

Keratoprosthesis: Current Choices and Future Development

Mehran Zarei-Ghanavati, MD, FICO*
and Christopher Liu, FRCOphth, FRCSEd†‡§

Abstract: Keratoprosthesis (KPro) is the last resort for corneal blindness. Boston KPro I and osteo-odonto-keratoprosthesis (OOKP) have the most favorable outcomes for their respective indications. Recently, better outcomes have been achieved for these 2 devices mainly because of improvements in postoperative care and modifications in complication management through years of experience and research. Unfortunately, some patients cannot benefit from these KPros due to lack of access to devices, trained surgeons, or both. Boston KPro I is heading toward a more affordable variation particularly for patients in developing countries. In addition, more patients with severely compromised ocular surface will be candidates for Boston KPro II variants. Biosynthetic or synthetic OOKP analogues will make the operation less complex and suitable for patients without canine tooth.

Key Words: Boston KPro, keratoprosthesis, KPro, osteo-odonto-keratoprosthesis

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There has been a long history of passion and perseverance by our predecessor ophthalmologists to invent a suitable KPro device. Strampelli¹ introduced the first useable KPro type, OOKP in 1963. Although Falcinelli² had done several modifications to improve OOKP outcomes, the original concept of OOKP is still without match in comparison to many failed versions or less optimal KPro types. Later, Professor Claes Dohlman's years of continuous effort created Boston KPro I as the most implanted KPro type with Food and Drug Administration clearance in 1992. These 2 KPro types have successfully endured the test of time.

INDICATIONS AND WISE ATTITUDE TOWARD KPros

An appropriate candidate should have a strong wish to regain vision and make commitment to life-long follow-up. They must be clearly informed of the risk of complications including irreversible visual loss. They should be ready to take a risk of endangering remaining visual function in the hope for better

From the *Eye Research Center, Farabi Eye Hospital, Tehran University of Medical Sciences, Tehran, Iran; †Sussex Eye Hospital, Brighton, UK; ‡Brighton and Sussex Medical School, Brighton, UK; and §Tongdean Eye Clinic, Hove, UK.

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Correspondence: Christopher Liu, Sussex Eye Hospital, Eastern Road, Brighton BN2 5BF, UK. E-mail: csliu@aol.com.

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vision which may be proven temporary. Therefore, formal psychological assessment is crucial to evaluate a prospective patient's resilience. Influence of patients' socioeconomic situation and family support should be meticulously considered.

KPro is indicated for bilateral corneal blindness or for one eye only. There are some instances of bilateral implantation or unilateral implantation in a patient with acceptable vision in the other eye. There is evidence against this practice. All KPros including OOKP have inherent instability and the risk of long-term complications is high, which needs subsequent procedures with their attendant risks. Although improvement in the quality of life has been shown after Boston KPro for legally blind patients,³ KPro implantation in patients with acceptable vision of the other eye would not increase visual field and stereopsis in most cases.^{4,5} Bilateral implantation of any KPro, especially in younger patients, is not advisable because it may endanger visual potential of both eyes. Moreover, a reserve eye with visual potential may benefit from a better device in the future.

CURRENT CHOICES OF KPros

OOKP and Boston KPro I are mainstream KPros among other devices which are abandoned or only practiced in a very small number of centers. The Boston KPro I is suitable for patients without significant dry eye and with normal lid protection, in other words "wet blinking eyes." Surgeons should be aware that stem cell transplantation may be an alternative in these cases.⁶ Unfortunately, there is not enough evidence to compare outcomes of Boston KPro I and stem cell transplantation partly due to lack of a standard format for research publications in this field. For patients with severe dry eye, keratinized ocular surface and permanent compromise of lid defense mechanism, OOKP is the standard criterion procedure. But of an OOKP to take place, a patient should have a suitable canine tooth to be fashioned as OOKP lamina. There are limited and less durable options for patients without tooth, including Boston KPro type II and its modifications, tibial KPro, Pintucci, Filatov, and allograft OOKP.⁷ A number of reports on Boston KPro II and tibial KPro show that their outcomes are less favorable in comparison to OOKP.^{8–10}

