Keratoprosthesis

The history of Keratoprosthesis (KPRO) development dates back to the 18th century. The modern era, in which various forms of polymethylmethacrylate (PMMA) are used, began in the 1950s. While KPro remains a procedure to be considered only in instances of poor prognosis keratoplasty, the improvements in design, surgical technique, and postoperative care have resulted in a dramatic improvement in results over the past quarter century.

The EXPERT’S CORNER on Keratoprosthesis in this issue, presents the views of a panel of experts with wide experience in the aforementioned subject. The development over the years in the technique and design of Keratoprosthesis, along with the peri-operative problems faced and their management, are discussed at length by Dr. Sana Tinwala with Dr. James Chodosh, Dr. Quresh Maskati, Dr. Radhika Tandon, Dr. Indu Singh and Dr. Geetha Iyer.

- Dr. James Chodosh (JC): MD, MPH; David G. Cogan Professor of Ophthalmology, Massachusetts Eye and Ear Infirmary, Howe Laboratory, Harvard Medical School, Boston, MA
- Dr. Quresh B. Maskati (QBM): MS, DOMS, FCPS, FICS; Hon. Ophthalmic Surgeon: Saifee Hospital, Mumbai, Hon. Ophthalmic Surgeon: Habib Hospital, Mumbai, Hon. Ophthalmic Surgeon: Hinduja Hospital (Khar), Mumbai, India
- Dr. Radhika Tandon (RT): MD, DNB, FRCOphth, FRCSEd; Professor of Ophthalmology, Cornea and Refractive Surgery Unit and Officer–in-charge National EyeBank, Dr. Rajendra Prasad Center for Ophthalmic Sciences, All India Institute of Medical Sciences, New Delhi, India
- Dr. Indu Singh (IS): MS, Consultant Ophthalmologist, Dr. Daljit Singh Eye Hospital, Amritsar, India.
- Dr. Geetha Iyer (GI): FRCS Senior Consultant, C. J. Shah Cornea Services, Dr. G. Sitalakshmi Memorial Clinic for Ocular Surface Disorders, Sankara Nethralaya, Chennai, INDIA
- Dr. Sana Ilyas Tinwala (SIT): MD, DNB; Senior Resident, Cornea, Cataract and Refractive Surgery Services, Dr. Rajendra Prasad Center for Ophthalmic Sciences, All India Institute of Medical Sciences, New Delhi, India

SIT: Who, according to you, are suitable candidates for keratoprosthesis? Your guidelines for patient selection based on your clinical experience.

JC: Keratoprosthesis implantation is indicated in any patient with corneal blindness when traditional keratoplasty, whether full thickness or lamellar, is likely to fail.

QBM: Those who have a functioning posterior segment, with no or controlled glaucoma, with multiple failed grafts or candidates unsuitable for grafts. For the Boston Kpro, they must in addition have a good eyelid action and adequate tears, with no keratinisation of the cornea and no history of corneal melts.

For the Pintucci Bio-Integratable Kpro we can even help those with bone-dry eyes with complete corneal keratinisation.

RT: Patients with bilateral blindness or severe visual impairment due to end stage corneal disease with some visual potential and not suitable for routine keratoplasty.

IS: A suitable candidate for Kpro is the one in whom we cannot hope to try any other treatment
SIT: What type of keratoprosthesis do you commonly use in your clinical practice?

JC: I use the Boston keratoprosthesis.

QBM: The Pintucci Bio-Integratable K pro since 1997 (85 cases); a modification we call the Chawan-Maskati-Pintucci Kpro (or CMP Kpro) since early 2013 (2 cases) and the Boston Kpro since early 2009 (approx 12 cases).

RT: Modified osteo odonto Keratoprosthesis (MOOKP) for patients over 18 years of age with end stage SJS with severe keratinization of ocular surface and ‘0’ Schirmer’s not amenable to other ocular surface reconstructive procedures, in patients who have a suitable canine tooth.

QBM: MOOKP surgery has been classically described as being performed in 2 stages as per the Rome-Vienna protocol. However, we prefer to do it in 3 stages. In the 2nd stage of the MOOKP procedure when the lamina is implanted in the eye.

GI: The technique of the Boston K-Pro surgery is as has been described in the literature. MOOKP surgery has been shown to be more effective as being performed in 2 stages as per the Rome-Vienna protocol. However, we prefer to do it in 3 stages. In the first stage, we prepare the eye and this includes the visual potential of the eye especially with respect to the optic nerve status. This also reduces the surgical time during the 2nd stage of the MOOKP procedure when the lamina is implanted in the eye.

