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COMMUNICATIONS

OBSERVATIONS ON SOME MATTERS ASSOCIATED WITH EXPERIMENTAL CORNEAL GRAFTING*

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EXPERIMENTAL work on the eyes of rabbits has shown that whole thickness corneal tissue from another rabbit can be transplanted successfully, and that the grafts can remain transparent, when a particular technique is followed. Records of these experiments have been published.

It is proposed in this paper to supplement those records by some further records of homogeneous grafts, and to compare the results of homogeneous and heterogeneous grafts. The method of prevention of adhesion of the iris to a corneal graft will be discussed, and some observations will be made on the sensitiveness of corneal grafts, and on the clinical examination of an eye with an opaque cornea.

Homogeneous Grafts

Since the publication of a paper giving the results of corneal grafting, 11 experiments have been performed, using the technique which gives the best results.

* Richard Middlemore Post-Graduate Lecture delivered at the Birmingham and Midland Eye Hospital, on December 5, 1933.

Two of these have to be discounted; one died on the second day after the operation, the other was accidentally contaminated.

The results of the remaining nine are as follows:—

Five became transparent; one was nebulous with clear areas; one was nebulous throughout; one quite opaque; and one partly detached.

The five clear grafts were free from adhesion of the iris, with one exception where the iris was slightly adherent for the first fortnight, and then became free. The importance of keeping the iris free has been emphasized in previous papers. One of the animals died five weeks after the operation, the graft being practically clear, and there is no doubt it would have remained transparent had the animal lived.

The other four are still alive, at periods ranging from eight months to twenty-eight months from the date of the operation.

Photographs of these five grafts (hitherto unpublished) are included for publication with this paper. (Figs. 1 to 6.)

The nebulous graft with clear areas (Fig. 7) was free from adhesion of the iris, but about the end of the second week there was a small furrow around the graft which interfered with normal healing and perfect union. At no time was there a complete detachment at any portion of the margin; had there been even a small complete detachment, the graft would almost certainly have become opaque.

The two opaque grafts.—One of these was uniformly nebulous (Fig. 8). The graft in this rabbit united well, and the iris remained free. The development of opacity was mostly due to the behaviour of the animal which subjected the eye to much more strain and unrest than is usual in experimental animals, by its sudden and frequent jumping movements. The result of this extreme unrest was that the graft became somewhat prominent and convex, causing it to become opaque by the fifth week. The opacity diminished after some months, and the animal is still alive, 11 months after the operation with a uniformly nebulous graft.

The other opaque graft exhibited an adhesion of the iris to the cornea, from which source the graft became vascularized.

One graft became partly detached, and the animal was killed 11 days after the operation. There are two reasons to account for the failure in this case. One of the stitches penetrated the anterior chamber, so that the trephining had to be done on a soft eye. This resulted in damage to the lens, which developed cataract. The swelling lens helped to push the graft from its bed. The other reason for failure is that the intra-corneal portion of one of the stitches was too long, so that the adjoining margin of the graft was not securely held in place. The iris was adherent

FIG. 1 = R 128.
Three weeks after operation.

FIG. 2 = R 128.
Two years and four months
after operation.

FIG. 3 = R 156.
Nine months after operation.

FIG. 4 = R 158.
Five weeks after operation.

FIG. 5 = R 160
Eight months after operation.

FIG. 6 = R 163.
Eight months after operation.

FIG. 7 = R 162.

Homogeneous corneal graft—nebulous with clear areas, eight months after operation.

FIG. 8 = R 151.

Homogeneous corneal graft—opaque, eleven months after operation.

FIG. 9 = R 137.

Heterogeneous corneal graft—opaque, seventeen months after operation.

FIG. 10 = R 159.

Heterogeneous corneal graft—uniformly nebulous, eight months after operation.

to the graft when the stitches were removed, and at that time there was no detachment. The swelling lens, however, soon broke down this early union, and the animal was then killed.

