THE CORNEAL GRAFT

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The idea of treating corneal blindness by trephine surgery first appears in English literature in 1796:

'After ulcerf of the cornea, which have been large, the inequalities and opacity of the cicatrix obscures the fight; in thif case could not a small piece of the cornea be cut out by a kind of trephine about the fize of a thick bristle, or a small crow-quill and would it not heal with a transparent fcar?'

Erasmus Darwin,
Zoonomia, Pt. II, p. 48, 1796.

Other notions about this time were those of Pellier de Quengsy who suggested the insertion of a crystal into the opacity of a corneal scar, of Chevalier Taylor whose advice was either to 'pare off the excrecence' or to rub it hard with a brush of barley awns. Meade (1775) preferred a powder of equal parts of glass and sugar, doubtless to be applied with the same vigour.

Abortive trials and unsuccessful experiments characterized the 19th century, but sufficient stimulus to surgical effort was provided by the corneal blindness of small-pox and trachoma, which had been spread far and wide throughout Europe by travelling armies. Contemporary experiments were mainly concerned with cross-grafting of animals; human experiments were rare and what there were usually failed from infection, poor tools and no anaesthesia. By the end of the century, however, ophthalmology had become a separate specialty and the golden era of eye surgery began. The influence of Pasteur and Lister began to control infection and general and local anaesthesia came into use, allowing accuracy of technique in eye operations to supersede speed of accomplishment.

The patient work of von Hippel¹ over ten years laid the foundation of modern corneal graft surgery; he showed a case at Heidelberg in 1886 and 1887 where a rabbit graft had improved the sight of a young girl. In 1905 came the famous lime burn case of Zirm², in which improved vision was

recorded for two years after operation. A child's cornea provided the graft which was held in place by overlay stitches; this represented a definite advance in the technique of fixing the graft.

By the beginning of the 20th century the surgical principles of corneal grafting had been established and these hold good today. They include the exclusive use of a human graft cut by trephine, safe anaesthesia and strict asepsis, minimum trauma of the graft together with secure fixation. The rest of the century to date has been occupied with refinements of technique and more mature selection of cases. Future problems which remain to be solved are the best methods of prolonged graft preservation and a correct appreciation of the immunological reactions which are set in motion when a corneal graft is transplanted.

Functions of a Corneal Graft

A corneal graft may serve three purposes, namely:

1. *Optical*, which is performed for the improvement of vision and consists of the removal of an opaque disc of corneal scar tissue and replacement by a similar transparent disc from another cornea.
2. *Therapeutic*, in which a graft is applied to hasten the healing of chronic corneal ulcers and to relieve severe pain. This method is employed on the same principle as a cross leg flap is used to cure varicose ulceration. Such a graft is used also to reinforce deficiencies in the wall of the eyeball which have resulted from old perforations.
3. *Cosmetic*, when it is desired to remove a hideous white scar on a blind eye. This type of graft is often combined with tattoo.

Corneal grafts are of three types: (a) *Full thickness*, in which the whole thickness of the cornea is used and the globe is opened; this type of graft is comparable to the Wolfe skin graft and is effective for deep corneal scars. The diameter of full thickness grafts is 5 to 6 mm. (b) *Partial thickness*, in which a layer of the cornea is split off and replaced by a wafer graft of partial corneal thickness. Although a safe procedure it is only applicable to superficial corneal scars or for

FIG. 1.—(a) Full-thickness graft; (b) partial-thickness graft; (c) flange graft.

therapeutic purposes. These grafts may be from 5 to 10 mm. in diameter. (c) *Flange*, which is a combination of a partial and a full thickness graft. This type has the merit of greater safety by forming an overlap joint but is more difficult to cut. Fig. 1.

The Operation

Absence of infection by repeated conjunctival cultures is established before operation in the host and donor eye. Anaesthesia is generally by regional orbital block, using 1 per cent. xylocain with 5 to 10 per cent. alcohol together with surface anaesthesia of 4 per cent. cocaine with adrenalin. The facial nerve is blocked as it emerges from the stylomastoid foramen in order to prevent inadvertent forcible closure of the lids by the patient; this would expel the contents of the eye when the globe was opened.