SIT: Do you have any experience with keratoprosthesis in the pediatric population?

JC: I am very selective when considering keratoprosthesis in pediatric patients. The Boston keratoprosthesis can rescue life-long vision for the right patient, but without excellent compliance and follow up, patients may develop severe infection and lose their eye. On the other hand, it is much easier to prevent amblyopia with a Boston keratoprosthesis than with keratoplasty because there is no astigmatism with the keratoprosthesis.

QBM: Yes, the Pintucci has been done by me in children as young as 7 years of age as well.

RT: No.

IS: Yes. I have done 10 Kpro in children less than 15 years. This procedure has best results if the blindness is recent. In case of congenital problems with opaque cornea, the amblyopia is so deep that the child never appreciates the images he sees. In very small children(less than 5 years) I don’t advocate performing this procedure.

Experts’ Corner

with better outcome. For example penetrating keratoplasty, optical iridectomy etc.

The guidelines for patient selection are: Corneal blindness with good perception and projection of light and normal B Scan. The cornea should be strong enough to hold the Kpro In case of staphylomatus or very thin cornea we can do para limbal Kpro.

GI: Patients with bilateral visual handicap due to corneal problem with a high risk of graft failure with conventional keratoplasty would be the ideal candidate. With this definition the ideal patient would be one with multiple failed grafts especially for Boston Type 1 keratoprosthesis.

However being a tertiary referral center our indications have been primarily Stevens Johnson Syndrome (SJS) and chemical injury.

It is important to understand that K-Pros are the last resort and you have exhausted all other options prior to performing the K-Pro procedures. At the same time, it is important to keep in mind the impact of the prior intraocular procedures on the outcome of the K-Pro surgeries. The broad guidelines would therefore be:

1) Bilateral visual handicap
2) End stage ocular surface disorder
3) Patients’ willingness to come for regular follow-ups
4) Those with realistic expectations

SIT: Any modifications from your side in the described technique of keratoprosthesis surgery?

JC: My technical approach is fairly standard, except I pay a lot of attention to proper corneal wound closure in order to minimize formation of retroprosthetic membranes.

QBM: The Boston Kpro is done by me in the standard way, except that I only use a 7mm back-plate. The latest version manufactured by Aurolab is also good. For the Pintucci, as mentioned earlier, we have made some modifications in the original design.

RT: In very young patients in the age range 18 to 30 years we do extracapsular cataract extraction (ECCE) instead of intracapsular cataract extraction (ICCE).

IS: Champagne cork Kpro relies for its support on two types of fixations. Local fixation is with 100 microns steel sutures on to the cornea and distant fixation is also with 100 microns steel sutures with the healthy sclera. Our aim should be to fixate it to the eye in the manner that it does not have micro movements when the eye moves. The pressure inside the eye and the pressure of these wires should be same. The sutures should be equidistant.

We also carry out para limbal fixation of this Kpro in the same way as we fix it on cornea.

GI: The technique of the Boston K-Pro surgery is as has been described in the literature. MOOKP surgery has been shown to be more effective as being performed in 2 stages as per the Rome-Vienna protocol. However, we prefer to do it in 3 stages. In the first stage, we prepare the eye and this includes the visual potential of the eye especially with respect to the optic nerve status. This also reduces the surgical time during the 2nd stage of the MOOKP procedure when the lamina is implanted in the eye.
GI: We have done the Boston type 1 keratoprosthesis surgery in 2 pediatric patients. One was for a failed graft in the case of sclerocornea with a follow up of close to 3 years now and doing well. The other was for congenital anterior staphyloma with the other eye being anophthalmic. However this eye developed a carrier melt and retroprosthetic membrane formation which required a repeat Keratoprosthesis along with membranectomy.

SIT: What are the outcomes of Boston K-pro in your setting?

JC: When one considers that most patients I operate on are blind with no other surgical or medical alternative, the outcomes are excellent. Pre-existing glaucoma remains the major impediment to visual improvement of patients in my practice.

QBM: Excellent, provided we have been choosy in patient selection.

RT: 80% anatomical retention, 100 % attained full visual potential, 100% retained vision longer than all previous corneal grafts. Retroprosthetic membrane occurs in over 60 % of cases, but is less with the Lucia.

IS: I don’t have experience with Boston Kpro.

GI: Our retention rate over the last 6 years has been close to 80% and a best corrected visual acuity of better than 20/200 was achieved in close to 70% of the patients.

SIT: While keratoprostheses are the last resort in patients with corneal blindness, Can we consider osteodontokeratoprosthesis (OOKP) as the last resort amongst keratoprostheses? Kindly give us a brief overview of your experience with the same?

