors of great importance in the choice of an operation, other things being equal. The operation of Lagrange presents no difficulty that cannot be overcome with practice, but sclerectomy by the punch-forceps or the trephine is held by many to be a simpler operation. Of the risks of accidents, such as vitreous prolapse, iritis, cyclitis, and sympathetic ophthalmitis, we can only hope to learn by our individual mistakes and misfortunes, or by the experience of others who have the courage to publish all their results, good and bad.

As several of the operations involve interference with the ciliary body, a considerable amount of material must now be accumulating to show whether the traditional fear of wounds in that region is justified.

It cannot be too often insisted on, and we may be allowed to repeat it in conclusion, that the great desideratum now is that every case of glaucoma operated on by one of these newer methods and reobserved on a subsequent date, should be carefully reported with reference to the details already enumerated, and, needless to say, considerable value will attach to any investigations that will throw light on the histological character of the resulting cicatrices.

BIBLIOGRAPHY.*

(1) de Wecker.—*Manuel d'Ophtalmologie*, 1889.
(2) Dianoux.—*Annales d'Oculistique*, février, 1905, T. CXXXIII.
(3) Wicherkiewicz.—*Annales d'Oculistique*, août, 1905, T. CXXXIV.
(4) Querenghi.—*Zeitschrift. f. Augenheilk.*, Januar, 1908.
(5) Querenghi.—*Annali d'Ottalmologia*, Vol. XXXVI, 1907.
(6) Bjerrum.—*L'Ophtalmologie Provinciale*, mars, 1909.
(7) Herbert.—*Transactions of the Ophthalmological Socie'y of the United Kingdom*, Vol. XXIII, 1903.
(8) Herbert.—*The Ophthalmoscope*, January, 1908.
(9) Herbert.—*British Medical Journal*, 14th May, 1910.
(10) Heine.—*Deut. medizin. Wochenschr.*, No. 21, 1905.
(11) Wernicke.—*Klin. Monatsbl. f. Augenheilk.*, November-Dezember, 1908.
(12) Meller.—Graefe's *Archiv. f. Ophthal.*, Bd. LXVII, Heft iii, 1908.
(13) Joudin.—*Westnik. Ophtalmol.*, mars, 1908.
(14) Boldt.—*Beiträge zur Augenheilk.*, Juni, 1907.
(15) Weekers.—*Klin. Monatsbl. f. Augenheilk.*, Bd. XLV, Heft ii, S. 230, September, 1907.
(16) Krauss.—*Zeitschrift. f. Augenheilk.*, Bd. XVI, Juli, 1908.
(17) Herbert.—*The Ophthalmoscope*, July, 1908.
(18) Holth.—*Annales d'Oculistique*, T. CXXXVII, mai, 1907.
(19) Holth.—*Ibid.*, T. CXLII, juillet, 1909.
(20) Borthen —*Archiv. f. Augenheilk.*, Bd. LXV, 1909.
(21) Lawson.—*Trans. Oph. Soc. of the U.K.*, Vol. XXIX, 1909.
(22) Lagrange.—*Rev. Général d'Ophtalmol.*, 1906.
(23) Lagrange.—*Archives d'Ophtalmol.*, août, 1906.
(24) Lagrange.—*Archives d'Ophtalmol.*, T. XXVII, 1907.
(25) Lagrange.—*Annales d'Oculistique*, février, 1907, T. CXXXVII.
(26) Lagrange.—*The Ophthalmoscope*, Vol. V. 1907.
(27) Lagrange.—*Archives d'Ophtalmol.*, T. XXVIII, 1908.
(28) Lagrange —*The Ophthalmoscope*, Vol. VI, 1908.
(29) Lagrange.—*Annales d'Oculistique*, novembre, 1908, T. CXL.
(30) Lagrange.—*Recueil d'Ophtalmol.*, 1908.
(31) Lagrange.—*Archives d'Ophtalmologie*, 1909.
(32) Rochon-Duvigneaud.—*Archives d'Ophtalmol.*, T. XXVIII, 1908.
(33) Rochon-Duvigneaud.—*Recueil d'Ophtalmol.*, 1907.
(34) Valude.—*Annales d'Oculistique*, T. CXL, 1908.
(35) Doyne.—*The Ophthalmoscope*, Vol. VI, 1908.
(36) Demicheri.—*Annales d'Oculistique*, T. CXL, 1908.
(37) Abadie.—*Archives d'Ophtalmologie*, 1909.
(38) Meller.—*Klin. Monatsbl. f. Augenheilk.*, Dezember, 1909.
(39) Schoeler.—*Berlin klin. Wochenschrift*, No. 36, 1881.

*Some of the volumes referred to contain more than one contribution by the same author.

(40) **Herbert.**—*The Ophthalmoscope*, Vol. V, 1907.
(41) **Fergus.**—*British Medical Journal*, 2nd October, 1909.
(42) **Fergus.**—*The Ophthalmoscope*, February, 1910.
(43) **Elliot.**—*The Ophthalmoscope*, December, 1909.
(44) **Verhoeff.**—*The Ophthalmoscope*, March, 1910.
(45) **Elliot.**—*The Ophthalmoscope*, July, 1910.
(46) **Bettremieux.**—*La Clinique Ophtalmologique*, 1907.
(47) **Bettremieux.**—*La Clinique Ophtalmologique*, 1908.
(48) **Henderson, Thomson.**—*The Ophthalmoscope*, December, 1907.
(49) **Henderson, Thomson.**—*The Ophthalmic Review*, September, 1907.
(50) **Henderson, Thomson.**—*The Ophthalmic Review*, July, 1907.
(51) **Herbert.**—*Ophthalmological Society.* Abstract in *British Medical Journal*, 14th May, 1910.
(52) **Weekers and Heuvelmans.**—*Archives d'Ophtalm.*, novembre, 1909.
(53) **Bettremieux.**—*Bull. de la Société Belge d'Ophtalm.*, No. 23, 1908.

CHAPTER III.

INDICATIONS FOR SCLERO-CORNEAL TREPHINING.

It would be possible to consider the subject dealt with in this chapter from the point of view of the exceptions, rather than from that of the rule. In other words, one might take up the position that, with very few exceptions, Sclero-corneal Trephining is the operation of choice in dealing with all forms of glaucoma. It is, however, admitted that in the present state of ophthalmological opinion, it is advisable to look at the question from the opposite point of view. This will therefore now be done.

(1) **Chronic glaucoma.** Sclerectomy has admittedly supplanted the older operations for the relief of this form of glaucoma. In choosing a method of performing sclerectomy, we shall go far before we find a simpler and easier *technique* than that of trephining, or one which permits of more subtle gradation of the effects produced. Sufficient time has elapsed to enable us to say, with certainty, that the filtration obtained in these cases is permanent. Some of our earliest cases, done in 1909, are still under observation, and continue to filter freely, whilst we have now a number of eyes, trephined over 2 and 3 years ago, which continue to preserve a normal or sub-normal tension, and to enable the patients to do useful and even strenuous work. It has been said of our Indian statistics that, inasmuch as it is only possible to follow up a percentage of the cases, the results are of little value; the obvious reply is that whilst we have admittedly not been able to follow up more than about 22 per cent. of our cases, the total bulk of operations performed has been so great that even this percentage comes to a total numerically larger than the whole out-turn of most operators. This mass of figures has shown most conclusively the value of sclero-corneal trephining. In order to convince medical opinion, however, one must look not to the statistics of the author of a method, or to those of any one surgeon, be he who he may, but to the results obtained by many workers in many lands, working under many conditions. For this reason the evidence given at the epoch-making discussion on glaucoma

operations before the International Congress of Medicine in London last year (1913) is one of the greatest importance. Men from Europe, Canada, America, Egypt and the East bore testimony to the results they had obtained with the trephine in chronic glaucoma. Nor must we omit to mention the Congress of Ophthalmology at Heidelberg in 1912, the discussion at the American Academy of Ophthalmology in Chattanooga in 1913, and the Symposium on glaucoma at Chicago in November, 1913. These have been only a few of the many occasions on which this subject has been discussed in many parts of the world, and the testimony has been so extraordinarily favourable that little more need be said. In addition to this evidence and to the many individual papers which have appeared so profusely in ophthalmological journals during the last two years, the author has received private and other communications of a like purport from practically every part of the civilised world. The fact that the new procedure has obtained a world-wide trial within four years of its first publication, provides a sufficient justification for leaving it confidently to the judgment of the medical profession. Some statistics will be found quoted in chapters XI. and XII.

(2) **Congestive glaucoma.**—It must be admitted that there still exists in many quarters a feeling against trephining in cases of acute glaucoma. Many, even of those who have found trephining "*a safe and easy method*" in simple cases, hesitate still to apply it for the relief of congestive glaucoma. No surgeon approaches an operation for glaucoma with a light heart. It is, and always must be, a hazardous procedure, be the *technique* what it may. The operating surgeon requires for it manipulative skill, courage and resource. The procedure that will recommend itself in the long run to ophthalmologists, will be that which combines, to the greatest possible extent, the elements of safety, certainty, and precision.

It is first necessary to clear away a possible source of misunderstanding as to what is meant by the term "acute glaucoma." Some would reserve the name for "the form of the disease which *begins* with acute symptoms," believing, as they do, that the onset of these symptoms marks, in some cases at least, the very beginning of the disease. Hence there appears from the operative point of view to be a tendency to place "acute primary attacks of glaucoma" in a category apart, and to draw a sharp distinction between them and the acute or subacute exacerbations of cases of chronic glaucoma. But despite its apparent suddenness, the first attack of high tension may be merely an exacerbation of an extremely mild glaucomatous

state. The histories given prove that this is so in many instances. One hears from surgeons who are confident that they have met with cases, in which the eyes were not glaucomatous before the acute attack began, but it is quite obvious that in every such eye the physical factors, which predispose the organ to an attack of high tension, must at least have been present, whilst to prove that the eye was normal beforehand would be difficult, if not impossible. It may be urged that in the exacerbations of chronic cases, iris adhesions introduce an element of complication. The same cannot be said of the class of case we shall deal with under the next heading, in which violently acute attacks of secondary glaucoma complicate the course of intumescent cataract. The only discernible difference between these cases and those of acute primary glaucoma, lies in the rapidity of the onset of those physical conditions which invite the glaucomatous explosion. It is quite certain that in the violence of their symptoms, these attacks sometimes yield pride of place to nothing less acute than a glaucoma fulminans. In India cases of acute primary glaucoma are rarely met with ; this is accounted for by the reluctance of the people to resort very early to medical relief, and by the fact that diagnosis is often not made at this stage, owing to the paucity of trained medical men; but we have trephined a number of cases of acute and sub-acute exacerbations of chronic glaucoma, and of acute glaucoma secondary to cataract, with the most satisfactory results. In fact, very soon after we first began to use the trephine in Madras (1909), we adopted it in the operative treatment of all forms of glaucoma, and there was no question in the minds of any of those who tried it there, that sclero-corneal trephining is at once the safest and the easiest method of dealing with acute and subacute, as well as with chronic, cases. A subconjunctival injection of adrenalin and cocaine renders the operation practically painless, and does away with the risks of vomiting and straining after the operation. The opening into the eyeball is minimal, and the relief of pressure is more gradual than that obtained by any other method ; indeed, in the last respect the effect of trephining is almost comparable to that obtained by scleral puncture. The two cases, published by the writer in *The Ophthalmoscope*, of November, 1910, will serve as examples of the value of trephining in patients suffering from acute congestive glaucoma. More could easily be added from our note books if necessary ; but we have felt that the opinthalmic world would hesitate until a confirmation of our views was afforded by other surgeons. The cases published by Sydney Stephenson (*The Lancet*,

October 21, 1911) and by Bradburne, of Southport (*Ibid.*, December 9, 1911) were the earliest contributions to the subject.

Since that time the volume of evidence has been growing. Wallis, reporting the practice of the staff of the Royal London Ophthalmic Hospital (*The Ophthalmoscope*, Vol. XI, p. 588), writes: "In not a few cases Elliot's trephining has been resorted to in acute glaucoma with satisfactory results. *This operation has usually been done, when the pupil has become dilated, and inactive to a myotic, or when a general anæsthetic has been contra-indicated* (the italics are the author's). During a recent visit of the writer to the Manchester Royal Eye Hospital, he was informed that in that institution sclero-corneal trephining had practically supplanted iridectomy and all other operative procedures, in the treatment of all forms of glaucoma. This statement is amply proved by a perusal of the annual report of the hospital. Grey Clegg, one of the first surgeons to take up trephining, and who has operated on over 100 eyes "according to the Elliot *technique*," writes:* "I have employed it not only in chronic and subacute glaucoma, but also in quite acute conditions, with most satisfactory results." Maddox,* another pioneer of the method, "regards the operation as admirable in most cases of both chronic and acute glaucoma." He adds, "In one case of double acute glaucoma, iridectomy was done on one eye and trephining on the other, and the trephining answered best."

In America, Webster Fox, Wendell Reber, Nils Remmen, Luther Peter, and many others are trephining for acute glaucoma and are well satisfied with their results. Not a few of the German surgeons have had the same experience, and notably Stock, of Jena, who when speaking at the International Congress in London (1913), was able to quote from statistics of 118 operations with the trephine. Last, but far from least, Meller has recently given some very valuable figures in connection with 178 trephine operations performed in the Vienna clinique; he holds that in difficult and dangerous cases, trephining may be substituted for the classical iridectomy of von Graefe. The facts we have quoted make a strong case for a full trial of sclero-corneal trephining in the operative treatment of acute and subacute glaucoma, and we therefore feel that it is neither necessary nor advantageous to take up more space by an enumeration of the names and experiences of the very many surgeons whom the author has had the pleasure of hearing from on the subject. Suffice it to say that they have been many, and that emboldened by success they are

*Private communications.

now employing the trephine operation for all cases of glaucoma alike. It is significant that not a few ophthalmologists, and amongst them men as distinguished as Professor Meller, though reluctant to give up iridectomy in their acute cases, nevertheless *employ the trephine in those where exceptional difficulty presents itself.* The author hopes that surgeons will publish their results in acute and subacute cases. At the same time he would remind his readers that any and all of the operations for the acuter forms of glaucoma will be attended by a percentage of complications and of failures. The contention that iridectomy, when employed in acute cases, gave results which were 'all that could be desired,' will not, we believe, bear statistical investigation. Von Graefe's operation gave a good percentage of excellent results; time and the publication of careful statistics can alone show whether trephining will not give us still better results. The author believes it will. One will sometimes hear a surgeon speak of the performance of an iridectomy as if it were an easy procedure, but this is never the language of a man of large operative experience. In Madras the author had the opportunity, given to very few, to teach the operative surgery of the eye, *on the living*, to a large number of surgeon visitors, and his experience was that it is more difficult to teach anyone to perform a clean neat iridectomy than to teach him to extract a cataract or to do almost any other operation on the eye. The man who has learnt this lesson is a past-master in operative *technique*, and will find other manipulations comparatively easy.

(3) **Glaucoma secondary to cataract.**—Judging from the literature of the subject, one gathers that this form of glaucoma is comparatively rare in European countries. It is, however, all too common in India for the simple reason that the patients do not resort to surgical aid so freely as they do in countries where the general standard of education is higher. The writer has himself followed quite a number of such cases from an early stage of the cataract, and witnessed in them the onset of well marked secondary glaucoma. Of these cases, two stand out pre-eminent in his mind, as in both of them all vision was lost after an acute glaucomatous attack, although he had repeatedly and over a period of years advised both patients to submit to cataract extraction, and had pointed out to them the ever-present danger of an access of high tension. Both were presumably well-educated men, and one was exceptionally intelligent. We have, on a number of occasions, seen the onset of acute glaucoma in patients waiting at the Government Ophthalmic Hospital, Madras, for cataract extraction, although they had come in with apparently normal

tension. In one period of nineteen months, no less than three patients who had been admitted for primary cataract developed secondary glaucoma whilst under observation in hospital. In one of these high tension came on within twenty-four hours, and in a second within twelve days of admission. In both of them the onset was presumably brought on by mental worry and anxiety. The third developed glaucoma twenty-six days after admission whilst under silver nitrate treatment for lid conditions.

To judge from the papers which have appeared in ophthalmic journals, many European surgeons have failed to make up their minds as to the existence even of this complication of cataract; on the other hand, the Madras out-patient room records show its occurrence in nearly 50 cases yearly. The appearance of the lens in these cases is characteristic of primary cataract, the history is unmistakable, and the existence of a primary, and hitherto uncomplicated, cataract in the opposite eye often clinches the diagnosis. At the best the prognosis is a bad one, especially when one takes into consideration the fact that the patients too often lose valuable time, after the onset of glaucoma, before they make up their minds to resort to European treatment. To extract the cataract at once is far too hazardous. Our practice formerly was to perform an iridectomy, and to await the settling down of the eye. When the globe had become quite quiet, extraction was undertaken. This line of treatment is by no means unsatisfactory when the class of case is taken into account. But the necessarily large wound, both of cornea and iris, presents very distinct disadvantages as compared with that made in trephining.

In Madras, glaucoma secondary to cataract is not only of common occurrence, but it is also, not infrequently, of a very acute type. In this connection it is interesting to note several points, *viz.*: (1) Glaucoma secondary to cataract is more than half as common again in females, as in males, in spite of the fact that many more males than females seek relief for cataract. (2) The period the cataract has lasted before glaucoma supervenes is always a protracted one, the complication resulting from continued neglect on the part of the patient to appeal to surgical interference until long after the cataract is fit for extraction. (3) It is a point which it would not be advisable to labour, but statistics taken over 50 cases showed that the age of onset of glaucoma secondary to cataract is not above that at which cataract extraction is ordinarily performed in Madras. The inference would appear to be that two factors are at work, *viz.*, an early onset and a long duration of the cataract. An important point of clinical interest is thus raised, for it is the

intumescent type of cataract which in our experience is most commonly complicated by secondary glaucoma. This would bear out Priestley Smith's contention as to the influence of lens-swelling on the production of glaucoma. In a number of cases trephined in Madras for relief of this form of glaucoma, the results were excellent; but in a few, the intumescent lens forced its way into the trephine hole, its semi-fluid contents following the line of least resistance. We were, therefore, led to go back to our old method of a preliminary iridectomy in these cases, the lens being extracted as soon as the eye had quieted down. Trephining was reserved for the class of case in which the lens was not semi-fluid, and in which no great forward movement of the lens and iris had occurred. It is more than doubtful whether it is sound practice to trephine when the lens is of the pearly-sectored, the intumescent, or the milky Morgagnian types.

The value of any method employed to combat this form of glaucoma will best be estimated by the visual results yielded after the patient has returned and had the cataract extracted. So far, we have only been able to perform extraction in a meagre percentage of those patients whom we have trephined for this condition. Every one of them was particularly requested to return, and all those who had a reasonable prospect of vision after removal of the lens, were carefully instructed as to the prospects awaiting them. Unfortunately, a large number of these patients placed no faith whatever in our explanation. The idea of the trephining operation was a new one to them, and they lost all confidence in us when they found their sight unrestored after an operation had been performed It is likely that some of them resorted to other practitioners, and not a few to Mahommedan couchers, whilst many probably settled down in their villages to what they believed to be inevitable blindness.

Dealing with those who did return, and remembering how long they had delayed to present themselves for the first operation, one can look with gratification on the visual results, quite a large percentage of which varied from 5/20 to 5/50.

Captain W. C. Gray, of Madras, has written to suggest, that when a cataract extraction is made on an eye which has been previously trephined, the incision should be brought out well within the cornea, so as to avoid all interference with the trephine aperture. It has been his experience that if the latter is interfered with, the resulting cicatrisation may, and often does, lead to obliteration of the filtration channel. The author is entirely in agreement with this proposition, and with the grounds on which it is made. He learnt very early, in his

work with the trephine, that it is most important to give the corneo-scleral aperture a wide berth in subsequent operations on the eye, and he therefore always made a point of cutting out into the cornea, just as Captain Gray suggests.

(4) **Staphyloma.**—In Madras we have trephined more than twenty-five eyes for staphyloma of the cornea, or of the ciliary region, with a view in most cases of arresting the progress of the bulging, and thus of avoiding the necessity for enucleation. In endeavouring to estimate the value of the operation in these cases, there are certain factors which must be borne in mind. In every such case it is safe to assume that there has been chronic peri-corneal inflammation and that this has been associated with adhesion of the iris to the cornea: both these conditions are extremely unfavourable to the maintenance of a permanent and satisfactory result in trephined eyes, and the prognosis must therefore obviously be a very guarded one. Moreover, secondary cataract is very likely to supervene, whether we operate or not. It does not necessarily follow that the tonometer reading in a case of staphyloma will be a high one, but it is clear that the tension is too high for the coats of the eye in their diseased state.

With these preliminary remarks, we may proceed to deal with the results we have attained. In several cases, in which high tension existed, vision distinctly improved with the subsidence of the staphyloma. This improvement was not always maintained, owing to degenerative changes in the eye, which continued to progress despite the fact that the tension remained reduced. We have been able to follow these cases for periods varying from five to twenty-three months after operation, and to satisfy ourselves that the reduction in tension of the eye, and the corresponding flattening of the staphyloma, promised to be permanent in quite a number of them. We can at least say that the results have been sufficiently encouraging to make us persevere with the method in selected cases. Coppez, of Brussels, trephined a staphylomatous eye which presented a rise in tension, consequent on an attack of blennorrhagic ophthalmia; the staphyloma disappeared, and the tissue remained normal. The author's *technique* was adopted. In a personal communication kindly made by Gray Clegg, it is stated that "trephining has also been employed in anterior staphyloma, with moderately satisfactory results." Others have written and spoken still more favourably of the procedure. In view of the ordinary behaviour of staphylomatous eyes, any prospect of improvement in the condition is to be welcomed.

(5) **Conical Cornea.**—The conditions of an eye suffering from conical cornea, both resemble and differ from those met

with in staphyloma of the cornea. In both the intra-ocular tension, though possibly not above the average for the human eye, is yet too high for the weakened tunic. On the other hand, the iris is not adherent to the sclero-corneal coat and the chamber is deep. Trephining should therefore be a comparatively easy operation. It will probably be admitted that no operative procedure, which has hitherto been recommended for the relief of conical cornea, can be regarded as wholly satisfactory. Trephining merits a trial in these cases, and even if it fails, it will leave the eye no worse than it found it. In Madras conical cornea is so rare a condition that we had few opportunities of trephining cases of the kind. The operation seemed to be of value in paving the way for the final procedure on the cornea. Our practice was to perform a preliminary free sclero-corneal trephining in order to permanently reduce the tension of the eye well below the normal, and then a few weeks later to trephine again over the apex of the corneal cone.

Very recently, Adams, of Oxford, has published the notes of eight cases, in which he treated conical cornea successfully by cauterising the apex of the cone, " and then at once proceeding to trephine the eye at the corneo-scleral margin, according to Elliot's method, with the performance of a subsequent small iridectomy."

(6) **Glaucoma following Cataract Extraction.**—We have trephined nine eyes for the relief of glaucoma supervening after the removal of a cataract. The condition is of such unusual interest as to justify some details of the cases being given.

In the first the patient had had an extraction eight years previously ; for five years his vision remained good ; then chronic glaucoma set in, and when he presented himself his vision was reduced to hand movements. A successful trephining was performed and he was seen a year and three days later ; the failure of vision had been arrested completely by the operation and the tension still remained normal (25 mm. Hg., by Schiotz tonometer). In the second case congestive glaucoma came on suddenly three months after a successful extraction in which, however, a tag of iris had been left impacted in the wound. Vision on re-admission was 5/50 ; he was trephined one week after the onset of congestive symptoms and his vision rapidly rose to 5/30. He was under observation one month after operation, and was doing well when last seen.

The third case was followed for eleven months after operation, with a tension of 12 mm. Hg. and with his visual power improved to 6/18 as contrasted with 6/36 before operation. In a fourth case in which sclerotomy had failed to reduce the tension, Dr. Temple Smith, of Sydney, Australia, who

was working in Madras, trephined the eye. Eleven months later the tension was 17 mm. Hg. and the vision had gone up from 5/50 to 5/20. In a fifth case, followed for three months, trephining had been performed one and a half years after cataract extraction; the tension before operation was 51 mm. Hg. and the vision 6/18. When last seen three months later the tension was 21 mm. Hg. and the vision 6/12. In one case the operation utterly failed to reduce the tension and the eye was lost. In the remainder the results were not unsatisfactory, but the cases were under observation for too short a period to justify any stress being laid on deductions from them.

It may be unhesitatingly said that the prognosis, in cases of glaucoma following cataract extraction, is always bad and often desperate. Under these circumstances the above review of the results attained by trephining must be considered as encouraging in the extreme. If the operation is to be successful, it is presumably a primary condition that the aqueous and vitreous chambers should be shut off from each other. If there is reason to think that there is a free communication between the two, it is probably inadvisable to trephine. On the other hand, a case of post-operative glaucoma in which the anterior chamber is filled with semi-fluid vitreous substance is probably a desperate one in any case.

(7) **Glaucoma secondary to Leukoma Adherens or to Occlusion of Pupil.**—On several occasions in Madras we have operated for these conditions, and so far as we have been able to follow these cases, the results have been satisfactory. Gray Clegg writes:* "In sympathetic disease trephining has caused long continued lowering of tension, without exciting anything beyond the most transient irritation, and the same may be said with regard to persistent plus tension in other forms of irido-cyclitis." He, of course, does not claim uniformly good results in such cases as these.

(8) **Glaucoma following Injury.**—We have trephined thirteen eyes in Madras for glaucoma following injury. As might be expected the conditions, which immediately gave rise to the increase of tension, were varied and the prognosis was never otherwise than bad. Nevertheless a careful review of the notes indicates that relief was almost invariably given, and that trephining proved of distinct service under conditions in which little could be hoped from any form of treatment.

(9) **Blind Painful Eyeballs.**—In India it is a common thing for a patient to first present himself for treatment after every vestige of vision has been lost as the result of

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* Personal communication.

long-continued high tension in the eye. It is our practice to trephine in most of the cases of this class. Should trephining fail, or should it in any way be contra-indicated, we perform an optico-ciliary-neurectomy.† Coppez,[1] Good,[2] and others[3] have successfully trephined eyes blinded by glaucoma, and have thus saved the necessity of enucleating the globes.

(10) **Prophylaxis.**—Whatever may be the verdict of other countries with regard to glaucoma, one fact stands out prominently in South Indian experience, *viz.*, that the disease is bilateral. One eye is usually attacked first, but once the disease has thus proclaimed itself, the involvement of the opposite side is merely a question of time. The local conditions of an ophthalmic surgeon in the East are different from those of his Western confrère. Many of his patients come hundreds of miles to see him, and not a few of them have begged or borrowed the necessary fares to do so. To such a man a journey to Madras is one of the events of a life-time. It is not the mere distance he has to travel, but the conditions under which he does it. He emerges from a mud village to encounter the bustle of a town of half-a-million people. He has possibly never seen a white man before, and the largest Government institutions of which he has any experience are the dispensary, the police station, or the sub-registrar's office of his village. His mental horizon is bounded to an extent that would astonish the stay-at-home Englishman. The surgeon who deals with him, must in many cases do so *once for all*, for, if he fails, it is unlikely that his patient will return. The methods that are applicable to the English patient who lives an hour's run from London, or from some large provincial centre, are wholly inapplicable to one of the type we are considering. If he has come with glaucoma in one eye, it is probable that the other is also affected, but if this be not the case, it will be idle to rely upon any warning being sufficient to bring him back to hospital at an early stage of the disease in the second eye. Nor is it only the ignorant ryot to whom this class of argument applies. Men of higher education, from whom one would expect very different behaviour, often procrastinate with fatal foolishness. It was

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†This operation skilfully performed reduces the tension and abolishes pain. It is much more certain in its action than trephining, but it is also more difficult to perform. The details of the procedure have been fully dealt with by the author in the *Indian Medical Gazette*, Vol. XLI, pp. 433-435 (Nov., 1906).

[1]*Bull. de la Soc. Belge d'Ophtal.*, No. 33, p. 29, avril, 1912; [2]*Ophth. Record*, January, 1913, p. 15; [3]*Proceedings Ophth. Section Canadian Medical Association*, 12th August, 1912.

therefore our rule in Madras to trephine both eyes, when one was affected with glaucoma. We have, on more than one occasion, done this on highly educated patients who fully appreciated their dangers, but whose stations were two or more days' travelling distance from Madras. We have been able to watch such patients closely, and have satisfied ourselves that a normal eye is little or none the worse for trephining. The operation is pre-eminently easy under these conditions; complications are absent; convalescence is uninterrupted; and safety is, we think, assured.

MacCallan, whose experience in Egypt marches closely with ours in India, writes:* "Trephining can and should be performed for a patient in the unaffected eye, as soon as the fellow eye has been definitely diagnosed as glaucomatous, since the operation is almost devoid of risk, and early operation is prophylactic against the development of increased tension; glaucoma usually affects both eyes sooner or later."

The more the writer sees of the conditions of European and of American practice, the more does the conviction deepen in his mind that prophylactic trephining has a part to play in Western as well as in Eastern countries. In a number of the hospitals he has visited, he has seen and heard of patients who having been operated on in one eye with good results, and having been discharged from surgical care with the second eye still showing no signs of glaucoma, have returned later with such signs well-marked, and with the vision either impaired or lost. It is impossible to contemplate such catastrophes without the feeling that some action is called for to avert their happening, if that be possible. A point that must not be lost sight of is that, though the disease may have begun gradually in the first eye, it may run a much more rapid course in the second; the age of the patient and the changes consequent thereon are all in favour of this. In any case it is incumbent on the surgeon to operate the moment the first signs or symptoms of high tension appear in the second eye. Formerly it was the custom to cling to non-operative treatment to the last possible moment; and there can be little doubt that this attitude was due to the very unsatisfactory results yielded by the operations then in vogue. The confidence, begotten in the minds of ophthalmologists by the results of the newer procedures, has however, altered this, and there is a growing tendency to rely less on drugs and more and earlier on surgery. This view of the case was very clearly in evidence at the recent Symposium on glaucoma, in Chicago, and is, we believe, steadily gaining ground everywhere.

*Personal communication.

(11) **Buphthalmos.**—A number of surgeons in the East, in Canada, and in Europe have had good results from the trephine in the treatment of this very difficult condition. The author's own experience both in India, and later in England, has been most encouraging. A point of importance is that the operation is a very easy one, for the conjunctiva strips back off the cornea to a very unusual distance and with great ease; so much so that dissection is hardly required for the purpose. Moreover, the chamber is so very deep that the trephine can be used with considerable boldness. It is not the case, at least so far as our experience is concerned, that an over-reduction of tension is brought about. The improvement in vision is obtained very early and is most gratifying.

(12) **Detachment of the Retina.**—Some time ago, the author diffidently offered the suggestion that trephining might prove of value in cases of detached retina. He gave the method a limited trial, but was unable to keep track of the subjects. More recently this method of treating retinal detachments has been employed by Parker of Detroit and by Tiffany of Kansas City. In the experience of both of these surgeons, it promises to yield valuable results. Both of them trephined over the detachment; Parker then made a free incision into the choroid, whilst Tiffany excised the projecting portion of that membrane just as we do the bulging iris in the sclero-corneal operation. Both found that the retina settled down and apparently became reattached, and that the visual field was restored. The writer had the opportunity of examining Dr. Parker's case, and it would have been impossible to say that there had ever been a detachment. He has therefore been encouraged to give the procedure a farther trial, and in view of the hopelessness of our present position in treating this condition, he suggests that other surgeons might do the same. He cannot help feeling that there are great possibilities in the method.

Chapter IV.

PREPARATIONS FOR THE OPERATION.

(1) **Preparation of the Patient.**—All glaucoma cases alike are admitted to hospital or sent to bed, and kept there for at least twenty-four hours before an operation is undertaken. The routine treatment is to give the patient a free purge of salts and senna, to instil a solution of eserine, to relieve pain and procure sleep by morphia, and if the case is acute or subacute, to apply four leeches to the forehead and over the temporal region. To some this may appear to be bad surgery. In Madras we were convinced that it was nothing of the kind. Tension is rapidly and distinctly lowered; the congestion of the eye diminishes markedly, and the patient's nervous system quiets down. It may be urged that cases of glaucoma occur in which vision is totally lost within twelve hours. It is possible that we did not see as acute a type of case in Madras as is met with in colder climates; but we never had cause to regret the delay and frequently found operation made much easier by it.

On the evening preceding the operation the lashes of the upper lid are cut close with scissors, and the skin around the orbit is carefully washed with synol soap and boiled water; the conjunctival sac is then freely flushed out with cool boiled water, containing 1·4 per cent. of common salt (isotonic with tears). In cases of chronic glaucoma a trial bandage is applied over the eye or eyes to be operated on. On the morning of operation the trial bandage is removed, and if there be no excessive secretion on the pad, the case is brought up for operation; otherwise, and especially if the discharge be purulent, the case is put back for further lid treatment. If the glaucoma is acute or sub-acute, the trial bandage is omitted.*

Before the patient is brought into the room the everted lids are exposed for from one to two minutes to a stream of perchloride lotion ($\frac{1}{3000}$). A solution of cocaine (4 per cent.), previously sterilised by boiling, is then instilled four or five times at two minutes' intervals, and the patient is brought on the table; the conjunctival sac is next swabbed out to its farthest recesses by means of sterilised mounted wool swabs, under a

*In European practice the author has discarded the trial bandage; he cuts the lashes, and attends to the other details of preparation, just before the operation.—R.H.E.

stream of the sterilised saline solution (1·4 per cent. sodium choride). All mucus and other exudation is thus completely removed. The Meibomian glands are emptied by firm pressure of the fingers on the two lids pressed together edge to edge. A speculum is inserted, great care being taken to avoid contamination of it in so doing; and the conjunctival sac is freely flushed with the same saline solution poured out of a metal irrigator resembling in shape a small tea-pot with a long spout. If there is much congestion, adrenalin chloride solution (1 in 1,000) is instilled. If congestion still continues, or if the eye appears hyperæsthetic, we give a sub-conjunctival injection of cocaine and adrenalin chloride solution, diluted with normal saline solution (0·7 per cent.) Two minims of the cocaine solution (4 per cent.) and two minims of the adrenalin chloride solution ($\frac{1}{1000}$) are mixed with four minims of normal saline solution for the purpose, and the fluid is injected from a freshly-boiled all-glass syringe.

In acute cases such an injection is a routine measure, whilst in the chronic cases, which form the bulk of our operative material, it is quite uncalled for. In the case of nervous patients, and in those in whom the eyeball is painful, a hypodermic injection of morphia is given about twenty minutes before operation. Chloroform is reserved for children and for hopelessly unmanageable adults. It is very rarely that we meet with a patient of the latter class. If we can dispense with the use of a general anæsthetic, we gain the great advantage of having the patient's co-operation during the steps of the procedure, and we are saved the risks attendant on vomiting and straining after he is put back to bed. Both items are very important.

Whereas in dealing with cases of cataract we are most careful to bring the adnexa of the eye into a healthy condition before undertaking any operative procedure, the same routine is not considered justifiable in dealing with glaucoma cases. Obviously an acute catarrh complicating a very chronic glaucoma would require to be dealt with first: but speaking generally, we do not wait, and the results have justified our action, for we did not lose a single case of trephining by suppuration or by acute irido-cyclitis in the course of over 900 operations performed in Madras. Our immunity is to be attributed (1) to our method of sterilising the conjunctival sac; and (2) to the use of a large conjunctival flap.

(2) **Sterilisation of Instruments.**—All instruments are boiled, and no instrument is used a second time without fresh sterilisation. Duplicates of all instruments which are likely to be required more than once during an operation, are kept

ready. Under this *régime* a single one of the author's trephine blades costing a negligible sum, lasted us from 26 to 30 times, while a pair of iris scissors lasted for about 40 cases.

(3) **The Surgeon's Hands** are well washed before operation, but no strong antiseptics are used. In this way his delicacy of touch is preserved, whilst if care be taken not to handle the operation-ends of the instruments, and to see that these do not come in contact with any foreign matter, no risk is entailed. It is of course essential that the operator's hands should be thoroughly dried on a sterilised towel, and that the trays in which the instruments are kept should be of such a nature as to allow them to dry. These are simple requisites. All dressings are sterilised by heat and are used dry.

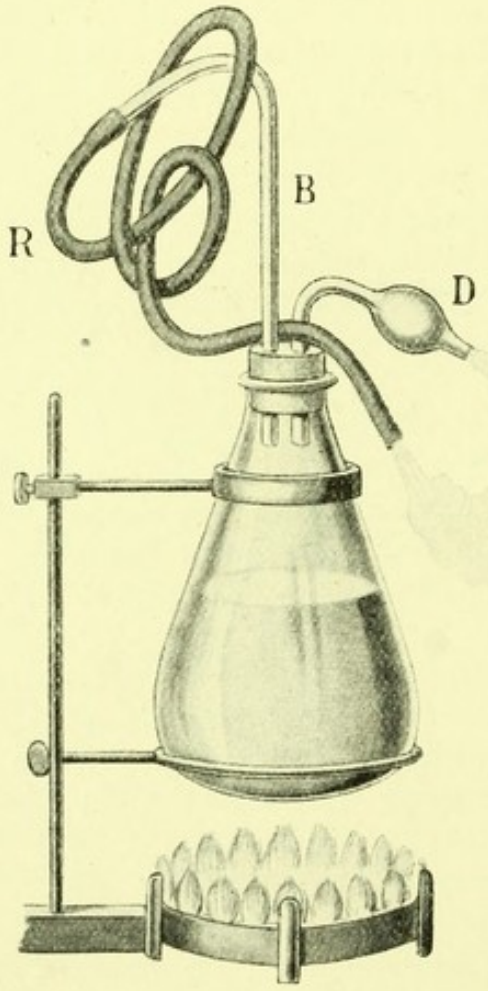

FIG. 10.

(4) **Sterilisation of McKeown's Irrigator.**—Detach the rubber bellows from the tube D, raise the glass tube B, as shown in Fig. 10, and arrange the rubber tubing R attached to it, so that the end hangs free and is not in contact with any surface ; the bottle should have been filled two-thirds full with normal saline solution, and is now ready for boiling. After

free ebullition, and immediately after removal of the flask from the flame, clamp the rubber tube R, and dip its free end into a bottle filled with sterilised normal saline solution, till the apparatus is to be used; lower the tube B to its usual place (*vide* Fig. 11); cool air now enters, but it can only do so through the tube D, the bulb of which is filled with asbestos wool. When one is about to operate the bellows are attached at D (Fig. 11) and a freshly-boiled cannula is adapted to the tube R; the clamp C is relaxed and the irrigator is ready for work. It is absolutely necessary to have the fluid carefully filtered before it is boiled.

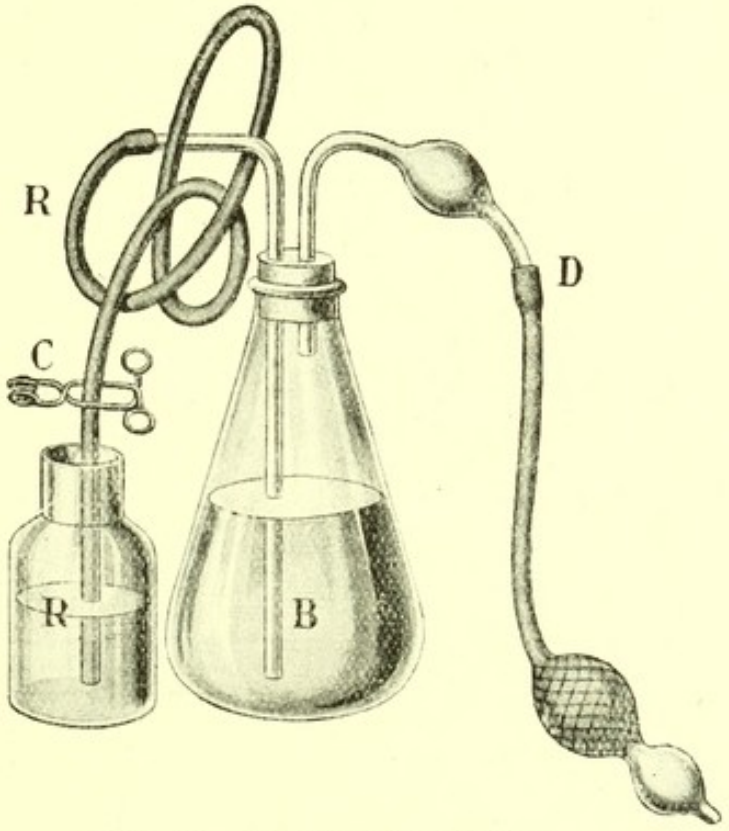

FIG. 11.—McKeown's Irrigator.

In English practice, the author has adopted a simpler but still efficient form of irrigator.* This consists of the barrel of an ordinary 2-oz. urethral syringe, to the nozzle end of which is securely fastened one end of a piece of fine india-rubber tubing, 3 feet in length, whilst the opposite end of the tubing carries a McKeown's irrigator nozzle. The whole apparatus is boiled for 5 minutes before use, and is then emptied and filled with normal saline solution (0.7 per cent.). A separate assistant takes charge of the apparatus, and gives the nozzle into the surgeon's hand when he is ready to use it.

(5) **Masks.**—In Madras, for every intra-ocular operation, the surgeon, his assistant, and any bystanders who lean over

* A modification of Bishop Harman's Undine Irrigator.

