

Boston keratoprosthesis for ocular chemical injury: one-year clinical outcome

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Abstract

Allograft corneal transplantation often fails in repeated corneal graft failure, chemical burns, herpes simplex virus infection, autoimmune and inflammatory diseases. Patients with such diseases may require alternatives such as use of keratoprosthesis. We report on a patient with alkaline chemical injury of both eyes who failed to respond to previous surgical treatment. A Boston keratoprosthesis was implanted in his right eye. The operation was completed uneventfully and he enjoyed good visual recovery with no postoperative complications. To the best of our knowledge, this is the first case of Boston keratoprosthesis implantation in Hong Kong. The patient's visual acuity improved from seeing hand movements before the operation to 6/15 which was maintained at 1 year after the operation. Not all patients are able to benefit from conventional corneal transplantation. The Boston keratoprosthesis may offer a valuable alternative in selected patients.

Key words: Corneal diseases; Corneal transplantation; Prostheses and implants; Prosthesis implantation

Introduction

Keratoprosthesis (KPro) is a surgical procedure where a severely diseased cornea is replaced with an artificial cornea. KPro is of particular value when conventional allograft keratoplasty contributes a high chance of graft failure. The success of KPro procedures is associated with the cause or

ocular disease necessitating corneal transplantation. The prognosis is best for non-cicatrizing diseases, followed by ocular cicatricial pemphigoid, chemical burns, and is the poorest in Stevens-Johnson syndrome.^{1,2} In Hong Kong, Osteo-Odonto-Keratoprosthesis (OOKP),^{3,4} a special type of KPro involving the creation of support for an artificial cornea from the patient's own tooth and the surrounding bone, has been practiced.⁵ However, OOKP is technically demanding and requires multi-stage operations. Due to its complexity, OOKP is performed by a limited number of centers in the world, and only a few reports on its use have been published from Asia, namely from Singapore⁶⁻⁸ and Japan.⁹

Boston KPro was approved by the United States Food and Drug Administration for marketing in 1992. At present, it is the most commonly used KPro in the world.¹⁰ We report the case of a man who received implantation of the Boston KPro in his right eye. To our knowledge, this is the first case of Boston KPro implantation in Hong Kong. The outcome was successful.

Case report

In 2010, a 52-year-old man with good past health was assessed for the possibility of implantation of the Boston KPro. He had received severe cement alkaline chemical injury to both eyes in May 1997. In February 1998, he received right eye superficial keratectomy, allograft limbal stem cell transplant, and amniotic membrane transplant. The transplanted limbal stem cells remained stable, with systemic cyclosporin A. In 1999, the limbal stem cell transplant was rejected after cessation of systemic cyclosporin A. Given the nature of his injury and the occurrence of limbal stem cell deficiency, there was a very high chance of failure

of conventional corneal transplantation and so he did not receive a corneal graft.

After discussion with the patient, he was eager to receive Boston KPro implantation in his right eye. Preoperatively, his best corrected visual acuity was seeing hand movements in the right eye and 1/60 in the left eye. Slit lamp examination of his right eye showed a completely opaque cornea with vascularization (**Figure 1a**). There was no clear view of his anterior chamber and fundus. Examination of his left eye revealed similar findings.

The operation was performed in January 2011. The surgery started with the assembly of the device. The front plate was fixed to the adhesive surface supplied with the device. A donor corneal button of 9.0 mm was prepared and a central 3 mm hole was trephined. It was then placed over the stem of the front plate and the back plate was slid into place on top. A titanium locking ring was then pushed onto the remaining exposed stem until an audible 'snap' was heard. The assembled KPro was examined under the operating microscope for correct assembly. The recipient cornea of 8.5

mm was then trephined (**Figure 1b**). Simultaneous cataract extraction was performed, leaving the posterior capsule of the lens intact (**Figure 1c**). The donor graft with the KPro was then sutured in place with interrupted 10–0 nylon (**Figure 1d**). A 16-mm soft contact lens (Kontur Contact Lens, Richmond, CA, USA) was then applied. The entire operation was completed uneventfully. **Figure 2** shows the different components and the assembly of the type I Boston KPro which was implanted.

