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Case Report
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CONTACT LENS MODIFICATIONS FOR BOSTON KERATOPROSTHESIS: NOVEL CASE REPORT AND REVIEW OF THE LITERATURE

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ABSTRACT

Boston Keratoprosthesis Type 1 (KPro), an artificial cornea, is a therapeutic option for patients in need of corneal transplantation when the prognosis of traditional keratoplasty is guarded. Bandage contact lens wear is essential in the post-operative management of KPro eyes in order to maintain adequate corneal graft hydration, and minimize the risk of adverse complications. Suitable bandage contact lens selection is imperative to preserve keratoprosthesis function, and customized modifications of contact lens parameters may be necessary to ensure adequate fitting. The available contact lens options, modifications, and protocols for the continued care of Boston Keratoprosthesis are discussed. A simple, yet unreported modification for contact lenses fit over KPro eyes in the setting of ocular surface irregularities is proposed, which may hold clinical utility when fitting keratoprosthesis patients with scleral elevations and glaucoma filtration devices.

Keywords: Boston keratoprosthesis; center thickness; contact lens modifications, keratoprosthesis, KPro

INTRODUCTION

Corneal transplantation is a commonly performed organ transplant indicated for corneal opacification or edema.[1,2] Although keratoplasty is considered to be one of the most successful types of organ transplantation, the survival time of corneal grafts is limited, particularly in patients with compromised host tissue and prior graft failure.[2] When prognosis for successful penetrating keratoplasty is guarded, the Boston Type 1 Keratoprosthesis

(KPro; Mass Eye and Ear, Boston, MA), an artificial cornea, may be considered as an alternative.[1-3] Long-term, continuous bandage contact lens (BCL) wear has become the standard of care in the post-operative management of KPro patients, and has reduced the risk of post-operative complications, such as corneal melt.[4-5] Therapeutic contact lenses maintain hydration and minimize exposure of the corneal tissue adjacent to the anterior plate of the keratoprosthesis, which is particularly vulnerable to evaporative drying.[4,6-7] Subsequent complications of corneal desiccation (which are lessened by soft contact lens wear) include epithelial dysfunction, stromal thinning, corneal melting, dellen formation, perforation, aqueous leakage and infection, and may be of particular concern in eyes with underlying inflammatory or ocular surface disease.[4-5,7-8] Historically, KPro devices were covered with conjunctival flaps to protect the ocular surface from tissue damage. This practice has since been outmoded in type I keratoprostheses.[4,8-9] Bandage contact lenses have eliminated the need for conjunctival flaps, and have conferred additional benefits including comfort, protection from abrasive interactions of the eyelid and sutures, reduction of the risk of corneal melt, possibility of refractive correction, improved cosmesis, and glare control via tinting.[4,6,10] Based on the vital role of BCLs in the preservation of keratoprosthesis function, proper bandage contact lens selection and adequate fitting are imperative. In this case report, we describe the utility of modifying the bandage contact lens center thickness to improve fit in the setting of KPro, and propose a possible indication for patients with ocular surface irregularities, such as glaucoma drainage devices.

CASE REPORT

A 47-year-old female presented for evaluation of redness and irritation in her left eye secondary to BCL wear over an existing type I Boston Keratoprosthesis. The relevant ophthalmic history in the left eye was significant for retinal detachment repaired with a scleral buckle and silicone oil tamponade, two failed full thickness penetrating keratoplasties (PK) with corneal neovascularization, moderate stage glaucoma secondary to multiple ocular surgeries, retrocorneal membranes and hypotony.