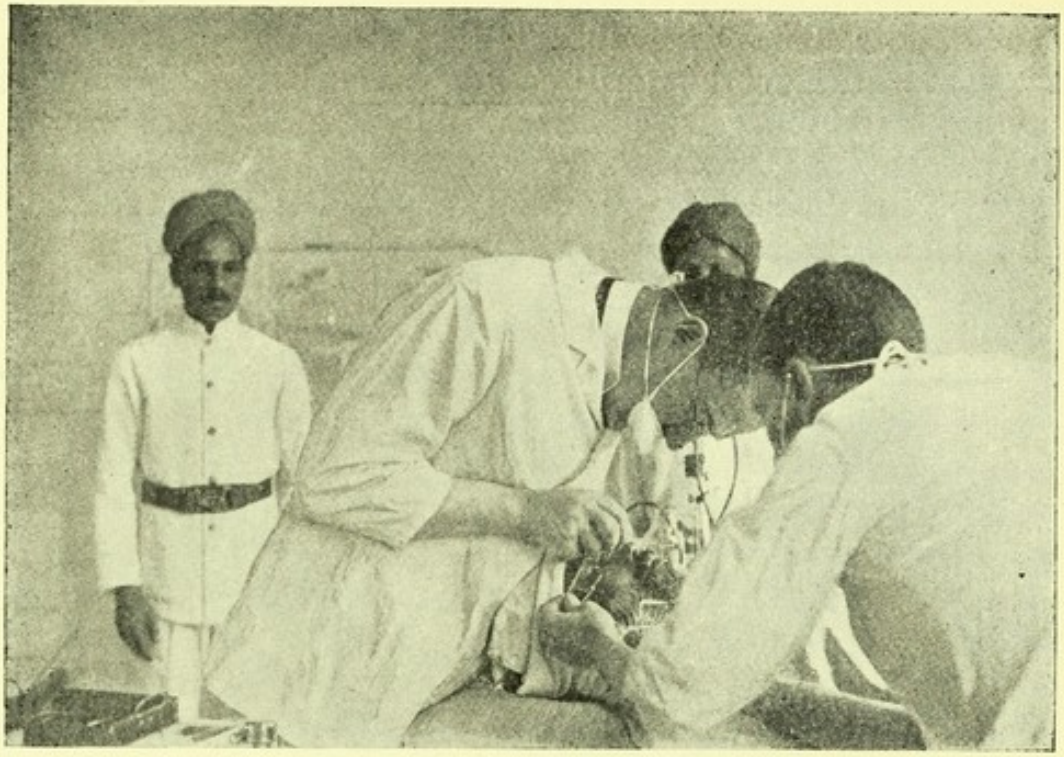

FIG. 12.—The act of trephining. The trephine can be seen below the fingers. Notice the mouth masks.

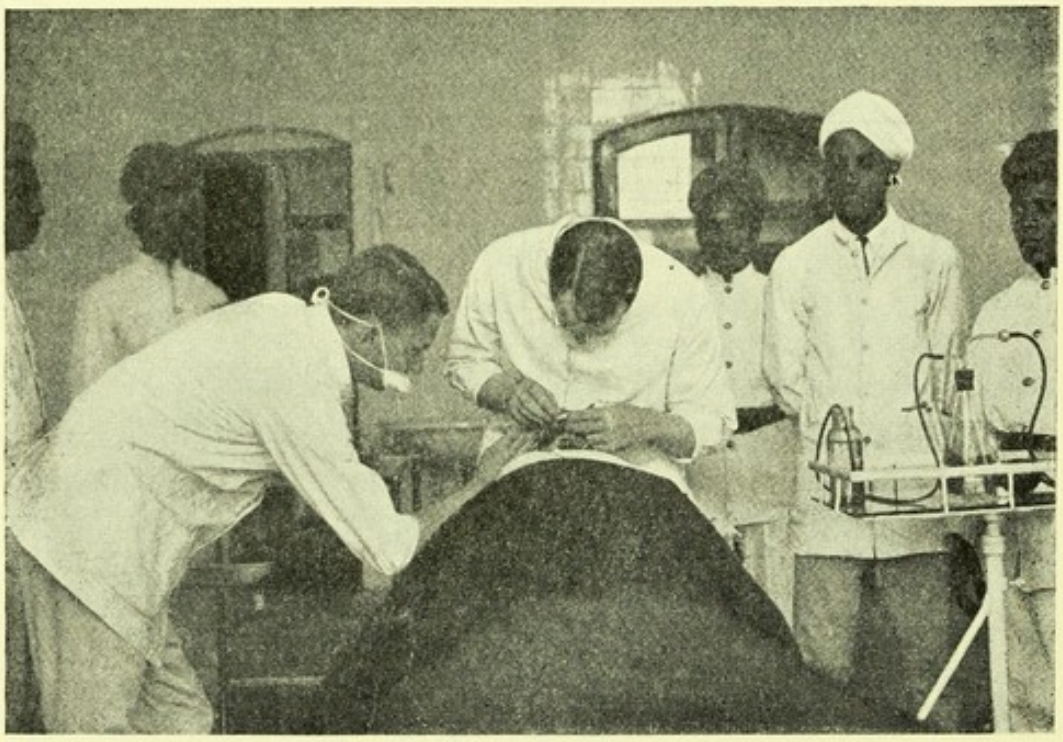

FIG. 12A resembles Figure 12. To the right is seen the McKeown's irrigator. To the left behind the chief assistant is the instrument table. The peon standing behind the chief assistant holds the tray, seen in the photograph, for catching the irrigation-fluid as it escapes.

the table, wear masks which consist of a layer of linen spread on a light aluminium frame (*vide* Figs. 12 and 12A). These are soaked beforehand in perchloride lotion and are put on damp with a view to prevent dust-droppings from their surface. Sterilised coats are also worn.

(6) **Fans.**—Those who operate in tropical and sub-tropical climates at temperatures varying from 80 to 120 degrees F., are obliged to work under fans. In order to prevent infection of the wound from these very necessary adjuncts to comfort, the fan blades should be wiped, immediately before operation, with a damp cloth, which has been soaked in perchloride lotion, and the body of the fan should be enclosed in a linen sac, similarly wetted before commencing the morning's work.

(7) **Arrangement of Patient on Table.**—The patient is laid on a glass table with his feet toward the window and his head resting on a small pillow, which is so arranged that its edge is level with his face on the side of operation. Those surgeons who use an irrigator will find this a not unimportant detail, as it enables the nurse who holds the tray for catching the escaping irrigator fluid, to keep both hand and tray well down out of the surgeon's way. We do not cover the patient's face, but his forehead and scalp are firmly wrapped in a clean towel soaked in perchloride lotion (1 in 3,000).

(8) **Method of Bandaging.**—The bandage we use was introduced into Madras by the writer in 1897. He has not seen it used anywhere else. It is in his opinion greatly preferable to any other bandage when the two eyes require to be closed (Fig. 13). A piece of bandage cloth, 4 inches broad, is taken, and of such a length that it will pass one-and-a-half times round the patient's head. The mid-point of the strip is placed over the patient's external occipital protuberance, and the two free ends are held in front of the face by an assistant; the position of the two ears and the size of their bases are carefully measured on the bandage. This is now removed, and two holes are cut, one on each side, to fit the bases of the ears. The object of so doing is to fix the bandage so that it cannot slide up or down. Each free end of the bandage is now slit into three tails from before backward to a point opposite the patient's temples; each centre tail is $2\frac{1}{2}$ inches broad, while the breadth of each of the four remaining tails, is $\frac{3}{4}$ of an inch.

To apply the bandage, the ears are fitted through the holes made for them, and the two upper and two lower tails respectively are tied together, the one pair over the vertex and the other below the chin. The patient is brought on the table with the bandage thus applied. After operation, one of the two broad tails is brought down across the dressings and held in position

by an assistant, while the operator brings the remaining tail down on top of the previous one, and fixes the bandage by means of a pin applied at each side.

At each dressing the pins are removed, the two broad tails are thrown backward, and the dressings are changed. The eye is then closed by re-applying the middle tails in the same way as before.

By this contrivance we are able to repeatedly dress our patient without raising his head from the pillow, or in any way disturbing him. Another advantage is that firm and graduated pressure can be very easily applied.

FIG. 13.—The figure to the left shows the patient when he comes on the table ready for operation. In the middle figure one tail of the bandage has been pinned in position, the other still hangs down. The figure to the right shows the bandage completed as the patient leaves the operation table.

(9) **After operation** in Madras, the patients walk back to bed, an exception being made in the case of old, feeble, or nervous people. All cataract patients are carried back to their wards on a stretcher, but it is not considered necessary to have this done after trephining. The large numbers dealt with and the habits of the patients necessarily modify the *technique*, A visitor to the wards after a trephining morning will probably find most of the subjects sitting up, discussing the earlier events of the day. The prevailing spirit is however calm and fatalistic, and the result is that harm is not often done. With Western patients, the sense of anxiety is greater, but the habit of disciplined self-control is far more highly developed ; and with such it is our rule to have them carefully carried back

to bed, or if possible to operate on them in their beds, and keep them immobile for 5 or 6 hours afterwards. Whilst on this subject there is one more point which deserves notice, *viz.*, the steady behaviour on the table of educated English people, as compared with that of many of the Indian patients. Here again the habit of self-control is a powerful factor in the favour of a happy ending to the operation.

(10) **Care of the trephine blade.**—On each occasion after use, the trephine blade should be carefully washed in warm water, and its inside should be cleaned, by passing up it a match, brought to a fine long point, and with a thin film of wool wrapped round its sharpened end. If this is dipped in warm water, the lumen of the blade can be easily and quickly cleaned without in the least damaging the edge. The life of the instrument is materially increased by this small attention. Before putting the blade away, it should be dried by the use of absolute alcohol, and finally vaselined.

CHAPTER V.

THE TECHNIQUE OF THE OPERATION OF SCLERO-CORNEAL TREPHINING FOR GLAUCOMA.

When we started trephining in August, 1909, we had everything to learn, not only as to the results we should obtain, but also as to the *technique* of the operation. Experience has considerably modified our original methods, and valuable suggestions have been received alike from those who have worked in the Madras clinique, and from not a few contributors, who have kindly communicated their views to us from all parts of the world.

The criticism has been offered that the operation has been said to be easy, but is often difficult. Those with a fair amount of experience will probably find it from the start a very easy procedure; but, like all other operations for glaucoma, it may at any time prove a difficult one in advanced and hazardous cases. When the author left India, the Madras figures showed over 900 cases, and the number of surgeons who had learnt to practise trephining there could be counted by tens. Since then the writer has had the opportunity of trephining 135 eyes in the course of a tour in America, and of performing the same operation on a number of cases in England. In both countries he has had the great advantage of receiving very valuable suggestions from those who attended his demonstrations. The object of this chapter is to place the experience so gained at the disposal of other surgeons, in a detailed manner. Each operator who has an individuality of his own will doubtless modify the method to suit his personal needs.

In the following pages we are about to deal with the *technique* of the operation in very considerable detail. It must not, however, be thought that the procedure is correspondingly complicated. Dealing as we have done with careful notes from such a large number of cases, it is probable that we have nearly exhausted the possible complications to be met with in performing this operation. Those who work with smaller numbers and with earlier cases will in all likelihood never be confronted with many of the difficulties described.

It is nevertheless our wish to be as thorough as possible in the hope that the usefulness of the work may be correspondingly extended.

(1) **In which quadrant of the eye should the trephining be performed?**—It is obvious that under most circumstances the upper is the quadrant of choice, for (1) the wound is then less exposed to infection; (2) the iridectomy, if one is performed, lies under cover of the lid; (3) the conjunctival flap rarely requires a stitch when made above; and (4) Rochon-Duvigneaud has shown that the measurement from the angle of the anterior chamber to the limbus is greater in the vertical than in the horizontal meridian, and greater above than below the cornea. This is due to the varying distance that the conjunctiva overlaps the cornea, which it does to the greatest extent above. The consequent advancement of the limbus in this direction gives the operator a proportionate increase in the amount of room available for the implantation of the trephine, without risk of doing damage to the ciliary body or to adherent iris. It is not, however, possible to trephine above the cornea in all cases, and it is inconvenient to do so in some others. When a patient is troublesome, and looks obstinately upward, especially during the performance of the operation on the second eye, it is a great convenience to do the trephining below: the efforts to defend the eye, by looking upward, then aid the operator instead of hindering him. This difficulty usually occurs in those who are already practically blind, and in them the presence of an iridectomy-coloboma within the palpebral aperture is of no consequence. Indeed, this factor need hardly be taken into account, even in cases with good vision, for the coloboma resulting from a properly performed operation is, in the vast majority of cases, so small and so peripheral that it can only be seen by raising the eyelid and looking carefully for it. In an occasional case, however, a more complete, though always narrow, iridectomy may be made, and then any site but an upward one may give rise to inconvenience. There are at least three other sets of conditions in which it is not possible to trephine above the cornea, *viz.*, (1) when the operation is undertaken for the relief of staphyloma, and the upper part of the cornea is involved in the swelling; (2) when, in chronic cases, it is obvious that the chamber is shallower in an upward direction than elsewhere; and (3) when a condition similar to the last-named is due to anterior synechia, accompanied by rise of tension. In most cases of partial staphyloma one can find an area in which the chamber can safely be tapped, and the same applies to the other two conditions mentioned above. The difference

between the depth of different parts of the chamber in some cases of chronic glaucoma is very striking.

As to the question of infection, our Madras experience has been a fortunate one, as we have not had a single case of wound infection after trephining, so that the precaution of selecting an upward flap, whenever we can do so, was originally based on theoretical grounds alone. Recent publications have shown, however, that others have been less fortunate, and that we cannot afford to sacrifice a single safeguard.

Our flaps gave us very little trouble in India; an upward flap very rarely required a stitch. In one series of 217 consecutive cases with the flap above, done by the author, it was found necessary to put in a suture only once at the time of operation, and two cases demanded a stitch during the after-course, owing to the flap turning back; these cases did well, and the insertion of the suture was made without difficulty under cocaine anæsthesia. A flap made in a downward direction more often requires a suture. In 58 cases of downward flap, we had occasion to put in a stitch three times during the operation, and twice during the after-treatment. If the flap is made in any other direction it is better to stitch it in every case at the time of operation, as the lid movements will otherwise be very liable to shift it from its proper position. We only used a lateral flap four times in a series of 278 cases.

When it comes to operating on Europeans, and still more so on Americans, the case is entirely different. The Asiatic is a fatalist, and moreover his life in hospital, with its unaccustomed rest and good feeding, fills him with a quiet content. He has nothing to worry about, and he worries about nothing. The case of the Western man is quite different; his mind is full of anxiety for the future; business worries hold carnival in his weary brain, and he tosses on a bed which to his active intelligence is a prison-house; his eyes share the movements of his mind and body, and he may displace the still feebly adhering flap. The result may be that, even if it does not slip badly down, it does so enough to broaden the resulting cicatrix in quite a fair percentage of cases. There is no proof that this does actual harm, and yet it is obviously undesirable. Be it understood that we recognise that there are placid European, and excitable Indian, patients. We are dealing with broad generalities, however, and the author's experience both in America and in England has shown him that it is advisable to stitch the flap much more often in Western than in Eastern practice. The indications for the use of a suture will be fully given at the appropriate place later on in this chapter.

(2) **The nature of the flap, and the method of making it.**—Something has been written about the danger of wounding Tenon's capsule whilst raising the flap, but it is hard to believe that any operator could be clumsy or careless enough to do such a thing; it is no real danger to the man of ordinary knowledge and skill. The underlying suggestion has evidently been that it would be safer to reduce the size of our conjunctival flaps. This is a subject which has engaged much of our attention, and our decision has been to hold on to the large flap for the following reasons: (1) it is a great safeguard against infection of the eye; (2) a negative point—our observations show us that we do not meet with any astigmatism in consequence of it; this has been proved by careful keratometer readings; and (3) the really important matter — large flaps mean free and easy filtration. A careful study of a number of cases after operation shows that the actual line of the incision is sometimes tied down on to the sclera; if one makes a flap of little length, it tends to curl in on itself; moreover, if the two ends of the incision reach the cornea, and if the line of union then cicatrises, it is obvious that the total area left for filtration is very limited (*vide* Fig. 14). A more generous flap is more inclined to lie in place, and is for this reason less apt to cicatrise at its edge, as it unites with the conjunctiva, from which it was cut, and not with the subjacent sclera. This helps to provide a larger area of subconjunctival tissue into which filtration can take place. A more important detail still remains to be mentioned. The incision we now employ does not begin and end in the limbus, but runs roughly concentric with it, and ends on either side opposite the highest point of the cornea, and about 8 mm. to its inner and outer sides (*vide* Fig. 15). The importance of this detail is obvious, for even if the line of incision cicatrises down all round, filtering fluid from the interior of the eye can still find a free exit through the trephine hole into the sub-conjunctival space outside the incision limits through the areas marked *a.a.* in Fig. 15. An important confirmation of the value of this form of flap was obtained in an early case, in which we were obliged to open up the wound some time after operation, in order to excise prolapsed iris. The line of incision was bound down to the sclera, but the moment we crossed this line in opening up the flap, free escape of filtering fluid took place into the wound.

In making the conjunctival flap, one should avoid the brow with the scissors; if this be not done, the eyebrows will be cut and dropped on to the wound, thus soiling it. In order to make the description of this important part of the operation

clear we may divide the "fashioning of the flap" into the following stages :—

(i) **The Incision.**—The conjunctiva should be seized as high up as possible on the bulb with forceps, and drawn well down,

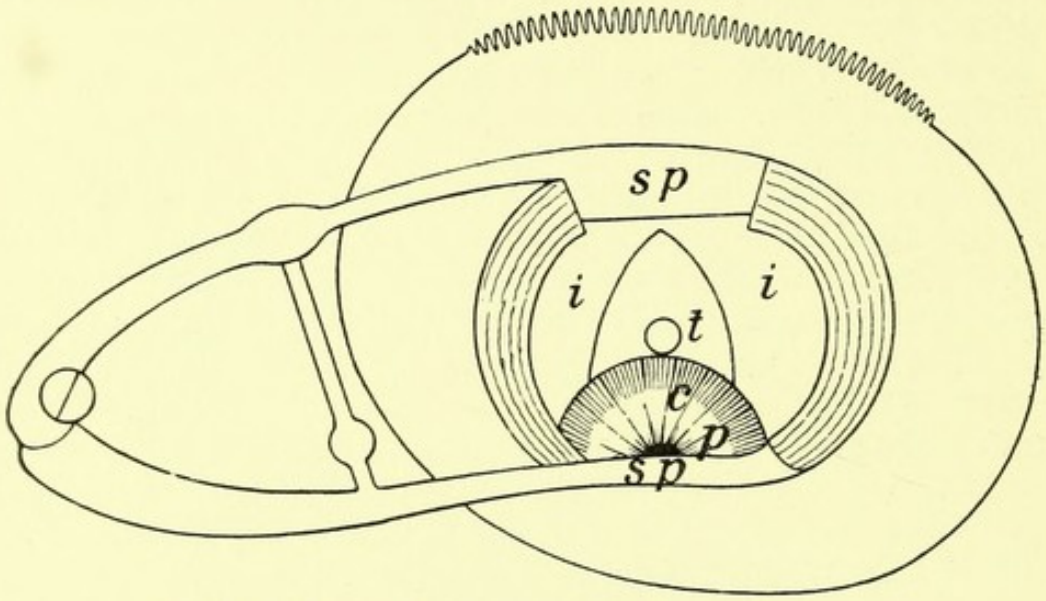

FIG. 14.—The incision, etc., in the early *technique*.

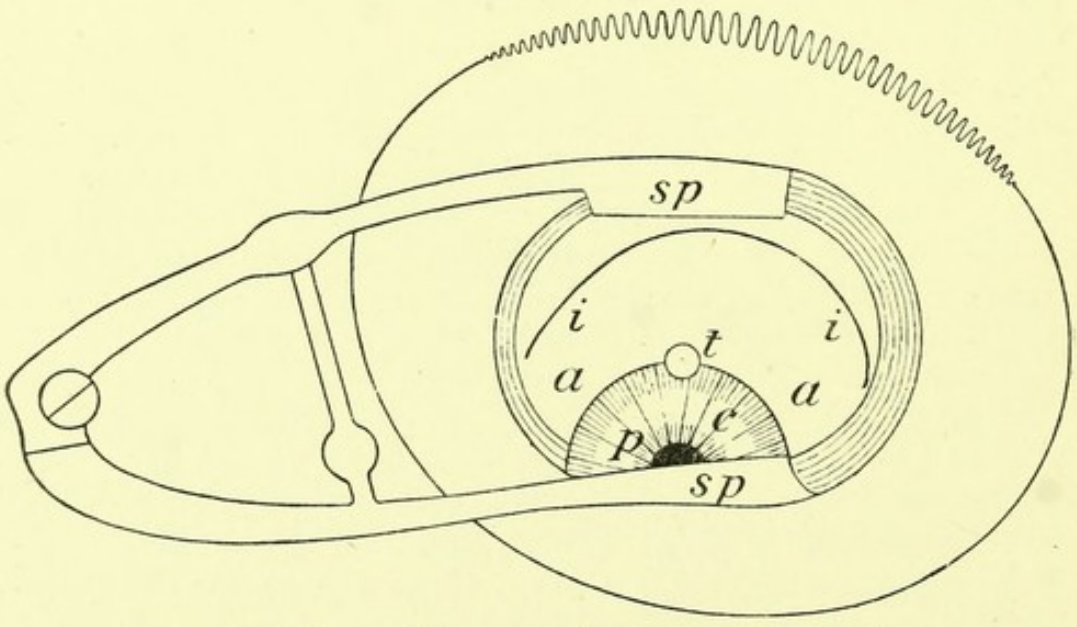

FIG. 15.—The incision, etc., in the present *technique*.

Sp. Speculum.
i. i. Incision.
c. Cornea.
t. Trephine hole
p. Pupil.
a. a. Channels in conjunctiva along which filtration fluid passes to enter the main area of the sub-conjunctival space.

at the same time asking the patient to look strongly downward ; one free horizontal cut, followed by a couple of snips at each

side, will often outline the flap throughout its extent; the shape and dimensions, etc., of the flap have already been given.

(ii) **The Dissection of the Flap.**—*It is unnecessary, and therefore unsurgical, to dissect up the whole area included in the flap*; moreover, by so doing we rob the flap of the check-ligament-like action of the connective tissue at the angles of the wound (Fig. 16 *efa.*). If we leave this tissue intact, the detached conjunctiva tends to spring back into place when released from the downward pull, whilst if we clear the margins

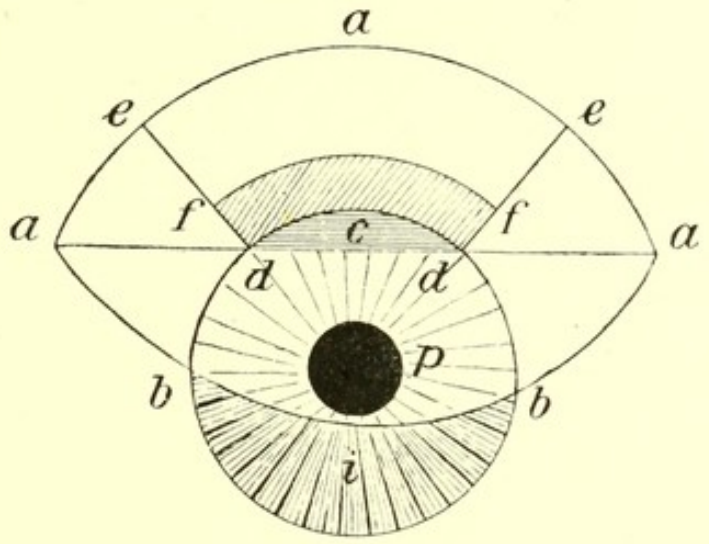

FIG. 16.—Diagrammatic representation of the area laid bare by the conjunctivo-corneal flap.

aaa. Line of conjunctival incision.
abba. Flap thrown down on the cornea.
c. Dark arc-like area of split cornea.
dd. Straight line of reflection of the flap.
edde. Area dissected up in order to enable the cornea to be exposed.
effe. Area of the upper part of the wound from which the conjunctiva alone is dissected up, when commencing to make the flap.
fddf. Area immediately above the limbus cleared right down to the sclera, in the course of the dissection of the flap.
ade. The area on each side in which the subconjunctival tissue is spared as much as possible in order to preserve the check-ligament-like action, which helps the flap to lie in good position after the operation is finished.
i. Iris.
p. Pupil.

of our wound, we find that at the end of the operation, the flap falls limp and inert over the cornea like a loose apron. We should for this reason carry our dissection down to the limbus over the central area only (Fig. 16 *edde.*). Such a procedure does not in the least prevent us from exposing the area we require for trephining, whilst it helps very materially to make

our flap lie in good position when the operation is finished, and so often enables us to dispense with the use of a suture. In the upper portion of the dissection, we do not need to take up anything but the loose conjunctiva. *As we approach the limbus we should work down to the sclera, and should expose the latter bare in the last few mm. of the wound* (Fig. 16 *fddf.*). At the same time the breadth of the dissection should contract as we approach the cornea, so that when we reach the latter, we only expose just such a breadth of it as we mean to split, and very little more (Fig. 16 *dd.*). Our *next landmark is the limbus, and we must clearly define this* as a rounded ridge slightly overhanging the adjacent sclera. A failure to do so involves a considerable risk of difficulty when we come to split the cornea in the next stage of the operation. If, however, there has been long-continued chronic congestion, it may be difficult to define this edge, as it then flattens out ; in that case the earlier stage of splitting of the cornea must be very carefully conducted, or the flap may be button-holed. *The area over which we are about to apply the trephine must be carefully cleared of all tags of loose tissue*; if this precaution is neglected, the trephine will not bite well, and will tend to shift from its position ; moreover when it does begin to cut, these tags may get caught in the action, and tend to draw the flap into the wound and damage it. The author has seen this happen to beginners. There is a little knack in getting the sclera clear ; this consists in closing the blades of a sharp-pointed scissors (those we have used so far in the operation), and making a number of scraping movements *from the centre of the wound out to each side*, close above the cornea ; this manœuvre succeeds in clearing the central area of loose tissue, and so provides a clean surface on which to apply the trephine blade, at a later stage of the operation,

(iii). **The Splitting of the Cornea.**—It must first be clearly stated that what we desire to do, is to *split the cornea*, and not to cut it. The examination of mlcroscopical preparations has shown that that membrane is really *split*, and that the flap we make includes not merely the anterior epithelium, and Bowman's membrane, but also some of the superficial corneal lamellæ, which can be traced for a long distance in the sections and can be seen to be separated from the deeper layers. The significance of this observation lies in the fact that we are thus enabled to open up the planes of the lymphatic spaces, and to keep them bathed, and unhealed, in the fluid which is steadily being poured out from the anterior chamber. The observation has been made by those who cut, instead of splitting the cornea,

that if they carry their trephine blade right on to the cornea, the hole tends to fill up. It is suggested that this is due to the cornea having its lamellæ cut clean across, instead of having its interlamellar spaces opened up by splitting; for we have had a more fortunate experience after splitting the membrane in the way we are about to describe.

The conjunctival flap should be drawn gently downwards by traction with closed forceps laid on it, and finding counter-pressure against the cornea; it must on no account be seized in the grip of forceps and pulled down therewith, or it may easily be torn and rendered useless for its purpose of covering the filtration hole. At the same time, the cornea is split with the scissor points, which are kept closed for the purpose; or if preferred a Bowman's needle, as used by Hingston, or a special wedge-shaped splitter as devised by McReynolds, or any other convenient instrument may be employed. The most important point is to *work at exactly the right place*, *i.e.*, just behind the line of reflection of the flap; a number of short purposive lateral strokes along this line speedily effect our purpose in most cases. If the cuts are made too far forwards, the flap is at once button-holed, whilst if they are made too far back, the surgeon merely wastes his time in an ineffective scratching of the sclera. The instrument is inclined at an acute angle to the cornea, bearing in mind that what we want to do is to dissect off its superficial layers in a thin flap. It is very necessary to have good eye-sight and a good light, though granted these two requisites the technique is not difficult. The author's own preference is very strongly to work by daylight, but if an artificial light is used, it is essential to have an additional small hand lamp which can easily throw in a beam sideways when required. The reflexes obtained by artificial light off the parts are most confusing and annoying, whilst in daylight the work is easy and pleasant. As the dissection proceeds the so-called "dark crescent" of cornea can be seen clearly (Fig. 16, *c*) as a dark area convex in outline towards the sclera, and with a straight edge on the corneal side. The figure produced is that of a small segment of a circle, in which the reflection of the flap forms the chord (*dd*), whilst the edge of the stripped cornea corresponds to the arc; a good simile is that of a bow and its string. If in the course of the dissection one sees the line of flap no longer curved at the corneal margin but crossing it in a straight line like the string crosses a bow, we may rest assured that the cornea has been split; this suggestion is not without value, for in some eyes the cornea shows up much less dark than it usually does, and an inexperienced operator, unaware of this fact, may fear he has not split the

cornea, and may persist till he button-holes his flap. In the very great majority of cases we can split the cornea easily for 1 mm.; in not a few the splitting may be carried 1·5 to 2 mm. on to corneal tissue; in a few cases and especially in those with long standing congestion it is difficult to get a crescent wider than 0·5 to 0·75 mm. Although this latter amount can always be secured, it sometimes is only done by tearing rather than by splitting. Such cases are fortunately rare; they occur in eyes which have been the subjects of long-standing congestion, and the prognosis for the maintenance of fistulisation is not so good as it is in the ordinary cases.

There are two other conditions under which one finds a difficulty in splitting the cornea, viz., (1) that in which the conjunctiva is found to be tied down to the sclera, as the result of the use at some previous date of subconjunctival injections in the quadrant we are operating in, and (2) that in which the subconjunctival tissue of the eye is found to be unusually dense and abundant. In connection with the former condition, our experience has been that any and all of the subconjunctival injections cause the formation of adhesions, as judged of by our findings at the time of operation, but that normal saline injections do so far less than those of sodium citrate or of the mercurial preparations; in the case of either of the latter, the adhesions are usually so dense as to make the approach to the limbus difficult, and the splitting of the cornea impossible. The obvious lesson is to avoid the injection of any fluids into the area which we may later on need to use for operative purposes. As to the second condition above discussed, we have found that there is a very great variation in the amount of subconjunctival tissue in the eyes of patients even of the same age, and that the scantier this tissue layer is, the easier is it to split the cornea and vice versa.

An important question and one often asked is, how is the operator to tell when he has dissected far enough forward, and when there is a danger of button-holing his flap? We must bear in mind that the object of splitting the cornea is to enable us to place the trephine as far forwards as we *safely* can. Now an experience of a large number of cases has shown us two things, viz., (1) that on the average, one can safely split the cornea a little over 1 mm., and (2) that such an area of splitting puts us practically in a secure position so far as the danger of trouble from the iris or ciliary body is concerned. To this we may add that it is possibly not desirable to have the whole of our trephine aperture sited on the cornea. Apart from all these considerations, if the surgeon sees that his flap is getting too thin at the edge, he will do well to be content

with the amount of splitting he has accomplished, and not to risk button-holing. So much has been written about the latter accident in connection with the splitting of the cornea that it is necessary to point out that the danger of its occurrence is certainly not great at this stage of the operation. It is more likely to occur when the trephine is actually being used, and still more so when the iridectomy is being performed.

In connection with the manœuvre of splitting the cornea, there is a small point of some interest; it will be observed especially in those cases which split easily, that one part of the line we are working on gives more readily than the rest, producing the appearance of a bite out of the straight edge of the flap-reflection, or that of a small shallow bay in it. The importance of the observation is that it is much easier to continue the splitting at one of these bays than elsewhere along the line. In conclusion, it is important to lay emphasis on the fact that the split area has a smooth appearance, indicating that we have dissected up along a plane of cleavage. This is what we have always believed we have been doing, and recent anatomical work has shown this belief to have been justified.

This manœuvre of splitting the cornea has been very minutely described at the special request of a number of surgeons, and it is hoped that it has now been made quite clear. At the same time, one desires to avoid giving any support to the views of those who maintain that splitting of the cornea is a very difficult procedure; it is true that it calls for care and skill, but that is all that need be said of it. To prove this point, we may quote some figures from our statistics in Madras. In 201 consecutive trephinings (between November, 1911, and March, 1912) the writer damaged his flap on four occasions only (*i.e.*, in 1·99 per cent.), and in not one of these cases was there any evidence that the tiny button-hole made had any influence on the satisfactory course of the case. During the same period ten other surgeons, learning trephining in Madras, button-holed seven times in 124 consecutive operations (*i.e.* in 5·6 per cent.) and on only one such occasion was it found necessary to shift the area for the application of the trephine.

When we started to practise "splitting of the cornea," the objection that first occurred to us was that the close attachment of the corneal conjunctiva to the deeper layers would cause these parts early to become firmly re-united, and that consequently the corneal area of the wound would be lost for filtration purposes. The photographs published on pages 139 to 142 clearly show that such a fear was wholly unfounded. Indeed,

the part of the wound overlapping the cornea has proved to provide a free and ready area of filtration with no tendency such as we had feared.

(3) **The Application of the Trephine.**—With increasing experience one thing has become absolutely clear, viz., that if we wish to trephine the chamber, and to establish a permanent filtering channel with a minimum of trouble, we have to be careful to place our trephine hole as far forward as possible.

A failure to observe this rule (1) makes a clean entry into the chamber uncertain; (2) complicates the free tapping of the aqueous fluid; (3) leads later on in some cases to an interference with filtration, due to uveal tissue blocking the trephine hole; and (4) exposes the eye to the danger of vitreous escape. If the trephine hole is far forward, the only part of the uveal coat with which we have to do is the iris, and this can easily be dealt with, as we shall show later on. If the iris base is adherent to the cornea, the advantage gained by placing the trephine hole as far forward as possible becomes still more obvious; hence the urgency of the need for dissecting the conjunctivo-corneal flap forward in the way already described. In applying the trephine we must not throw away any of the advantage so gained; the flap should be pulled gently towards the centre of the cornea by traction exerted with the points of the closed forceps, and the trephine placed on the prepared corneo-scleral surface so that its edge will *just clear* the flap, thus making use of every fraction of a millimetre of the area which has been gained by the splitting; the dark crescent of corneal tissue bordering the base of the flap can very easily be seen and defined.

The trephine should not be dumped down on the spot on which it is to work, but should be slid into place from the scleral side, the edge of the flap being keenly watched the while; this manœuvre greatly minimises the risk of button-holing the reflected edge.

The beginner may find some difficulty in keeping his cutting edge to one spot at the commencement of the trephining. As a rule, this manœuvre becomes quite easy with a very little practice, especially if a sharp instrument be used. Considerable assistance may be obtained by seizing the trephine blade low down, close to the eye, in the grasp of a pair of conjunctival forceps, and thus steadying the cutting edge of the instrument. Various instrument-makers have, at the author's suggestion, supplied a handle carrying a small collar or hook to steady the trephine when applying it to the eye. Several other operators, amongst them Dr. Ernest Maddox, of Bournemouth, have been using similar devices, and appear well

pleased with them. Our own preference is, however, still for the forceps grip if any steadying is needed.

Some of the surgeons who worked in Madras preferred to discard any trephine-steadier, and instead to fix the eye by gripping it with forceps at one angle of the incision, asking an assistant to draw the flap downwards over the cornea by means of any convenient blunt instrument. There can be no doubt that this modification of technique is greatly appreciated by those who make a practice of using it.

The **exact amount of pressure necessary** can only be learnt by experience; some beginners appear afraid of using enough force and needlessly lacerate their wound by niggling efforts on different spots, the trephine slipping from one place to another each time they re-apply it; others, but they are very few in number, go through with an ever-bold confidence and find themselves in the vitreous chamber before they know what they are doing. In order to avoid both these errors, it is necessary (1) to work in a good light with a very sharp trephine; (2) to keep the area of operation clear of blood, so that the operator can see exactly what he is doing; (3) to make sure of cutting a definite groove on the first application before raising the trephine to see what has been done; and (4) to steady the trephine blade and keep it to one spot by seizing it gently quite close to its cutting edge in the grasp of a pair of conjunctival forceps. Once a definite groove has been started, the trephine blade finds its way into it again with astonishing ease; from this stage onwards the operator, till he has acquired the necessary experience, must raise his blade frequently to see how deep he has cut; with practice this will become unnecessary, and he will then be able to tell when he is through by the sucking feeling which accompanies the completion of the trephining; at the same time aqueous may often be noticed to escape around the instrument, and frequently the patient by a slight movement or by an exclamation shows his consciousness of a little pain: this latter is not severe, and a patient never starts violently because of it; a movement or an exclamation is all that escapes him. There is a fourth sign to which attention has been drawn by Axenfeld, Hill Griffith, Wallis and others, *viz.*, the upward movement of the iris at the moment the trephine cuts through, which results in the production of a pear-shaped pupil; this is evidently due to the outrush of aqueous from the chamber, carrying the iris along in the direction of its current. For the detection of this sign it is necessary to hold the flap at right angles to the eye whilst the trephine is cutting its way through. The correct use of the trephine by light, steady cutting strokes requires learning, and can be easily practised

on the eyes of animals. The author, when using the earlier form of light handle, worked with the index finger and thumb, and constantly moved his fingers up the instrument as they tended to slide down; it is this downward slide of the fingers which gives operators most trouble at first, and some require to use a second hand each time they move their fingers back into position again. The method adopted by Hime, in the Madras clinique, meets this difficulty in an ingenious way, and is perhaps easier to acquire than the above described method; he places his index finger on the top of the trephine and keeps it there throughout the cutting, working the instrument with his thumb and middle finger. The adoption of the heavier handle which we now use has greatly simplified this part of the technique. No pressure need be used, as the instrument works by its own weight, and consequently the tendency of the fingers to slip down is practically abolished. All the instrument makers who manufacture the author's trephine have been requested to supply in future the heavier weight of handle, *viz.*, one of 2·5 drachms (9·7 grammes).

The direction in which the blade of the trephine is to be held relative to the corneo-scleral surface is a matter of great importance. It is to be remembered that in the neighbourhood of the limbus the cornea is thicker than the sclera. If, therefore, we hold our blade perpendicular to the surface (*i.e.*, radial to it), we penetrate the coat first on its scleral edge. Now for a double reason this is exactly what we wish to avoid doing, for (1) our one great aim throughout this technique is to place the fistula we are endeavouring to establish as far forwards on the eye as we can, that is to say, as far as possible from the ciliary body or from adherent iris; this can obviously be best attained by cutting steep into the anterior chamber on the corneal edge of the wound; and (2) when we come to speak of the division of the hinge left at the close of the trephining, it will be obvious that so far as the reflected edge of the conjunctivo-corneal flap is concerned, this will be more safely and easily avoided, when we are cutting through the hinge, if the latter lies the breadth of the opening away from the flap, than if the two are contiguous. In the latter case the danger of button-holing is obviously much increased. Our object should therefore be to make the blade cut through first on its corneal edge, and in order to ensure this, we must slope the upper end of the instrument a little towards the patient's feet. The result will be that as soon as the trephine has cut its way through, the disc, hinged on its scleral side, will be pushed upwards and outwards by a bead of iris tissue, prolapsing through the corneal side of the opening. If the manœuvre is correctly carried out,

this prolapse occurs with great regularity. It is, however, dependent on two factors, (1) the presence of a moderately contracted pupil before the operation is commenced, and (2) the use of a sharp trephine. It is important that the pupil be at least not dilated, for one finds that when dealing with dilated pupils, two things may happen, *viz.*, (*a*) practically the whole breadth of the iris may bulge into the opening, in which case it will be found very difficult to avoid making a complete iridectomy, an event to which there are obvious objections; or (*b*) the iris may bulge through so far that its free edge presents in the hole and allows the escape of all the aqueous fluid, in which latter case the membrane will very likely fall back again into the chamber, making a subsequent iridectomy both more difficult and more hazardous.

The next question of importance is **the size of trephine** to use. We have tried all sizes from 3·5 mm. down to 1 mm., and our personal preference is, on the whole, in favour of a 2 mm. instrument. An opening of this size is practically always large enough, whilst a smaller one has this grave disadvantage—that it does not give room for the use of iris forceps and scissors, should the iris happen to be accidentally dragged into the wound and impacted there. In the event of repeated trephining with a 2 mm. blade failing to keep the drain open, we may try a larger instrument. As an experimental measure, we have tried this in occasional and rare cases.

In our earlier experience with the trephine we found ourselves constantly confronted with the difficulty of deciding whether the whole disc marked out by the instrument should be removed or not; we realised that we were between the dangers of removing too much and too little. If in a recent case we take the whole 2 mm. disc away, we may find that the tension remains very low for a long time, possibly indefinitely; on the other hand, if we do not take the whole disc away in chronic congestive cases, the hole is likely to fill up, and filtration may thus cease. With a very little experience of the 2 mm. trephine it will be found possible, provided the instrument is sharp, to detach the disc the whole way round, or to leave it uncut at one small hinge only; in the latter case a single snip of the scissor points does the rest. If we wish, we can cut off any desired portion of the disc, thus removing a third, a half or more of it at will. The same end may be more neatly and methodically attained by deliberately pressing yet a little more on the corneal edge of our trephine, and so entering the chamber round a half or more of the circumference on that side, thus leaving a comparatively large hinge uncut; in

completing the detachment of the disc, we formerly cut across the hinge obliquely with the deliberate intention of leaving the deeper layers of this part *in situ*. Further reflection has showed us that this last procedure is not above criticism, since it must obviously leave the tunic of the eye unnecessarily weakened at that spot. We now determine how much of the disc we intend to remove, and cut it off *at right angles* to the surface, thus leaving the posterior edge of the fistula we aim at making as steep as its anterior edge, which has been cut with the trephine. There is no difficulty in carrying out this manœuvre ; all that it is necessary to do is to draw the hinge well away from the eye, and to cut with the plane of the scissor blades at a tangent to the eye, and as close to it as possible. On the contrary if we do not pull the disc well out, and if we cut with the scissors directed obliquely to the eyeball, we shall evidently cut the hinge obliquely, the very contingency we desire to avoid. It may be urged that we are sacrificing a part of the area of our wound in the sclera, and had much better have diminished the size of our trephine to begin with. The question is, however, not quite so simple as it looks, for we can never in any case say beforehand that the iris will not give trouble by becoming impacted in the wound during or after the performance of the iridectomy ; and although this accident is not a frequent one, it must be thoroughly dealt with if met ; it is quite an easy matter to resect the deeper layer left, by using a pair of small cross-action Terson forceps and the scissor points, and we are then in the position of being able to deal easily with the offending iris. Similarly, if during the trephining—and with a blunt instrument this may easily happen—we accidentally leave a part of the deeper layers when we meant to remove them, the manœuvre above described enables us to do so quickly and easily. If the trephine blade is sharp, and the operator finds that though he has tapped the aqueous, possibly only at one point, the main circumference of the incision still remains uncut, he may re-insert the trephine, and working with light, quick movements may complete the removal of the disc, even though the chamber may have been practically emptied beforehand. The patient will complain of some pain whilst this is being done, but it is never severe. In any case the application of a crystal of cocaine to the wound right over the trephine hole will make the part absolutely anæsthetic.