JC: I prefer to use the Boston keratoprosthesis type II in patients who are in need of a “last resort”, typically those with end stage cicatricial conjunctivitis and ocular surface keratinization. The type II device has very similar outcomes to OOKP, when one compares those outcomes by diagnostic category. The advantages of the type II device are less operating time and better cosmesis. But both techniques are evolving, and perhaps one day will merge into a single method for treating the cicatricial corneal blind.

QBM: The Pintucci and the MOOKP have similar indications. The Pintucci is easier to perform, can be done in a private set-up, does not need healthy teeth, therefore can be done for children and does not need a dentist or serial MRIs at regular intervals to check the health of the implanted tooth.

RT: Agreed. Cosmesis is a problem. Due to chronic inflammatory nature of SJS, reabsorption of ODAL after 5 years is another problem.

IS: I have done just one case of OOKP. The vision of that patient lasted for one year. I have seen and managed the complications of OOKP done elsewhere. I have seen extrusion, infection, retroprosthetic membrane and dislocation of this Kpro. If the surgery of this Kpro is perfect and there are no micro movements, the longevity of vision increases. In case of complications they also have to be managed the same way as other prosthesis. So in my opinion the best results are the results of good surgery.

GI: Firstly we would like to stress here that the indications for the 2 types of Kpros are basically different with a very minimal overlap.

Boston Keratoprosthesis type 1 is an option for eyes with adequate tears, good blink, no exposure and preferably without an underlying systemic immune condition like Stevens Johnson syndrome or ocular cicatrical pemphigoid (OCP). Meaning it is a good option for failed grafts or chemical injuries with limbal stem cell deficiency but well-formed fornices in an adequately wet eye.

MOOKP is an option in eyes with severe ocular surface damage associated with dryness and/or keratinization usually noted in patients with an underlying systemic immune condition like SJS or OCP. One of the main pre-requisites for a successful outcome of the MOOKP procedure is a good dental hygiene and this has to be ascertained preoperatively in consultation with the oro maxillo facial surgeon.

MOOKP can also be performed in eyes where a Boston type 1 K-Pro is primarily indicated however considering the challenging nature of the MOOKP surgery and the need for a multi-disciplinary approach, the Boston Type 1 K-Pro can be performed in these eyes if the patient is willing for the postop care and regular follow-ups. In patients with poor dental hygiene that precludes performing the MOOKP surgery, other options such as the Tibial bone or Pintucci K-pro might be required for visual rehabilitation.

SIT: What is your success rate with keratoprosthesis? What is the patient acceptance rate of the procedure in terms of satisfaction and quality of life?

JC: Success can mean many things. My definition is whether the life of the patient is improved by the device. By that definition, keratoprosthesis implantation has a near 100% success rate, at least in the short and intermediate time frames (several years). In the longer term (decades), postoperative complications including infection and glaucoma remain significant obstacles to retention of quality vision for many patients.

QBM: My success rate with the Pintucci is around 65% overall and around 50% if you only consider SJS patients. The success rate with the Boston Kpro is around 80%.

RT: Success rate for improvement in vision was 100% with Boston Kpro and 80% with MOOKP. The latter was due to one patient having a chronic shallow retinal detachment which was missed pre-operatively. Patients’ quality of life by informal assessment improved with gaining ambulatory vision and coming out of the World Health Organisation (WHO) category of blindness.

IS: I believe if we can make a patient ambulatory in terms of vision, it will be considered successful. 90% of my patients have ambulatory vision for one year. They are satisfied and at least 60% of them have very good quality of life. The
problem my patients face is that the corneas have multiple other problems. They can develop recurrent corneal ulcers or leakages from thin corneas. In order to avoid that I have started using buccal mucosal graft on these eyes.

GI: Success rate depends on the type of keratoprosthesis, the indication for which the K-Pro has been performed and the presence of co-morbid conditions, of prime concern being glaucoma. It is extremely important to reiterate here the importance of the preoperative counseling for these patients stressing upon the need for regular follow-ups, postoperative care, and the cosmetic outcome especially for the MOOKP procedure.

Our retention rate for the MOOKP procedure over the last 10 years has been close to 75% with a BCVA of better of 20/200 in more than 60% of patients. Broadly speaking, the patients’ acceptance is reasonably good and we have had patients resuming their studies and joining public sector undertakings after these sight restorative procedures.

SIT: What are the commonly seen complications intra-operatively and post-operatively?

