

Results from the Multicenter Boston Type 1 Keratoprosthesis Study

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Purpose: To report indications, practices, complications, and outcomes from the first multicenter study on the Boston Type 1 keratoprosthesis.

Design: Prospective, noncomparative, interventional case series.

Participants: We analyzed 141 Boston Type 1 keratoprosthesis surgical procedures, from 17 surgical sites, done from January 2003 through September 2005 in 136 eyes of 133 patients.

Methods: Forms reporting 70 preoperative, intraoperative, and postoperative parameters were collected and analyzed at a central data collection site (Cornea Consultants of Albany, Albany Medical College, Albany, New York).

Main Outcome Measures: Visual acuity (VA) and keratoprosthesis survival.

Results: Common preoperative diagnoses were graft rejection, in 73 eyes (54%) (average prior grafts, 2.24); chemical injury (20 eyes [15%]); bullous keratopathy (19 eyes [14%]); and herpes simplex virus keratitis (9 eyes [7%]). Additionally, 82 eyes (60%) had preoperative glaucoma. Preoperative best-corrected VA ranged from 20/100 to light perception, and was <20/200 in 96% of eyes. At an average follow-up of 8.5 months (range, 0.03–24; standard deviation, 6.1; median, 12), postoperative vision improved to $\geq 20/200$ in 57%. Among eyes at least 1 year after the operation (62 eyes), vision was $\geq 20/200$ in 56% of eyes and $\geq 20/40$ in 23%. At an average follow-up of 8.5 months, graft retention was 95%. Severe visual loss or failure to improve from keratoprosthesis was usually secondary to comorbidities such as advanced glaucoma, macular degeneration, or retinal detachment.

Conclusions: The Boston Type 1 keratoprosthesis seems, based on early follow-up, to be a viable option after multiple failed corneal grafts or in some situations of a poor prognosis for primary penetrating keratoplasty. *Ophthalmology* 2006;113:1779.e1–1779.e7 © 2006 by the American Academy of Ophthalmology.



Several groups have worked for many years to develop a keratoprosthesis to treat patients with corneal blindness and a poor prognosis for penetrating keratoplasty (PK).^{1,2} These include patients with repeated graft failure and those with severe ocular surface disease (e.g., Stevens–Johnson syndrome, chemical burns, ocular cicatricial pemphigoid [OCP], stem cell deficiency, severe keratoconjunctivitis sicca, severe corneal vascularization). There are several keratoprosthesis

designs that have been developed throughout the world. One of the most commonly used designs in the United States is the Boston Type 1 keratoprosthesis. In 1974, Dohlman et al first reported results from the implantation of a polymethyl methacrylate collar-button keratoprosthesis in 36 patients.³ In 1992, the Boston Type 1 keratoprosthesis was approved by the Food and Drug Administration for marketing in the U.S.⁴ The design and manufacture of this keratoprosthesis has been described prior,⁵ with the recent addition of a titanium locking ring to hold the back plate in place.

Although several Boston Type 1 keratoprosthesis case series from single centers have been reported, data from multiple sites were not compiled in the past. The purpose of this study is to report preoperative, intraoperative, and postoperative variables, as well as outcomes, for a large number of patients from multiple surgical sites.

Materials and Methods

Surgical Procedure

The Boston Type 1 keratoprosthesis is obtained from the Massachusetts Eye and Ear Infirmary (Boston). (No surgeons in the study group have any proprietary interest in the Boston Type 1 kerato-

