

# Boston Type 1 Keratoprosthesis: The University of California Davis Experience

Jay C. Bradley, MD,\*† Enrique Graue Hernandez, MD,\* Ivan R. Schwab, MD,\*  
and Mark J. Mannis, MD\*

**Purpose:** To compare the University of California Davis experience using the Boston keratoprosthesis with the Boston Keratoprosthesis Study Group's initial report.

**Design:** Retrospective chart review.

**Participants:** We analyzed 30 eyes of 28 patients who previously underwent Boston type 1 keratoprosthesis surgery at our institution between 2004 and 2008.

**Methods:** Preoperative, intraoperative, and postoperative parameters were collected and analyzed.

**Main Outcome Measures:** Visual acuity and keratoprosthesis stability.

**Results:** Preoperative diagnoses were failed graft (26 eyes, 87%), chemical injury (3 eyes, 10%), and Stevens–Johnson syndrome (1 eye, 3%). Twenty eyes (66%) had preoperative glaucoma. Preoperative best-corrected visual acuity ranged from 20/150 to light perception and was  $<20/200$  in 83% of eyes. At an average follow-up of 19 months (range, 1–48; SD, 13.8; and median, 13), postoperative vision improved to  $\geq 20/200$  in 77% of eyes. Among eyes at least 1 year after the operation (16 eyes), vision was  $\geq 20/200$  in 75% of eyes and  $\geq 20/40$  in 25% of eyes. At an average follow-up of 19 months, retention of the initial keratoprosthesis was 83.3%.

**Conclusions:** The Boston type 1 keratoprosthesis is a viable option after multiple keratoplasty failures or in conditions with a poor prognosis for primary keratoplasty. Patients with autoimmune disease are at higher risk for complications. The University of California Davis experience seems equivalent to the initial report of the Boston Keratoprosthesis Study Group. With longer follow-up, additional surgical procedures may be required but good anatomic and functional outcomes can be maintained.

**Key Words:** Boston type 1 keratoprosthesis

(*Cornea* 2009;28:321–327)

Received for publication July 1, 2008; revision received August 9, 2008; accepted August 18, 2008.

From the \*Department of Ophthalmology & Vision Science, University of California Davis, Sacramento, CA; and †Department of Ophthalmology & Visual Science, Texas Tech University Health Sciences Center, Lubbock, TX.

Reprints: Mark J. Mannis, MD, Department of Ophthalmology & Vision Science, University of California Davis, 4860 Y Street, Suite 2400, Sacramento, CA 95817 (e-mail: mjmannis@ucdavis.edu).

Copyright © 2009 by Lippincott Williams & Wilkins

Decades of effort have been spent in attempts to develop a modern keratoprosthesis to treat patients with corneal blindness and a poor prognosis for penetrating keratoplasty (PK). These include patients with repeated graft failure and patients with severe ocular surface diseases such as Stevens–Johnson syndrome, ocular cicatricial pemphigoid (OCP), chemical burns, limbal stem cell deficiency, severe keratoconjunctivitis sicca, and severe corneal neovascularization.<sup>1,2</sup> A variety of designs have been studied with variable success. One of the most commonly employed devices in the United States is the Boston type 1 keratoprosthesis. The first series of patients with this design was reported in 1974, and the device was eventually approved in 1992 by the Food and Drug Administration for marketing in the United States.<sup>3,4</sup>

Case series of the Boston type 1 keratoprosthesis from other centers have been reported previously.<sup>5,6</sup> In 2006, Zerbe et al<sup>7</sup> reported a large multicenter series of Boston type 1 keratoprosthesis patients and extensively analyzed preoperative, intraoperative, and postoperative characteristics. This report provided a comprehensive analysis of these patients, but average follow-up was brief, limiting the ability of the study to determine these high-risk patients' long-term success and prognosis with the Boston type 1 keratoprosthesis. The purpose of this study is to present the Boston type 1 keratoprosthesis experience at University of California Davis (UC Davis) with long-term follow-up and to compare these findings with this initial multicenter report.