RECENT IMPROVEMENTS

OOKP

Although nowadays surgeons perform OOKP with nearly the same surgical technique as Falcinelli's one, the optical cylinder has been redesigned to improve visual field and decrease glare.¹¹ Surgeons' better understanding of timely and effective

management of buccal mucosal ulceration and glaucoma has improved anatomical and visual success. Moreover, technical improvements were done for treatment of postoperative complications including endoscopic vitrectomy, tube shunt operation for glaucoma, and augmentation of OOKP lamina by bone morphogenetic protein.^{12–14}

Boston KPro

There was a change in Boston type I from Poly(methyl methacrylate) (PMMA) backplate to titanium so as to decrease postoperative retroprosthetic membrane. The newer click-on type makes procedure easier by obviating the need for a locking ring in the older version (ie, snap-on type). Current version of Boston KPro I is modified to Lucia version to make it more affordable. It has the same front plate properties but it is a different design of titanium backplate which makes the manufacturing process cheaper.

Postoperative care after Boston KPro has been improved by long-term use of topical antibiotics and bandage contact lens which has decreased the risk of infectious keratitis and sterile keratolysis. One of the most important advances in management of Boston KPro is better understanding of glaucoma which is one of the most common causes of poor visual success. Although most surgeons rely on digital palpation for estimation of intraocular pressure (IOP), sensor has been implanted after Boston KPro.¹⁵ Shunt tube surgery is the main treatment modality of glaucoma in these patients due to failure of topical antiglaucoma medications.

LVP is a modification of Boston KPro to be implanted under buccal mucosal graft in patients with severely affected ocular surface like Stevens-Johnson syndrome and chemical burns. The optical cylinder was elongated in LVP to protrude from the surface of buccal mucosa. Early results including pediatric patients are promising.¹⁶ Boston KPro II has been similarly modified to be open through oral mucosal graft instead of upper lid skin. The main changes are an elongated PMMA optical cylinder and titanium sleeve around the cylinder (personal communication with Professor James Chodosh).

KPro COMMUNITY DEVELOPMENT

There is a worldwide need for experienced surgeons to deal with corneal blindness in ocular surface disease. Surgeons have to go through a steep learning curve to achieve enough expertise in the field of KPro. Therefore, junior surgeons will need long-term mentorship and support from their teachers. KPro surgeons should not be misled by satisfactory short-term outcomes as opposed to long-term results (meaning more than 5 years) of any KPro.¹⁷ They should also be familiar with other therapeutic modalities like stem cell transplantation. Moreover, international collaboration among KPro surgeons and experts in stem cell transplantation is needed to reach mutual understanding and conduct research to find out long-term outcomes and advantages of each modality.

EXPECTING FUTURE DEVELOPMENTS

Oral mucosal membrane provides a robust and durable protective surface for any KPro including OOKP that makes any alternative less imaginable in the near future. It is hoped that there is enough oral mucosa to harvest in most cases. Nevertheless, the main barrier to OOKP is a need for patients

to own canine tooth. Some patients lack suitable tooth and should be excluded from this operation. Moreover, it makes surgery more complex and lengthier. Biosynthetic or synthetic versions would be a solution to make OOKP operation easier and applicable for many patients.

Boston KPro type I will be heading for modifications to make it more affordable especially for developing countries. More evidence on long-term outcome of this device will guide its use for improved prevention, diagnosis, and management of postoperative complications. Boston KPro type II seems to have reached its end point. It has been modified to be implanted under buccal mucosa rather than that under lid skin.

On the contrary, advancements in other fields of ophthalmology may decrease the need for any KPro. Community-based prevention implementation will decrease corneal blindness because of infectious keratitis and chemical burn. Worldwide application of corneal cross-linking will help more patients with keratoconus and infectious keratitis. Better understanding of corneal immunological mechanisms may lead to more effective strategies for increase survival of multiple graft failure and control of immunological eye diseases such as Stevens-Johnson syndrome and mucous membrane pemphigoid. Finally, opaque cornea would be bypassed by intraocular implantation of electronic microdisplays in the near future.¹⁸

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