KERATOPLASTY—A MODIFIED METHOD

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A full-thickness corneal graft into a deep lamellar bed down to Descemet's membrane, has advantages of value in certain cases, particularly in aphakia. Lamellar grafts to Descemet's membrane have been described by Paufique *et al.*[1] and others, but the use of a full-thickness donor transplant into such a bed has not to my knowledge been previously recorded, except that Stocker[2] discussed this method for bullous keratopathy at a recent congress.

Graft Reaction

Clinical experience has shown that a total penetrating corneal graft or a smaller eccentric one abutting the limbus, has a negligible chance of escaping what the French term *'maladie du greffon'* 'sickness of the graft', which is now recognized as an immune reaction. The proximity of such grafts to the limbal blood-vessels is adduced as the reason for this failure. Hence a graft as small as is practicably possible and a cornea free of blood-vessels are given as the ideal conditions for the success of a transplant. On the other hand, lamellar grafts are clinically noted to be less affected by this reaction, and even total or near-total lamellar grafts are advocated as a preliminary step to penetrating grafts in very vascular corneas.[3] Likewise, lamellar grafting in recurrent pterygia is a recognized procedure.

It thus seems that contact of the graft with the aqueous might play a part in facilitating the development of the immune reaction. However, it might merely be that a perforating graft is more traumatic, as it usually has more sutures that are left in for a longer period. No record, however, has been found of work indicating that deeper lamellar grafts are more likely to develop the *'maladie'* than superficial grafts.

Optical Properties

It is well known that perforating grafts are optically better than lamellar grafts, but the latter can give remarkably good results, if the bed and transplant have been smoothly cleaved in one plane and all opacities have been removed from the recipient bed. However, even should the opacity extend throughout the thickness of the cornea, Descemet's membrane by itself, is still very transparent unless it is permanently rucked. Furthermore, in the type of graft being described, the donor surface is obviously perfectly smooth. The optical quality of this graft is almost, or can be made to be, as good as a perforating graft. The host's endothelial-Descemet's membrane remains as a layer deep to, and separated by fluid from the donor endothelium of the full-thickness graft. With healing, the host's layer contracts to a taut membrane, in section like a bowstring across the concavity of the transplant. This membrane is easily needled after the eye has settled, to create a perfectly clear optical zone.

Aphakia and Bullous Keratopathy

Perforating grafts in aphakic eyes are clinically known to be fraught with complications caused by the presentation of vitreous into the anterior chamber. It is well recognized that cases requiring both a graft and a cataract extraction should have the graft done as the primary procedure. Corneal opacity occurring after a cataract operation is most commonly due to bullous keratopathy. The treatment of this condition is notoriously difficult. The only treatment I have found to be of value are Gundersen flaps and/or corneal grafts. Paufique once advocated curettage of the endothelium in cases of Fuch's dystrophy to remove the diseased tissue in order to allow new endothelial growth from the periphery to improve that membrane before doing a graft.[4] I have found this treatment to be of no value at all. The few cases on whom I used it were made worse. Paufique himself has stated he has now abandoned this treatment.[5] The Gundersen flap and corneal graft are not mutually exclusive. In deciding the method of treatment an estimate must be made of the site or sites of endothelial leak. It is well recognized that the pathology of bullous keratopathy is primarily endothelial disease, so that its 'water pump' action becomes deranged and aqueous permeates the cornea, eventually causing the bullous state. Those cases that have complicated anterior chamber lens implants are thus more likely to have the damaged endothelium towards the angle. In such a case a Gundersen flap as a first procedure is advisable in order to drain the leak. This can lead to a marked improvement of the centre of the cornea, but should secondary changes have caused an additional opacity, a small central graft can then be done. Obviously those cases with the damaged endothelium more centrally sited must be grafted so that the circumference of the graft encloses the diseased endothelium, and a graft can be used successfully as a primary procedure. It is in such cases that a full-thickness graft into a deep lamellar bed has proved most useful.