## MATERIALS AND METHODS

### Surgical Procedure

The Boston type 1 keratoprosthesis is obtained from the Massachusetts Eye and Ear Infirmary (Boston). Details of the device and the surgical technique for implantation technique have been described in detail.<sup>7</sup> The surgical technique and postoperative management implemented at UC Davis do not differ significantly from that described in the initial Boston Keratoprosthesis Study Group report.

### Data Collection and Analysis

We collected data retrospectively by chart review after the institutional review board approval. We included all Boston type 1 keratoprosthesis implantations performed at UC Davis over a 4-year period (May 2004–2008) (Table 1). Six of these eyes were included in the initial Boston Keratoprosthesis Study Group report.

TABLE 1. Patient Data

Patient Number	Age	Eye	Follow-up (mo)	Prior Grafts	Preoperative Diagnoses	Keratoprosthesis Type	Postoperative BCVA	Postoperative Complications	Postoperative Procedures
1	36	OD	17	4	Failed graft, <i>Acanthamoeba</i> keratitis	Pseudophakic	20/20 – 2	None	YAG capsulotomy of preexisting posterior capsular opacification
2	63	OD	11	1	Failed graft, aniridic keratopathy	Pseudophakic	20/150	Suprachoroidal effusion/hemorrhage and retroprosthetic membrane	Drainage of suprachoroidal hemorrhage, YAG of retroprosthetic membrane
3	65	OD	20	2	Failed graft, keratoconus	Pseudophakic	20/60	Vitreous hemorrhage	None
4	44	OD	1	2	Failed graft	Pseudophakic	20/200	None	None
	44	OS	20	3	Failed graft	Pseudophakic	NLP	Advancement of glaucoma because of noncompliance with medication and retroprosthetic membrane	YAG of retroprosthetic membrane
5	61	OD	6	7	Failed graft	Pseudophakic	CF at 1 ft	Retroprosthetic membrane	None
6	82	OD	36	0	Stevens–Johnson syndrome	Pseudophakic	20/150 – 1	Corneal melts, endophthalmitis, and infectious keratitis	Corneal patch graft, keratoprosthesis replacement (4), temporary keratoprosthesis, intravitreal antibiotics, pars plana vitrectomy, and tarsorrhaphy
7	67	OS	44	4	Failed graft	Pseudophakic	NLP	Choroidal effusion/hemorrhage, increased intraocular pressure, and advancement of glaucoma	None
8	40	OS	11	5	Failed graft, HZV keratitis	Pseudophakic	20/20 – 1	Increased intraocular pressure and retroprosthetic membrane	YAG of retroprosthetic membrane
9	87	OS	15	3	Failed graft	Pseudophakic	CF at 3 ft	Retroprosthetic membrane	YAG of retroprosthetic membrane
10	62	OD	43	1	Failed graft, exposure keratopathy, Apert syndrome	Pseudophakic	20/150	Retroprosthetic membrane, infectious keratitis, corneal melt, and endophthalmitis	YAG of retroprosthetic membrane, surgical membranectomy, subconjunctival antibiotics, keratoprosthesis replacement (2), pars plana vitrectomy, and intravitreal injections
11	51	OS	32	6	Failed graft, keratoconus	Pseudophakic	20/30 – 2	Increased intraocular pressure immediately after surgery	None
12	63	OS	7	2	Failed graft, aniridic keratopathy	Aphakic	HM	Retroprosthetic membrane	None
13	23	OD	10	0	Alkali burn	Pseudophakic	20/50	Iris prolapse	Replacement of broken suture
	23	OS	40	3	Failed graft, alkali burn	Pseudophakic	CF at 1 ft	None	None
14	47	OD	9	3	Failed graft, aniridia	Pseudophakic	20/50	Sterile vitritis and infectious keratitis	Tap/inject and keratoprosthesis replacement
15	74	OS	27	3	Failed graft	Pseudophakic	20/60 – 2	Retroprosthetic membrane	YAG of retroprosthetic membrane
16	61	OS	10	3	Failed graft, HSV keratitis	Pseudophakic	20/60 + 2	Retroprosthetic membrane, increased intraocular pressure immediately after surgery, and hyphema	None
17	65	OD	12	2	Failed graft, alkali burn	Pseudophakic	20/40 + 2	None	None
18	60	OD	8	3	Failed graft	Pseudophakic	20/70	High myopic postoperative refraction	None

