

Descemet Stripping Automated Endothelial Keratoplasty

BY MALAIKA DAVID, SENIOR ASSOCIATE EDITOR



This installment of "Peer Review" highlights the most recently published articles on Descemet stripping endothelial keratoplasty (DSEK) and Descemet stripping automated endothelial keratoplasty (DSAEK). Because of the volume of current peer-reviewed literature on this topic, we will present the most relevant data in two parts, with the second installment focused exclusively on Descemet membrane endothelial keratoplasty (DMEK).

When we last addressed the subject in July 2008, there was still much debate about the success of DSEK compared to traditional penetrating keratoplasty (PKP). In 2011, DSEK and DSAEK are the procedures of choice among cornea specialists for the treatment of Fuchs corneal endothelial dystrophy as well as pseudophakic and aphakic bullous keratopathy. It should be noted that DSAEK is not meant to replace all PKP, because patients presenting with stromal scarring, corneal irregularity, or significant opacification will still benefit more from a full-thickness or deep-lamellar procedure. With the advent of new techniques and instruments, endothelial survivability has increased, visual rehabilitation has quickened, and the induction of refractive errors has been greatly reduced in comparison with PKP. As ophthalmologists overcome the challenges of DMEK, postoperative outcomes will continue to improve.

Some of the advances being explored in DSAEK today include corneal tissue injectors like the Neusidl Corneal Inserter (Fischer Surgical, Imperial, MO) and femtosecond laser-assisted preparation of the donor graft. In January, Henry D. Perry, MD, discussed the benefits of the NCI inserter at the Royal Hawaiian Eye Meeting in Maui.¹ The device enables the implantation of an endothelial graft with minimal manipulation of the donor tissue and does not require coating of the endothelial surface with viscoelastic prior to placement in the anterior chamber. Femtosecond lasers can facilitate the creation of significantly thinner donor grafts, but the long-term effects of the laser treatment on the corneal endothelium are still unknown.

Surgeons just getting started with DSAEK should be aware that, although most grafts will clear within 2 to 8 weeks, excessive intraoperative manipulation of the corneal tissue will lengthen the process. When combining the procedure with cataract surgery, surgeons should adjust their IOL power calculations and target -1.50 D spherical equivalence, because the graft tissue typically induces about that much hyperopia. Surgeons should also anticipate a final postoperative BCVA of between 20/25 and 20/50 secondary to optical aberrations at the graft-host interface.

I hope you enjoy this installment of "Peer Review," and I encourage you to seek out and review the articles in their entirety at your convenience.

—Mitchell C. Shultz, MD, section editor

PRECUT VERSUS INTRAOPERATIVE PREPARATION OF DSAEK TISSUE

Terry reviewed data suggesting that, as long as a surgical protocol is strictly followed, precut tissue performs as well as surgeon-cut tissue as it relates to complications such as dislocation and iatrogenic primary graft failure. The surgeons' level of experience had no impact

on the tissue's performance. He concluded that, as "DSAEK surgery techniques evolve, both novice and experienced surgeons need to constantly question each step of their DSAEK procedure to evaluate its effect on donor endothelial health and then, as a priority, make necessary changes in technique, which favor donor endothelial survival."²

According to Price and colleagues, when cataract extraction and IOL implantation are performed before or combined with DSAEK, it is important to factor the expected refractive shift from the DSAEK procedure into the IOL power calculation. In their review, the investigators found that the range of the shift in spherical equivalence after DSAEK was 4.00 to 5.00 D, which limits the accuracy of an IOL calculation. They stated that finding ways to reduce variability in the corneal graft's thickness and contour should lead to more reproducible refractive results with DSAEK. Further optimization of microkeratome- and femtosecond laser-assisted dissection for DSAEK may be beneficial in this regard. Alternatively, DMEK should cause a minimal refractive shift because no donor stroma is transplanted.³

Based on their analysis of the peer-reviewed literature, Dapena and colleagues stated that the major challenges with DSEK and DSAEK are suboptimal visual acuity, relatively slow visual rehabilitation, limited accessibility due to required investments in equipment or the purchase of pre-dissected tissue, and a drop in donor endothelial cellular density in the early postoperative phase. They concluded that, compared with DSEK or DSAEK, DMEK may have a higher clinical potential; more than 75% of the cases they reviewed achieved a visual acuity of 2/25 or better (≥ 0.8) within 1 to 3 months postoperatively. However, surgeons may require more training in order to obtain consistent outcomes with the DMEK surgical technique.⁴