A 5-mm. graft is next cut by trephine from a donor eye; the graft must have clean edges, free from tags, and this is best obtained by punching the graft. A bed of the same size is then drilled in the receiving eye and the graft is placed in it. The graft is held in place either by minute direct edge to edge sutures around the periphery or by overlay sutures which cross the graft. Fig. 2.

Both eyes are bandaged for a week and at the end of that period the graft has healed in position, but final clarity is not established until the third week when the graft begins to live on the host. Fig. 3.

Complications

Immediate. (1) The graft may fit badly owing to corneal distortion when the eye is opened, and the wound will leak; this is bound to lead to an opaque graft as a water-tight joint between host and donor is absolutely essential for success. Hence at least two donor corneas must be available to provide alternate size grafts. (2) Infection is no longer a menace and is adequately controlled by antibiotics. If the donor cornea comes from a cadaver special care is needed to ensure sterility as

B. coli, streptococci and haemolytic staphylococci have been found in post-mortem eyes. (3) Defects of technique should not arise and instruments and needles must have perfect edges and points; they are scrutinized by slit lamp microscopy before operation.

Late. (1) Secondary glaucoma may be a problem owing to adhesion of the iris to the graft; this is a sequel of a leaking section which causes non reformation of the anterior chamber. (2) Opacification of the graft from the immunological reactions of oedema and vascularization are unpredictable. Fortunately cortisone, by local drops or subconjunctival injections, is of some value in controlling neo-vascularization and pre- and post-operative B-radiation to the cornea helps to prevent vascularization.

The Donor

1. *The sources.* When corneal graft operations were few in number sufficient donor material could usually be obtained from eyes which had to be excised for sarcoma of the choroid or injury and, indeed, this remains an important, though inadequate, source today. The main source, however, must now be the cadaver. Such donor eyes or corneas should be removed within ten hours of death under aseptic conditions and are best obtained from aged adults who have died a natural death. Another source of great potential value is the bequest eye. Since 1953, by virtue of the Corneal Grafting Act, it has been legal for a person to bequeath his or her eyes simply by expressing such a wish verbally or in writing. After death the nearest relative or doctor informs the local Eye Bank or hospital where corneal grafting is carried out and the hospital then makes arrangements to obtain the eyes. At East Grinstead this source is of great value and arrangements work well; a team is always on call and a set of sterile enucleation instruments always ready. Relatives treat the procedure of carrying out the deceased's wishes with dignity and co-operation.

2. *Preservation.* Whilst a fresh, living graft is

FIG. 2.—General View of Corneal Graft Operation. (Left Eye: 5 mm. penetrating circular graft.) The Franceschetti trephine is being applied to mark the site of the graft. Retraction stitches are placed above, in the superior rectus muscle sheath and below, in the lower lid so that external pressure on the globe by a speculum is avoided. This is an important point of technique in penetrating graft cases.

FIG. 3

the best material for transplantation this is obviously a counsel of perfection which can rarely be realized; methods of preserving graft material have, therefore, to be used. At present, immersion in an antibiotic—liquid paraffin emulsion at 4°C . in which they are suitable for use up to 14 days, or in water vapour at 4°C . for three days, are two popular methods. Recently Polge, Parkes and Smith³ have shown that it is possible to preserve gonad tissue over long periods by impregnating the tissue with glycerol and freezing it rapidly to -79°C .; after thawing out the gland tissue functions again. Attention has been drawn to the possibility of preserving corneal tissue by this

means by Eastcott and his colleagues.⁴ So far results have not yet proved entirely satisfactory but research continues, for, if this method proves to be successful, the banking and storage of corneal graft material will be greatly facilitated and wastage will be eliminated. The orderly admission of patients waiting for corneal grafts will also be more conveniently arranged.

Pathology

When a graft from one individual is transplanted to an individual of the same species it is called a homograft; homografts always die as a result of immunological reaction at varying periods after

transplantation with the possible exception of gland tissue, cartilage and cornea.

