

Descemet Stripping with Endothelial Keratoplasty

a report by

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Corneal transplants are the oldest, most common, and arguably the most successful form of solid tissue transplantation in the world. Since the first full-thickness corneal transplant was performed in 1905 by Eduard Zirm, penetrating keratoplasties (PKs) have been performed to provide a clear, optically functional visual pathway to improve vision, provide tectonic support for an eye, alleviate pain from corneal decompensation, and eliminate an infection in danger of spreading intraocularly. Corneal disease processes requiring transplantation may involve either the anterior cornea (e.g. scars, ectasias) or the posterior cornea (e.g. bullous keratopathy, endothelial dystrophies). In the past 10 years, a new and evolving alternate technique, known as Descemet stripping with endothelial keratoplasty (DSEK), has come about in which only the diseased portion of the posterior cornea is replaced by healthy posterior donor tissue. Important advantages of DSEK over PK are that the host cornea remains structurally intact and more resistant to injury, intra-operative and post-operative suture management issues are non-existent, and concerns about late wound dehiscence after suture removal are virtually absent. Furthermore, the risk of expulsive intra-operative suprachoroidal hemorrhage is minimized because the wound is small and can be closed quickly. Of importance to the patient are the rapid visual recovery, minimal induced astigmatism, and relative

safety of topical anesthesia. This article will provide a brief overview of DSEK, an elegant technique for selective replacement of dysfunctional corneal endothelium that is constantly evolving and rapidly revolutionizing corneal transplantation.

History

In 1998 in The Netherlands, Melles presented a significant advance in the way in which corneal transplants were performed for endothelial disease.¹ This alternative surgical technique, which he called posterior lamellar keratoplasty (PLK), involved transplanting an unsutured posterior lamellar disc consisting of posterior stroma, Descemet's membrane, and endothelium through a sutured scleral incision. Host preparation of this lamellar disc tested the skill of surgeons as it required an often difficult recipient lamellar dissection at 80–90% stromal depth using curved blades.

Terry performed the first endothelial keratoplasty in the US in 2000, and called it deep lamellar endothelial keratoplasty (DLEK).² Melles modified his technique in 2002 by introducing a larger, folded posterior disc through a smaller self-sealing scleral tunnel incision.³ The following year, Melles reported how a folded transplant insertion could be combined with removing the recipient endothelial layer by means of stripping Descemet's membrane,⁴ a procedure now referred to as DSEK.⁵ The technique further evolved when Gorovoy introduced the use of a microkeratome preparation of the donor graft instead of hand dissection and called it Descemet's stripping automated endothelial keratoplasty (DSAEK).⁶ The preparation of donor tissue moved toward becoming truly automated when Cheng et al. used a femtosecond laser for the first time in humans to prepare the posterior corneal disc in a standardized and fully automated fashion.⁷

In 2006, Melles described the first clinical results of selective transplantation of only Descemet's membrane and endothelium, without posterior stroma—Descemet membrane endothelial keratoplasty (DMEK).⁸ A roll of donor Descemet membrane was inserted into the anterior chamber through a self-sealing corneal incision of a patient who went on to achieve 20/20 best-corrected visual acuity one week after transplantation. Tappin also described a novel technique of similar concept, called true endothelial cell (Tencell) transplant, for the transfer of donor endothelial cells with only a Descemet's carrier in patients with endothelial cell failure.⁹ Tappin's carrier is a specially designed platform that connects to the end of a cannula. The lumen of the cannula opens in the center of the platform, and injection of air floats the donor disc up to the host corneal stroma.

These rapid advances and improving outcomes have sparked a keen interest in this alternative surgical technique. According to the Eye Bank Association



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of America, requests for endothelial keratoplasty grafts have increased from 4.5% of all corneal graft orders in the US in 2005 to 18% in 2006.¹⁰ In the last half of 2006, close to half of the requests for grafts at Vision Share—the largest eye bank group in the US, providing 35% of the corneas for the nation—was for DSEK/DSAEK procedures (J Requard, President of Vision Share, personal communication). In fact, the increased demand for endothelial grafts contributed to a 5.5% increase in the number of overall grafts in the US in 2006, reversing a five-year decline in total grafts.