**TABLE 1.** (continued) Patient Data

Patient Number	Age	Eye	Follow-up (mo)	Prior Grafts	Preoperative Diagnoses	Keratoprosthesis Type	Postoperative BCVA	Postoperative Complications	Postoperative Procedures
19	61	OS	20	2	Failed graft, rheumatoid arthritis, corneal melt with perforation	Pseudophakic	20/25	Corneal melt with perforation (2), infectious keratitis, and nonvisually significant retroprosthetic membrane	Keratoprosthesis replacement and corneoscleral patch graft
20	87	OS	11	2	Failed graft	Pseudophakic	20/100 – 1	None	None
21	76	OD	48	0	Chemical burn	Pseudophakic	20/20 – 2	Increased intraocular pressure and posterior capsular opacification	YAG of posterior capsular opacification
22	85	OS	8	3	Failed graft	Pseudophakic	20/60	Retroprosthetic membrane	None
23	67	OS	4	3	Failed graft, HZV keratouveitis	Aphakic	20/40	None	None
24	46	OS	43	4	Failed graft	Pseudophakic	20/50 – 2	Increased intraocular pressure	YAG of preexisting posterior capsular opacification
25	3	OD	9	2	Failed graft, Peters anomaly	Pseudophakic	LP	Corneal melt, infectious keratitis, endophthalmitis, and phthisis bulbi	Keratoprosthesis replacement (2), corneal patch graft, lateral tarsorrhaphy, and keratoprosthesis removal with PK
26	72	OS	5	3	Failed graft	Pseudophakic	20/60 – 1	None	None
27	36	OD	13	0	Alkali burn	Pseudophakic	20/70	Increased intraocular pressure and retroprosthetic membrane	None
28	43	OS	15	1	Failed graft, HLA-B27 uveitis	Pseudophakic	20/150	Retroprosthetic membrane and increased intraocular pressure immediately after surgery	YAG of retroprosthetic membrane (surgical membranectomy deferred)

CF, count fingers; HM, hand motion; HSV, herpes simplex virus; LP, light perception; NLP, no light perception; HZV, herpes zoster virus.

**RESULTS**

**Patient Demographics**

Fifty-seven percent (57%) of patients were male and 43% were female. The average age of the patients was 56.5 years (range, 3–87 years). Each eye had undergone on average of 2.57 prior corneal transplants (range, 0–7; SD, 1.68; mode, 3). The most common preoperative corneal diagnosis was failed graft (26 eyes, 87%), followed by chemical injury (3 eyes, 10%), and Stevens–Johnson syndrome (1 eye, 3%) (Table 1). Preoperative visual acuity (VA) ranged from 20/150 to light perception (median, count fingers) (Fig. 1).

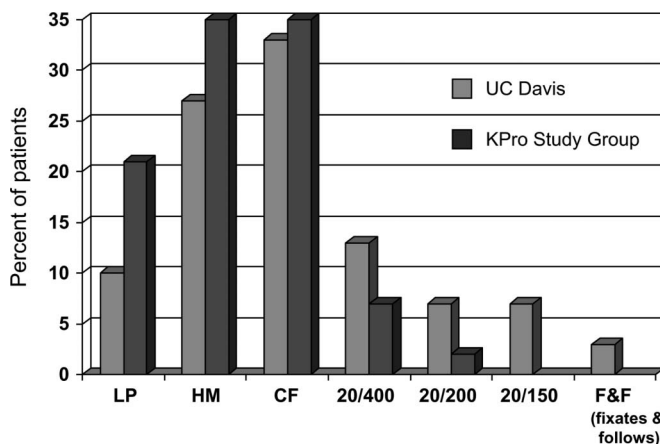
**Intraoperative Variables**

We used the pseudophakic Boston type 1 keratoprosthesis in 93% of eyes (28/30) and the aphakic model in 7% of eyes (2/30) (Table 1). Concomitant procedures included cataract extraction with intraocular lens implantation (9 cases), tarsorrhaphy (3 cases), fornix reconstruction (1 case), Baerveldt tube shunt implantation (1 case), and a temporary keratoprosthesis with pars plana vitrectomy (1 case).