It has thus been possible to ascertain the causes of failure in cases where a transparent graft has not been obtained. These causes of failure are pitfalls that can be avoided in most cases if sufficient care is taken, and it is entirely useless to expect good results in corneal grafting unless meticulous attention is given to every detail.

The following is a summary of the results of the nine homogeneous grafts with seven others (previously published) operated on by the same technique, which was found to give the best results.

Of the 16 homogeneous grafts :—

- 10 were transparent.
- 1 had a clear area.
- 1 was nebulous with clear areas.
- 3 were opaque.
- 1 became partly detached.

This represents 62 per cent. clear grafts, and 75 per cent. which would allow useful vision.

Five Heterogeneous Grafts

One graft was taken from a human eye, and the other four were from cats' eyes.

All five became united, but none was clear.

Four were opaque, and in only one was there any suggestion of transparency; this one would be described as nebulous.

This brief summary of results needs to be qualified by reference to certain other facts.

The human cornea was kept for 19 hours before it was utilized for the experiment. This fact would have to be kept in mind as a possible cause of ultimate opacity even if the graft were taken from another rabbit. The graft was practically clear for the first week, but opacity began to develop about the end of the second week, and in the fourth week the graft became quite opaque. There was evident a slight rounding of the edges of the graft after about three weeks, and vascularization took place from the periphery of the cornea. The iris remained free, so that one prominent factor in the causation of opacity did not affect this case.

The graft was quite opaque when the animal died three months after the operation.

Four grafts taken from cats' eyes.—In three of these the iris was adherent, and the grafts were opaque. One has been observed for 17 months (Fig. 9), one was killed at two months, and one on the 15th day. The adhesion of the iris in each of these three cases would account for the development of opacity even in homogeneous grafts, so that one can not say definitely that these grafts would have become opaque if the iris had remained free.

The fourth of the grafts (Fig. 10) is more helpful in establishing the course of events. This graft united well, and the iris remained free. There was a slight tendency to retraction of the lower margin on the tenth day, and the graft was correspondingly slightly prominent. A milky opacity developed during the second week, followed by vascularization of the graft. At the end of four months the graft was still opaque, but by the seventh month the opacity had diminished so that the graft could be described as being nebulous. If this had been a homogeneous graft, it is most likely that union would have been very good, and with freedom from adhesion of the iris the graft would probably have been transparent.

It is therefore of interest to note that although 62 per cent. of homogeneous grafts become transparent, not one of this small series of heterogeneous grafts, operated on by the same technique, could be described as clear, while four out of the five were quite opaque.

Another observation worthy of note is the tendency that heterogeneous grafts have to become vascularized.

It is a fact that a homogeneous graft which unites well, and without complications, remains clear and avascular when a particular technique is followed.

Progress of Opacity in Homogeneous and Heterogeneous Grafts

The following chart (Fig. 11) indicates the presence and depth of opacity in these grafts subsequent to the operations. The numbers on the left of the chart refer to the rabbit concerned, and the space opposite each is blacked in according to the depth of the opacity, being left blank if the graft is clear, and completely blacked in if the graft is opaque. The chart shows the progress for the first four weeks, with a note as to the subsequent history. It will be seen that the clear homogeneous grafts all developed a cloudiness and slight opacity during the first week, which never led to complete opacity, and cleared up in the second to the fourth week. The heterogeneous grafts, on the other hand, although clear for a few days became cloudy, and in the second week became opaque, but in one of them the development of complete opacity took longer. They do not show the tendency to improvement

EIGHT HOMOGENEOUS GRAFTS

TABLE SHOWING DEPTH OF OPACITY

FIVE HETEROGENEOUS GRAFTS IN RABBITS

FIG. 11.

that is shown by the nebulous homogeneous graft with clear areas (R 162), which reached the height of its opacity about the second and third week. This graft (R 162) could be compared with the heterogeneous graft (R 159) inasmuch as they both united in a somewhat similar manner; in each case the iris remained free, and they were observed for eight months, and seven months respectively. The difference in the ultimate opacity of these two grafts was considerable, and leads one to the conclusion that this difference is due to the fact that one of them was taken from an animal of different species.