On presentation, the patient's vision in the left eye was hand motion. Despite numerous previous ocular surgeries, the patient presented for surgical evaluation. She worked in the healthcare field and expressed a strong desire to try to regain any vision possible in her left eye. A decision was made to proceed with KPro placement due to high probability of failure for an additional corneal graft, given her prior failures and corneal neovascularization. The patient underwent a combined surgery which included removal of existing PK, placement of temporary KPro, removal of a retrocorneal membrane, silicone oil exchange, endolaser treatment, and placement of a permanent KPro (Figure 1). Postoperatively, the patient began using prednisolone acetate 1% 4 times per day, moxifloxacin 0.5% 4 times per day, and vancomycin drops, which she ultimately tapered to one drop in the left eye once daily for long-term use.

The patient was fit with a BCL of unknown parameters immediately, post-surgery. An outside provider determined that this original BCL fit was

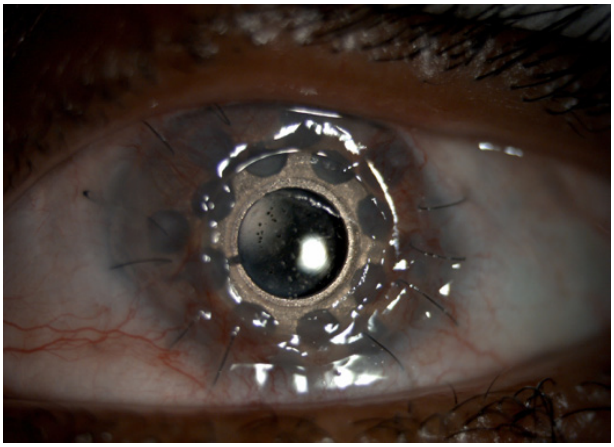

FIGURE 1. Boston Keratoprosthesis, no contact lens in place.

inadequate, and switched her to a Westcon Horizon sphere 55% BCL with 9.2 mm base curve, 16 mm diameter, plano, with which she presented to our practice. When assessing BCL coverage on slit lamp exam, an inferior nasal scleral elevation was noted in the left eye, and was determined to be scarring, resulting from a prior scleral buckle procedure. This elevation proceeded to cause obstacles in achieving optimal BCL fit. In the following year, an adequate fit was never obtained. Multiple BCL fits were attempted (Table 1). The lenses were observed to decenter superior temporally with inferior nasal fluting, uneven edge landing, and a large air bubble (Figures 2–3). The lenses were also noted to rub against the scleral elevation inferonasally, resulting in subjective reports of irritation.

In order to improve the fit and coverage over the inferior nasal elevation, BCL diameter was increased several times, but an acceptable fit was never achieved, and fluorescein pooling was observed near the elevation. In an attempt to vault over the elevation by weighing the lens down, a customized Kontur BCL was ordered with an increased center thickness of 0.30 mm. On application of this new lens, a stabilized fit was observed, with the lens successfully draping over the elevated area of scleral scarring (Figure 4). The increased thickness allowed the lens to drop inferiorly due to the added weight, allowing for enhanced lens centration. A tighter fitting relationship was also observed, contributing to less lens movement and promoting stability. With this well-fit lens in the setting of KPro placement, visual acuity in the left eye improved to 20/200. Subjective comfort was reported to be improved in this new lens, and the patient continues to report a decreased perception of irritation with 30 months follow-up. In this case, increased center thickness, a simple yet underutilized modification available for certain custom soft lens designs, was

TABLE 1 Bandage contact lenses initially trialed in present case.

Type of Contact Lens	Base Curve (mm)	Diameter (mm)	Center Thickness (mm)
Kontur Precision Sphere	9.0	18.0	0.2
Westcon Horizon Sphere	9.2	16.0	Not specified
Westcon Horizon Sphere	9.8	20.0	Not specified
Flexlens Large Diameter	9.2	20.0	Not specified
Flexlens Large Diameter	9.8	20.0	Not specified

