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

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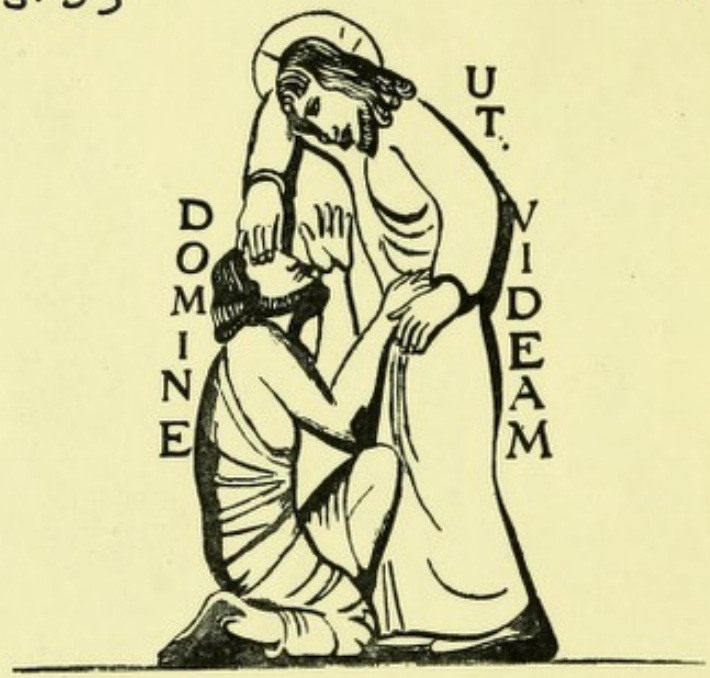
IN
THE OPERATIVE TREATMENT OF GLAUCOMA

R. H. ELLIOT



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IN

THE OPERATIVE TREATMENT OF GLAUCOMA

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 magnificient 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 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.

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 one could say 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 in the body of the book, 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.

CONTENTS.

		PAGE
CHAPTER I.	Introductory	1
CHAPTER II.	Historical	4
CHAPTER III.	Indications for Sclero-Corneal Trephining	33
CHAPTER IV.	Preparations for the Operation	41
CHAPTER V.	The Technique of the Operation	48
CHAPTER VI.	Modifications of Operative Technique suggested by other surgeons	64
CHAPTER VII.	Complications met with during the Operation ...	78
CHAPTER VIII.	After-management of the Patient	85
CHAPTER IX.	The Diagnosis of Glaucoma in Southern India ...	92
CHAPTER X.	Method of Compiling Statistics	99
CHAPTER XI.	The Results of Trephining as Judged of by the Statistics of Returned Cases	105
CHAPTER XII.	On the Site of Trephining for Glaucoma: Its Importance	111

LIST OF ILLUSTRATIONS.

FIGURE		PAGE
1.	Section of the Sclera and Conjunctiva, in Lagrange's operation	13
2.	Resection of the Sclerotic, in Lagrange's operation	14
3.	Making of the Iridectomy, in Lagrange's operation	14
4.	Result of Lagrange's operation	15
5.	Position of the knife blade in making the first Incision, in Herbert's operation	17
6.	Position of the knife blade in making the second Incision, in Herbert's operation	17
7.	The Histology of Sclerectomy	23
8.	Holth's Punch Forceps	24
9.	Section of a Sclerectomy Cicatrix (Holth)	25
10,	McKeown's Irrigator	42
11.	Do. do.	43
12 and 12A	Photographs of Operation Groups	45
13.	The Madras Cataract Bandage	46
14.	The Incision etc., in the earlier trephine operation	51
15.	The Incision etc., in the present trephine operation	51
16 to 19.	Diagrams showing the possible Interferences of Iris Tissue with the Trephine Hole	58-61
20.	Sydney Stephenson's Trephine	64
21,	Maddox's Trephine	65
22A and 22B.	George Young's Trephine	67
23.	Lang's Trephine	69
24.	Lang's Knife for Splitting the Cornea	69
25.	Elliot's Instruments for Trephining	70
26.	von Hippel's Trephine	71
27 and 28.	Verhoeff's Sclerectome	73
29 to 31.	Verhoeff's Operation	75
32.	Fixation of an Eye by means of a Suture during Operation	79
33	A section of the Eye in the neighbourhood of the trephine area	113

INDEX.

A

	PAGE
Accidents following operations	30
Adrenalin	34, 82
Anæsthesia, general, rarely used	43
Anterior chamber, establishment of communication between and sub-conjunctival spaces	24, 63, 116
Arrangement of patient on table	44
Arterial tension, influence of, in glaucoma	97
Astigmatism, post-operative	11

B

Ballantyne on history of trephining	4, 112, 114
Bandage, date of opening	85
Bandage, Madras; method of application	46
Bandage, Madras; method of opening for dressing	47
Bandaging, indications for prolonged	85
Bettremieux's operation	20
Bilaterality of glaucoma	39
Birmingham Meeting	111
Bjerrum's operation	9
Bjerrum's screen	92
Blanco's trephine operation	5
Blind painful eyeballs, operative treatment of	39
Borthen on iris incarceration operations	12
Button-holing of flap	78

C

Cases, selected	108
Cataract, progress of, in glaucoma	109
Choroidal detachment after iridectomy...	10
Chronic glaucoma, trephining in	33
Ciliarotomy, Abadie's	10
Ciliary body, avoided during trephining	3
Ciliary body, interference with	30
Clegg, Gray, method of trephining	65
Clegg, Gray, on recurrent tension	89
Collins, Treacher	92, 112
Completion of trephining, indications of	54
Congestive glaucoma, trephining in	33

PAGE

Conical cornea, trephining in 37
Corneal crescent 52
Corneal crescent area filters permanently 53
Cribriform ligament 113
Cruise's retractor and guide 76
Cyclodialysis 112
Cyclodialysis, an integral part of the Fergus' operation ... 10, 19
Cyclodialysis, Heine's 10
Cyclodialysis, late histology of 29
Cystoid cicatrix 21

D

Defects in existing trephines 68, 69
Diameter of trephine 55
Difficulties during trephining 57
Disc, loss of, during trephining 79
Disc, trephined, severance of 55
Dressings, sterilisation of 44
Dried hands essential in operating 44

E

Easy operation, trephining an... 2
Elliot's operation contrasted with Fergus' 6, 19, 116
Elliot's trephine 70

F

Failure to tap chamber, causes of 60
Fans, protection of 44
Fergus's account of his own operation... 112
Fergus's trephine operation 6, 18
Filtering cicatrix 21
Filtering cicatrix, proof of 23, 98
Filtering cicatrix, varieties of 15
Filtering scar, de Wecker's views 8
Filtering scar, Dianoux 8
Filtering scar, effect on intra-ocular tension 6
Filtering scar following iridectomy 1
Filtering scar, histology of 22, 25, 27
Filtering scar, Wicherkiewicz 8
Filtering zone, Bettremieux's 20
Filtration area limited by earlier flap 50
Filtration, evidence of 22

PAGE

Fistulisation of anterior chamber, demonstration of 116
Flap, care of, in trephining 53
Flap, conjunctival, new and old 51
Flap, displacement of 86
Flap, injury to 78
Flap, large, advantages of 50
Flap, method of forming 50
Flap, size of 50
Frohlich's trephine operation 5
Fuchs 112
Fuchs at Belfast meeting 115

G

Glaucoma following cataract extraction 37
Glaucoma following injury 38
Glaucoma secondary to cataract, frequent occurrence in India 34
Glaucoma secondary to cataract, results of, after extraction 35
Glaucoma secondary to cataract, trephining in 35
Glaucoma secondary to leukoma adherens 38
Glaucoma secondary to occlusion of the pupil 38

H

Hæmorrhage, intra-ocular, during operation 62, 81
Hæmorrhage, superficial, during trephining,... 81
Hands, cleansing of 44
Heine's cyclodialysis 10
Henderson, Thomson 113
Herbert's operations 1, 16
Heuvelmans 116
Hime's method of manipulating trephine 55
Hingston 52
Holth 111
Holth's operation 11
Hyperopic eye, association of, with glaucoma 94

I

Incision in conjunctiva, new and old 51
Instillation of drops after operation 63
Instruments, dryness of, insisted on 44
Instruments, sterilisation of 43
Iridectomy, influence of, on sclerectomy 13, 27
Iridectomy in glaucoma 7
Iridectomy in trephining 3, 57
Iridectomy, rôle of in sclero-corneal trephining 19

PAGE

Iris complications during operation 56, 57
Iris incarceration operations 11
Iris incarceration operations, dangers of 12
Iris prolapse, treatment of 87
Iritis, post-operative 63, 86
Irrigator, sterilisation of 44

J

James, Brooksbank 18

L

Lagrange's operation 1
Lang's trephine 68, 69
Lens, impaction of, in trephine hole 83, 87
Limbus, overhanging 52
Local conditions, influence of, on diagnosis 92

M

Maddox on recurrent tension 89
Maddox's trephine 64, 65
Maher on iris incarceration operations 12
Maklakoff tonometer 95
Manipulation of trephine 53, 54, 55
Masks, mouth 44
Mayou's operation 76
Method of returning patients to bed after operation 47
Morphia, administration of, before operation 43

N

Normal eyes, effect of trephining in 40
Norman, on transillumination of filtration angle 95

O

Œdema, conjunctival 22
Operations, results of various compared 30
Ophthalmoscopic appearances in glaucoma, unusual... ... 93, 94
Optic atrophy, progressive 110
Optico-ciliary-neurectomy 39
Original methods of operating modified 48

P

Panophthalmitis, post operative, never seen after trephining 43
Parsons 115
Perchloride irrigation 41
Preilimbal tissues, matting of, in glaucoma 94

PAGE

Permeable cicatrices, Herbert's... ... ... 16, 26
Plugging of trephine wound 82
Posterior chamber, accidental tapping of 61
Preparation of the patient for operation 41
Pressure necessary during trephining 54
Prolapse of iris 87
Prophylactic trephining 39
Punch-forceps, Holth's 24
Punch-forceps, sclerectomy with 18
Pupil non-dilated in glaucoma 92

Q

Querenghi's operation 9
Quiet iritis 63, 86

R

Rabbits, experiments on 116
Recurrent tension, causes of 88
Recurrent tension, treatment of... 89
Re-insertion of trephine... 54
Repositor, use of, in Fergus' operation 19
Results after operation classified 105
Robertson, Argyll... 4
Rules, cardinal, of operation 63
Rules for using trephine 54

S

Scleral ring 113
Sclerecto-iridectomy, Lagrange... 13
Sclerecto-iridectomy, rôle of iridectomy in, ... 15, 30
Sclerectome, Verhoeff's 73
Sclero-choriotomy, Querenghi's... 9
Sclerotomy, de Wecker's 8
Sclerotomy, Herbert's 9
Sclerotomy, Quaglino 8
Schiotz tonometer 96
Scotometer, Priestley Smith's 92
Shallow chamber 85
Silk drainage of chamber 76
Splitting cornea, methods of 76
Splitting cornea, use of Bowman's needle in 52
Spud, replacement of iris with 60, 83
Staphyloma, trephining in 36

PAGE

Statistics, compilation of 99
Stephenson, Sydney, on history of trephining 4
,, ,, on trephine 64
Sub-conjunctival injections before operation 42, 63
Suprachoroidal space 114
Suturing of flap, when required in trephining 49, 63

T

Technique, modified, to suit local conditions 47
Tension, post-operative, recurrence of 88
Tension, post-operative, treatment of 89
Tension, reduction of, by newer operations 7
Toilette of the wound 62, 86
Tonometry in glaucoma 95
Traction on iris, dangers of 57
Transillumination of filtration angle 95
Trephine, application of 53
Trephine handle 54
Trephine, steadying of 54
Trephining, absence of infection of wound after 49
Trephining as a prophylactic measure 39
Trephining elsewhere than above cornea, indications for ... 49
Trephining, object of 3, 27, 63, 115
Trephining, repeated 90, 91
Trephining, site of 48, 53

V

Valve-like entry into chamber during operation 57, 60
Verhoeff's operation 20, 73
Vision, deterioration of, after successful operation 30, 110
Vitreous, loss of, during trephining 80
Vitreous presentation, diagnosis of in trephine hole 83
Von Hippel's trephine 55, 71

W

Walker, Nimmo, on recurrent tension 90
Walker, Nimmo, on trephining 71
"Wedge-isolation" operation 16
Weekers 116

Y

Young's method of trephining 66

Z

Zorab's operation... 76

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 some six years ago, 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. 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 XII of this book. 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 many important details, to modify the technique of his operation; the essential feature of his 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 "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

SYDNEY STEPHENSON,

LONDON, ENGLAND.

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

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 suprachoroidal 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.

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THE NEWER OPERATIONS FOR GLAUCOMA

BY

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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

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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[6] 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 Opthalmological 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 moré 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'Ocultistique* 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 comparabie 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.

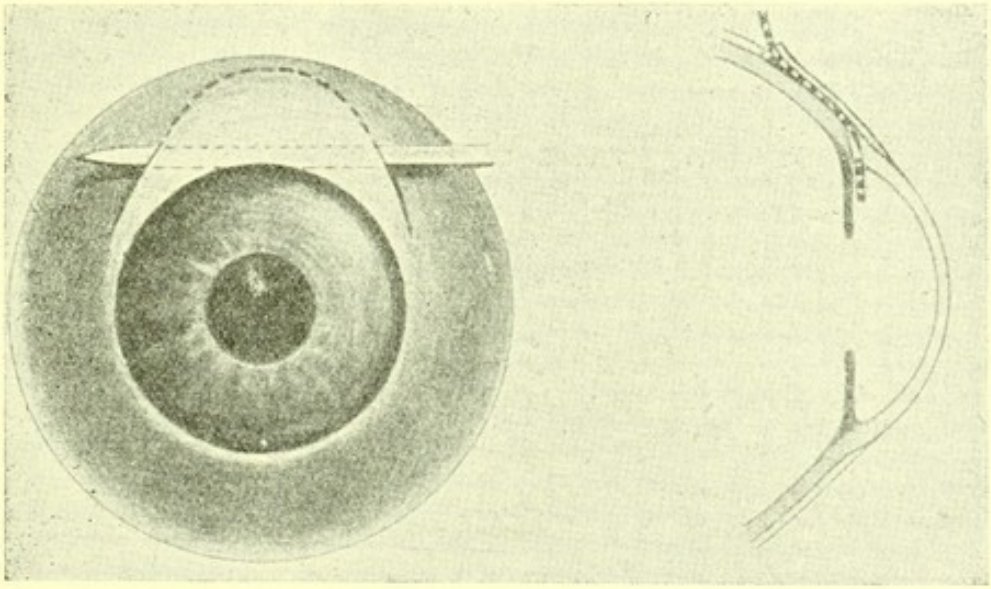

FIG. 1.—Section of the Sclera and Conjunctiva.