JC: Intraoperative complications with keratoprosthesis surgery are the same as for keratoplasty and not difficult to manage for an experienced corneal surgeon. Postoperatively, keratoprosthesis complications are now very well known, including infection, glaucoma, retinal detachment, sterile vitritis, and retroprosthetic membrane. Those specific to keratoprosthesis are retroprosthetic membrane, sterile vitritis, and infections around the keratoprosthesis stem that if unrecognized or delayed in treatment, can lead to infectious endophthalmitis and loss of the eye.

QBM: Too many to list here. Suffice it to say that there is hardly any one of my 85 Pintucci patients who did not have some minor or major complication, including 3 endophthalmitis and 8 retinal detachments (all successfully operated and retina flattened) I also have the world’s only series of dropped Kpros (3 cases) in the vitreous. For the Boston Kpro, glaucoma and retroprosthetic membrane and infections are the commonly seen complications.

RT: MOOKP- intraoperatively vitreous hemorrhage, fracture of ODAL and poor visibility from excessive mucosal bleeding, expulsive hemorrhage. Post-operatively, mucous membrane overgrowth, ulceration, necrosis, absorption of ODAL, extrusion of ODAL, endophthalmitis, retroprosthetic membrane, retinal detachment, chronic glaucoma.

Boston Kpro- fracture during assembly, hemorrhage from corneal vessels tracking into vitreous cavity, expulsive hemorrhage, choroidal detachment. Post-operatively, instability of BCL, sterile corneal melt, infectious keratitis, endophthalmitis, secondary glaucoma, retroprosthetic membrane.

IS: I have very few intra-operative complications after more than a 1200 of these procedures. Post operatively these eyes can develop leakage, retroprosthetic membrane, corneal ulcers and very rarely extrusion or endophthalmitis.

GI: With respect to the Boston Keratoprosthesis the common intraoperative complication would be hemorrhage trickling into the vitreous cavity, or a decentered central opening in the carrier graft.

Post operatively retroprosthetic membrane, glaucoma, infection, carrier melts have been noted with Boston Keratoprosthesis.

The intraoperative complications in MOOKP include blood loss during harvesting the tooth, inadvertent entry into the maxillary sinus and decentered corneal opening during stage 2 of the procedure. The risk of suprachoroidal hemorrhage exists during the preparatory stage as well the 2nd stage. Postoperative complications include glaucoma, lamina resorption and endophthalmitis.

SIT: Considering the high rate of complications and meticulous post-operative care required, what is the routine post-operative follow-up regime for your patients?

JC: Really, the most important point to make about postoperative complications is to choose surgical candidates carefully. Then, frequent follow up visits with repeated reminding about the absolute necessity to continue topical antibiotics is the next most important aspect of good postoperative care. My postoperative regimen in keratoprosthesis patients after allograft rejection is once daily topical antibiotic, often trimethoprim/polymixin B, and in some cases, once daily corticosteroid. I generally try to stop the latter, within the first 6 months after surgery. I may see such patients in clinic every 3-6 months. In contrast, keratoprosthesis implantation in patients with auto-immune disorders requires much more intensive follow up care. I examine my Stevens Johnson patients with keratoprosthesis every two months, and use twice daily fluoroquinolone and vancomycin drops.

QBM: For the Pintucci Kpro, they are weaned off topical steroids and antibiotics about 3 months after the second stage and maintained on lubricants. The Boston Kpro patients have to change their large diameter scleral bandage lenses every 2 months and be on topical antibiotics for life.

RT: MOOKP- monthly follow up till 6 months, them 2 monthly till 1 year and 3-6 monthly thereafter, lifelong monitoring for visual acuity, healthy mucous membrane, stability and cleanliness of surface of optic, intraocular presure (IOP) assessed by digital palpation, fundus evaluation.

Boston Kpro- monthly follow-up till 6 months, then 2 monthly lifelong.

IS: I like to see my patients very often. I tell them to visit me at least once in two months and in case of a complication or decrease in vision, they have to report immediately.

GI: With respect to the MOOKP the post op care is minimal with yearly checkups including visual field spiral CT scan to assess the lamina dimension. Postoperative medications include topical antibiotic ointment and lubricant drops and systemic acetazolamide in case of glaucoma. Postoperative care following Boston type-1 kpro is more stringent. We routinely use prophylactic antibiotics in the form of vancomycin 14mg/ml 2/day and 4th generation fluoroquinolone 2/day for a long period. The bandage contact lens (BCL) is changed once every 3 months and patients are required to report back for follow up once every 3 months indefinitely.
**SIT: What is the rate of re-surgeries in your patients?**

**JC:** This depends entirely on the preoperative diagnosis. Reoperation is rare in allograft rejection patients, and common in autoimmune diseases.