TECHNIQUE

As far as the surgical technique is concerned, besides care and patience, a binocular microscope is absolutely essential for the dissection. As the dissection of the bed proceeds, forceps such as the St. Martins or Colibri type become inadequate when dealing with the deepest layers. Plain forceps that have been sharpened to a very fine point are a great help in grasping these last layers of the corneal stroma. A small right-angled delicate hook is also useful to start the dissection of these final lamellae.

Slit-lamp illumination obviously would be ideal at this stage of the dissection, but this refinement is not readily available

at the moment. A hand-held slit-lamp is of some value. However, when the bed is ½-¾ dissected it is very helpful to puncture the cornea at the limbus and replace the aqueous with air. The residual thickness of the bed is then more easily seen and should the endothelium be punctured, welling aqueous does not obscure the field and the air does not escape so readily if the opening is small. The deeper layers of the corneal substantia peel off readily and when Descemet is reached, it is easily recognized as a smooth glasslike membrane.

A variety of knives are available for the dissection, but I have found ordinary no. 15 BP and Gillette blades adequate. The BP knife with the back of the blade bevelled obliquely at the point, allows it to be held cutting-edge upward in order to trim the dissected laminae flush with the wall of the bed with less danger of the point harming the bed. In certain cases, the central 3-4 mm. of the Descemet-endothelial bed is excised so that with the graft *in situ*, the central part forms a perforating graft and the lateral, a deep lamellar one. This is akin to the mushroom graft, but is easier to prepare.

Keratoconus. This procedure has been used in cases of conical cornea:

(*i*) With superficial vascularization that apparently followed prolonged use of contact lenses for many years.

(*ii*) The cornea was so thin that an ordinary penerating graft would have been too hazardous because the suturing would be difficult; edge too thin for firm healing; large area of exposed donor-edge projecting into the anterior chamber could prolong oedema of the graft and jeopardize its clarity. These hazards of the thin host cornea are lessened (*i*) by cutting the deeper part of the wall of the bed slightly obliquely, i.e. funnel-shaped; (*ii*) slightly under-cutting the wall about the middle of its depth (Paufique knife); (*iii*) using a graft cut with a trephine 0·1 mm. larger than the bed. A tighter and broader fit into the recipient bed is thus obtained. The fringe of host Descemet-endothelium seals the edge of the donor button that projects into the anterior chamber.

Donor—host gap. If the host's endothelium is quite healthy then that layer on the graft can be wiped off and the graft down to Descemet's membrane sutured in position as an ordinary lamellar graft. These grafts, as mentioned for full-thickness grafts, can also heal with a gap between the bed and the graft, but in these cases the gap closes within a month and the donor and host Descemet's membranes apparently fuse. Those with the donor endothelium left intact have the gap persisting as previously mentioned. In several cases it has been left intact for various reasons. Although a rather small amount of fusion occurred at the periphery of the graft, the central gap has persisted. Several such cases have been observed for many years.

RESULTS AND ILLUSTRATIVE CASES

Twenty cases of this type of graft have been done during the past 11 years. Ten of these were aphakics. The others included keratoconus with superficial vascularization or very thin corneas, and cases of corneal scarring from trauma, chemical burns, or infection with considerable vascularization. An analysis of the visual acuity alone does not give a true reflection of the clarity of the grafts as many cases had retinal lesions or vitreous clouding. Thirteen of the 20 have remained perfectly clear.

The following cases are of interest:

Case 1

Mine-blasting accident case with 1 eye completely destroyed. The patient was sent to England for a corneal graft but it failed. A 7 mm. perforating graft was then done in South Africa. The iris, found adherent to the cornea, was almost totally excised. The traumatic cataract had practically completely absorbed and after the cornea had healed, the capsular remains were needled. The vision with correction was 6/36. Three months later the graft had clouded. A 5 mm. full-thickness graft into a deep lamellar bed was then done in 1954. The retained endothelium-Descemet bed was not needled. This was the first case I did with this type of graft. It remained perfectly clear, and the vision with correction was 6/60. He managed to get about very well and ran his business. It was unfortunate that 3 years later, while playing cricket with his children, he was struck by the ball and developed a retinal detachment that could not be rectified.