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

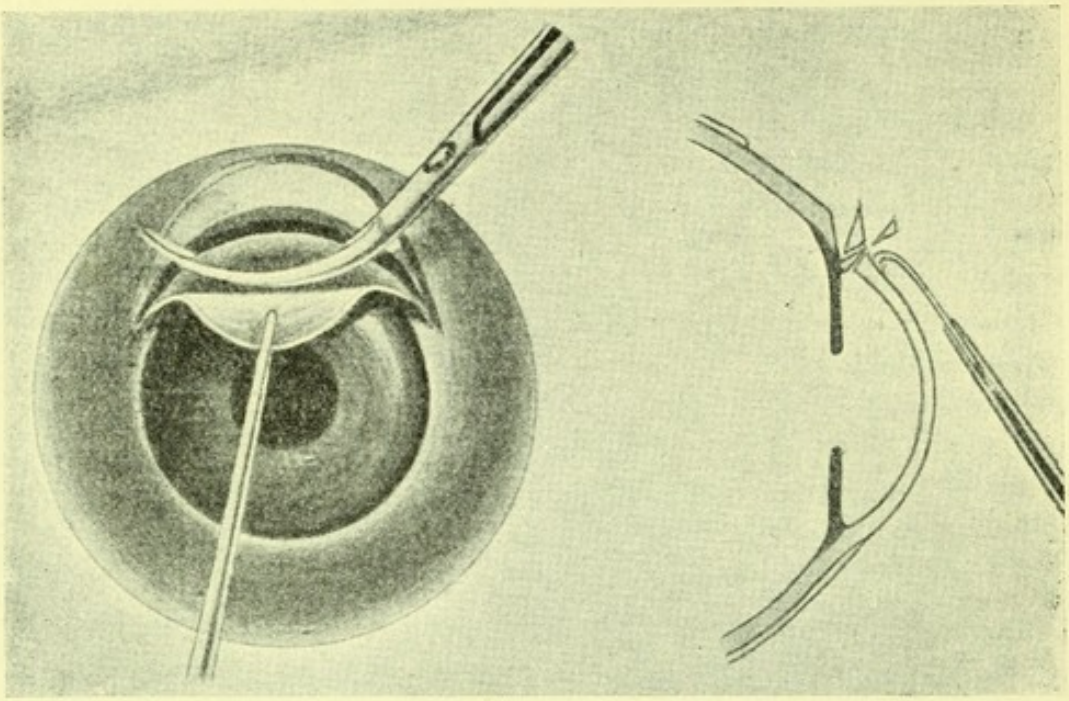

FIG. 2. – Resection of the Sclerotic.

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,

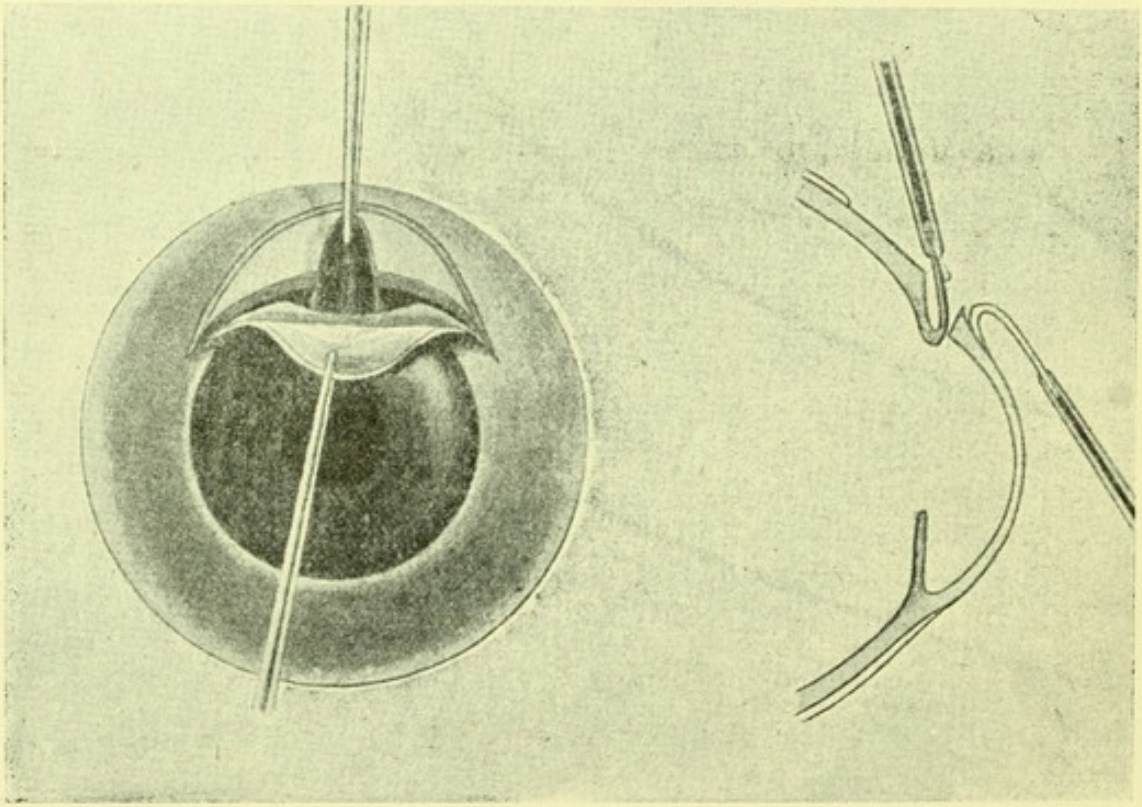

FIG. 3.—The Making of the Iridectomy.

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

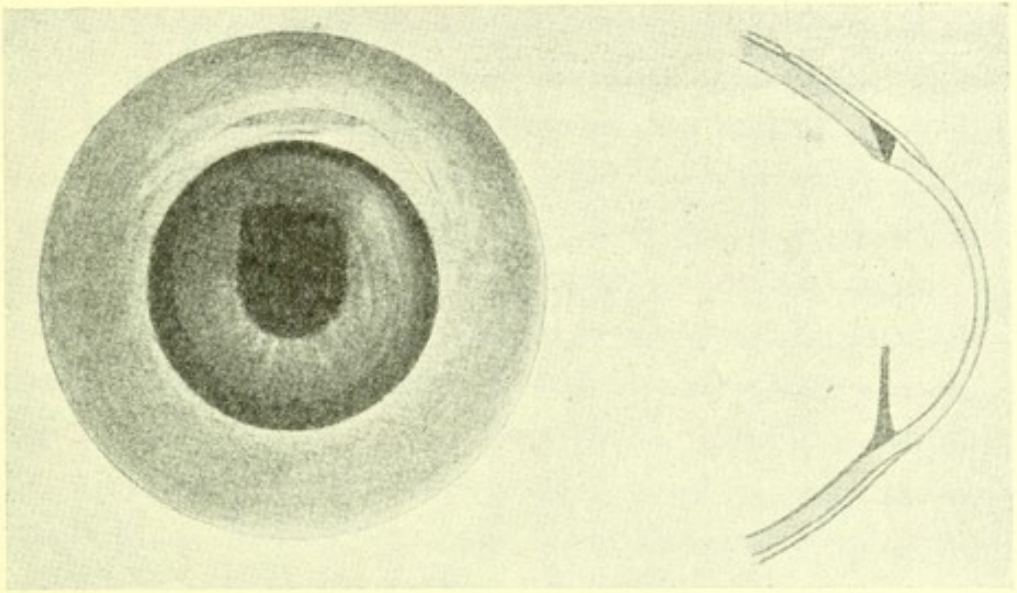

FIG. 4.—The Result of the Operation.

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

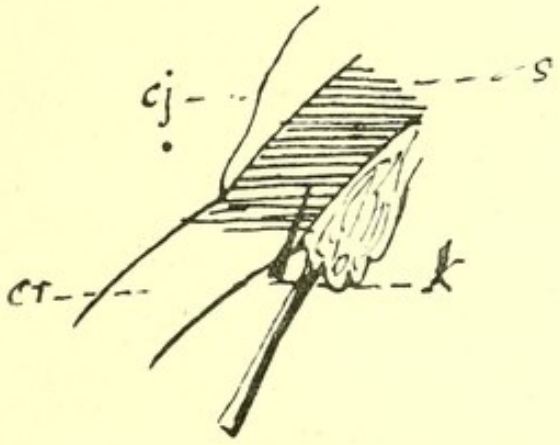

FIG. 5.—Position of the knife blade in making the first incision.

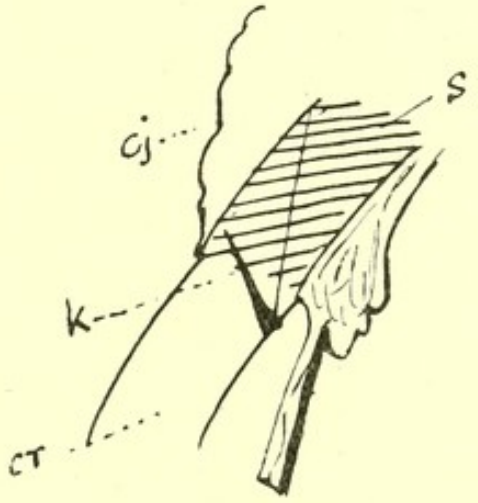

FIG. 6.—Position of the knife blade in making the second incision. The thin line shows the position of the first incision which has been partly made.

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,[43] 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 ben 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 intraocular 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 comptete 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[51] 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 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 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 oedema 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 incarceration of 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

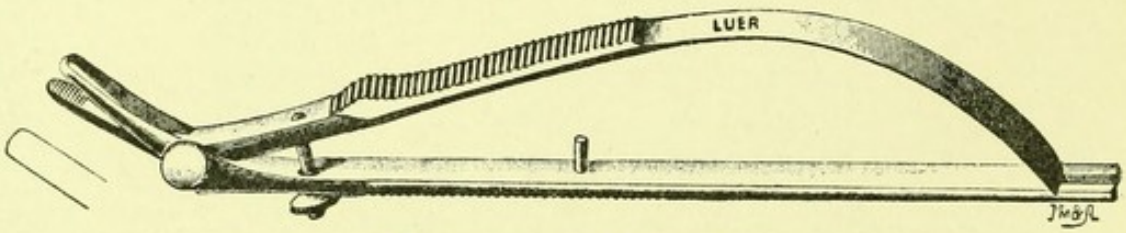

Fig. 8.—Punch-forceps.

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

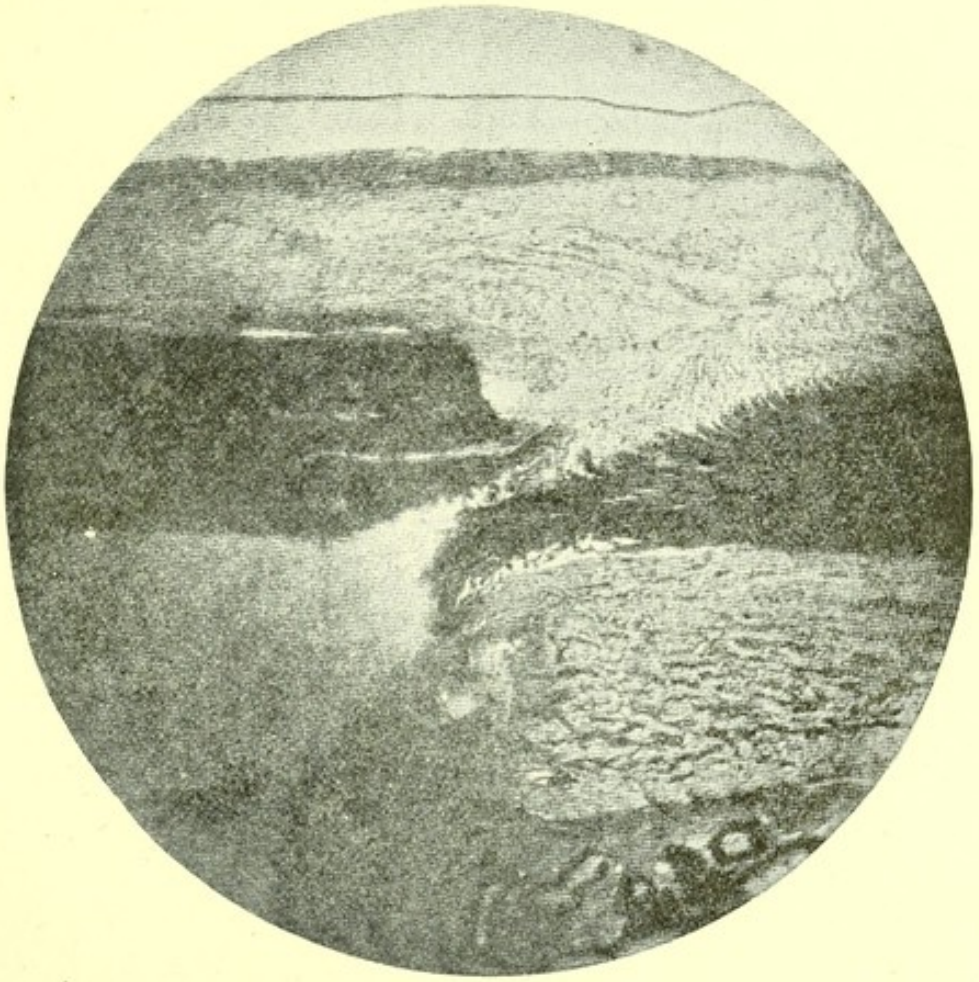

Fig. 9.—Sagittal section through the cicatrix of a sclerectomy of the anterior lip with the punch-forceps six weeks after the operation. The patient died from pulmonary embolism following a fracture of the femur.

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 " 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[25], 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.

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,[13] 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.

