Corneal optical prostheses

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Recent advances in the field of plastic optical corneal prostheses suggest that they have finally moved from the experimental to the clinical field. To some extent this feeling is justified because in the past 10 years many types of keratoprotheses have been used, improving vision in eyes which would otherwise have remained blind. The numerous publications on this subject and the various models and modification of existing prostheses indicate that the ideal corneal prosthesis has not yet been found and that this search continues (see Bibliography).

The main problem with these devices continues to be that of extrusion, which in our limited but varied experience occurs with any type of prosthesis. The purpose of this paper is to report our experience with the Cardona prostheses and the Girard model, and to bring attention to a previously unrecognized cause of extrusion, that of rejection of the homografted tissue used as tectonic material.

Report of cases and results

Altogether 21 prosthokeratoprotheses of three types were implanted (to July, 1970).

- (1) Six implants with a fenestrated interlamellar plate (Cardona) also called the "through-and-through";
- (2) Five acrylic implants with dacron mesh interlamellar plate (Cardona and Girard-Fig. 1);
- (3) Ten "optico-cosmetic" implants (Cardona-Fig. 2).

FIG. 1 Cardona 2.3 mm. "through-and-through" prosthesis, and Girard 3.5 mm. dacron mesh prosthesis

FIG. 2 Cardona optico-cosmetic keratoprosthesis, also called "nut-and-bolt"

The results in each case are shown in the Table, opposite.

- (1) The first type of Cardona implant was placed in two corneae with repeated failed grafts for bullous keratopathy, one opaque vascular cornea, and three eyes with previous failed grafts for chemical burns. One prosthesis was replaced by the mesh type implant

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Table *Results in three groups of cases*

Type of prosthesis	Case no.	Visual acuity*		Size (mm.)	Time (mths)		Condition
		Degree	Whether improved		Extruded	Retained	
Cardona all-acrylic	1	20/200	Yes		4	Re op. Case 5a	Failed grafts
	2	20/400	Yes		30	—	Chemical burn
	3	20/100	Yes		—	24	Failed grafts
	4	Counting fingers	Yes		—	18	Scar, vascularization
	5	Perception of light	No		24	Re op. Case 3b	Chemical burn
	6	Hand movements	Yes		32	32 Reop. Case 10b Re op. Case 10b.	Chemical burn
Acrylic mesh	1a	Counting fingers	Yes	3.5	—	30	Lye burn
	2a	20/400	Yes	4	5	—	Failed grafts
	3a	Hand movements	No	4	4	—	Failed grafts
	4a	20/400	Yes	4	(conjunctival flap)	24	Lye burn
	5a	20/400	Yes	2.3	—	18	Failed grafts, Extruded prosthesis, Rejected grafts
Optico-cosmetic	1b	20/400	Yes		—	13	Lye burn
	2b	Perception of light	No		5 (rejected graft)	—	Lye burn
	3b	Hand movements	No		—	6	(Failed graft previous-prosthesis)
	4b	Counting fingers	Yes		12	—	Chemical burn
	5b	20/80	Yes		3 (necrosis)	—	(Advanced bullae scarring vascularization)
	6b	Perception of light	No		10	10	Failed grafts
	7b	Counting fingers	Yes		—	12	Failed grafts
	8b	Counting fingers	Yes		—	16	Lye burn
	9b	20/50	Yes		—	14	Alkali burn
	10b	Perception of light	No		1 (infection)	—	(Lye burn, Previous prosthesis)

*In every case the preoperative visual acuity was perception of light

when a large corneal erosion developed around the cylinder 4 months later. Two were extruded at 2 and 2½ years respectively and were replaced by an optico-cosmetic implant. The other three implants have been retained for 2 years or more with minimal central erosion (Figs 3 and 4).

FIG. 3 *Cardona all-acrylic prosthesis with three fenestrations in a cornea with a failed transplant. It has now been in place for over 2 years*

FIG. 4 *A similar type of Cardona keratoprosthesis which has been in place for 2 years*

(2) Three of the five mesh type prostheses are still retained after $1\frac{1}{2}$ years. Two were extruded at 4 and 5 months respectively, because of necrosis of the sclera in one case and rejection of scleral graft in another. The impending extrusion of Case 4a was treated successfully with a conjunctival flap and has now been retained for over 2 years. (Fig. 5).

FIG. 5 4 mm. mesh keratoprosthesis which has been in place for over $2\frac{1}{2}$ years in an eye with lye burns. A conjunctival flap covers part of the prosthesis and there is an intermittent leakage of aqueous humour

(3) Six of the ten optico-cosmetic prostheses have now been in place for up to $1\frac{1}{2}$ years, and two of these show tissue loss around the cylinder.