Surgical Technique

The DSEK surgical technique has been described previously in detail, and can be seen in video format.¹¹ The preparation of the donor lamellar disc with an artificial anterior chamber can be performed either manually, using dissecting blades, or in a semi-automatic fashion, using a hand-driven microkeratome. The posterior donor disc is trephined to an 8–9mm donor size and stored in a tissue storage solution while the recipient is prepared. Difficulties with preparation of the donor tissue can be minimized by using tissue prepared by an eye bank. The recipient preparation can be performed under local anesthesia and requires a soft eye with minimal back pressure. The steps consist of creation of a 3–5mm temporal scleral tunnel or clear corneal incision, stripping and removal of Descemet's membrane under continuous infusion of the anterior chamber, then gentle insertion of the folded donor tissue through the incision with special, single-point fixation forceps designed to minimize damage to endothelial cells. An alternative method of insertion is running a 'hitch suture' through the peripheral edge of the donor disc before folding it and using a hook introduced through the opposite side of the cornea to pull the donor into and across the anterior chamber.¹² At the 2007 Annual Meeting of the American Society of Cataract and Refractive Surgery (ASCRS), Massimo Busin introduced a funnel-shaped instrument that curls the donor graft when it is being inserted through the wound into the anterior chamber. We have actually inserted the device into the wound to minimize crush damage to the tissue while passing through the wound.

Air is then used to unfold the folded donor tissue slowly so that donor stroma sticks to recipient stroma. Once the donor is properly positioned by massaging the recipient corneal surface with a roller and draining fluid from the host–recipient interface via corneal stab incisions, the anterior chamber is filled with air for several minutes to push the donor graft up against the host stroma and encourage graft adhesion. The procedure is completed by removing some air from the anterior chamber and dilating the pupil to avoid pupillary block.

DSEK represents a truly new method of surgery that is different from the techniques with which most corneal surgeons are familiar, unless they have performed either PLK or DLEK. However, very few surgeons have performed many PLK or DLEK cases because of the significant learning curve and complexity of these techniques. While DSEK represents a more efficient and straightforward surgery compared with the earlier endothelial keratoplasty methods, it still has a significant learning curve and can have a host of difficulties and complications that novice surgeons are not acquainted with handling. Insertion of the donor tissue into the eye, unfolding of the tissue, placement of air to push the donor against the recipient, and removal of the air at the end of the case all represent areas of potential difficulties. The situation is analogous to the hurdles surgeons encountered when switching from either intracapsular or extracapsular

cataract surgery to phacoemulsification. As with phacoemulsification, it is advisable either to take a comprehensive course on DSEK or to spend significant time with someone who can mentor a new surgeon.

Pre-operative Management Issues

DSEK was initially used for treatment of Fuchs' endothelial dystrophy, pseudophakic bullous keratopathy, and aphakic keratopathy. We have shown that it can also be used to treat corneal edema associated with iridocorneal endothelial syndrome;¹³ it has also been shown to restore clarity to a failed prior penetrating graft.^{14,15} A failed PK in the absence of guttata does not have to be stripped of its Descemet's membrane, and the new posterior donor tissue can successfully adhere to the posterior surface of the failed graft.¹⁴ Although a failed PK can be challenging to treat and may be slower to clear post-operatively, DSEK can provide faster visual recovery with fewer complications than a PK re-graft. Finally, special modifications to the surgical technique should be considered when evaluating aphakic and/or aniridic patients.¹⁶

Intra-operative Management Issues

In the operating room, getting a good donor tissue dissection and performing the proper steps to ensure graft adhesion are of key importance in achieving success with DSEK. Compared with hand-dissected tissue, microkeratome donor tissue dissection for endothelial keratoplasty reduces the risks of donor tissue perforation and early graft failure. Furthermore, microkeratome donor dissection provides faster visual recovery and a refractive-neutral visual outcome.¹⁷ Because a microkeratome and associated equipment, such as an artificial anterior chamber, are significant capital expenses, a number of eye banks have begun providing pre-dissected donor tissue. In a prospective randomized study we recently conducted comparing the use of surgeon-dissected or eye-bank-dissected corneas for DSEK, we found no statistically significant difference in graft dislocation rate, six-month visual outcomes, and six-month endothelial cell loss (2007 ASCRS Annual Meeting).