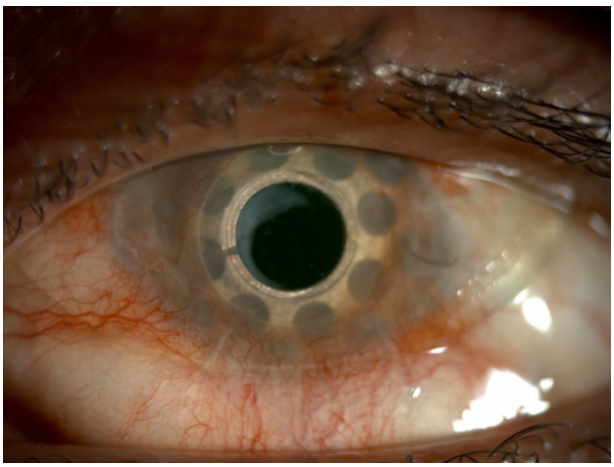

FIGURE 3. Unacceptable fit with Flexlens Large Diameter contact lens.

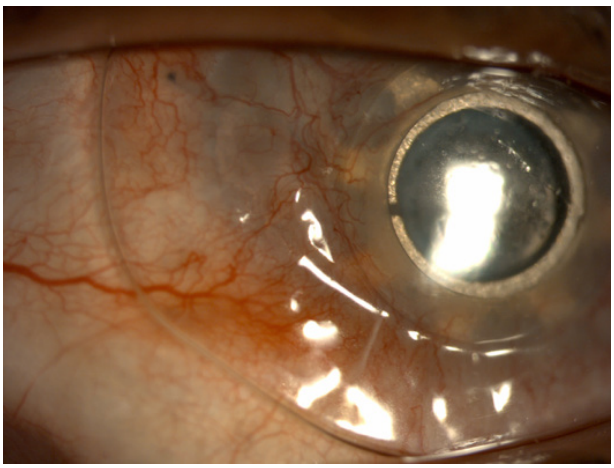

FIGURE 2. Unacceptable fit with Flexlens large diameter contact lens.

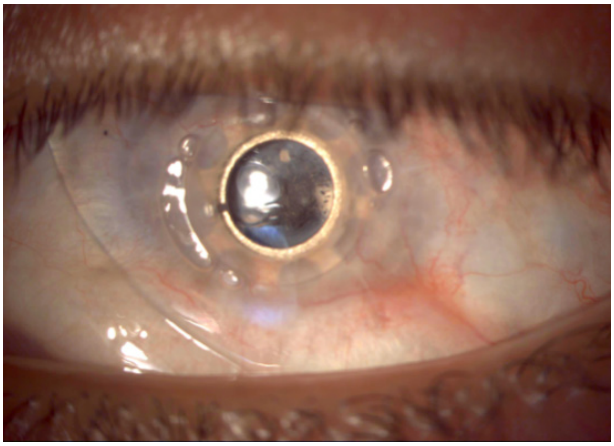

FIGURE 4. Acceptable fit with 0.3 mm center thickness Kontur contact lens.

sufficient in achieving adequate lens fit when traditional modification of BCL sagittal depth failed to produce appropriate lens stability and centration.

DISCUSSION AND REVIEW

Contact lenses used over KPro

A variety of contact lenses have been reported in the post-surgical care of Boston Keratoprosthesis patients (Table 2). The lens brand of choice most commonly used is the Kontur (Kontur Kontact Lens, Hercules, California, USA).[1,3-8,10,13-18] These lenses are composed of 55% Methafilcon A hydrogel material, and are available in a wide range of base curves (6.8mm to 9.8mm), diameters (12 mm to 24 mm), spherical powers (+10.00 to -20.00 D), and toric powers (-0.75 to -5.00 D).[1,4,6] Kontur lenses have a relatively low oxygen permeability (Dk) of 18.8, and may be replaced annually, although practitioners often replace them more frequently.[1] Lenses are placed on the ocular surface upon completion of KPro surgery, and are often preferred over other types of soft contacts due to suitable thickness and diameter, as well as improved retention and tolerability.[4]