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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. One of the earliest cases done on August 7th, 1909, was still filtering freely when last seen two-and-a-half years after the operation, and there was no indication that the drainage was likely to lessen. Besides this, we have under our observation a number of other cases, ranging in duration from a few weeks up to and well over two years.

(2) **Congestive glaucoma.**—It must be admitted that at the Birmingham Meeting of 1911, there was a general feeling against trephining in cases of acute glaucoma. Even those speakers who had found trephining "*a safe and easy method*" in simple cases hesitated to apply it to those 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. In Madras the great majority of cases are chronic

or sub-acute, but we have met with not a few of the acute type. During the past three years our routine treatment for these has been trephining, and there is no question in the minds of any who have tried it here that this is at once the safest and the easiest method of dealing with these cases. A sub-conjunctival injection of adrenalin and cocaine renders the operation practically painless. 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 be added from our note books if necessary; but we clearly recognise that the ophthalmic world will hesitate until a confirmation of our views is afforded by other surgeons. The cases published by Sydney Stephenson (*The Lancet*, October 21, 1911) and by Bradburne, of Southport (*Ibid*, December 9, 1911) are therefore welcome contributions to the subject. Others are still being reported.

(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.

If one may judge from the papers one reads in ophthalmic journals, many European surgeons have failed to make up their minds even as to the existence of this complication of cataract; on the other hand, our 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 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 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 Priestly 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 have been excellent; but, in a few, the intumescent

lens has forced its way into the trephine hole, its semi-fluid contents following the line of least resistance. Our tendency at the present time is, therefore, to go back to our old method of a preliminary iridectomy in these cases, the lens being extracted as soon as the eye has quieted down. Trephining is reserved for the class of case in which the lens is not semi-fluid, and in which no great forward movement of the lens and iris has occurred. It is 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, it is quite clear that a large number of these patients placed no faith whatever in our explanation. The idea of the trephining operation is a new one to them, and there seems no doubt that a very large number of them lost all faith 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 Muhammadan couchers, whilst many have probably settled down in their villages to what they believe to be inevitable blindness. A special effort is now being made to obtain the addresses of all such patients and so to keep in touch with them.

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. This subject has been more fully dealt with in *The Ophthalmoscope*, Vol. X., p. 244. May 1912.

(4) **Staphyloma.**—In Madras we have trephined 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.

(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 have had few opportunities of trephining cases of the kind. The operation seemed to be of value by paving the way for the final procedure on the cornea.

(6) **Glaucoma following Cataract Extraction.**—We have trephined nine eyes for the relief of glaucoma supervening after the removal of the 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 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.

(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 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.*

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 very 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 or woman 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 a patient of the type we are considering. If he has come to us 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

*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).

being sufficient to bring the patient 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 procrastinate with fatal foolishness. It is therefore our rule in Madras to trephine both eyes, when one is 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. It is a matter for the consideration of our Western confrères whether the practice of prophylactic trephining should not be seriously entertained by them.

CHAPTER IV.

PREPARATIONS FOR THE OPERATION.

(1) **Preparation of the Patient.**—All glaucoma cases alike are admitted to hospital, 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 are convinced that it is 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 do not see as acute a type of case in Madras as is met with in colder climates; but we have never yet had cause to regret the delay and have 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.) 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 stream of sterilised saline solution (1.4 per cent. sodium chloride), isotonic with

the tears. 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,

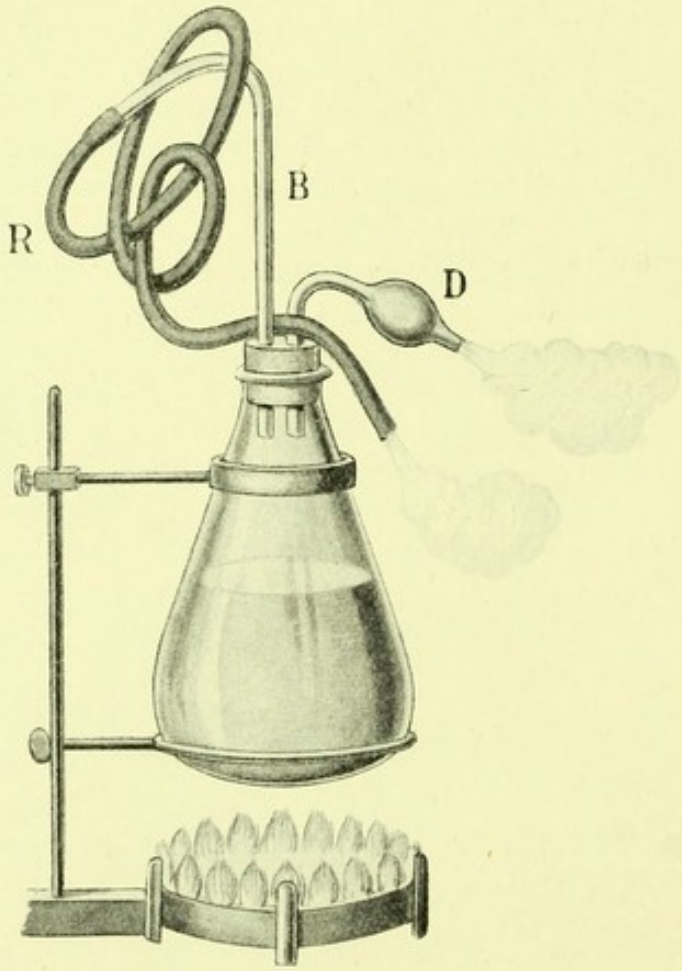

FIG. 10.

or if the eye appears hyperæsthetic, we give a sub-conjunctival injection of cocaine and adrenalin chloride solution, diluted with normal saline solution (0.8 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.

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

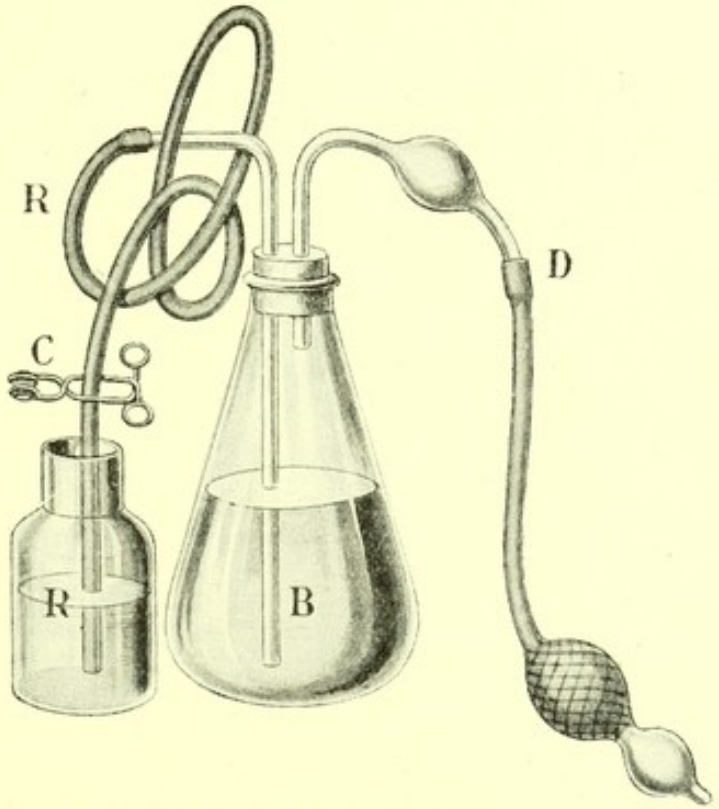

FIG. 11.—McKeown's Irrigator.

action, for we have not lost a single case of trephining by suppuration or by acute irido-cyclitis in the course of over 780 operations. 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, lasts us from 26 to 30 times, while a pair of iris scissors lasts 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.

(4) **Sterilisation of McKeown's Irrigator.**—Detach the rubber bellows from the tube D, raise the glass tube B, which dips below the surface of the liquid, 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.

(5) **Masks.**—In Madras, whenever we perform an intra-ocular operation, the surgeon, his assistant, and any by-standers who lean over 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.

(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

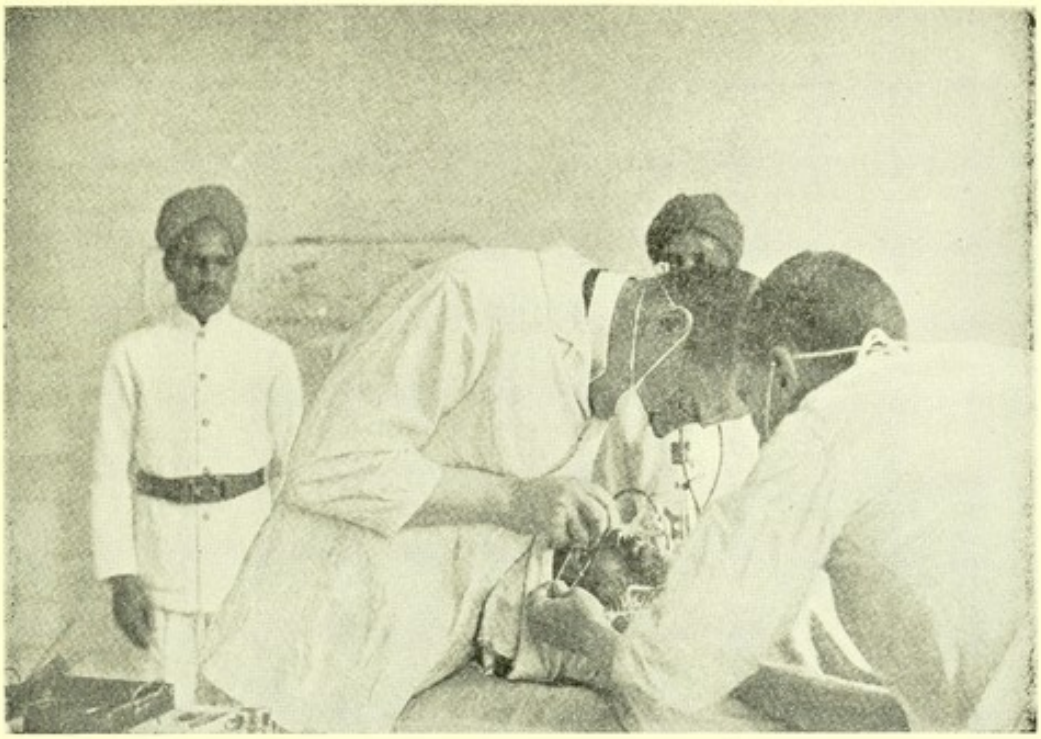

FIG. 12.—The act of trephining. The trephine can be seen below the fingers. Notice the mouth masks.

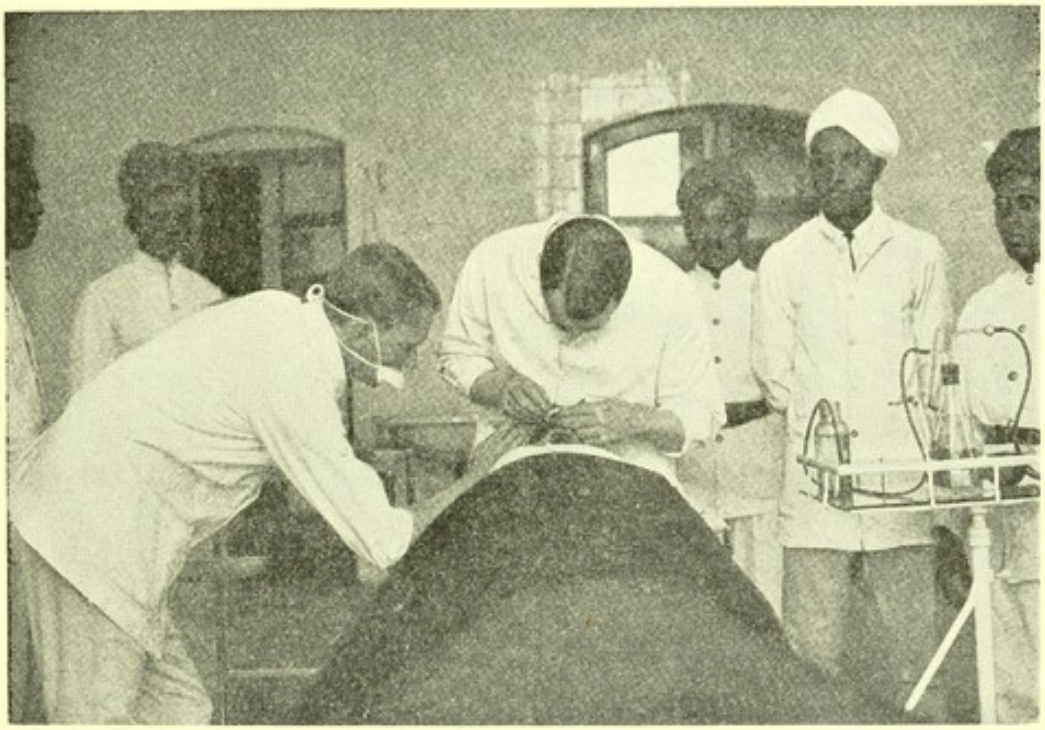

FIG. 12A resembles Figure 12. To the right is seen the McKeown's irrigator. To the left behind the chief assistant is the instrument table. The peon standing behind the chief assistant holds the tray, seen in the photograph, for catching the irrigation-fluid as it escapes.

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 the Madras Hospital fourteen years ago by the writer. He has not seen it used anywhere else. It is in his opinion greatly preferable to any other bandage when the two

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.

eyes require to be closed (Fig. 13). A piece of bandage cloth is taken 4 inches broad, 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 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 other way disturbing him. Another advantage is that firm and graduated pressure can be very easily applied.

(9) **After operation** our patients walk back to bed; an exception is made in the case of old, feeble, or nervous people. All our cataract patients are carried back to their wards on a stretcher, but we have not considered it necessary to have this done after trephining. Doubtless in Europe a different practice will prevail. Our large numbers and the habits of our patients necessarily modify our technique. A visitor to the wards after a trephining morning will probably find most of our patients sitting up, discussing the earlier events of the day.

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 our clinique, and from not a few contributors who have kindly communicated their views to us from various countries.