The patient was prescribed topical steroids and antibiotic eye drops after the operation. A 14-mm senofilcon-A silicone hydrogel contact lens (Acuvue OASYS, Johnson & Johnson Vision Care Inc., Jacksonville, FL, USA) was applied and was changed every 2 to 4 weeks. Following the acute phase, he was maintained on long-term prophylactic moxifloxacin eyedrops (Vigamox; 0.5% moxifloxacin hydrochloride ophthalmic solution, Alcon Laboratories, Inc, Fort Worth, TX, USA) 4 times a day. He enjoyed an uneventful recovery, and no postoperative complications were noted. He maintained a best corrected visual acuity of 6/15 at 2 months, 4 months, 7 months and 1 year after the operation.

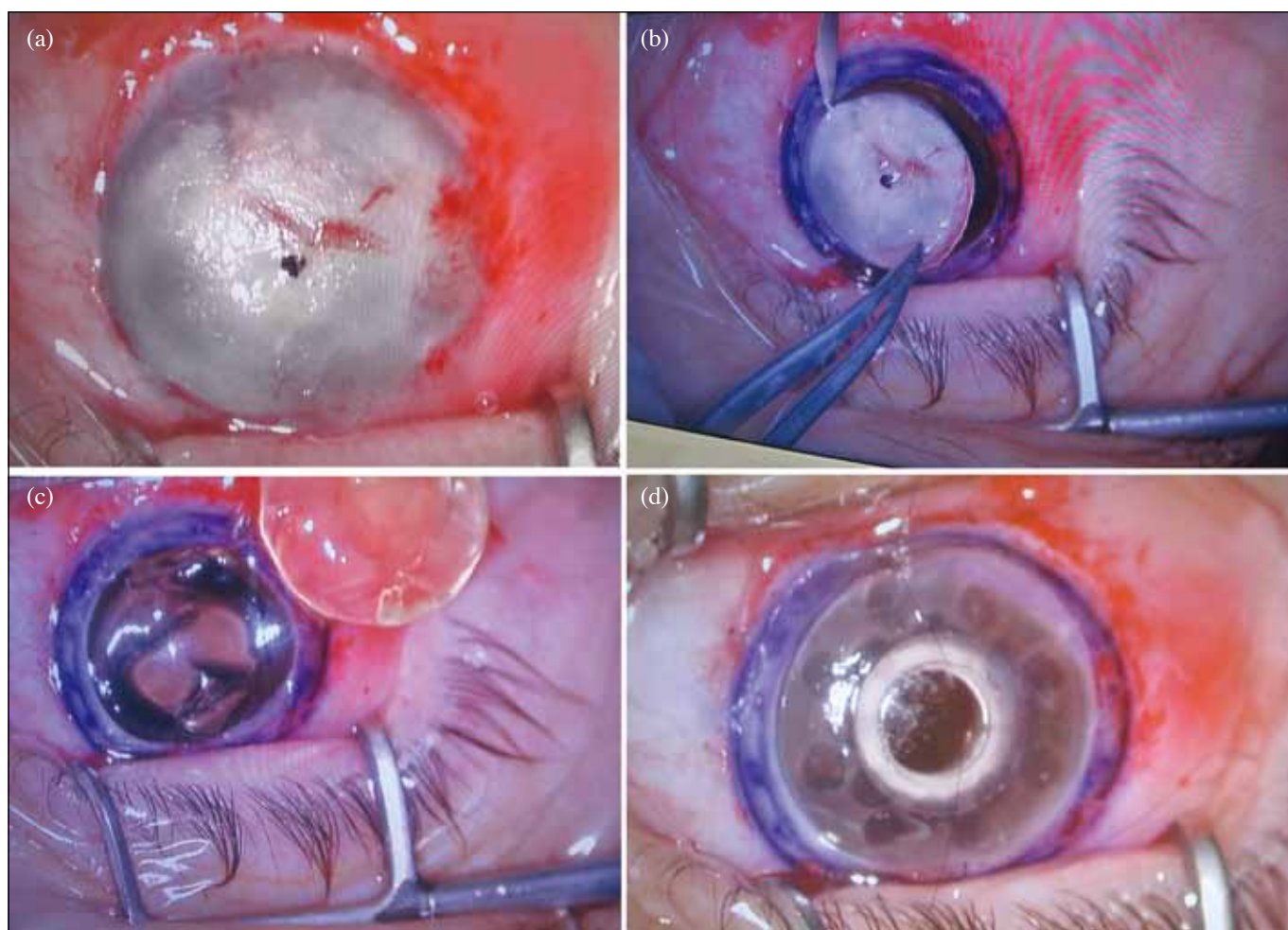


Figure 1. (a) A completely opaque cornea with vascularization in the right eye is shown. (b) Recipient cornea of 8.5 mm was trephined. (c) Simultaneous cataract extraction was performed. (d) The donor graft with the Boston keratoprosthesis was sutured in place with interrupted 10–0 nylon.