As reported by Kammerdiener et al., suitable options for eyes that experienced poor retention of Kontur BCLs included: Permalens, Flexlens Tri-curve, Hydrasoft, Purevision and SynergEyes.[8] For ocular surfaces irregular in contour, Flexlens (X-Cel Contacts Inc., Bellevue, WA) offers options for very flat (Flexlens ARC, Flexlens 74), as well as very steep surfaces (Flexlens Tri-curve Keratoconus Lens).[2,4] For patients expressing cosmetic concerns, custom colored lenses are available, with Hue et al. reporting successful preliminary fitting of a "walnut" colored Alden HP49 (Lancaster, NY) BCL in a KPro patient dissatisfied with Kontur color availability.[18]

Silicone hydrogel BCLs with more frequent replacement schedules have been reported in the use of post-KPro care, and have the benefit of multipack packaging and lower cost.[1] Parameter availability, however, is limited with such standard lenses, most ranging between 13.8 mm and 14.5 mm in diameter.[1] One such lens reported by several studies is the Air Optix Night and Day Aqua (Alcon, Fort Worth, Texas, USA), which may be a preferred choice due to high Dk and low cost.[2,6,13] Other silicone hydrogel lenses that have been considered include Acuvue Oasys (Vistakon, Jacksonville, FL), Biofinity (Coopervision, Fairport, NY) and Focus Night & Day (CIBA Vision, Duluth, GA; discontinued), although achieving satisfactory fit over KPro devices with standard soft lenses may be difficult and not always possible.[2,10,17] Nau et al. found that the number of lenses necessary to achieve satisfactory fit over a KPro with Acuvue Oasys lenses far exceeded that of Flexlens and Kontur.[2] Furthermore, high water content silicone hydrogel lenses form deposits quickly. Beyer et al. observed improvement in deposit accumulation with the use of low water content nonionic lenses.[4,7]

Hybrid, scleral, and rigid gas permeable BCLs have been suggested as an alternative to soft lenses for KPro eyes, and may confer the added benefits of decreased pannus and deposit formation as well as increased lens retention.[2,7,9,19-22] Beyer et al. noted significantly increased patient satisfaction in 7 KPro eyes that were switched to hybrid or large diameter rigid lenses after previously experiencing dense deposits along the visual axis while wearing

TABLE 2 Bandage contact lenses reported for use in eyes implanted with Boston Keratoprosthesis

Type of Contact Lens	Study	Base Curve (mm)	Diameter (mm)	Center Thickness (mm)
Kontur*	2	9.8	16.0	**
	2	9.0	16.0	**
	2	9.8	20.0	**
	2	9.8	16.0	**
	2	8.9	15.0	**
	2	9.0	22.0	**
	2	7.6	16.0	**
	2	9.8	16.0	**
	2	9.8	16.0	**
	2	9.0	20.0	**
	3	**	**	**
	4	9.8	16.0	**
	5	Range of 7.0 - 9.8	Range of 16.0 - 20.0	**
	6	9.8	16.0	**
	6	8.0	20.0	**
	7	Range of 7.0 – 9.8	Range of 14.0 – 24.0 (typically 16.0)	**
	8	9.8	16.0	**
	11	9.8	16.0	**
	15	**	**	**
	16	**	16.0	**
	17	**	**	**
	21	9.8	16.0	**
	22	9.8	16.0	**
Kontur Precision Sphere	1	9.8	16.0	**
	12	**	**	**
	13	**	**	**
	14	8.9	16.0	**
	P	9.0	18.0	0.20
	P	9.0	18.0	0.30
Kontur 55 Sphere	18	8.5	15.0	**
Alden HP49	18	8.3	15.0	**
Air Optix Night and Day Aqua	1	**	13.8	**
	2	**	**	**
	6	8.4	13.8	**
	13	**	**	**
Acuvue Oasys	2	8.4	14.0	**
	10	**	**	**
	17	**	**	**

(Continues)