In a retrospective study, researchers from the Wilmer Eye Institute at Johns Hopkins University in Baltimore reviewed the details on 913 corneal tissues that were processed by trained technicians at Tissue Banks International with an automated microkeratome for use in posterior lamellar transplantation. Over a 1-year period, the rate of successful tissue preparation increased from 95% in the first quarter to 99.5% in the fourth quarter. Early failed attempts at cutting tissue were likely due to the initial learning curve of the involved technicians. Graft material was frequently cut slightly thicker than requested by the operating surgeon, with 28.3% of tissues cut thicker than requested. "This is an issue about which the operating surgeon should be aware because it may possibly influence tissue handling," the researchers asserted. After cutting, endothelial cellular density increased by an average of 4.7% over the 1-year period.⁵

The Iowa Lions Eye Bank designed a 19-question survey, which was completed by 53 surgeons around the United States who were using pre-cut corneal allograft tissue for 197 DSAEK cases. All surgeries were performed between April 1 and December 31, 2006. Surveys were completed retrospectively within a few weeks of surgery. The tissue was found to be acceptable in 98% of DSAEK

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cases. Difficulties with pre-cut tissue were reported in 10% of cases and included the lack of anterior cap adherence to the posterior lamella, an invisible or decentered central dot, and an undermined anterior edge. A rebubbling procedure was performed in 23% of cases for donor dislocation. In 86% of cases, the donor lenticule adhered with resulting corneal deturgescence. Surgeons declared 92% of the cases to be successful procedures. Of the 14 unsuccessful cases, the quality of the donor tissue was the underlying cause in only one. Success rates were related to the surgeon's experience ($P = .002$), lenticule adherence after only one anterior chamber air bubble ($P = .005$), no small perforations to release fluid ($P = .005$), and the presence of corneal deturgescence ($P = .002$).⁶

DSAEK PROCEDURE, RESULTS, AND COMPLICATIONS

Recent advances in endothelial keratoplasty include an expansion of its indications to include a broader range of endothelial disease, modifications in host preparation (peripheral scraping, surface massage, fenestration incisions, and air tamponade), and the development of pull-through insertion techniques as an alternative to forceps. Because of these improvements, endothelial keratoplasty's use has broadened, its intraoperative ease has improved, and postoperative complications have decreased. Surgeons have successfully used the procedure after PKP; in cases of iridocorneal endothelial syndrome, aniridia, aphakia, and complex anterior chambers with anterior chamber lenses; and in pediatric patients. As the surgical procedure becomes faster and easier, "surgeons must critically evaluate the impact of these modifications on long-term patient outcomes."⁷

In a prospective study, 167 patients with endothelial decompensation from Fuchs corneal endothelial dystrophy or pseudophakic bullous keratopathy underwent DSAEK. The donor cornea was folded over and inserted with single-point fixation forceps using an incisional width of 5 or 3.2 mm. Researchers assessed the effect of the incision's width on graft survival, endothelial cellular loss, and

complications by evaluating central endothelial images at baseline and at 6 months and 1 year postoperatively. No primary graft failures occurred in either group. One-year graft survival rates were 98% in the 5-mm group and 97% in the 3.2-mm group ($P = 1.0$). Complications such as graft dislocation, graft rejection episodes, and elevated IOP occurred at similar rates in both groups. Mean baseline donor endothelial cellular density was 2,782 cells/mm² in the 5-mm group and 2,784 cells/mm² in the 3.2-mm group. At 6 months postoperatively, mean endothelial cellular loss was 27% \pm 20% ($n = 55$) in the 5-mm group and 40% \pm 22% ($n = 71$) in the 3.2-mm group. One year postoperatively, it was 31% \pm 19% ($n = 45$) in the 5-mm group and 44% \pm 22% ($n = 62$) in the 3.2-mm group ($P < .001$). According to the investigators, the key finding in this study was that “the 5.0-mm incision width resulted in a substantially lower endothelial cell loss at 6 and 12 months.”⁸