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. Our Madras figures now show over 780 cases, and the number of surgeons who have learnt to practise trephining here can be counted by tens. 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 we have described. It is nevertheless our wish to be as thorough as possible in the hope that the usefulness of our 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; and (3) the conjunctival flap rarely requires a stitch when made above. 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 patient's 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 looking up under the limbus with the aid of oblique illumination. In an occasional case, however, a more complete, though always narrow, iridectomy may be done, 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 of our Madras cases of chronic glaucoma is very striking; it probably is not met with, to anything like the same extent in countries, where patients resort early to trained medical men for relief. In India we often get the cases only after they have tried home remedies, native physicians' treatment and religious exercises, such as rolling daily round a temple in the sun with no clothes on but a loin-cloth.

As to the question of infection, our 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, is really based on theoretical grounds alone.

Our flaps have given us very little trouble; an upward flap very rarely requires 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 once at the time of operation: 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.

(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 enough 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 in Madras, 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 readings with the Sutcliffe keratometer; 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 use in the Government Ophthalmic Hospital, Madras, does not begin and end in the limbus, but runs roughly concentric with it, and ends on either side about 4 mm. below the highest point of the cornea, and 4 mm. to the inner or outer side, as the case may be, of the limbus (*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

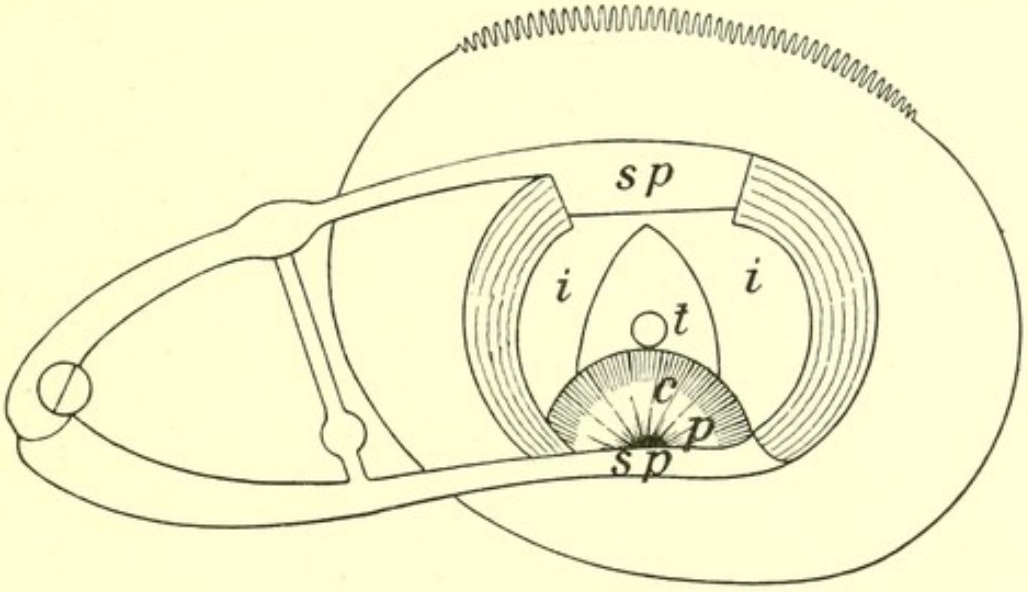

FIG. 14.

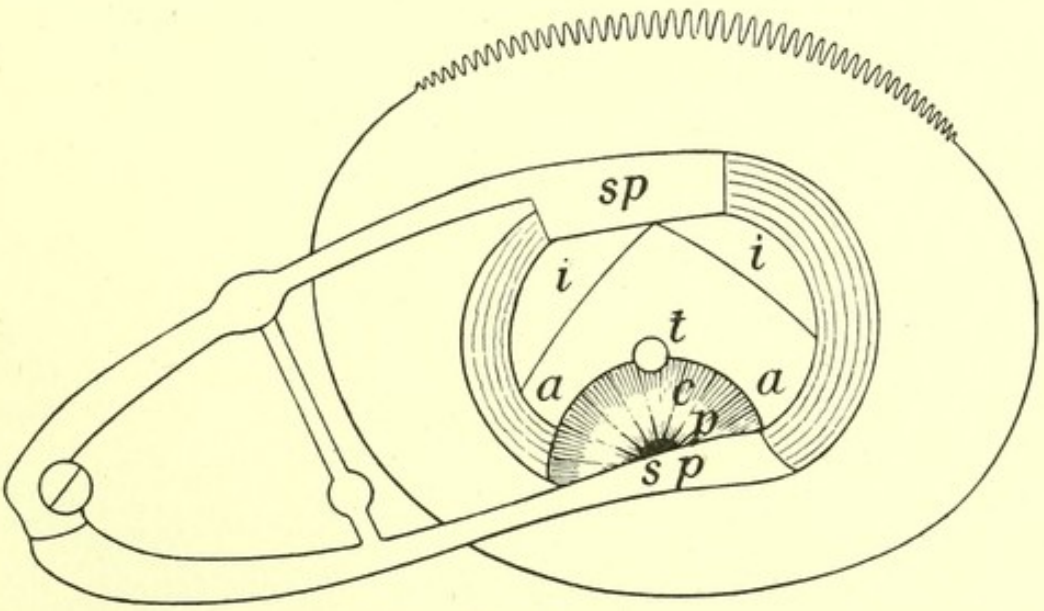

FIG. 15.

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.

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 reached the border *a.a.*, on either side, free escape of filtered fluid took place into the wound.

In clearing 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. The conjunctiva should be seized as high up as possible on the bulb with forceps, and drawn well down, at the same time asking the patient to look strongly downward; one free cut in the direction in which the flap is to be made, followed by a couple of snips at each side, should fashion the flap throughout its extent; the shape and dimensions, etc., of the flap have already been given: the subconjunctival tissue in the middle of the wound should be lifted up and with a very few cuts of the scissors the tissue must be cleared down to the limbus *in the middle of the wound;* it is unnecessary to clear the sides, and doing so entails obvious disadvantages. Next closing the points, and using the scissors as a scraper, we should separate the conjunctiva from the deeper parts right up to the limbus; in so doing the flap must not be seized in the grip of the forceps, but drawn out of the way by gentle traction with the closed forceps laid on it, and finding counter pressure against the cornea; if this precaution be omitted, the flap will be torn, and made ragged and useless for its purpose of covering the filtering hole. The limbus will be seen through the flap to overhang the neighbouring sclera, and at this stage one may safely count on entering the chamber.

In dealing with chronic cases, which had been exposed to long-continued congestion, it was found necessary to carry the separation of the conjunctiva from the cornea to a farther stage with the scissors points; as a result of this manœuvre the cornea could be seen to be split, and a thin crescent, of dark colour over a millimetre in breadth, surrounding the base of the flap, showed the area over which this splitting had taken place. We were then sure of striking the chamber with the trephine; we have never failed to do so in Madras after observing these precautions.

Captain Hingston, I.M.S., whilst officiating as Superintendent of the Government Ophthalmic Hospital, Madras, used an ordinary Bowman's needle instead of the scissor-points for separating the conjunctival layer of the cornea from the deeper parts. We have adopted this suggestion with very considerable advantage, and find it of especial value in congested cases of long standing, in which the manœuvre is otherwise often a difficult one.

In thus practising "splitting of the cornea" the objection that first occurred to one's mind 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 consequentiy the corneal area of the wound would be lost for filtration purposes. It has been a matter alike of surprise and of relief to find that this has not been the case. 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. The consequence has been that we have drifted into splitting the cornea in every case, and are satisfied that this has been an important step in the right direction.

(3) **The Application of the Trephine**.—With increasing experience one thing became absolutely clear, viz., that if we wished to trephine the chamber, and to establish a permanent filtering channel with a minimum of trouble, we had 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, probably 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 at once be excised should it show any tendency to prolapse into the wound. If the iris base is adherent to the cornea, the advantage gained by placing the trephine hole as far forward as possible becomes more obvious than ever; hence the urgency of the need for dissecting the covering 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 so that its edge will *just clear* the flap. If the cornea has been split, one makes use of every fraction of a millimetre of the area so gained; the dark crescent of corneal tissue bordering the base of the flap can very easily be seen and defined.

Before the trephine is applied to the sclera, the area selected for its application should be carefully cleaned of connective tissue tags attached to the flap; this can be easily done by dissection with any sharp pointed instrument such as the scissors or a needle. If this precaution be neglected, the flap may be drawn into the instrument as it works, and be thereby button-holed or otherwise damaged.

The beginner may find some difficulty in keeping his

cutting edge to one spot at the commencement of the trephining, and indeed one of our pupils seemed quite unable to do so. As a rule, this manœuvre becomes quite easy with a very little practice, but if the instrument is blunt even an expert will find that his incision is apt to be rather ragged. Considerable assistance is 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. Messrs. Arnold & Sons have at the author's suggestion devised a handle carrying a small collar through which the trephine is pushed before applying it to the eye, and in which it works smoothly and easily. 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.

Some of the surgeons who have worked in Madras have 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 learners 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 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 in one's early cases (1) to work 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 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. 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 works with the index finger and thumb, and constantly moves his fingers up the instrument as they tend 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 Major Hime, R.A.M.C., in the Madras clinique meets this difficulty in an ingenious way, and is 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.

There is always a likelihood that the surgeon will leave the disc of sclera attached at one point, and this is most often on the corneal side; a snip with a pair of sharp iridectomy scissors separates this attachment. If the trephine is very sharp, even this is unnecessary, as the disc is cut out clean; it is advisable whilst trephining to lean a little on the corneal edge rather than on the opposite one. In this way we make sure of entering the chamber as far forwards as possible. It is probable that in a large percentage of cases some portion of the deepest layer of the sclera is left *in situ*, however clean the trephining may appear. We have lately been led to this conclusion in a rather curious manner. A few trephinings were made in Madras with a von Hippel's clockwork instrument, and it was obvious that the instrument rapidly cut out a very clean disc in each case. An interesting observation followed, *viz.*, that iris-prolapse was a much more frequent complication in the after-course of these cases than it had before proved when the hand trephine was in use. It was suggested that the hand-used instrument probably left a portion of the deepest layer of the sclera *in situ*, and that this portion although separated round most of its edge had a trap-door attachment at one point. A close study of our latest trephine wounds at the time of operation has appeared to confirm the correctness of this suggestion.

The next question of importance is **the size of trephine** to use. In Madras we have tried all sizes from 3·5 mm. down to 1 mm., and experience has declared 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, and consequently the iris is apt to be dragged into the wound and impacted there. Should a rare case arise in which repeated trephining with a 2 mm. blade fails to keep the drain open, we may try a larger instrument. As an experimental measure, we have in Madras tried this in occasional and rare cases. The exception does not invalidate the rule.

In performing this operation one is constantly confronted with the difficulty of deciding whether the whole disc marked out by the instrument should be removed or not; we are between the dangers of removing too much and too little. If in a recent case we take the whole 2 mm. disc away, we 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 at any rate to leave it uncut at one small bridge only; in the latter case a single snip of the scissors points does the rest. If we wish, we can cut the disc off obliquely with the scissors, leaving a part of its deeper layer *in situ*. The same end may be more neatly and methodically attained by deliberately cutting a little more on the corneal edge of our trephine, and so entering the chamber round a half of the circumference on that side earlier than on the opposite side; in completing the detachment of the disc, the deeper layers of the outer half remain *in situ* without any special effort on our part. It may be urged that we are thus sacrificing half the area of our wound in the sclera, and had much better have halved the size of our trepine to begin with. This is not so, however, for we can never in any case say beforehand that the iris will not give trouble by becoming impacted in the wound; 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 a 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.

(4) **Difficulties which may be met with in tapping the aqueous fluid, and the management of the iris.** —If the anterior chamber has been successfully entered, aqueous can be seen to escape freely and the cornea falls back on the iris and lens, showing that the chamber has been emptied. Sometimes the aqueous escapes scantily, and it is observed that the chamber remains full ; this may be due to one of two causes—either the iris is blocking the wound, or the latter is oblique and valve-like in its entry into the chamber. In the most simple case of all, the aqueous has carried a portion of the iris in front of it in its rush out, and the membrane can be seen bulging like a black bead in the opening. Two courses then lie open to us, and the action we take will be determined by our attitude to the question of adding an iridectomy to the trephining. We may simply make a cut into the iris with the scissors, thereby allowing the free escape of pent-up fluid, or we may excise the bulging portion with the same result. If we adopt the former course, the protruding membrane will at once slide back into the chamber. This manœuvre may often be safely performed, and in our earlier cases in Madras we frequently resorted to it with excellent results. In extension of the same principle it was formerly our custom to leave the iris severely alone in those cases in which it did not present in the trephine hole. Later experience has made us doubt whether this is sound surgery. In many cases the coloboma of an iridectomy in this operation is small and peripheral and there can be no doubt that it is not in any way a disadvantage to the patient. Even when the iridectomy is complete, the gap in the iris is a narrow one and is probably of very little consequence. It is true that our results have shown that an iridectomy is not an essential part of the operative procedure and that just as good results, both as regards filtration, and as regards reduction of tension, can be obtained with an intact iris. On the one hand there can be little doubt that a clean iridectomy, whether peripheral or complete, reduces the risk of plugging of the trephine hole by uveal tissue, and thus adds a decided element of safety to the case. On the other hand, if traction is exerted on the iris during iridectomy, there is a probability that the membrane will become dragged into the trephine hole and be impacted there. The narrowness of the aperture greatly increases this

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 a portion of the membrane. Far the safest and easiest time for this step of the operation is, when the membrane is bulging