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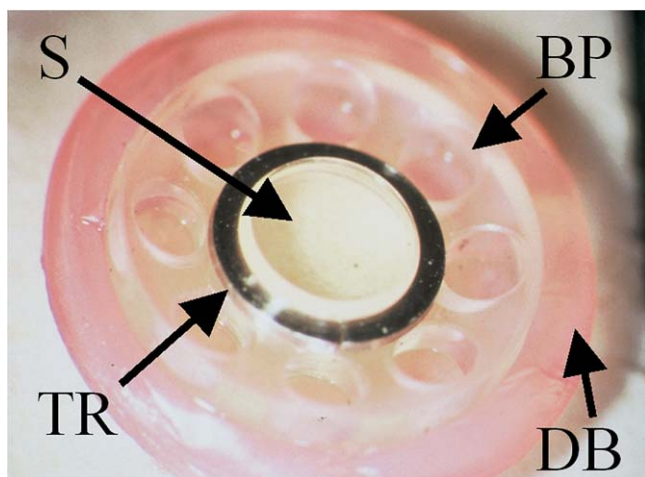


Figure 1. Boston Type 1 keratoprosthesis, posterior view. BP = back plate (front plate underneath, not shown); DB = donor button; S = stem; TR = titanium ring.

prosthesis.) The refractive power of the keratoprosthesis is selected based on whether the patient is pseudophakic or aphakic, and the axial length of the eye.

The technique for implanting the Boston Type 1 keratoprosthesis has been described.⁶ Briefly, a donor button (usual size, 8.5–9.0 mm) is prepared and a central 3 mm hole is trephined. The donor button is then placed over the stem of the front plate, and the back plate is screwed into place on top of this. A titanium locking ring is then snapped into place to prevent loosening of the back plate. An assembled Boston Type 1 keratoprosthesis is shown in Figure 1 (available at <http://aaojournal.org>).

The recipient cornea is prepared as for a traditional PK (usual host trephine, 0.5 mm < the donor). If pseudophakic, the intraocular lens can be left in place; if aphakic, a core vitrectomy generally is performed. The donor graft with the keratoprosthesis is then sutured in place with multiple interrupted 10-0 nylon, as with a standard PK. At the completion of the procedure, 400 µg of intracameral dexamethasone often is given, and a soft Kontur contact lens (Kontur Contact Lens, Richmond, CA) is placed. An in situ Boston Type 1 keratoprosthesis is shown in Figure 2 (available at <http://aaojournal.org>).

Data Collection and Analysis

This multicenter study is a large retrospective and prospective case series gathering data on Boston Type 1 keratoprostheses implanted since January 1, 2003. Thirty-nine surgeons known to be performing multiple procedures were contacted about this study and encouraged to participate. To date, 17 sites (44% of those contacted) are participating, and data from 141 procedures on 136 eyes from 133 patients have been analyzed. Submissions were at the discretion of the surgeons; however, all participants were encouraged to submit data on all procedures performed in the U.S. within the specified time frame, regardless of outcome. The surgeons performing the procedure assess the patients and report data via a mail-in report form evaluating approximately 70 preoperative, intraoperative, and postoperative variables. To comply with Health Insurance Portability and Accountability Act of 1996 regulations, patients were assigned a unique study number; names were not used on reporting forms. These forms were sent to a central collection site, under institutional review board approval (Cornea Consultants of Albany, Albany Medical Center Department of

Ophthalmology). In general, follow-up is reported at 1 month, 6 months, and 12 months and every 6 months thereafter. An Excel (Microsoft, Redmond, WA) spreadsheet was used to compile and calculate the results.

Results

Preoperative Characteristics

Numbers of males and females were similar (48% and 52%, respectively). Each eye had undergone an average of 2.24 prior corneal transplants (range, 0–8; standard deviation [SD], 1.51; mode, 2) (including lamellar and prior keratoprostheses). On average, there were 2.86 quadrants of corneal vascularization preoperatively (range, 0–4; SD, 1.8; mode, 4). The most common preoperative corneal diagnosis was graft rejection (73 eyes [54%]), followed by chemical injury (20 eyes [15%]) and aphakic or pseudophakic bullous keratopathy (19 eyes [14%]). Other corneal diagnoses are listed in Table 1. Preoperative visual acuity (VA) (shown in Table 2) ranged from 20/100 to light perception (median, hand movements).