**Glaucoma and Keratoprosthesis**

Preoperatively, 20 eyes (60%) had glaucoma, and these patients were using an average of 1.5 medications. Nine eyes

(30%) had a prior tube shunt, and 4 eyes (13%) had a prior trabeculectomy. After implantation of the keratoprosthesis, elevated intraocular pressure (as estimated by tactile tensions) was present in 8 eyes (27%) and progression of the underlying glaucoma occurred in 2 eyes (7%), primarily because of poor compliance with medication regimens and loss to follow-up (Table 1). Serial optic nerve head photographs and visual field



**FIGURE 1.** Preoperative BCVA with keratoprosthesis.

testing were performed in glaucomatous eyes. No eyes have required surgical intervention to control intraocular pressures after keratoprosthesis implantation.

**VA Outcomes**

Postoperatively, VA improved significantly in the vast majority of patients (Figs. 2, 3). The number of patients with best-corrected visual acuity (BCVA) 20/200 or better increased from 14% preoperatively to 77% postoperatively. Twenty-three percent (23%) had postoperative vision of 20/40 or better (Table 1).

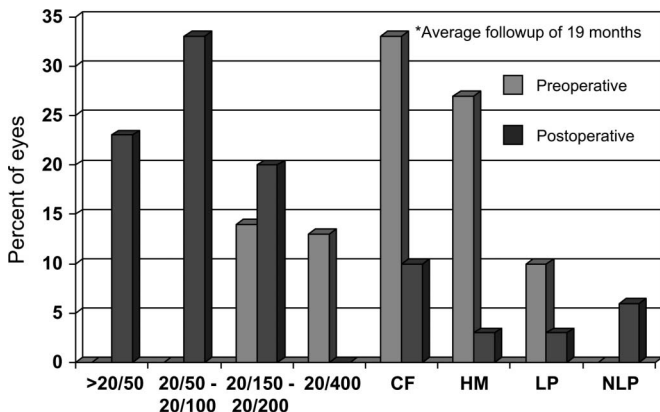
In the subgroup of 16 eyes followed for at least 1 year after keratoprosthesis implantation (mean follow-up, 28 months; range, 12–48 months; SD, 12.8 months; median 24 months), vision was  $\geq 20/200$  in 75% of eyes and  $\geq 20/40$  in 25% of eyes (Fig. 4). The anatomic retention rate of the initial keratoprosthesis was 81.3% (13/16) in this subgroup. Decreased vision was most common because of end-stage glaucoma or other posterior segment pathology.

Subgroup analyses of visual and anatomic outcomes based on select preoperative diagnoses (graft failure from noncicatrizating disease, chemical burns, and Stevens–Johnson syndrome) are shown in Table 2.

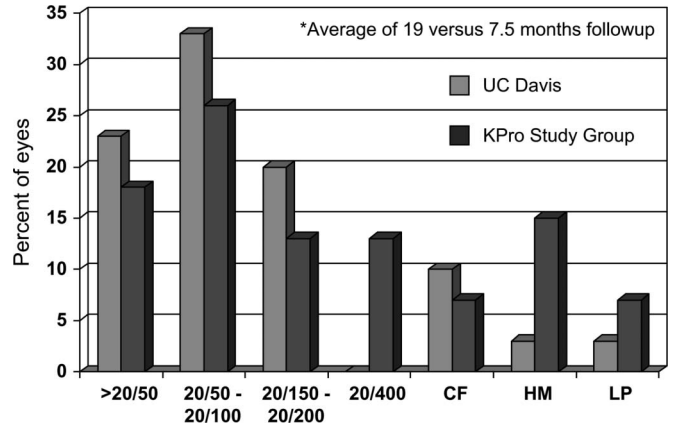
**Postoperative Complications and Management**

The most common nonsurgical complication was retroprosthetic membrane formation [13 eyes (43% of eyes), of which 7 (53%) were treated with yttrium–aluminum–garnet (YAG) laser membranectomy] (Table 1). One eye (7.7%) required surgical membranectomy, and the others required no treatment. One patient developed a retroprosthetic membrane that we could not open with the laser but has deferred surgical membranectomy (Fig. 5).