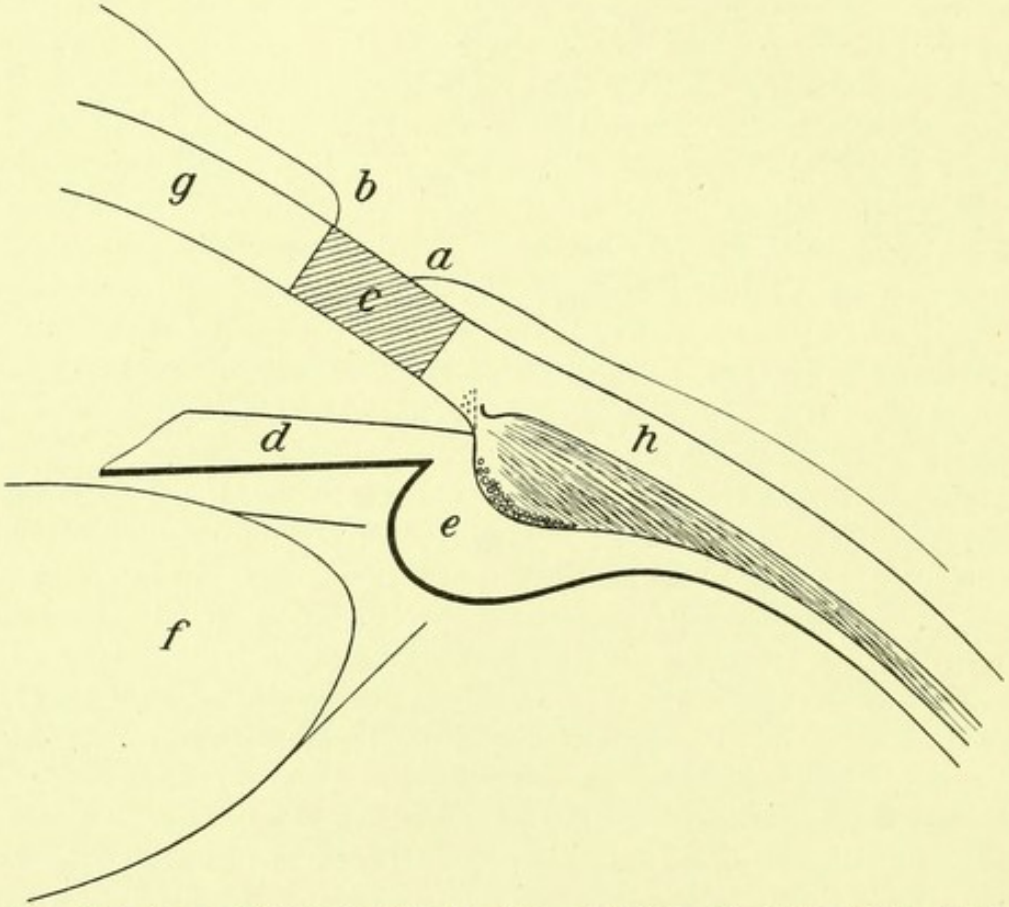

Fig. 16 shows diagrammatically the relation of parts in a case of trephining in which the iris base has not adhered to the cornea.

through the hole, immediately after trephining. It is then quite easy to gently grasp the protruding portion with iris forceps, using a minimum of traction and to cut it off flush. A still easier method, which we have lately adopted with very great advantage, is to include the disc and the bulging iris in one grip of the forceps and to divide both at the same time by a single snip of the scissors; the disc hinged at one point is pushed to that side by the bulging bead of membrane, and the same cut which severs it from the surrounding sclera simultaneously removes a portion of the iris. The great advantage of this is that the grip of the disc steadies the eye, and

effectively prevents even a troublesome patient from rotating the eyeball until after the portion of iris has been removed. We are thus able by this easy manœuvre to avoid all risk of the uveal tissue becoming dragged into or impacted in our narrow wound. It is true that this modification of our former procedure sometimes involves a rather freer iridectomy than is otherwise necessary. We think, however, that the price is well worth paying. All this applies of course only to those operations in which the iris bulges spontaneously.

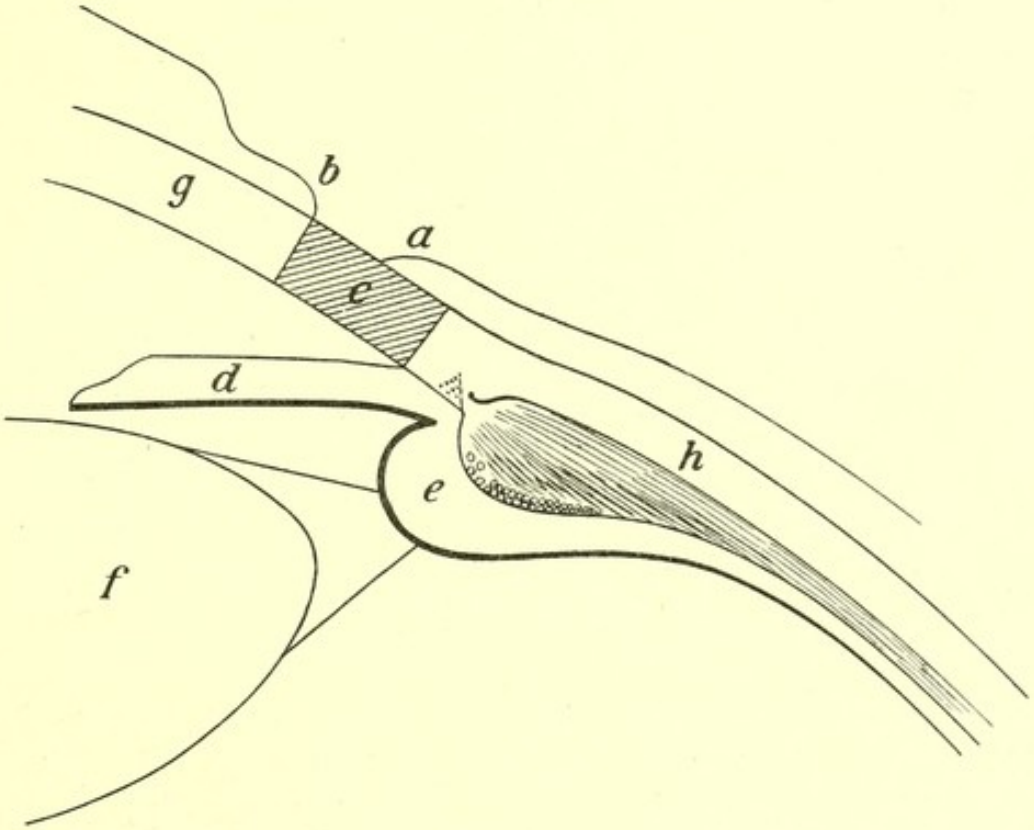

Fig. 17 shows diagrammatically the iris base adherent to cornea; the trephine hole lies just in front of the anterior attachment of the iris. The danger of iris prolapse is obvious.

The next class of case to consider is that in which there is no very distinct bulging of the iris through the wound, though the membrane, hitherto uninterfered with, is apparently closing the disc hole. Here, again, an excision, carefully conducted with a minimum of traction, is called for; it may then happen that aqueous at once gushes out, and we may infer in such a case that the iris base is adherent to the cornea up to within a small distance of the trephine hole (*vide* Fig. 17). The reasoning is obvious.

Figures 16 to 19 show diagrammatically the interference of iris with the trephine hole.

(*a*) Normal position of conjunctiva.
(*b*) Conjunctiva reflected after dissection oft 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.

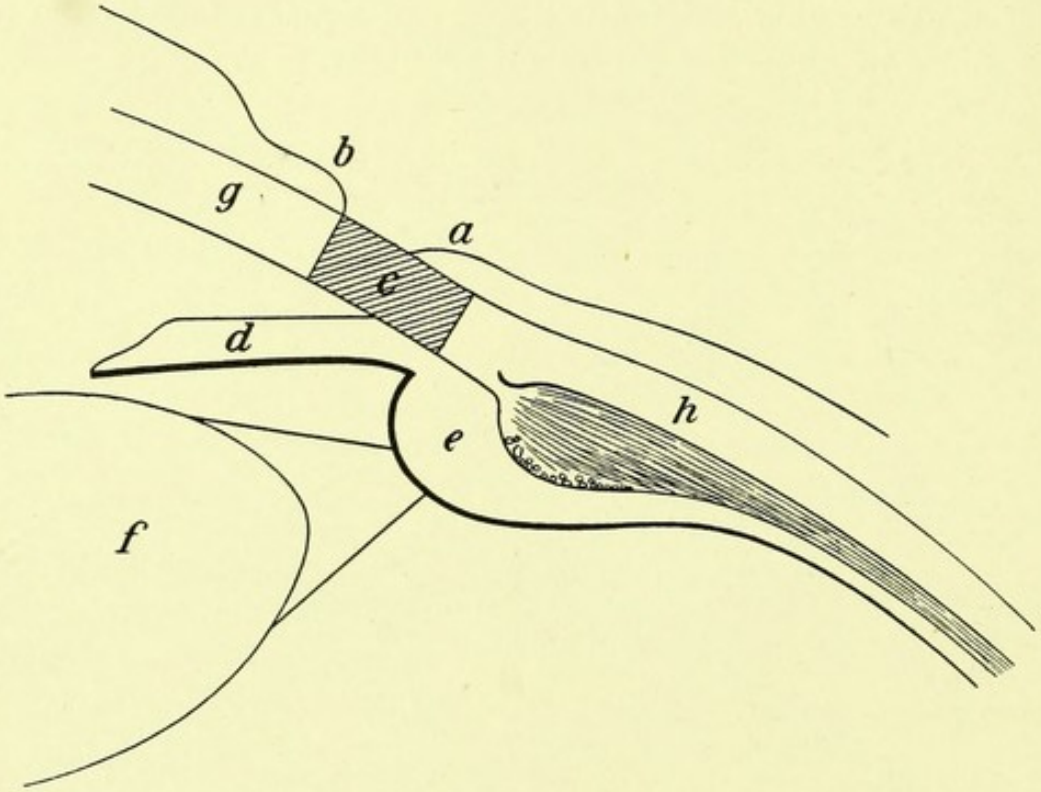

Fig. 18 shows diagrammatically the trephine hole entering the chamber at the anterior part of its circumference.

Even after such an excision, as we have described above, we may still be in difficulty with the aqueous, for though a few drops escape we may observe that the chamber does not empty ; we are then dealing with (1) an impaction of iris stump in the trephine hole, or (2) an oblique and valve-like wound of entry into the chamber (*vide* Fig. 18). A spud, bent forward at the end for the sake of safety, is slid gently into the chamber, directing its point carefully towards the cornea all the time, and its course is carefully observed ; if it enters in front of the iris we have to do with an iris impaction or an oblique entrance into the anterior chamber (Fig. 18), but if it passes behind the iris we obviously have to do with a case in which the iris is adherent far forward to the adjacent cornea (*vide* Fig. 19). It is advisable to consider these cases more at length. If it is only a question of blockage by a stump of iris, one can often free the trephine hole by using the spud and pushing the impacted iris back ; an irrigator is also often useful for the

same purpose ; it is not safe, however, to attempt too much. The question of an oblique entry into the chamber is a more difficult one ; this would appear to be the obvious explanation of a class of case for which no other is available. The fact (1) that one can push the spud easily into the chamber, (2) that there is no resistance to its passage, and yet (3) that aqueous does not escape shows the nature of the obstruction. Since we have adopted the practice of splitting the cornea and so placed our trephine hole a little farther forward, we have apparently ceased to meet with this difficulty. Even with our earlier position of trephine hole, it is inconceivable

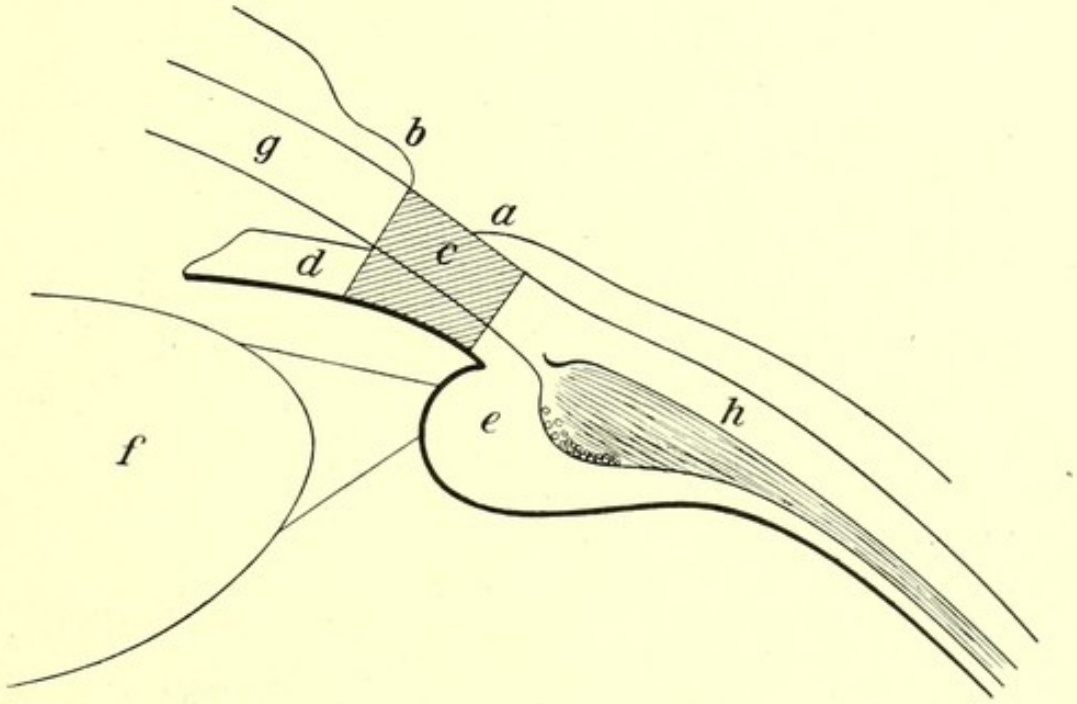

Fig. 19 shows diagrammatically the trephine hole passing through the cornea and the subjacent layer of adherent iris, in a case in which the iris is adherent to the cornea far forwards.

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

that there could be any difficulty unless the iris base is adherent to the periphery of the cornea. When we come to the next class, in which the spud passes into the chamber behind the iris, it is obvious that we are dealing with cases in which the adhesion between the corneal and iridic surfaces has progressed so far forwards as to place a line of adherent tissue in front of the spot where the trephine has entered the chamber (Fig. 19) : we have tapped the posterior chamber, and not the anterior. When this happens, a very interesting feature is noticed : the aqueous escapes with a gush, and we may think that the chamber is freely tapped till we notice that the anterior portion of it is still full of fluid ; pressure with a

curette on the surface of the cornea has no influence in emptying it, and at the same time reveals that the eye is still quite hard. The only available explanation appears to be that the edge of the iris fits down like a valve over the adjacent portion of the lens capsule, and prevents fluid from passing back under pressure from the anterior to the posterior divisions of the chamber. It is then inadvisable to push interference. Although the eye feels hard at the time, and the operation therefore appears to have failed to effect its object, we find that, on the following day, it is soft ; it is therefore obvious that the channel for filtration has been opened up, even though fluid cannot be pressed through it mechanically ; when the posterior chamber is once re-established, the channel of escape of fluid opens of itself.