Intraoperative Variables

The aphakic Boston Type 1 keratoprosthesis was used in 51 procedures, and the pseudophakic in 85. The design was not specified for 5 eyes. The average host trephine size was 8.22 mm (range, 7.75–10.5; SD, 0.44; mode, 8.0). The average donor trephine was 8.65 mm (range, 8.5–11.0; SD, 0.43; mode, 8.5). Concomitant procedures are listed in Table 3 and included vitrectomy (41 cases), lens removal (20), and tube shunt (14). Intraoperative complications were varied and rare, each occurring in only 1 case. These included vitreous loss, front plate dislodgement, host corneal perforation, hyphema, very thin host rim, and difficult anesthesia (25 cm³ lidocaine/maracaine used).

Glaucoma and Keratoprosthesis

Preoperatively, 82 eyes (52%) had glaucoma. Forty-four had a prior tube shunt, and 9 had a prior trabeculectomy (6.4%). The

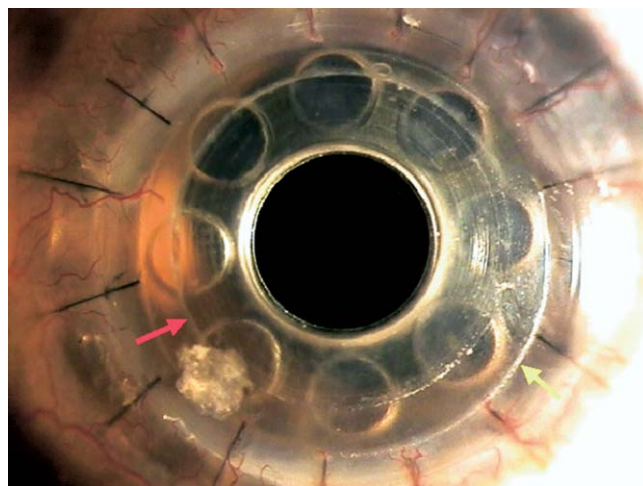


Figure 2. Photograph of the implanted Boston Type 1 keratoprosthesis, with the edges of the front plate (red arrow) and back plate (yellow arrow) visible.

Table 1. Preoperative Diagnoses and Comorbidities in Patients with the Boston Type 1 Keratoprosthesis

Preoperative Diagnoses	No. of Eyes
Graft rejection	73
Chemical injury	20
Aphakic or pseudophakic bullous keratopathy	19
Herpes simplex virus keratitis	9
Neurotrophic keratopathy	8
Corneal dystrophy	7
Severe dry eye	6
Ocular cicatricial pemphigoid	5
Band keratopathy	5
Bacterial ulcer	4
Congenital corneal opacity	3
Boston keratoprosthesis malfunction	3
Other* (trauma, fungal keratopathy, corneal edema after glaucoma surgery, exposure, AlphaCor [Cooper Vision Surgical, Perth, Australia] failure, keratoconus, thermal burn, silicone oil keratopathy, Salzmann nodular degeneration, trachoma, chronic uveitis, Stevens-Johnson syndrome, interstitial keratitis, systemic lupus erythematosus, Alpert's syndrome, uncontrolled glaucoma, limbal stem cell deficiency [unspecified], retrocorneal fibrous membrane, aniridia, corneal thinning, severe peripheral anterior synechiae)	28

*Each occurring in only 1 or 2 eyes.

average number of glaucoma medications per eye decreased from 1.02 preoperatively to 0.78 postoperatively. After the keratoprosthesis was implanted, high intraocular pressures (IOPs) were reported in 21 eyes, and 11 eyes received tube shunts.