These observations lead to the conclusion that heterogeneous grafts should not be used for corneal transplantation when applied to man. Experiments on animals have shown that it is quite possible for these grafts to become united, but they do not become transparent. Homogeneous grafts can unite and remain transparent, both in experimental animals, and when applied to man.

The Prevention of Adhesion of the Iris to a Corneal Graft

Attention has been drawn in a previous paper to the deleterious effect of an adherent iris on the clarity of a corneal graft. Further proof of this statement is furnished by an examination of the eight united homogeneous grafts referred to in this paper. Six of these were free from any adhesion of the iris, and one other

exhibited a small adhesion of the iris which became free in three weeks. Five of these were clear, one had clear areas, one was opaque—although not densely opaque, for reasons which have been given. The remaining graft was the only one in which the iris was prominently adherent, and this graft was densely opaque. Every possible measure must be taken to ensure freedom from adherence of the iris in cases where transparent corneal grafts are desired.

The technique of the operation described in previous papers, by the "cross-stitching" method is such that the gap in the cornea of the host is filled up accurately by the graft, which is held securely in place. A water-tight union is obtained, and re-establishment of the anterior chamber is ensured. These results depend in large measure upon the sloping or shelving edge of the graft, and of the hole in the cornea, and upon the adequate and uniform pressure on the graft to hold it securely in place.

Re-establishment of the anterior chamber as soon as possible after the operation is necessary to allow the iris freedom from adhesion to the graft. The central position of the graft over the middle of the pupil, and the optimum size of the graft, are factors which allow the iris to remain free when the pupil dilates.

Notwithstanding these precautions, it was found on experiment that the iris not infrequently became adherent, and it became evident that further investigation was necessary to obtain better results.

It had been noted from the earliest experiments that after opening the anterior chamber, a fibrinous clot was formed in the conjunctival sac, and fibrinous material rapidly formed on the stitches. The stitches would sometimes be bound together so firmly that it was a very difficult matter to separate them without doing any harm to the graft. Lumps of fibrin would form on the stitches, so making it difficult to manipulate them, and to tie the necessary knots. The aqueous of the rabbit contains fibrinogen, and the troublesome clot was fibrin. The first attempt to overcome this difficulty was to mop up the aqueous as soon as the anterior chamber was opened. This resulted in some improvement, but fibrin was still formed.

Prevention of formation of fibrin was then attempted by using 1 per cent. sodium citrate solution to wash away the aqueous after opening the anterior chamber. The result of this was to eliminate the difficulties of fibrin formation during the operation, but in two experiments the iris was in each case adherent to the graft.

It is now realized that the fibrinous clot which formed lumps on the stitches and caused them to stick together so firmly would form a basis by which the iris would adhere to the graft, and

that this attempt to reduce the technical difficulties of the operation was leading towards a solution of an important problem in experimental corneal grafting, the problem of keeping the iris free. It was now appreciated that the adherent iris in the last two experiments was probably due to the fact that the graft itself had not been washed with citrate solution, so that thrombin would form on the graft, which would act on the fibrinogen in the aqueous, even in the presence of citrate, when the graft was applied to the eye. Thus a fibrinous clot would form—facilitating adhesion of the iris to the graft. Realising the tendency of the pupil to contract, even after the use of atropine, when the anterior chamber was opened, the problem presented itself of keeping the pupil dilated under these conditions.

In the next experiment the graft was bathed with citrate solution as soon as it was cut, and the eye of the host was treated similarly. In addition to these precautions, an attempt was made to limit the dilatation of the blood vessels in the iris, as well as to limit the formation of fibrinogen, by the use of adrenalin drops after opening the anterior chamber. The result was that the pupil was dilated and free from the graft *at the end of the operation* in a manner that had not been obtained in previous operations. The experiment was repeated, with the same result. In each case the iris remained free.