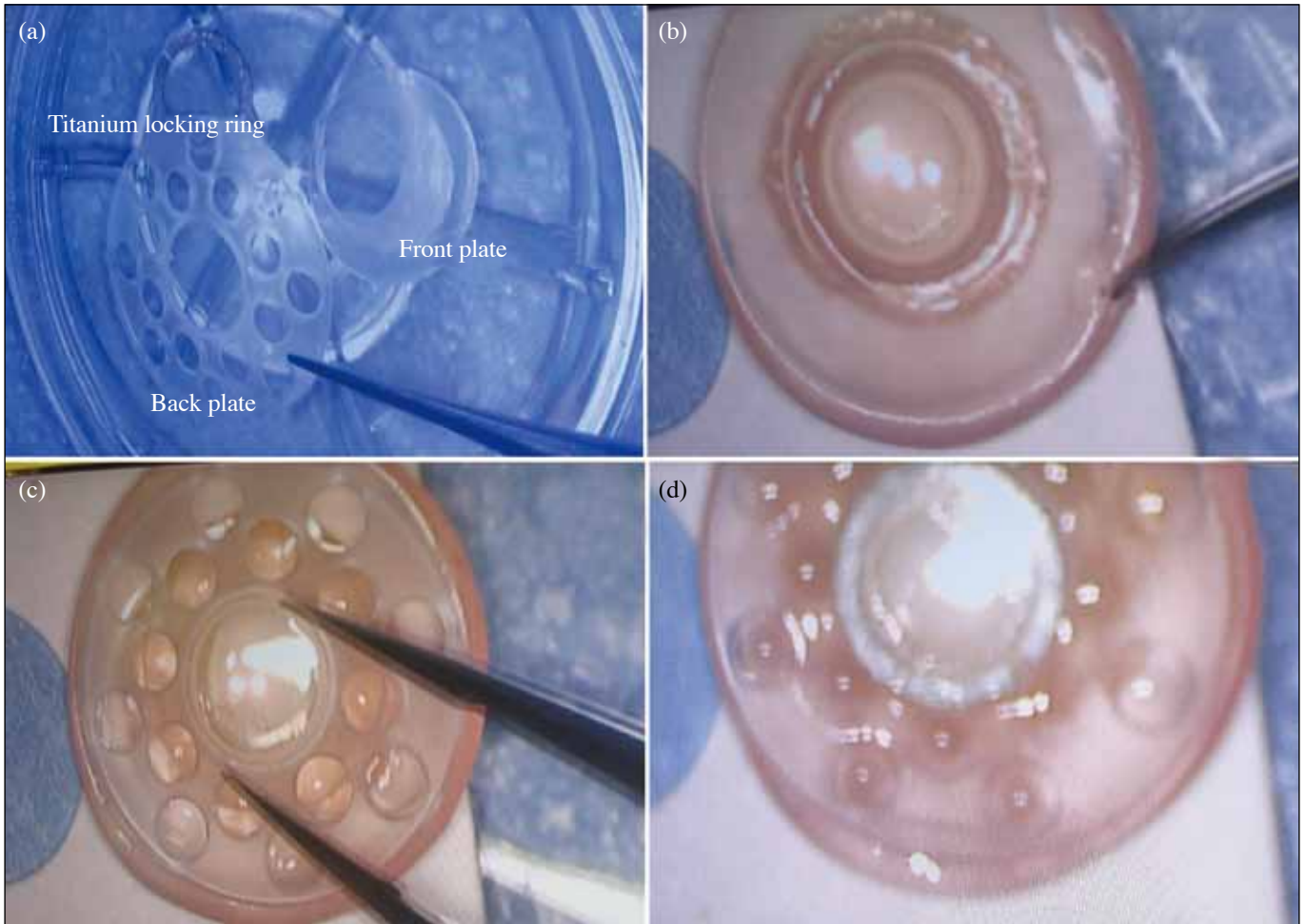


Figure 2. (a) The front plate, the back plate, and the titanium locking ring of the type I Boston keratoprosthesis are shown. (b) A donor corneal button with central hole is placed over the stem of the front plate. (c) The back plate is slid into place on top of the donor corneal button and the front plate. (d) The titanium locking ring is pushed into the exposed stem until an audible ‘snap’ is heard.