There is undoubtedly another side to this question, which we may put thus : (1) since we have made splitting of the cornea a regular feature of our technique, the trouble we formerly had with iris in the wound has practically disappeared ;

there can be no doubt that the method of seizing the disc and iris together during the iridectomy has contributed materially towards this happy state of things; (2) our anatomical measurements of the space available for trephining, without interference with adherent iris, or with the ciliary body, have shown that this is limited, and that in case the iris is adherent the limitation becomes still more marked; (3) a reduction of the diameter of the trephine blade to 1·5 or even to 1 mm., did not prevent our getting excellent and permanent filtration in a number of our early cases; and (4) we must not lose sight of the fact that for any definite length of wound, a circular incision gives the maximum of surface area, and therefore the minimum possible of weakening of the ocular tunic. It may then be argued that we shall do well to reduce our trephine blades if we possibly can, and in a certain percentage of cases we make a practice of doing so, but rightly or wrongly our leaning is still towards the use of the 2 mm. blade. This question is discussed at some length in chapter XV.

(4) **The Iridectomy: its nature and the method of performing it.**—An iridectomy should be made, as a routine step, in every trephining operation, simply to avoid the risk of iritic tissue becoming impacted in the trephine aperture during convalescence. The *rôle* of an iridectomy in this operation is the same as it is in the combined extraction of a cataract; no more and no less. It provides a sluice-gate through which rushes of escaping fluid can take place, without carrying the iris in front of them on their way out. This view of the case has been combated by certain ophthalmologists, but it is borne out by the fact that our experience and that of many other surgeons has shown that cases in which no iridectomy has been performed, have done just as well as those with iridectomy, provided always that the hole remained iris-free. It also has the sanction of Lagrange's consent. It is obvious that all that it is necessary to do is to remove a small peripheral portion of the membrane right opposite the trephine hole.

It is a common experience that the trephine disc, when cut by hand, nearly always remains attached at one point to the scleral coat by a narrow hinge. With a little practice it is possible, as indicated in the last section, to so trephine that the hinge is regularly left on the scleral side of our wound. When this is done with a sharp trephine which cuts its way through round a large area at once, we find that the iris bulges into the hole as soon as we withdraw the instrument. If this prolapse is watched, it will be observed that the most peripheral part of the iris is the first to pass into the hole;

this is exactly what we should expect from its anatomical position. If the patient squeezes, more and more of the membrane bulges, till at last the free edge of the iris protrudes, the aqueous escapes, and the membrane, now relieved from the vis a tergo, drops back into the chamber again. This sequence of events depends to a great extent on two factors, *viz.*: (1) The anterior position of the wound, and (2) the state of contraction of the pupil. For it to fill the trephine hole in this way it is a necessary condition that the prolapsing iris should be free and untethered; it must also be in a state of moderate contraction, or the pupillary edge will early present in the wound, the fluid will escape, and the prolapse disappear. The appearance of the little white disc, pushed upwards by the small black bead of iris is characteristic, and it is an easy matter to include both disc and iris in one grip of the forceps, and to divide both together with a single snip of the scissor points, thus performing our iridectomy with the same cut that severs the hinge. The great advantage of this is that our grip of the disc steadies the eye, and effectively prevents even a troublesome patient from rotating it until after the portion of iris has been removed. We are thus enabled to avoid all risk of the uveal tissue being dragged into and becoming impacted in the trephine hole. One sometimes finds that one has unintentionally made a complete, instead of a peripheral iridectomy. This is attended later on by obvious disadvantages, *viz.*: (1) it tends to cause blurring of images, (2) it exposes the patient to unnecessary "dazzling," and (3) it deprives the surgeon of the power of producing strong myosis, should he subsequently need to do so. We can avoid this accident in most cases. When the pupil has been small before operation, and the prolapse of iris is not large, the resulting coloboma will be peripheral, no matter how we make the iridectomy, unless we drag on the iris, which we should of course never do. When the prolapse is free and large, it is necessary to avoid seizing the whole of it in the forceps grip; it is not difficult to lay hold of just so much of it as lies near the disc, *i.e.*, the peripheral portion only, and we shall thus attain the end we desire. If however the whole breadth of the iris has passed through the trephine hole, it is scarcely possible to avoid making a complete iridectomy, especially as we are then pressed for time, and must catch hold of the iris as best we can, before it slips back into the chamber.

What are we to do if the iris thus re-enters the chamber before we can perform an iridectomy, or if it never prolapses from the start? The latter contingency arises (1) if a blunt trephine is used, which either effects an entry into the chamber

at one spot only, or at least over too short a circumference to allow of the disc being raised up by the bulging iris; the fluid then drains gently off, the chamber empties, and the pressure behind the iris falls, so that the tendency to prolapse passes away; (2) if the iris is tied down by synechiæ to such an extent as to make prolapse impossible; and (3) if the pupil is widely dilated and rigid before the operation. In order to answer our question, we must consider the pros and cons of the case. In favour of performing an iridectomy, we have to remember that it saves the danger of a prolapse during convalescence, and the necessity, which then arises, of a second operation, always so unwelcome, especially in private work. Against the iridectomy are the following arguments: (1) in endeavouring to seize the iris we may damage the lens, the suspensory ligament or even the vitreous; (2) in the event of a sudden movement on the part of the patient, we may get iris tissue impacted in the wound; (3) experience shows that, provided a prolapse does not occur, we get quite as good a result without iridectomy as with it; and (4) the use of a myotic makes the risk of a secondary prolapse comparatively small. After very carefully weighing the risks on both sides, it is the author's opinion that if iris fails to present (and in a properly carried out operation, this is in his experience seldom the case), it is better to leave well alone, and deal with any prolapse at a later stage if necessary. The question resolves itself into one of deciding which is the lesser of two evils. In this connection it is always to be borne in mind that the narrowness of the trephine aperture markedly increases the danger of impaction and renders replacement of the membrane correspondingly more difficult, thus adding a possible and serious complication to the case and rendering the after-treatment more difficult. The method of performing an iridectomy is consequently of more importance in trephining than in most other operations. It is essential to *put no traction on the iris*, and to carry the scissor-points right down into the wound whilst excising the portion of the membrane.

The Toilette of the Wound.—It is most important that the iris should be thoroughly replaced, and that no uveal tags should be left in the wound. For this purpose we use the irrigator already described, and placing the nozzle at the entrance of the trephine hole, we direct a bold stream of saline solution into the chamber; this easily and quickly washes the iris back into place, always provided that it has not been dragged into the wound and impacted there at an earlier stage of the procedure. At the same time the chamber is washed free of any blood which may have been effused, thus giving

us a clear view of details. The presence of a round central pupil affords proof that the iris has been thoroughly replaced. Sometimes when there is a little difficulty, we may attain our object by gentle massage with a spoon over the neighbourhood of the wound, succeeded by another irrigation. If we are still unsuccessful, it is probably due to one of two very different conditions, *viz.*, (1) Impaction of iris in the wound, as already mentioned, or (2) a return of intra-ocular tension, as the result of the free effusion of fluid into the posterior segment of the eye. The differential diagnosis is easy, for in the former case the eye can still be felt to be soft under the pressure of a spoon applied carefully over the cornea, whilst in the latter the almost stony hardness of the globe is very easily detected. To deal with the former case first:—It is quite safe, and, in skilful hands, certainly not difficult to introduce a spud, with its tip bent forwards, into the trephine hole, and to clear the latter of iris. The use of the irrigator will often complete the replacement still more satisfactorily, once the imprisoned iris has been loosened from its attachment to the sides of the tunnel in the sclero-cornea. On the other hand, when we are dealing with a hard eye, such manipulation as we have been describing, should only be used with the greatest caution. If this rule is disobeyed, there will be considerable danger of damage being done to the deeper parts, for these are packed tight against the hole by the pressure of the fluid behind. The pathology of this condition is discussed at length in another chapter, but the clinical aspect of it may profitably find a place here. It is best understood by reference to a phenomenon which may readily be observed by any surgeon who operates on late cases of glaucoma. Up to a certain stage all goes well. The trephine enters the chamber, the aqueous escapes freely, and the iris and lens move forward in the usual way; at this stage a spoon placed on the cornea shows that the eye is still soft, and yet in a very short space of time the globe is found to harden. We have felt this happen whilst the instrument was actually upon the eye, the tension passing from a condition in which the globe could be easily dimpled into hardness within a minute. At the same time, the outflow channel for the escape of aqueous has become blocked; fluid may actually be imprisoned in the anterior chamber, and yet it cannot find its way out, although a spud bent as above indicated can be seen to pass right into the chamber in front of the iris, and in doing so to give vent to the imprisoned aqueous. The lesson is perfectly simple; a rapid effusion of fluid has taken place into the posterior chamber of the eye, either into the vitreous or between the coats of the globe. This has pushed forward

the diaphragm of the eye (iris, lens capsule, lens and ciliary body) and by pressure of one or more of these deep structures has blocked the trephine hole. If the patient is got back into bed at once, the eye will, after a variable period, and often even after 24 hours, be found to be sub-normal in tension and to be filtering freely. The author holds most strongly that it is not in the interest of the patient to indulge in any manipulation once this hardening condition has manifested itself. He considers the *patient should be got back to bed with the least possible delay*. It is true that he has at times been able to get a better replacement of the iris by a cautious use of the spud, but he doubts whether even this is justified. To wait, and to use myotics is, he thinks, sounder practice.

There remain to be considered two conditions which were not very uncommon in our earlier experience, but which we have not met with since we took to splitting the cornea, and thus placing our trephine hole farther forwards. In visiting a large number of hospitals in different parts of the world, the author has clearly seen that still, from time to time, surgeons, either through a want of appreciation of the importance of trephining far forwards, or through an inability to always carry out the necessary *technique*, make the mistake of placing the trephine hole too far back, either at or even behind the limbus. It seems, therefore, advisable to deal in this edition also with the two possible complications above referred to, which may result from this mistake. They are (1) the effecting of an oblique or valve-like entry into the anterior chamber (*vide* Fig. 19), owing to the iris base being adherent to the cornea over a large area of the space covered by the trephine, and (2) the direct entry of the trephine into the posterior division of the aqueous chamber by reason of its cutting through the cornea and the adherent iris as one disc (Fig. 20). We are here dealing with cases in which the adhesions between the corneal and iridic surfaces have progressed so far forwards as to place a line of adherent tissue in front of the spot where the trephine has entered the chamber; we have tapped the posterior, and not the anterior, division of the aqueous chamber. It is scarcely necessary to insist that the best way of dealing with these difficulties is to avoid them, as may be almost invariably done if the *technique* advocated in this chapter is carried out. In the last 325 consecutive cases operated on in the latter part of the author's time in Madras, he found that it was always possible to effect a clean entry into the chamber, and to tap it directly thereby. In the 135 cases operated on in America, and in all those done in England, the same experience has held with one solitary

exception. We shall not, therefore, discuss the treatment of a complication which should hardly ever be allowed to occur. Prevention, and not cure, is called for.

Having satisfied ourselves that the iris is well returned, we next replace the conjunctival flap in good position, by first laying it back over the raw surface from which it was dissected up, and then stroking it well into place with the aid of a spoon or of some similar rounded and blunt instrument. If after so doing, the surgeon waits a minute or two, he will soon see whether the flap is going to adhere to its bed or not. If it rapidly becomes stuck down, and if the gap made by the incision in the conjunctiva is easily reduced to very narrow proportions, he can confidently close the eye, and dismiss the patient to bed. But if the wound gap is wide, or if the flap shows a tendency to be very easily displaced by slight movements of the globe, it is better to insert a suture at once, rather than to risk the inconvenience of having to do so the next day. There are certain other indications for the insertion of a suture; one should always be used, (1) if the patient is likely to be fidgety or unruly during convalescence; (2) if a general anæsthetic has been given, since this deprives the patient of self-control during the earlier hours after the operation; (3) in children; (4) in those cases in which the area chosen for trephining has been other than the superior quadrant of the eye; lower flaps often, but not always, require a stitch, whilst lateral flaps should invariably be sutured, or the movements of the lids will certainly displace them; and (5) in those (mostly acute) cases in which a subconjunctival injection has been employed before operation to induce local anæsthesia; for in these cases the edges of the incision tend to curl inward, and it is hard to get them to lie in good apposition with the opposite cut edge of conjunctiva.

An operator of large experience cannot fail to be struck with the very different coagulability of the blood in different patients. In one, the blood effused into the chamber clots so rapidly and so firmly that it is difficult subsequently to dislodge it, even with an irrigator, whilst in another case the tendency to coagulation appears to be almost in abeyance, and the chamber can be washed clear of its fluid, though bloodstained, contents without the least difficulty. The interest of the observation lies in the fact that in patients with rapid coagulability the flap seals down quickly and firmly, whilst in those whose blood tends to remain fluid after effusion, the opposite is the case. The latter, therefore, more often require a stitch.

A single suture will suffice to keep the flap in place, though two may sometimes secure better apposition.

The question naturally asked is: what are the objections to suturing in every case?

They are:—(1) that it is often unnecessary, and that experience shows that if a stitch is required, it can be put in easily, safely and painlessly the next day under instillation of cocaine and adrenalin; (2) that in this, as in all glaucoma operations, the sooner the patient can be put back to bed with a sound eye, the safer it is for him; and (3) that to insert a suture even at the margin of a flap, which is, at least for the first few hours, irrigated by fluid which is in continuity with that in the interior of the eye, cannot be an absolutely safe procedure.

It is to be borne in mind that after a trephine operation, the condition we aim at setting up is very different from that which should follow a cataract extraction, an iridectomy or anyone of a number of other similar procedures. In those operations, one desires to get the anterior chamber to close at the earliest possible moment, and to shut it off firmly from the space included beneath the conjunctival flap; whilst after trephining, we deliberately endeavour to keep open a free communication between the chamber and the sub-conjunctival space. In the latter case it is obvious that a fault in the asepsis of our stitch may be a much more important matter than it is in one of the former. It is urged in reply that it is not in the least difficult to put in an aseptic stitch. This is a view with which the author regrets that he cannot concur, and he speaks after having carefully watched the procedure carried out by a large number of very first-rate surgeons. Let anyone who doubts this quietly watch surgeons of undisputed skill putting in a suture high up in the fornix, and let him then say how often the *technique* would pass the criticism of a bacteriologist. Apart entirely from the surgeon's own hands, he will notice the risks of contamination that befall the suture from contact, if not with the face, then at least with the lid edge, but often with the former as well. Should the watcher be inclined to be censorious, let him next carefully watch, or better still ask someone else to watch, his own sutures as they are inserted, and he will probably cease to criticise others adversely for faults in *technique* which he himself only too often fails to avoid. It is not suggested that the risks of the insertion of a suture are large; they are indeed quite small, but they exist, and inasmuch as the best surgeon is, like the greatest general, he who makes the fewest mistakes, we cannot afford to give the smallest point away. Others will weigh the relative risks differently, and each will decide on the course which it is right for him to pursue in this matter. The author does not venture to criticise them in this; he merely puts the case as it presents

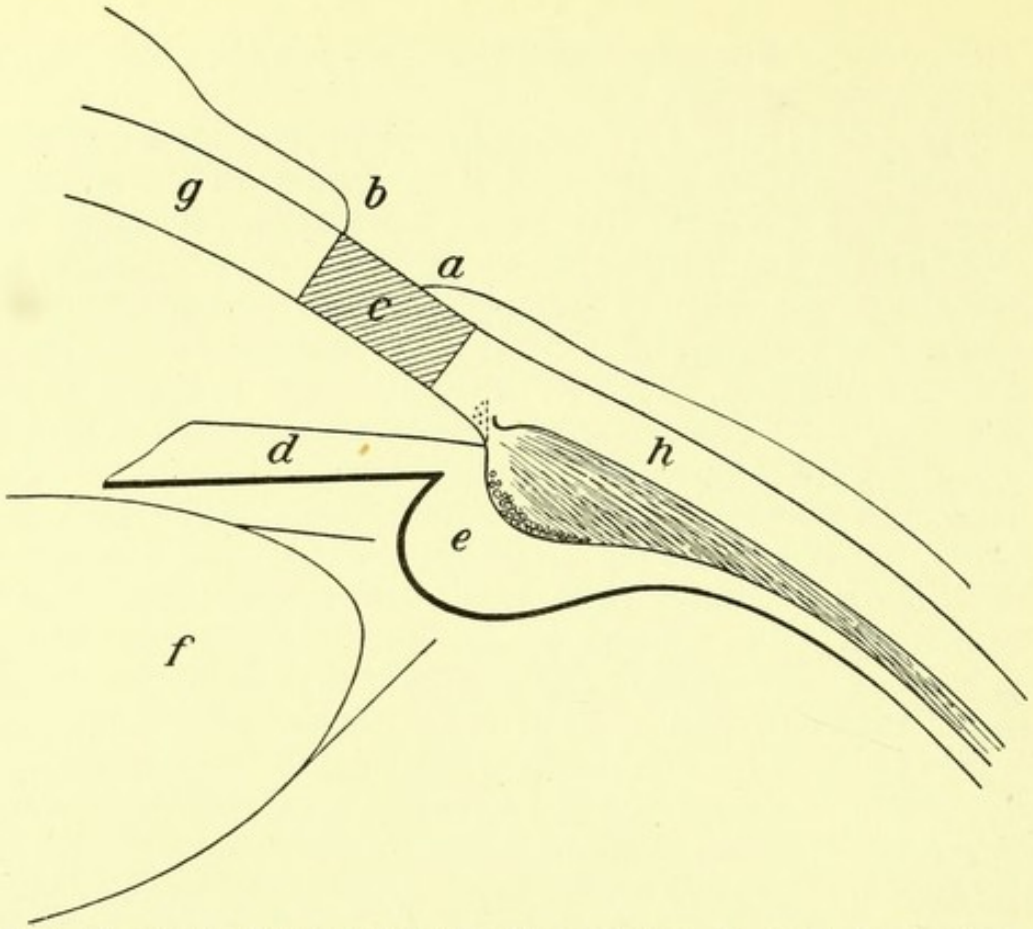

Fig. 17 shows diagrammatically the relation of parts in a case of trephining in which the iris base has not adhered to the cornea.

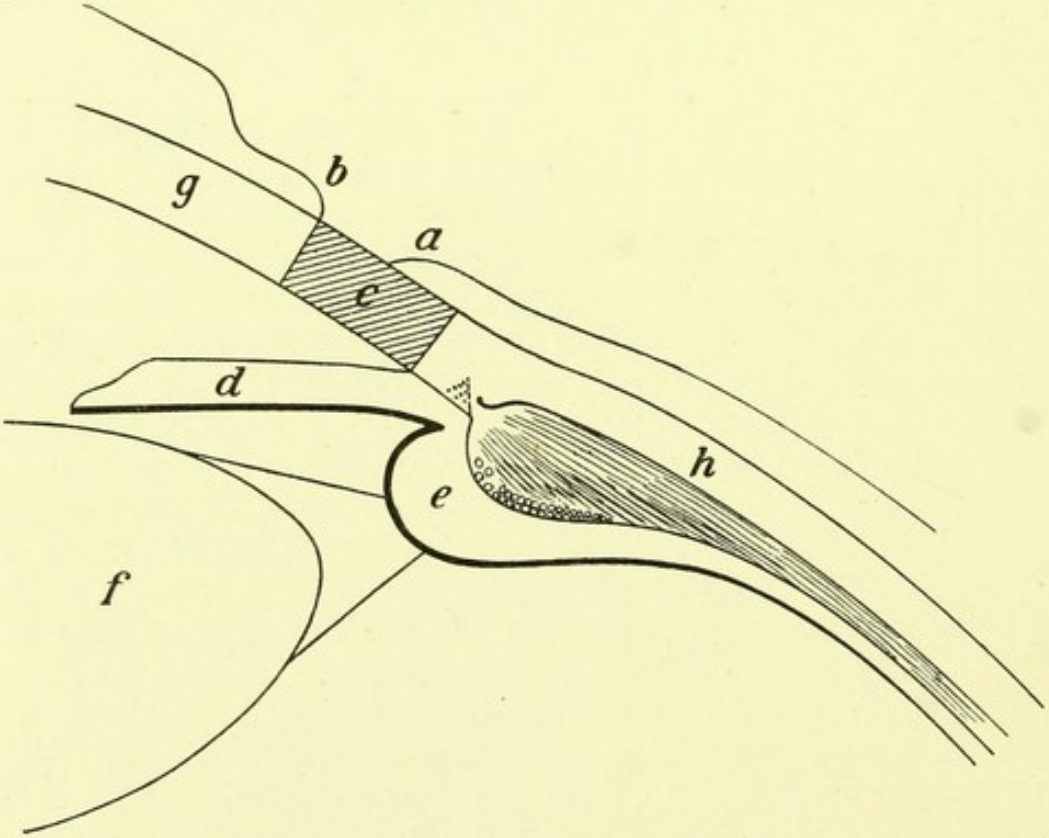

Fig. 18 shows diagrammatically the iris base adherent to cornea; the trephine hole lies just in front of the anterior attachment of the iris. The danger of iris prolapse is obvious.

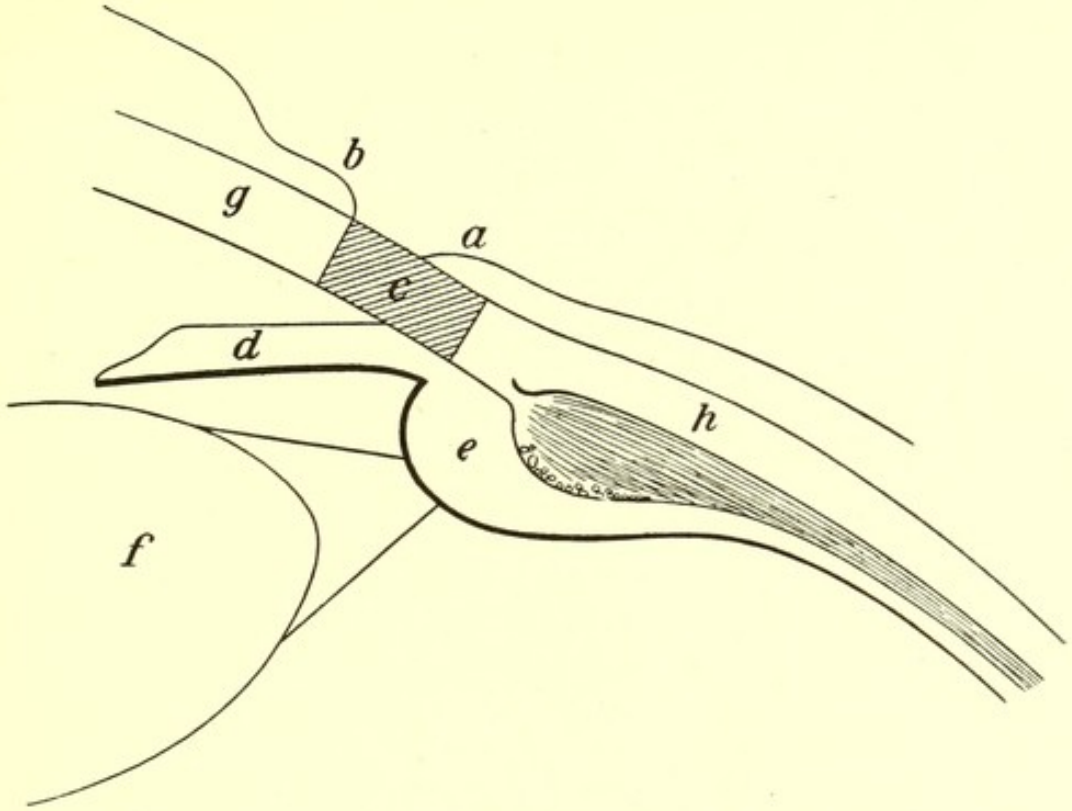

Fig. 19 shows diagrammatically the trephine hole entering the chamber at the anterior part of its circumference, the posterior part being blocked by adherent iris.

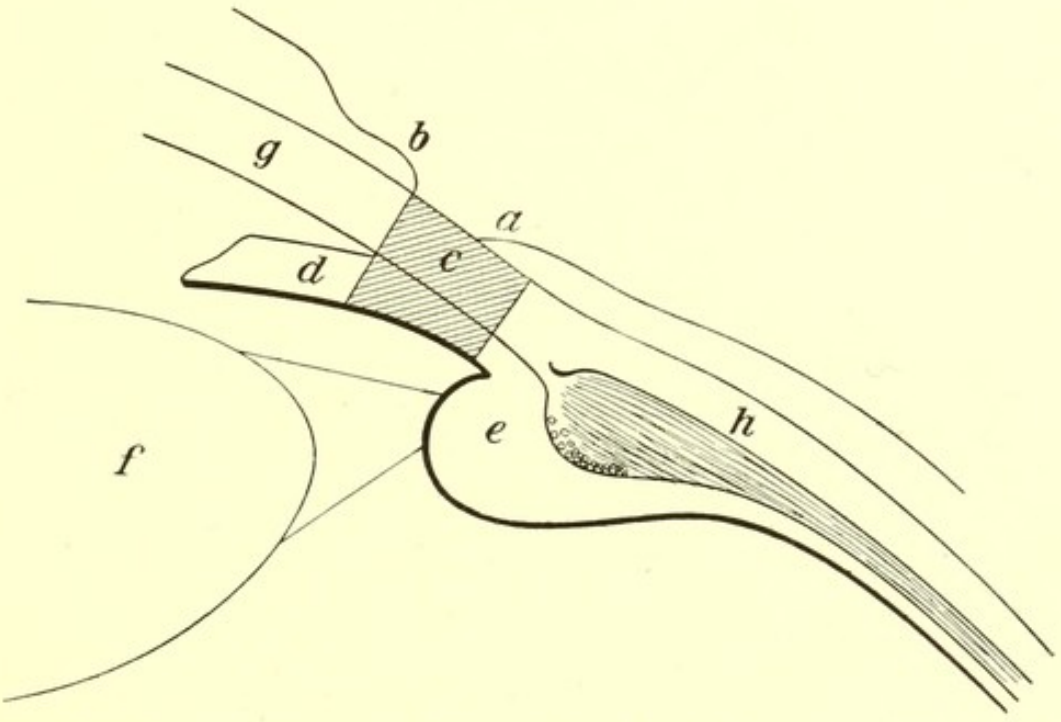

Fig. 20 shows diagrammatically the trephine hole passing through the cornea and the subjacent layer of adherent iris, in a case in which the iris is adherent to the cornea far forwards.

The diagrams have been modelled on a drawing of Thomson Henderson's.

Figures 17 to 20 show diagrammatically the interference of iris with the trephine hole.

(*a*) Normal position of conjunctiva.
(*b*) Conjunctiva reflected after dissection off the underlying cornea.
(*ab*) Represents a section of the crescent seen on stripping the conjunctiva from the cornea.
(*c*) Shaded, represents the piece removed by the trephine.
(*d*) Iris.
(*e*) Ciliary body.
(*f*) Lens.
(*g*) Cornea.
(*h*) Sclera.

itself to him, after careful thought and prolonged observation, and after having had the opportunity of discussing the question freely with many able and experienced surgeons.

Finally, the upper lid is lifted off the eyeball and brought down to meet the lower one, the patient being at the same time told to look up and to close his eyes. Immediately before doing this, however, we gently stroke the cornea toward the trephine hole with a curette, in order to ascertain whether the eyeball is still soft, and whether the escape of aqueous from the chamber is free.

Both eyes are then closed with aseptic pads and a bandage.

Instillation of Drops.—Our rule is to avoid all instillation immediately after operation, unless the pupil shows a tendency towards upward displacement, in which case eserine drops (grs. 4 ad. oz. 1) are instilled. On the third day, provided that the tension is down, we drop in a solution of atropin (grs. 4 ad. oz. 1) unless the pupil is already widely dilated and active. Our reason for this latter instillation is that we find in congestive cases a strong tendency to the formation of posterior synechiæ; the quiet iritis which leads to this exudation gives no other evidence of its occurrence, and must therefore be constantly guarded against.

In conclusion it may be permissible to repeat that the operation which the writer has practised and which he has endeavoured to introduce to the notice of the profession, is that of *simple* sclero-corneal trephining. The motive is to reach, tap, and sub-conjunctivally drain the anterior chamber, with a minimum of injury to the structures of the eyeball. To this end the junction of the cornea and sclera is trephined as far forwards as possible, the ciliary body is avoided, the chamber is entered directly by the trephine, and the iris is only dealt with in order to obviate any tendency it might otherwise have to block the trephine hole, and so to interfere with filtration. The cardinal rules are few and short, viz.:—(1) dissect the

conjunctivo-corneal flap as far forwards as possible, splitting the cornea for the purpose; (2) utilise every fraction of a millimetre of the space so gained and apply the trephine as far forwards as possible, consistent with the avoidance of injury to the flap, and (3) use a sharp trephine.

CHAPTER VI.

MODIFICATIONS OF OPERATIVE TECHNIQUE SUGGESTED BY OTHER SURGEONS.

The object of the present chapter is to review the various modifications that have been introduced into the technique of the operation of trephining by other surgeons, leaving the reader to estimate the relative value of each for himself.

Modified Corneal Trephines, and the methods of using them.—The original Bowman trephine was an extremely crude instrument. It was difficult to obtain a grip of, and it was consequently very unsatisfactory to work with. In *The Ophthalmoscope* of June, 1910, Sydney Stephenson presented an instrument, devised by himself and made by Weiss & Son, which he described as a modification of Argyll Robertson's handle-trephine. The instrument is made from

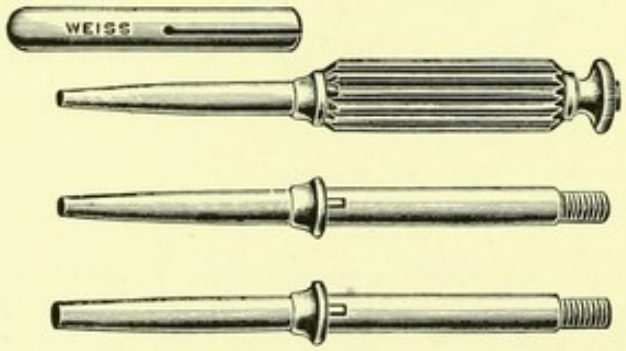

FIG. 21.—Sydney Stephenson's trephine.

solid steel and drilled. The handle is fixed by a nut which screws on the proximal end and several blades can be obtained with each handle. Each blade is furnished with a cap for protection (Fig. 21).

Maddox has abandoned his early trephine with a tubular guide for "one with a dress-coat guard having a rounded knob at the tip." He writes in a personal communication "this "seems to me a desirable thing for beginners, since it gives "them confidence that they cannot go plump through against "the edge of the lens or the suspensory ligament. It is "certainly better than any annular stop, since it does not "touch the conjunctiva or interfere with the setting of the "trephine as far forward on the eye as you teach. Moreover, "by noticing the gap between it and the sclera, the beginner

" knows how deep he is getting, and is more likely to make a " door-shaped disc with the hinge behind, if he bears forward " well."

Gray Clegg, who has trephined upwards of 110 cases since 1910, has kindly furnished an account of his *technique*, which closely resembles that described in Chapter V, except that he uses curved blunt-pointed scissors in fashioning the conjunctival flap. He has been using a 1·5 mm. trephine for the last 18 months, " but sees the advantage of the 2 mm. trephine, in " that iris can be easily dealt with in a hole of that diameter, " and agrees that when the anterior two-thirds is cut through " by the trephine, the whole of the disc need not be taken " away; there is thus left practically a 1·5 mm. hole in the " antero-posterior direction, and a 2 mm. in the lateral. Thus " the advantage of the 2 mm. hole for the iris is combined " with the smaller opening." He adds, " I consider it better " to do a peripheral iridectomy, but it is not essential, as " several of my cases prove."

Dr. George Young, of New York, writing in the *Ophthalmic Record* for September, 1910, described his own trephine and his method of using it in the following words: " The trephine I now use can easily be obtained, as it is merely one part of the instrument made for me by Hardy & Co., with the superfluous parts eliminated. It consists, as shown in Fig. 22A, of a tubular knife with a very keen edge that cuts the prescribed hole of 2 mm. in diameter. The bevel which produces the cutting edge is exactly 1 mm. long, and a sliding collar which

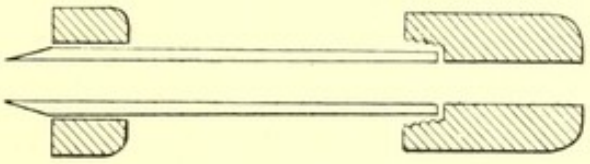

FIG. 22A.—George Young's Trephine.

hugs the knife closely can be moved with the finger nail and a sliding (not rotary) motion. It is easy to place the collar just at the beginning of the bevel, so the trephine will cut 1 mm. deep, and can cut no deeper. It is safe to start this way, although the sclera is rather less than 1 mm. at the point usually chosen for trephining, at the limbus. It is not possible to wound the ciliary body, which is soft and yields before the cutting edge. A short screw thread at the other end of the knife takes a small perforated nut which acts as an excellent handle. Of course, the instrument can be made any length to suit the operator. I like a short one, and my own measures 35 mm., nut and all (Fig. 22A)."

"I now operate in the following manner:—After the conjunctival flap is cut and laid back over the cornea, a silk stitch is passed through the episcleral tissue just at the point which is to be the centre of the disc to be removed, *i.e.*, 1 mm. from the limbus. This needs no further comment, Fig. 22B will show what I mean. The step is easy. We are all doing it in advancement operations. The only point to observe is, not to include more tissue in the stitch than can be comfortably surrounded by the calibre of the trephine. The needle is now removed from the thread, the two ends of which are twisted together and threaded through the trephine from the cutting edge toward the nut. The threads are put on the stretch with one hand and the trephine put into

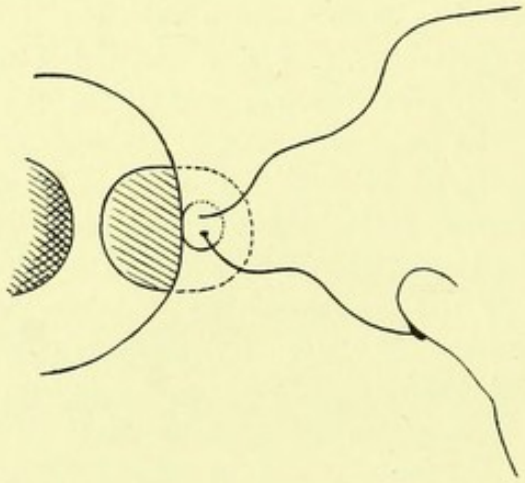

FIG. 22B.

action with the other. While cutting, the thread not only fixes the eyeball, but pulls the sclera, where it is to be cut, well up against the cutting edge of the trephine, and affords a most excellent way of cutting keenly against a firm base. Furthermore, the eyeball is not indented or squashed; on the contrary, all pressure is taken off it, and the collar makes it absolutely impossible for the trephine to penetrate the ciliary body. It is quite delightful to see how every fibre of sclera, tissue is severed cleanly and completely, so that as soon as this happens, the disc comes away at the end of the thread, like a cork out of a bottle, right through the trephine."

"For keeping the edge of the knife keen I use a horsehide strop, perfectly cylindrical, which fits the trephine rather tightly, bevelled to a rat tail at one end so it can be threaded easily into the trephine from the nut towards the cutting edge. It is pulled right through, and repeating this two or three times, will keep the edge keen as a razor. The strop is impregnated with instrument paste. I had to make my own strop, and hope

others will have better luck in getting one made to order than I did! For cleaning, I use ordinary pipe cleaners. They can be dipped in olive oil to remove any paste adhering to the inside of the tube, or in water, to swab away any débris of tissue or blood after trephining; to dry the inside, it is quite sufficient to dip a pipe cleaner in ether, and pass it through several times, when the knife will be ready for the next sterilization. It is best to have several knives on hand, as they have to be reset after some use, and that is best left to the instrument maker."

The one objection to Dr. Young's otherwise attractive *technique*, is the difficulty of keeping the cutting edge of the trephine sterile, whilst passing the thread through the lumen of the instrument. Possibly this difficulty is not insuperable.

Subsequently to writing as above, Dr. Young has published a modification* of his method. With the idea of imitating a free sclerotomy he "removes two discs of sclera sufficiently far from the limbus to avoid the anterior chamber." Our views on this subject have been so fully stated throughout the book that it is needless to say more than that we consider it a retrograde step.

McReynolds has suggested an allied *technique* to be substituted for trephining, should a sharp trephine blade be not available.—"Prepare a flap, according to Elliot; take very fine sharp full curved needle, carrying black silk thread; introduce it through the sclera 2 mm. from the cornea, carrying the point forward to the anterior chamber, from the angle of which the needle should now immediately emerge through the periphery of the cornea; this enables you to securely grasp 2 mm. of sclera in the loop of your thread, which can now be held gently taut with the left hand; with gentle strokes of a small knife mark out a semi-circular incision just enclosing on the outer side the small portion of sclera in the grasp of the thread: as the incision passes through the thickness of the sclera the flap thus formed will be drawn towards the cornea by the thread, and the scleral flap may be thus extended by the knife until the anterior chamber is opened at its periphery, when the sclero-corneal flap may be excised as far forward as desired, etc." The author found this suggestion most valuable on one occasion in the thin buphthalmic eye of a child, into which the trephine had entered without cutting out a sufficient portion of the disc.

Mr. Basil Lang, who came out to work with the author in Madras, devised a trephine which consists of a handle, a blade, and a corrugated nut. The last named enables the blade to be fixed firmly in the handle, whose expanded upper surface is

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* *The Ophthalmoscope*, May, 1912.

concave for the reception of the index finger during trephining. This finger supplies the downward pressure, while the middle finger and thumb seizing the corrugated nut furnish the rotatory motion. The idea is distinctly ingenious, and if the

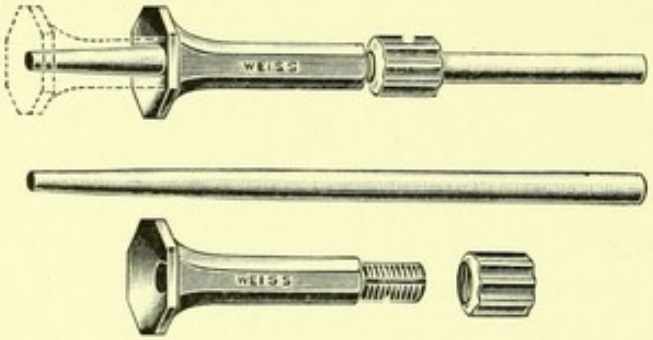

FIG. 23.—Lang's Trephine.

The solid part of the upper figure is the instrument ready for use. The blade can be pushed out to suit the operator. The skeleton outline represents the blade drawn into the handle for protection during boiling. The middle figure is the steel tube, and the two lower figures are the handle and its nut, which clamps the blade and holds it firm.

FIG. 24.—Desmarres' secondary cataract knife, modified by Lang for splitting the cornea.

projecting portion of the blade were shortened to half its present length, the instrument might easily become very popular (Fig. 23). We understand that Lang has adopted this suggestion. Anderson's trephine resembles Lang's.

All the various hand-worked trephines before the profession appeared to have the following imperfections: (1) the distance from the handle to the cutting edge, was, excepting in Dr. Young's instrument, too long, making the instrument difficult to hold steady; (2) the handle did not provide a good grip; and (3) the blades were expensive and rather difficult to get well sharpened.

The author's trephine (Fig. 25) represents an effort to modify Sydney Stephenson's instrument on the lines above indicated. The new features presented are as follows:—

(1) **The Shape of the Handle** (A). In order to give the surgeon a good grip and to prevent his fingers from constantly slipping down as he presses, (i) the handle is made conical with the apex of the blunt cone upwards, (ii) the fluting is spiral in arrangement, and (iii) the edges of the fluting are serrated at right angles to its length.

(2) **The Nature of the Blades** (B). These are made so that they can be used and thrown away as soon as they

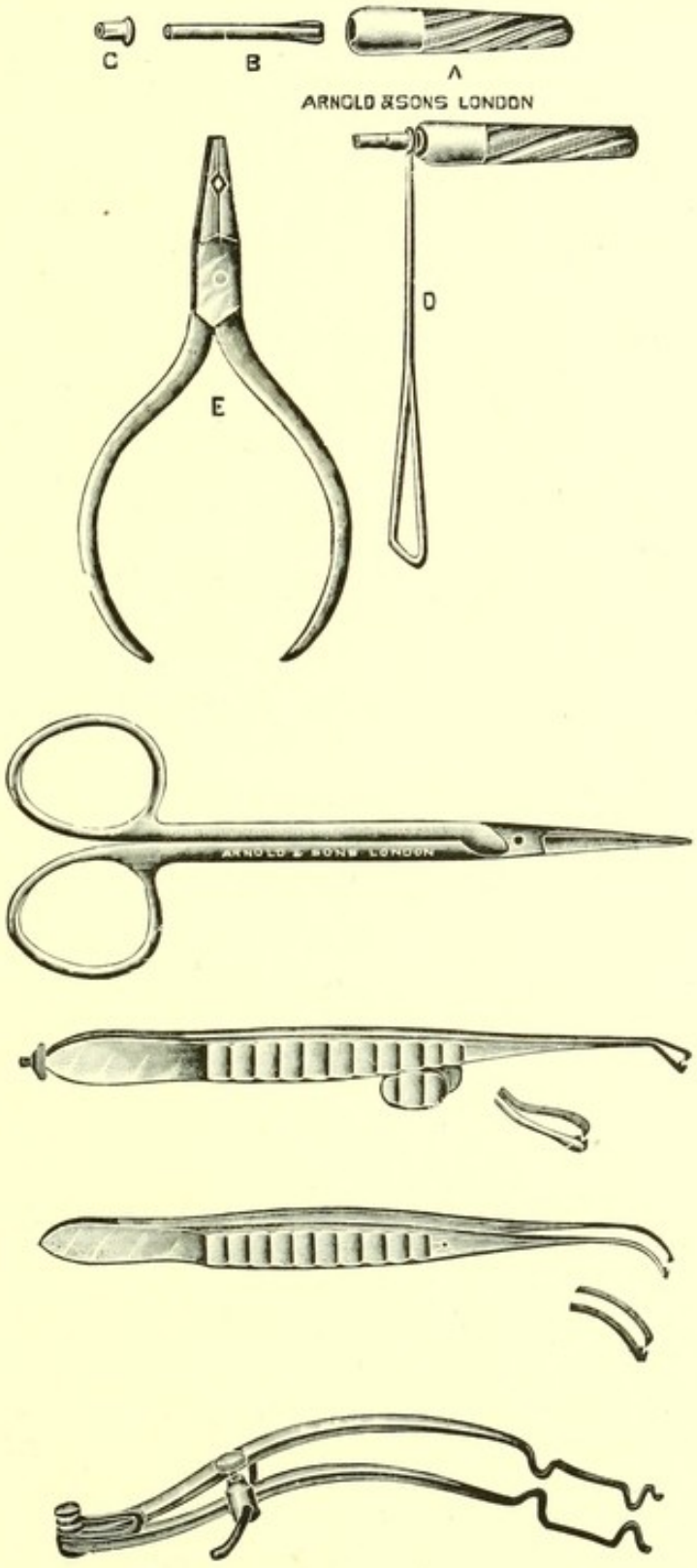

FIG. 25.

become blunt. They are manufactured from solid drawn steel tubing; one end of each blade is divided into three parts, and opened to form a spring—this when inserted into the handle

holds the trephine firmly—the other end forms the cutting blade, and the edge is brought up sharp *from the inside*. This enables the operator to cut a hole the exact size of the trephine.