One of these grafts was homogeneous, and in this case the graft became transparent. A few haemorrhages were present on the iris a few days after the operation. The other graft was heterogeneous, and it was the only one of the five heterogeneous grafts in which the iris remained free, the other four having been transplanted before these improvements were introduced.

The presence of small haemorrhages on the iris in the last experiment, possibly influenced by the use of 1 per cent. sodium citrate, indicated the desirability of reducing the amount of citrate, and balancing the solution with a percentage of sodium chloride. Matthews' Biological Chemistry contains a statement that 0.125 per cent. to 0.25 per cent. sodium citrate is sufficient to prevent blood from clotting. In the next experiment the solution used was 80 c.c. normal saline (0.9 per cent.) with 20 c.c. of 1.25 per cent. sodium citrate corresponding to 0.25 per cent. (0.9 per cent. of sodium citrate solution. The pupil in this case was free and dilated at the end of the operation and the iris remained free. There was, however, just a little fibrin formation during the operation, and rather a lot of the citrate solution had to be used to prevent its formation. It seemed that there was only a small margin, with hardly any allowance for dilution by the aqueous, and that with hardly any allowance for dilution by the aqueous, and that for the next experiment a slightly stronger citrate solution should be used.

The relative tolerance to atropine in rabbits is acknowledged, and a trial was made of various mydriatics in order to choose the most suitable for the purpose. According to Dixon laevo-hyoscyamine is 12 times more powerful than dextro-hyoscyamine, and twice as powerful as atropine in its action on the eye. A comparison between laevo-hyoscyamine and hyoscine showed that the former has a stronger and more prolonged effect on the pupil in rabbits. The mydriatic used for the experiments is in oily "solution." It was found that 2 per cent. laevo-hyoscyamine in olive oil caused the oil to become very viscid and jelly-like when cold, but that 1 per cent. did not do so. Consequently 1 per cent. laevo-hyoscyamine was chosen for use in the experiments.

In the next experiment these improvements were introduced. The citrate solution consisted of 80 c.c. of 0.9 per cent. sodium chloride, with 20 c.c. of 2.5 per cent. sodium citrate, corresponding to 0.5 per cent. sodium citrate. The result was very encouraging inasmuch as the pupil was dilated and free at the end of the operation, and was not even adherent to a stitch which had by accident penetrated the anterior chamber, and a portion of which lay deep to Descemet's membrane. The importance of using a solution that would be isotonic necessitated some investigation as to the tonicity of citrate solutions. The citrate molecule can dissociate into a number of ions according to the strength and pH of the solution. A theoretical estimate coupled with tests for isotonicity on rabbit's red blood-cells seemed to indicate that the best results would be obtained by a 3 per cent. solution.

For the remaining experiments entire satisfaction was obtained by using a solution consisting of 70 c.c. of 0.9 per cent. sodium chloride, and 30 c.c. of 3 per cent. sodium citrate. This resulted in 0.9 per cent. sodium citrate in the solution, which was sufficient to ensure freedom from fibrin, while the osmotic value was as near being correct as possible, and the percentage of sodium chloride in the solution would give an isotonic balance that would be reliable. One small detail has yet to be mentioned. It was noted that with all these precautions, a trace of fibrin was formed on the stitches, hardly enough to cause any difficulty, but it is much better to have the stitches supple and free, than for them to be in the slightest degree hardened and stiff by the formation of fibrin. The reason for the formation of this trace of fibrin on the stitches was that they had passed through corneal tissue, and the defect was remedied in the experiments that followed by dipping the sutures before use into the citrated saline solution.

