KERATOPROSTHESIS: AN ALTERNATIVE IN ANTERIOR SEGMENT RECONSTRUCTION

Patricia E. Bath, M.D.

Blindness due to corneal causes has long been a challenge to anterior segment surgeons, and keratoplasty with or without anterior segment reconstruction is not universally successful. Fortunately, recent technologic alloplastic advances in the field of keratoprosthetic research have improved the success rate for anterior segment reconstruction.

The idea of replacing the scarred cornea with artificial material was first conceived by Pellier de Quengsy, who suggested intracorneal implantation of glass. In 1853, Nussbaum[1] reported implantation of glass in the rabbit cornea. Later investigators unsuccessfully implanted glass, celluloid and quartz in human corneas.[2] Shortly after World War II, it was found that the cornea tolerated imbedded acrylic plastic (Plexiglas) exceptionally well. This observation stimulated research into both corneal and lens alloplastic implants.

Stone[3] developed the conceptual framework for keratoprosthetic design; his polymethylmethacrylate keratoprosthetic device consisted of a fenestrated sup-

porting plate with a threaded removable optical cylinder (Fig. 1). The fenestrations permit ingrowth of connective tissue and improve nutrition of anterior corneal layers. The supporting plate accepts either a perforating or a nonperforating optical cylinder (Fig. 2),[4] allowing the surgeon to postpone perforation until the supporting plate is fixed on the host cornea.

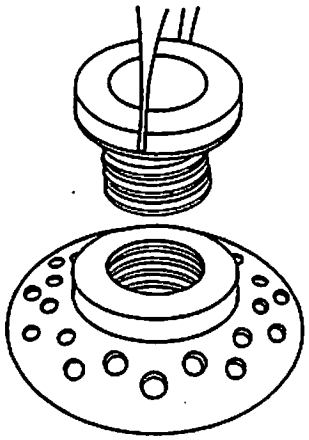

Fig. 1(Bath). Stone keratoprosthetic device.

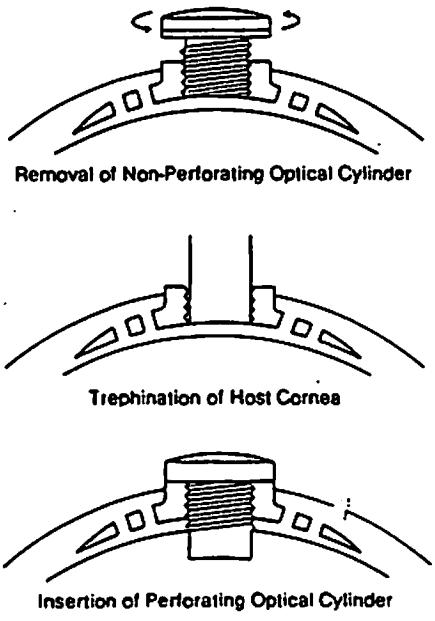

Fig. 2(Bath). Stone keratoprosthetic device: sequence shows conversion of nonperforating optical cylinder to perforating.

Cardona and his associates[5] developed the nut-and-bolt and the through-and-through (TT) keratoprosthetic devices, which are the most widely used keratoprostheses in the United States. The TT keratoprosthetic device (Fig. 3) has a flexible Teflon supporting plate which improves conformation to the corneal contours. The optical cylinder of both styles is threaded with an inner pigmented core to reduce glare.

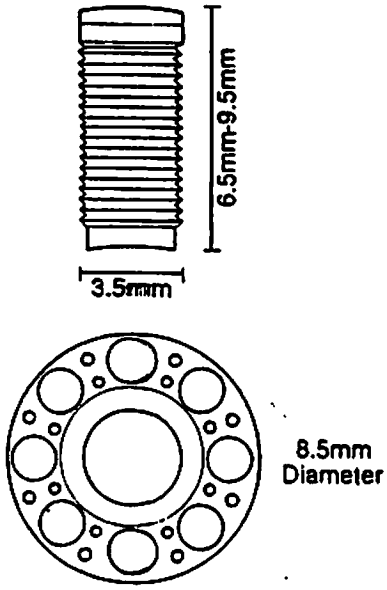

Fig. 3(Bath). The Cardona TT keratoprosthetic device has a polymethylmethacrylate optical cylinder and a Teflon skirt.