Other nonsurgical complications encountered after Boston type 1 keratoprosthesis implantation included increased intraocular pressure (8 eyes, 27%), corneal melt (5 eyes, 17%), infectious keratitis (5 eyes, 17%), endophthalmitis (3 eyes, 10%), progression of glaucoma (2 eyes, 7%), choroidal effusion or hemorrhage (2 eyes, 7%), vitreous hemorrhage (1 eye, 3%), iris prolapse (1 eye, 3%), sterile



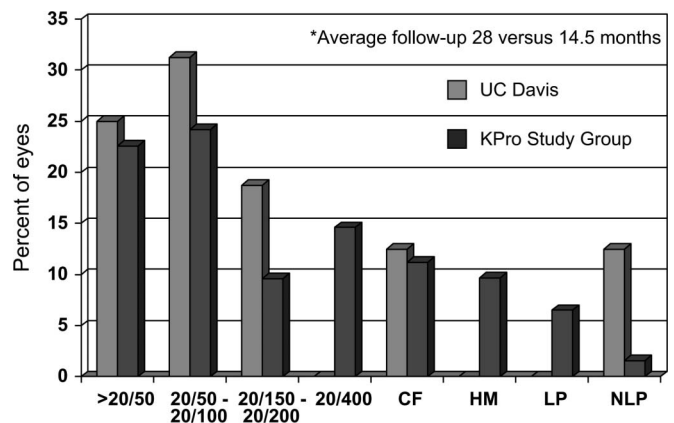
**FIGURE 2.** UC Davis preoperative versus postoperative BCVA with keratoprosthesis (N = 30 eyes).



**FIGURE 3.** Postoperative BCVA (N = 30 eyes).

vitritis (1 eye, 3%), posterior capsular opacity (1 eye, 3%), high myopic refraction (1 eye, 3%), hyphema (1 eye, 3%), and phthisis bulbi (1 eye, 3%). All 3 patients with endophthalmitis were using topical vancomycin at the time of presentation. Each patient was culture positive for a different organism with 1 patient growing each of the following bacteria: *Pseudomonas aeruginosa*, *Proteus mirabilis*, and *Haemophilus influenzae*. Other procedures performed after initial Boston type 1 keratoprosthesis implantation included keratoprosthesis replacement [10 occurrences, 5 eyes (18% of patients)], YAG laser capsulotomy (3 eyes, 10%), intravitreal antibiotics (3 eyes, 10%), corneal patch graft (3 eyes, 10%), temporary keratoprosthesis with pars plana vitrectomy (2 eyes, 7%), tarsorrhaphy (2 eyes, 7%), broken suture replacement (1 eye, 3%), subconjunctival antibiotics (1 eye, 3%), surgical membranectomy (1 eye, 3%), drainage of choroidal hemorrhage (1 eye, 3%), and keratoprosthesis removal followed by PK (1 eye, 3%).

The retention rate of the initial keratoprosthesis at an average follow-up of 19 months (range, 1–48 months; SD, 13.8 months; median, 13 months) was 83.3%, with only 5 failures. The causes of failure included corneal melting in 4 eyes and infectious keratitis in 1 eye. Of these 5 eyes



**FIGURE 4.** BCVA in 16 eyes at least 1 year after keratoprosthesis.

**TABLE 2.** Visual and Anatomic Outcomes for Selected Preoperative Diagnoses at UC Davis\*

Preoperative Diagnosis	Eyes Achieving BCVA >20/200	BCVA >20/200 Maintained	Anatomic Retention of Initial Keratoprosthesis
Noncicatrizing graft failure	73.1% (19/26)	89.5% (17/19)	80.8% (21/26)
Chemical burn	100% (3/3)	100% (3/3)	100% (3/3)
Stevens–Johnson syndrome	100% (1/1)	100% (1/1)	0% (0/1)

\*Average follow-up of 19 months.