TABLE 2 Continued

Type of Contact Lens	Study	Base Curve (mm)	Diameter (mm)	Center Thickness (mm)
Focus Night & Day	10	**	**	**
	17	**	**	**
Flexlens ARC	1	**	**	**
Flexlens Spherical 74%	2	8.7	13.0	**
Flexlens Tri-curve Keratoconus	2	7.0	15.0	**
	4	**	**	**
Flexlens 49%	2	9.7	19.0	**
Flexlens PRS	2	11.0	17.0	**
	2	11.0	16.0	**
	2	11.0	16.0	**
Flexlens Large Diameter	P	9.2	20.0	**
	P	9.8	20.0	**
Medlens Rev Eyes	2	8.60	15.0	**
SynergEyes Hybrid	7	8.4	14.5 (soft skirt)	**
	22	7.9	14.5 (steep skirt)	**
Jupiter Mini-Scleral RGP	7	7.5	15.5	**
Boston Scleral	21	**	**	**
Westcon Horizon Sphere	P	9.2	16.0	**
	P	9.8	20.0	**

**Type of Kontur lens not specified, **Parameter not specified, (P) Lenses trialed in the present case.*

soft BCLs.[7] While such lenses require greater fitting expertise and may have higher cost, benefits include improved patient satisfaction, decreased need for lens replacements and office visits, and decreased doctor chair time.[7] Additionally, Chew et al. noted a case of a scleral lens fitted in a KPro patient with Steven-Johnson's syndrome that was successfully able to prevent melting or dellen on such a high-risk ocular surface.[21] Hybrid lenses that have been proposed include SynergEyes hybrid lenses (SynergEyes, Carlsbad, CA), with SynergEyes KC hybrids for steeper and SynergEyes PS hybrids for oblate ocular surfaces.[7,22] The Jupiter Mini-Scleral RGP lens (MedLens Innovations, Inc., Front Royal, VA) and Boston Scleral have demonstrated utility for rigid gas-permeable (RGP) and scleral lenses respectively, in the setting of KPro.[7, 21]

Fitting tips and contact lens modifications in KPro eyes

Suitable bandage BCL fit over a KPro is essential for lens retention and protection of the ocular surface from the risks of dehydration.[19] It is imperative that the lens centers over the KPro, as lens decentration increases the likelihood of corneal desiccation and keratopathy.[1-2,23] A well-fit lens should display adequate movement with blinking, and should not be too loose and exhibit edge fluting, nor too tight, and exhibit air bubbles or vascular compression.[1-2] In cases of markedly prolate or oblate topography, a lens with appropriate base curve should be selected, which may necessitate steep keratoconus or flat reverse-geometry designs.[2]

In order to achieve a stable fit, sagittal depth is often modified by changing lens diameter or

base curve.[19] One indication for modifying sagittal depth is central buckling of the BCL, which necessitates decrease in diameter or a flatter base curve.[1] Increasing diameter has been reported as a good strategy for improving lens retention, promoting comfort by protecting from mechanical trauma during blinking, and stabilizing BCLs on irregular corneas.[2,5] Nau et al., however, observed that increased lens diameter may not be suitable if a conjunctival elevation, such as a cystic bleb, is present, and noted that such elevations may lead to air bubbles resulting in focal drying and related complications, such as dellen formation.[2] In such cases, diameter can be decreased to avoid mechanical contact with conjunctival elevations.[6] Furthermore, filling the lens with an artificial tear and applying with a scleral lens plunger has been recommended for patients prone to air bubble formation.[2]

An important consideration in the fitting of BCLs over KPro concerns lens retention, as lens loss in the post-operative period has been found to be significant, with Harissi-Dagher et al. indicating 39% and Huh et al. citing 60% of patients experiencing lens loss.[3-4] Modifications reported to increase lens retention include modifying sagittal depth of the lens by increasing the diameter or steepening the base curve, refitting into a soft silicone hydrogel, hybrid, large diameter RGP or scleral lens, refitting into a different brand of contact lens and resolving eyelid laxities with oculoplastic procedures, such as lateral tarsorrhaphy or fornix reconstruction.[4,7,17,19-21] Oculoplastic consultations may be particularly beneficial for eyes with eyelid abnormalities, forniceal foreshortening and an irregular ocular surface secondary to Tutoplast grafts over tube shunts, as it is necessary to ensure that the fornices are able to accommodate a large contact lens.[17,20]