**QBM:** The Pintucci is a surgery of last resort. If it fails, no more surgery is possible. For the Boston Kpro once can always change it if there is infection of the donor graft.

**RT:** 5%.

**IS:** I would like to call this “management of complications”. Almost 60% of my patients have to come for re-evaluation of their eyes. There are instances when conjunctiva grows on Kpro, so we have to create an opening. Sometimes we clean the surface of Kpro. Some patients need refixation of Kpro if it is slightly loose.

**GI:** Surgical intervention following kpro surgeries can be for multiple indications. Re-surgeries meaning re-keratoprosthesis procedure was required in 10 % of the MOOKP patients to salvage or replace the lamina over a 10 year period and same has been 7 % for the Boston K-Pro over a 5 year follow up period.

**SIT:** AlphaCor is another keratoprosthesis that has shown good results in some hands- we would like to know your views on the same.

**JC:** I do not use the AlphaCor any longer.

**QBM:** AlphaCor has been given up world wide as its usefulness was very limited.

**RT:** It is expensive and contraindicated in those with Herpes Simplex keratitis.

**IS:** I don’t have experience with it.

**GI:** We do not have experience with the same.

**SIT:** We would like to know your views on the economics of these procedures- how cost-effective are these surgeries considering the complication rate and the long term follow-up?

**JC:** It happens that the majority of corneal blind live in less financially well off communities. We have shown the cost utility of the Boston keratoprosthesis type I is excellent (~ 16,000 quality-adjusted life years), roughly equivalent to a corneal transplant, but still too expensive for less affluent parts of the world. I have been working on a $50 keratoprosthesis design, we call the “Lucia”, which shows great promise, but will not address the cost of postoperative medications and visits. The Boston keratoprosthesis type II has the same cost utility as a hip replacement (~64,000 quality-adjusted life years), and should be used selectively. Lastly, when considering cost-effectiveness, one has also to consider the cost benefit to patients and communities when the eyesight of blind individuals is restored.

**QBM:** To give a bilaterally blind person sight, sometimes after decades of darkness at a fraction of the cost of the same procedure done abroad is an awesome feeling. This is the only thing which keeps the handful of us doing these procedures in India going. Financial rewards are nil as almost all bilaterally corneal blind patients in India belong to the economically weaker sections of society and have to run around trusts and donors to scrape up the money to pay for the Kpros.

**RT:** Considering the procedures give visual rehabilitation for a finite period of time, typically 2-5 years, rarely 10-15 years, and are very effort intensive for chronic use of medications and mandatory follow up, they should only be offered for end stage disease in patients for whom there is no other option. Informed consent should include discussion of complications, cosmesis, expenses incurred in follow up visits and risks of severe irreversible sight threatening complications.

**IS:** Champagne cork Kpro is easily affordable and since we never charge the patients for re-visits, our patients do not have any problem.

**GI:** Keratoprostheses surgeries are sight restorative procedures in patients who are bilaterally visually handicapped. In the event of an uneventful surgical procedure, these patients recover a good visual outcome and can get back to a relatively normal course of life. Most of these patients are young individuals and are otherwise socio economically dependent on others. The cost of kpro surgery to the patient includes the surgical charges with the cost for the implant and the cost of the postoperative care and follow-ups. There have been studies to determine the cost effectiveness of the surgeries for both MOOKP and Boston type 1 kpro. These studies have shown after taking into consideration various parameters that these procedures are definitely cost effective.

**SIT:** Any other innovative design from your side?

**JC:** The titanium back plate was recently FDA approved for use in the Boston keratoprosthesis, and will revolutionize keratoprosthesis outcomes because of better biocompatibility, and lower physical profile in the eye. Future innovations will include a change in physical design of the back plate with surface modifications to the titanium to improve both cosmesis and device retention.

**QBM:** Yes, as I mentioned earlier, we are making a new design called the CMP Kpro which incorporates some of the concepts of the Boston Kpro in the Pintucci model. However, I have done only 2 so far, so it is too soon to share results.

**RT:** We have initiated cost effective techniques for ocular surface reconstructive procedures with cultured limbal epithelial cells and COMET for chemical burns. Biological scaffold has been developed in collaboration with Stem Cell Facility, AIIMS and IIT Delhi.

**IS:** Paralimbal Kpro is our innovation.

**GI:** We are in selected cases performing the Boston K-Pro through the oral mucosa.

I would like to acknowledge the entire Kpro team at Sankara Nethralaya and specifically the ocular surface team – Drs. Bhaskar Srinivasan and Shweta Agarwal.