Visual Acuity Outcomes

The keratoprosthesis improved vision dramatically in most patients (Table 2, Fig 3). The number of patients with best-corrected

Table 2. Preoperative versus Postoperative Best-Corrected Visual Acuity (BCVA) with Keratoprosthesis

BCVA	Preoperative No. of Eyes	% [†]	Postoperative No. of Eyes	%*
≥20/20	0	0	2	1.4
≥20/25	0	0	4	2.8
≥20/30	0	0	14	10
≥20/40	0	0	27	19
≥20/50	0	0	37	26
≥20/60	0	0	51	36
≥20/70	0	0	58	41
≥20/80	0	0	61	43
≥20/100	2	1.4	66	47
≥20/200	5	3.6	81	57
≥20/400	18	13	97	69
≥CF	62	44	111	79
≥HM	108	76	129	91
≥LP	140	99	139	98
NLP	0		2	

CF = counting fingers; HM = hand movements; LP = light perception; NLP = no LP.

Average follow-up of 8.5 mos (range, 0.03–24; standard deviation, 6.1; median, 12).

*Of 141 total implants.

Table 3. Concomitant Procedures at the Time of Keratoprosthesis

Concomitant Procedures	No. of Cases
Vitrectomy	41
Lens removal	20
Tube shunt	14
IOL removal	13
IOL placement	12
Tarsorrhaphy	12
Iridectomy	6
Punctal occlusion	6
Pupilloplasty	2
Other* (conjunctivoplasty, cyclitic membrane removal, IOL suture with Tutoplast [IOP Inc., Costa Mesa, CA], symblepharon lysis, goniosynechiolysis, lid reconstruction)	6

IOL = intraocular lens.

n = 141.

*Each occurring in only 1 case.

VA (BCVA) 20/200 or better went from 3.6% preoperatively to 57% postoperatively. Nineteen percent had postoperative vision of 20/40 or better.

In the subgroup of 62 eyes followed for at least 1 year after keratoprosthesis implantation (mean follow-up, 14.5 months; range, 12–27 months; SD, 4.1 months; median, 12 months), 56.4% retained BCVA of 20/200 or better, and in 22.6% BCVA was 20/40 or better (Table 4). In this subgroup, at last follow-up relative to 1 month postoperatively 11 (17.7%) eyes had improved VA and 8 (12.9%) had decreased VA. The anatomic retention rate was 95.2% in this subgroup. Decreased vision was most often due to end-stage glaucoma, followed by retinal detachment (RD) and age-related macular degeneration.

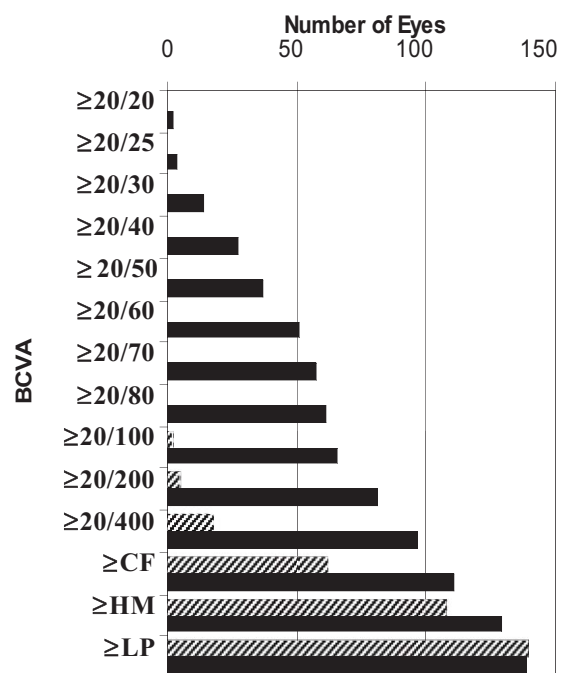


Figure 3. Comparison of preoperative (gray bars) with postoperative (black bars) best-corrected visual acuities (BCVAs). CF = counting fingers; HM = hand movements; LP = light perception.