Graft detachments are mechanical in nature, and can potentially arise from viscoelastic or trapped fluid in the donor–host interface, geometrical mismatching between the donor and recipient curvatures, strands of stroma or Descemet's membrane preventing tight apposition of the graft, a soft eye or wound leak, eye rubbing, and a non-viable donor due to graft overmanipulation causing injury to endothelium or due to upside-down placement of the graft with the donor endothelium in contact with the host stroma. The senior author had a dislocation rate of 50% in his first 10 DSEK cases. After implementing techniques to reduce donor dislocation, such as leaving air in the anterior chamber for longer intra-operatively, and removing fluid trapped between the graft and recipient cornea by massaging the corneal surface with a flap roller and placing four small drainage fenestrations in the mid-peripheral recipient cornea,¹⁸ the dislocation rate fell to about 4%. To reduce donor dislocations, selectively scraping the peripheral recipient bed has been found to increase donor edge adhesion.¹⁹ An air–fluid exchange system has also been described to promote graft adhesion during DSEK.²⁰ The majority of graft dislocations occur very early in the first post-operative week. An air injection procedure can be repeated to reattach a detached graft,¹⁷ although spontaneous reattachments have been reported.²¹

Post-operative Management Issues

Management of the post-operative DSEK patient largely revolves around monitoring intraocular pressure (IOP), assessing visual rehabilitation,

preventing rejection, and following the endothelial cell count. In a recent study we conducted to determine whether DSEK affects Goldmann applanation tonometry IOP readings in non-hypertensive eyes, we found that changes in central corneal thickness were not significantly correlated with changes in IOP, and that Goldmann tonometry seems to be an adequate method of monitoring glaucoma and steroid-responsive IOP changes after DSEK.²²

Visual recovery is quite rapid after DSEK compared with PK. Mean best spectacle-corrected visual acuity of 20/40 is generally achieved within three to six months of surgery.^{17,23} In addition, hard contact lenses are not required for best vision after DSEK because the corneal surface is minimally altered, whereas 10–15% of PK eyes often require a hard contact lens to normalize the corneal surface and achieve best vision. DSEK causes very minimal changes in corneal surface topography, mean spherical equivalent refraction, and mean refractive cylinder—these are important advantages compared with standard PK. At most, some surgeons report the induction of a small mean hyperopic shift with DSEK, which can be factored into intraocular lens calculation nomograms.^{5,23} In addition, the relatively predictable refractive outcomes achieved with DSEK allow cataract extraction with intraocular lens implantation to be performed beforehand, thereby avoiding endothelial cell loss from subsequent surgical trauma. This represents a paradigm shift from PKs, which have such unpredictable refractive outcomes that cataract surgery is often postponed until afterward to help reduce induced refractive error.

A new European–American multicenter study reported a two-year incidence of graft rejection episodes of 7.5% in a combined series of nearly 200 DLEK and DSEK cases.²⁴ The two-year rejection rate observed after PK for similar cases in the Swedish Corneal Transplant Register was 13%.²⁵ An important consideration when comparing rejection rates between various types of corneal transplants is the post-operative steroid regimen that is employed. The above multicenter study also showed that steroid usage differs significantly between DSEK and PK patients. Whereas almost all PK patients

had stopped using steroid drops during their first post-operative year to encourage wound healing, 80% of DSEK/DLEK patients were still using topical steroid drops at two years because wound healing is not a major concern in endothelial keratoplasty.²⁴

Endothelial cell density has been a source of concern following endothelial keratoplasty²³ because DSEK involves greater manipulation of donor tissue than does PK. A recent report comparing endothelial cell density longitudinally after grafting revealed a mean cell count of 3,100 cells/mm² before surgery, 2,000 cells/mm² at six months, 1,900 cells/mm² at one year, and 1,800 cells/mm² at two years.¹¹ Although cell loss in the first post-operative year following DSEK was found to be higher than cell loss noted in a recent, separate PK series at the authors' center, it was found to be within the wide range that has been reported historically in various PK series. Of note is that the larger graft size often used in DSEK (9mm) transfers 26% more surface area of health donor endothelial cells in comparison with the graft size typically used in PK (8mm)—this may reduce the rate of cell loss over the long term. More importantly, this study showed that modifications to certain elements of the surgical technique were associated with reduced rates of endothelial cell loss. These modifications include using single-point fixation forceps, which compress the donor tissue only at the tip during graft insertion, and using a clear corneal incision rather than a scleral tunnel incision to insert donor tissue as there is less tissue compression associated with clear corneal incisions.