If no steps are taken to prevent the formation of fibrin, or if the measures are inadequate, a fibrinous clot is apt to be formed on the deep surface of the graft. This often leads to impairment of clarity of the graft, and can do so in three ways: 1. By

establishing adhesion of the iris. 2. By forming a pabulum for the growth of connective tissue from the cut surface of the cornea, behind the graft, which, even when the iris remains free, causes an opacity to develop, deep to the graft's Descemet's membrane. 3. By organization and contraction of the fibrinous clot, wrinkling and folding of Descemet's membrane take place, appreciated clinically as grey lines in the deep layers of the graft, and confirmed histologically.

Thus, limitation of fibrin formation, and freedom from iris adhesion in operations for corneal transplantation, are of paramount importance, and can be ensured by the following procedure :

1. Establishing close apposition of the graft to its bed by the technique previously described as giving the best results. In this way a water-tight union can be obtained.

2. The use of a suitable mydriatic before the operation, and in the after treatment of the case.

3. Limitation of engorgement of the iris by adrenalin after opening the anterior chamber.

4. The use of citrated saline (70 c.c. of 0.9 per cent. sodium chloride and 30 c.c. of 3 per cent. sodium citrate) for application to the graft while it is being cut, to the eye of the host while the portion is being removed, and to the sutures before insertion.

With these precautions, in experimental rabbits, the iris remains free, and the pupil is dilated and free at the end of the operation.

Concerning Needles

In the operation for corneal transplantation, the needle has to pass for a distance of a few millimetres in the stroma of the cornea, and various needles were tried in order to select the most suitable. Although grafts of different sizes have been tried experimentally, it is found that the best results are obtained when the size of the hole in the cornea of the host is just over 4.5 mms. The needle most suitable for this size is, however, not so suitable when a larger graft is used.

For the standard operation it was found that a No. 3 needle (not eyeless) was too large, and there was a tendency for the superficial layers of the cornea to be torn at the point of exit of the needle when drawing the needle through. A No. 4 needle, which is about 5.5 mms. shorter than a No. 3, was found to be quite suitable, and gave every satisfaction. The needle used is of the half curved type. A straight needle was tried, but proved much more difficult to insert properly. Eyeless needles were also used. The length of a No. 4 eyeless needle corresponds nearly to that of a No. 3 needle with an eye, and this proved to be too long.

The needle corresponding in length to a No. 4 with an eye, is a No. 6 eyeless. It will be found, however, that the steel of an eyeless needle is more pliable than that used in the other variety of needle, and this is a disadvantage when the needle has to be passed accurately for some 4 mms. in the substance of the corneal stroma. Undue pliability is likely to lead to lack of control over the point of the needle, with the result that it may penetrate the anterior chamber, or cut its way out to the surface too soon. It is, however, an advantage that the eyeless needle can be drawn through so easily and smoothly without the added bulk of an eye with a double thickness of thread. The disadvantages of a No. 6 eyeless have been overcome by using an eyeless needle specially made, of harder steel, and similar in curve to a No. 4 half curved needle (with eye), but slightly shorter. In the application of corneal transplantation to man, it has been found that a needle of this type and length gives satisfactory results.

Concerning the threading of small eyeless needles with fine silk.—For threading these needles with No. 0 silk, a special pressure forceps is necessary, but many needles are liable to be spoilt by attempts at threading, as the procedure for fine silk is not as simple as it is for fine catgut. After trial of many methods, it was found that: 1. The pressure by the forceps frequently cut the thread, or 2. The thread slipped out of place when the pressure was applied. The forceps provided has a pressure surface of about 7 mms. with a small groove in which the end of the needle is placed. It was found necessary to cut the pressure surface down to not more than 3 mms., so that the blunt end of the needle could be left protruding about 0.5 mm., thus avoiding cutting the end of the thread where it leaves the end of the needle. Difficulty was experienced in keeping the thread in its proper place in the end of the needle, and this was largely due to the fact that the silk is so fine that it could slip about in the groove freely. Doubling and twisting the silk or moistening with water or a gummy substance to increase its thickness did not prove satisfactory, but the following procedure was found to give entire satisfaction if carried out carefully.