Table 4. Best-Corrected Visual Acuity (BCVA) in Eyes at Least 1 Year after Keratoprosthesis

BCVA	No. of Eyes	%*
≥20/20	1	1.6
≥20/25	3	4.8
≥20/30	8	12.9
≥20/40	14	22.6
≥20/50	20	32.2
≥20/60	25	40.3
≥20/70	26	41.9
≥20/80	26	41.9
≥20/100	29	46.8
≥20/200	35	56.4
≥20/400	44	71
≥CF	51	82.2
≥HM	57	91.9
≥LP	61	98.4
NLP	1	

CF = counting fingers; HM = hand movements; LP = light perception; NLP = no LP.

Average follow-up of 14.5 mos (range, 12–27; standard deviation, 4.1; median, 12).

*Of 62 implants.

Subgroup analyses of visual and anatomic outcomes based on select preoperative diagnoses (graft failure from noncicatrizating disease, such as bullous keratopathy, infection, and dystrophies; chemical burns; OCP; and Stevens–Johnson syndrome) are shown in Table 5.

Postoperative Complications and Management

After Boston Type 1 keratoprosthesis implantation, patients were on a continuous regimen of eyedrops. The most common topical medication used was prednisolone acetate (124 eyes), followed by vancomycin (91), fourth generation fluoroquinolones (66 eyes), non–fourth generation fluoroquinolones (61), and medroxyprogesterone (33) (Table 6). In addition to the routine regimen used, 23 eyes received periocular triamcinolone injections, usually for vitritis or prevention of a developing retroprosthetic membrane. Oral cephalexin or fluoroquinolones also were used occasionally for vitritis of unknown etiology. Amphotericin B also was used in 5 eyes in patients with preoperative or postoperative fungal keratitis or ocular inflammation of unknown cause. Systemic steroids were used in 4 eyes with either preexisting immune disorders or ocular inflammation.

The most common nonsurgical complication was retroprosthetic membrane formation (35 occurrences, of which 26 were

Table 6. Routine Postoperative Medications after Keratoprosthesis

Medication	No. of Eyes
Topical prednisolone	124
Topical vancomycin	91
Topical fourth generation fluoroquinolone	66
Topical non–fourth generation fluoroquinolone	61
Topical medroxyprogesterone	33
Oral doxycycline	16
Topical polymyxin B/trimethoprim	2

n = 141.

treated with a yttrium–aluminum–garnet [YAG] laser membranotomy). An additional 4 required surgical membranectomy, and the others required no treatment. Other nonsurgical complications that occurred after Boston Type 1 keratoprosthesis implantation are listed in Table 7. Table 8 lists all procedures reported in eyes after Boston Type 1 keratoprosthesis implantation.

The retention rate at an average follow-up of 8.5 months (range, 0.03–24; SD, 6.1; median, 12) was 95%, with only 7 failures. The causes of failure were corneal melting (twice in a terminally ill patient), corneal rim thinning, front of Boston Type 1 keratoprosthesis lost, graft discoloration, recurrent fungal keratitis, and enucleation in a blind painful eye after a large RD. The Kaplan–Meier curve in Figure 4 shows the high probability of retention throughout the follow-up period.

Discussion

Preoperative Characteristics

Although there were several high-risk patients who received the Boston Type 1 keratoprosthesis with no prior transplant, the vast majority of keratoprosthesis patients had failed on multiple PK attempts. One study by Yaghouti et al of 53 eyes showed that eyes with prior transplant failure from noncicatrical causes had the best prognosis (83% of those achieving vision of at least 20/200 maintained it at 2 years), followed by OCP (72%) and chemical burns (64%). Patients with Stevens–Johnson syndrome had the worst prognosis (33% maintained at least 20/200 at 2 years), and the authors recommended avoiding Boston Type 1 keratoprosthesis implantation in these patients.⁷ Our database showed excellent outcomes in chemical burns and noncicatrizating graft failure

Table 5. Visual and Anatomic Outcomes for Selected Preoperative Diagnoses

Preoperative Diagnosis	Eyes Achieving BCVA≥20/200	BCVA≥20/200 Maintained*	Anatomic Retention
Noncicatrizating graft failure	58	52 (90%)	94/97 (97%)
Chemical burn	17	16 (94%)	17/19 (89%)
Ocular cicatricial pemphigoid	4	3 (75%)	4/5 (80%)
Stevens–Johnson syndrome	0	NA	1/1 (100%)

BCVA = best-corrected visual acuity; NA = not applicable.