Discussion

In 1789, Pellier de Quengsy suggested using a glass lens in a silver ring for a leukomatous cornea.^{11,12} In 1853, Nussbaum published the first human trial using a quartz crystal implant.¹³ Although these early attempts at an artificial cornea often led to disastrous results, people interested in the field of KPro have continued to strive to improve the visual prognosis of those with otherwise hopeless and debilitating external ocular diseases.

KPro plays a role when conventional allograft corneal transplantation is unlikely to be successful. The **Table**^{3,14-23} shows the features and special surgical technique required of some commonly used keratoprostheses. The Boston KPro is now a proven primary treatment option for repeated graft failure, and is used in many other conditions, including ocular burns. The Boston KPro has 2 types. Type I consists of a collar button design, made of polymethylmethacrylate, which clamps within it a donor ring of corneal tissue that is sutured in place as one would in traditional penetrating keratoplasty (**Figure 3**). This device is suitable for patients

with repeated corneal graft failure, including those with herpes simplex virus infection and certain chemical burns. The type II through-the-lid device is designed for autoimmune and inflammatory diseases. Studies of the type I Boston KPro have shown an excellent retention rate of 97% at 16 months,²⁴ and 56 to 83% of patients enjoyed postoperative best-corrected visual acuity of 20/200 or better.^{14,15,24}

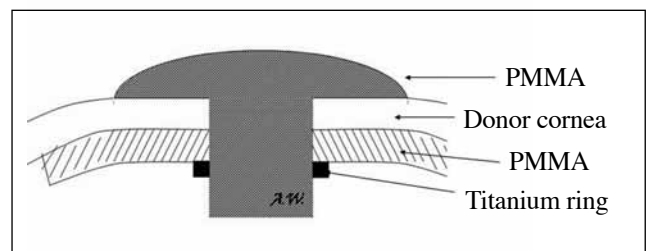


Figure 3. Cross-sectional illustration of the type I Boston keratoprosthesis. The donor cornea is placed within the polymethylmethacrylate (PMMA) plates of the keratoprosthesis and position is fixed with a titanium ring.

Table. Features and special surgical technique required of some commonly used keratoprotheses.			
Model	Origin (year)	Materials / designs	Special surgical technique
Cardona ¹⁶	New York, USA (1962, 1967)	2 types: ± flange, acrylate / PMMA / cellulose	Periosteum / tensor fascia lata may be needed
Osteo-odonto (OOKP) ³ / Strampelli / Marchi	Italy (1963)	Donor dentin tissue with PMMA cylinder	2-3 stages 1. The removal of iris and lens, as well as the preparation of the osteo-dental lamina complex After 4 months: 2. Preparation of buccal mucosal surface 3. Implantation of complex
Girard ¹⁷	USA (1969)	Flexible Dacron skirt with Cardona nut and bolt	Use of scleral expander and Tenon graft, instead of scleral graft
Boston ^{14,15}	Boston, USA (1970)	PMMA. 2 types: type I (collar-button) type II (for autoimmune)	Type I: sutured in place as traditional penetrating keratoplasty Type II: through-the-lid in dry eyes
Yakimenko Style ¹⁸	Ukraine (1972, 1993)	PMMA optic with a tantalum-titanium alloy haptic	Depending on corneal status: anteriorly penetrating, posteriorly penetrating, fully penetrating, or optico-cosmetic approach; 2-stage method
Dacron fabric Pintucci keratoprosthesis ¹⁹	Italy (1981)	PMMA optic and Dacron supporting	2-stage (1st stage: colonization of Dacron with oral muscosa; 2nd stage: placing of optical cylinder)
Fluorocarbon haptic (Legeais) ²⁰	France (1995)	PMMA optic with microporous fluorocarbon haptic	Intralamellar dissection with central trephination
AlphaCor / Chirila KPro ²¹	Australia (2001)	Synthetic hydrogel	2-stage with conjunctival cover and anterior corneal lamella. Contraindicated in herpes simplex
Seoul type KPro (S-KPro) ²²	Korea (2000, 2002)	Fluorinated silicone ePTFE skirt, PMMA tube, polypropylene skirt and haptics	Need amniotic membrane cover and scleral-fixed haptics
MIKOF ²³	Moscow, Russia (2003)	Moscow-design, titanium frame with PMMA optic	2-stage: inserting frame into the lamellar pocket, implanting an optical part 3 months later