Case 2

Molten-iron burns of eyes, face, body and arms. There was a total symblepharon sealing the whole of both lower fornices and in the right eye, the lower lid was also adherent to the lower two-thirds of the cornea, so that the pupil was covered. After various skin and mucous membrane grafts to the lids and fornices, a more than half-circle-shaped, total deep lamellar graft was done. As the host endothelium was clear except for a peripheral anterior synechia at 6 o'clock, the endothelium was wiped off the graft. Figs. 1 and 2 show the result. Vision = 6/12 with correction. This graft was done in 1960

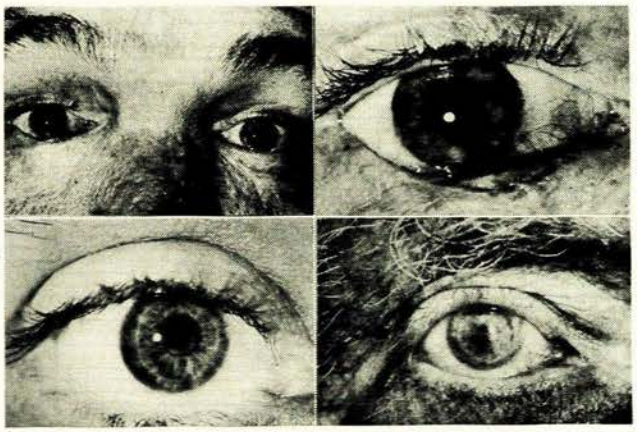

Fig. 1: top left. *Fig. 2*: top right. *Fig. 3*: bottom left. *Fig. 4*: bottom right. } See text.

and still remains perfectly clear. A perforating graft of this size, total except for the upper third, would almost certainly have developed the '*maladie*'. The optical value is self-evident.

Case 3

Pyocyaneous corneal ulcer with marked hypopyon that responded to local Polymyxin therapy. There was an extensive leucoma, heavily vascularized. In 1959, an 8 mm. graft with the endothelium wiped off, restored vision to 6/9p with correction (Fig. 3). The faint white scar is a partial pupillary membrane, which is the result of the hypopyon and iritis.

Case 4

This patient is a man aged 84, with bilateral glaucoma. The left eye had a clear cornea, slight lens changes, marked cupping of the optic disc and he could see 6/18 corrected. The visual field, however, was less than 5°. Tension was under control with pilocarpine 2% and varied from 5-6/5·5. The right eye had a marked leucoma and although the tension was not controlled, 1·5-2/5·5, the visual field by light projection appeared full. An 8 mm. full-thickness graft with the endothelium wiped off followed immediately by a 2 mm. cornea-scleral trephine was done in January 1961. A thin layer of blood between the graft and lower half of the bed was present the following day. This took a month to clear and the final vision was 6/24 (Fig. 4). The tension measured 7/5·5. The good field of vision made it possible for him to get about by himself once again. When last examined early this year the left field, despite miotics and the fact that the tension has been well controlled, had decreased still more to involve the macula so that vision was 1/60. The right eye could see 6/24p and the tension has ranged between 5·5-7/5·5.

