Keratoprostheses are finding broader application

Roibeard O’Héineachain
in Monte Carlo

KERATO PRO STHESES have long been reserved as an option of last resort in patients with advanced corneal disease. However, recent advances in keratoprosthetic design and surgical technique and the understanding of corneal physiology may broaden the indications for such devices, according to reports from a session of the ESCRS Winter Refractive Surgery Meeting’s Cornea Day.

Günter Grabner MD, University Eye Clinic, Paracelsus Medical University, Salzburg, Austria told attendees at the session that the urgent need for keratoprostheses is evident from the large number of patients with corneal blindness worldwide who have been virtually abandoned as hopeless cases.

“Some patients have normal retinal function but are conally blind when we decide not to do their number eight transplant and finally give up. This is a fairly large group of patients who are blind and could be helped with keratoprostheses.”

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He noted that around five million or possibly more intracorneal lenses are implanted every year but only around 100-300 keratoprostheses. There are at most only about 100 researchers worldwide who are actively investigating such devices and only three or four companies are interested in producing them, he added.

“It is amazing that we have 12 million people with corneal blindness and yet you have only 200-300 keratoprostheses implanted per year. It would be wonderful to have a transplant that works permanently and is readily available in developing countries.”

Keratoprostheses have a long history in ophthalmology but only fairly recently have they been considered as potentially a broadly feasible option, said Sadeer Hannush MD, Wills Eye Hospital, Philadelphia, Pennsylvania, US. Though first proposed in 1789 by Peller de Quesnay, it was not until the second half of the 20th century that such devices were implanted in any appreciable numbers.

The keratoprosthetic designs that are currently in use are similar in having a central plastic, usually PMMA, optical portion. They differ primarily in how they are fixed to the recipient’s cornea.

Some designs, like the osteoentodonto-keratoprostheses of Falciuelli use autologous bone, tooth and mucous membrane as biological haptics. Others such as Boston K-Pro fix the prostheses mechanically to a donor button, which is then sutured into place. The AlphaCor and Pintucci keratoprostheses employ a biocollapsible skirt, which allow the corneal tissue to integrate into the device’s haptics.

An alternative to re-grafting

The devices most widely used today include the Boston K-Pro, the AlphaCor and the osteoentodonto keratoprostheses. Dr Hannush said that, in particular, the Boston keratoprosthesis is likely to emerge as a superior alternative to multiple re-grafting in eyes with a wet ocular surface.

The Boston Keratoprosthesis was originally developed by Claes Dohlman MD, Harvard University Medical School, in the 1960s. The Boston K-Pro consists of two 0.9mm thick PMMA plates and a 3.35mm diameter stem, which is the optical portion of the keratoprosthesis. The device’s 7.0mm diameter front plate and 11.0mm diameter back plate clamp onto a donor button of corneal tissue which is sutured into the recipient’s eye.

“With the Boston K-Pro, the donor tissue acts purely as a carrier. It does not need to stay clear because the patient is not seeing through the donor cornea but through the keratoprosthesis,” Dr Hannush told EuroTimes.

The Boston K-Pro was approved in 1992. About 700 implantations have been performed. It is the most commonly used keratoprosthesis in the US.

Enhancements have reduced complications

Although results with the earlier forms of the Boston K-Pro were somewhat marred by complications such as extrusion, corneal melt and endophthalmitis in a certain percentage of cases, recent improvements in surgical technique, the design of the device and the postoperative management of patients have virtually eliminated those problems, Dr Hannush said.

The latest design of the Boston K-Pro has fenestrations in its posterior plate to allow nutrition of the cornea and a titanium locking-rings to prevent the posterior plate from becoming dislocated. In addition, only healthy corneal tissue is now used for composing the keratoprosthesis/donor complex.

Furthermore, patients are now prescribed lifetime treatment with topical antibiotics, usually a fluoroquinolone and vancomycin, to eliminate the possibility of endophthalmitis. Finally, all patients are now given a bandage contact lens over the keratoprosthesis to decrease the evaporative forces that lead to melting around the neck of the K-Pro in the past.

No K-Pro failures in re-graft patients

An international trial is now underway with the Boston K-Pro. Under the direction of Michael Belin MD, the study is collecting data from 17 centres around the US and Europe which are implanting the latest design of the type II Boston K-Pro for a range of indications.

Initial results show that after a mean 33 months’ follow-up the overall retention rate of the keratoprosthesis in 141 eyes was 95%. Among those in whom previous graft failure was the indication for surgical implantation the retention rate was 100%.

In addition, while average preoperative vision ranged from hand movements to 20/100, most eyes achieved their macular potential postoperatively and about 20% achieved a visual acuity of 20/40 or better.

Better than re-grafting

Early experience with the newly modified keratoprosthesis has shown that while it has provided excellent results in patients with repeated graft failure, success of the keratoprosthesis was less in patients with Stevens-Johnson’s syndrome, cicatrical pemphigoid and chemical burns.

“Although many of them saw better than before surgery the prognosis was decidedly worse than in those in whom we placed the prosthesis for the explicit indication of graft failure,” Dr Hannush said.

On the other hand, the Boston K-Pro’s success in those with multiple graft failure compares favourably with that of multiple re-grafting in several retrospective studies. Dr Hannush noted that in a review of 3992 grafts, RW Thompson et al (Ophthalmology, 2003) showed that in first-time grafts the cornea remained clear in 90% of eyes at five years and in 82% at 10 years. However, after second grafts only 53% of eyes were clear at five years and only 41% were clear at 10 years.