The Method of fitting the Blades. A small pair of pincers (E) is supplied, with which the blade can be easily fitted into or removed from the handle. This should always be done at the time of operating. The blades must never be left in after use. The handle is hollowed throughout so that it can be easily and quickly cleaned and dried after use by means of a pipe cleaner (the best form being the Metropolitan pipe cleaner made in the United States and sold by all tobacconists).

The bore of the proximal portion of the hollow is slightly less than that of the distal portion. This, whilst enabling the handle to be cleaned, at the same time prevents the blades from passing up more than the correct distance.

(4) A stop (C), which can be fitted to any of the blades, has, by special request of other surgeons been supplied. The author does not recommend its use.

(5, **A small handle is provided** (D) with a loop or hook at the end, through which the blades can be passed. This enables an operator to keep the cutting edge of his blade in one position during the operation, and was intended to be an improvement on the method of holding the blade with forceps. The latter is however much to be preferred.

The whole instrument is supplied in a small case by Messrs. Arnold & Sons, of Giltspur Street, E.C., to whom the author is much indebted for the assistance they have given him in working out the details of the instrument.

The remaining instruments shown in Figure 25, are supplied in a case complete. This was done at the request of one of the leading English surgeons.

More recently, Messrs. Weiss have made a handle, which presents some advantages. It weighs 9·7 grammes, and takes tubular blades of any diameter from 1 mm. to 3 mm.; it consists of three parts, *viz.*, (1) an outer sleeve or casing of aluminium, tapering toward the proximal end, fluted spirally and grooved laterally, (2) a spring holder cut in four sections from solid steel somewhat on the principle of a lathe chuck, and (3) a screw with a milled head. When this screw is loosened, and the chuck is pushed forward, the sections of the latter open, and the trephine blade can be inserted between them; when it is worked home, on the other hand, it draws the chuck back into its sleeve, and the blade is then gripped firmly and in the middle line. A pin and groove prevent the chuck from rotating within the sleeve. The use of this handle

enables a surgeon to set his trephine blade as long or as short as he wishes to, and also to use any size of blade from the smallest to the largest. Before putting the instrument away after use, it is necessary to take the handle to pieces, to dry each part, and then to vaseline the screw and the outer surface of the chuck. If this be done, the instrument will always be found in working order when needed.

Our description would be incomplete without a reference to some of the models of trephines which have been quite recently brought before the profession. The wealth of ingenuity which surgeons have displayed is strong evidence of the popularity enjoyed by the operation of sclero-corneal trephining. Cross's instrument* consists of "a two-inch handle of metal, pivoted at the top of which there is a small, freely revolving finger-rest in the form of a shallow saucer-like disc to permit freedom of rotation and allow perfect control of the pressure and location of the instrument. Immediately below this the handle takes the form of a cone with apex upward. This conical portion can be held with ease, owing to the presence of three knurled rings upon its surface. An expansion chuck at the lower end of the instrument is designed to lock or release the blade or trephine on a half-turn of the handle, the chuck allowing the use of blades of various sizes. This trephine can be revolved from above by means of the thumb and forefinger placed upon the cone, or it can be operated from the side by placing the forefinger upon the loose top and rotating the barrel with the thumb and second finger. By either method the operator has complete control of pressure and position as well as an unobstructed view of the field of operation."

Leigh's trephine* has "the handle both corrugated and cross-hatched to prevent any possible slipping of the grip. The handle is bulbous at each end and contracted in the middle. It can thus be manipulated between the thumb and forefinger, like the Elliot instrument, without the danger of the fingers working off at the top. The trephine blade is attached to the handle by a solid shaft, it has a 2 mm. diameter, is about 5 mm. long, and has an ample perforation to facilitate cleansing. It is a simple little instrument that costs but one dollar, and because of its cheapness can be thrown away when dull."

Kuhnt has devised a trephine, whose tubular blade carries a solid style, which can be set at any desired depth from the cutting edge ; he places this guard at a distance corresponding

* Both were shown on December 18th, 1913, before the Section on Ophthalmology of the College of Physicians of Philadelphia.

with the thickness of the sclera. The *rationale* of this procedure is not obvious. Brown Pusey " felt the need of a shoulder attachment as a factor of safety," but found it in the way. He writes:—" To avoid these troubles (troubles at least for the beginner in this very promising operation), I have had made a trephine with a barrel of even diameter for 0·75 mm. from the cutting edge, then a slight flare, as shown in the accompanying picture. This makes a very safe and very efficient instrument." (Fig. 26.)

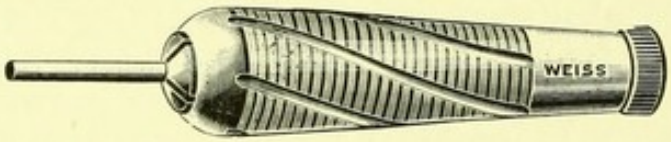

FIG. 25A.—Elliot's Trephine.

FIG. 26.—Pusey's Sclero-corneal Trephine.

A number of surgeons have had trephines made for them with a variety of devices to keep the blade to one point during the actual cutting of the hole. Some have had a central pin provided, similar to that on the cranial trephines; others have introduced a hook which passes down the blade, and not only seizes the sclera, but also draws it up as the blade sinks into the tissue, thus affording counter-pressure; others again (amongst them Freeland Fergus) have used a wavy or toothed blade. The author is not in favour of any of these devices. To begin with they are in his opinion unnecessary. If one works with a sharp trephine it is easy to make the blade cut a groove with the very first rotation; and sharp blades can now be had from any of the first-class instrument makers; *very great trouble has recently been taken to ensure this.* Furthermore, these devices make sterilisation more difficult, and in the case of the toothed blades, the instrument makers assert that they are difficult to sharpen and unsatisfactory, even when much trouble has been taken over them.

Rollet and Gradle have each brought out a mechanical trephine, which is held in one hand whilst the other rotates the blade by means of a special handle, and a system of cogwheels. These are ingenious, but they keep both the surgeon's hands employed, which is a decided disadvantage.

Some surgeons prefer to use a von Hippel's clock-work trephine (Fig. 27), of which Dr. Nimmo Walker spoke as follows, in a paper read before the Liverpool Medical Institution, on April 20th, 1911 :—

" Experience of these difficulties in my earlier cases led me to try a mechanical trephine. To this instrument, which was devised originally by von Hippel for transplantation of the cornea, I had fitted very small blades, first 1 mm. then 1.5 mm. in diameter ; I am now having a 2 mm. blade fitted, and the shaft shortened so that the operator can steady his hand by resting his little finger on the patient's forehead. This mechanical trephine has proved very satisfactory. Owing to the hand having to impart only one movement, that of pressure, the trephine can be kept level and the disc cleanly cut. The rapid rotation enables the edge to cut easily and with little pressure, so that the danger of too sudden entry into the anterior chamber is lessened. It also enables the trephine

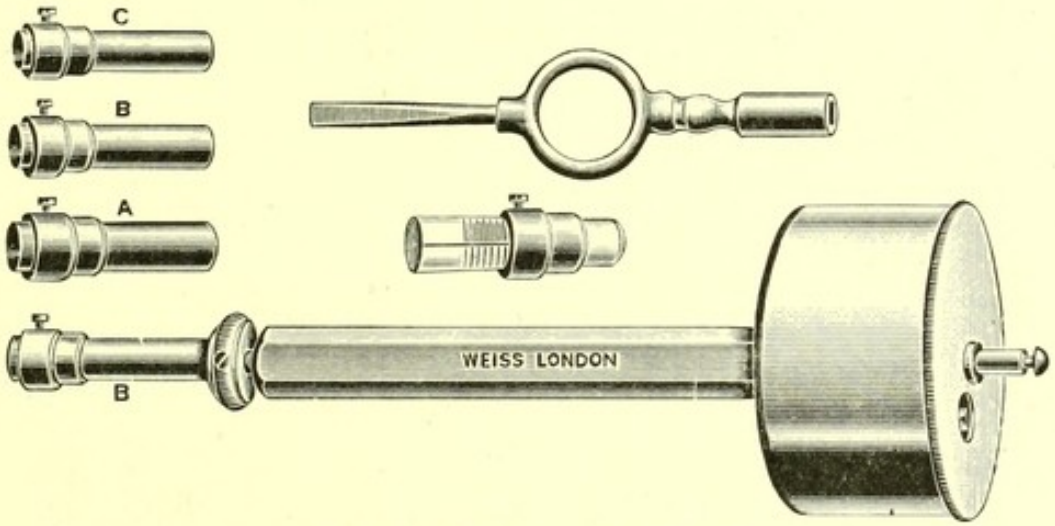

FIG. 27.—von Hippel's Trephine.

to work on soft tissues, and permits of another small, but to my mind important, modification of the operation. Elliot makes the conjunctival flap with scissors and endeavours to get as close to the limbus as possible by dissecting with the points directed towards the plane of the posterior pole of the lens ; in this way the limbus is undermined and a deep groove formed. He insists on the importance of the making of this overhung groove in order that the anterior chamber may be entered with certainty. I have found it advantageous, after dissecting as far as possible with the scissors, to continue the dissection with a fine knife even further, and to go right into the cornea, so that the flap has its base on the superficial layers of the cornea : finally, if the tension is high, I pass the tip of the knife into

the anterior chamber and allow the aqueous to escape very slowly until the tension is considerably reduced. This tapping removes the chief source of danger and of pain, the sudden alteration of tension, and diminishes the risk of intra-ocular hæmorrhage and of prolapse and injury of the iris, but it makes a clean trephining with the hand trephine more difficult, owing to the yielding of the tissues: the mechanical trephine, however, with its evenly and rapidly rotating blade, has no difficulty in cutting out a clean disc."

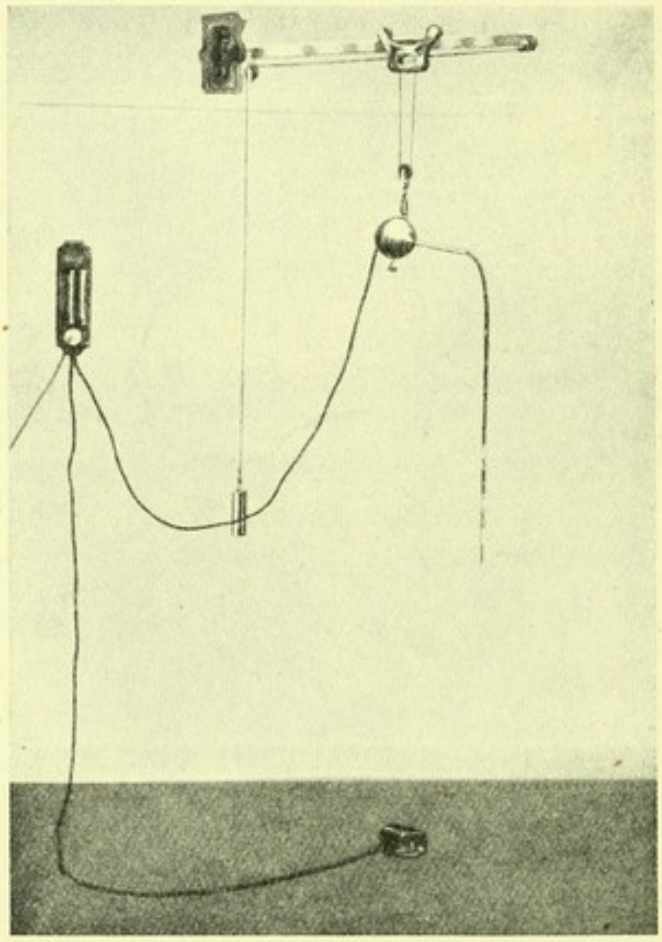

FIG. 28.—Vogt's Motor Trephine, showing wall-resistance, foot-control, suspension-bar, etc.

FIG. 29.—Taylor's Motor Trephine.

Our experience in Madras of the von Hippel's trephine was not altogether satisfactory. The instrument is open to the objections that it is expensive and hard to sterilize thoroughly. On the other hand after nearly four years' experience, Nimmo Walker still continues to use it and to get excellent results with it. Nor is he alone in his preference, for a number of very able surgeons, and amongst others von Roemer and Webster Fox, are advocates of von Hippel's instrument, whilst an influential and growing body of workers prefer a trephine

driven by a dental engine, or by some similar source of power, to the hand-worked instrument. One of the pioneers of this movement, if not the very first, was Taylor, of Brighton, who has provided a suspension type cable engine (Fig. 29), which is hung from the ceiling by a wire and chain device, and which actuates specially fitted trephine blades; he claims that this makes trephining safer and easier. Vogt, of Aarau (Fig. 28), considers that certain risks are inseparable from the use of the hand-worked trephine, and that such risks are enhanced if the chamber is shallow, or if a posterior sclerotomy has been done as a preliminary step; he therefore uses an "electro motor driven trephine, fitted with a fixed stop, which does not completely encircle the blade, and so does not interfere with the surgeon's field of view." He urges that the hole is clean-cut, and that no pressure need be made in the axis of the instrument, since the rapid revolution of the blade does all that is necessary. Reber, of Philadelphia,* "has had made some straight tubular trephines that are easily slipped into the catch of the ordinary dental engine with its flexible shaft; these have served the purpose beautifully, the only objection being that the engine cannot be carried in the bag to the house or hospital. He is having a small flexible shaft attached to an 8 oz. motor, that can be driven by an ordinary dry battery." Stuart has also recommended a similar device.

It is the author's wish to put before his readers the methods and opinions of as many able surgeons as possible, and then to leave each operator to make his choice, guided by the exigencies of his own situation, and by his personal predilections. He would only say that in favour of the hand trephine are cheapness, ease of transportation, the fact that it can be worked anywhere, and the safety that manual control confers in the use of any instrument; whilst against it can be urged that, if at all blunt, it may not cut out a sufficient circle of disc, and so may land the operator in a form of trouble which the mechanical trephine certainly avoids. The argument that the hand trephine presses on the ciliary body and thereby causes pain is refuted by our experience, and we consider there is nothing in it; a sharp trephine skilfully handled appears to give no pain whatever, though no doubt, suffering might be inflicted and danger incurred by a surgeon with a heavy hand. The advocates of mechanical trephining, men whose opinions must be listened to with respect, say that they can control their engine so perfectly as to make the rapidly driven trephine quite safe. The reader

*_Ophthalmic Record_, Vol. XXIII, pp. 22 and 23.

must decide his own course. Our personal preference is for the simplest instruments in skilled hands, but it is probable that not a few surgeons will disagree with the grounds for our choice.

FIG. 30.
Sclerectome, ready for use.

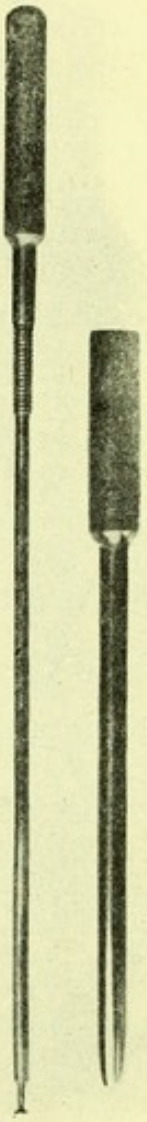

FIG. 31.
Sclerectome with inner rod removed to show construction of instrument.

In *The Ophthalmoscope* for March, 1910, Dr. Verhoeff described an interesting and ingenious instrument which he has called a sclerectome. He wrote: —

"The illustrations will no doubt make the construction of the instrument sufficiently clear. It consists of two parts, an inner rod, and an outer tube, which has at one end a sharp cutting

edge like a trephine. The inside diameter of the cutting end of the tube is 1·4 millimetres. The inner rod fits snugly into the outer tube, especially near its cutting end. Projecting from this rod is a thinner rod about 2 millimetres long, which carries at its end a button with a rounded base and a flat face. The button exactly fits into the outer tube when drawn up into it. The upper part of the main rod screws into the upper part of the outer tube, so that by holding the handle of the rod with one hand, and turning the tube with the other, the cutting edge of the tube is forced over the button. The instrument, it will be seen, combines the actions of a punch and a trephine" (Figs. 30 and 31).

The object aimed at was to obtain a cleaner opening in the sclera, than could, in Dr. Verhoeff's opinion, be cut with a trephine, and thus to avoid the closing of the opening by tissue proliferation. We purchased a sclerectome from Dr. Verhoeff's manufacturer, and it was given a good trial by two of us in the Madras Eye Hospital. The holes we were able to cut in the sclera with the aid of the sclerectome contrasted very unfavourably with those which we could obtain as a routine matter with a hand trephine, and we gave the instrument up in consequence. It is possible that the manufacturer failed to send us a first-rate instrument; but in any case it would appear to be difficult to keep the sclerectome sharp, and the not inconsiderable price of the instrument will militate against its being brought into general use. It is also more difficult to sterilise than a simple trephine. Under the circumstances, it is not surprising that few, if any, surgeons have taken it up.

Mr. Cruise demonstrated to the author an ingenious little instrument which he used for guiding his blade, and at the same time holding the flap out of the way during trephining. It was practically one blade of a Muller's retractor, mounted on a handle, and with the hooks set a few millimetres apart. It was said to prove very useful in practice, and it had every appearance of justifying the claim. It is made by Messrs. Weiss, of Oxford Street, and is figured in their catalogue.

Mayou and Zorab, in the pages of *The Ophthalmoscope* for May, 1912, independently suggested the drainage of the aqueous fluid by means of a silk thread introduced through a small scleral incision. One end of the thread lies in the chamber, and the other in the sub-conjunctival tissue where it is covered by a large flap. The operation is clearly a modification of that dealt with in this work, since the underlying principle is the sub-conjunctival draining of the anterior

chamber. It was with the utmost diffidence that one offered the criticism that the introduction of a foreign body into the eye was a procedure which one would hesitate to adopt, whilst any other course was open. The difficulty of efficiently sterilising silk and of keeping it sterile during introduction is enough to

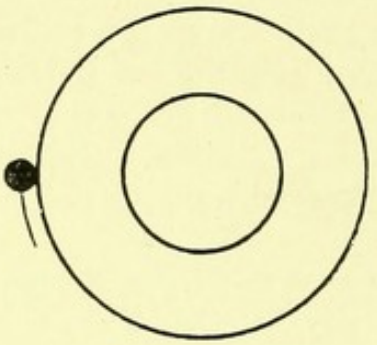

FIG. 34.
Fistula completed. Button hole in iris not shown.

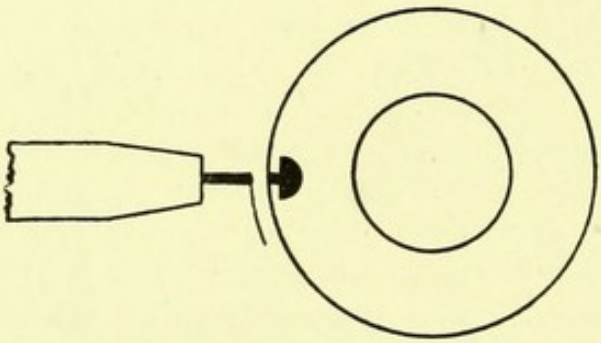

FIG. 33.
Sclerectome in position ready to cut.

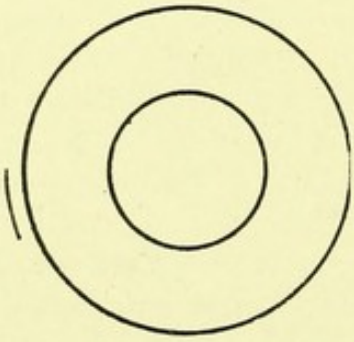

FIG. 32.
Position of incision. Conjunctival flap not shown.

make one hesitate. It has been said that you may judge a surgeon by the boldness with which he buries silk; when, however, the sight of one eye, and possibly of two, may hang on the least fault in the operative *technique*, it becomes an open question whether boldness is justifiable.

Recently Mayou* has written, " I have taken to trephining, and I am inclined to think, that on the whole, the latter will probably give better final results than the thread operation." Zorab* has published his results, which appear to the writer to justify the fears which a theoretical consideration of the method seemed calculated to inspire.

Methods of splitting the cornea.—The original instrument employed in Madras for this purpose, was a pair of straight, sharp-pointed iridectomy scissors, already in the hand for the purpose of shaping the flap; in most cases these can hardly be improved upon. Gray Clegg prefers to use sharp-pointed scissors curved on the flat. Lang dissects up the conjunctiva by the aid of a special knife (Fig. 24), whilst Hingston introduced into the Madras Hospital the use of a Bowman's needle, and we employ it whenever any difficulty is found in detaching the conjunctival layer from the subjacent cornea.

Wallis quotes the preference of some of the Moorfields' staff for the routine use of a Desmarres' knife when splitting the cornea, and considers that the clean cut made favours the maintenance of filtration over the area thus laid open. This is a view with which the author does not agree, as he has already said. McReynolds has devised two ingenious instruments,

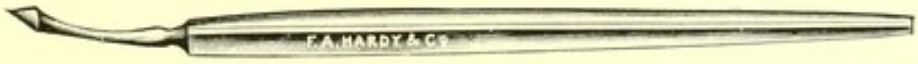

Fig. 35. McReynolds' Corneal Wedge.

Fig. 36. McReynolds' Conjunctival Forceps.

viz., a wedge for splitting the cornea (Fig. 35), and a pair of special forceps (Fig. 36) for holding the flap during the operation. We have used the former with great satisfaction, but not the latter, as we prefer to leave the flap alone as much

* *The Ophthalmoscope*, Vol XI., pp. 211 and 258.

as possible. Those who like to adopt McReynolds' *technique* will doubtless find his forceps admirably adapted for their purpose

Modifications of the Flap suggested by other surgeons.—von Mende, Dupuy Dutemps, Webster Fox, Hill Griffith, and others have suggested modifications of the flap used. Without entering into detail as to the exact *technique* used by each of these surgeons, it will suffice to point out one respect in which every one of the methods so advocated differs from that which the author has from the first recommended, and which he still thinks to be the best. A very important point in our *technique* is that *we place the trephine hole as far as possible from the breach in the conjunctival surface.* In order to do so, we raise a flap from above and dissect it down to the cornea; consequently the hole is separated from the conjunctival wound by the whole breadth of an extensive flap. On the other hand, the outstanding feature common to all the modifications we are discussing, is that in every case the incision which fashions the flap separates the conjunctiva from its corneal attachment directly over the wound in the sclero-cornea, a wound, be it remembered, which leads into the interior of the eye. It is obvious that in the latter case the risks (1) of septic infection, and (2) of the downgrowth of epithelium through the trephine hole must be greatly enhanced. Nor is this all; the likelihood of early union of the flap to the deeper parts, and therefore of prompt re-establishment of the anterior chamber is obviously increased when there is a broad flap between the point of exit of the fluid from the interior of the eye, and the edge of the flap as compared to the condition in which that edge lies close to if not actually over the hole. The danger of the "sliding flap" slipping down and uncovering the hole has been denied by some of its advocates, but it is to be remembered that the number of cases so far operated on, according to this *technique*, is still limited. Should such an accident happen when we are operating by the author's method, it is an easy matter to insert a stitch, and so at once safely and certainly to draw the flap into place, a remedy which cannot so easily, if it can at all, be applied when using one of the modified methods.

A last point of great importance remains to be considered. With the author's flap, the corneal filtration-area extends anteriorly well beyond the trephine hole, and there is a distinct area of separated and filtering corneal flap on the pupillary side of that hole. The photographs in Chapter XI show this very clearly, and the matter is dealt with more at length in Chapter XV. Suffice it here to say that the flap made by

splitting the cornea along its planes of cleavage and by flushing those planes at once and permanently with isotonic asceptic aqueous fluid, does not tend to cicatrise down to the underlying sclera. Very different are the conditions of the modified operation. Even if, as in von Mende's *technique*, the surface of the cornea is freshened to promote adhesion between it and the under surface of the flap, it is obvious that the latter must heal down to the former, right up to the anterior (or pupillary) edge of the trephine hole. One cannot but look with apprehension on any method which necessarily introduces plastic tissue up to the very margin of the hole we wish to keep patent for drainage purposes.

In conclusion, it may once again be emphatically stated that the difficulties of splitting the cornea, have been very greatly over-estimated, as the author has had the opportunity of showing in many clinics both in Europe and America, as well as in the East. There is no need to resort to modifications of the flap, on the ground that the *technique* here advocated is too difficult. It is nothing of the kind, and is within the reach of any ophthalmic surgeon of ordinary manipulative dexterity.

On the question of the Advisability of including an Iridectomy as a Routine Step in the Operation. It will be remembered that in his earliest writing on the subject, the author left the above question open. Time has, however, defined his opinions, and whilst he clearly recognises, as the result of experience, that one can get as good a result without an iridectomy as with it, provided always that no prolapse of iris takes place into the trephine hole, he has learnt that the latter danger is one we should not run a risk of encountering, so long as we can by any means avoid it. Hence, he has for a long time past advocated and practised the routine performance of an iridectomy, whenever possible. The pendulum of surgical opinion has swung in the same direction. Very few surgeons can now be found who practise or recommend the omission of an iridectomy, or the making of a radial incision into the prolapsing bead of iris, as do Nimmo Walker and Schenck. A few, amongst whom are MacCallan, of Egypt, and Hill Griffith, of Manchester, prefer to make a complete iridectomy. The former's comment on this is "no iritis then follows, and no atropinisation is necessary." This, however, is not quite in accordance with the author's experience; he wishes it were so. The advocates of a button-hole peripheral iridectomy are very many. Schnaudigel says that in many cases the iris need not be touched, and that at any rate the sphincter should be left, so as not to interfere with the induction of full myosis, when desired. Gray Clegg who has been trephining for four

years, and who has performed the operation over 110 times, writes:* "I consider it better to do a peripheral iridectomy, but it is not essential, as several of my cases prove." Nimmo Walker, who has likewise had four years of experience with the operation, writes:* At first I regarded prolapse of the iris at the time of operation as unfortunate, . . .; now I endeavour to obtain it by telling the patient to shut his mouth and squeeze gently; as soon as the bead of iris presents, I incise it with a pair of sharp-pointed scissors, etc." McReynolds, and a number of other American surgeons are in favour of the peripheral button-hole iridectomy, and the author believes that it will in the near future gather to itself many more adherents.

*Personal communications.

Chapter VII.

COMPLICATIONS WHICH MAY BE MET WITH DURING THE OPERATION OF SCLERO-CORNEAL TREPHINING.

Button-holing of, or injury to, the flap.—It is most essential that the flap should be of sufficient extent and that it should be dealt with as gently as possible. The importance of the former point is obvious, and the matter has already been discussed. With regard to the latter condition, we desire to lay stress on the advisability of avoiding all unnecessary traction by means of forceps on the delicate conjunctival structure. The flap should never be seized in the grip of these instruments, or there will be a grave risk that it will become ragged, torn and useless for our purpose. We have seen this accident happen on several occasions to learners in Madras. The area on which we propose to trephine can be efficiently laid bare by gently drawing down the detached conjunctival apron by the aid of the closed forceps or of any similar blunt instrument. A well-trained assistant will deal with the flap, and thus leave the surgeon both hands free for the various steps of the operation. During the actual application of the trephine, a skilful operator, who is aware of the danger, should rarely if ever, button-hole the base of his flap. A much greater risk arises after the trephine has been laid aside, and whilst the disc is being separated by means of scissors from its hinged attachment to the sclera, especially if the hinge has been left on the corneal side. The danger of perforating the flap is considerably accentuated by a sudden movement of the eye during the performance of this delicate manœuvre. The patient should be warned to lie quiet, and to look down ; and the surgeon should ask his assistant to pull the flap well down out of his way, and should make a point of seeing exactly what he is doing. In dealing with intractable patients it is advisable to fix the eye by means of forceps, or of a silk thread run round the lower half of the corneal circumference close to the limbus. The two ends of the thread are left long and the eye can be held down by an assistant whose hand is

thus kept well out of the operator's way. (Fig. 37.) This valuable and little-known method of controlling an eye during operation is applicable to many other conditions, *ex. gr.*, to the extraction of a cataract; for it has no tendency to pull open a corneal section in the way that the use of a pair of forceps does.

Sometimes when dealing with the brittle conjunctivæ met with in old people and in eyes which have long been subject to glaucoma, the thread method of control is not practicable, and the following device may then be made use of with considerable advantage both to the operator and to the patient. The superior rectus tendon, which has been partly exposed by

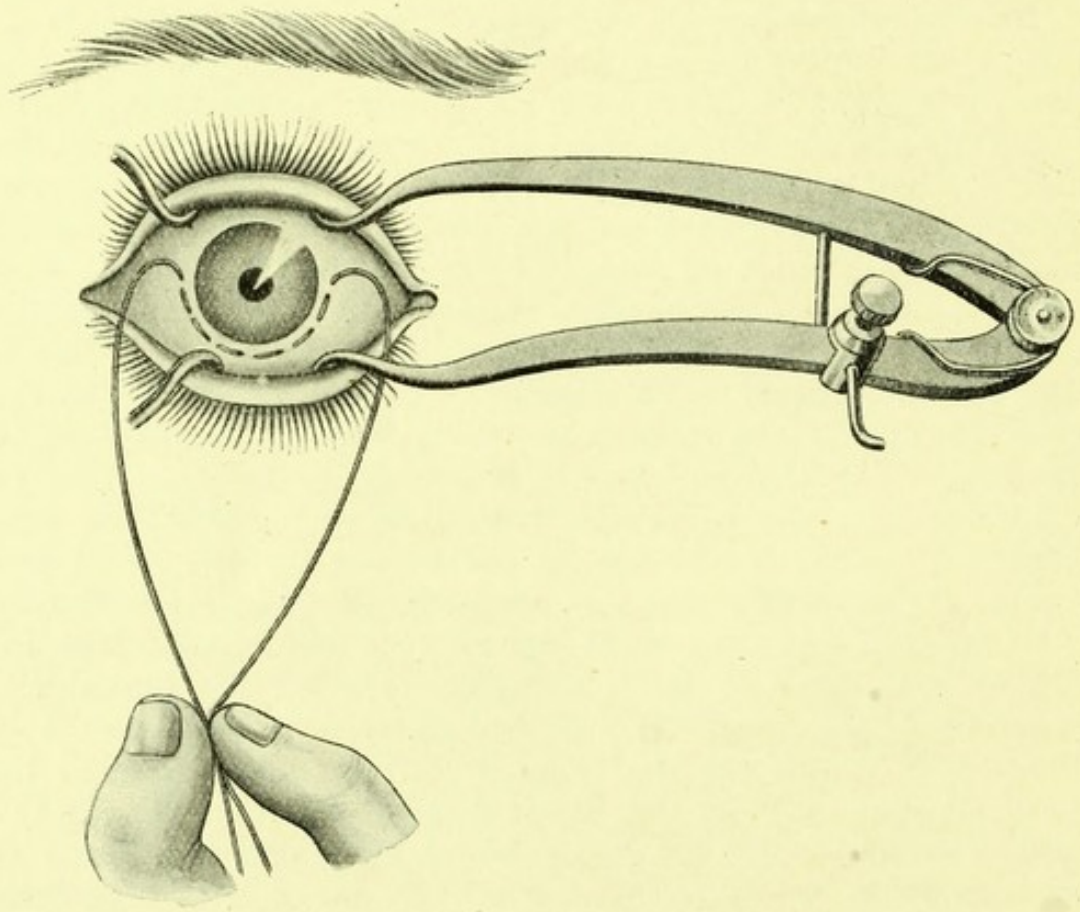

FIG. 37.—Showing the thread, in position for the fixation of an eye, but not yet drawn tight by traction.

the throwing down of the flap, is laid bare and is seized in the grip of a pair of Prince's forceps; the eye can thus be easily held in the desired position, without inconvenience to the operator or danger to the patient. If a general anæsthetic is not being administered it is better to substitute a loop of silk for the forceps. The silk is passed under the tendon, and its two ends are knotted together. Simple traction on the loop pulls the globe down into position.

A small button-hole does not appear to constitute a dangerous complication. We have carefully watched cases in which such an accident has happened and have fortunately found that the opening becomes closed by cicatrisation and that the eventual result seems to be as good as if no such complication had supervened. It is, however, obviously our duty to avoid button-holing whenever we can.

Loss of the Trephined Disc in the Anterior Chamber.—This accident happens in about 1·6 per cent. of cases trephined, and can only occur when the whole circumference of the disc is cut through at one time, or when at the most a very slender hinge is left. It would seem that the risk of dislocating the disc into the chamber is greater when using a 1·5 or a 1 mm. trephine, than when working with a larger instrument. The ultimate cause of the accident, however, is undoubtedly the use of undue force at the conclusion of the trephining. Once the main thickness of the sclera has been cut through, the trephine should be spun rapidly between the fingers with light even strokes; heavy pressure in the direction of the length of the instrument should be carefully avoided. If, at the conclusion of the trephining, the disc cannot be found, we turn back the flap and can then usually see it lying at the upper part of the chamber and close to the hole. We have never found the disc impacted in the hollow of the blade, and have only heard of one single instance of such a thing occurring. Care should now be taken to avoid all drag on the iris during iridectomy: this is a very important point, as any impaction of the iris in the trephine hole at this stage makes the subsequent delivery of the disc very difficult. A gentle stream from a McKeown's irrigator will in most cases quickly wash the missing piece of sclera through the hole to the outside, or at least replace it in such a position that its removal proves quite easy. It will often be found that it still remains hinged at one point. A snip with the scissors divides this attachment. The writer has never yet failed to carry out this manœuvre, nor has he experienced any difficulty in effecting his purpose. Stress is laid on this because of the remarks of a speaker at the International Congress in London (1913), who said: "Col. Elliot advises what to me is an utterly incomprehensible plan of washing it out. When one considers that the disc exactly fits the hole and that washing it out implies the passage of a stream of water downwards through the hole, the process of washing the disc out seems fanciful in the extreme and ideal rather than practical." He then went on to describe his own plan of "coaxing" out the disc by what is, in our opinion, a very dangerous manipulative procedure, and one which on one

occasion took him "*quite half an hour.*" Since the author left India, where he had on a number of occasions demonstrated the washing out of the disc, he has twice (in over 150 cases) had a disc slip into the anterior chamber, *viz.*: once in Chicago when operating before the Clinical Congress of Surgeons of America (November, 1913), and again quite recently in London, with three well-known surgeons present. On both occasions he called attention to the accident, and to the above comments which had been made on his *technique* of washing out the disc, and then proceeded to carry the manœuvre to a successful issue *in a few seconds.* The manipulation resembles that of washing out wax casts from the external ear, with this difference that the little disc readily folds on itself, and so escapes through the aperture without the least difficulty. This is a point our critic had evidently lost sight of.

Among the cases operated on by others the disc was four times lost in the chamber. It remained there in spite of their efforts to remove it, and it was thought better to advise the operators (each of these four cases belonged to a different surgeon) to leave it rather than to persist in instrumentation. We followed these cases very closely; in two of the four the fellow eye had been operated on the same day, thus affording us a normal to judge by. In not one single case was there any evidence of inflammatory reaction. Stress is laid on this because other surgeons have suggested that the dislocation of the disc into the chamber may result in post-operative irido-cyclitis. Our own view is that, provided the disc is aseptic, no such danger need be feared and our clinical results have borne out this opinion. Moreover we have heard from several surgeons, who having acted upon our advice and left the discs *in situ*, found no harm result therefrom.

Loss of Vitreous during Trephining.—If the surgeon is not careful to keep his trephine hole well forward, he will run a distinct risk of encountering vitreous loss. In chronic long-standing cases the ciliary body is drawn forward (Thomson Henderson) and the uveal tissue in the neighbourhood is not infrequently thinned. In addition to this the vitreous is pathologically fluid; and owing to changes in the vessel walls, and to the state of congestion prevailing throughout the vascular system of the eye, and associated with high tension therein, hæmorrhage, or an excessive secretion into the vitreous chamber, is an ever-present danger. We have, therefore to hand, all the elements necessary for the expulsion of vitreous. The surgeon who adopts the operation of "Sclero-Corneal Trephining," which has been advocated

throughout this book, is for obvious anatomical reasons, in a much safer position than one who opens the eye by an incision. Provided he avoids unjustifiable roughness of manipulation, he can only encounter a vitreous escape by way of the anterior chamber. Even in those cases in which the iris is adherent so far forward that the trephine blade perforates that membrane together with the cornea, there is still a large margin for safety afforded by the aqueous which fills the posterior division of the chamber. Granted a ruptured suspensory ligament, or the occurrence of intra-ocular hæmorrhage expressing the hyaloid contents through that membrane thinned and weakened, loss of vitreous will be an imminent event. This combination of circumstances, though not very uncommonly met with in India, must be extremely rare in Europe, where glaucoma patients resort early to a competent surgeon for relief. It is unnecessary to burden the reader with statistics, but it may most positively be stated that vitreous loss is practically unknown in Madras in cases which resort to treatment at any but the late stages.

Intra-ocular Haemorrhage.—The question of a rise of intra-ocular pressure due to hæmorrhage, or to excessive secretion into the vitreous chamber has been alluded to not only in the last paragraph but also incidentally in dealing with the "Technique of the Operation." It was an ever-present danger in the old days when iridectomy held sway as the only operative measure for the relief of high tension; nor did our experience of the methods of sclerectomy advocated by Lagrange and Herbert help to convince us that these operations had done anything to eliminate this danger. Given the conditions we have discussed above, it is probable, if not certain, that the danger of intra-ocular hæmorrhage, or of a sudden excess of secretion will ever dog the footsteps of the glaucoma surgeon. The conclusion that has been borne in upon us after a careful review of those cases in which these complications have occurred during trephining, is that the risk of this accident is a remarkably small one, when all the factors are considered, and when the class of case on which we too often have to operate is borne in mind. This relative safety may probably be ascribed to the following factors :—

(1) when working with a sharp trephine, the eye is subjected to only a very moderate degree of pressure ;

(2) the portion of sclera removed, and the consequent loss of support to the deeper parts, is very small ; and

(3) once the trephining is accomplished and the chamber is opened, the amount of interference with the contents of the eye is minimal.

Granted that it is necessary to remove a piece of sclera in order to establish a filtering scar, it is submitted that no easier, quicker, neater, or gentler method than trephining can well be found.

Superficial haemorrhage which obscures the details of trephining.—In operating on congested eyes, the field is often obscured by the blood poured out. In most cases the hæmorrhage can be kept under control by the instillation of a drop of adrenalin chloride solution, 3 or 4 minutes before the incision is commenced. In any case, the hæmorrhage can be controlled, if need be, by dropping the adrenalin solution on the sclera laid bare by reflection of the flap, and by supplementing this action by local pressure with small mounted cotton-wool swabs soaked in the solution. It has already been stated that in acute congestive cases we do not hesitate to inject a mixture of a solution of cocaine and adrenalin under the conjunctiva before commencing the operation. There is no doubt that in this way a powerful action is obtained, but the method has its drawbacks, one of which is that the flap tends to roll in and is therefore all the better for the insertion of a couple of sutures at the close of the operation, in order to keep it in place. This interferes with the ideal *technique* of a minimum of manipulation, which should be our constant aim.

When the area has been sufficiently cleared of blood to admit of the use of the trephine, the operator should make a point of seeing that on its first application, the cutting edge of the instrument marks out for itself a deep groove in the corneo-scleral tunic of the eye. The reason for this direction is that operative experience shows that in vascular eyes it is the surface layers of the sclera which are most deeply congested; comparatively free hæmorrhage frequently attends the first application of the trephine in these cases. If a deep groove be cut in the sclera before the instrument is lifted, the blade will easily find its way into this when it is again applied, even though the field be obscured by blood; as the surgeon cuts deeper into the tunic of the eye the hæmorrhage frequently becomes less profuse, and often ceases as soon as the tension of the ocular tunic is relieved. The latter action is doubtless due to two factors, *viz.*, (1) the lowering of intra-ocular vascular tension by the free escape of blood from the eyeball during the earlier stages of the operation; and (2) the opening up of the *vasa vorticosa* by the release in the tension of the scleral walls. This slackening of the ocular tunic tends to allow the apertures through which these large veins pass to return to their normal anatomical conditions.