Although keratoprosthesis, or prosthokeratoplasty, has been advocated as the primary treatment for aphakic bullous keratopathy,[6] the severity of potential complications should reserve this procedure for advanced cases which would have a poor prognosis with penetrating keratoplasty. Use of keratoprosthesis may be considered in the following set of conditions: 1) bilateral blindness due to corneal scarring and corneal vascularization; 2) a history of repeated keratoplasty failure or the presence of keratitis sicca, pemphigoid or alkali burn; and 3) vision of at least light perception, with some evidence of projection and macular function. Keratoprosthesis may be contraindicated by useful vision in one eye, a keratoprosthetic device in one eye, or no evidence of macular function.

Reported rates of implant extrusion,[5-9] the most serious potential complication of keratoprosthesis, are not comparable with respect to preoperative diagnosis and follow-up times. However, the most recently reported data, from Rao's series[9] of 21 cases receiving Cardona TT keratoprosthetic devices implanted with Cardona's techniques,[5] show an encouraging absence of both extrusion and endophthalmitis over a maximum follow-up period of 3½ years.

The complication of endophthalmitis is usually observed in conjunction with erosion and extrusion of the keratoprosthetic device; however it may also occur independently as a result of aqueous leakage around the optical cylinder and concomitant intraocular invasion by pathogens. Aqueous leakage may also be associated with ingrowth of epithelial tissue along the optical cylinder, resulting in epithelial downgrowth and retroprosthetic membranes.[7-9]

The extensive anterior segment pathology in eyes eligible for keratoprosthesis makes glaucoma a frequent problem either preoperatively or postoperatively. Diagnosis and management of glaucoma in a keratoprosthetic eye is complex because there is no accurate way to measure intraocular pressure and standard perimetric measurements are altered by the optics of the prosthesis. Serial observations of the optic nerve head coupled with tactile tonometry are clinically rational and useful methods of glaucoma assessment; however better methods of glaucoma surveillance are needed for these cases.

Extrusion of implanted keratoprosthetic devices has spurred on-going investigations of autologous tissues which may offer better bioadhesion than the polymethylmethacrylate, Teflon and Dacron synthetics. Strampelli[10] describes a technique of osteo-odontoprosthokeratoplasty which uses a patient's tooth as the supporting structure for the acrylic optical cylinder. Using this technique, he has rarely observed extrusion and never encountered the complication of conjunctival overgrowth. Other investigators are exploring the feasibility of using human ungual tissue (onychotransplantation).[11,12] Promising alloplastic research is being done by Frank M. Polack, M.D., using a ceramic keratoprosthetic device (unpublished data, 1979). The ceramic material (aluminum oxide-magnesium oxide) offers improved bioadhesion,[13] and it is available with a larger optical cylinder to give a wider visual field.[14]

Modern prosthokeratoplasty is an appropriate surgical alternative for anterior segment reconstruction in selected cases. Continuing advances in keratoprosthetic design and technology will undoubtedly increase the indications for this procedure in the future.

Patricia E. Bath, M.D.
Jules Stein Eye Institute
Los Angeles, CA

REFERENCES

1. Nussbaum JN: *Cornea Artificialis*. Munich, Carl Robert Schurich Press, 1853
2. Cardona HA: Keratoprosthesis. *Am J Ophthalmol* 54:284, 1962
3. Stone W, Siderman M: The plastic artificial cornea (an 18-year study): basic principles, in Rycroft PV (ed): *Corneo Plastic Surgery*. Oxford, Pergamon Press, 1967, pp 375-379
4. Stone W, Yasuda H, Refojo MD: A 15-year study of the plastic artificial cornea - basic principles, in King JH, McTigue JW (eds): *The Cornea World Congress*, Washington, DC, Butterworths, 1965, pp 654-671
5. Cardona H, DeVoe AG: Prosthokeratoplasty. *Trans Am Acad Ophthalmol Otolaryngol* 83:271, 1977
6. Donn A: Aphakic bullous keratopathy treated with prosthokeratoplasty. *Arch Ophthalmol* 94:270, 1976
7. Choyce DP: The Choyce two-piece perforating keratoprosthesis, 70 cases, 1967-1973. *Trans Ophthalmol Soc UK* 93:333, 1973
8. Girard LJ, Hawkins RS, Nieves R et al: Keratoprosthesis: a 12-year follow-up. *Trans Am Acad Ophthalmol Otolaryngol* 83:252, 1977
9. Rao GM, Blatt HL, Aquavella JV: Results of keratoprosthesis. *Am J Ophthalmol* 88:190, 1979
10. Strampelli B: Osteo-odontoceratoprostesi. *Ann Ottal* 89:1039, 1963
11. Mazhdrakova I: Implantation of ungual particles in the eye tissue of rabbit. *Buloftalmologiya* (Sofia) 25:127, 1977
12. Schimmelpfennig B: Study on the tissue compatibility of intracorneal horn lenses in experimental animals. *Klin Monatsbl Augenheilkd* 172:464, 1978
13. Blencke A, Hagen P, Bromer H, Deutscher K: Study of the use of glass ceramics in osteo-odontokeratoplasty. *Ophthalmologica* 176:105, 1978
14. Hoffman F, Harnisch JP, Strunz V et al: Osteo-keramokeratoprosthesis. *Klin Monatsbl Augenheilkd* 173:747, 1978