Similarly, in a study by Bersudsky et al

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A review of 76 eyes with initial re-grafts showed that the five-year graft survival rate was only about 25%, while in 34 eyes with subsequent re-grafts none of the grafts survived for five years.

“This made us think we should have a paradigm shift in how we treat graft failure in patients who have a wet surface and a normal blink mechanism; perhaps we should consider placing the keratoprosthesis after the second graft has failed despite having tried topical peribulbar or systemic immune suppression using 1-3 agents.”

**Implantation technique**

Implantation of the Boston K-Pro is a fairly simple procedure, Dr Hannush noted. It involves first creating an 8.5mm donor button, then making a 3.0mm trephination for the central aperture. The donor button is then placed over the anterior plate delivering the optical element stem through the central 3mm trephination. The posterior plate is dialled over the threaded stem. The titanium ring is used to lock the posterior plate in place.

The surgeon then trephines the host cornea, performs any adjunctive surgery and sutures the donor/keratoprosthesis complex into position, concluding the surgical incision.

Dr Hannush noted that IOP control is adversely affected by the keratoprosthesis. This should be dealt with prior to or during the keratoprosthesis procedure with implantation of a tube shunt.

He added that inflammation and corneal melting can be prevented by the lifetime use of steroids, the application of anticyclogenases like medroxyprogesterone and agents of the tetracycline family, and by the constant and assiduous use of bandage contact lenses.

“Permanent keratoprosthesis implantation surgery is an effective alternative to re-grafting many of the historical concerns such as surgical demands, costs and complications are being successfully addressed. And while we need long-term follow-up you have to remember that these patients have no vision until you offer them another option.”

**Biointegrated keratoprosthesis**

The AlphaCor™ (Argus Biomedical Pty Ltd/CooperVision Surgical Inc) is another keratoprosthesis that has been showing high proportion retained at one year.

As of December 31, 2005, 299 AlphaCor keratoprostheses have been implanted worldwide. After a mean follow-up of 15.4 months (range: 0.5 - 86 months) the one-year retention rate has been around 80%.

Dr Aasly noted that the overall results with the AlphaCor have been roughly parallel with her own case series.

She and her associates implanted the devices in eight eyes of seven patients. They ranged in age from 39-87 years and had as many as five in failed grafts. All were at a high risk of graft failure with conventional keratoplasty. Preoperative visual acuity ranged from light perception to counting fingers.

After a mean follow-up of 15.4 months, seven of eight devices were retained in the eye. Postoperative best-corrected visual acuity ranged from counting fingers to 6/6.

There were no instances of retinal detachments or endophthalmitis. One case developed an inflammatory membrane. One implant was removed following stromal melting around the device after 22 months and the patient received a donor graft to maintain the eye’s structural integrity.

“The Trondheim series and overall data support the AlphaCor’s safety and efficacy but further follow-up remains important in judging the risks and benefits of this technology,” Dr Aasly added.

**New implantation technique**

Dr Stulting MD PhD, Emory University, Atlanta, Georgia, US, told the Monte Carlo Meeting that he has devised a new technique that may simplify implantation of the AlphaCor and improve results with the device.

The conventional AlphaCor implantation technique involves creating an extensive perilimbal wound to half the depth of the corneal thickness, dissecting and reflecting an anterior stromal flap to allow trephination of the central posterior stroma. However, this approach can be both difficult to learn and difficult to perform, he said.

Dr Stulting therefore developed a new technique. It involves making a half-thickness opening within the existing failed graft wound by blunt dissection and using that as a starting point for a lamellar dissection that extends beyond the graft-host interface. Finally, a flap is prepared by blunt dissection through the graft-host interface.

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of the original patients implanted with the corneas.

Dr Grabner noted that while osteodontokeratoprosthesis is the still experimental supradasemetic Kerall® K-pro might be considered. He added that in unilateral cases with dry eyes there is no practical option.

In bilateral cases the same options apply where there is a wet surface, except that more complex procedures such as osteodontokeratoprosthesis and other hard keratoprostheses like the Boston and Pintucci devices may also be considered. Moreover, the Pintucci K-Pro and osteodontokeratoprosthesis would also become an option in dry eyes.

He noted that other indications for the osteodontokeratoprosthesis and Pintucci K-Pro include severe bilateral chemical burns, mucous membrane pemphigoid, Stevens-Johnson-syndrome, epidermolysis, and trachoma.

Seeing through a tooth
Dr Grabner noted that the osteodontokeratoprosthesis consists of a PMMA optic, a haptic of osteodental tissue fashioned out of a single-rooted tooth and a transplanted flap of buccal mucous membrane which overlies the implant.

As with the AlphaCor, implantation takes place in two stages. In the first stage the tooth and periodontal bone is prepared, the optic is attached and the keratoprosthesis is placed into a skin pouch to allow soft tissue to grow into it.

The second stage of surgery takes place two-to-three months later and involves retracting the mucous membrane graft, trephination of the cornea, removing the iris, lens and vitreous, and suturing the prosthesis in place. The mucous flap is then reattached with a trephined hole through which the optical cylinder protrudes.

He pointed out, however, that the difficulty of such surgery is immense for both surgeon and patient, and the learning curve is steep. Such transplants must therefore be reserved for patients in whom all other options have been exhausted, he emphasised.

I think that that the gold standard is still osteodontokeratoprosthesis. However, implantation takes two or three surgical days, which is the equivalent of 30-40 cataract surgeries. Indications for this type of surgery are therefore quite restricted, it is the very last hope for patients that have absolutely no other chance of success," Dr Grabner said.