A single knot is tied in the silk, and the thread held taut is introduced into the groove in the needle; the thread is now drawn along the groove so that the knot enters the end of the needle and is drawn up to the other end of the groove. Still keeping the thread taut—a touch on the groove with a pin or the back of a knife will ensure that the thread and knot are in position. The forceps is then applied, leaving the last half millimetre of the needle projecting. The pressure effectively closes the needle end over the thread and knot, so that the suture is firm and secure.

The Sensitiveness of Corneal Grafts

Observations on the return of sensitiveness in corneal grafts were carried out over a number of years, and it was found that some of the grafts regained sensitiveness, while some did not. A record of these observations has already been published (*Proc. Roy. Soc. B.*, Vol. CVIII, 1931). The observations were based on 29 grafts, of which 21 became sensitive to light touch, and eight remained insensitive. Precautions were taken to ensure the accuracy of the observations.

23 grafts were central in position in the cornea. Of these, 16 became sensitive. There was no uniformity in these 16 grafts in regard to adhesion of the iris to the graft, good primary union, or ultimate opacity. Most of them were opaque, one nebulous, and two had clear areas. None was clear.

The common factor in all was that each had become vascularized. In some the blood vessels came from an adherent iris, in some from the periphery of the cornea, in some from both sources.

The seven insensitive grafts were free from adhesion of the iris, but in four of them there had been a minute adhesion of the iris for a short period. All seven had united well, and five were clear. One was opaque, and in it were some blood vessels.

Six grafts were situated near the periphery of the cornea.—Five became sensitive, and each had an adherent iris, was opaque and vascularized.

The insensitive graft also had an adherent iris, and was opaque.

In the whole series it was found that all the sensitive grafts were vascularized, while all the clear grafts were either completely or almost completely avascular, and remained insensitive. In one case a graft had a blood supply from an adherent iris for two months, but then the iris became free, so that the blood supply ceased; this graft became sensitive.

The conclusion was drawn that the establishment of an afferent nerve supply to a corneal graft depends upon a precedent or concurrent growth of blood vessels in that graft. It seems to matter little whether the blood vessels are supplied from an adherent iris or whether they grow in from the margin of the cornea.

Concerning Examination of the Pupil, Iris and Anterior Chamber in Cases where the Cornea is Opaque

During the course of the experiments it became necessary to find some means of ascertaining the presence or absence of adhesion of the iris in an eye with a dense and extensive corneal opacity. For this purpose a double transilluminator was made, controlled by a switch so that either light could be used separately, or both together. This has since been found a very useful method when

applied to man, in cases of dense corneal opacity, where the usual methods of examination leave one in doubt as to the state of the iris and anterior chamber. The transilluminators are applied on opposite sides of the eye. The room is darkened, and transillumination of the eye is carried out from either source of light, or from both together, without removing the lamps from their position on the eye. During transillumination of an eye with a clear cornea, such as an eye with a sarcoma of the choroid, one holds the light on one side of the eye, and observes the reflex from the other side, so that one has to move one's head from point to point—according to the place of application of the transilluminator.

In dealing with a dense corneal opacity, the conditions are different, inasmuch as the cornea acts as a screen on which the

FIG. 12.

Switch used for double transillumination.

light impinges, proceeding from the interior of the eye through the pupil on to the cornea. The illuminated area of cornea can be seen without having to move the position of observation, no matter what part of the eye be transilluminated. Thus one can compare the illuminated area of cornea by transillumination of opposite parts of the eye. These areas can be contrasted in succession, or simultaneously by use of the switch (Fig. 12). In this way a good impression can be gained of the relative and actual size of the two illuminated areas, and of their positions on the cornea.