Just why the cornea behaves differently from other grafts is not clearly understood. It may be because a corneal graft has few cells and is small; the antigen stimulus, therefore, is low, or it may be because of absence of blood vessels. It is, however, quite certain (Billingham⁵) that corneal tissue *per se* is capable of creating an immunological reaction. Then again, the graft may act simply as a scaffold after the initial cells have died; the cells may be replaced by migration from the host. It is possible that this is a more likely view rather than the cornea should be endowed with the special properties of a true graft. The invasion of the blood vessels as a result of reaction is the signal for physiological failure and opacification; no optical graft is likely to succeed where deep corneal blood vessels are present. Blood groups of host and donor have no apparent significance.

Criteria of Selection and Prognosis

These criteria concern the local eye conditions, the condition of the donor graft and the initial disease which caused the corneal scar.

The host eye. Local condition. The eye must be white and free from infection or vascularization if an optical graft is to be used. There must be no increase of intraocular pressure and retinal function must be normal. It cannot be too strongly urged that a corneal graft will only restore sight *where blindness is due to a corneal scar and where the posterior structures of the eye are normal*, i.e. free from retinal degeneration, detachment or glaucoma. Cataracts may be successfully removed after grafting. The scar which is to be removed should not occupy the entire cornea but a rim of normal corneal tissue should be present.

The donor graft must be as fresh as possible with good lustre, transparency and a clean-cut edge. Loss of surface epithelium is of no consequence but the stroma and membranes must not be separated. The graft must have been proved to be sterile at all stages of preservation.

Initial disease. The diseases which cause blindness from corneal scars and which may be treated by grafting are grouped for prognosis as follows:

Favourable (about 70 per cent. clear grafts).	1. Thin scars of corneal ulcers.
	2. Conical cornea.
	3. Corneal dystrophies.
	4. Certain corneal degeneration.
	5. Mild interstitial keratitis.
Fair (about 40 per cent. clear grafts).	6. Neuropathic scars.
	1. Dense scars of corneal ulcers.
	2. Non-specific and severe interstitial keratitis.
	3. Moderate burns and explosion injuries.

Bad (less than 10 per cent. clear grafts).	1. Severe burns and splash injuries.
	2. Pemphigus.
	3. Dense scars of corneal perforation with adherent iris.

Results

A clear graft is considered by some surgeons to be a success but it does not always mean improvement of vision; sometimes there may be undetectable amblyopia or macular degeneration which spoils the result of surgery. But in general, and certainly for the patient, the improvement of vision is the standard of success.

In the favourable group at least 70 per cent. of cases will have restored vision to varying degrees. In the middle group about 40 per cent. will have improved vision but in the unfavourable group there will be few. Yet it must be remembered that even in this group a slight improvement such as will enable perception of large objects gives some measure of independence which is of inestimable value.

The latest published results of a larger series in detail are those of Townley Paton⁶ which cover 299 transplantations followed up for two months or longer.

Transparent Grafts (anatomical assessment)

Of these 64.5 per cent. had clear grafts which are differentiated as follows:

	Clear grafts Per cent.	No. of grafts
Conical cornea	89.3	84
Groenouw's dystrophy	85.7	28
Non-specific scars	68.8	16
Inactive ulcers	66.7	20
Interstitial keratitis	62.2	45
Leukoma	55.6	10
Active ulcer	50	6
Trachoma	45.5	11
Burns, explosions and wounds	39.1	23
Adherent leukoma	35.3	17
Fuch's dystrophy	30	13

Visual Improvement (physiological assessment)

So far as vision is concerned Paton analyzes 222 grafts as follows:

	Cases
72.1 per cent. showed improvement	160
20.7 per cent. remain with the same vision	46
5.9 per cent. had reduced vision	13

In corneal grafting the words of de Wecker must always be borne in mind: 'We have no right in these cases to refuse the slightest aid to sufferers who have but this one remaining chance to recover a little sight.'

Future Problems

Three main problems remain to be solved. Infection is no longer a menace, principles of technique have been generally established and the selection of cases has been clarified by increased experience.

But the problem of vascularization and oedema causing early or late opacification of the graft is still unsolved; the solution will more likely be found in the laboratory than in the operating theatre.

Closely associated is the best method of storing donor material for on this depends the whole future of the organization and expansion of corneal graft surgery.

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