Eyes never achieving BCVA≥20/200 are not included in the visual outcomes in this table, but are included in the anatomic retention rate.

*Average follow-up of 8.5 mos (range, 0.03–24; standard deviation, 6.1; median, 12).

Table 7. Occurrence of NonSurgical Postoperative Complications

Nonsurgical Complications	No. of Occurrences
Retroprosthetic membrane	35
High intraocular pressures	21
Vitritis	7
Vitreous hemorrhage	6
Retinal detachment	5
Choroidal hemorrhage/effusion	5
Posterior capsular opacity	5
Other* (epiretinal membrane, severe dry eye, wound leak, peripheral corneal thinning, corneal melting, keratitis, high refractive error, iris prolapse into wound, Boston Type 1 keratoprosthesis extrusion, OCP progression, fungal keratitis, cystoid macular edema, wound dehiscence Boston Type 1 keratoprosthesis discoloration, scleral ischemia, hypotensive maculopathy, suture exposure, Soemmering's ring in visual axis, scleritis, ptosis and lagophthalmos)	25

OCP = ocular cicatricial pemphigoid.
n = 141.

*Each occurring in only 1 or 2 eyes.

(94% and 90%, respectively, of eyes achieving at least 20/200 vision maintained it at last follow-up [average, 8.5 months]). Fewer with OCP maintained at least 20/200 (75%), and our only Stevens–Johnson syndrome eye never achieved at least 20/200 vision. Our follow-up is still short, and in the future, this database should serve as a useful tool to compare prognoses for various diagnoses in a larger number of patients and longer follow-up period using the current keratoprosthesis design and current intraoperative and postoperative regimens.

Intraoperative Variables

Most of the steps and skills to implant the Boston Type 1 keratoprosthesis are similar to those required for a traditional PK. This may contribute to the low complication rate.

Table 8. Additional Procedures Required after Keratoprosthesis

Post–Boston Type 1 Keratoprosthesis Procedure	No. of Occurrences
Nd:YAG membranotomy	26
Tube shunt	11
Surgical membranectomy	4
Retinal detachment repair	4
Tarsorrhaphy	4
Nd:YAG capsulotomy	4
Corneal wound repair	3
Other* (iris repositioned, ptosis repair, pars plana vitrectomy alone, Nd:YAG iridotomy, fornix reconstruction, levator recession)	6

Nd:YAG = neodymium:yttrium–aluminum–garnet.
n = 141.

*Each performed in only 1 case.

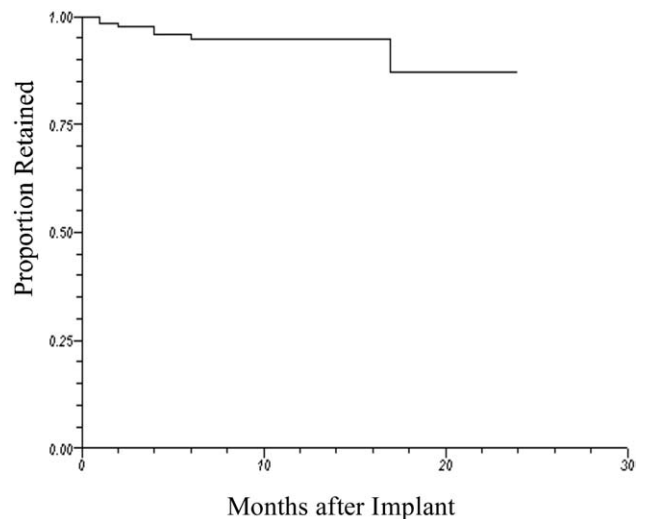


Figure 4. Kaplan–Meier survival curve for the Boston Type 1 keratoprosthesis.