Researchers evaluated nine patients (nine eyes) who underwent DSAEK to analyze its influence on corneal curvature and anterior segment parameters. One and 3 months postoperatively, the investigators used the Pentacam Comprehensive Eye Scanner (Oculus, Inc., Lynnwood, WA) to measure anterior and posterior corneal curvature, anterior and posterior corneal astigmatism, anterior chamber depth, anterior chamber volume, anterior chamber angle width, central corneal thickness, and corneal volume. Mean preoperative central corneal thickness decreased from 687 \pm 85 μ m to 631 \pm 68 μ m at 3 months postoperatively ($P = .07$). Mean anterior keratometry readings of the cornea flattened from 43.30 \pm 1.65 D preoperatively to 42.70 \pm 1.50 D at 3 months ($P = .03$). Anterior corneal astigmatism did not change significantly. Mean posterior keratometry reading of the cornea steepened significantly from -5.60 \pm 0.60 D preoperatively to -7.20 \pm 0.40 D at 3 months ($P = .007$). Mean posterior corneal astigmatism increased from 0.52 \pm 0.17 D preoperatively to 0.95 \pm 0.57 D at 3 months ($P = .07$). Mean corneal volume increased from 65.8 \pm 5.6 μ L preoperatively to 85.2 \pm 4.2 μ L at 3 months ($P = .007$). The anterior chamber angle, anterior chamber depth, and anterior chamber volume did not change significantly after DSAEK. The average postoperative spherical equivalent changed from 0.50 \pm 2.50 D before surgery to 1.41 \pm 0.59 D at 3 months ($P = .05$).⁹

In a prospective, noncomparative, interventional cases series, investigators evaluated precut donor corneas in 100 DSAEK cases. They measured the preoperative donor characteristics and the rates of dislocation and primary graft failure. The average donor's age was 57.6 \pm 10.8 years, the average time from death to preservation was 9.8 \pm 3.2 hours, the average time from death to implantation was 94.5 \pm 33.5 hours, the average time from cutting

to implantation was 26.0 \pm 17.4 hours, and the average residual stromal bed thickness was 169 \pm 36 μ m. The average endothelial cellular density after cutting was 2,709 \pm 292 cells/mm² ($n = 100$). In the subgroup of donors for whom presection and postresection endothelial cellular densities were available ($n = 80$), the mean endothelial cellular density before cutting was 2,743 \pm 253 cells/mm², and the mean endothelial cellular density after cutting was 2,644 \pm 257 cells/mm². This average cellular loss of 3.7% was statistically significant ($P < .001$). There was only one dislocation, and there were no primary graft failures. The researchers concluded that the wide range of donor characteristics made available resulted in excellent adhesion of the tissue and clear grafts.¹⁰

A prospective, noncomparative, interventional case series involved 90 patients (100 eyes) who underwent DSAEK from June 2006 to May 2007. Investigators evaluated postoperative BSCVA, refractive astigmatism, topographic keratometry, and specular endothelial cellular densities at 6 and 12 months postoperatively. The donor characteristics analyzed were the time from death to preservation, from death to surgery, and from precutting resection to surgery as well as the graft's thickness. Six months postoperatively, patients' mean BSCVA improved from 20/83 to 20/38 ($P < .01$). Of the eyes with no known comorbidity ($n = 60$), 92% had a visual acuity of 20/40 or better, and 20% saw 20/20 or better at 6 months. On average, astigmatism changed by 0.09 D, and topographic keratometry changed by +0.09 D. Neither was significant, and both were stable to 12 months. Mean postoperative endothelial cellular density ($n = 65$) was 1,918 cells/mm² at 6 months and represented a 31% loss of cells from preoperative measurements ($P < .001$). Mean endothelial cellular density ($n = 61$) was 1,990 cells/mm² at 12 months and represented a 29% loss of cells from preoperative measurements ($P < .001$), with no significant change from 6 to 12 months ($P = .172$). The preoperative-to-postoperative improvement in visual acuity in eyes without comorbidity was not correlated with any donor characteristic. Greater endothelial cellular loss correlated with a higher preoperative density of endothelial cells ($P < .001$) and a trend toward longer intervals between precut resection and surgery at both 6 ($P = .049$) and 12 months ($P = .051$). Donor endothelial cellular loss from 6 to 12 months was stable and comparable with reports involving tissue that was cut intraoperatively.¹¹