By this method of examination definite information can be obtained as to the size and form of the pupil, the depth of the anterior chamber, and the presence of anterior synechiae at the pupillary margin of the iris. The effect of mydriatics on the pupil can be determined. All these observations are difficult, if not impossible, by other means in cases where the cornea is completely and densely opaque; it is in such cases that this knowledge of the condition of the anterior segment of the eye is of great assistance when the operation for corneal transplantation is contemplated. By the method of double transillumination the following observations can be made:—

1. *The depth of the anterior chamber* can be judged by the distance apart of the two illuminated spots on the cornea. With a very shallow anterior chamber the two spots are practically superimposed (Fig. 13¹). With a normal anterior chamber they are separated (Fig. 13²).

2. *The pupil.*—If the anterior chamber is shallow, the spot of light gives an approximate idea of the size of the pupil. The deeper the anterior chamber, the less clearly defined are the margins of the lighted areas. With a normal anterior chamber, if the pupil

DOUBLE TRANSILLUMINATION

FOR OPAQUE CORNEA

FIG 13.

- 1 = SHALLOW ANTERIOR CHAMBER. SMALL PUPIL.
 2 = NORMAL ANTERIOR CHAMBER. SMALL PUPIL.
 3 = NORMAL ANTERIOR CHAMBER. LARGE PUPIL.
 4 = NORMAL ANTERIOR CHAMBER. ECCENTRIC PUPIL.
 5 = NORMAL ANTERIOR CHAMBER. SLIT-LIKE PUPIL. Transilluminated at 180°
 6 = NORMAL ANTERIOR CHAMBER. SLIT-LIKE PUPIL. Transilluminated at 90°
 7 = SHALLOW ANTERIOR CHAMBER. SLIT-LIKE PUPIL. Transilluminated at 90°
 8 = ANTERIOR SYNECHIA at "A."

is small, the spots of light are small and separated entirely from each other (Fig. 13²), while with a large pupil, the lighted areas are large and overlap (Fig. 13³). If the pupil is eccentrically placed, the arrangement of the illuminated areas on the cornea gives the clue to its position (Fig. 13⁴). With a normal anterior chamber, an elongated slit-like pupil (with the slit at 180°) gives overlapping slit-like lighted areas if transilluminated at 180° (Fig. 13⁵), but they are separated if transilluminated at 90° (Fig. 13⁶). With a shallow anterior chamber the two lighted

areas are almost superimposed, and their shape gives a clue to the shape of the pupil (or coloboma) (Fig. 13⁷).

3. *Anterior synechiae*.—An adhesion of one margin of the pupil to the cornea will give two patches of light on the cornea, having one common border, corresponding to the synechia, whereas the free margin of the pupil allows a separation between the other margins of the illuminated patches (Fig. 13⁸).

4. Alteration in the size of the pupil by mydriatics or miotics can be observed and recorded, and the presence of holes in the iris, or an atrophic thin iris frequently can be determined.

The examples given will serve to show the usefulness of this method of examination in cases of this type, and the information gained has proved of real service in dealing with cases of opaque corneae in man, and their treatment by corneal transplantation.

SUPPLEMENTARY NOTE

ON

IRIS INCLUSION FOR CHRONIC GLAUCOMA

BY

H. HERBERT

THE recent Oxford Congress debate on the operative treatment of glaucoma seems to provide an occasion for the remedy of faults and omissions in my paper "The Future of Iris Inclusion in Glaucoma," *Brit. Jl. Ophthalm.*, Vol. XIV, pp. 433-48, 1930.

I.—The later phases in Operative Development

In the above paper the thesis was developed that progress in iridencleisis had for more than a decade resolved itself into a practical study of conjunctival fibrosis, protective against late infection. Work begun in India during the War, and continued fairly steadily up to the date of the paper, was reviewed.

There were three phases in this experience. The first was that of the uncut iris prolapse, condemned chiefly on account of a remote liability to the formation of a most dangerous leaking point in an over-stretched prolapse undergoing fibrosis.

Throughout the long second period the essential feature was free subconjunctival radial division of the iris with straight, narrow, blunt-pointed scissors, close to the forceps gripping the iris. By this means, together with such mydriasis as was obtainable by the omission of miotics from the previous afternoon or evening, and by