Plugging of the wound by intra-ocular contents.—When the anterior chamber is emptied through the trephine hole, the iris, the ciliary body, the suspensory ligament, the lens, and the vitreous body make a movement forward. Under varying conditions any one of these structures may present in and block up the wound. Such an accident, as has already been pointed out, is more likely to occur when during operation the tension of the eye has been raised by sudden exudation from the ciliary body into the posterior segment of the globe, or by intra-ocular hæmorrhage. Indeed, it may well be doubted whether in the absence of one of these conditions, the trephine hole ever becomes plugged, always provided that the operator does not drag the uveal tissue into the wound whilst performing an iridectomy. The plugging of the trephine hole by uveal tissue is, however, much more likely to occur in those long-standing cases in which beforehand the iris is adherent far forward to the back of the cornea.

To leave the trephine hole blocked with uveal tissue is a misfortune, and will probably entail the failure of the operation. An effort should first be made by the careful use of iris forceps and scissors to clear the obstruction. In doing so, great care should be taken not to drag on the uveal tissue, and to carry the scissor-points right into the wound. When this has been cleared as far as possible, the surgeon takes a narrow spud, the last 4 or 5 millimetres of which are bent at an obtuse angle to the rest of the instrument. This is carefully introduced into the chamber, endeavouring in so doing to push the impacted iris back into position. A gush of aqueous and the simultaneous emptying of the chamber may reveal that our object has been accomplished. If, however, this is not easily effected, and if the tension is still high, it is wiser and safer to abstain from further interference rather than to persist; for, we may easily do more harm than good and may imperil the scanty hope still remaining to our patient. As has previously been stated, our later *technique* has made iris complications very much rarer than they used to be.

After an iridectomy has been performed, we sometimes find a dark bead projecting through the trephine hole. Trans-illumination of this through the pupil by oblique illumination reveals that the obstructing substance is translucent and of a greenish colour; and we then know that we are confronted with a prolapse of the lens or of the vitreous. In either case it is our duty to at once close the eye, for, if the structure has been pushed forward by hæmorrhage, we may find the pressure relieved, and the trouble over within 48 hours, owing to the absorption of the effused blood. If, on the other hand, we are

so unfortunate as to be confronted with a dislocation of the lens as a result of overstretching or rupture of the suspensory ligament, the case can just as well be dealt with at a later stage, when all doubts as to diagnosis have been set at rest. This matter will be discussed in the chapter on "after-treatment." The surgeon may rest assured that the conditions that we have been dealing with will never arise to trouble him in any early or comparatively early case. They are limited entirely to patients who have long neglected to present themselves for surgical treatment.

The complicated conditions, under which the channel we have cut out in the sclera enters the anterior division of the aqueous chamber obliquely, or else passes directly into its posterior division, have been discussed in the chapter on "Technique of the Operation" and it is not necessary to refer to them again here.

In the earlier cases operated on in Madras it was not an uncommon experience to find that at the completion of trephining we had failed to tap the aqueous, and, *ipso facto*, to relieve tension. We were then obliged to push a fine curette into the anterior chamber in order to open up the filtration channel. This complication arose in no fewer than five of our first 128 cases. Our earlier impression was that we were combining cyclodialysis with the trephining, a procedure which is deliberately adopted by Mr. Freeland Fergus, of Glasgow. More mature consideration showed that the explanation was impossible of acceptance on anatomical grounds. What we had really done was either to enlarge the trephine opening into the chamber, or in cases where even the minutest aperture into it did not exist, to break a way through. Placing our trephine blade as we then did, there can have been but a thin partition between the hole and the aqueous chamber. Under normal conditions the aqueous would have been tapped, but the blocking of the angle of the chamber by adherent chronically inflamed uveal tissue had shut off the fluid from the trephine. Since the corneo-scleral site has been adopted for the application of the instrument, this complication has been but rarely met with, and we now never fail to tap the aqueous either at the completion of trephining, or as soon as we have dealt with the knuckle of prolapsed iris which often blocks the hole immediately the disc is cut through. *The use of the curette has therefore all but vanished from our technique.*

"**Wounding of the lens or of its capsule, by driving the trephine into the anterior or posterior chambers,**" has been quoted as one of the possible complications of the

operation. It is an event of which we have fortunately had no experience, though one case in which the lens was damaged by the slipping in of the trephine was mentioned to us by an ex-pupil; at the time he was working in a strange clinic with a blunt instrument. The fear of such an accident has underlain the advice given by some surgeons that, when operating on an eye in which the coloboma of an old iridectomy is present, the trephining should be performed to one side of the coloboma. The author had many opportunities of showing during his tour in America, that one can safely and easily trephine right over the coloboma, and thereby gain the material advantage of avoiding the impaction of iris in the wound. One is thereby placed in a similar happy position to that of a surgeon who has to extract a cataract from an eye which has previously been subjected to a preliminary iridectomy.

CHAPTER VIII.

AFTER MANAGEMENT OF THE PATIENTS AND TREATMENT OF COMPLICATIONS.

In Madras very little effort was made to keep trephine patients in bed after operation, for the simple reason that it was impossible to do so. European patients, the more intelligent of the Indian patients, and those who were operated on in private, were all warned to lie as still as possible for the first five or six hours, and to remain recumbent for at least twenty-four hours. It is doubtful whether the general run of hospital patients really suffered in any way from the greater licence allowed them. The first dressing took place at the end of twenty-four hours and the eye was then opened and inspected. We carefully noted (1) whether the chamber had reformed; (2) whether the pupil was central; (3) whether the iridectomy was partial or complete, and whether it was hidden by the lid; (4) whether the flap was in good position; (5) whether filtration was free; and (6) what the tension of the eye was. If the case was in all respects doing well, the opposite eye was now left open. This was our rule with both private and hospital patients. When both eyes had been trephined and the patient was found with the anterior chamber filled, with free filtration, and with the eye normal in appearance, we sometimes released both eyes of an intelligent patient during the day, from the first dressing on, and only bandaged them at night. In any case where the progress was uneventful, we released both eyes from the fourth day onward.

As indications for prolonging bandaging we recognised the following: (1) emptiness of the anterior chamber pointing to a failure in the union of the flap; (2) the presence of hæmorrhage in the anterior chamber; and (3) the existence of iritis or of any other cause of continued congestion of the eye.

Shallowness of the Chamber.—It must be borne in mind that in a certain number of cases the chamber will remain shallow, even though the wound be healed. This is due to a free filtration into a loose flap. After an interval the chamber will deepen, but in the meantime we need not fear septic invasion of the eye, the interior of which is effectually

shut off from the conjunctival sac. The use of a binocular loupe and gentle massage of the cornea with the aid of a blunt instrument will demonstrate that free filtration is taking place into the sub-conjunctival tissue and not beyond.

In cases in which the chamber obstinately remains very shallow, the eye should be cocainised, the lids widely separated, the patient told to look down, and the whole length of the incision gently dried by dabbing it with a cotton wool swab, mounted on a small stick. It will then be found that in some of these cases, a small fistulette exists somewhere along the periphery of the flap. Through this tiny opening the fluid can be seen to be escaping in a steady trickle. The spot should be touched with a pledget of wool soaked in a 2 per cent. solution of silver nitrate and the opening will speedily close.

A quite different condition is that in which the shallowing of the chamber is due to an over-stretching of the diaphragm of the eye, as the result of a long-existing hyperdistension of the vitreous chamber. It is here manifestly impossible to do anything.

Displacement of the Flap.—In a small percentage of cases (3·6 per cent.) the flap fails to unite with the deeper tissues and may be rucked up or rolled in on itself. It is then necessary to fix it in place by means of a couple of stitches, which may be removed three days later. The insertion of these sutures, under cocaine and adrenalin, gives no pain and is an easy matter; the delay does not appear in any way to prejudice the case. On the other hand, by reserving sutures for those cases only in which they prove to be required, we simplify our operative *technique*, shorten our procedure, and lessen the danger of sepsis. The management of the flap has been so fully described, under operative *technique*, that it is unnecessary to deal with it further. There is, however, one condition to which allusion may be made, *viz.*, that following prolapse of vitreous through the trephine hole. When this occurs, the surgeon will be well advised to insert two sutures at once, removing any vitreous substance from under the flap immediately before fixing the latter in place. The prognosis under these circumstances is, at the best, a poor one.

Blood in the Chamber.—If a McKeown's Irrigator is used as a routine measure in the toilette of the eye, we comparatively seldom leave blood in the chamber at the close of the operation. Sometimes, however, the iris persists in bleeding, and it is not worth while prolonging the irrigation. At other times the blood poured out early in the operation, coagulates freely, and is difficult to wash out. In yet a third class of case, probably always due to injury, hæmorrhage

takes place into the chamber after the patient has been removed from the table. Whatever may be the source of the blood, the eye should be bandaged after instilling a solution of atropine sulphate. This *regime* should be followed until the chamber clears, which, in most cases, it speedily does.

Iritis.—Although we do not meet with well-marked signs of acute or sub-acute iritis, an eye after trephining will sometimes remain in an irritable condition. Our routine treatment consists in the use of atropine, the application of leeches, the administration of saline purges, and the use of all the other measures which are indicated when dealing with inflammation of the iris or ciliary body.

There is one danger against which we should always be most carefully on our guard, *viz.*, the existence of a *quiet iritis*. This appears to be a very common complication, and is all the more to be feared because it is unaccompanied by the ordinary signs of inflammation of the uveal tract. The eye may look quite healthy, the patient may complain of no pain, and the size of the pupil may not at first be such as to attract attention, and yet the insidious process may be steadily going on, firmly fastening the pupillary margin to the lens capsule, and leading eventually to occlusion or exclusion of the pupil, or to both. So deeply have we been impressed with the importance of watching for this menace to our success, that we now make it a routine procedure to instil atropine into every trephined eye on the third day. We only make an exception when the pupil is already widely dilated. If in doubt, we continue the instillation of atropine drops during convalescence. Provided the uveal tissue is not blocking the wound, the free use of mydriatics is quite harmless. The pathological aspect of the question of iritis following trephining is fully discussed in Chapter XV.

Prolapse of uveal tissue into the trephine hole.—This is a comparatively rare complication, and will be still more so in the hands of those surgeons who make an iridectomy a routine step in the performance of their operation. There can be no doubt that the tissue commonly protruded is iridic, though the ciliary body may easily be involved in the misfortune, thus rendering the case much more serious from every point of view. If the ciliary body is pushed far forwards, or if the iris-base is adherent to the corneal periphery, then tethered uveal tissue lies in close propinquity to the aperture in the sclera and is much more likely to prolapse into the wound than it is when it lies free of abnormal attachments, and with a good space separating its base from the margin of the hole. Uveal tissue may be pushed into the trephine hole by a

dislocated lens, as we have proved by anatomical examination, but this is a very rare event. It is probable that in the great majority of cases the iris is carried into the trephine hole owing to the patient squeezing the eye from time to time, and thereby ejecting gushes of fluid from the anterior chamber into the subconjunctival space. The presence of an iridectomy coloboma provides a sluice-gate, through which such gushes of fluid can escape, without carrying the uveal membrane in front of them. In other words, the function of an iridectomy in trephining is exactly similar to that which it holds in cataract extraction. It is no integral part of the operation but merely a safe-guard.

When a prolapse of iris occurs, the tension of the eye at once rises. The flap should be raised without delay and the prolapsed membrane freely excised. If care is taken to avoid all drag on the iris during excision and if no undue delay has occurred in undertaking the procedure, the pupil will return at once to its normal position. A stream from a McKeown's irrigator may materially assist in its replacement. A very interesting point in this connection is that the protruded iris is very slow to contract adhesions to the sides of the hole. This reminds one of Thomson Henderson's work on the absence of cicatrisation in the edges of an iris after an iridectomy, and of Sattler's observation of the absence of proliferation in the edges of a trephine wound a fortnight after operation. The clinical importance of the observation lies in the extreme ease with which the impacted iris can be replaced in the secondary operation.

If the prolapse be a very slight one, as judged not only by the appearance of the trephine hole, but also by the amount of displacement of the pupil, and if there be any contra-indication to a second operation, such as the unwillingness of the patient to submit to it, we may first try the free instillation of eserine drops. In a few cases we have found this of decided benefit. We must, however, bear in mind the danger of the prolapse recurring at a later date, after the patient has left our hands. Such an accident would then be very unfortunate, and under the circumstances the surgeon will do well to consider most seriously the advisability of immediate excision in every case of iris prolapse.

Dislocation of the lens or vitreous body into the trephine hole.—It sometimes will happen that, on the day following operation, tension is found to be still high, and a bead is observed bulging into the aperture in the sclera. An immediate diagnosis is called for, since so much depends on the correct treatment of the condition, which may be that of presenting lens

or vitreous on the one hand, or of prolapsed iris on the other. As the treatment of these two sets of conditions is very different, it is essential we should make no mistake at this stage. Fortunately, the differentiation is usually quite easy. All that is necessary, is either to employ a transilluminator, or to use a lens and throw a strong beam of light through the pupil from below (when the trephining has been made above), and at the same time to observe the bulging bead. If this consists of iris, it remains opaque, whilst if the offending tissue is transparent (lens or vitreous body) the bead is illuminated and an opalescent appearance is at once obtained. The diagnosis can be advanced one stage farther, with at least some degree of probability of correctness, if we have observed whether there was evidence of sudden hardening at the time of operation, and if we note the relative depth of different parts of the anterior chamber, when the bulging is under examination. We shall take these two points in turn. (1) When at the close of the operation, the tension of the eye suddenly rises, we may safely conclude that a free exudation or an intra-ocular hæmorrhage has occurred, and though dislocation of the lens is not to be forgotten, the great probability is in favour of vitreous rather than lens being thrust into the hole. The immediate indication is to close the eye and return the patient as quietly as possible to bed. If on the other hand, the blockage is first noticed when the eye is inspected on the second or third day, we are more likely to be correct if we think of dislocation of the lens rather than of presenting vitreous. (2) A careful inspection of the aqueous chamber under oblique illumination, will often reveal that its anterior division is shallower in the neighbourhood of the trephine hole than it is in the opposite quadrant. This is a most suggestive sign, and it will be safe to conclude that it indicates a displacement and tilting of the lens. What are we to do? We may settle the diagnosis by puncturing the protruding bead with a cataract needle, when the nature of the escaping contents will at once set all doubts at rest. Is this good surgery? It would be a grave mistake to be premature in taking such a step, though one may be driven to it. If the case is one of the impaction of the ocular contents in the trephine hole under the pressure of an intra-ocular effusion, the obvious thing to do is to await the cessation of that effusion and the subsequent absorption of the fluid. This complication is only met with in long-standing and desperate cases, and premature interference will probably aggravate the mischief, whereas if we take the ordinary steps for the arrest of hæmorrhage (both general and local) we not infrequently find that the tension falls, and a less hopeless result is obtained than we

would have anticipated. If in the course of three or four days things do not mend, we can puncture the bead of bulging matter, knowing that, desperate as the remedy is, the condition is still more so, and demands drastic action. The escape of fluid vitreous may better the conditions and lead to a fall of tension, though one of course recognises that one is fighting with one's back against the wall. Stranger far is the observation recorded in the previous edition, that if the incision of the bead leads to the extrusion of lens matter, the tension is sometimes at once relieved, and yet widespread opacification of the lens does not always occur. A possible explanation of this has been suggested by a correspondent, *viz.*, that a fine funnel of capsule and semi-fluid lens matter is thrust into the hole, and that when this is peripherally punctured, the semi-fluid contents escape, and the mouth of the funnel becomes sealed, immediately by twisting and later by exudation. It is difficult to understand where such a twist could come from, and possibly the mere collapse of the fine funnel of capsule is all we need postulate ; but in any case the clinical observation above recorded stands on several very carefully noted cases.

What is the pathological explanation of these cases of presentation of the lens or vitreous body ? We have had the opportunity of examining two cases in Madras which throw some light on the matter. It will probably be generally admitted that in a large number of instances, the first event of moment in the development of the glaucomatous state is an *increase in the volume of the vitreous body.* How that is brought about does not concern us for the moment. The effect, however, is well known, and consists of a push-forward of the diaphragm of the eye, *i.e.*, of the lens, suspensory ligament, ciliary body and iris, with a corresponding shallowing of the anterior chamber. Such a condition, if long continued and extreme, must obviously lead to an over-stretching of the suspensory ligament, and hence result in the lens possessing an undue freedom of movement so soon as the *vis a tergo* is removed or lessened. Anatomically we have twice observed a dislocation of the lens in sections of frozen eyes removed after trephining, and in both cases it appeared that the ligament was so unduly lax as to have permitted the lens to tilt and move bodily towards the trephine hole. There was nothing to indicate that intra-ocular hæmorrhage had played a part in the phenomenon. In one case the lens was separated from the trephine hole by uveal tissue, whilst in the other it presented directly into the hole.

Three other conditions suggest themselves as likely to cause

a blockage of the trephine hole by lens matter, or by vitreous, *viz.*, (1) a rupture of the suspensory ligament, (2) an abnormal fluidity of the vitreous, and (3) that fluidity or semi-fluidity of the lens, which is associated with the hyper-maturity of a cortico-nuclear cataract. With regard to the first, it is obvious that the relationship of the site of the tear to the position of the trephine hole may determine to some extent at least whether the lens drifts towards and blocks the hole, or whether vitreous escapes thereat. As to the second heading, if the *technique* we have outlined is adopted, it is clear that a vitreous escape cannot take place until the suspensory ligament is ruptured, and that prolapsing vitreous must be covered by that membrane. The question of abnormal fluidity of the lens has been fully discussed in Chapter III.

Recurrence of increased tension after operation.—Whatever method we adopt for the operative treatment of glaucoma, there can be little doubt that a percentage of cases will present themselves, in which the tension of the eye, successfully lowered for a time by the procedure, will again rise, the condition of glaucoma being thereby re-established. To this rule trephining has proved no exception. A curious feature of the case is the steadiness of the percentage of such recurrences. In a paper read before the British Medical Association at Birmingham in 1911, the author quoted a series of 278 cases, in 4·67 per cent of which a secondary trephining proved necessary, and he drew attention to the fact that the cases in which the need for a second interference arose were all of long standing, and therefore *ipso facto* of unfavourable prognosis under any line of treatment. In the analysis of a subsequent series of over 300 cases, it was found that secondary operative interference had been called for in 4.5 per cent., that every one of these had had glaucomatous symptoms for years, and that their visual power ranged from perception of hand movements down to bare perception of light or absolute blindness. This furnishes an interesting confirmation of our earlier conclusions, and although it is always unpleasant to be faced with the necessity of operating a second time for the same condition, some comfort at least may be derived from the comparative rarity of the need of so doing, and from the reflection that the results would probably have been the same, had we adopted any other operative procedure in lieu of trephining.

The causes of recurrent tension have already been indicated and may be summarised as follows:—(1) placing of the trephine hole too far out, and consequent failure to enter the chamber freely; (2) blocking of the trephine hole by uveal

tissue; this in rare cases may occur when the iris has normal relations, but is very much more common and also more dangerous when that membrane is adherent to the cornea exceptionally far forward; (3) filling up of the trephine hole by proliferation of connective tissue and matting down thereby of the superjacent conjunctiva; and (4) plugging of the trephine hole by lens or vitreous.

The conditions dealt with, under the first two of the above headings, bring about recurrent tension directly, or indirectly, through the plugging of the wound with uveal tissue; directly, if more and more of this tissue becomes prolapsed into the wound; indirectly, if proliferation of connective tissue take place in the uveal plug. On the third heading, it is necessary to speak with more diffidence, but from clinical observation one would judge that there are cases of obstruction of the trephine hole, in which the proliferating tissue belongs to the sclero-cornea, and to the superjacent sub-conjunctival tissue. At least this is the interpretation that we have been led to put on some of the cases we have had the opportunity of watching. With the fourth heading, we have dealt in Chapter VII, and it is not necessary to go over the ground again.

The question of how recurrent tension should be dealt with has presented itself to the minds of a number of surgeons. Gray Clegg[1] found eserine of service, and in a difficult case did an iridodialysis three weeks after trephining, by opening the anterior chamber and passing a repositor from it to the hole; a small second iridectomy had to be made, as the patient squeezed the iris through the new incision. In another case he trephined a second time. Maddox[2], in a case in which the tension again rose to +3 after two or three months, performed an ordinary sclerotomy through the anterior chamber, carrying the Graefe knife through the closed trephine hole, and then under the conjunctiva, so as to leave a broad conjunctival bridge. The result was perfect and the tension remained normal six months later. In another case the same surgeon passed a platinum repositor under the conjunctiva to re-open the aperture. But this time he was less successful. He suggests that it might have been better, had he employed a fine sharp gouge or a stout platinum needle. Nimmo Walker[3] who at first felt that trephining was experimental and that he was only justified in operating on the worst cases, met with one recurrence of tension in eight operations, but does not say how he dealt with it.

In Madras our large numbers have given us an opportunity of trying various methods of treatment. Sometimes a secondary trephining has served us well. In all cases the

use of eserine deserves a trial in the first instance, and if combined with *massage* it may prove very useful. We have already dealt with those cases in which lens matter blocks the wound, and also with those in which an iris prolapse has taken place into the trephine hole. The really difficult class of case to know how to deal with is that in which the hole is definitely plugged by proliferation of connective tissue. Obviously, the first essential is a study of the pathology of the condition. Stephenson has already made a useful beginning in this direction (*The Ophthalmoscope*, November, 1913). It might be suggested that the chronic inflammation, of which this proliferation is a manifestation, is due to a low form of sepsis introduced at the time of operation. Clinical evidence negatives such an idea; for, if trephining is repeated with care at another part of the corneal circumference, the same result ensues. That it is due to a low form of septic inflammation must probably be admitted, but the source of the sepsis is still to seek. There can be little doubt that future surgeons will classify, and possibly sub-classify, the cases which we at present are content to "lump" under the heading of "primary glaucoma." The behaviour of some of these as evidenced by the tendency to the formation of synechiæ after operation, implies a tendency to inflammation of the uveal tract, as distinguished from a mere congestion thereof. As to the causation of this inflammation, it would be idle to speculate, but clinically it is advisable to bear in mind the possibility of the existence of a not very obvious septic focus in a certain number of the eyes we select for trephining.

We meet with a few cases in which all methods of operation appear to be hopeless, and it is far from easy to lay down the lines on which they should be dealt with. In Madras we have tried a second, and even a third, trephining, and at times have been rewarded with success. In dealing with congestive cases we have been able to make an observation of some value. Sometimes the first trephining will give temporary relief, but the hole fills up and tension returns. If we now trephine at another spot, the relief of tension lasts longer than on the previous occasion. Once again the hole fills up and the tension rises, and once again we seek a new spot and trephine. Each time a little is gained, and on the third or fourth attempt our efforts to relieve the glaucoma may be crowned with success. We have also tried enlarging the trephine hole with scissors, performing in fact a modified Lagrange's operation. The use of a trephine with a larger crown seemed on one occasion to be serviceable, but it is doubtful whether this suggestion has much to recommend it, either on anatomical or on pathological grounds.

Detachment of the Choroid.—Several observers, amongst others Hudson[4] and Knapp,[5] have placed on record cases of this complication following trephining. It is associated with a delay in the re-formation of the anterior chamber, and its prognostic significance does not appear to be serious, the membrane re-attaching itself when normal, or nearly normal, tension is restored. It is probable that a number of cases occur without being recognised, owing to the fact that the majority of these are very anterior in position. The question of the pathology of the condition is more fully discussed in Chapter XV. One fact has been overlooked by some recent writers, *viz.*, that detachment of the choroid is far from being peculiar to trephining; indeed, Meller has found that it occurs in more than 22 per cent. of cases which have undergone Lagrange's operation. Fuchs found it in 4 per cent. of cataract extractions, and in 10 per cent. of glaucoma iridectomies, while Hudson goes so far as to suggest the invariability of its occurrence, in some degree at least, in all cases of perforating lesion of the eyeball involving the escape of aqueous fluid.

Late infections after trephining.—Fourteen cases of late infection are now on record, and considerable stress has been laid in certain quarters on the occurrence of this complication. There would seem to be a tendency to forget that during the last four years, an enormous number of eyes have been trephined, that the disease for which this operation is done is a very desperate one, that many of the operators are still new to the method, and that the same disaster is on record as following other operations for glaucoma, *ex. gr.* Lagrange's irido-sclerectomy. Gifford and Story, both of whom have had the misfortune to meet with late infection, have pointed out that the occurrence of this complication affords no indication for abandoning the operation. It is no part of the author's intention to exhaustively discuss at this stage the details of the reported cases, but he would point out that some at least of these records are not beyond criticism. One cannot class under late infections, cases in which the inflammation first showed itself very shortly after operation. Such would be more correctly included either in the category of operation-infections, or in that of the delayed infections which are met with after any form of major operative procedure, and which may presumably be attributed to some form of auto-intoxication, or to a very mild operation-infection. Nor are the cases which have followed an injury to be included without considerable reservations. Gifford, in an able and generous article, has pointed out that neither Lagrange nor the author has met with one of these late disasters, and has attributed this immunity to our *technique* of using thick flaps. Lagrange's

experience is a very large one, extending over many years, whilst the author is now able to speak from the figures of over a thousand trephinings, amongst which more than two hundred have been followed for periods varying from months to years. It is not intended to belittle the importance of late infections, or to suggest that such an occurrence constitutes the least reflection on a surgeon's method: in the case of an operative procedure which is of so recent an origin as sclero-corneal trephining it is obvious that we all still have much to learn.

The author would suggest that there are two conditions, which may possibly pave the way for the occurrence of a late infection. The first of these is the persistence of a leakage somewhere along the line of the original conjunctival incision. In a certain number of cases, one observes that after operation the anterior chamber remains very shallow. It has already been mentioned that if, after an eye is cocainised, the lids are widely separated and a cotton wool sponge mounted on a stick is applied by gentle dabbing along the periphery of the original conjunctival flap, one will find, in a certain percentage of cases, that a steady escape of fluid is taking place through a tiny fistulette at a point where the conjunctival incision has evidently failed to close. It seems not improbable, that this affords an explanation of late infection in those cases in which a shallow chamber has been noted as a prominent feature of the case. Presumably, where fluid can escape from within outwards, accidentally introduced pathogenic organisms may be able to effect an entrance from without. The second condition is that in which the filtration area is found to be covered by a very thin layer of tissue: in such cases the appearance presented is almost visicular, and in some the vesicle is extremely prominent. An abrasion of the surface epithelium would under these conditions, not only be likely to occur, but would be of very serious import if it did occur. In any case it is clear that two distinct and very unfortunate conditions must be present in order to determine the onset of a late infection, *viz.*, (1) an abrasion of the surface epithelium, and (2) a co-incident growth of pathogenic organisms in the conjunctival sac. The obvious lessons to be learnt are (1) to aim at forming flaps with thick bases (*vide* chapter V on the *technique* of the operation), (2) to protect an operated eye from injury by every means in our power, (3) to impress on patients the importance of remaining for a considerable time at least under medical supervision and of always looking upon any catarrhal condition of the conjunctiva as serious, and (4) to keep in touch with every trephined eye so long as a catarrh is present, and to give instructions for the treatment of any conjunctivitis which may subsequently arise.

REFERENCES.

1. **Clegg, J. Gray.**—"Observations on Trephining the Sclera." *British Medical Journal*, p. 1162, Nov. 1911.
2. **Maddox. Ernest E.**—"A Miscellany of Small Contributions." *The Ophthalmoscope*, Vol. IX, p. 97, *et seq.* Feb., 1911.
3. **Walker, A. Nimmo.**—"Sclero-corneal Trephining of Glaucoma." A paper read before the Liverpool Medical Institution, April 20, 1911."
4. **Hudson.**—*R.L.O.H. Reports*, Vol. XIX, Pt. 2, Jan. 1914.
5. **Knapp.**—*Arch. of Ophth.*, Vol. XLIII, No. 2, 1914.

CHAPTER IX.

THE DIAGNOSIS OF GLAUCOMA IN SOUTHERN INDIA.

The diagnosis of glaucoma in Southern India is modified by several factors. Not the least important of these are the conditions under which the people live. Most of the patients come to hospital very late indeed; many of them will allow the vision of one eye to be completely lost and will only seek medical aid when the failure of the second prevents them from earning a livelihood in their usual way.

Perimetry is nearly always difficult, partly owing to the deficient intelligence of many of the patients, but largely due to the advanced state of the disease. Often, by the time the patients present themselves, the central vision is very poor and the fields are extremely constricted. The rough and ready hand-method of testing the latter is then the only one available. With more educated patients and in earlier stages, perimetry proves as valuable there as in Europe, and both Priestley Smith's scotometer, and Bjerrum's screen are used with advantage.

In connection with this subject, the author desires to bring to the attention of his readers a method of mapping out enlargements of the blind spot on a Bjerrum screen. Many glaucoma patients are easily fatigued when examined by daylight; he therefore uses a Bjerrum screen especially adapted for the dark room. The fixation object is a 6mm. hole in the centre of the screen; this hole is covered with a ground glass disc which is illuminated by a small electric lamp placed in a box at the back of the screen. The travelling object is likewise electric lit; the device* consists of a long black metal handle, held in the right hand. It bears at one end a small electric lamp, and is provided there with two revolving discs, one of which carries a number of small apertures, whilst the other is armed with glass discs of various spectrum colours. The hand which holds and controls the rod is encased in a black glove. A resistance enables the operator to vary the intensity of the illumination employed. It is thus possible (*a*) to command a bright, a moderate, or a dim light, (*b*) to vary the diameter of the illuminated area, and (*c*) to use colours if required. The author has found this

*This is a modification of Dr. Thomson Henderson's Scotometer (for use with a Maddox Tangent Scale), which was shown at the Oxford Congress of Ophthalmology in 1913.

an easier and a more delicate test than any of the many others he has tried, and he recommends it to his readers. The screen was made for him by Messrs. Spiller & Co., and the rod device by Messrs. Weiss & Sons.

A point that strikes any one, who works even for a short time in Madras is the large number of cases of glaucoma in which the pupils are not markedly dilated. It is no uncommon thing to find a man with an eye as hard as stone, presenting pupils that do not attract attention by their size. It is necessary to bear this constantly in mind in our out-patient work. An associated fact is that a large number of the South Indian cases are extremely chronic in their course. If the surgeon is on the look-out for them, these cases present no difficulty. The iris is very inactive, the lenses have the greenish blue look, so characteristic of glaucoma, the advanced state of blindness renders the patients helpless and gives them a staring look (not so marked however as that which characterises optic atrophy), and finally as already mentioned, the eyeballs are extremely hard. Treacher Collins* deals with this subject in the following words :—

" In chronic cases of glaucoma, when the onset of tension is gradual, and there has been time for compensatory changes to take place in vessels and nerves, the dilatation of the pupil and atrophy of the iris may be absent."

We meet with another form of clinical aberration of no less interest than the preceding one, although far rarer. From time to time a patient presents himself with all the outward signs of high tension. The tonometer confirms the diagnosis in an unmistakable manner, and yet there is not a sign of cupping of the disc. In the absence of pathological investigation, one can only conclude that the region of entry of the optic nerve has not yet yielded before the pressure. The real interest of the observation lies in the fact that in these cases we must act upon the indications of the tonometer and not on those of the ophthalmoscope. Fortunately it is but very seldom that our allegiance to the latter instrument is thus rudely shaken.

Ophthalmoscopy.—A typical case of glaucomatous cupping is so characteristic, as to need no comment in a work like this. The whole disc is thrust bodily backward, and the vessels as they curl round its edge to appear at the fundus level, appear to lie on the retina from their first point of emergence onwards. Anyone who has made a large number of ophthalmoscopic examinations in glaucoma, must be familiar

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*Page 223, ' Pathology and Bacteriology ' by E. Treacher Collins, F.R.C.S., and Stephen Mayou, F.R.C.S., 1911.

with another type of appearance in which a varying width of the centre of the disc is punched backward, whilst the remaining, and not inconsiderable, portion of its periphery retains, for a time at least, the level of the surrounding fundus. The kink in the vessels is typical. The cupping affects all meridians equally, and vascular pulsation may be, and often is, marked. The condition is quite unlike that of physiological excavation of the disc, and rather imitates the appearance of a partial coloboma. The symptoms of glaucoma are, however, typical. We have been able to follow several of these cases after trephining, and to note a marked atrophy of the depressed portion of the disc, which followed even when the operation had relieved tension, brought back vision, and to some extent restored the field to its former dimensions.

Another aberrant type of cupping of the disc is that in which a physiological excavation is closely imitated. It is a rare form, but we have absolutely no doubt that it exists. A case in point may be quoted. Two years ago, one of our confrères, an European Ophthalmic Surgeon, honoured us by visiting Madras with the request that we should trephine both his eyes. He had naturally followed the progress of his own case with the greatest interest and accuracy. The diagnosis had been confirmed by an European Surgeon, second to none as an authority on glaucoma. The tonometer showed a very appreciable rise in tension in both eyes, and vision was steadily failing; on ophthalmoscopic examination, the discs presented the appearance one would have expected to find in optic atrophy attacking an eye which had previously shown deep physiological excavation. The outer third of each disc sloped steadily up to the fundus level, and vessels could be traced on it without a kink at any part of their course. Both eyes were trephined; the improvement in vision and the enlargement of the visual fields were unmistakable within a fortnight. One can only throw out the suggestion that the deep physiological cupping, which had been seen by an expert many years before the onset of the glaucoma, had influenced the appearance of the case.*

Another ophthalmoscopic peculiarity may be touched on, viz., the fact that in some cases the blood vessels are all drawn

*Whilst these sheets were passing through the press, this patient wrote once again to report progress. "My eyes have kept about the same;—V. of L E.=15/200, V. of R.E.=counting fingers at 2 metres distance; field of vision of L.E. practically the same as two years ago. The photopsia is very much less, and I think as you did that I may hope for no farther reduction of sight." In view of the fact that the case was a desperate one on which others had refused to operate, this is a very gratifying result. —AUTHOR.

over to the nasal side. They cross the floor of the disc and emerge at its inner edge almost in a leash. In the majority of cases on the other hand, the meridional direction of the retinal vessels shows no evidence of having been altered in the least degree.

On the use of Homatropine as an Adjuvant in the Diagnosis of Glaucoma.—In making a diagnosis of glaucoma, every feature of the case must be taken into account. The vision, the visual field, the tension, the history, and the ophthalmoscopic appearances are all of importance. Each must be weighed, and in doubtful cases our judgment must be based on a consideration of all available evidence. In India we met with many cases in which, owing to want of dilatation of the pupil, to haziness of the media, to corneal nebulæ, to cataract, or to some other cause, it was not possible to obtain a clear view of the disc without dilating the pupil. We tried the hydrophthalmoscope in Madras, only to reject it as an interesting toy which has little practical application. Our rule was therefore to dilate the pupil with homatropine in every case of doubt, nor did we ever find cause to regret our temerity. This line of action was not ventured on until after we had most carefully considered all the bearings of the case. It is true that homatropine has been known to produce an attack of glaucoma in predisposed eyes; but, so far as our information goes, this accident has never yet occurred until after several hours of continuous mydriasis. Moreover, in cases in which the drug is used for purposes of diagnosis, it is always possible to control the rise of tension by the use of eserine. Homatropine mydriasis can, in our experience, always be converted into myosis within a period of thirty minutes. Its use has often enabled us to clear up a doubtful diagnosis, whilst an experience of a large number of cases has justified us in the belief that it is a perfectly safe proceeding, so long as we are careful to instil a myotic as soon as we have completed the examination for which the mydriatic was used.

It is generally accepted that **glaucoma is more liable to occur in eyes of the hyperopic type,** and this for reasons which have often been dwelt on. One cannot help being struck with the accuracy of this observation. If one examines high tension eyes with the patient in the recumbent posture, and widely separates the lids by the fingers, the small size of a large percentage of the globes arrests one's attention. Measurements of the cornea confirm the observation.

The operating surgeon's attention should always be directed to **the state of the perilimbal tissues**. A matting of these parts such as is met with in late cases of glaucoma must obviously interfere with the filtering cicatrix by whatever

method we endeavour to establish it. Apart from this fact, clinical experience shows, as might have been expected, that there is a close relationship existing between matting of the perilimbal tissues and adhesions between the cornea and the base of the iris. The significance of this, when an operation is contemplated, will not be lost on any surgeon. It is of interest to learn that in Egypt, where the almost universal prevalence of trachoma-scarring has made perilimbal matting very common, surgeons have not found this complication a bar to the necessary splitting of the cornea, though, of course, it makes the step more difficult.

Dr. Alfred C. Norman, writing in *The Ophthalmoscope* for January, 1912, pointed out that by **the use of Würdemann's transilluminator** pressed against the lower lid (with a speculum still *in situ*) it is possible to see how far forward the iris is adherent to the cornea. Acting on the information so gained, he modifies the distance to which he splits the cornea. He suggests that transillumination in the dark room will prove of value in determining how much of the iris is adherent to the filtration angle in all cases trephined for glaucoma, and that it will prove a help to beginners in their early cases if they practise this manœuvre during the actual stages of the operation. Sydney Stephenson has pointed out that Würdemann had already announced that his transilluminator could be employed for showing up the filtration angle, although he had apparently not anticipated Dr. Norman in this very practical use of the instrument.

We have reserved to the last the consideration of what to those in India, at least, is the most important item of all, viz., **the estimation of tension.** The great value placed on tonometry by modern ophthalmic surgeons is shown clearly by the number of types of instruments recently devised for this purpose. Speaking with every respect for the distinguished inventors, the opinion may be recorded that the only forms of tonometer on which reliance can be placed are those which rest directly on the globe of the eye. The intervention of the lids with their active and powerful orbicularis muscles must obviously introduce factors which it is wiser to eliminate. There is an argument which has been used against the direct tonometers, and which applies with equal force to the others, viz., that two factors enter into their estimations: (1) the tension of the eye, and (2) the resistance of the orbital tissues. Without pretending to any unusual knowledge of physics, one may surely say that, in working with an instrument such as the Maklakoff, or the Schiotz tonometer, the latter element may be neglected. One eye will

sink back into the orbit more than another, but a tonometric reading will be obtained only when the value of the tension of the eye is reached. Whether the eye lies in soft and yielding orbital tissue and requires to be deeply pressed in before it offers the necessary resistance, or whether that resistance is reached at an earlier stage owing to the greater firmness of the orbital contents, does not appear to really influence the question.

In our earlier cases we used the Maklakoff tonometer and found it of the greatest assistance. Given the same eye, one might rely confidently on the *relative value* of a series of readings, taken under different circumstances. But it was impossible to argue from one case to another; the value of the instrument was confined to relative readings taken from the same eye. It was a great advance on finger-estimation, as it gave a graphic record, and in practised hands eliminated the mental bias that we most of us must feel in favour of a mode of operation in which we are personally interested. There were, however, two great objections to it, *viz.*, (1) that as above pointed out, the readings were relative, not absolute; and (2) that the gradations of tension recorded were comparatively few, and the readings were correspondingly coarse. It was as great an advance on finger tonometry as the Schiotz tonometer, in its turn, has proved to be on it.

In February, 1911, we obtained our first model of the Schiotz tonometer from Christiania, and after a very short trial we unhesitatingly substituted it for the Maklakoff instrument which we had had in use for several years. On the first day we unpacked the Norwegian instrument, four of us independently took measurements of the tension of a pair of eyes, and all our results were practically identical; moreover, experience taught us that, within very wide limits, the curvature of the eye does not appreciably influence the nature of the result. This is in accordance with the conclusions arrived at by others who have used the instrument and it constitutes a very important advance on the Russian tonometer. Another great element of superiority possessed by the Schiotz meter is that its readings run millimetre by millimetre from 5 to 90 mm., thus giving a much greater delicacy of recorded result than that which is obtainable when using the Maklakoff method.

In common with others who have used the Schiotz instrument, we have had one curious experience. Although as a rule one is able to judge fairly of the tension of an eye, once the organ has definitely transgressed the normal limit, there are not wanting instances in which a globe whose tension is

well above the average appears to have a normal feel. In order to test this matter, a number of the staff and of visitors to Madras, from time to time, were asked their opinions on such cases, and were in each instance requested to make a very careful examination. Although they were all experienced surgeons, they fell into the same pitfall as ourselves. On the other hand, eyes which appear to be unduly hard and which in old days one would have labelled T+?, now prove in some cases to be well within normal limits. Once again, in cases in which the tension is well below normal, such as some of the eyes we meet with shortly after a trephining, it is most difficult to say which of two has the lower tension ; one may easily go wrong here, in spite of feeling every confidence in one's estimation of the difference by the digital method. The result was to make all who worked in Madras very guarded about giving opinions in the absence of a tonometer ; the feeling was that one might just as well guess at a patient's temperature, by passing one's hand over his skin, as attempt to estimate his ocular tension by the finger method alone.

As an explanation of the phenomena we have been discussing, it has been suggested, and the suggestion has been widely accepted, that in the finger test, two elements enter into our appreciation of the hardness of an eye, *viz.*, (1) the state of the intra-ocular tension, and (2) the degree of rigidity of the scleral envelope. In support of this latter point may be quoted the observation that not only does the sclera vary greatly in thickness, but that it also differs very materially in texture, as judged of by the resistance which different eyes offer to the trephine.

No better proof of the value we placed on the Schiotz tonometer in Madras can be given than the fact that, apart from our own private instrument with which the work began, we had five of these tonometers in the Government Ophthalmic Hospital, Madras, each department being supplied with its own instrument.

In support of our views, we may quote the conclusions drawn by Polak-van-Gelder from a study of this instrument ; these have been summarised in *The Ophthalmic Review*, Vol. XXXI, p. 113 (April, 1912). He finds it both accurate and useful. In a series of careful comparative readings, in which he used it and a manometer side by side on the eyes of rabbits, the discrepancy was found to be a quite negligible quantity, not more, in fact, than 1 mm. of mercury.

Since the writing of the above paragraphs for the first edition of this work, the Schiotz instrument has been steadily establishing itself in popular favour, and it is scarcely too much

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to say that no paper on the results obtained by an operation for glaucoma will carry much weight at the present time, unless i is based on careful tonometric readings.