MONITORING DSAEK BY CORNEAL THICKNESS

In a prospective study, 86 patients (88 eyes) underwent DSEK for Fuchs corneal endothelial dystrophy or

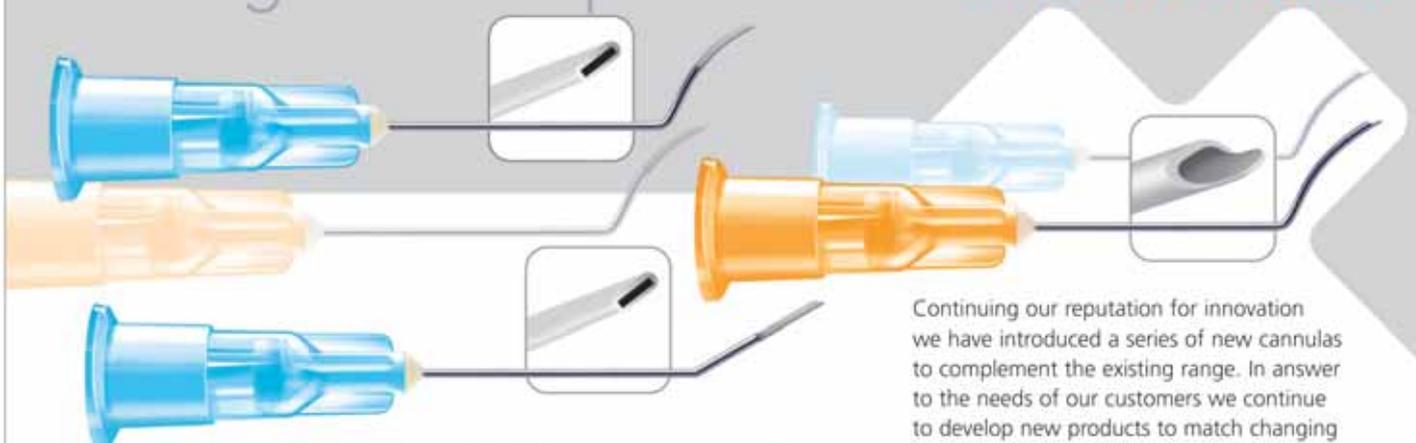
“Researchers noted that BCVA and forward light scatter did not correlate with corneal or graft thickness after DSEK.”

pseudophakic bullous keratopathy. Using anterior segment optical coherence tomography at the 12-month follow-up visit, investigators looked for the presence of interface fluid or graft dislocation. They measured central corneal thickness and endothelial graft thickness at multiple time points. The average central corneal thickness was 788 μm preoperatively and 816 μm on postoperative day 1. Mean endothelial graft thickness was 191 μm on postoperative day 1. Entrapped fluid at the graft-host interface was detected on postoperative day 1 by slit-lamp examination in 14 eyes and by optical coherence tomography in 28 eyes. From 1 month to 12 months after DSEK, central corneal thickness significantly diminished ($P < .001$); the most rapid decrease was observed between 1 week and 1 month postoperatively (5.34 $\mu\text{m}/\text{day}$ for the entire cornea and 2.54 $\mu\text{m}/\text{day}$ for the endothelial disc). Between 1 month and 1 year, the thickness of the central cornea and endothelial graft as stable.¹²