A condition resembling the above, but really distinct from it, is that in which, even after the chamber has been fully emptied of aqueous, the tension of the eye still remains high ; the eye feels quite hard. This complication only occurs in long-standing cases, and is undoubtedly to be ascribed to intra-ocular hæmorrhage. The proof of this lies in the fact that after the trephining, or even after the escape of fluid from the anterior chamber, the eye can sometimes be felt to be quite soft for a moment and then it suddenly hardens. In a case in which this happens, vitreous escape is an ever-present danger, and the sooner the eye is closed the better. Sometimes the first sign that the eye has hardened is the welling up of vitreous into the wound. If these cases are followed for a few days, the tension falls to subnormal. In a case on which Major Hime was operating, the welling up of the vitreous drew attention to the fact that the eye, which had been quite soft a few moments earlier, had become very hard; the Schiotz tonometer showed a tension of 72 mm. Hg. ; ten days later the patient went out with a tension of 10 mm. Hg.

Toilette of the Wound.—Before replacing the flap it is necessary to inspect the eye, in order to make sure that the pupil is central in position, and that no iris tags are impacted in the trephine hole. Should either of these conditions be found, we use a McKeown's irrigator and endeavour to wash back the uveal tissue into the chamber. This manœuvre is often successful, but if it fails we may trim off projecting iris tags and endeavour to replace the base of the iris into the chamber by means of a spud introduced through the trephine hole. There can, however, be no question that the less of such manipulation we employ the better will the patient's prospects be. Again, if the chamber fills with blood, the irrigator often proves useful in evacuating it. Having satisfied ourselves that

all is well, we replace the flap in position, using a stroking movement of a curette or other blunt instrument for the purpose, and endeavouring to bring the opposing edges of the incision into as neat apposition as possible. 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 soft and whether the escape of aqueous from the chamber is free. It has already been stated that we seldom employ a suture in dealing with upward flaps; an exception to this rule should probably be made in those cases in which we have employed a sub-conjunctival injection, for under these circumstances the edge of the flap tends to curl inward, and it is much harder to get it to lie in good apposition with the opposite cut edge of the conjunctiva.

Both eyes are closed with aseptic pads and a bandage.

Instillation of Drops.—Our rule is to avoid all instillation immediately after operation, unless the pupil shows an obstinate tendency towards upward displacement, in which case eserine drops (grs. 4 ad. oz. 1) are instilled. On the third day 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 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 interfere with filtration. The cardinal rules are few and short, viz.: (1) dissect the conjunctival flap as far forwards as possible, separating it from 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 conjunctival 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

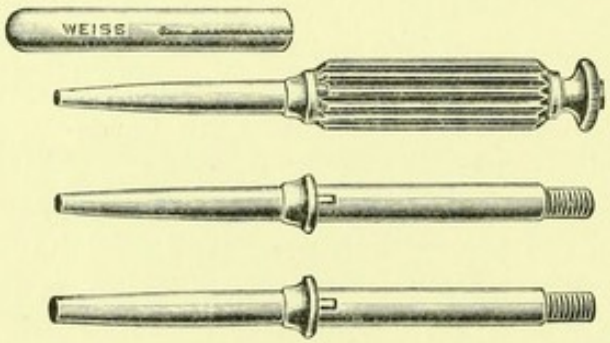

FIG. 20.—Sydney Stephenson's trephine.

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. 20).

Dr. Ernest E. Maddox's trephine has an external stop which is designed to prevent the instrument from cutting too deeply and which is adjustable by means of a little screw in the manner shown by Fig. 21. The instrument is furnished with a guide which the inventor considers to serve the seven-fold purpose of :—

" (1) Finding the best spot for the trephine.

" (2) Guiding it to that spot.

" (3) Retaining it from slipping over the sclera during the " cutting.

" (4) Shielding the conjunctiva from damage.

" (5) Holding the eye instead of forceps.

" (6) Regulating the depth to which the trephine can go.

" (7) Preserving the patient from apparent 'wobbling' of " the field of vision.

" It consists of a thin steel tube, out of which a window is " cut behind. It is furnished with a handle convenient for " holding, and this, again, with a disc of thin blackened metal " to obstruct the patient's eyesight. From the lower front " edge of the tube project one or two fine flattened teeth, the " points of which are intended to be inserted into the angle " between the reflected conjunctiva and the sclera, so that the " eye is drawn downwards by their means. The handle is

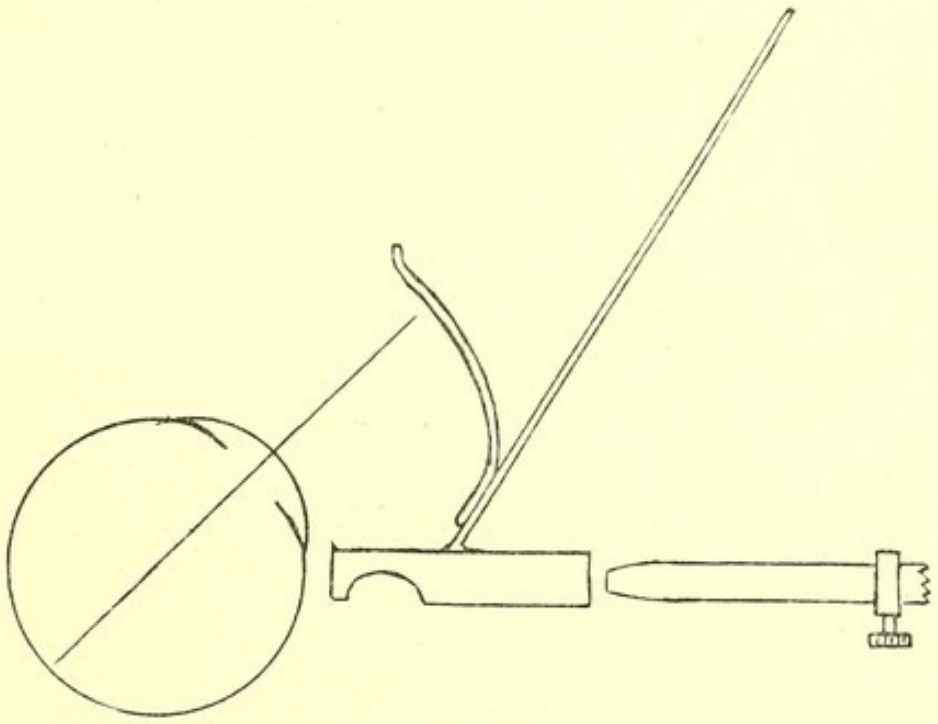

FIG. 21.—Maddox's trephine.

" broad and rough, to furnish a good grip. The trephine is " surrounded by a small metal ring, high up, adjustable by " means of a screw, by which the depth of the incision can be " regulated, since when this ring abuts against the upper edge " of the guide, the trephine can proceed no further." (Fig. 21.)

Dr. Gray Clegg, in a paper read before the British Medical Association at Liverpool, in 1911, and speaking from an experience of twenty-three cases, wrote :—

" A large triangular flap of conjunctiva was raised and reflected over on to its corneal attachment, care being taken

not to perforate it. Scissors with blunt ends curved on the flat, used with the concavity towards the eye, were found to be the most satisfactory instrument, for the cutting ends always pointed towards the centre of the globe. For the first few cases a 2 mm. diameter trephine was used, but afterwards 1.5 mm. was always preferred.

" It does not appear necessary to have any stop to the trephine instrument, as the depth of the incision can be estimated, if desired, from time to time by taking it out, and no difficulty was found in refitting it into the trough already formed. The instrument should be applied so that the proximal periphery of the trephine circle just lies about 0.5 mm. within the circle of the apparent corneal margin. This ensures the direct communication with the anterior chamber. Sclerae were found to vary much in density. If the disc of sclera was not separated all round, the removal was completed by seizing it with straight iris forceps and cutting it free with sharp-pointed scissors. The aqueous usually escaped at once, or it forced the periphery of the iris into the trephine hole. A mere snip of the prolapsed iris with the sharp-pointed scissors allowed the fluid to escape and the iris to fall back into position, otherwise a very small piece was seized and cut off. The resulting coloboma was not always visible through the cornea, but iridectomy is not essential to success if the anterior chamber is properly opened. In some cases the aqueous did not escape, and to make certain of a communication from the anterior chamber an iris repositor was passed through the trephine hole into it, the end being, of course, visible through the cornea."

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. 23A, 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 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.

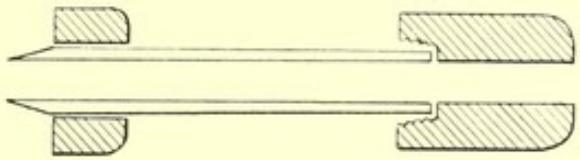

FIG. 22A.—George Young's Trephine.

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

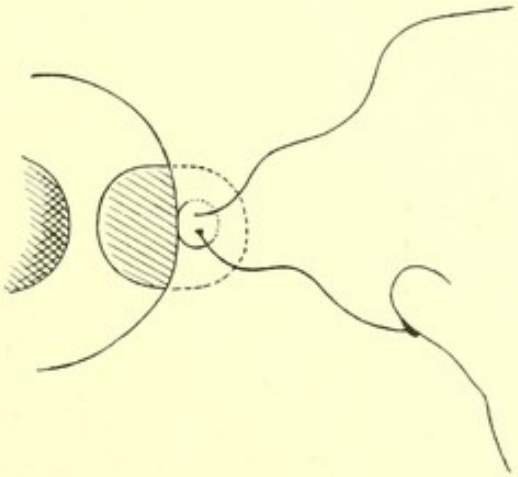

FIG. 22B.

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 scleral

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 and a violation of the first principles on which successful trephining should be founded.

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 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 ratatory motion. The idea is distinctly ingenious, and if the 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.

All the various hand-worked trephines before the profession

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* The Ophthalmoscope, May, 1912.

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

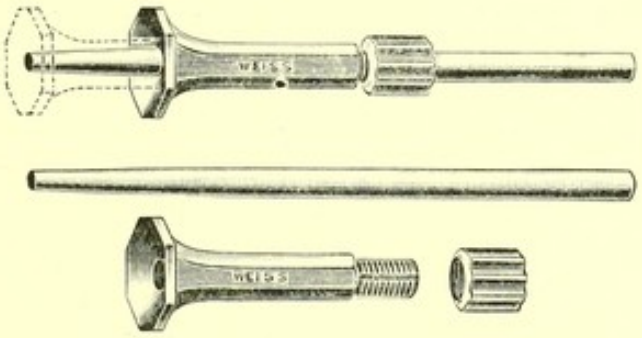

FIG. 23.—Lang's Trephine.

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.

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 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

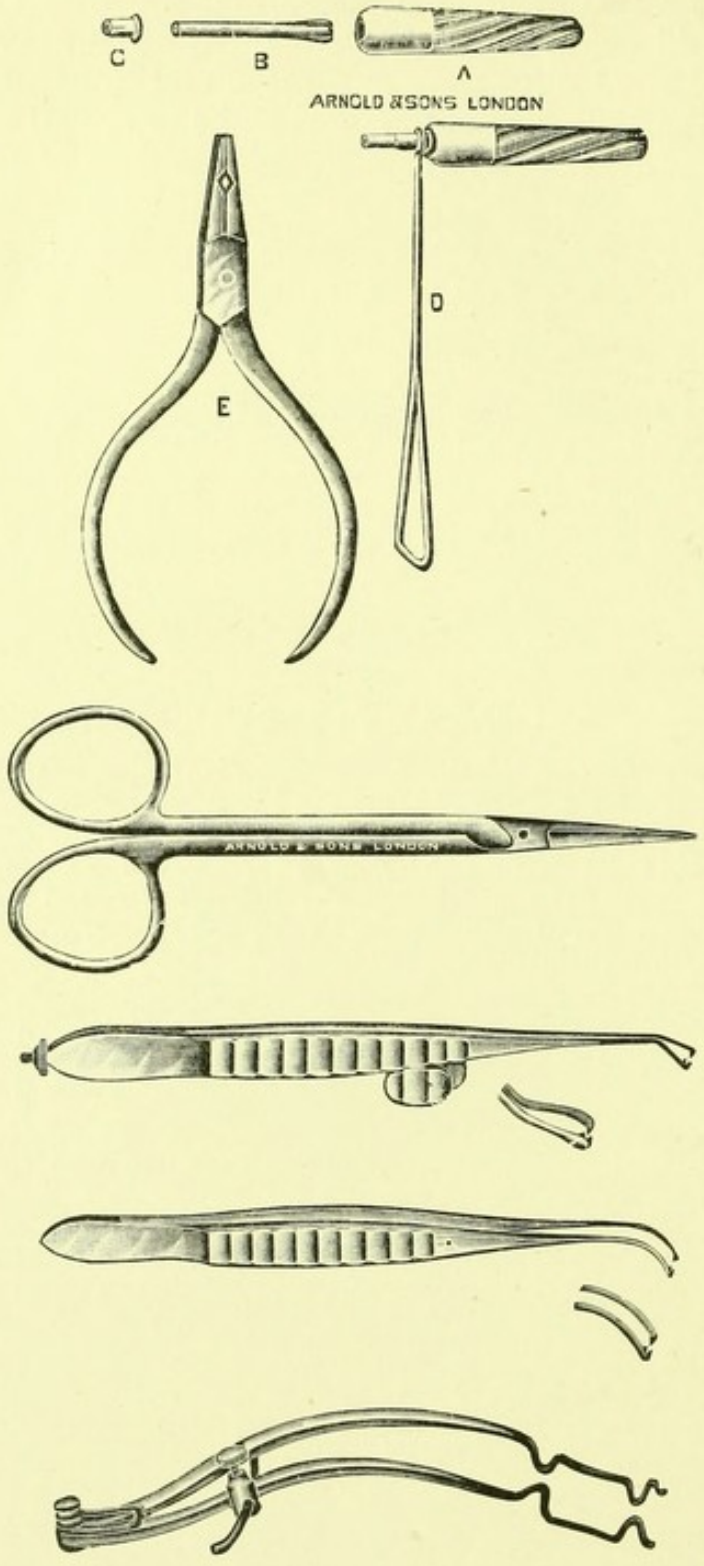

FIG. 25.