Burns with lye or ammonia were the original cause of injury in eleven of 21 cases. Three of these ("through-and-through" model) extruded the implant after 2 years. This is a good tolerance period if one compares them to three cases with repeated graft failure

FIG. 6 Epithelialization of the corneal perforation in an eye with an optico-cosmetic prosthesis—a round cell inflammatory reaction is present in the anterior portion of the cornea. Haematoxylin and eosin. $\times 80$

which extruded at 4 and 5 months. Extrusion in two eyes with a failed graft with lye burns, and in one with a scleral homograft, seemed to have been caused by rejection of the homograft into which the prosthesis was placed, with epithelium advancing into the anterior chamber through the corneal fenestration in one case (Figs 6 and 7). In another extrusion of an optico-cosmetic implant and in a cornea with a "through-and-through" prosthesis, epithelium also advanced to the anterior chamber (Fig. 8).

FIG. 7 Higher magnification of area of inflammation and tissue destruction shown in Fig. 6. Lymphocytes and plasma cells form the infiltrate where there is destruction of corneal lamellae. Haematoxylin and eosin. $\times 160$

FIG. 8 Growth of corneal epithelium along the corneal fenestration into the anterior chamber. Haematoxylin and eosin. $\times 78$

Comment

Even though the tolerance of plastic implants in the cornea is limited, its use is indicated in eyes with multiple graft failures and particularly in corneae with chemical burns. Most of our patients with chemical burns are now fitted with the Cardona optico-cosmetic prosthesis on a corneal transplant; the follow-up period for these implants is short when compared to the earlier "through-and-through" model. Some of the objectionable complications inherent to the first models mentioned were solved with the cosmetic prosthesis, but we feel that reoperations are easier and complications less severe with the former implants.

Epithelial downgrowth is one of the risks of this procedure and may develop with any of the prostheses used, including the implant with rigid interlamellar plate. Infection is another possibility but is fortunately not common; it occurred in one patient shortly after the implantation of an optico-cosmetic prosthesis when he left the country for 2 weeks without medical approval.

Early and late complications are present with all implants (Girard, Moore, Soper, and O'Bannon, 1969; Castroviejo, Cardona, and DeVoe, 1969). Erosion of tissue around the prosthesis is probably the most common complication. It may occur as "melting" of the cornea in interlamellar implants, loosening of optico-cosmetic implants through necrosis, or destruction of homografted tissue by an immune reaction. This phenomenon may occur with corneal or scleral grafts and its recognition may permit the eye to be treated with steroids and so to avoid extrusion. Scleral necrosis due to poor conjunctival covering is another possibility and is difficult to treat once the scleral graft has started to disintegrate.

If an implant can be replaced by a corneal graft or by a new one when extrusion is imminent, a tolerance of 2 to 3 years is a good average in eyes with chemical burns. Tolerance may be higher in eyes with bullous keratopathy, but we feel that these eyes deserve one or more grafts before a prosthesis is implanted. The extrusion rate in large series of cases with random corneal diseases varies from 11 per cent. in a 4-year follow-up (Girard Wong, Lempert, Moore, Soper, and O'Bannon, 1969) and 10 per cent. in an 8-year follow-up (Cardona, Castroviejo, and DeVoe, 1967), to 20 per cent. in a 10-year follow up (Castroviejo and others, 1969). Therefore, the prognosis is not so poor if one considers that this is the only procedure available for eyes which carry the worst visual prognosis (Cardona, Castroviejo, and DeVoe, 1963).

Most of these eyes have previous retinal disease and glaucoma, two conditions which account for the poor visual results in these series and often make the assignment of numerical visual results irrelevant. However, in one case of lye burn with an optico-cosmetic prosthesis, a vision for distance of 20/50 was obtained with a hydrophilic lens over the prosthesis. It is possible that glaucoma, if present, may be controlled by aqueous leakage around the prosthesis as it could be observed in one case which has had a built-in fistula for over 3 years (Fig. 5). It is our impression that the all-acrylic "through-and-through" prosthesis offers a better insurance against epithelial downgrowth when placed in an interlamellar situation even though this complication may still occur.

Another complication observed with all prostheses is the formation of a fibroblastic membrane behind the prosthesis or a pre-vitreous membrane which causes a decrease in visual acuity. Sectioning or excision of the latter is not always successful. Retinal detachment was suspected in two cases and was observed in one through a 4 mm. prosthesis 4 months after implantation. It was not possible, however, to obtain good visualization for surgery.

Because of the eventual extrusion of the implants and the number of potential complications, this is necessarily an experimental procedure open to modifications and improvements.

Summary

Three types of keratoprosthesis were implanted in 21 eyes. Eleven cases had a history of alkali burns, and most of the eyes had retained a prosthesis for 2 years or more. Several frequent complications include necrosis of the recipient tissue around the implant, epithelial downgrowth, and infection. Rejection of tectonic corneal or scleral homograft (often used as part of the procedure) is another complication not previously recognized.

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