UCLA Keratoprosthesis Study: 1978-1990

Patricia E. Bath, MD
UCLA School of Medicine
Jules Stein Eye Institute
Department of Ophthalmology
800 Westwood Plaza
Los Angeles, CA 90024
(FAX) (213) 296-9566

BACKGROUND: A study on keratoprosthesis was designed and initiated by the author at the Jules Stein Eye Institute, UCLA Department of Ophthalmology in 1979. The study was conducted under the auspices of the Human Subject Protection Committee from 1978-1990. The purpose of the study was to assess the efficacy of the keratoprosthesis in the restoration of vision in those eyes that were blinded because of severe corneal scarring and that were unsuitable for conventional keratoplasty. The first patient was entered into the study in 1979 and the last patient was entered in 1989.

METHODS: All candidates for prosthokeratoplasty had to meet the following selection criteria[1] as determined by of a majority of the Keratoprosthesis Study Committee:

1. Blindness in both eyes caused in part by opacification of one or both corneas.
2. Minimum vision of light perception with projection in at least two quadrants.
3. Associated disease which would probably render an unsuccessful result with conventional keratoplasty, eg, dry eye, cicatricial pemphigoid.
4. At least one previously failed graft in which the reason for failure was believed to be due to anterior segment disease rather than due to donor material or postoperative complications.
5. No keratoprosthesis in the opposite eye.

The Cardona through and through keratoprosthesis[2] was used for all subjects, including many of Cardona's original surgical techniques. All surgeries were performed by the author.

RESULTS: A total of 10 keratoprostheses were performed in 9 eyes of 9 patients between 1979 and 1989. One patient (1) underwent removal and insertion of a second keratoprosthesis in the same eye. Of the 10 insertions, 8 eyes experienced an improvement in vision for more than 2 years (Table).

Two eyes experienced no improvement, but in one case the optical cylinder was never exteriorized due to the patient being transferred to a nursing home out of the area. In the other case, the lack of visual improvement was due to severe glaucomatous optic atrophy discovered postoperatively.

Table
UCLA Keratoprosthesis Study (Bath)

Case No.	Preoperative Visual Acuity	Best Postoperative Visual Acuity
1A	LP	20/20
1B	LP	20/20
2	LP	20/20
3	LP	LP
4	LP	20/20
5	LP	20/40
6	LP	LP
7	LP	20/400
8	LP	5/400
9	LP	FC

Regarding major complications, there was one case of presumed endophthalmitis. No extrusions occurred. Following blunt trauma, one case each of retinal detachment and intravitreal hemorrhage occurred.

Severe and progressive glaucomatous optic atrophy resulted in eventual loss of vision in two eyes.

CONCLUSION: The UCLA Keratoprosthesis Study was formally concluded in 1990 when it was reported to the Human Subject Protection Committee that the procedure should no longer be considered experimental, based on our institutional results. We think that prosthokeratoplasty represents acceptable medical practice. Our experience was published in 1990 in a textbook of ophthalmic surgery.[3]

REFERENCES

1. Bath PR. Keratoprosthesis: an alternative in anterior segment reconstruction. *American Intraocular Implant Society Journal.* 1980;6:126-128.
2. Cardona H, Devoe AG. Prosthokeratoplasty. *Transactions of the American Academy of Ophthalmology and Otolaryngology.* 1977;83,271-280.
3. Bath PE. *Atlas of Contemporary Ophthalmic Surgery.* Clayman HC, ed. St Louis, Mo: CV Mosby; 1990 (chapter 6):125-158.