Conclusion

The evolution of endothelial keratoplasty over the past decade and the continued advances from around the world in both the transplantation of selective components of the cornea and the regeneration of human corneal endothelial cells have truly been remarkable. DSEK is fast becoming the favored way of treating endothelial dysfunction. The evolving surgical technique will undoubtedly produce faster visual recovery, a tectonically stronger eye, an improved safety profile, and, most importantly, a more satisfied patient. ■

- Melles GRJ, Eggink FAGJ, Lander F, et al., A surgical technique for posterior lamellar keratoplasty, *Cornea*, 1998;17:618–26.
- Terry MA, Ousley PJ, Deep lamellar endothelial keratoplasty in the first United States patients: early clinical results, *Cornea*, 2001;20:239–43.
- Melles GRJ, Lander F, Nieuwendaal C, Sutureless, posterior lamellar keratoplasty, *Cornea*, 2002;21:325–7.
- Melles GRJ, Wijdh RH, Nieuwendaal CP, A technique to excise the Descemet membrane from a recipient cornea (descemetorhexis), *Cornea*, 2004;23:286–8.
- Price FW Jr, Price MO, Descemet's stripping with endothelial keratoplasty in 50 eyes: a refractive neutral corneal transplant, *J Refract Surg*, 2005;21:339–45.
- Gorovoy MS, Descemet stripping automated endothelial keratoplasty (DSAEK), *Cornea*, 2006;25:886–9.
- Cheng YY, Pels E, Nuijits, RMMMA, Femtosecond-laser-assisted Descemet's stripping endothelial keratoplasty, *J Cataract Refract Surg*, 2007;33:152–5.
- Melles GRJ, San Ong T, Ververs B, et al., Descemet membrane endothelial keratoplasty (DMEK), *Cornea*, 2006;25:987–90.
- Tappin M, A method for true endothelial cell (Tencell) transplantation using a custom-made cannula for the treatment of endothelial cell failure, *Eye*, 2006; advance online publication:1–5.
- Eye Bank Association of America, 2006 Eye Banking Statistical Report, 2006.
- Price MO, Price FW Jr, Endothelial cell loss after Descemet stripping with endothelial keratoplasty, *Ophthalmology*, Epub ahead of print 2007 Sep 13.
- Vajpayee RB, Agarwal T, Jhanji V, et al., Modification in Descemet-stripping automated endothelial keratoplasty: Hitch suture technique, *Cornea*, 2006;25:1060–62.
- Price MO, Price FW Jr, Descemet's stripping endothelial keratoplasty for treatment of iridocorneal endothelial syndrome, *Cornea*, 2007;26:493–7.
- Price FW Jr, Price MO, Endothelial keratoplasty to restore clarity to a failed penetrating graft, *Cornea*, 2006;25:895–9.
- Covert DJ, Koenig SB, Descemet stripping and automated endothelial keratoplasty (DSAEK) in eyes with failed penetrating keratoplasty, *Cornea*, 2007;26:692–6.
- Price MO, Price FW Jr, Trespalacios R, Endothelial keratoplasty technique for aniridic aphakic eyes, *J Cataract Refract Surg*, 2007;33:376–9.
- Price MO, Price FW Jr, Descemet's stripping with endothelial keratoplasty: Comparative outcomes with microkeratome-dissected and manually dissected donor tissue, *Ophthalmology*, 2006;113:1936–42.
- Price FW Jr, Price MO, Descemet's stripping with endothelial keratoplasty in 200 eyes: Early challenges and techniques to enhance donor adherence, *J Cataract Refract Surg*, 2006;32:411–18.
- Terry MA, Hoar KL, Wal J, et al., Histology of dislocations in endothelial keratoplasty (DSEK and DLEK): a laboratory-based, surgical solution to dislocation in 100 consecutive DSEK cases, *Cornea*, 2006;25:926–32.
- Meisler DM, Dupps WJ Jr, Covert DJ, et al., Use of an air-fluid exchange system to promote graft adhesion during Descemet's stripping automated endothelial keratoplasty, *J Cataract Refract Surg*, 2007;33:770–72.
- Price FW Jr, Price MO, A nonsurgical treatment for donor dislocation after Descemet stripping endothelial keratoplasty (DSEK), *Cornea*, 2006;25:991.
- Trespalacios R, Price MO, Jordan CS, et al., Changes in intraocular pressure measurements after Descemet's stripping with endothelial keratoplasty (DSEK), 2007; submitted.
- Koenig SB, Covert DJ, Dupps WJ Jr, Visual acuity, refractive error, and endothelial cell density six months after Descemet stripping and automated endothelial keratoplasty (DSAEK), *Cornea*, 2007;26:670–74.
- Allan BDS, Terry MA, Price FW Jr, et al., Corneal transplant rejection rate and severity after endothelial keratoplasty, *Cornea*, 2007;26:1039–42.
- Claesson M, Armitage WJ, Fagerholm P, et al., Visual outcome in corneal grafts: A preliminary analysis of the Swedish Corneal Transplant Register, *Br J Ophthalmol*, 2002;86:174–80.