(16.7%), which underwent keratoprosthesis replacement, 3 eyes (60%) required repeat keratoprosthesis replacement and 1 patient with Stevens–Johnson syndrome eventually required 4 replacements because of recurrent corneal melt. Ultimate retention of a keratoprosthesis was attained at 80% (4/5) with only 1 patient requiring keratoprosthesis explantation. This patient subsequently developed phthisis bulbi. Visual acuities of the patients undergoing successful keratoprosthesis replacement ranged from 20/25 to 20/150, and the patients have maintained both the device and stable VA at the last follow-up (7 months).

## DISCUSSION

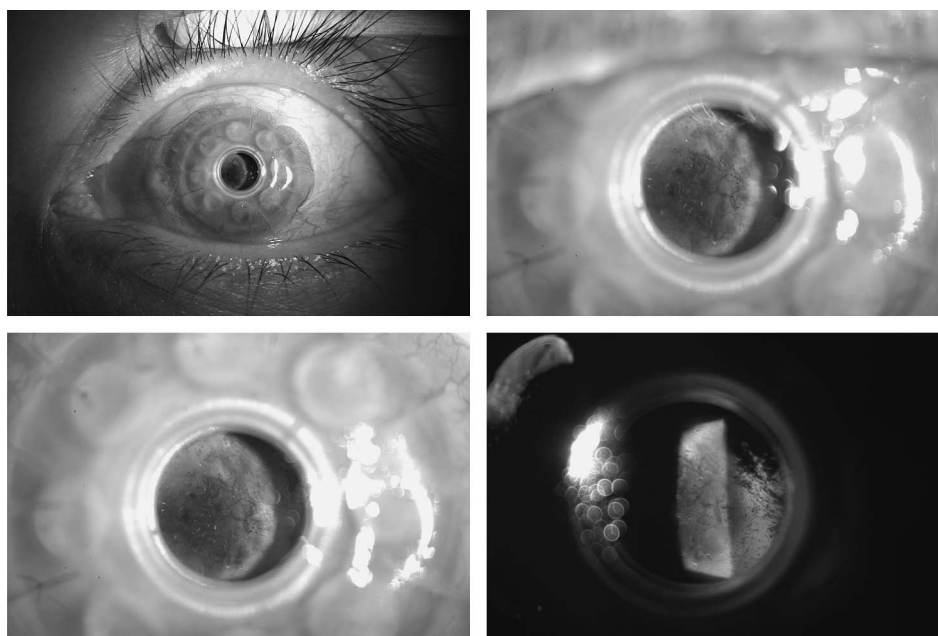
### Preoperative Characteristics

The majority of patients undergoing Boston type 1 keratoprosthesis implantation at UC Davis had multiple prior failed grafts. Only a few high-risk patients (3 eyes with alkali burn and 1 eye with Stevens–Johnson syndrome) received the keratoprosthesis without prior transplant. A previous study of Boston keratoprosthesis patients demonstrated that eyes with prior transplant failure because of 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%), chemical burns (64%), and Stevens–Johnson syndrome (33%).

Because of the poor prognosis in Stevens–Johnson syndrome, the authors recommended avoiding Boston type 1 keratoprosthesis implantation in these patients.<sup>8</sup>

Zerbe et al<sup>7</sup> also reported good outcomes for patients with chemical burns and noncicatrizing graft failure [94% and 90%, respectively, of eyes achieving at least 20/200 vision maintained it at the last follow-up (average 8.5 months)]. This report also confirmed a less favorable prognosis with OCP (75% of eyes maintained at least 20/200) and Stevens–Johnson syndrome (only one eye enrolled in study which achieved less than 20/200 vision).