Information on the intraoperative variables collected (including aphakic vs. pseudophakic design, donor and host trephine sizes, concomitant procedures, and complications) should be useful in the future to determine intraoperative prognostic factors.

Glaucoma and Keratoprosthesis

Glaucoma presents a challenge after keratoprosthesis. High IOPs were noted as a postsurgical complication in 21 eyes (15%) in this study, and patients often have advanced disease before keratoprosthesis surgery. It is also difficult to monitor IOP (often based on tactile estimates). In a small series of patients, functional testing with Humphrey (Carl Zeiss Ophthalmic Systems, Dublin, CA) or Matrix (Carl Zeiss Ophthalmic Systems) visual fields were more reliable than structural testing (HRT [Heidelberg Engineering, Heidelberg, Germany] and GDx [Carl Zeiss Ophthalmic Systems]) to monitor glaucomatous changes, but both can be useful after keratoprosthesis implantation (Spitzer S, Belin MW. Paper presented at: World Cornea Congress, April 2005, Washington, DC). Management is similar to conventional transplantation, with medications utilized first, followed by a tube shunt. The decrease in glaucoma medications after keratoprosthesis implantation relative to before most likely reflects the use of concomitant or subsequent tube shunts and perhaps the difficulty detecting increased IOPs.

Visual Acuity Outcomes

Most patients had a significant improvement in VA after Boston Type 1 keratoprosthesis implantation. Patients without significant improvement generally had vision limited by comorbidities such as advanced glaucoma and retinal pathology. In the few patients in whom vision decreased after keratoprosthesis, the cause was usually progression of advanced glaucoma or retinal pathology.

We are unaware of any prospective direct comparison studies between the Boston Type 1 keratoprosthesis and other alternatives for patients at high risk for corneal transplant failure. However, at this point our data seem to compare favorably to published data on both the AlphaCor keratoprosthesis (CooperVision Surgical, Perth, Australia) and repeat PK. In the current study, 56.4% of eyes at least 1 year after Boston Type 1 keratoprosthesis implantation (average follow-up, 14.5 months) had BCVA of 20/200 or better, compared with 41.5% of eyes with the AlphaCor (average follow-up, 16 months).⁸ Boston Type 1 keratoprosthesis results are similar to those found by Bersudsky et al⁹ 1 year after only one repeat PK (58.5% of eyes with BCVA 20/200 or better), and with multiple repeat PKs, outcomes in their study were significantly worse. Additionally, at 1 year postoperatively 22.6% of Boston Type 1 keratoprosthesis eyes had BCVA 20/40 or better, compared with 16.9% after one repeat PK.⁹

Postoperative Complications and Management

Although retroprosthetic membranes were the most common postoperative complication, occurring in 25% of eyes (a rate higher than published data on the AlphaCor [9.3%]¹⁰ and similar to prior published data on the Boston Type 1 keratoprosthesis [27%–35%]⁷), they warranted treatment in only 18% of eyes and generally were treated easily, with minimal morbidity for the patient. Although 4 cases (11% of retroprosthetic membranes) required surgical membranectomy, the majority of these (63% of retroprosthetic membranes) were treated effectively with simple uncomplicated YAG membranotomy, and an additional 9 cases (26% of retroprosthetic membranes) required no treatment. The reason for the higher reported rate of retroprosthetic membranes with the Boston Type 1 keratoprosthesis versus the AlphaCor is unknown; however, the AlphaCor study reported only those requiring treatment, and the percentage of patients with retroprosthetic membranes too thick for YAG was actually higher with the AlphaCor (4.9% of eyes)¹⁰ than in our study (4 eyes [2.8%]).

The occurrence of RD in our series (3.5% of eyes) is less than reported in a prior series of 110 eyes (12%).¹¹ The reason for this is unknown, but may be secondary to a shorter follow-up time in our study or changes in the procedure or keratoprosthesis design since the prior series.