The 10 aphakias included 8 bullous keratopathies and of these 4 were complications of rigid anterior chamber implants. Of the latter, the first had been referred with glaucoma

besides the keratopathy. The glaucoma was seemingly controlled by cyclodialysis and perforating cyclodiathermy. An 8 mm. full-thickness graft into a deep lamellar bed restored very good vision, but follow-up was difficult as he left soon afterwards in order to settle in England. However, it was learnt that the vision remained extremely good for about 3 - 4 months. He then developed corneal ulceration that apparently did not respond to treatment. Either the glaucoma or bullous keratopathy recurred. I suspect the latter, particularly as the second and third cases had similar grafts which after 3 - 4 months also became oedematous—recurrence of the original lesion and not the typical graft-rejection phenomenon. A Gundersen flap was then done on 1 of these 2 cases, over the previous site of contact of 1 edge of the implant where the dystrophy had first manifested itself. A subsequent graft has remained perfectly clear (15 months follow-up). The fourth case had Gundersen flaps as the first procedure over the original contact areas of the implant. A subsequent clear graft followed by endothelial needling has restored vision to 6/9p with correction—12 months follow-up (Fig. 5).

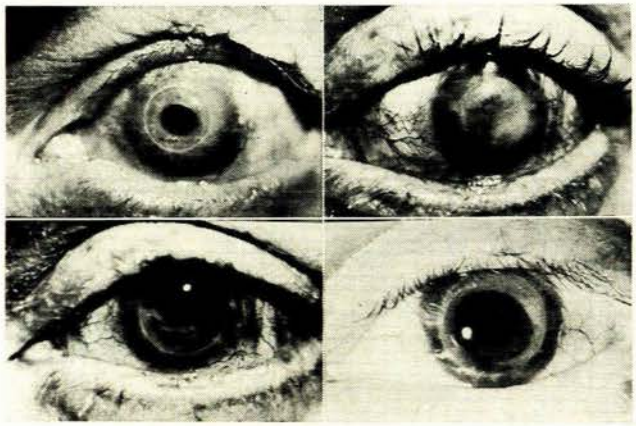

Fig. 5: top left. *Fig. 6*: top right. *Fig. 7*: bottom left. *Fig. 8*: bottom right. } See text.

The other 4 aphakic cases with bullous keratopathy included 3 with open-angle glaucoma in whom successful drainage operations had been done. This had been followed, as far as could be ascertained, by cataract extraction, in 2 cases from below and in 1 through a corneal section that was made to cut out the cornea just below the filtering bleb. The last case has been followed-up for 3 years and the result has been most satisfactory. The results of the other 2 mentioned above are also excellent so far, but have been watched for 5 months only.

The fourth case of aphakic bullous keratopathy apparently had more than average manipulation within the anterior chamber at the time of the cataract surgery. A very severe bullous keratopathy with vascularization followed. A 7 mm. lamellar graft of about half the thickness of the cornea was done in England, but it soon clouded and the bullous state returned (Fig. 6). A full-thickness 8 mm. graft into a deep lamellar bed was then done in South Africa and 2 months later the host-bed was needled. The resultant vision with correction was 6/9 (Fig. 7). Six months later, however, he returned with a vessel invading the graft. After beta-ray therapy this subsided leaving a very faint scar in the sector involved.

Fig. 8 is a case of keratoconus whose cornea was thin almost to the limbus and with many superficial vessels. The modified 'mushroom graft' mentioned above was done. Vision today, 18 months postoperatively is 6/6, with correction.

SUMMARY

Full-thickness grafts into deep lamellar beds have the following advantages:

1. As with lamellar grafts in general they are safer and easier for the patient who can be allowed greater freedom of movement.

2. They heal more quickly, therefore sutures may be removed sooner.

3. They are less hazardous in vascular corneas and seem to be affected less by '*maladie du greffon*'.

4. Optically they seem better than ordinary lamellar grafts and they are as good as perforating grafts in those cases where the host-bed is subsequently needled.

5. In my experience this is the best method of keratoplasty for aphakic eyes.

6. In keratoconus when the host cornea is thin this method is safer and simpler than any other.

Their one disadvantage is that they are tedious to do perfectly.

I wish to thank Prof. M. Luntz for referring 2 of the aphakic bullous keratopathy cases and Mr. Shevitz of the medical photographic department for illustrations.

ADDENDUM

Since this paper was submitted for publication 2 of the bullous keratopathy cases have developed the '*maladie*'—one after 18 and the other after 11 months.

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