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 U.S.A. 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) can be supplied which can be fitted to any of the blades.

(5) **A small handle is provided** (D) with a loop 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.

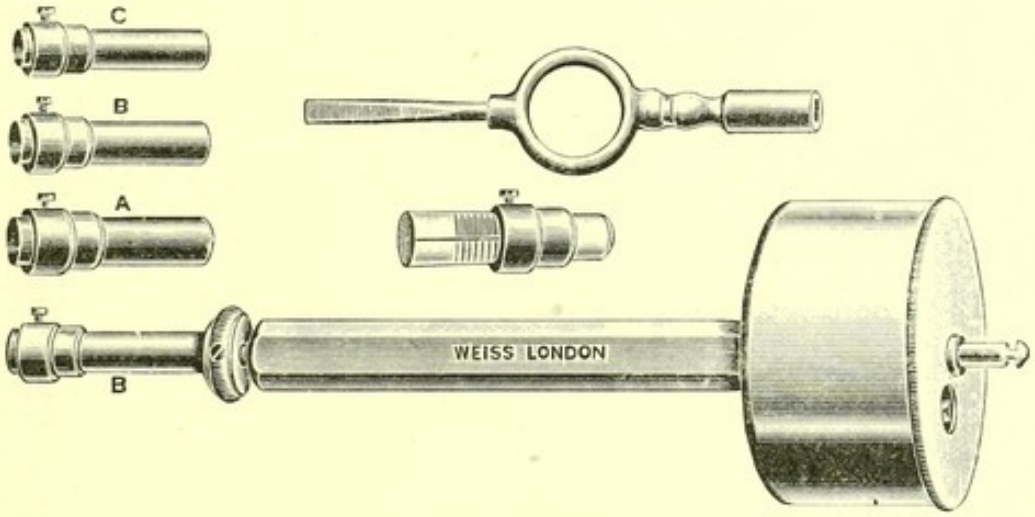

FIG. 26.—von Hippel's Trephine.

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. (Fig. 25.)

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.

Some surgeons prefer to use a von Hippel's clock-work trephine (Fig. 26), 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 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 grove 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 intraocular 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."

Our experience in Madras of the von Hippel's trephine has not been altogether satisfactory. The instrument is open to certain objections : (1) It is expensive ; (2) it is hard to sterilize thoroughly ; (3) and most important of all, it has appeared to us that trouble with uveal tissue is more common after using it. We attributed this to the very clean punched hole made by the instrument and thought that the relative safety attained by the hand-used instrument was due to a thin layer of hinged sclera occupying a part of the depth of the trephine hole. It is possible that Dr. Nimmo Walker's explanation is the true one, and that, with the precautions he takes, the mechanical trephine is in no way inferior to the other. 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.

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

FIG. 27.
Sclerectome, ready for use.

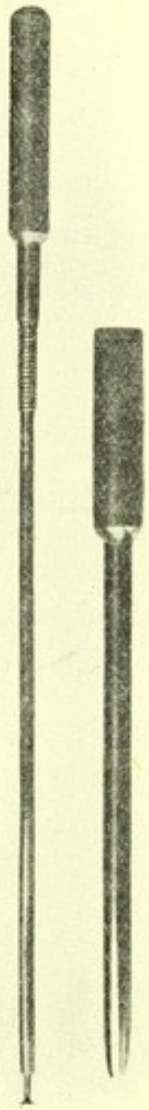

FIG. 28.
Sclerectome with inner rod removed to show construction of instrument.

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. 27 and 28).

In carrying out the operation, a large conjunctival flap is first dissected up, and then by means of a small broad bent needle, keratome, or Graefe knive, an incision 2·5 to 3 millimetres long is made parallel with and at about one half millimetre from the limbus. One end of the incision should lie under the middle of the conjunctival flap. The button of the instrument is then gently introduced through the incision, the instrument being tilted at an angle to render this easy of accomplishment. After the anterior chamber is entered, the instrument is held perpendicular to the sclera and carried to one side, so that the fine rod with the button fits closely in the end of the incision corresponding to the middle of the conjunctival flap. The outer tube is now screwed down, the inner rod being held stationary, or turned slightly in the opposite direction if necessary to obviate undue twisting of the eye. If resistance is encountered, as it may be towards the end, the outer tube may be screwed backwards and forwards a few times instead of continuously forward. A clean round hole is thus cut in the sclera. The diameter of the hole is only one millimetre, somewhat less than that of the cutting edge of the instrument (Figs. 29 and 31).

A small button-hole is now made in the iris, exactly beneath the hole in the sclera. The conjunctival flap may be sutured or not, as thought advisable. In case an iridectomy has previously been done, a conjunctival flap may be unnecessary, since here a small opening in the conjunctiva would no doubt suffice.

The instrument illustrated above has proved satisfactory, but I think it could be improved in minor details. It would be preferable to have the handles made larger and corrugated, and to decrease the pitch of the screw, so that the cutting would be done less abruptly. It is important that the cutting edge should be sharp and true. The instrument could, of course, be made larger, but the disadvantages of a large opening have been pointed out. It would be undesirable also, I think, to make two holes, one at each end of the incision, as this would increase the tendency of each to close.

Thus far I have performed the operation in human subjects only on two blind, painful, glaucomatous eyes. The result,

however, have sufficed to show that the opening remains patent and is effective in lowering the tension. For a few days following the operation the hole in the sclera is not visible, being hidden by the swollen and congested conjunctival flap, but later it can be plainly seen. I have also performed the

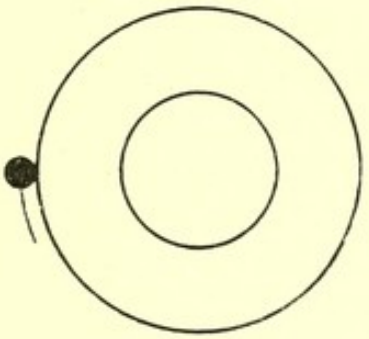

FIG. 31.
Fistula completed. Button hole in iris notshown.

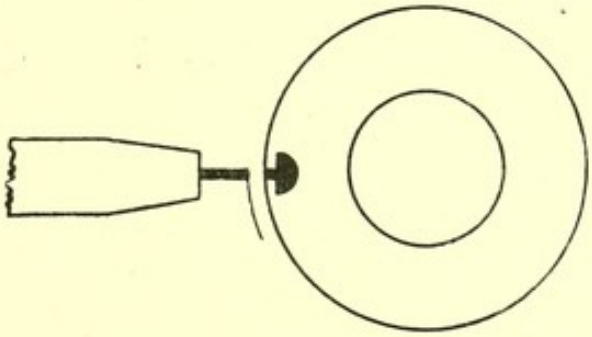

FIG. 30.
Sclerectome in position ready to cut.

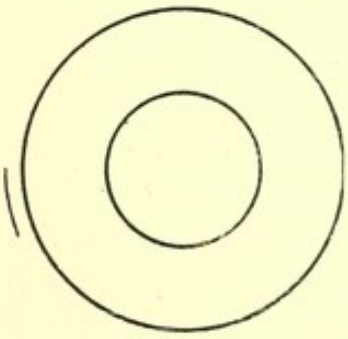

FIG. 29.
Position of incision. Conjunctival flap not shown.

operation with most successful results upon rabbits' eyes, etc."

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 fair 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 both 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.

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 was made by Messrs. Weiss, of Oxford Street, and is figured on page 27 of their catalogue.

Dr. Stephen Mayou, and Dr. Arthur Zorab, in the pages of *The Ophthalmoscope* for May, 1912, have 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. The verdict for or against the procedure, can only be authoritatively given when others have tried it, and have had time to follow up their cases.

It is therefore with the utmost diffidence that one offers the criticism that the introduction of a foreign body into the eye is a procedure which one would hesitate to adopt, whilst any other course is open. The difficulty of efficiently sterilising silk and of keeping it sterile during introduction is enough to 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. The one recommendation of the method appears to be the ease with which it can be carried out.

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. Dr. Gray Clegg, on the other hand, prefers to use blunt-ended scissors curved on the flat. Mr. Basil Lang dissects up the conjunctiva by the aid of a special knife (Fig. 24), whilst Captain Hingston introduced, and we in the Madras Hospital have recently adopted, the use of a Bowman's needle. We employed it at first whenever any difficulty was found in detaching the conjunctival layer from the subjacent cornea (*vide* Chapter V, p. 52), and have now adopted it as a routine measure in all cases.

As some confusion appears to have arisen on this subject, it may be well to explain what is meant by 'splitting the cornea.' In the great majority of cases, what the surgeon actually does is to dissect off the conjunctival layer from the deeper corneal strata, and this is what should always be aimed at. In cases in which there has been long standing inflammation leading to matting of the perilimbal part, it is probable that the superficial layers of the cornea are actually split, especially if a sharp instrument be used. Our impression, founded on evidence not amounting to proof, is that better and more lasting filtration is secured, if we confine ourselves to raising the conjunctival layer of the cornea alone, and thus keep our plane of filtration the same over the corneal, as over the scleral, layer.

CHAPTER VII.

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

(1) **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, or by the use of Cruise's ingenious retractor referred to in Chapter VI. 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. The danger of perforating the flap is considerably accentuated by a sudden movement of the patient's eye during the performance of this delicate manœuvre. He 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. 32.) 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.

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

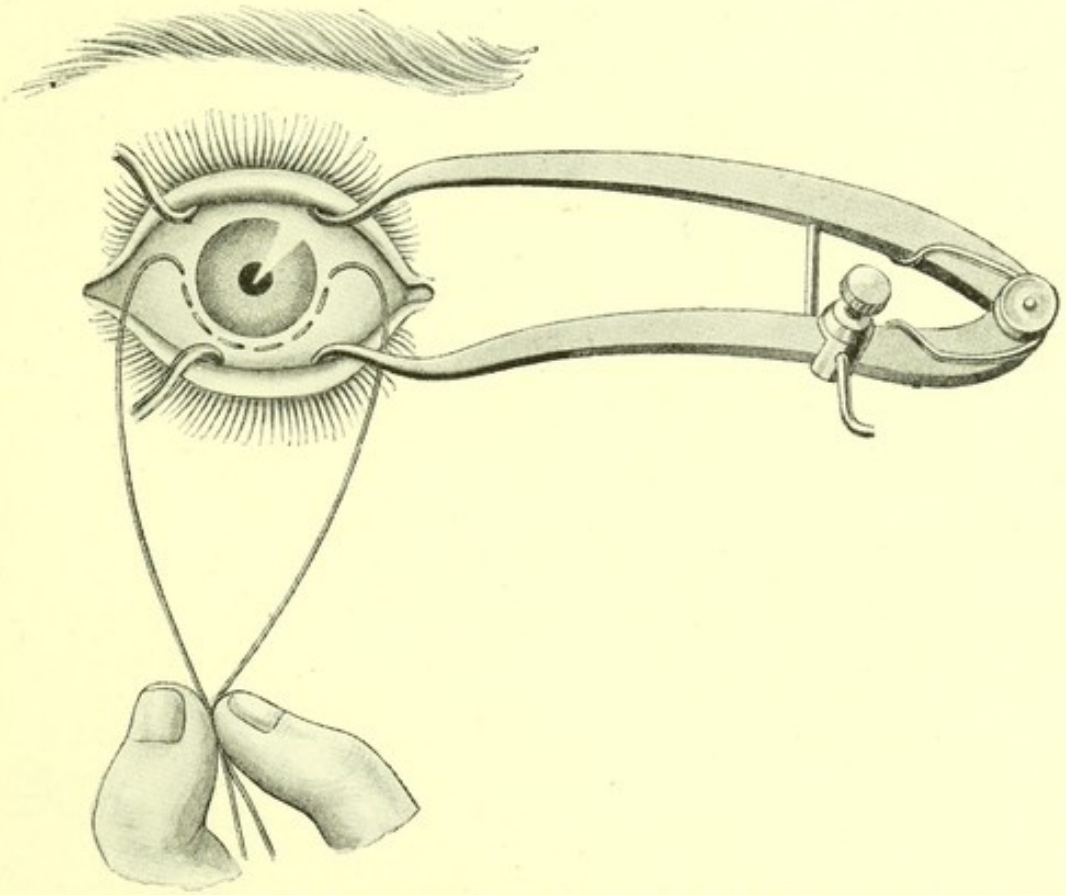

FIG. 32.—Showing the thread, in position for the fixation of an eye, but not yet drawn tight by traction.

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. 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. 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 it 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 to the sclera at one point. A snip with the scissors divides this attachment. Among the cases done by other operators the disc was four times lost in the chamber. It remained there in spite of 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, so far, borne out this opinion.

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 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. 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 his 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 unknown in Madras in cases which resort to treatment at any but the late stages.

Intra-ocular Haemorrhage.—The question of intra-ocular hæmorrhage has been dealt with 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 catastrophe of intra-ocular hæmorrhage 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 intra-ocular hæmorrhage 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 outlet for the escape of fluid, 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. It is, however, an open question whether we should not do better to avoid a hæmostatic, and thus save our patients from the risk of intraocular hæmorrhage during the after-reaction. Given a little time and patience, most cases can be successfully operated on without having recourse to artificial vaso-constriction. 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 the tension of the vitreous has been raised by intra-ocular hæmorrhage. Indeed, it may well be doubted whether in the absence of such hæmorrhage, 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 the iris has become 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, 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.

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 so fully discussed in the chapter on " Technique of the Operation " that 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 shamber 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 definitely vanished, 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 practically vanished from our technique.*

Chapter VIII.

AFTER MANAGEMENT OF THE PATIENTS AND TREATMENT OF COMPLICATIONS.

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

As indications for prolonging bandaging we recognise 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.

Shallowing 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.

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 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 it 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 shall 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 may take 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 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 in all the other measures which are usually 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 appears to be quite harmless in these cases.

Prolapse of the iris 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. It is probable that 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 the McKeown's irrigator may materially assist in its replacement.

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.