Although vitritis was reported in 7 eyes, we had no reports of bacterial endophthalmitis or other bacterial complications. A prior series reported bacterial endophthalmitis in 13 of 108 eyes.¹² The absence of this devastating complication in our series may be due to the availability of improved antibacterials, as well as all the factors listed above for our low rate of RD. Nouri et al found that the most important risk factor for endophthalmitis was preoperative diagnosis, with the highest rates in Stevens–Johnson syndrome, followed by OCP and then chemical burns.¹²

Although our follow-up period is still short, the probability of retention in our study compares favorably to that of the AlphaCor and traditional PK after failed grafts.^{8,9} This is demonstrated in Figure 5 by comparing Kaplan–Meier curves. The retention rate in this series is also better than prior published data for the Boston Type 1 keratoprosthesis,¹³ perhaps

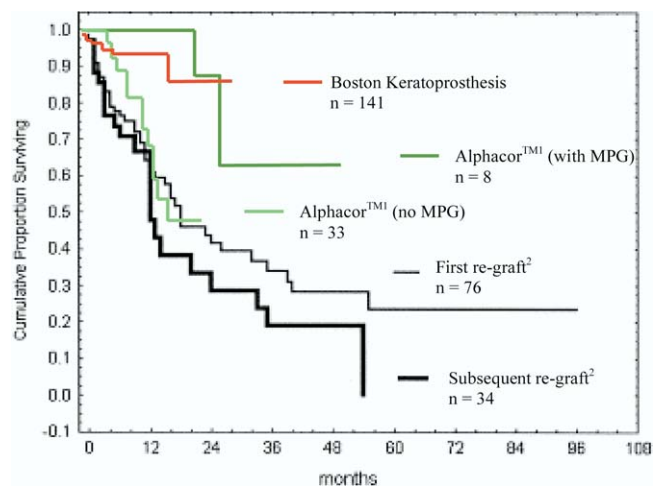


Figure 5. Comparison of Kaplan–Meier survival curves for the Boston Type 1 keratoprosthesis, AlphaCor treated with and without medroxyprogesterone (MPG), corneal allograft after one failed graft, and corneal allograft after multiple failed grafts. ¹Hicks CR, Crawford GJ, Tan DT, et al. AlphaCorTM cases: comparative outcomes. *Cornea* 2003;22:583–90. ²Bersudsky V, Blum-Hareuveni T, Rehany U, Rumelt S. The profile of repeated corneal transplantation. *Ophthalmology* 2001;108:461–9.

due to higher numbers of patients and considering only more recent surgeries (since January 2003). With voluntary participation, it also may be that surgeons with poor outcomes did not participate in this study. Because of the short follow-up period, it is difficult to compare our retention rate with that in a recent report of the osteo-odontokeratoprosthesis, which involves a more difficult procedure but had an excellent 85% retention rate at 18 years.¹⁴ More long-term follow-up is required to see whether the retention rate remains high.

This is the first collaborative multicenter effort to evaluate the Boston Type 1 keratoprosthesis. We have a database that is valuable because it allows the analysis of a large number of cases from multiple practitioners, despite the limitations to this study design due to variability of reporting, surgical technique, and postoperative care for each participating surgeon. The database could be used to evaluate outcomes in subgroups of patients to determine the prognostic significance of various preoperative diagnoses, intraoperative variables, and postoperative care. Also, continuing this effort will give more insight into long-term survival and visual outcomes for the Boston Type 1 keratoprosthesis and allow surgeons to anticipate and manage postoperative complications better.

In conclusion, the Boston Type 1 keratoprosthesis seems to be a viable option after multiple failed corneal grafts or in some situations with a poor prognosis for primary PK (such as chemical burns and OCP). Although a direct comparison has not been made, in early follow-up the Boston Type 1 keratoprosthesis appears at least equal to other available keratoprosthetic technologies.

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Appendix: Boston Keratoprosthesis Type 1 Study Group

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