Modifying center thickness and utility for tube erosion

Increasing BCL center thickness in order to drape over an elevation in the setting of Boston Keratoprosthesis is an unreported, yet very simplistic, modification. We propose that if adequate fit is not achieved by modifying contact lens diameter or base curve in eyes implanted with KPro, increasing lens weight by modifying center thickness may be a plausible next step, and may preclude the need to switch to a different lens type. Increased lens weight may also be achieved by fitting a high plus lens, and was considered in the present case. But ultimately a decision was made not to alter refractive correction. Although, traditionally, increased center thickness may be of concern due to decreased oxygen transmissibility, oxygen transmission is not prioritized in KPro eyes as the donor cornea is considered a carrier.[6-7]

One particular utility of weighted bandage contact lenses may apply to KPro eyes with glaucoma drainage devices (GDD). Many KPro patients develop secondary glaucoma or experience exacerbation of existing glaucoma, which necessitates GDD implantation.[3,6] In these cases, tube erosion through the conjunctiva poses a risk; it has been posited that mechanical trauma from BCLs may be a contributing factor.[3,6,21] Oh et al. reported a case of conjunctival tube erosion resolved by refitting into a smaller diameter BCL to prevent mechanical contact between lens and conjunctival defect, which subsequently improved.[6] We postulate that a weighted BCL with increased center thickness may sufficiently vault over conjunctiva susceptible to tube erosion, thereby decreasing risk by minimizing mechanical interaction from the contact lens. Surgeons have taken other precautions to minimize risks associated with GDDs, such as implantation of a pars plana GDD with a corneoscleral patch graft.[3] Additionally, conjunctival scarring and adequate post-operative BCL fit should be considered when determining tube placement during GDD implantation, and a thin patch graft should be utilized to reinforce the tube and prevent exposure.[20,24]

Protocols for continued care

Following KPro placement, most practitioners advocate continuous BCL wear in order to maintain sufficient hydration and prevent complications.[6,8,25] Lens removal can occur at follow-up visits every 1-3

months, although some practitioners change lenses at longer intervals (3-4 months), as well as shorter intervals in cases of heavy deposits or frequent lens loss.[2,6,12,15,20] During the follow-ups, lenses are either replaced or cleaned and disinfected with commercially available contact lens cleansing solutions and extra-strength cleaners as needed, and observed for adequate fit.[4,6,8] Patients are educated on the need for continuous, lifelong BCL wear and antibiotic prophylaxis, and advised not to remove or handle the lens.[1,25]

Although adherence to the post-surgical medication regimen as well as appropriate lens care and follow-up may mitigate risks, possible complications may arise secondary to long-term, extended BCL wear over a keratoprosthesis. Lens deposits and biofilms may develop and interfere with comfort and vision, as well as increase risk for inflammatory and infectious disease.[4,7,12,19-20] KPro patients remain at life-long risk of infection, particularly in the presence of high microbial loads on BCLs, and benefit from compliance with medications, good hygiene, periodic povidone-iodine rinses, and routine replacement of contact lenses.[8,12,26]

CONCLUSION

The utilization of BCLs in the setting of KPro has become standard, and an adequate fit is essential in order to prolong survival of the keratoprosthesis and minimize the risk of complications. To date, there have been no reports of modifying BCL center thickness in order to drape the lens down and vault over conjunctival defects. In cases where application of a BCL over a KPro fails to yield stable fit, we propose that increasing BCL center thickness may be akin to modifying sagittal depth by altering base curve or diameter, and may forestall the need to switch to a different lens type.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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