The influence of a high arterial tension on the incidence of glaucoma.—An interesting series of experiments was carried out in the Government Ophthalmic Hospital, Madras, by Lieut. Craggs and Assistant Surgeon Taylor, with a view to discover whether there is any constant relationship between a heightened systemic arterial tension and the incidence of glaucoma. If such a relationship exists, they desired to estimate its possible influence in the causation of the disease. They made a large number of observations (a) on young people (b) on cataract patients and (c) on glaucoma patients, taking the intra-ocular tension and the systemic arterial tension in each case. They found that the glaucoma patients had acquired at the age of forty-eight a systemic arterial tension, which those suffering from cataract did not reach till they were six years older. The inference would appear to be that systemic arterial tension may be a very distinct factor in the ætiology of many cases of glaucoma. On the other hand, they found (1) that very high degrees of intra-ocular tension may occur in patients whose systemic tension is certainly not above that of the average person of their own age; and (2) that a normal intra-ocular tension is not infrequently found in patients who present a very high and pathological grade of systemic tonus. This last observation has of course been frequently made before.

There is a small point which does not actually concern the diagnosis of glaucoma, but which may yet be conveniently dealt with here. It has to do with the **determination of the presence of filtration after a sclerectomy.** If a probe be taken and gently pressed on the conjunctiva in the neighbourhood of a trephine or other sclerectomy wound, there will be a very definite pitting of the conjunctiva if filtration is taking place beneath that membrane. This method is on all fours with that of pressing the finger on a patient's skin over a bone, such as the tibia, in seeking to discover the presence of the œdema due to cardiac insufficiency. The two procedures are equally simple and equally precise. If necessary, cocaine may be instilled beforehand, but we find as a rule that it is not required.

CHAPTER X.

METHOD OF COMPILING STATISTICS.

The method employed in the Government Ophthalmic Hospital, Madras, for recording notes, and for following up our cases at later visits, always attracted the attention of visitors. It was the rule for a visiting surgeon to ask to be allowed to carry away copies of our forms. It is therefore thought that our readers may be similarly interested in the Madras methods of dealing with the records of patients suffering from glaucoma. On admission full notes are taken in the subjoined form, the responsibility for the accuracy of the notes being in each case definitely fixed on one of the medical officers attached to the institution. The notes are read to the Superintendent on the day previous to operation, and he amends them if he thinks necessary. Subsequent to operation, a note is taken at each dressing. When a patient returns to hospital after discharge, he is at once sent from the out-patient room to the office of the Surgical Registrar, who is responsible for seeing that a full note is made on each occasion. For the purposes of reproduction the form is necessarily reduced. Those used by us were of foolscap size. In dealing with large numbers such as are handled in Madras, where we have already accumulated records of over 1000 trephine operations, it was imperative that we should have some easy system which would enable us from time to time to review our statistics with a view to clearing up the various points of clinical interest which may, and constantly do, arise. To this end, the Surgical Registrar keeps a large book thirty-eight inches across. This is sewn down the middle, thus halving its width when closed. Each pair of pages constitutes a form and is ruled out accordingly. At the back of these forms and attached to the cover is hinged a strip of paper of corresponding width. This strip is ruled in a direction corresponding with the length of the page into a number of divisions. In each division is written a heading corresponding to one or more of the facts elicited by the note forms. By means of this system, page after page can be dealt with and turned over without the necessity of entering a heading for each. Day by day, as the glaucoma sheets which we have previously described come into his office, the Surgical Registrar files them. But before doing so, he enters the various facts from the sheet, each in its proper column. It is not an infrequent occurrence for a visiting surgeon or for a member of

the staff to raise a question as to the best method of dealing with some complication, or the question may be one of statistics, or of the benefit or otherwise of some modification of *technique*. Whatever it be, it is best settled by the hard logic of facts. The question is referred to the Surgical Registrar, who opens his register and in a very short space of time furnishes an authoritative answer. To make the matter clear, a copy is given below of the glaucoma form in use, and of the headings in the register we have been speaking of. It must, however, be understood that from time to time fresh columns are opened, or old ones eliminated, as experience dictates.

GOVERNMENT OPHTHALMIC HOSPITAL, MADRAS.

Glaucoma.

Name. Age. Sex. Caste.
Occupation. Residence.
Admitted. Operated. Discharged.
Side affected. Primary—Secondary.
Acute—Sub-acute—Chronic
Indications for operation.

Synopsis.

Date of operation. Side.

Evidence of filtering cicatrix	Date of re-formation of chamber.	Position of pupil.	Prolapse of iris.	Iridectomy performed or not	Disc cut out or not.	Tension.	Vision.	Field of vision. Note results only.
						Before operation. After operation. Subsequently. (note date).	Before operation. After operation. Subsequently.	Before operation. After operation. Subsequently.

Ætiology—

1. State of refraction before onset of trouble.
   Ask about vision; elicit signs of myopia or hyperopia.
   Note size of eyeball.
2. History of grief, excitement or worry before onset of first and later attacks.
3. Have any drops been put in eye; if so, did they dilate pupil? Was vision worse after such drops?
4. Was there any febrile disease or debilitating disease (*e.g.*, influenza) before first or other attacks?

Prodromata—

1. Increase of presbyopia.
2. Flashes of light before eye.
3. Rainbows round lamps.
4. Objects seen as through a fog.
5. Pain in the eye.
6. Headache; was it accompanied with vomiting?

History—

1. Consecutive history of the disease.
   Has it begun suddenly or gradually?
2. Have there been intermittent attacks of severe glaucoma (headache, congestion of eye, etc.)?
3. Has vision failed? Give details; steadily or in bounds.
4. Does patient complain of contracted field (as if looking down a tube)?

Vision—

1. Central vision in each eye.
2. Note any improvement with glasses.
3. Colour vision in each eye. Particularly note failure to distinguish reds and greens.

Field of vision—

1. Perimeter tracing.
   (For educated persons.)
2. Hand movement test, recording results in degrees up, down, in and out.
   (For others.)

3. History of "seeing down a tube" and limitation of nasal field.
   (In blind and uneducated people.)

Present condition—

Conjunctiva—Note any congestion, especially circumcorneal or episcleral.

Cornea—

1. Diameter.
2. Transparency.
3. Sensation.
4. Evidence of past corneal trouble and especially of perforation.
5. Signs of iridocyclitis past or present (dots on back of cornea), etc.

Sclera—

Presence of patches of scleritis or evidence of staphylomata.

Iris—

1. Look for patches of atrophy, for ectopion, for atrophy of margin, and for signs of old or present adhesions.
2. Shape and diameter of pupil.
3. Pupil—central or eccentric; and if the latter, why so?
4. Is pupillary reaction normal or slow?

Chamber—

1. Depth.
2. Contents clear or turbid?

Tension—Digitally and also by tonometer.

Lens—1. Colour.
2. Appearance.
3. Position.
4. Evidence of past injury.
5. Describe any cataract.
6. If cataract is present, is it primary or secondary?
7. Give reasons.
8. Note any evidence of old operation for glaucoma or cataract.

Ophthalmoscopic Examination—

1. State of vitreous.
2. State of fundus.
3. Disc (specially note cupping).

Vascular system—

1. Heart sounds. 2. Tension of systemic arteries.
3. Enquire for giddy fits, headaches (not directly connected with the glaucoma attacks, *e.g.*, long preceding the latter).

Urine—

Sp. Gr. ; reaction ; alb. ; sugar.

Preliminary treatment before operation—

Results of treatment before operation, e.g., *tension, etc.*—

Operation—

Date. Operator. Side.
Nature of operation performed. Size of trephine used.

Short notes of operation—

1. Anæsthetic used; (i) Local. (ii) Sub-conjunctival. (iii) General.
2. Section.
   (i) Position of flap.
   (ii) Amount of sub-conjunctival tissue.
   (iii) Presence of perilimbal adhesion.
   (iv) Definition of overhanging limbus.
   (v) Splitting of cornea; (*a*) easy, medium, difficult. (*b*) width of area split.
3. Disc (i) cut out clean, ragged.
   (ii) hinge left on side.
   (iii) how hinge dealt with ?
4. Behaviour of iris bulged or not into wound, falling away from wound, plugging wound.
5. Treatment of iris.
6. Complications in dealing with iris.
7. Aqueous escape.
8. Chamber.
9. Escape of fluid on stroking cornea, and tension of eye.
10. Instillations; (i) before operation, (ii) after operation.
11. Remarks.

After-course of case—

Note particularly (i) any prolapse of iris; (ii) evidence of filtering cicatrix; (iii) state of tension (with tonometer); (iv) date of re-formation of chamber; (v) position of pupil; (vi) vision and field of vision after operation.

	Serial number.	
	Name.	
	Age.	
	Sex.	
	Caste.	
	Date of admission.	
	Side affected.	
	Acute.	Course of disease.
	Sub-acute.	Course of disease.
	Chronic.	Course of disease.
	Primary.	Course of disease.
	Secondary.	Course of disease.
	Tension.	Condition on admission.
	Field of vision.	Condition on admission.
	Vision.	Condition on admission.
	Tension.	Results of preliminary treatment.
	Field of vision.	Results of preliminary treatment.
	Vision.	Results of preliminary treatment.
	Date of operation.	
	Drops.	Anæsthetic.
	Sub-conjunctival injection.	Anæsthetic.
	General.	Anæsthetic.
	Size of trephine used.	
	Above.	Site of Section.
	Below.	Site of Section.
	Lateral.	Site of Section.
	Trephine hole too far out.	Notes of operation.
	Flap sutured.	Notes of operation.
	Clean.	Disc cut out. / Notes of operation.
	Ragged.	Disc cut out. / Notes of operation.
	Aqueous escape.	Notes of operation.
	Chamber emptied with the aid of instruments.	Notes of operation.
	Iris presented at operation.	Notes of operation.
	Iris prolapsed at operation.	Notes of operation.
	Large.	Iridectomy. / Notes of operation.
	Small.	Iridectomy. / Notes of operation.
	Vitreous escape.	Notes of operation.
	Position of iris at the end of operation.	Notes of operation.
	Mydriatics.	Instillations after operation.
	Myotics.	Instillations after operation.

	Date of re-formation of chamber	After-course of case.
	Evidence of filtering cicatrix.	After-course of case.
	State of filtration.	After-course of case.
	Position of pupil.	After-course of case.
	Prolapse of iris.	After-course of case.
	Tension.	After-course of case.
	Date of tension rising to normal.	After-course of case.
	Field of vision.	After-course of case.
	Vision.	After-course of case.
	Iris adhesions.	After-course of case.
	Date of discharge.	
	Blind painful eye.	Indications for the operation.
	Glaucoma secondary to cataract.	Indications for the operation.
	To prevent glaucoma in cataract cases.	Indications for the operation.
	For vision with hand movements only.	Indications for the operation.
	For better vision.	Indications for the operation.
	To remove impacted iris.	Secondary operation, if any.
	To remove prolapsed iris.	Secondary operation, if any.
	To relieve high tension.	Secondary operation, if any.
	Result.	Secondary operation, if any.
	How long after operation was the patient seen again ?	
	Evidence of filtering cicatrix.	Condition at later visits.
	State of filtration.	Condition at later visits.
	Position of pupil.	Condition at later visits.
	Tension.	Condition at later visits.
	Vision.	Condition at later visits.
	Field of vision.	Condition at later visits.
	Systemic blood-pressure taken before operation.	
	Operator's name.	
		Remarks.

CHAPTER XI.

THE RESULTS OF TREPHINING AS JUDGED OF BY STATISTICS OF RETURNED CASES.

It is not possible, in a work like the present, to attempt to do more than give a summary of our results. Some idea of the magnitude of the labour involved may be gathered from a knowledge of the fact that we are dealing with over 1,000 cases, and that the headings under which each of these cases is analysed, occupy no less than 70 columns in the register described in the previous chapter. The task of printing this mass of material would in itself be a prohibitive one, even if we could hope that one reader in twenty would take the trouble of personally studying such a mass of statistical information. The decision has therefore been arrived at to summarise our results briefly and concisely, just as was done in the previous edition.

It has frequently been said that the results obtained by Anglo-Indian surgeons are less reliable than those of their Western *confrères* by reason of the fact that so few of the patients can be continuously followed up. We recognise that the criticism is to some extent just, but we made a very special effort in Madras to keep in touch with our glaucoma cases, and thus to obtain material from which it might from time to time be possible to draw reliable inferences as to the value of trephining. We find that out of 1048 eyes, 203 (or nearly 20 per cent.) have been kept under observation for periods ranging from a few months up to about four years after the operation. It is obvious that the percentage figure would have been higher if we had excluded the more recently operated cases which have not yet had time to return for inspection. Of the 203 cases, 90 were under observation for periods varying from one to six months, 47 from six months to a year, 41 from one to two years and 25 from two to four years. For purposes of convenience in reviewing our statistics, we may divide the "returned eyes" into five classes, on the basis of the state of the vision at the time of operation: (1) Those whose vision was nil; (2) those who had a vision amounting to perception of light and nothing more; (3) those who could only recognise hand movements; (4) those who could count

fingers at any distance up to three metres, and (5) those who could read Snellen's types at varying distances. We shall proceed to discuss each of these classes in its turn.

(1) **Cases in which the vision at the time of operation was nil.**—Twenty-five such eyes returned for examination after periods varying from over a month, up to two years and eight months. In four hyper-tension returned. In the rest the tension was permanently lowered. Six cases came back with an improvement in vision. Four of these had vision of hand movements at two years six months, two years three-and-a-half-months, one year five months and one year two months respectively, after operation; one had P.L. one year nine-and-a-half months after operation, and one had $\frac{5}{60}$ V. one year six-and-a-half months after operation. Of the cases in which vision had improved, one was in an acute, and one in a sub-acute condition at the time of operation.

(2) **Cases in which the vision at the time of operation was perception of light.**—Eight of these cases returned. In two the tension again rose above normal; in these two, and in two others vision fell to zero; in one it was still P.L. three months later; and in three it rose to V.H.M. and was still so five months, eleven months, and two years respectively after operation.

(3) **Cases in which the vision at the time of operation was perception of hand movements.***—In thirty-five of the eyes that come under this group the patients returned at periods varying from six months, up to three-and-a-half years after operation, twenty of them being under observation for over one year, and five for over two years.

The whole group comprises sixty-six cases, in thirteen of which a distinct improvement in vision was recorded, the best results being one of 6/12, two of 6/18, and one of 6/36. Of the rest, vision remained steady in forty-two, and fell to P.L. in five and to 0 in six. The tension rose again above 25 mm. Hg. in eight; remained normal or subnormal in fifty-seven, and could not be taken in one.

(4) **Cases in which the vision at the time of operation was a finger-count.**—This group comprises forty-one eyes, of which twenty-seven were seen up to a year after operation, six from one to two years, five from two to three years, and three, three years and over. The tension rose again in only two cases, and remained normal or sub-normal in thirty-nine. Vision improved in twenty-seven, remained stationary in one, and deteriorated in thirteen, the deterioration

*Hereafter described as V.H.M.

being explained by maturation of cataract in nine. Eighteen cases showed striking improvement, the results in these being as follows :—3/50 in two, 6/60 in 4, 6/36 in 4, 6/24 in 1, 6/18 in 3, and 6/12 in 4.

(5) **Cases in which the patient could read Snellen's types at various distances at the time of operation.**— The cases in this group had a vision ranging from 2/60 to 6/6, and included our most intelligent patients. They numbered sixty-three in all; of these twenty-five were under observation less than six months, eighteen from six months to one year, twelve from one to two years, and eight from two to nearly four years. In fifteen cases there was distinct deterioration of vision; this was due to maturation of cataract in ten cases, to iritis in two cases and the cause is unexplained in three. In ten cases there was slight deterioration, but useful vision was retained; in thirteen the vision remained stationary, and in twenty-five it distinctly improved; the end result was 6/6 or better in seven, 6/9 to 6/18 in twenty, 6/36 to 6/60 in ten, and good but unrecorded in one.

The out-standing feature of this group is that there was only one case, in which the tension rose above normal, subsequent to the operation. In this instance the rise was to 30 mm. of mercury, but at the same time vision improved from 6/36 to 6/9. In all the rest, a normal or sub normal tension was maintained.

If the reader would justly estimate the significance of the results which have been laid before him, he must bear in mind that they are not derived from the operative practice of one man. In the Government Ophthalmic Hospital, Madras, an effort was made to educate others in the *technique* of the operation. About thirty surgeons have availed themselves of this opportunity, and in estimating results, we have included all returned cases, absolutely regardless of the identity of the original operator. It is also to be remembered that we have in no way picked our cases; every single eye, in which it appeared that advantage might be obtained from trephining has been submitted to operation, regardless of the effect on statistics of such a course of action; lastly, we were, especially in the early stages, feeling our way. Many questions, such as the site for trephining, the diameter of the trephine to be used, the treatment of the iris, etc., had all to be found out. The surgeon who commences trephining now, should be able to avoid many of the pit-falls which beset us in our earlier work, and his results should show corresponding improvement.

One great disadvantage that we suffered from was the want of

intelligence on the part of our patients. Comparatively few of them would co-operate with us in any way. The majority, having obtained relief from their symptoms, would wash their hands of the surgeon without a scruple. We consequently are led to attach great value to the notes of those comparatively few persons who, having sufficient intelligence to understand what was at stake, presented themselves either before us or before some other trained ophthalmologists at stated intervals for a routine examination. Our aim was always to make such an examination quarterly. We have been fortunate enough to have amongst others, some exceptionally intelligent and very highly educated patients, who have endeavoured, even at great personal inconvenience, to carry out their part of the contract. A very short summary of these cases cannot fail to be of interest.

*No. 220 A. and B.—An educational officer, seen three and a half years after trephining of both eyes for chronic glaucoma: vision had improved from 6/6 to 6/5 in each eye; filtration was free; tension in the right eye was 8 mm. Hg., and in the left 12 mm. Hg.; pupils central; fields practically full normal. He is doing his full work, which is of an arduous nature, and his last report of his own condition was "better in vision, and quite comfortable."

No. 223A.—A prominent Government Official seen three years and four months after trephining of the right eye for rapidly progressing non-congestive glaucoma; vision has advanced to 6/5; filtration free; tension 13 mm. Hg.; pupil central; coloboma imperceptible: field full; complains of weariness from time to time, but especially in the opposite eye; continues to carry on the very laborious and responsible work of his office. The history of the opposite eye is of very considerable interest. It had failed while he was absent from India, some months previous to the operation on the right eye, and a clean broad iridectomy had been done. Trephining of this eye was advised at the time the other was operated on, but declined. The patient went to England and consulted another surgeon who found the tension had again risen, and trephined. Filtration has remained free over a period of thirteen months. The field, which had flattened, has considerably recovered. Vision is 6/9 and 6/6 with difficulty; the slight loss appears to be largely due to blurring from the wide coloboma of the original iridectomy in England. T. is 17 mm. Hg.

Nos. 368 and 369.—Mr. B., a veterinary officer, seen two years and ten months after both eyes had been trephined

*These and the following case numbers quoted are serial in our register.

for sub-acute glaucoma; vision improved in R.E. from 6/18 to 6/5, and in L.E. from 6/12 to 6/5 and 6/4 nearly; filtration free in both eyes; pupils central; tension 14 mm. Hg. in R.E., 17 mm. Hg. in L.E.; fields normal. The patient is not conscious of any defect in the eyes, and carries on his usual work, which includes a great deal of both office work and touring, without any sense of effort.

No. 342.—Miss C., a well-known lecturer on Theosophy; was last reported two years and a month after operation; right eye vision had improved from 6/6 bar 3 letters to 6/6; filtration was free; pupil central; tension normal; the patient wrote that she was quite well, doing an enormous amount of very successful lecturing on behalf of her sect, and was also writing a book on Theosophy. Subsequently, two years and nine months after operation, she wrote again, "What do you think of forty lectures in five weeks, and scarcely any feeling of fag after it?—no holiday for five months—writing long reports several times a week," etc.*

No. 343.—Her left eye vision had risen from fingers at 0.5 metre to fingers at 4.5 metres when last reported. The tension was normal and in all other respects she was doing well.

Every one of these eight eyes has been carefully ophthalmoscoped from time to time and not one of them has revealed any abnormality of the fundus or of the media. These observations are very significant in the view of the suggestions that have been thrown out that such marked lowering of tension, as trephining often produces and more seldom maintains, may be the cause of perversions of nutrition leading to loss of vision.

Ramanadha Modali, male, Hindu, age 50, operated August 24th, 1909, for primary chronic glaucoma. A typical case. R.E.V. = H.M., L.E.V. counts fingers at 2 m, T = + 2. R.E., + 1. L.E. (4 and 5·25 mm. Maklakoff tonometer).

Operation on August 24th, 1909. Trephined under local anæsthesia, trephine-diameter 1·5 mm., iris bulged into wound and excised, aqueous escaped freely, iridectomy peripheral. Convalescence uninterrupted, T. low both eyes (5·25 mm. R.E., 7 mm. L.E. Maklakoff), discharged September 4th, 1909, R.E.V.=H.M., L.E.V. counts fingers at 2 m., filtration free, pupils central. Seen again on eight occasions at short intervals up to February 21st, 1913. On the last occasion, 3½ *years after the operation*, R.V.=H.M., R.E.T. =25 mm. Hg. (Schiötz), L.E. counted fingers at 2½ m., L.E.T. =18 mm. Hg. (Schiötz). The appearance of cupping was still marked. It will be noticed that the vision had been maintained in the R.E. and been

* P.S.—May 6th, 1914. News received of this case after expert examination, 3 years 1 month after trephining, confirms the maintenance of the improvement effected by the trephinings.—R.H.E.

slightly improved in the left eye. There had been no change for the worse in the media of either eye.

Pokar Doss, male, Hindu, age 35 years. Chronic congestive glaucoma. History and clinical condition typical; R.E.V.= H.M. L.E.V. = 5/60, with—2D. sph. = 6/36, T=+1 (5 mm. Maklakoff), R.E. had been subjected to an iridectomy elsewhere, and the patient declined an operation on it. L.E.

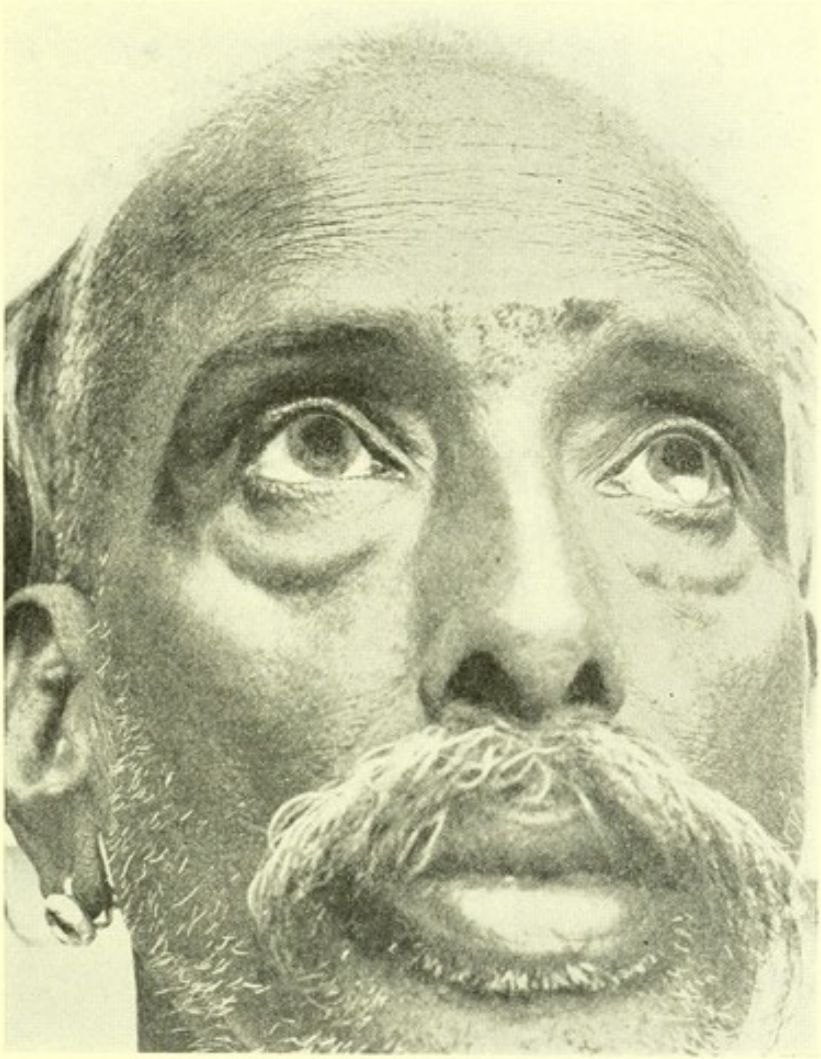

FIG. 38.

Ramanadha Modali.

3½ years after operation; trephined below left eye. Notice the invasion of the cornea by the filtering bleb.

trephined on April 21st, 1910, under local anæsthesia, trephine diameter 2 mm., iris prolapsed into wound and excised (a broad complete coloboma), aqueous escaped freely, patient discharged on May 18th, 1910, with normal tension and free filtration. Last seen on April 9th, 1913, R.E.V.=O, L.E.V. =6/36, filtration free, marked cupping still seen, T.=16 mm. Hg. (Schiötz). Thus, the iridectomised eye had lost all vision,

whilst the trephined eye *three years after operation*, had slightly improved in vision and showed a tension distinctly below normal.

C. Ramaswamy Asari, male Hindu, age 40 years. Chronic congestive glaucoma. History and appearances typical. R.E. counts fingers at 1·5 m. field contracted on all sides; T.=+1,

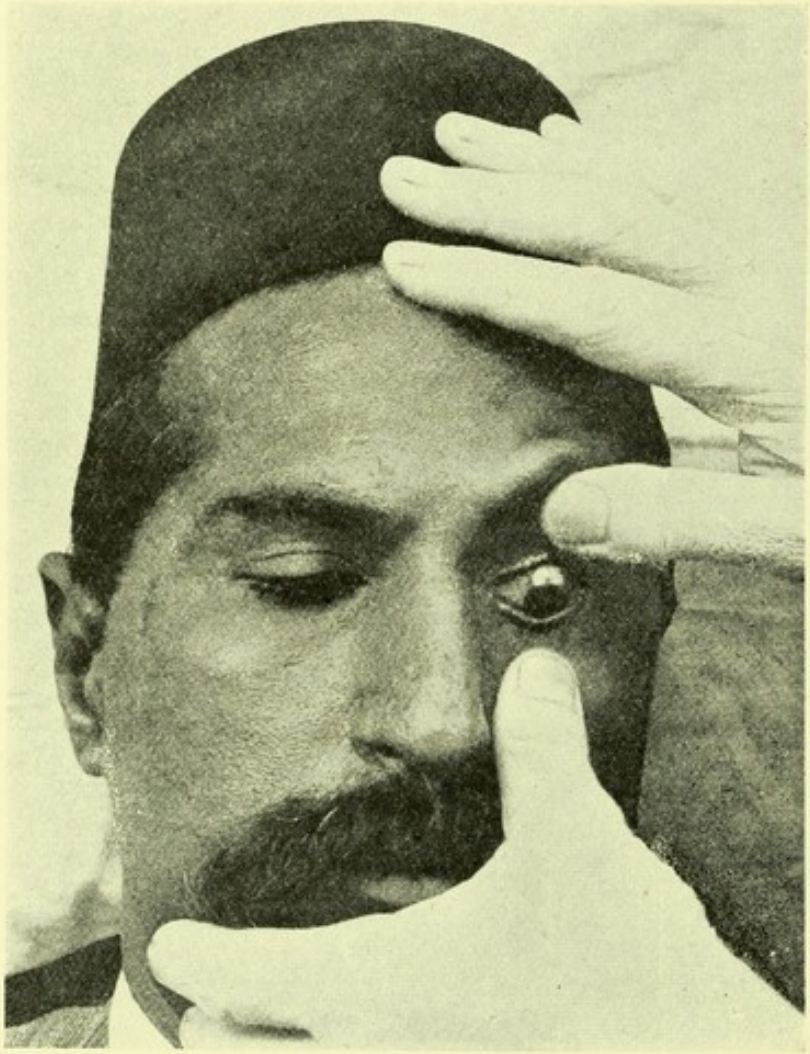

FIG. 39.
Pokar Doss.
Three years after operation. Notice prominent bleb, invasion of cornea, and dark trephine-hole.

(5 mm. Maklakoff), L.E.V.=O; T.=+2 (4 mm. Maklakoff); eyes congested at the time of operation and in a state of subacute glaucoma; secondary cataract both eyes. August 18th, 1910, both eyes trephined under cocoaine, trephine diameter 1·5 mm., iridectomy performed on right eye and iris left untouched in left eye. Discharged on September 5th 1910. R.E.T.=low, V. with —1.5D. sph.=5/30, L.E.T.= low, and V.=H.M. Last seen on February 4th, 1913, *two*

years, five months, sixteen days after operation R.E. counts fingers at 4 m., T.=15 mm. Hg. (Schiötz), L.V.=H.M., T.=12 mm. Hg. (Schiötz). There is a marked filtering cicatrix in both eyes.

FIG. 40.

Mrs. B. B.

Five months after operation. Notice extensive invasion of cornea both eyes.

Mrs. B. B., nurse, with chronic primary glaucoma in both eyes; R.E.V.=6/9 bar 1 letter, L.E.V.=H.M.; R.E.T.=95 mm. Hg., L.E.T.=120 mm. Hg.; marked cupping of both discs. Both eyes trephined on 23rd August, 1912; discharged on 13th September, 1912; last seen nearly seventeen months after operation; R.E.V.=6/12; R.E.T.=7 mm. Hg.; L.E.V.=H.M., L.E.T.=9 mm. Hg. Captain Gray reports:—"R. E. there is slight indication of cupping, and no more; disc is a little grey, with a pigmented ring round it; the vessels are smaller than normal; there are white lines along some of the arteries, showing undue thickening of their coats; there is no lenticular

opacity; œdema over the trephine hole is well marked; filtration is free and the pupil is central. L.E. the cupping of the disc is still marked all round; the disc is decidedly pale; the coats of the vessels (especially of the arteries) are thickened; there is marked pigmentation around the disc, especially above; to the outer and lower side the pigmentation over the macular area is disturbed; the macula has a granular look: there is no

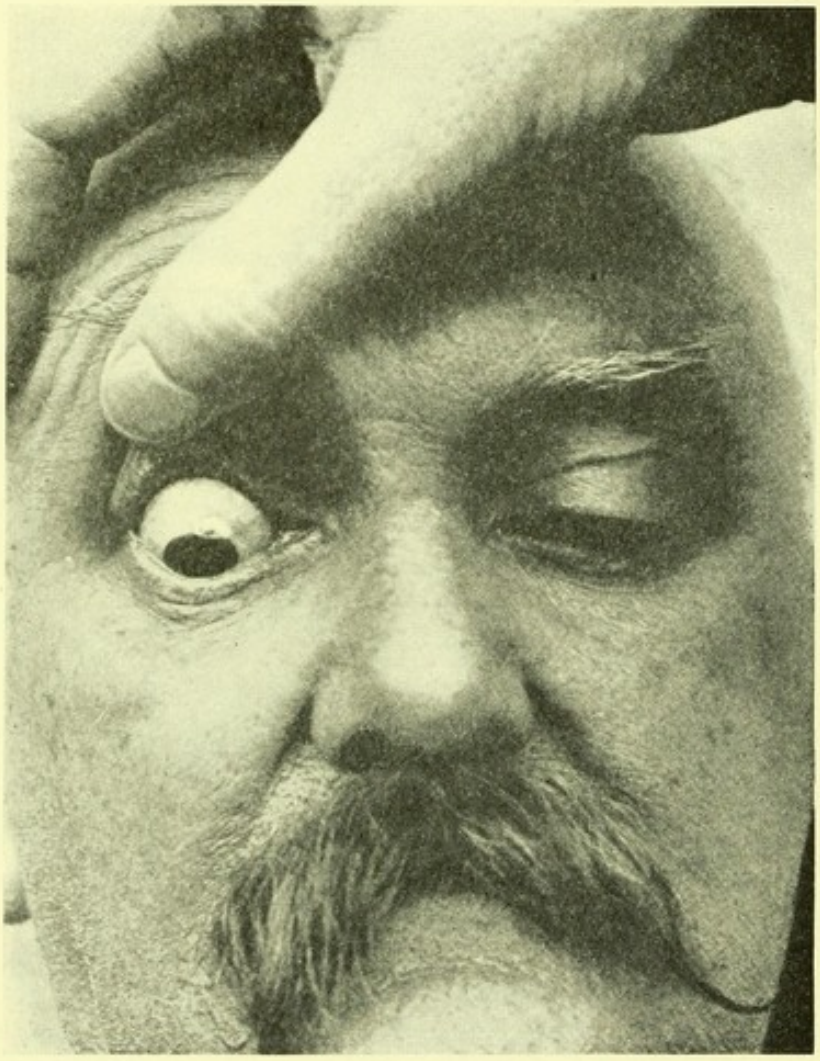

FIG 41.

T. S.

Over four months after operation. Notice invasion of cornea and dark trephine-hole.

lenticular opacity. The œdema over the trephine hole is well marked; filtration is free, and the pupil is central."

There are some points of interest in connection with the photographs which appear in this chapter. In two of them (Figs. 39 and 41) the trephine hole can be distinctly seen as a dark spot (the negatives are quite untouched). All the pictures show that the area of splitting of the cornea has participated in the

permanent filtering zone of the conjunctivo-corneal flap. Figures 39 and 41 clearly demonstrate that the corneal filtering area not only extends right up to the hole, but actually beyond it, on its pupillary side. In trephining we always make a special effort to place the instrument as far forward as the splitting of the cornea will allow, and the above appearance therefore shows that the filtering fluid dissects up, as it were, the space that has been made available, and that it does so to the farthest possible limit, utilizing more of the area thus gained, than the operator is able to do by his *technique*. In studying these pictures (Figs. 38-41), it is important to follow the line of the cornea round from below; we then see how far on to the latter structure the filtration extends. The author has often been asked, when he was examining trephined cases in various clinics, how it was that the hole did not seem to be on the cornea, though the operator was convinced that he had split that membrane well. Attention was then called to the above-mentioned point, and the surgeon was thereby convinced that he had in reality trephined far forward. To put the matter in another way: the split cornea with its opaque loosened superjacent layer imitates the appearance of the neighbouring sclera and its conjunctival covering, but can be easily differentiated therefrom if one carries the eye round the line of the cornea from below. This prolonged line will then be found to cut through the opaque tissue of the conjunctivo-corneal flap a millimetre or more behind the *apparent limbus*. Also if the cornea is carefully looked at with the lids widely separated, it can be seen to be, as it were, truncated above.

We come next to consider a phenomenon which our notes have shown to occur from time to time in returned cases. We refer to the fact that cataracts, present in an immature condition at the time of trephining, have sometimes been observed to progress steadily to maturity after, and in spite of the fact that, the tension of the eye had been maintained at a normal or subnormal level from the time of operation onward. We may probably assume that this maturation of an existing cataract is the outcome of a perversion of nutrition, and the questions that we anxiously asked ourselves were :—is this brought about by the alteration in tension which we have produced ? or, is it a manifestation of conditions existing precedent to our interference ? That glaucoma profoundly influences the nutrition of an eye is well known. A fact, hard to explain, is that the alteration in nutrition does not always manifest itself along the same lines. To take the case in point: — a cataract is by no

means an invariable accompaniment of glaucoma ; we see not a few cases of advanced glaucoma with perfectly clear lenses, and this doubtless is the experience of others elsewhere. The factors which, in the first instance, lead to the development of a lens opacity in glaucomatous cases, and those which at a later stage determine whether the opacification shall progress, or be arrested after operation, are at present but dimly known to us. We fall back on the supposition that ophthalmologists will at some later date learn to sub-classify the mass of cases which we at present group under the name " glaucoma," blindly guided, as we now are, by the one leading feature of tension. We would not be understood as wishing to imply a belittlement of the very important *rôle* of this sign, but we are convinced, and we believe that most ophthalmologists share the opinion, that there are many very distinct ways in which hypertension is brought about.

Closely allied to the condition we have just been discussing is the phenomenon met with in certain cases of a steady fall of vision, associated with the progress of an atrophy of the optic nerve, after tension has been relieved by operative procedure. Every surgeon is familiar with the patients who present themselves before him with marked evidence of cupping, unassociated with any perceptible increase in the tension of the eye. If such cases be kept under observation, and tonometric readings taken at intervals, it may be found that at one time or another during the twenty-four hours a rise in tension occurs. Or again, even in the absence of any such evidence of hypertension, we may easily satisfy ourselves with the explanation that the patient has, under the quieting influence of a hospital or of a nursing home, been removed from the exciting causes of hypertension, be they mental or physical. Moreover, the introduction of the Schiötz tonometer has materially modified our opinion of many of these cases, by showing that what we have been accustomed to regard in an eye as a normal tension, may really be distinctly above normal, though the difference may not be perceptible to fingers, no matter how highly trained.

In the cases we are discussing, however, an entirely new factor is introduced. The operation of trephining may have effectually eliminated any possibility of a rise in tension, the tone of the eye may indeed be markedly below normal, and yet the atrophy of the optic nerve may progress. It is obvious that side by side with the factor which produces increase of tension, there may co-exist another and a possibly quite distinct one, which brings about an atrophy of the optic nerve fibres. Such cases will, for the present at least, tax to the utmost the resources of the surgeon.

CHAPTER XII.

THE EXPERIENCES OF OTHER SURGEONS IN TREPHINING.

In the Preface to the First Edition the author wrote:—"I desire to lay my case fully and freely before the Medical Profession.

"At that bar we must one and all be tried, and I for one have no doubt that the ultimate verdict, even though it may be delayed, will be the just and right one, be it what it may."

Since those words were written a very extraordinary volume of evidence on this subject has been furnished. Within the short space of four years, the operation of sclero-corneal trephining has made such a powerful appeal to the medical profession that it has been tried in every civilized country. Scientific assemblies, from the great International Congress in London downward, have discussed it in all its bearings; the Medical Press has been full of reports of, and opinions on it; and men of world-wide reputation have published their statistics, and have thereby arrested the attention of the profession. The Second Edition would be incomplete indeed were it to take no account of such evidence as this, and the aim of the present chapter is to collect, even though in a condensed form, some of this valuable testimony. The author thinks that for the most part comment or criticism on his part would be out of place, and that the unadorned tale of great workers will carry more weight than any embellishments that he can add to their story. Hence the bulk of the chapter will take the form of short extracts from the work of such surgeons. He does not fail to recognise that behind all this there lies a force much greater even than the individual opinions of a number of great ophthalmologists—a force comparable to that of a swollen river fed by innumerable rivulets—the force of wide-spread medical opinion. The number of men in many parts of the world who are quietly and unobtrusively trephining for glaucoma is legion; men who say they have done only a few cases, and who consider their evidence not worth having on account of the individual smallness of their statistics, but who, none the less, write and speak of the wonderful results they have obtained, and of the comfort it has been to them to find an operation so safe, so easy, and so satisfactory for a condition

which previously reduced them to hopelessness. Surgeons such as these will not lightly give up the method; they are the backbone of its permanence, and though it is not possible to place all their valuable evidence on record, it is none the less fully and deeply appreciated.

Wallis[1] collected the statistics from the case sheets of 91 patients, operated on in **Moorfields Hospital**, and wrote:—"I have excluded all but primary chronic glaucoma patients, and amongst these were not a few for whom the prognosis was very grave—cases that had failed to receive permanent benefit from previous operative methods (other than Elliot's), and absolute glaucomata; also all operations are included, whether performed by the honorary staff, by senior house-surgeons or by clinical assistants. Of 91 patients suffering from primary chronic glaucoma, upon whom Elliot's operation has been performed, those who have developed repeated plus tension within a year of the operation give a case percentage of 9·8. The operation percentage of failures amongst these patients is 15·3—this larger figure is due to the cases that have failed to be improved by more than one operation in the same eye, and from failure in the two eyes of the same patient when this occurred." It is obvious that the test of the value of trephining here dealt with is a very severe one, by reason both of the nature of the cases accepted for operation, and of the number and varying experience of the operators.

Statistics.

Stock,[2] of **Jena,** published the results of 118 trephinings for glaucoma, with 88 good results (74·6 per cent.). Of the poorer results 14 were in operations undertaken for glaucoma absolutum, while the rest had vision not above 1/60 before operation. This is a striking confirmation of what the writer has long said, viz., that our failures lie in the group of cases which are late in seeking relief. Vision improved after operation in 39·8 per cent., remained the same in 34·1 per cent., and decreased in 25·6 per cent.; in 8 of those which showed a decrease, this was due to the maturation of a previously existing cataract, in 1 it was due to hæmorrhage into the vitreous, and in 5 to iritis.

Meller[3] of Vienna, has recently published a report based upon 389 Lagrange operations, and 178 sclero-corneal trephinings supported by the microscopical examination of a number of globes removed after failures. He states that "the great advantages of the Elliot operation is that its *technique* is so much more easy." In not a single case of the 178 was

there an injury of the lens. He compares the two operations, dividing his cases into two groups, *viz.*, (1) good results, Lagrange 69 per cent., Elliot 72 per cent., and (2) bad results, Lagrange 8·4 per cent. and Elliot 2·4 per cent. "Complications such as lens opacities, severe irido-cyclitis with atrophy of the globe, expulsive hæmorrhage, etc., not at all infrequent after the Lagrange operation, are scarcely met with after trephinng." He finds a tendency after both operations for the iris to block the wound, and is in favour of "a complete iridectomy in the Elliot operation." The percentage of vitreous loss is 3·4 per cent. after the Lagrange and 2·8 per cent. after the Elliot and he finds that "vitreous prolapse after the Lagrange is a much more serious complication than the escape of a bead of vitreous from a small trephine opening." To show the genesis of relapses, he compares the figures found in the two operations. (1) After total iridectomy, Lagrange 9·3 per cent., Elliot 7·5 per cent. (2) After peripheral iridectomy, Lagrange 11·8 per cent., Elliot 18·7 per cent., and (3) Without iridectomy, Lagrange 20·0 per cent., Elliot 23·0 per cent. He therefore inclines to the view that iridectomy is more important than Lagrange or Elliot consider it to be. "With an equally high percentage of excellent results, the Elliot operation has a much smaller percentage of bad results, than the Lagrange. Further points in its favour are the considerably easier *technique* and the much smaller number of complications, especially in the severe forms of acute and absolute glaucoma. With the Elliot operation only 15·4 per cent. of the absolute glaucoma cases ended badly, while 38·0 per cent. of such cases were lost entirely after the Lagrange operation." As to indications he says, "the situation has been simplified to an extraordinary degree by the introduction of the Elliot operation. It is indicated in all cases of glaucoma, in acute as well as in chronic and simple; in secondary glaucoma, and especially in those cases of increased tension which have developed after the performance of other operations. It can likewise be recommended for hydrophthalmus, for it is attended with less danger than an iridectomy, or even a sclerectomy. The height of the tension has no effect upon the course of the operation or upon the development of complications, and especially not that bad effect which high tension must have in all methods of operating in which the eye is opened by a section."