Our study confirms these trends with a longer duration of follow-up (Table 2). In our series, patients with chemical burns and noncicatrizing graft failure attained vision of at least 20/200 in 100% and 73.1%, respectively. Of these patients, 100% and 89.5%, respectively, maintained vision of at least 20/200 at last follow-up (average follow-up 19 months). Our study did not include any patients with OCP, but 1 eye with Stevens–Johnson syndrome achieved 20/150 vision and maintained stable vision over 36 months of follow-up. Although no conclusions can be drawn from this anecdotal report of 1 patient with Stevens–Johnson syndrome, Boston type 1 keratoprosthesis implantation may provide an option in patients with bilateral corneal blindness from this condition despite its guarded long-term prognosis.



**FIGURE 5.** Slit-lamp photography of a Boston type 1 Keratoprosthesis patient from UC Davis with a dense retroprosthetic membrane.

## Intraoperative Variables

Compared with the initial Boston Keratoprosthesis Study Group report, the pseudophakic type keratoprosthesis was used much more common and fewer concomitant procedures were performed. This is likely because of our smaller patient number, patient selection, and surgeon preference.

## Glaucoma and Keratoprosthesis

Despite the technical limitations of intraocular pressure measurement after keratoprosthesis measurement, increased intraocular pressure was noted in a significant number of patients (8 eyes, 27%) (Table 1). In most of these patients, the increase in intraocular pressure seen in the early postoperative period seemed to be transient and responded well to topical therapy. No surgical interventions for intraocular pressure control were required at last follow-up. This contrasts with the Boston Keratoprosthesis Study Group's initial report in which only 21 eyes (15%) had increased intraocular pressure postoperatively, and 7.8% (11 of 141 eyes) of eyes underwent a tube shunt.<sup>7</sup>

## VA Outcomes

Consistent with previous reports, most patients had a significant increase in vision after Boston type 1 keratoprosthesis implantation. Patients without significant improvement or worsening of vision generally had underlying advanced glaucoma or other underlying posterior segment pathology.

Although our study does not provide a direct comparison to other alternatives for patients at high risk of corneal transplant failure, our data compare favorably published data both on AlphaCor keratoprosthesis (Addition Technology Inc, Des Plaines, IL)<sup>9</sup> and on repeat PK.<sup>10</sup> In our study, 75% of eyes at least 1 year after Boston type 1 keratoprosthesis implantation (average follow-up, 28 months) had BCVA of  $\geq 20/200$ . This compares favorably with the Boston Keratoprosthesis Study Group's initial report in which 56.4% of eyes at least 1 year after surgery (average follow-up, 14.5 months) had BCVA of 20/200 or better (Fig. 4).

In our study at UC Davis, at 1 year postoperatively, 25% of Boston type 1 keratoprosthesis eyes had BCVA of 20/40 or better. This is similar to the Boston Keratoprosthesis Study Group's initial report in which 22.6% of patients maintained this level of VA. Both reports compare favorably with the previously reported 16.9% after 1 repeat PK.<sup>10</sup>

## Postoperative Complications and Management

In our study, retroprosthetic membrane was the most common postoperative complication occurring in 43% of eyes. The frequency of this complication in our patients was higher than the Boston Keratoprosthesis Study Group's initial report (25% of eyes)<sup>7</sup> and prior published data on the Boston type 1 keratoprosthesis (27%–35% of eyes)<sup>8</sup> and AlphaCor (9.3% of eyes).<sup>11</sup> In our study, the majority of retroprosthetic membranes required no treatment or were amenable to YAG laser treatment. Only 2 eyes had retroprosthetic membrane formation requiring surgical membranectomy, and only 1 eye underwent the procedure.

The reported incidence of retinal detachment in prior series of Boston keratoprosthesis patients varies from 3.5% to 12%.<sup>7,12</sup> In our series, no patient developed a retinal detachment despite a longer duration of follow-up. In our series, sterile vitritis was seen in 1 patient (3%) and endophthalmitis in 3 eyes (10%). The incidence of endophthalmitis was more common than reported in the Boston Keratoprosthesis Study Group's initial report and of similar incidence to another prior report.<sup>13</sup> The previously reported association of endophthalmitis with patients with Stevens–Johnson syndrome was also seen in our study.<sup>13</sup> The low incidence of endophthalmitis in the Boston Keratoprosthesis Study Group's initial report may be related to the shorter length of follow-up.