Lens blocking trephine hole.—This constitutes a much

more serious condition than the one which we have just discussed. It may be due (1) to an overstretching of the suspensory ligament in existence before the operation, (2) to a tear of the ligament either during operation or possibly as a result of intra-ocular hæmorrhage accompanying or following operation, or (3) to fluidity of the lens contents. When this complication occurs, it is always an early one, and it is usually noticed either at the time of the operation, or at the first dressing. It constitutes a very serious feature of a case. If relief be not given, certain blindness will ensue. There is some comfort in the reflection that this accident only happens in very long-standing cases, in which it could hardly be hoped that any operation could give a good result. It has been already said that it would be inadvisable to interfere with these cases at the time of operation, owing to the difficulty of distinguishing them then from those in which there is prolapse of the vitreous. Whereas a vitreous prolapse, pushed into a trephine hole by intra-ocular hæmorrhage, will go back of itself when the rise in tension subsides owing to the absorption of effused blood, our experience of lens impactions is a much less happy one. In our early cases we were driven to open the wound and deliver the lens. Such a remedy is, however, far too desperate. We then tried cutting into the prolapsed lens with a Graefe knife and allowing some of its contents to escape. The results were far beyond our expectations. The tension fell and the lens did not become opaque whilst under observation; an explanation of this latter phenomenon has not yet occurred to us. There is no question that it was lens matter which escaped.

In dealing with fluid or semi-fluid cataracts complicated by glaucoma, trephining is probably contra-indicated. But this matter has already been dealt with 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 has been found that secondary operative interference has 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 are 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 so fully in Chapter VII, that 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, in the previous chapter, 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. Unfortunately, we are at present only in a position to guess at this. 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, if not the probability, of its existence 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. 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.

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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 here as in Europe, and both Priestly Smith's scotometer, and Bjerrum's screen are used with advantage.

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

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

to take place in vessels and nerves, the dilatation of the pupil and atrophy of the iris may be absent." Looking at the question from a clinical point of view, it appears to us that this explanation hardly covers the ground. The iris muscle gives every evidence of being atrophic, and the atrophy has apparently progressed *pari passu* with the crushing of the nerve filaments. Unless fibrous tissue replaces the constrictor muscle of the iris before the nerves become paralysed, it is difficult to explain the inactive and relatively contracted pupil we are discussing. It is hard to believe that the nerve filaments can retain their vitality in one of these stony eyes, however gradually the pressure may be applied.

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 is not the weakest part of the ocular tunic in such an eye. 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 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, though it 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 fields to their former dimensions.

A third 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. Recently one of our confrères, an European Ophthalmic Surgeon honoured us by coming to 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 a 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 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.

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.

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. Mr. 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 us 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. If the diameter of the disc of dye removed were 2 mm. on the admission of the patient, 3 mm. after he had been twenty-four hours under treatment in hospital, 8 mm. a few days after operation, and 6 mm. when the patient was seen six months later, one could confidently say (1) that he was in a dangerous condition on admission; (2) that treatment in hospital had improved his condition; (3) that operation had overdone the lowering of tension; and finally (4) that half-a-year later, the balance had been re-established, and the eye brought to a normal condition. But it was impossible to argue from one case to another; a small microphthalmic eye with a 3 mm. reading might easily be normal, whilst a large myopic globe might well be hard, though the record showed a 5 mm. disc. In other words, 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 has seemed to teach 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 reading 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 visitors have from time to time been asked their opinions on such cases, and have in each case been 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 has been to make all who work in Madras very guarded about giving opinions in the absence of a tonometer ; the feeling amongst us is that one might just as well guess at a patient's temperature by passing one's hand over his skin as estimate his ocular tension by the finger method alone.

No better proof of the value we place 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 have 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.

The influence of a high arterial tension on the incidence of glaucoma.—An interesting series of experiments is being carried out in the Government Ophthalmic Hospital, Madras, by Lieut. Craggs and Assistant Surgeon Taylor. Their object is 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 desire to estimate its possible influence in the causation of the disease. In the first instance a series of fifty young men were examined and it was found that the average systemic tension at the age of twenty-four was 122 mm. Hg.

In the next instance twenty-five patients suffering from uncomplicated cataract were taken. Their average age was fifty-four, their average intra-ocular tension 16 mm. Hg., and their average systemic arterial tension was 143 mm. Hg. Finally a series of twenty-five glaucoma patients was taken. Their average age was forty-eight, their average intra-ocular tension 58 mm. Hg., and their average systemic arterial tension 142 mm. Hg. The investigation is still in progress, but the obvious lesson would appear to be 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 glaucoma. The determination of the average tension in healthy people at the ages of forty-eight and fifty-four respectively is being carried out.

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, has always attracted the attention of visitors. It is 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 our 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 are of foolscap size. In dealing with large numbers such as we handle in Madras, where we have already accumulated records of over 780 trephine operations, it is imperative that we should have some easy system which will 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 we 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. Susequently. (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 reformation of chamber; (v) position of pupil; (vi) vision and field of vision after operation.

Glaucoma Register.

	Serial number.		
	Name.		
	Age.		
	Sex.		
	Caste.		
	Date of admission.		
	Side affected.		
Course of disease.	Acute.		
	Sub-acute.		
	Chronic.		
	Primary.		
	Secondary.		
Condition on admission.	Tension.		
	Field of vision.		
	Vision.		
Results of preliminary treatment.	Tension.		
	Field of vision.		
	Vision.		
	Date of operation.		
Anæsthetic.	Drops.		
	Sub-conjunctival injection.		
	General.		
	Size of trephine used.		
Site of Section.	Above.		
	Below.		
	Lateral.		
Notes of operation.	Trephine hole too far out.		
	Flap sutured.		
	Disc cut out. Clean.		
	Disc cut out. Ragged.		
	Aqueous escape.		
	Chamber emptied with the aid of instruments.		
	Iris presented at operation.		
	Iris prolapsed at operation.		
	Iridectomy. Large.		
	Iridectomy. Small.		
	Vitreous escape.		
	Position of iris at the end of operation.		
Instillations after operation.	Mydriatics.		
	Myotics.		
	Date of reformation of chamber		
After-course of case.	Evidence of filtering cicatrix.		
	State of filtration.		
	Position of pupil.		
	Prolapse of iris.		
	Tension.		
	Date of tension rising to normal.		
	Field of vision.		
	Vision.		
	Iris adhesions.		
	Date of discharge.		
Indications for the operation.	Blind painful eye.		
	Glaucoma secondary to cataract.		
	To prevent glaucoma in cataract cases.		
	For vision with hand movements only.		
	For better vision.		
Secondary operation, if any.	To remove impacted iris.		
	To removed prolapsed iris.		
	To relieve high tension.		
	Result.		
	How long after operation was the patient seen again ?		
Condition at later visits.	Evidence of filtering cicatrix.		
	State of filtration.		
	Position of pupil.		
	Tension.		
	Vision.		
	Field of vision.		
	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 780 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 as briefly and concisely as possible.

To those who do us the honour of visiting the Madras Hospital our original notes and statistics are gladly made available for study.

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 have made a very special effort in Madras to keep in touch with our glaucoma cases, and thus to obtain material from which it may from time to time be possible to draw reliable inferences as to the value of trephining. Excluding our more recent cases on the ground that they have not yet had time to present themselves again, we find that out of about 650, 142 (or 21.84 per cent.) have returned at varying periods ranging from a few months up to two years and eight-and-a-half months after the operation. 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.**—Sixteen such eyes returned for examination at periods varying from nearly a month up to over two years. One was a blind staphylomatous eye; hyper-tension returned and was unrelieved even by a second operation. This was the only known failure in this group. Three cases returned, one at eleven months, one at a year and five months, and one at a year and six-and-a-half months after operation with vision respectively of perception of light, recognition of hand movements, and 5/60. Another case, seen over two years after operation, had still marked lowering of tension. Of the cases in which vision had improved, one was in an acute, one in a sub-acute, and one in a chronic condition at the time of operation.

(2) **Cases in which the vision at the time of operation was perception of light.**—There were six of these cases. Two were frank failures; in one, tension remained lowered but vision disappeared; in three, vision improved to perception of hand movements; in two of the latter, the improvement was delayed till after the extraction of cataracts.

(3) **Cases in which the vision at the time of operation was perception of hand movements.**—In fourteen of the eyes that come under this group the patients returned at periods varying from seven months up to two years and seven months after operation, the average period for the group being well over one year and four months. In only two of these was a failure recorded as a result of a fresh rise of tension, and in both of them it might have been averted had the patient returned earlier. There were three other failures; one was due to the progress of a condition of retinitis punctata albescens; in one the cause of failure, though unrecorded, was clearly not a return of tension; whilst in the third (one of the earlier cases operated on by another surgeon) chronic irido-cyclitis supervened. The rest held their ground.

The whole group comprises fifty cases, in nine of which a very distinct improvement in vision was recorded, the best results being two of 6/18, one of 6/24, and one of 6/36.

(4) **Cases in which the vision at the time of operation was a finger-count.**—This group comprises twenty-seven eyes, fifteen of which were seen from seven-and-a-half months to nearly two years and nine months after operation. The average period for these fifteen comes to one year and seven-and-a-half months. The results in these cases when last seen were 3/50 in one, 6/60 in four, 6/36 in two, and 6/12 in one. In another case in this group, vision one month after operation was 6/12, whilst in yet another case seen four months after operation, vision was 6/18 in one eye, and 6/12

in the other. In five cases, deterioration of vision continued, and was attributed to the progress of a cataract which had not yet been operated on. One patient left us in a satisfactory condition and resorted to a native charlatan, with the not unusual result that his cornea was destroyed, and rendered opaque by the use of irritant drugs. The remaining cases just about held their own.

(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. They were seen at periods varying from one month to over two years after operation, and included our most intelligent patients. They numbered forty-three in all, twenty-eight of whom retained the vision they had before operation or obtained better. In eight the vision deteriorated due to the development of a cataract. In four a diagnosis of the cause of a distinct degeneration of vision was unfortunately not made. In one the deterioration was due to the development of synechiæ, the result of quiet iritis. Finally in one case in which vision at operation was 6/6, and in which a perfectly successful trephining was performed, the tension remained permanently lowered, but vision was abolished within two years; a dense cataract hid the fundus details, but there seemed a strong presumption that a concomitant optic atrophy had been responsible for the failure of the case. In one case the vision fell from 6/12 to 6/24 after operation and remained at that level. The patient was unfortunately lost sight of.

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 has been made to educate others in the technique of the operation. No less than twenty-four 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 tnat we suffer from is the want of intelligence on the part of our patients. Comparatively few of them will co-operate with us in any way. The majority, having obtained relief of their symptoms, will wash their hands of us 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 is at stake, will present themselves either before us or before some other trained ophthalmologists at stated intervals for a routine examination. Our aim is always to make such an examination quarterly. We have been fortunate enough to have amongst others four exceptionally intelligent and very highly educated Europeans, 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 nearly two 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.

No. 223A.—A prominent Government Official seen two years after trephining of the right eye for rapidly progressing non-congestive glaucoma; vision remains 6/6; 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 left 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

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

considerably recovered. Vision has fallen to 6/9, but this appears to be largely due to blurring from the wide coloboma of the original iridectomy in England.

Nos. 368 and 369.—Mr. B., a veterinary officer, seen fifteen-and-a-half-months after both eyes had been trephined 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; filtration free in both eyes; pupils central; tension 10 mm. Hg. in R.E., 15 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 touring, without any sense of effort.

No. 342.—Miss C., a well-known lecturer on Theosophy; was last reported eighteen months after operation; right eye vision had improved from 6/6 bar 3 letters to 6/6; filtration was free; pupil central; tension normal; patient writes that she is quite well, and doing an enormous amount of very successful lecturing on behalf of her sect. She is also writing a book on Theosophy.

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.

This leads us naturally to consider a phenomenon which our summary has 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 at an earlier stage 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

* P.S.—These four cases are still under observation three months later and all continue to do well. AUTHOR.

glaucoma profoundly influences the nutrition of an eye is well known. A fact which we find much harder to explain is that the alteration in nutrition does not always manifest itself along the same lines. To take a 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 have learnt 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 symptom 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 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 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. In the cases we are discussing, however, an entirely new factor is introduced. The operation of trephining has 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 progresses. 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.

ON THE SITE OF TREPHINING FOR GLAUCOMA: ITS IMPORTANCE.

BY

E. TEMPLE SMITH, F.R.C.S.E., D.O.Oxon.,

SYDNEY, AUSTRALIA.

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 seens 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.

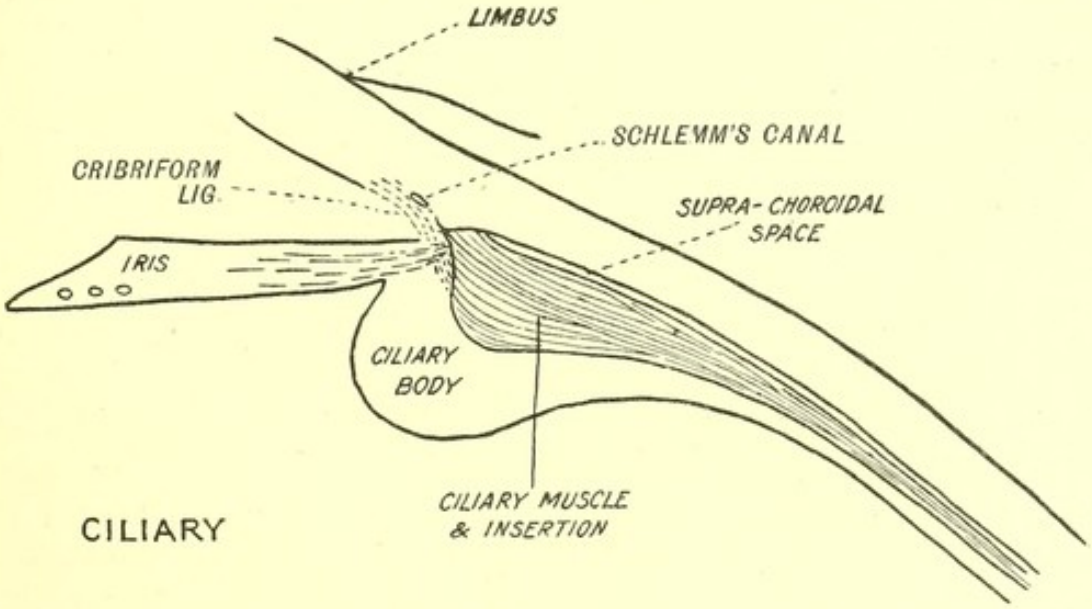

FIG. 33.

"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 Elliott'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*[3], 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.

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(15) **Elliot.**—*Ibid.*, December, 1909, p. 806.
(16) **Weekers.**—Quoted in *The Ophthalmoscope*, March, 1910, p. 225.