Axenfeld[4] states that in his own operative material the trephine hole, after a varying period, and often quite quickly, became closed with such thick tissue, approaching to the level

of the sclera, that free sub-conjunctival filtration was out of the question. He, however, modifies this statement by saying that it would be quite wrong to limit the successful cases to those in which a permanently filtering cicatrix, with formation of œdematous area, is found. His own experience, and he states that of many others also, is that numerous cases with closure without apparent filtration are favourably influenced; he suggests that possibly a sub-conjunctival microscopic filtration is present in these cases. The remark reminds the author of the many cases, which have been presented to him in various clinics, as instances of cases, in which the old-fashioned iridectomy has cured glaucoma, and in every one of which he has been able to demonstrate to the satisfaction of those present that though to the naked eye no filtration was occurring, yet such filtration could be readily demonstrated by the use of a spud or probe, gently pressed upon the conjunctiva in the neighbourhood of the operation wound site. It is suggested that the same phenomenon may serve to explain the apparently anomalous cases cited by Professor Axenfeld.

Guglianetti, of Naples, before the International Congress of Medicine in London, reported twenty-five cases with favourable results in simple glaucoma, and varying in other cases.

Pischel,[5] of San Francisco, operated 19 times on 15 eyes; 3 eyes were operated on twice and one thrice. Vision was improved in 6 cases, the same in 3, and worse in 3; 3 eyes were blind before the operation. The tension was relieved in every eye. Field was larger in 7 cases, the same in 2 and smaller in 1; in 5 it could not be taken. He uses a dental engine to rotate his trephine, and warmly recommends it for the purpose. If the 3 blind eyes are excluded, it will be seen that vision was maintained or improved in 9 out of 12, *i.e.*, in 75 per cent.

Remmen[6] has reported twenty cases of Elliot's operation, in which the tension was reduced in every case, and in none was vision lost.

Wendell Reber,[7] of Philadelphia, publishes the notes of 26 cases in which he operated for glaucoma by sclero-corneal trephining, and thus summarises his experience.—"Twenty-six eyes were operated on by Elliot's method in 16 subjects. The results are as follows:—

"In six eyes that were sightless, the seat of absolute glaucoma, and in every way degenerated eyes, the patients were rendered free from pain and an eyeball that was cosmetically satisfactory was preserved to them. This is no small matter, as they were all the very type of eyes that are

likely to develop expulsive choroidal hæmorrhage at the time of operation. Moreover the teaching in many quarters is that in absolute glaucoma, the safe measure is enucleation, an operation from which people instinctively shrink with horror. If trephining will preserve to such patients an eye that will be painless and quiet, it has on this premise alone proven its title as an acceptable operation.

" In five other eyes that were sightless, there was a small degree of vision gained by the operation, such as hand movements at 1 to 3 feet.

" In the remaining fifteen eyes the results were good in that the eyes gained considerably in vision and in usefulness. The greatest gain in vision after trephining was from 2/60 to 6/12. The least gain was from 5/12 to 5/10, but this gain was greater than appears on its face, for it was the patient's remaining eye, the fellow eye having been already blinded by chronic simple glaucoma. To-day (after one year) this patient's optic nerve excavation remains just what it was one year ago. His field of vision is enlarged and the cicatrix is filtering nicely ; we are therefore justified in feeling that the usefulness of this eye will be preserved to him for many years, which is all that can be claimed for any glaucoma condition."

In conclusion he adds :—" It is therefore our feeling that sclero-corneal trephining (sclerostomy) has come to stay ; that it is by all odds the safest operation for glaucoma in the hands of the neophyte ; that if this postulate is correct, many more prophylactic operations for glaucoma may be done now, than have been done in the past. And if this operation is the safest one in the hands of the operator of small experience, is it not reasonable to push the argument further, and hold that it is therefore the operation of greatest safety under the guidance of the operator of large and long experience ? Time only can bring a just and full judgment of this latest method for the surgical control of glaucoma."

Denig,[8] of New York, has himself trephined twenty-one eyes, and has an experience of fifteen cases of the same operation in the practice of others. He prefers trephining to other operations in simple, in hæmorrhagic and in secondary glaucoma.

Peter,[9] speaking from an experience of twenty-six cases of trephining, says " from the results thus far obtained, the operation promises to be the operation of the future in all forms of glaucoma. My oldest case, and one of the worst of the series, I trephined over eighteen months ago. Relief from pain was prompt, as in all cases, and visual acuity is as good and fields quite as large to-day, as they were immediately after operation.

. . . we approach a case of glaucoma *in extremis* to-day with much less doubt as to the outcome. . . . The value of the operation as a prophylactic cannot be over-estimated; . . . this is a measure which may save many eyes which otherwise might be doomed to blindness."

El Rasheed,[10] of Assiut, furnishes statistics of 125 eyes operated on by Drs. MacCallan, Oulton, and Sobhy and by himself; the figures are as follows:—operations for acute and sub-acute glaucoma 17, for chronic glaucoma, 81, for glaucoma absolutum 24, for secondary glaucoma 3; vision was improved in 64, remained the same in 29, diminished in 8 and was absent from the commencement in 24. Tension was permanently reduced in 100, was reduced but again rose to above normal in 14, remained above normal throughout in 11; trephining was repeated with improvement in tension in 3. Simple trephining was done in 40; a buttonhole iridectomy was made in 7, and a complete iridectomy in 78. Iris prolapsed and had to be excised in 2 cases; the conjunctival flap required a stitch at the first dressing in 4; the conjunctiva was buttonholed once; vitreous prolapsed 4 times; retinal detachment occurred once: hæmorrhage in yellow spot seen once; wound became septic in 2; eyes excised after operation to relieve pain or tension in 2. The author is indebted to Dr. MacCallan for these figures, which embrace the cases operated on from October 20th, 1911, to February 15th, 1913.

Zubizarreta,[11] of Buenos Aires, "thinks that Elliot's operation is the most simple and certain method of establishing a filtering scar, and that this is at the moment to be regarded as the operation of choice in cases of chronic glaucoma."

The author has heard from a number of British surgeons, who have been practising trephining practically since the operation was first described, and who, though, owing to pressure of work, etc., they have not been able to furnish him with exact statistics, have yet assured him that they have definitely adopted the operation in their practice, and that they continue to be well satisfied with their results therefrom. Amongst others may be mentioned **Lawson,** of London, who has been trephining since 1910, and who has used the method on about 100 cases, **Gray Clegg,** of Manchester, another of the pioneers of the method in England, who has over 110 cases on record, and **Nimmo Walker,** of Liverpool, who has trephined over 30 cases since April, 1910, and who has kindly furnished the following notes of his earliest case: "A case of acute glaucoma in which tension had twice returned after trephining; V reduced to light perception; rose after trephining to 5/9, and remained good till patient's death a few months ago from

apoplexy" (*i.e.*, a history of about 3½ years). **Maddox,** of Bournemouth, who ranks amongst the first supporters of the operation, writes in a personal communication: "I still regard your operation as admirable in most cases of both chronic and acute glaucoma, except in the absence of tension. In one case of double acute glaucoma, iridectomy was done on the one eye, and trephining on the other, and the trephining answered best."

In addition to the names which have already been mentioned, there are many distinguished Continental surgeons who have performed a number of sclero-corneal trephinings, and have expressed their satisfaction with the method. Among such are:—**Barraquer,** of Barcelona; **Coppez,** of Brussels; **Fuchs,** of Vienna; **Kuhnt,** of Bonn; **Sattler,** of Leipzig; **Schnaudigel,** of Frankfurt; **Vogt,** of Aarau (Switzerland); **von Mende,** of Mitau (Russia); and **Wagenmann,** of Heidelberg.

From Canada and America the volume of evidence is overwhelming. There a host of surgeons are freely using the trephine; amongst others the list includes:—**de Schweinitz, Webster Fox, Friedenwald, Gifford, Jackson, Knapp, Marple, McReynolds, Reeve, Todd, Weeks** and **Wyler.**

REFERENCES.

(1) **Wallis.**—*The Ophthalmoscope*, October, 1913.
(2) **Stock.**—*Proceedings of XVIIth International Congress of Medicine, London*, 1913, Section IX, Part 2.
(3) **Meller.**—Abridged translation and epitome from *Klinische Monatsblätter für Augenheilkunde*, Januar, 1914. *The Ophthalmoscope*, April, 1914, by Wilbur B. Marple.
(4) **Axenfeld.**—"Newer Operations for Glaucoma." *Klinische Monatsblätter für Augenheilkunde*, September, p. 383.
(5) **Pischel.**—*California State Journal of Medicine*, October, 1913.
(6) **Remmen.**—*The Ophthalmic Record*, January, 1914.
(7) **Reber.**—*The Ophthalmoscope*, April and May, 1914.
(8) **Denig.**—*The Ophthalmic Record*, January, 1914.
(9) **Peter.**—*The Ophthalmic Record*, January, 1914.
(10) **El Rasheed.**—*Bulletin de la Soc. d'Ophtal. d'Egypte*, 1914.
(11) **Zubizarreta.**—*Archiv. de Oftal. Hisp-Amer.*, Noviembre, 1913.

CHAPTER XIII.

ON THE SITE OF TREPHINING FOR GLAUCOMA: ITS IMPORTANCE.

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Holth, of Christiania[1] recently put forward the *obiter dictum* that "anterior sub-conjunctival sclerectomy is destined to be the basis of all future surgical treatment of chronic glaucoma." This attitude, one is led to believe, is becoming more and more widely adopted by thinking men in our specialty, and, indeed, may be said to be to-day the orthodox one.

The writer was present at the Birmingham meeting of the British Medical Association, and gathered that the consensus of opinion among these present was not, however, in favour of adopting similar views with regard to acute glaucoma. Whether further experience of the newer operations in this connection will modify these opinions remains a question of time. Possibly it will.

The writer has recently had the privilege of spending three months in Lieut.-Colonel R. H. Elliot's clinic at the Government Ophthalmic Hospital in Madras, India. While there, Colonel Elliot, with great generosity, placed the whole of his large amount of clinical and statistical material dealing with trephining at his disposal for investigation. The writer has had the opportunity of seeing the operation done often and of doing it himself some thirty odd times.

It is not proposed in this communication to attempt to justify the operation *qua* operation by reference to results or to statistics. This has already been done by Colonel Elliot in papers read at the Ophthalmological Society[2], at Oxford, and at the Birmingham meeting[3]; and further results and statistics will be forthcoming in due course.

It is only intended to emphasise points of detail in the operation elaborated by Elliot, points, as it seems to me, of such importance that no apology is needed for their reiteration.

The historical aspect of the question has been ably dealt with by Sydney Stephenson[4], but, as trephining for glaucoma is still

sometimes spoken of as the " Fergus-Elliot " operation, the essential difference between the operations done by these two surgeons cannot be too clearly borne in mind. So vital is the difference in procedure and aim between the two that the future of trephining for glaucoma may be said to stand or fall on its just appreciation.

Dr. Freeland Fergus's own account of his operation is as follows :—" My operation is only a modification of that of Lagrange ; it is merely an easier and more convenient way of performing it. If Lagrange's operation is bad, so is mine ; if Lagrange's is good, mine is only a simpler way of performing it. A large conjunctival flap is dissected up, as for the operation of advancement. Then the trephine is used to remove a piece of sclera as near to the cornea as possible. The point of a fine iris repositor is next passed from the scleral opening right into the anterior chamber."[5]

Mr. E. Treacher Collins, who was present when Dr. Fergus described his operation, said at the time : " Dr. Fergus clearly did two things (i) the removal of a small piece of sclera by trephining, (ii) the breaking through the pectinate ligament with a spatula—*i.e.*, a cyclo-dialysis."[6]

Dr. Fergus himself[7] at a later date, wrote : " Mr. Treacher Collins very properly said in the discussion at Belfast, that my operation was not merely a trephining, but was also a cyclo-dialysis. I have combined the trephining with cyclo-dialysis since the month of March, 1909 ; I do not remember to have performed a simple trephining since that date."

Dr. A. J. Ballantyne, a colleague of Dr. Fergus in Glasgow, who, one presumes, has seen the operation frequently performed by its originator, writes in a very able and comprehensive review of the subject[8] " cyclo-dialysis has again appeared as an integral part of Fergus's sclerectomy with the trephine. A conjunctival flap is dissected up towards the cornea, and laid over the corneal surface, while, with the trephine, a small disc is removed *a millimetre or two from the apparent corneal margin*. At first, the operation was completed at this stage by replacing the conjunctival flap, but Fergus soon introduced a modification *which now forms an essential part of this operation*, namely, the passage of an iris repositor from the trephine hole into the anterior chamber, *keeping it in close contact with the sclera and cornea*. The conjunctiva is then replaced and stitched in position." (The italics are mine.)

Fuchs[9], in defining cyclo-dialysis, says : " In this operation, a blunt instrument, introduced through an incision made in the sclera *several millimetres behind the cornea*, is worked forward so as to detach a portion of the ciliary body

from its insertion." This definition squares with one's preconceived ideas of what is meant by cyclo-dialysis; also, with what the word itself implies. The aim of the procedure is to open up a communication between the anterior chamber and the supra-choroidal lymph space by separating the attachment of the ciliary body over a limited area.

Some anatomical considerations will now be adduced, mainly derived from the recent work of Dr. Thomson Henderson[10], the value and accuracy of whose anatomical observations have not, so far as we are aware, been controverted. These throw some light on the question of cyclo-dialysis. By the term cribriform ligament is meant the structure usually known as the pectinate ligament.

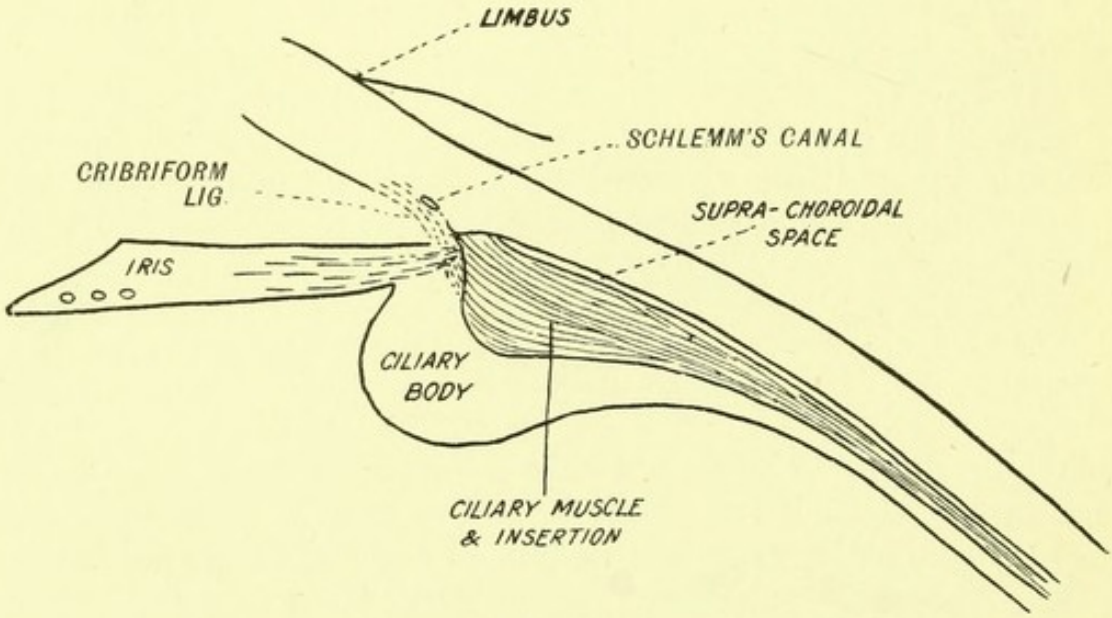


FIG. 42.

"In the region of the corneo-sclera are a large number of fibres running in a circular direction, of which the most prominent collection lies just posterior to Schlemm's canal, where it has received the name of the scleral ring. This particular aggregation of fibres is of great importance in keeping the ciliary muscle in position (p. 24). The scleral ring itself is not, however, as has been described, the point of attachment of the ciliary muscle, but it merely acts as a fixed point which steadies the cribriform ligament during action of the muscle (p. 28).*

"The loose connective-tissue stroma of the iris root is attached to the fibres of the ligament at a point just posterior

*Pages 24, 26, 28, and 29 referred to in this chapter are from Dr. Thomson Henderson's book above quoted and not from the present work.

to the scleral ring. The ciliary body proper is thus excluded from taking any part whatever in the formation of the angle of the anterior chamber, which is a true angle, the outer boundary being formed by the cribriform ligament and the inner by the anterior surface of the iris root, while its apex is formed by the junction of these two " (p. 26).

A reference to the figure, which is adapted from Henderson's work on *Glaucoma*, will illustrate some of the above points. The drawing is from an eye hardened in Müller's fluid, which causes detachment of the ciliary body. The attachment of the ciliary body at a point behind the scleral ring, and its association with the stroma of the iris root are shown. The figure also shows the supra-choroidal space converted from a potential to an actual one. " The supra-choroidal lymph space is regarded as being closed anteriorly by the attachment of the ciliary body to the sclera " (p. 29). To effect a cyclo-dialysis, these connections must be divided.

Now it is clear from the foregoing that to perform a cyclo-dialysis from without, some part at least of the trephine hole must lie behind the attachment of the ciliary body, which, as we have seen, lies behind the plane of the filtration angle and the stroma of the iris root ; unless, indeed, one passes the repositor backwards in the direction of the ora serrata. But this, from his own description, Fergus obviously does not do. Fergus himself says that he places his trephine hole " as near as possible " to the cornea. Ballantyne says a disc is removed " a millimetre or two from the apparent corneal margin." One presumes that the trephine used is not larger than 2 millimetres in diameter.

In the absence of more precise information, we are driven on to the horns of a dilemma. Either the posterior margin of the trephine hole is placed behind the attachment of the ciliary body, posterior to the plane of the angle of the anterior chamber ; or else, if not so placed, we must assume that the repositor does not effect that cyclo-dialysis " which is an essential feature of the Fergus operation." In the latter contingency, one may surmise that in some cases of chronic glaucoma, an adherent iris may be detached or perforated by the iris repositor, and the posterior chamber thus entered.

The Fergus operation is stated above to be merely a modification of that of Lagrange, whose aim is, while making his incision, " to sever the scleral insertion of the ciliary muscle " —in effect, a cyclo-dialysis : this, in addition, to his sclerectomy. To do this, he necessarily makes a very peripheral incision.

It is obvious from what has gone before that the Fergus

operation of trephining has, in common with all the old operations for the relief of glaucoma, from von Graefe's classical iridectomy down to Lagrange's and Herbert's latest procedures, the essential feature of a very peripheral opening into the anterior chamber. Lagrange and Fergus go further, and apparently place the opening behind or over the ciliary body—a necessity, if interference with that organ or its insertion be deemed desirable.

The question that now arises is whether this is sound practice. Parsons states[12] that "the lymph which passes along this (supra-choroidal) route is small in quantity, and is derived solely from the choroid and the ciliary body, involving only the internal economy of these structures, and having nothing to do with the maintenance of the intra-ocular pressures."

Fuchs, at the Belfast meeting[13] said that "he had tried trephining further away from the cornea. He had tried cyclodialysis in several cases, but he had recently given it up, as he had found that the symptoms recurred, and pathological examination had shown that in the places where the cyclodialysis was performed the tissues were more cicatrised, and that no permanent communication between the anterior chamber and the perichoroidal space had been obtained."

One does not raise what Dr. Fergus has called "the bogey of the ciliary body"[14] from the side of septic or sympathetic dangers, but rather from that of increased liability to vitreous accident and to hæmorrhage from the engorged ciliary vessels, points strongly brought out by Elliot in his original communication.[15] Both these occurrences are likely, in the writer's experience, to nullify the effect of the most carefully planned operation. And one feels sure that in less skilled hands than those of Dr. Fergus, both these accidents must not infrequently happen, and in many cases inevitably. This is, and ever has been, the danger of all previous glaucoma operations.

Now the one notable advance of recent times which really breaks fresh ground in the operative treatment of this disease has been made by Elliot, who has insisted that it is desirable in the interests of safety to open the tunics of the eye as far in front of the ciliary region as possible, and has devised a *technique* whereby a fistula may be obtained so far forward as to be semi-corneal in position. Furthermore, he has shown that it is possible to obtain permanent and satisfactory filtration by so doing. This insistence on a semi-corneal opening as an essential feature of the procedure, at once places Elliot's trephine operation in a class of its own.

Colonel Elliot has described his method in detail, as before stated, in the *Transactions* of the Ophthalmological Society,[2]

and in *The Ophthalmoscope*, to which those interested are referred. Only a few points therefore will be alluded to here.

It is essential that a portion of the trephined disc shall consist of clear corneal tissue—from one-fourth to three-fourths of its area. The site is exposed by stripping the conjunctiva by short snips with the scissors and blunt dissection, not only up to the limbus, but sometimes from one to two millimetres beyond it. The conjunctival layer of the cornea, continous with the bulbar conjunctiva, appears to strip along its natural plane of cleavage. The distance that this can be done without button-holing the flap needs to be seen to be believed.

The iris is dealt with only if it prolapses into the hole on the completion of trephining. This it appears to do in about 50 per cent. of the cases. A button-hole iridectomy is made by snipping with fine scissors *in situ*. This is done to prevent blocking of the wound, and for no other reason. Further experience may show that such an iridectomy is desirable in a majority of cases ; the writer's preference is certainly in this direction. With this exception the uveal tract is left severely alone.

In performing the operation of trephining for glaucoma, one must decide definitely whether to adopt Fergus's procedure of trephining and cyclo-dialysis, with all that the latter implies, or Elliot's corneo-sclerectomy. The two operations must not be confused merely because the same instrument is used in the initial stage of both.

The writer visited Madras with a prejudice in favour of a modified Lagrange's operation, *i.e.*, a small iridectomy, plus a sclerectomy with scissors, having performed this with success in a number of cases. He now feels convinced that trephining, if carried out on the above lines, is the simplest and safest method of obtaining an effective fistulisation of the anterior chamber.

In this connection, the conclusions reached by Weekers and Heuvelmans, of Liége[16], are interesting. They performed an experimental subconjunctival fistulisation of the anterior chamber in rabbits, and found that after five months, the tract was patent, microscopically as well as clinically. They summarised as follows :—" (i) The whole thickness of the sclera is to be excised, if a permanent fistula is to be obtained. (ii) For several reasons the incision must be made as close to the cornea as possible. When the sclerectomy is made too far from the limbus, the loss of substance in the sclera may be obstructed by the ciliary body, which may prolapse." Their conclusions thus support Elliot's main contentions.

That fistulisation of the anterior chamber, which has every

appearance of permanence, is demonstrable clinically at least two years after operation, the writer has satisfied himself by personal observation in Madras. And, since iridectomy is not eminently satisfactory in a large class of glaucomas, if the dictum at the head of this paper be accepted as axiomatic, Elliot's operation of corneo-sclerectomy with the trephine may well become the operation of the future.

REFERENCES.

(1) **Holth.**—*The Ophthalmoscope*, November, 1909, p. 781.
(2) **Elliot.**—*Transactions of the Ophthalmological Society*, Vol. XXXI, 1911.
(3) **Elliot.**—*British Medical Journal*, November 4th, 1911, p. 1160.
(4) **Stephenson, Sydney.**—*The Ophthalmoscope*, February, 1910, p. 99.
(5) **Fergus.**—*Ibid.*, February, 1910, p. 75.
(6) **Collins.**—*British Medical Journal*, October 2nd, 1909, p. 984.
(7) **Fergus.**—*The Ophthalmoscope*, February, 1910, p. 75.
(8) **Ballantyne.**—*Ibid.*, July, 1910, p. 515.
(9) **Fuchs.**—"Diseases of the Eye," third edition, p. 425.
(10) **Henderson, Thomson.**—"Glaucoma."
(11) **Lagrange.**—Quoted in *The Ophthalmoscope*, July, 1910, p. 511.
(12) **Parsons.**—"Pathology of the Eye," p. 995.
(13) **Fuchs.**—*British Medical Journal*, October 2nd, 1909, p. 984.
(14) **Fergus.**—*The Ophthalmoscope*, February, 1910, p. 76.
(15) **Elliot.**—*Ibid.*, December, 1909, p. 806.
(16) **Weekers.**—Quoted in *The Ophthalmoscope*, March, 1910, p. 225.

CHAPTER XIV.

A COMPARATIVE STUDY OF THE MODERN OPERATIONS FOR GLAUCOMA.

The time has come when surgeons may judge the modern glaucoma operations from the standpoint of scientific surgical principles, and may endeavour to formulate the conditions which they should aim at fulfilling in the performance of a sclerectomy. Once this has been done we can proceed, in the light of the conclusions so reached, to study the various operations now before the profession, with a view to determine which of them best recommends itself for our adoption.

The following list represents an effort in the direction indicated:—

(1) The filtration produced should be sufficiently free, and should be permanent in character; (2) the piece of sclera or of corneo-sclera removed should be as small as possible, consistent with the maintenance of efficient and permanent filtration; (3) the method of removing the piece of the ocular tunic should be such that no tissue is "cut to waste"; in other words, every scrap of the space occupied by the tissue to be removed should be made available for the filtering channel provided; otherwise, there will ensue a needless weakening of the coats of the eye; (4) it should be possible (*a*) to determine beforehand the precise dimensions of the portion of the ocular tunics to be removed, and (*b*) to give exact mathematical effect to that determination when the time comes to translate it into operative action; (5) the risks of the operation should be reduced to a minimum; (6) the *technique* should be made as easy as possible, consistent with efficiency; and (7) the performance of the operation should not, in the event of failure, be a bar to its repetition, or to the selection of some other operative procedure in its stead.

If the foregoing conditions are accepted, we may proceed to examine the various operations now in vogue, taking each in turn.

We commence with **sclero-corneal trephining.**

(1) We have under our observation a number of cases in which uninterrupted filtration has been going on for periods varying from one to four years, without mentioning those of shorter

duration. The size of the disc removed in these cases has varied from 1 mm. to 2 mm. The tension of the eyes has shown no tendency to rise above normal, and the freedom of filtration is clearly demonstrated by the presence of a filtering area in each case. We may therefore fairly conclude that permanent filtration has been established.

(2) It is hardly possible to understand how a smaller scleral resection can be made than that represented by a circular disc 1 mm. in diameter, or by the corneal half of a 2 mm. disc; and yet we have shown that if the cornea is split, and the iridectomy is performed according to our latest *technique*, there is no difficulty in obtaining permanent filtration by the removal of this very tiny piece of tissue. The contention, put in other words, is that the size of the sclerectomy has been reduced to the smallest possible limit. Moreover, for any definite length of incision made, a circular wound gives the maximum possible of surface area.

(3) A cylindrical piece of corneo-scleral tissue is neatly removed by the trephine, leaving a clean-cut, straight-walled canal of the desired size, of uniform calibre throughout, and running perpendicular to both surfaces of the ocular tunics. Could the conditions be more ideally fulfilled?

(4) By varying the diameter of the trephine, the size of the sclerectomy can be arranged with mathematical accuracy. One can start a trephine operation, with the absolute certainty of making the hole in the ocular tunics of the exact size determined on, before the patient leaves his bed for the operation table. This obviously makes for operative accuracy. Even if we use a 2 mm. trephine, and deliberately sacrifice half, or more of our disc, our conditions are such as to still leave us with very complete control over the size of the piece of sclera removed.

(5) No one can afford to overlook the question of safety in a glaucoma operation, and although the arguments advanced in this section will appeal to a surgeon in a ratio inverse to his operative experience, they are, none the less, such as must be weighed even by the most expert. In trephining, we *perform our actual sclerectomy on an eyeball which is to the last moment closed, and distended with fluid.* The deeper parts are thus obviously greatly protected. Moreover, all the structures of the globe, and not the least in importance, the lens and the vitreous body, enjoy to the latest possible moment, their full integrity, their usual position, and their accustomed support. Yet another point.—The trephine wound is made as far away as possible from the angle of the chamber, thus minimising the dangerous possibilities of interference with the

ciliary body or with adherent iris-base. This subject has already been dealt with, but we would return to it only to say, that our fear of complications arising from such interference, grows with every year of operative experience. It is a widely shared and very deliberate opinion, that every possible effort should be made to give this "dangerous area" as wide a berth as possible.

There is a last point of such importance as to demand a separate paragraph. In dealing with cases of acute glaucoma, various writers have recommended that before any other operation is attempted, the tension of the eye should be lowered by performing a posterior sclerotomy, and thus draining off some of the excess fluid in a gradual manner. It has been recognised that the slow reduction of the tension, and the protection afforded by the fact that the wound or wounds in the scleral coat are very small, are two factors which make powerfully for safety in such cases. The same argument applies to those late chronic cases of glaucoma, in which the height of the tension and the state of the vessels make an intra-ocular hæmorrhage a pressing danger. *The writer claims for trephining that, by virtue of the small aperture made, it approaches more nearly to the conditions, and therefore to the implied safety, of a sclerotomy, than does any other form of sclerectomy.*

(6) It has already been urged that the operation of sclero-corneal trephining is not a difficult one. Looking back, we can count by tens the surgeons who learnt to trephine in Madras, and can say that not a single one of them who was able to perform, or to learn to perform, ordinary intra-ocular operations, had any real difficulty in acquiring the *technique* of this procedure. In addition to this, it has been the author's good fortune to visit a large number of clinics in America and in England, and to see there the results of not a few operations performed according to the *technique* he has advocated. This experience has conclusively proved to him that very many surgeons have appreciated the details of the procedure from written descriptions alone, and have succeeded in obtaining results which could hardly be improved upon.

(7) With our new *technique* we seldom find a second trephining necessary; but in our earlier experience we have trephined the same eye on a second and even on a third occasion, or have resorted to some other form of operative procedure when we found trephining had failed. Later trephinings have sometimes proved successful when the first attempt had disappointed us.

We pass on next to the erstwhile classical **iridectomy** of

von Graefe, and the author believes that he is not alone in maintaining that this operation is only of value when it leads either to the establishment of a permanent filtration, or, at any rate, of a filtration which goes on long enough to allow the normal conditions of the eye to be re-established for a time at least. In the many clinics which he has visited, it has been no infrequent experience for him to be asked to explain the *modus operandi* of cure by iridectomy in cases in which filtration had not been established. On asking to see the cases, they have been presented to him with the comment that "the conjunctiva over the old iridectomy wound was smooth and even." On calling for a probe or spud, he has had no difficulty in demonstrating well-marked conjunctival œdema in every such case, and in satisfying the surgeons present that free filtration was obviously taking place. *A smooth appearance of the conjunctiva is no test of the absence of filtration.* It is admitted that a certain amount of œdema may be demonstrable in glaucomatous eyes which have not undergone operation; this is an expression of obstructed circulation, but is easily distinguishable from the free and watery œdema, which we are discussing. With a very little experience, no confusion between the two need arise. Iridectomy, in the author's experience, is practically useless in chronic glaucoma, and less certain than trephining in acute glaucoma. Where, however, it is most open to attack is on the ground of safety. We have to take into account the large scleral wound made, and the fact that this lies close to the ciliary body. The sudden release of all tension and the simultaneous weakening of the supports of the lens and vitreous body create very unfavourable conditions under which to make the crucial step of the operation. The author has had the opportunity, granted to very few, of teaching the operative surgery of the eye, on the living, to a large number of medical men and women, and as a result of this experience, which probably embraces over one hundred pupils, he has not the least hesitation in asserting that even under the most favourable circumstances, it is harder to teach a learner to make a neat, clean iridectomy, than it is to teach him to perform a cataract extraction or any other eye operation. The man who can make a "finished iridectomy," quietly and cleanly, has graduated as an ophthalmic operator. Not the least of his difficulties is the management of the sharp point necessarily introduced into the anterior chamber. When to the initial difficulties, we add all that an iridectomy for glaucoma implies, we constitute an operative procedure which even the boldest never undertakes lightly, and which by comparison makes

trephining seem a safe and easy operation. The writer has been at considerable pains to ascertain whether the views of other surgeons of large operative experience coincide with his own as to the difficulties and risks of a glaucoma-iridectomy, and the answer has been overwhelmingly convincing. Not a single one of them had the least hesitation on the subject. It is not that we have any slavish fear of the procedure, but rather that experience has taught us not to undervalue its difficulties and its dangers.

On **Herbert's operation** the author diffidently offers two criticisms of a tentative nature, *viz.* : (1) he thinks it doubtful whether this method gives the same assurance of permanent filtration that trephining does (this seems to be the experience of others also) and (2) it is, to his mind, a grave objection that the incision is made so near to the ciliary region and to the iris base.

We come now to **Lagrange's operation,** and in discussing this procedure, one writes with the greatest deference of its distinguished author, to whom surgery owes so much, and who has been the pioneer of sclerectomy.

(1) The Lagrange method is open to the objection that it demands the making, in the first instance, of a scleral wound which is far larger than that which the surgeon contemplates as permanently necessary.

(2) The actual sclerectomy is performed on an eye which has *already been laid open to this wide extent.* It is the experience of very many, that every moment of such an operation is fraught with the dangers of accident to the lens or vitreous body, or of intra-ocular hæmorrhage, and is full of anxiety to the surgeon.

(3) The wound made in the second stage of the operation, in resecting the piece of sclera, is spindle-shaped, tapering off at each end ; in consequence, a part of each end of it will be sacrificed by primary union. It is obviously the intention that the ends of the original knife-incision should become re-united, and to this, attention was directed in paragraph (1) above ; but our present point is, that over and above this, the union invades the sclerectomy wound itself. An inspection of Lagrange wounds, whilst in process of healing, will demonstrate this. It is difficult to say how far this healing will extend, and although we lay little stress on the possibility of resulting astigmatism, it is obvious that we have here a factor which makes the exact gradation of the size of the wound very uncertain.

(4) This uncertainty is accentuated by the difficulty the surgeon finds in removing, according to the *technique* of the operation, a piece of sclera of the exact size which he desires

to remove. In the experienced and able hands of Professor Lagrange, this difficulty has doubtless long ceased to exist, but it is a very real one for the average surgeon, in whose practice it involves a want of scientific accuracy in the results obtained.

(5) The scleral wound (*vide* Professor Lagrange's drawings) is triangular on cross-section, the base of the triangle lying beneath the conjunctiva, and the apex against the angle of the chamber. The filtering channel is therefore much wider at its outflow end than at its inflow: if the deep end of the channel is wide enough for the purpose of filtration, the conjunctival or outflow end must be needlessly wide, and an unnecessary weakening of the scleral tunic must be involved; and *vice versa*.

(6) The first incision lies over the neighbourhood of the ciliary body and of the iris base, a condition to which our objections have already been stated.

It cannot fail to be of interest to review the *pros* and *cons* of this last question. Lagrange (1) urges that inasmuch as the angle of the chamber is the normal site for the escape of fluids from the eye, we should keep our filtering scars to that neighbourhood; (2) he agrees with the views of Weber, Czermack, and others, as to the possibility of an increase in the filtration at the level of Schlemm's canal being brought about by various operative measures; and (3) he is inclined to attribute an important *rôle* to the opening up of a communication between the anterior chamber and the supra-choroidal space. Axenfeld has lent his support to the suggestion that operative measures may bring about an increase of drainage in the deeper and perhaps less shut-off layers of the sclero-cornea, and suggests that such a result recalls the normal filtration of Schlemm's canal and the advantages sometimes reaped by simple sclerectomy or by irido-dialysis. de Wecker held that scleral wounds are more porous than corneal ones, and Lagrange believes that this is a factor in the success of the old iridectomy. In possible relation with this idea it has been recently suggested that all wounds made in the cornea must necessarily fill up; the view would appear to be that a corneal wound has an inherent tendency to proliferate: Sattler's observation proves this hypothesis to be erroneous. The belief in the existence of "porous wounds" has recently been championed by Herbert, who has, however, failed to bring forward any anatomical evidence in support thereof. So much for the argument in favour of confining the opening in the tunic of the eye to the sclera, and of not permitting it to invade the cornea.

Now for the other side of the case:—(1) Lagrange has himself said "it is essential, if one desires to cure a glaucomatous

patient, that one should avoid touching the ciliary body." With that sentiment the author has always been in absolute agreement; indeed it has been to him almost an article of faith: the object he has set before him has been to tap the eye of its fluids while rigidly abstaining from all interference with the ciliary body or iris. (2) In establishing subconjunctival filtration, which is Lagrange's avowed object as well as our own, we are making a new and abnormal path for the escape of the aqueous; and there would appear to be no definite object in keeping close to the old site of filtration, if we can more safely and more easily accomplish our purpose by adopting a more anterior route. The writer has now an experience of well over 1,050 trephinings to judge from, and if one fact has stood out more clearly than any other, it is that the further forward we place our filtering stoma, the safer are we from trouble due to the involvement of some portion of the uveal tract. (3) The view that an increase in filtration may be brought about at the level of Schlemm's canal by operative measures, is one that still lacks the sanction of anatomical confirmation, and the same criticism applies to all that has been said in favour of the possibility of the existence of a filtering, as opposed to a fistulous scar. As to the latter point, the writer submits that all that we know of the behaviour of scar tissue elsewhere in the body is rigidly opposed to the conception that it is likely to remain "porous," and thereby to favour the transudation of fluid across its mass. (4) A clinical experience of cases which have been watched for varying periods up to about four years after trephining, has conclusively shown that filtration by the sclero-corneal route suffices to maintain the tension of an eye below the normal. The photographs, which appear on pages 140 and 142 show the black hole of the fistula on the sclero-corneal tissue months and years after the operation, and it is quite obvious that the corneal tissue has not made any attempt to proliferate. On the contrary it has (presumably owing to being kept bathed in aseptic aqueous fluid) shown the same tendency to remain unhealed,* which Henderson first pointed out as occurring in the cut edge of the iris after iridectomy. In a large number of hospitals both in Europe and America, the author has seen similar results, so much so indeed that he feels that it is no longer necessary to labour an observation which is rapidly becoming well and widely recognised. (5) With regard to the stress

*A very interesting confirmation of this view has been furnished by Sattler, who enucleated an eye fourteen days after trephining and found that the cut edges of the cornea showed no tendency whatever towards proliferation.

laid on cyclodialysis, one may safely say that the operation is losing such favour as it once enjoyed, and that it has now very few supporters. It owes its inception to the theory of the existence of a "posterior glaucoma" which ascribes this condition to a damming up of fluid in the suprachoroidal space. It seems doubtful whether there is any evidence that such a condition ever exists. There is, we believe, no anatomical evidence to support such a view. What certainly does happen is that the vitreous becomes over-distended and the diaphragm of the eye is thereby pushed forward; but it is difficult to see how cyclo-dialysis can benefit such a condition. On the other hand, there is some anatomical evidence in favour of the view, which would *a priori* present itself to most minds, *viz.*, that a detached ciliary body will tend to speedily re-attach itself, and so to defeat the end for which the operation was undertaken. Apart from this, should a surgeon desire to add a cyclodialysis to his trephining, he can easily and deliberately do so, by following the *technique* advocated by Fergus.

To summarise the writer's objections to the Lagrange operation:—the original incision is unnecessarily and dangerously large, and is placed over a dangerous area; exact gradation of the piece of sclera removed is difficult; and, lastly, the channel made is mechanically incorrect.

In conclusion, it is to be clearly understood that in this chapter no account has been taken of the clinical results of the cases operated upon; the appeal has throughout been to scientific surgical principles, and to nothing else.

Chapter XV.

ANATOMICAL AND PATHOLOGICAL.

In writing the previous chapters, an effort has been made to render them as practical as possible, and to omit anything which might be considered to be superfluous. The result has been that some subjects of very great interest have been passed over with less notice than their importance really demands. It has therefore been decided to collect these, and to deal with them in a final chapter, which the reader can omit, if he will. It is not, however, suggested that the matters discussed are merely of academic interest. The author believes them to be full of deep and practical import.

In selecting a heading for this chapter, the above has been chosen as the most suitable, since the object kept before us has been to study each subject in turn, in the light of anatomical and pathological evidence.

Section 1.

The modifications of the conjunctival flap which have been suggested by other surgeons.

It will be of interest here to discuss, more fully than we have previously done, some of the modifications of the conjunctival flap proposed by different surgeons. **von Mende's**[1] flap

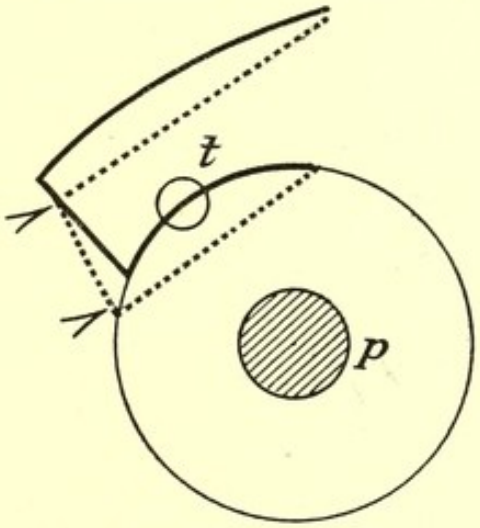


Fig. 43. von Mende's Flap.

The thick lines show the conjunctival incision and the dotted lines show the flap brought into position and sutured there.

t. Trephine hole.
p. Pupil.

is shown in the accompanying diagram. In order to ensure the adhesion of the raw surface of the transplanted conjunctiva to the subjacent cornea, the Russian surgeon removes the corneal epithelium by scraping it with a sharp instrument.