In a prospective, cohort study, 44 eyes that underwent DSEK were examined preoperatively and at 1, 3, 6, and 12 months postoperatively. Investigators measured the total thickness of the central cornea and the thickness of the graft with confocal microscopy. They assessed patients' BCVA using the electronic Early Treatment Diabetic Retinopathy Study (ETDRS) protocol and measured forward light scatter using a stray light meter. Mean total corneal thickness was 610 \pm 50 μm preoperatively. It increased to 680 \pm 74 μm by 1 month postoperatively and stabilized at 660 \pm 68 μm by 3 months postoperatively. Mean graft thickness was 170 \pm 57 μm at 1 month. It decreased to 157 \pm 49 μm at 3 months and stabilized through 12 months (156 \pm 51 μm). BCVA was 20/55 preoperatively. It improved to 20/36 at 3 months and to 20/29 at 12 months. Researchers noted that BCVA and forward light scatter did not correlate with corneal or graft thickness after DSEK. They concluded that “variations in corneal thickness after DSEK do not contribute to visual acuity or intraocular forward light scatter.” Also, stromal edema resolved by 3 months postoperatively for Fuchs dystrophy, whereas BCVA continued to improve through 12 months postoperatively.¹³

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SPECIAL CONSIDERATIONS IN DSAEK: CATARACTS, GLAUCOMA, IOLS

Investigators conducted a retrospective review of an initial consecutive case series of 1,050 DSEK procedures. They assessed the rate of and risk factors for cataract formation with multivariate proportional hazards modeling and survival analysis. Cataract extraction was performed after DSEK in 22 eyes (37%) without complication, and all grafts remained clear with a median follow-up of 18 months. Six eyes were regrafted; all underwent cataract extraction either simultaneously ($n = 4$) or subsequently ($n = 2$). One year postoperatively, the probability of cataract extraction was 0% in patients who were 50 years or younger at the time of DSEK ($n = 20$) and 31% in older patients ($n = 40$). Three years postoperatively, the probability was 7% and 55%, respectively. The difference was statistically significant ($P = .0005$).¹⁴

Researchers reviewed the literature on DSAEK and its association with preoperative IOP elevation. They also explored DSAEK's association with secondary glaucoma and the surgical challenges it presents in patients who have previously undergone glaucoma surgical procedures. The relatively high rate of induced or worsened glaucoma after PKP, they said, led to corneal graft failure and irreversible vision loss from glaucomatous optic neuropathy. DSAEK may lower the risk of serious, vision-threatening, glaucoma-related complications, but pupillary block glaucoma, steroid-induced elevated IOP, and the development of peripheral anterior synechiae have been reported after the procedure. In patients with a history of glaucoma surgery such as trabeculectomy or tube shunt implantation, special attention should be paid to utilizing the proper techniques in order to perform DSAEK safely and effectively. Researchers concluded that the currently limited data suggest that DSAEK offers good visual outcomes and a faster visual recovery than PKP and thus may be a suitable surgical alternative in patients who have corneal endothelial disease and coexistent glaucoma with or without a history of glaucoma surgery.¹⁵

In a retrospective, interventional case series, investigators compared the results of DSAEK on 19 eyes in which an ACIOL was exchanged for a PCIOL (study group) and 188 eyes in which the PCIOL was left in place (comparison group). Graft dislocation, primary graft failure episodes, and pupillary block were recorded for all eyes. BSCVA and mean central endothelial cellular density were measured preoperatively and compared with preoperative measurements. No dislocations occurred in the study group, whereas five eyes experienced dislocation in the comparison group ($P = .47$). There were no recorded primary graft failures or episodes of pupillary block in either group. The preoperative mean BSCVA for eyes without any underlying ocular comorbidities was 20/205 in the study group and

20/100 in the comparison group ($P = .18$). Six months postoperatively, the mean BSCVA had improved to 20/48 in the study group and to 20/34 in the comparison group, a statistically significant difference ($P = .01$). Mean donor cellular loss at 6 months was 33% in the study group and 26% in the comparison group ($P = .18$).¹⁶

Researchers retrospectively reviewed the records of 11 patients with corneal decompensation and ACIOLs who underwent DSAEK. All but one patient had an open-looped ACIOL, and all patients had adequate anterior chamber depths. At the time of surgery, six patients had a temporary suture to secure the graft. One graft had completely dislocated into the anterior chamber on postoperative day 1 and was successfully reattached with an air bubble. By 6 months, all patients had experienced at least a two-line improvement in visual acuity. One primary graft failure without dislocation occurred during the mean 12-month follow-up. Researchers concluded that this study confirms reports that DSAEK without IOL exchange may be a viable alternative to DSAEK with lens exchange in patients with corneal decompensation.¹⁷ ■

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