Abbreviations: PMMA = polymethylmethacrylate, ePTFE = polytetrafluoroethylene.

A bandage contact lens is often placed indefinitely in eyes receiving the Boston KPro.²⁵ The main purpose of long-term use of around-the-clock soft contact lenses is to protect the ocular surface from excessive dehydration. Ocular surface exposure may lead to stromal melt or necrosis and failure of the KPro.²⁶ The contact lens can also protect the patient from exposed sutures and improve patient comfort. Nevertheless, prolonged use of a contact lens is associated with an increased risk of infection, especially in patients receiving KPro when the contact lenses are worn on an extended basis.

As with any surgery, KPro implantation is not without risks. Studies have shown that intraoperative complications include those recognized for penetrating keratoplasty, namely expulsive choroidal hemorrhage, retinal detachment and vitreous hemorrhage.^{27,28} Postoperatively, KPro can be associated with infectious keratitis,²⁹ chronic inflammation, vitritis, infectious endophthalmitis,³⁰ retroprosthetic membranes,³¹ epithelial downgrowth,³² tissue necrosis and melt at the prosthesis-corneal interface.³³ Cost is also one of the factors to be considered.³⁴ In 2010, the cost of ordering the Boston KPro was approximately US\$3000.

Most importantly, glaucoma exists almost universally and appears to be the most significant reason for long-term vision loss after successful vision-restoring KPro surgery. Often, a glaucoma implant is needed to control the

intraocular pressure.^{35,36} The reason why glaucoma remains the most challenging postoperative management problem following Boston KPro is multi-factorial. Preoperatively, it is often difficult to evaluate whether the operating eye with poor corneal status has co-existing glaucoma, as accurate intraocular pressure measurement is difficult and fundal view is poor. In addition, patients who require Boston KPro are those with repeated corneal graft failure and chemical burns. They often have underlying damage to the angle and therefore pre-existing secondary glaucoma.

Development of glaucoma in eyes receiving Boston KPro was postulated to be due to gradual closure of the anterior chamber angle.²⁶ Following the operation, monitoring of intraocular pressure is a major challenge because traditional methods of tonometry cannot be used on an eye with a KPro. When the first author received training under the supervision of Dohlman, the inventor of the Boston KPro, the author was advised that the simplest way of intraocular pressure monitoring was to rely on digital palpation of the sclera. Apart from this, in patients with adequate vision and a view that allows documentation of optic nerve appearance and structure, perimetry and optic nerve imaging can be performed to follow the status of glaucoma.³⁷ Anterior segment optical coherence tomography (AS-OCT) is also useful. Gonioscopic visualization of the anterior chamber angle is not always possible in eyes receiving the Boston KPro. The AS-OCT can be used to evaluate the depth of the

central anterior chamber and status of the anterior chamber angle and serves as an adjunct to perimetry and optic nerve imaging for early detection of secondary angle-closure glaucoma.³⁸

One suggested approach to management of glaucoma in patients receiving the Boston KPro is to implant glaucoma drainage devices at the time of KPro surgery in all eyes requiring treatment with antihypertensive drops before the surgery,^{37,39} though this appears relatively aggressive. Apart from glaucoma implants, other treatment modalities — such as transscleral or endoscopic cyclophotocoagulation — may also be required.⁴⁰ Close liaison with an expert glaucoma specialist is necessary.

In conclusion, although this is a case report and it is necessary to gather more cases in order to further comment on the results of Boston KPro implantation performed in

Hong Kong, we believe that it is a valuable alternative to patients with ocular diseases who are unable to benefit from conventional allograft corneal transplantation. We recommend ophthalmologists consider implantation of the Boston KPro in these patients as appropriate, as our experience reveals that it can offer welcome improvements in vision in selected patients.

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Declaration

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