Webster Fox[2] uses a very similar *technique*, but does not abrade the cornea, and leaves the flap to take care of itself. Obviously, in such a case, it can heal down to the cornea only, around the edge of the trephine hole.

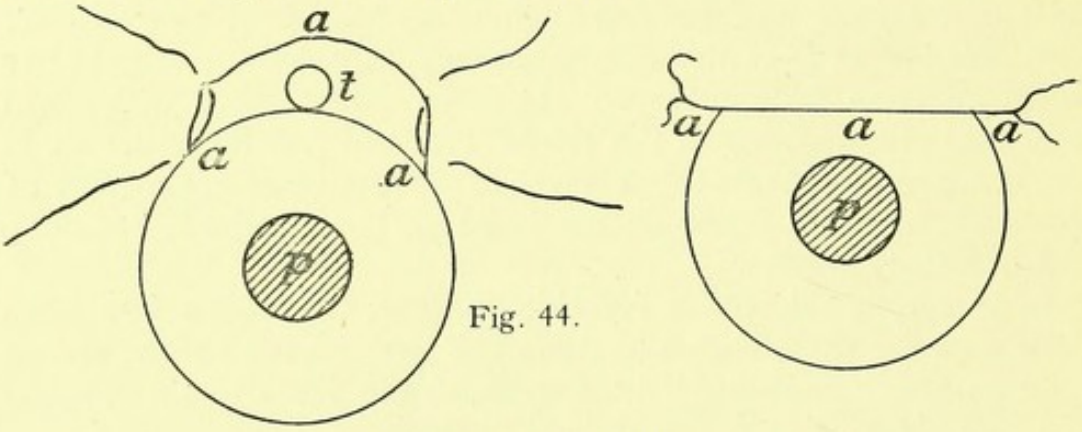


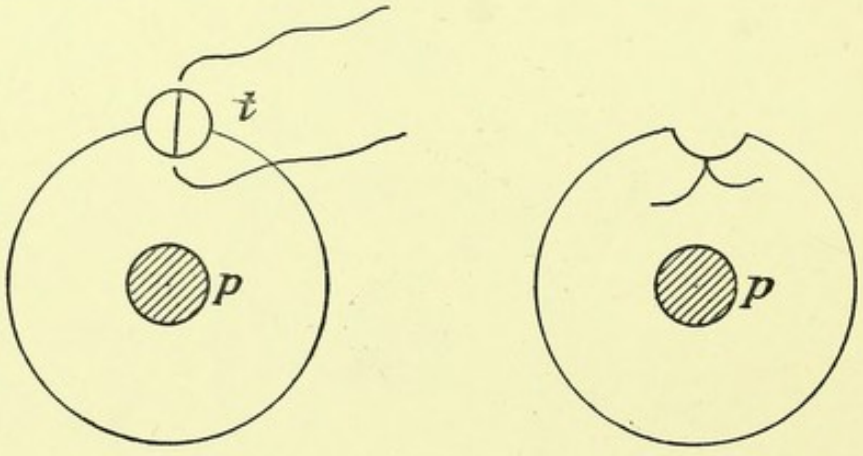
Fig. 44.

Dupuy-Dutemps' Flap.

Flap prepared, and sutures in place for tying. Flap drawn into place, and sutures tied.

a. a. a. Cut edge of conjunctiva.
t. Trephine hole.
p. Pupil.

Dupuy-Dutemps[3] employs the sliding flap shown in the accompanying drawings, and places his trephine hole immediately behind the limbus.



I. II.

Fig. 45. Hill Griffith's earlier Flap.
I. Showing suture in position.
II. Showing it tied.

Hill Griffith's[4] original *technique* was to trephine half on the cornea and half on the sclera without any previous preparation. He then picked up the cut conjunctiva with a fine

needle and suture and attached it to the neighbouring cornea, thus drawing down the conjunctiva and thereby covering in the trephine hole. Later, he modified his *technique* and used a flap very similar to that of Dupuy-Dutemps with this exception, that his trephine hole was placed astride of the limbus as before.

The writer has already given his opinion on the value of these ingenious procedures. The best comment he can now offer on them is to quote at length the remarks made by **Treacher Collins,** before the International Congress, in London (1913). He said: " The question to which he wished to direct attention was that of the essential physiological factors which underlie the formation of a filtration. Some years ago he examined several eyes microscopically in which a filtration scar had formed accidentally in connection with an iridectomy for glaucoma, and found that in them a fold of iris tissue had prolapsed into the wound, preventing closure of the sclero-corneal wound and in time stretching and atrophying. For a time he doubted if a filtration scar could be formed without the entanglement of a piece of iris. Some cases shown by Colonel Herbert convinced him, however, that this was possible. Why was it, then, that an opening made at the angle of the chamber did not always become filled with granulation tissue, become covered anteriorly by epithelium, posteriorly by endothelium, and be as impermeable to aqueous humour as the normal corneal tissue? What prevents the filtration of the aqueous into the normal tissue of the cornea is the endothelium lining Descemet's membrane. He thought, therefore, that the first essential of a filtration scar was to form a permanent gap in the endothelium lining of the cornea. They knew that wounds of the iris, if aseptic, never became closed by granulation tissue; it would seem probable also that wounds of the substantia propria of the cornea, if kept bathed by the aqueous humour and aseptic, would also not be closed by granulation tissue. A wound of the surface of the cornea if kept open becomes filled by a downgrowth of epithelium, and in an unclosed perforating wound the epithelium would extend down along its margins into the anterior chamber. The third essential in the formation of a filtration scar would seem, therefore, not to have the opening in the surface epithelium coinciding with the opening in the sclero-corneal tissue. Lt.-Col. Elliot's operation of trephining seems to meet these three essentials in a most satisfactory way; by removing a circular piece of Descemet's membrane it became difficult, if not impossible, for the gap to be bridged across by endothelium. The substantia propria was left exposed to the aqueous humour, and the large conjunctival flap prevented the surface

epithelium extending into the substantia propria. He thought it most desirable not to make a buttonhole in the conjunctival flap."

Section 2.

THE BEST SIZE OF TREPHINE BLADE TO USE.

In deciding the question of the best size for our trephine blade, we are guided by a number of anatomical, pathological, and clinical data. It is important to have these clearly arrayed before us, in advance. We shall begin with the ascertained anatomical facts.

The anterior chamber is larger than the transparent cornea, and its periphery lies hidden behind the opaque border of the sclera. This point is brought out strikingly under examination of an eye with a corneal microscope; it also explains the ring of light, seen just behind the limbus, when the globe is lit up by a powerful transilluminator. In long standing cases of glaucoma, this portion of the chamber is obliterated by the adhesion of the iris base to the adjacent sclera and by the pushing forward of the ciliary body.

The anterior chamber has an almost exactly circular contour, while the cornea is oval in shape with its long axis transverse; the consequence is that the extent of the angle of the chamber concealed by the scleral border varies considerably in different directions. Rochon-Duvigneaud[5] worked this matter out with great care and gave the following measurements of the interval between the transparent edge of the cornea on the one hand, and the angle of the anterior chamber on the other: (1) above the cornea in the vertical axis, 2·25 mm.; (2) below the cornea in the same axis, 2 mm.; (3) to the nasal or temporal side of the cornea in the horizontal axis, 1·25 mm. These measurements naturally vary in individual eyes, and the author's researches showed that in the smaller and lighter Indian patient they are slightly less than those obtained on European subjects by the French worker.

If the reader will refer to Fig. 42, on p. 154, or to any other reliable illustration of the anatomical arrangements of the parts surrounding the anterior chamber, he will at once see that if the trephine hole is placed far back, its internal opening lies on practically the same plane as that of the iris, whilst the more anteriorly the trephining is done, the greater is the antero-posterior distance separating the two. Now, when a chamber refills after an operation, the natural tendency of the iris is to fall back into its own plane, and thus to be carried as far as possible from any opening in the corneo-sclera, always provided

that this opening lies on a plane anterior to that of the iris, and that the latter membrane is not itself pushed forwards by structures lying behind it, *ex. gr.*, the lens or vitreous body. These anatomical arrangements show that, apart from any pathological considerations arising out of uveal adhesions, there is a distinct element of safety in making the trephine hole well forward.

We turn from the purely anatomical side of the question to its clinical and pathological aspects, and again marshal the facts at our disposal.

Our own experience, supported by that of a large number of other surgeons, has shown that we can, by splitting, in the great majority of cases, easily expose an area of cornea 1 mm. in breadth, whilst in quite a large number of eyes the measurement runs to 1·5 or even to 2 mm.; only in long-standing cases or in those which have been previously treated with sub-conjunctival injections, do we find any real difficulty, and even then we can split the cornea for a space of 0·5 to 0·75 mm.

As has already been explained on p. 143, the splitting of the cornea gives an appearance as if the limbus had been shifted farther forwards on to the cornea. What has really happened has been that we have (1) detached the superficial layers of the cornea from the deeper ones, (2) *exposed the transparent cornea* in the depth of our wound over a small segment of its disc, and (3) thereby rendered the corneal portion of the flap opaque, whereas before it was transparent. It is the more necessary to make this matter very clear, since there is much confusion in some minds as to what the "dark crescent of cornea exposed in the wound" really is. It is not to be explained, as has been done, on the ground that the sclera overlaps the cornea at its edge, and that the transparent cornea is seen through a thin layer of sclera; such an argument is not only beside the point, but it also tends to confuse a very important issue: *this dark crescent, or segment of cornea, is taken from what was before clear transparent membrane*, and it represents the margin of safety gained by the splitting process. It is in fact a measure of the increased distance which we have been enabled to place between our opening in the sclera, and the angle of the anterior chamber.

The investigation of globes which have been removed after the failure of trephining operations has confirmed the correctness of the view, long ago put forward by the author on clinical grounds alone, that impaction of uveal tissue in the trephine hole constitutes a grave complication of a case of trephining. In the first place, it tends to block the hole mechanically, and,

in the second, it is liable to lead to a later obstruction owing to the proliferation of inflammatory connective tissue. Experience has most conclusively shown that since we have adopted the more anterior position for our trephine hole, we have very materially lessened those dangers of the procedure, which were incidental to uveal tissue complications.

If, during the operation, we are to be in a position to deal easily, safely and effectually with any complications, which may arise out of the impaction of iris, or of ciliary body in the wound, we must have a sufficiently large hole to work through ; and our experience, supported by that of many other observers, is, that for this purpose, the trephine should not be less than 2 mm. in diameter. Any smaller opening cramps the surgeon and makes his task difficult and uncertain. At the same time, it is unnecessary to take away the whole of the disc mapped out by the instrument. If we are careful to leave the hinge on its scleral edge, we can easily, neatly and certainly cut off as much of it as we wish to, and can leave the remainder *in situ*, between the permanent hole we have made in the corneo-sclera and the angle of the chamber, thus removing our fistula farther away from the dangerous area.

We may summarise our conclusions as follows :—

(1) It is, on both anatomical and pathological grounds, a great advantage to place our trephine wound far forwards.

(2) It is in most cases possible to so place it, that its anterior edge lies at least 1 mm. in front of the limbus.

(3) If we are working in the upper quadrant of an average European eye, we may consider that we have 3·25 mm. of antero-posterior space on which to plant our trephine, *viz.*, 2·25 mm. from the angle of the chamber to the limbus, + 1 mm. gained by splitting the cornea.

(4) In the event of adhesions existing between the iris base and the sclero-cornea, a variable amount of this space may be lost, but, in operation experience, such loss rarely amounts to 1 mm., and then only in very old and hopeless cases.

(5) If we use a 2 mm. trephine and remove the whole of the disc, the posterior edge of our hole will under favourable circumstances be 1·25 mm. from the angle of the chamber and consequently from attached uveal tissue (3·25 mm. minu 2 mm. = 1·25 mm.). Under unfavourable conditions o adhesion of the iris base, this margin may be sensibly reduced.

(6) If we use a 1·5 mm. trephine, we place the posterior edge of our hole 0·5 mm. farther away from the dangerous area ; but if trouble occurs with uveal tissue impacted in the wound, it is very difficult indeed to cope with it.

(7) By using a 2 mm. trephine, and cutting off one half or

more of the disc, as may seem best suited to the needs of the individual case, we can keep our trephine hole as far away from the angle, as we do when using the smaller blade, or even farther; and yet we can command all the advantages of sufficient room to work in should uveal complications occur.

(8) By placing the trephine hole far forward, we not only gain the advantages incidental to the greater distance between it and the uveal tissue, but we also ensure our wound being on a plane anterior to that which the iris naturally tends to fall into as the chamber fills.

(9) The balance of advantage seems therefore to rest with the use of a 2 mm. blade, and the sacrifice of a part of the aperture by leaving a certain portion of the scleral side of the disc behind.

Section 3.

A rise of intra-ocular tension immediately following trephining.

When the trephine blade enters the anterior chamber of the eye, aqueous fluid at once escapes, unless it is dammed back by prolapsed iris, in which case the flow is delayed, until after the performance of an iridectomy or of an iridotomy. If a blunt instrument, such as a spoon, is now gently pressed on the surface of the cornea, the eye is felt to have become quite soft and yielding. In favourable cases, this reduction in the tension of the globe is maintained, and the patient leaves the operating table with a markedly hypotonic eye. This is, however, not invariably so, and in a certain number of cases the tension again rises, and the globe, within the course of a few minutes, may once more become quite hard. This hardening is so pronounced that it can quite easily be felt by placing the spoon on the cornea. It will then be observed that not only does that membrane fail to dimple under pressure, but also that aqueous fluid, imprisoned in the chamber, can now no longer be expressed through the trephine hole, as it could be when the eye was soft, after the first entry of the trephine. A careful inspection reveals that the angle of the chamber has become obliterated by the pushing forward of the "diaphragm of the eye;" in this way the trephine hole has been mechanically blocked, and filtration through it has been suspended. The chain of events just described is of quite frequent occurrence when dealing with eyes which have long been the subjects of glaucoma; nevertheless the condition has escaped recognition at the hands of many able and observant surgeons, simply because they have not expected it, and

have not been specially on the look-out for it. The surgeon feels the tension relax after the first escape of aqueous fluid, but omits to test it again in the way now suggested, and he therefore discovers the rise of tension only at the first dressing, although it was crying for recognition before the eye was closed on the operating table. In the course of the many demonstrations he has been privileged to give, the author has met with a number of very able surgeons who had peviously failed to recognise this phenomenon, but who were at once able to understand some of their past difficulties in the light of the knowledge so gained. Not only so, but he has also had the satisfaction of predicting before an operation commenced that the course would be as above described, and of subsequently demonstrating every stage of it to the ophthalmologist who was kindly assisting him ; and this not in one clinic, but in several. The point he is emphasising is, that the condition we are discussing is not a rare and mysterious phenomenon, so difficult of observation that those who have not seen it may be justly excused for regarding it with doubt and suspicion, but that on the contrary it is an easily observed occurrence, which is frequently met with in the practice of those who have occasion to operate with the trephine on late cases of glaucoma. Surgeons are familiar with the type of eye in which there is evidence of permanent *distension* of the efferent veins of the eye, in addition to, or even apart from, the signs of congestion. Such eyes are the very ones which are most likely to harden in the way we have described after operation. The supposition is that the diseased and overstretched condition of the vessels is possibly a causative factor in the case.

The after-history of these cases is pregnant with suggestion. In the course of between two and ten days, and sometimes even after 24 hours, the eye becomes soft again, free filtration is established and the margin of the chamber is seen to have been restored to its usual depth, or near it.

As we review these facts, we feel that there are certain deductions which we may safely draw. Beyond these lie a number of questions to which our answers must necessarily be of a speculative character. We will take the former first.

(1) The phenomena we have been discussing are due to an effusion of fluid somewhere behind the diaphragm of the eye (*i.e.*, the diaphragm formed by the ciliary body, suspensory, ligament, lens and iris).

(2) This effusion of fluid causes a movement forwards of this diaphragm, thereby making the anterior chamber more shallow, and mechanically closing its angle.

(3) Filtration of fluid through the trephine hole is consequently suspended until such time as the angle re-opens.

(4) Re-absorption of fluid subsequently takes place, the diaphragm of the eye then falls back into its usual position, and filtration is re-established unless, owing to a long duration of the condition, adhesions have formed and have sealed up the angle of the chamber.

(5) The accident we are discussing invariably occurs while the patient is still on the operation table.

So far we have been on firm ground, but we must now pass on to ask.—What is the fluid whose effusion causes the troubles we have been discussing? Whence does it come? Into what part of the posterior segment of the eye is it effused? How is it re-absorbed? And, lastly, how are we to deal with the condition to which its effusion gives rise?

In view of the suddenness with which the tension rises, the most natural answer to the first question would be that the fluid is blood. In a few rare cases this is correct, but such constitute the exceptions and not the rule. Careful ophthalmoscopic examination fails to reveal any sign of hæmorrhage in the great majority of the cases; and in the opinion of sound pathologists, the speedy re-absorption of the fluid, as evidenced by the fall in tension within such short periods, negatives the idea that it is blood.

Dr. Lancaster,[6] of Boston, to whom the author is much indebted for his assistance, has made the following suggestions in connection with this subject.—"The enormously rapid pouring out of liquid after a paracentesis, by which the anterior chamber may be filled in a few minutes is well known. The fluid partakes more of the nature of a transudation, than the ordinary aqueous does. In the case of the very great change in pressure following the trephining, the liquid must ooze freely out of the ciliary body during the first few minutes. Thus, if other conditions were favourable, we should have a *vis-a-tergo* capable of pushing forward the lens etc., and temporarily blocking the hole."

The idea that the fluid is of the nature of a transudation, is the one that most strongly recommends itself to us. As to the source of that transudation, we are reminded of **Hudson's**[7] work on choroidal detachments, and of his remark that the "fluid responsible for the detachment is derived, probably from the choroidal blood-vessels and not improbably from the veins."

How are we to deal with these cases? It has been suggested that we should perform posterior sclerotomy, and possibly this advice may be sound. The author has, however, no practical experience to speak from, as he has always shrunk from any

active interference, in view of the fact that in the majority of cases tension soon falls of itself. If, however, it does not do so, the condition is truly desperate and *any* measure might well be tried. His own practice under these circumstances has been to throw back the flap and puncture the vitreous through the trephine hole. In some cases this procedure has been justified by a measure of success, but it is conceivable that a posterior sclerotomy might be a more satisfactory operation to perform.

It would be as undesirable as it would be incorrect to give the impression that this post-operative transudation of fluid is, by any means, peculiar to the operation of sclero-corneal trephining. It is nothing of the kind. Every surgeon of large experience meets with cases in which, during an iridectomy or a Lagrange operation, the vitreous wells up into his wound, forcing him at once to close the eye ; too often then the vitreous remains permanently impacted in the incision. The condition depends simply on the sudden lowering of the intra-ocular tension, which must follow the perforation of the globe by any operative measure destined for the relief of glaucoma. If it is more commonly seen after trephining than after the older operations, this is because the safety of the former method has encouraged us to include in our operation list many cases, which under the old conditions we would not have dared to touch, and which we would have feebly left to their fate of inevitable blindness.

It has been suggested that we should do well to perform a posterior sclerotomy as a preliminary step to the operation with the trephine. The author has considered this suggestion very carefully and is not in favour of adopting it. Trephining so nearly approaches sclerotomy in its *modus agendi* that he cannot see that anything would be gained by thus doubling the operation. Sclerotomy, like trephining, must effect a marked reduction of tension, or it fails in its purpose. Its superiority over the older operations, all of which involved an extensive wound in the coat of the globe, lay in the fact that extrusion of the contents of the eye could not occur through the very limited aperture made. In this, trephining closely imitates it. The trephine hole is so small that the unsupported area of ocular contents involves but little danger. It must be obvious that, given the same pressure from within, the risk of a rupture of the limiting membrane, and of the consequent extrusion of the semi-fluid contents, increases rapidly with any increase in the size of the aperture made in the supporting tunic. Experience has abundantly satisfied us that if a surgeon will abstain from all further interference the moment he discovers the occurrence of a post-operative rise in tension, he can be sure of getting

his patient back to bed with the hyaloid membrane intact and without loss of vitreous. He is in a very different position from that which he formerly found himself in, with the vitreous gaping through a large wound and with rupture of its limiting membrane threatening him, not merely whilst the patient was on the table, but even after he had been put back to bed.

Section 4.

The influence of entanglement of the iris in a wound, on the production of a permanent filtration scar.

A view, widely held among ophthalmologists, is that the entanglement of uveal tissue, in the track of a wound in the globe, favours the formation of a filtering cicatrix. Every surgeon has seen wounds in which the enclesis of iris has occurred, and in which permanent filtration has been established. This co-incidental experience has been taken as supporting the cause-and-effect relationship of the two things. So imbued have some ophthalmologists been with this idea, that they have gone so far as to express a doubt "whether permanent fistulisation ever occurs unless some heterogeneous element forms a mechanical obstacle to regular cicatrisation." The author suggests that the view that iris inclusion favours the production of a filtering scar has been far too readily accepted, and should be reconsidered. It will now be discussed.

Clinical experience has clearly shown us (1) that the impaction of uveal tissue in the trephine hole is a great menace to the maintenance, and often even to the establishment of filtration, in our trephine cases; and (2) that the more carefully we guard ourselves against iris complications the more even and uneventful is the course of our patients' convalescence.

Moreover we have had the opportunity of observing eyes, in which subconjunctival filtration had been accidentally produced by various operative measures, and had been maintained for many years, without there being any clinical evidence of the entanglement of iris tissue in the wound.

Nor has anatomical evidence been wanting of the freedom from uveal tissue of a fistula which had permitted free filtration to occur. On the other hand the examination of eyes, in which the trephine hole had become blocked by the proliferation of connective tissue has shown the presence of pigmentary tissue in a large number of the wounds, thus

suggesting a cause-and-effect relationship between the entanglement of the uveal tissue and subsequent blockage of the wound.

The question may also be approached from another point of view. It has happened to most surgeons, at one time or another, to have to open a cataract wound in order to free it of impacted iris tissue. If this be done within twelve hours of the prolapse, or even within twenty-four hours, there is not the slightest difficulty in breaking down the feeble adhesions between the lips of the wound. If, however, we attempt to do the same thing after three or four days, or longer, we find that the most difficult part of the wound to open is that where the iris tissue is impacted. This is only what might have been expected, since the vascular iris provides a proliferative exudation more readily than does the much less vascular tunic of the eye. Such an experience suggests that impacted iris does not tend to keep a wound open, but rather to help to seal it firmly up. Is there strong evidence in favour of the view that the enclesis of uveal tissue in a wound leads to the formation of a filtering scar at that point? On the contrary may it not be that those wounds, which have a predisposition (owing to the fact that they gape, or that they are slow in healing) to become filtering wounds, are the very ones into which intra-ocular tissues, such as the iris, are most apt to prolapse, and hence to become imprisoned therein? Our suggestion is that the impaction of iris in a wound is not the cause of its developing into a filtering scar, but that it is merely an accidental complication which is more likely to occur in the type of wound which favours the production of such scars. Clinically, the question is one of very great importance, and it therefore merits the most careful consideration.

The author believes that ere long anatomical evidence will be forthcoming to prove that *the ideal filtering scar after trephining is that in which the fistula is free of all heterogeneous elements.* This is a question which should be worked out on the eyes of suitable animals. Dogs or monkeys will probably serve us best.

Section 5.

Experiments and researches in connection with the operation of trephining.

There are a number of questions, in connection with this operation, which might easily be answered by the results of research work conducted in the post-mortem room and in the laboratory.

The experiments made by Ducamp,[8] of Paris, and by Barraquer,[9] of Barcelona, are extremely interesting contributions to the literature of this subject. There is one important point to be taken into account in all work on animals, *viz.*, the difficulty of separating the flap *even up to* the edge of the limbus, and still more so beyond that limit. Ducamp found such difficulty with this part of the *technique* that he fell back on the use of Dupuy-Dutemps' flap in his work on cats. The author when demonstrating his method of splitting the cornea at the Oxford Congress (1911), and elsewhere, on sheep's and pigs' eyes, could only obtain unsatisfactory results, in spite of the exercise of the utmost care. He therefore suggested to Captain W. C. Gray, of Madras, and to Captain Reinhold, of the Punjab, that they should conduct a number of experiments on dogs, and he has heard from them that they have successfully done so. The main objective, in this work, has been to obtain anatomical evidence of the state of filtering scars at varying periods after the performance of a trephining operation.

Ducamp's[8] experiments on cats led him to conclude that in these animals the trephine holes speedily fill up with impermeable tissue. This is an interesting observation, and one which bears out our views as to the method in which failure occurs after trephining in man; but it in no way indicates that failure will be as uniform in man as in cats. The anatomical conditions are quite different, and they dominate the position. In any case Ducamp did not follow the *technique* we have advocated, but adopted Dupuy-Dutemps' modification thereof. Whilst offering this criticism, the author wishes to express his admiration for the enterprise, the originality and the carefulness of this work, and his regret that conditions in this country make it so difficult for our younger men to follow Dr. Ducamp's inspiring example. He would, however, suggest the advisability of studying the anatomical relations of the parts affected by trephining, in the eyes of cadavers. In order to carry out such work under conditions closely resembling those of the operation table, it is necessary to raise the tension of the eye above the normal level during the manipulations. This can be quite easily done by passing a hypodermic needle into the vitreous chamber, having first connected it with a column of water which will keep the tension of the globe at the required level (say about 35 mm. of mercury). All that is required is a funnel filled with water and connected to the hypodermic needle, by means of a sufficient length of rubber tubing. In practising the operation on the cadaver, from the point of view of the teacher of operative surgery, the same device may be adopted with great

advantage. Nothing is more unsatisfactory than trephining a "squashy" eye, or more realistic than working on one in a state of high tension.

Section 6.

THE POST-OPERATIVE IRITIS MET WITH IN TREPHINED EYES.

What is its real nature? What is its significance? How far is it to be considered as important?

There is a good deal of misunderstanding in connection with this complication. Several quite diverse conditions seem to have been included under one heading, with the result that differences of opinion, often more apparent than real, have sprung up. Three conditions at least appear to be confused by some recent writers on this subject, *viz.*, (1) the commonly occurring post-operative complication, usually called "quiet iritis," with which every surgeon who has done much trephining is familiar; (2)an exacerbation of, or maybe merely a continuance of, an acute or sub-acute condition, which existed prior to the operation; and (3) a true septic condition of the wound, due to an accidental contamination at or after the operation.

Unless these three conditions are clearly defined in a surgeon's mind, and definitely separated in his case-sheet analyses, he will be apt to do grave injustice to the operation of trephining, and surgical science will suffer unjustly thereby. We therefore propose to discuss each head in turn.

(1).—**A quiet iritis** is unpleasantly frequent after trephininge but is it really a result of the operation? Is it the *techniqu*, of the procedure which is to blame? We think not, and shall give our reasons for venturing such an opinion:—this complication is not marked by the incidence of any of the usual signs of an invasion of iritis; pre-existing pain is relieved by the operation, signs of congestion diminish, vision improves, and the patient appears to be making excellent progress, so much so that unless we are forewarned and thereby fore-armed, we discover the complication only when it is too late. After we adopted in Madras a campaign of vigorous anti-sepsis of the conjunctiva, our practical acquaintance with post-operative sepsis became very small; but it was not ever thus, and in those early days one saw a truly lamentable amount of post-operative sepsis, due doubtless to the frequency with which the conjunctiva harbours septic organism in the East. Looking back on an all-too-extensive past experience of this complication, one can say without the least hesitation, that the type of iritis

we are now discussing, has nothing in common with a septic uveitis, due to accidental contamination of the wound at the time of operation. It is true that surgeons recognise a "quiet iritis" occurring under quite other circumstances, and somewhat closely resembling that which we have under discussion, but most people agree in attributing it to constitutional causes, and in considering that its type is quite distinct from that of the great majority of post-operative infections.

The question asked will obviously be "if this is not a post-operative inflammation, what is it?" It is suggested that it is the manifestation of a condition existing before the operation, but unable to find visible expression until the alterated physical conditions empowered it to do so. To begin with, the act of trephining alters the relations of the parts which border on, or project into, the aqueous chamber. The chamber is for a time at least practically empty, with the consequence that the iris lies in direct contact with the lens capsule, the posterior chamber being temporarily reduced to a potential cavity; at the same moment the long-continued mydriasis has given place to a state of more or less marked myosis; so it follows that we have to hand the very conditions which render the formation of posterior synechiæ most easy. Then again there can be little doubt that the nature of the fluid secreted under the new conditions may be such as to render the deposition from it of fibrin more liable to occur, without in the least premising any access of inflammatory action.

It has been asked why this quiet iritis is so much more often met with after trephining than it was after the old iridectomy. Is it really the case that it is more frequent? It is far from a rare experience to see the iris tied down after an iridectomy for glaucoma. It must not be forgotten that after a well-performed iridectomy, the chamber will be completely closed in a few hours, and often after only a few minutes. Remember too that a wide coloboma makes the effects of posterior synechiæ both less obvious and less injurious to the results, since it leaves a wide area for visual purposes, even should some amount of adhesion take place between the iris and the deeper parts. It is suggested that surgeons should carefully watch their cases for the occurrence of this *so-called* quiet iritis with a view to establishing its relative frequency under the old and under the new operations. It is hardly necessary to point out that if such statistics are to be of any value, the possibility of the occurrence of this quiet complication must never be lost sight of in the iridectomy cases, no matter how well they seem to be doing. It is an old adage that we only see what we look for, and most surgeons

will agree that many deductions from statistics would require profound modification were the notes taken daily on a schedule which reminded the overworked observer of the possible, and still more of the probable, complications he has to be on the look-out for. These remarks constitute no reflection on the work of any one, but merely enter a plea that the importance of the subject demands a thorough and unprejudiced enquiry into the facts. And what is the real importance of the subject? It lies in the fact that the fear of iritis may weigh with timid surgeons, and deter them from trephining. We have shown most conclusively, over an experience of many hundreds of consecutive cases, that a solution of atropine may be safely used on the second or third day, and that if this is done we need no longer dread post-operative occlusion of the pupil. Others have confirmed this statement, whilst a few have gone farther still, and instilled atropine drops at the close of the operation. We do not think it is necessary to do this so early, and of one thing we are quite sure, *viz.*, that the use of a strong mydriatic is positively harmful, if, on the second or third day, we find iris tissue plugging the wound and causing a rise of tension thereby. Eserine and not atropine is then called for, if reliance is to be placed on drugs at all. One cannot help feeling that if the use of atropine aggravates the blocking of the wound, when it is present, it may bring it about when the tendency to the accident is in the ascendant, or even in existence. Whatever the individual surgeon's final decision may be as to the exact date at which atropine should be instilled after trephining, there can, we think, be no disputing the fact that the condition which gives rise to synechiæ in this quiet way after the operation of trephining, and which, for want of a better term, we at present call a "quiet iritis," can in the immense majority of cases be controlled and rendered harmless, if the surgeon is on the alert to recognise the risk, and to promptly treat the condition by maintaining full mydriasis, whenever the use of atropine instillations reveals a tendency to the formation of posterior synechiæ in a recently trephined patient.

A very different view must be taken of the two other conditions we have still to consider; we will take them in turn:—

(2). A continuation of, or even an exacerbation of, an acute or sub-acute condition which existed prior to the operation, may severely try the nerve and resources of the surgeon. The condition is to be treated on ordinary lines, and with that side of the question we are not now concerned. A much more important thought is suggested by such cases. Everyone who has dealt with large numbers

of glaucoma cases and has pondered over their almost endless variety, has probably come to the certain conclusion, that whilst the term glaucoma is a very convenient label for a huge mass of cases, which all have the common feature of a rise of intra-ocular tension, the causes which bring about this rise in tension are many and various.

The stormy course of the affection, once the rise in tension has become established, serves to monopolise the surgeon's attention, distracting it from this very important aspect of the case. If a simile may be permitted, it would be that of a man standing by the bank of a narrow cataractous river, which is fed by a number of broad slowly-moving streams. The tossing, turbid, tumultuous torrent impresses his imagination far more than the quiet channels; and he leaves with the lasting impression of rushing waters predominant in his mind, to the exclusion of any thought of the very streams on which the torrent depends. Is not this the position, even now, of many who are engaged in the treatment of glaucomatous patients? Are we not apt to forget the ætiological side of our cases in the absorbing interest of the momentous factor of increased tension? Priestley Smith has set us an inspiring example, and others have followed in his footsteps; but we are still groping in semi-darkness. One important element in the situation is that of intra-ocular sepsis. We use the term in its largest possible meaning, and have been led to make this observation from a clinical study of the very class of cases we are now considering. Two explanations may be offered of the continuance or increase of intra-ocular congestion after an operation for glaucoma. It may be due (1) to the continuance of a septic action which was in existence before we operated, or (2) to an accidental infection at the time of operation. The subject is a difficult one and requires careful study, but will well repay the pains spent on it. To begin with, the usual course of a case of congestive glaucoma, after successful trephining, is that the signs of congestion rapidly subside, and the eye returns quickly to its condition of health. This is obviously what should happen if the main trouble is a condition of intra-ocular congestion brought about by a rise in the tension of the eye, for by lowering that tension, we have removed the cause of the congestion. When this happy result is not attained, we are justified in concluding that another factor has complicated the problem, and that factor often is, in our opinion, some form of sepsis. The really important point, to which we now come, is the source of this sepsis. Has it been introduced by the surgeon, or was it there before he stepped in at all? Is he to blame for it, or is it merely a

complication he must expect to meet with, despite the most careful *technique?* Speaking from a clinical standpoint, we have no hesitation in affirming that the condition may arise from pre-existent causes, and be quite beyond the control of the operator. The first point is, that the congestion present remains practically unchanged after operation, or at most undergoes the slight aggravation which may be expected to follow mechanical interference. Now this is not consistent with the theory of introduced sepsis, which we know begins to manifest itself about the third day, and rapidly increases in intensity during the few succeeding days. When a more marked aggravation of the signs present manifests itself, the solution of the problem becomes more difficult, but even then we meet with not a few cases, in which it is difficult to decide whether such aggravation is due to the amount of interference at the time of trephining or whether a farther explanation is called for. The second point is the frequency with which we find adhesions between the iris and the cornea in late cases of glaucoma, in which there has been no operative interference whatever. Of evidently the same nature is the peri-limbal matting, which, when it exists, makes splitting of the cornea so difficult. Again these cases tail off imperceptibly into those of the so-called "quiet iritis" discussed under the preceding heading; for one meets with an eye in which the marked pre-operative congestion markedly subsides, and all appears to be going well, and yet close synechiæ may form, and sight be impaired or lost if by any chance the surgeon is caught napping. The third and last point is based on a class of cases more familiar in Europe than in India. A patient, often with a gouty history, develops evidence of raised tension. He is advised to diet himself, to take more exercise, and to be more careful of himself in a variety of ways, with the result that he very speedily improves in his general health, and at the same time his signs and symptoms of increased tension disappear, to the great relief both of doctor and patient. Many surgeons will be able to recall such cases. The plain meaning of them would appear to be that the threatening of glaucoma was due to a toxic condition, which has been removed, or at least ameliorated, by the constitutional treatment employed. We do not pretend to assign the threat of raised tension definitely to bacteria or to circulating toxins, but prefer to leave the matter open. One cannot review the above evidence without a deepening conviction that toxicity, possibly in many forms, is playing no unimportant part in the pathogenesis of some, at least, of the conditions which we now, for convenience sake, are content to group together under the term "glaucoma!"

We do not doubt that there are many who have thought with us in these matters, even if some of them have not formulated their ideas so definitely as has just been done. We would ask any such to look back for a moment over the work of the past few years, with its triumphs in bacterial diagnosis, in serum reactions, and in vaccine therapy. What does the future hold for the surgeon interested in glaucoma? Is it possible that a new era is dawning, an era in which the newer medicine, the medicine that has sprung Minerva-like from the microscope and the laboratory, will stand shoulder to shoulder with the newer glaucoma surgery, the surgery that, be its technical variations what they may, finds expression in the magic of the word "sclerectomy?" May we not look forward with confidence to the day when this dual alliance will still further rob glaucoma of its terrors, believing, as we must, that medicine so applied will not merely make surgical interference more secure, but that it will go farther still, and save a number of glaucoma cases from the need to resort at all to the knife or to the trephine.

(3) **A Septic Condition of the Eye, due to Contamination at the Time of Operation,** requires little comment here. In nearly 900 consecutive cases trephined in Madras from the first operation of that nature on August 2nd, 1909, up to the time when the author left India we did not meet with a single case of suppuration of the globe, nor with any cases of severe irido-cyclitis, which could without hesitation be put down to septic contamination in the theatre. We cannot absolutely exclude an element of sepsis in some of the cases, in which an irido-cyclitis existing before the operation, continued thereafter, sometimes in an aggravated form. That would be an irrational claim, and no one could make good such a position. Be the method of operating what it may, we shall get such cases, and in the present state of our knowledge, we cannot with certainty differentiate between them and those discussed under the previous heading. India is a land where sepsis is rife, and yet we have seen a wonderful change come over our practice there, since we have employed rigid conjunctival antisepsis. If there is one proposition which we would venture to put forward with less hesitation than any other, it would be that contamination of an operation wound *depends less on the particular method employed, than on the preparatory technique*, especially on conjunctival asepsis or the reverse. These remarks are made, because others have attributed their failures to what they consider is the scanty protection afforded by the thin conjunctival flap. Under cover of this explanation, there have been included cases of quiet iritis, cases of varying degrees of irido-cyclitis, and even losses of the eye due to

panophthalmitis. The data on which such conclusions have been founded have sometimes been insufficient for the purpose. We must remember firstly, that the layer of anterior epithelium suffices, so long as it is intact, to guard the cornea against the inroads of so virulent an organism as the gonococcus, and, in the second place, that the great majority of our conjunctival wounds after trephining are healed, and the chamber thereby sealed, on the first dressing. Finally, our Indian experience of 900 cases, already quoted, shows that the conjunctiva, when properly dealt with, affords sufficient protection to the important structures it covers. It is to be clearly understood that we are not dealing now with cases of "late infection," which are met with months or even years after operation ; these have been discussed already, in the course of Chapter VIII.

Section 7.

Detachment of the Choroid.

This condition was first described by Knapp[10] nearly fifty years ago. Fuchs[11] considers that it is due to rupture of the ligamentum pectinatum during operation, a channel being thus afforded whereby the aqueous humour can escape from the anterior chamber into the supra-choroidal space. Meller[12] holds the condition to be due to a violent exudation from the blood vessels of the ciliary processes. Hudson[7] believes that serous detachment of the choroid and ciliary body is a natural accompaniment of considerable reduction of intra-ocular pressure, the degree of the detachment varying with the degree of the reduction of this pressure. He considers that the exuded fluid comes from the choroidal blood vessels and not improbably from the veins. There is one point which must be mentioned, viz., that choroidal detachments, which can be recognised ophthalmoscopically, are conspicuous by their absence in a number of very successful cases of trephining, in which the tension has remained markedly subnormal over a period of years. The author has had several such eyes under his observation, in which the most careful ophthalmoscopy has failed to reveal any abnormal condition of the fundus. Schur,[13] of Tubingen, has reported three cases of detachment of the choroid out of 85 trephinings, *i.e.*, 3.5 per cent. Fuchs' estimate of this complication after glaucoma iridectomies is 10 per cent. and Meller's figure for it after Lagrange operations is 22 per cent. Schur quotes these figures in support of Fuchs' view that it is an injury to the ligamentum pectinatum, which permits the aqueous to find its way into the suprachoroidal space, and so leads to these detachments of the choroid. He points out that

such a disturbance of the pectinate ligament is obviously less often brought about by a well-performed trephining than it is by an iridectomy or by a Lagrange operation, since in the first-named operation this structure is deliberately torn, whilst in trephining it is sedulously avoided.

Section 8.

SPONTANEOUS TREPHINING.

The author has had his attention called by two surgeons to cases of a very curious nature. The first was reported to him by Captain W. C. Gray, who said "it looks almost as if spontaneous trephining had occurred." A definite filtration area was found at the usual seat of trephining. The second case was quite independently reported by an American colleague, whose name the author regrets he has forgotten, but who said he would publish details of the case. The condition closely resembled that in Captain Gray's case. In both, high tension seems to have been relieved by the establishment of filtration; in both, it was apparently quite certain that no operation had been performed; and in both the filtration area appears to have lain in the neighbourhood of a perforating vessel. The author suggests that a spontaneous relief of pressure had been established by the occurrence of the escape of fluid in some way from the interior of the eye into the sub-conjunctival area, through an aperture of exit of one of the perforating vessels. It would be of great interest if surgeons would report any cases of the kind in full.

BIBLIOGRAPHY.

(1) **von Mende.** — *Klinische Monatsblätter für Augenheilkunde*, Januar, 1913.
(2) **Webster Fox.**—*Ophthalmology*, October, 1912.
(3) **Dupuy-Dutemps.**—*Proc. de la Société d'Ophtalmologie de Paris*, 4 mars, 1913.
(4) **Hill Griffiths.** – *Ophth. Review*, January, 1914.
(5) **Rochon Duvigneaud.**—Treatise on "The Topography of the Angle of the Anterior Chamber, 1892," quoted by Ducamp, *vide* (8)
(6) **Lancaster.**—Personal communication.
(7) **Hudson.**—*Roy. Lond. Ophth. Hosp. Reports*, Vol. XIX., Pt. II.
(8) **Ducamp.** — "La Trépanation Cornéo-sclérale d'Elliot : Étude Technique,Recherches Anatomiques et Expérimentales." Publishers, Vigot Frères, Paris.
(9) **Barraquer.**—*La Clinique Ophtalmologique*, mars, 1913.
(10) **Knapp.**—"Die intraoculare Geschwulste," p. 194.
(11) **Fuchs.** –*Arch. f. Ophth.*, Bd. LI., Heft 2, 1900; Bd. LIII., Heft 3, 1903.
(12) **Meller.**—*Arch. f. Ophth.*, Bd. LXXX., Heft 1, 1912.
(13) **Schur.**—*Klin. Monatsbl. f. Augenheilkunde*, September, 1913.

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