Retention of the initial keratoprosthesis in our study was 83.3% (average follow-up, 19 months), which compares favorably with previously reported data on AlphaCor and repeat PK.<sup>9,10</sup> The retention rate of the Boston Keratoprosthesis Study Group's initial report was 95% (average follow-up, 8.5 months), possibly related to the short duration of follow-up. Keratoprosthesis replacement was required more frequently in our study (16.7% of eyes) as compared with the Boston Keratoprosthesis Study Group's initial report (5%). Repeat keratoprosthesis replacement in our study was also more frequently encountered (10 vs <1%). This increase may be because of longer follow-up and individual patient characteristics. Two of the 5 patients requiring keratoprosthesis replacement had autoimmune disease, Stevens–Johnson syndrome, and uncontrolled rheumatoid arthritis, and a third patient had Apert syndrome with severe exposure keratopathy despite large medial and lateral tarsorrhaphies. These characteristics likely predisposed these patients to this complication. After accounting for the device replacements, a keratoprosthesis was ultimately maintained in 96.7% of patients with only 1 patient requiring keratoprosthesis explantation. Continued follow-up is required to see whether the retention rate remains high.

In conclusion, the Boston type 1 keratoprosthesis is a viable option after multiple keratoplasty failures or in conditions with a poor prognosis for primary keratoplasty. All patients undergoing the procedure require close follow-up and ongoing maintenance. Patients with autoimmune ocular surface disease are at higher risk for complications. The UC Davis experience seems equivalent to the initial overall report of the Boston Keratoprosthesis Study Group. With longer follow-up, additional surgical procedures may be required but good anatomic and functional outcomes can be maintained.

## ACKNOWLEDGMENT

*During the course of this research, Dr. J.C.B. was a Heed Ophthalmic Foundation fellow (2007–2008) and would like to acknowledge the Foundation's support.*

## REFERENCES

1. Barber JC. Keratoprosthesis: past and present. *Int Ophthalmol Clin*. 1988; 28:103–109.
2. Hicks CR, Fitton JH, Chirila TV, et al. Keratoprostheses: advancing toward a true artificial cornea. *Surv Ophthalmol*. 1997;42:175–189.
3. Dohman CH, Schneider HA, Doane MG. Prostho-keratoplasty. *Am J Ophthalmol*. 1974;77:694–700.

4. Dohlman CH. Background of the present Boston Kpro I for graft failures. *Boston Keratoprosthesis Update*. 2004;(1):1–2.
5. Ma JJ, Graney JM, Dohlman CH. Repeat penetrating keratoplasty versus the Boston keratoprosthesis in graft failure. *Int Ophthalmol Clin*. 2005;45:49–59.
6. Aquavella JV, Gearing MD, Akpek EK, et al. Pediatric keratoprosthesis. *Ophthalmology*. 2007;114:989–994.
7. Zerbe BL, Belin MW, Ciolino JB, et al. Results from multicenter Boston type 1 keratoprosthesis study. *Ophthalmology*. 2006;113:1779–1784.
8. Yaghouti F, Nouri M, Abad JC, et al. Keratoprosthesis: preoperative prognostic categories. *Cornea*. 2001;20:19–23.
9. Hicks CR, Crawford GJ, Tan DT, et al. AlphaCor cases: comparative outcomes. *Cornea*. 2003;22:583–590.
10. Bersudsky V, Blum-Hareuveni T, Rehany U, et al. The profile of repeated corneal transplantation. *Ophthalmology*. 2001;108:461–469.
11. Hicks CR, Hamilton S. Retroprosthetic membranes in AlphaCor patients: risk factors and prevention. *Cornea*. 2005;24:692–698.
12. Ray S, Khan BF, Dohlman CH, et al. Management of vitreoretinal complications in eyes with permanent keratoprosthesis. *Arch Ophthalmol*. 2002;120:559–566.
13. Nouri M, Terada H, Alfonso EC, et al. Endophthalmitis after keratoprosthesis: incidence, bacterial causes, and risk factors. *Arch Ophthalmol*. 2001;119:484–489.