# Descemet Stripping Automated Endothelial Keratoplasty Performed by Cornea Fellows

*Hassan Hashemi, MD,*† Hossein Asghari, MD,† Kazem Amanzadeh, MD,* Mahmood Jabarvand Behrooz, MD,† Amirhooshang Beheshtnejad, MD,† and Mehrdad Mohammadpour, MD†*

**Purpose:** To evaluate the outcomes of Descemet stripping automated endothelial keratoplasty (DSAEK) in 78 eyes with corneal endothelial dysfunction performed by cornea fellows under the supervision of experienced faculty members in an academic hospital.

**Methods:** In this interventional case series, 78 eyes of 73 patients with corneal endothelial dysfunction of different underlying etiologies were enrolled for DSAEK. Healthy donor corneas with more than 2000 endothelial cells per square millimeter were requested. Intraoperative and postoperative complications were recorded. Best-corrected visual acuity, postoperative refraction, central corneal thickness, and endothelial cell density at 6 months after surgery were also registered and analyzed.

**Results:** Among 78 eyes of 73 patients with corneal endothelial dysfunction, DSAEK was performed on 55 eyes (70.5%) due to pseudophakic bullous keratopathy, which was the most common indication. Other indications included aphakic bullous keratopathy in 6 (7.7%), Fuchs endothelial dystrophy in 7 (8.9%), failed penetrating keratoplasty in 5 (6.4%), failed DSAEK in 3 (3.8%), and congenital hereditary endothelial dystrophy in 2 eyes (2.6%). All operations were performed by 4 cornea fellows supervised by the faculty members. Mean preoperative best-corrected visual acuity was 1.8 LogMAR, which improved to 0.77 LogMAR 6 months after the surgery. At this time, the mean central corneal thickness was 709.09 ± 109.24 μm and mean 6-month postoperative endothelial cell density was 1180 cells per square millimeter representing a mean cell loss of 61%, and mean spherical equivalent was +0.53 ± 1.83 diopter. Lenticule detachment was observed in 17 eyes (21.8%). Graft failure occurred in 8 eyes (10.2%).

**Conclusions:** Outcomes of DSAEK performed by cornea fellows supervised by the faculty members seems to be fairly acceptable.

Received for publication April 12, 2010; revision received August 9, 2011; accepted December 20, 2011.

From the *Noor Ophthalmology Research Center, Noor Eye Hospital, Tehran, Iran; and †Eye Research Center, Farabi Hospital, Department of Ophthalmology, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran.

The authors state that they have no proprietary interest in the products named in this article.

Reprints: Mehrdad Mohammadpour, Eye Research Center, Farabi Hospital, Department of Ophthalmology, School Medicine, Tehran University of Medical Sciences, Tehran, Iran (e-mail: mahammadpour@yahoo.com).



**Key Words:** Descemet stripping automated endothelial keratoplasty, cornea fellows

(*Cornea* 2012;31:974–977)

Corneal endothelial cell dysfunction is one of the leading indications for corneal transplantation. For over 100 years, penetrating keratoplasty (PKP) was the only solution for endothelial dysfunction.[1] Nonetheless, full thickness graft survival was about 72% after 5 years,[2,3] and it also had certain disadvantages including limited visual acuity in the early postoperative period because of high and/or irregular astigmatism, suture-related problems, prolonged visual recovery, and need for numerous follow-up visits.[4,5]

Endothelial keratoplasty has evolved over time and Descemet stripping automated endothelial keratoplasty (DSAEK) is currently the most popular method. In DSAEK, the recipient endothelium and the Descemet membrane (DM) are excised and replaced with the donor tissue consisting of posterior stroma carrying the healthy endothelium.[6–17]

A recent addition to these procedures is the selective transplantation of the endothelium and DM only, or Descemet membrane endothelial keratoplasty, which is thought to provide even better visual outcomes.[18–21]

Herein, we report the outcomes of DSAEK, for the treatment of endothelial dysfunction of various etiologies, performed by senior cornea fellows under the supervision of faculty members in an academic hospital.

## MATERIALS AND METHODS

This interventional case series study was conducted at Farabi Eye Hospital, Tehran University of Medical Sciences, from April 2007 to April 2009. During this period, all patients with endothelial dysfunction and corneal edema, scheduled for DSAEK, were enrolled. Inclusion criteria were the presence of corneal edema due to endothelial dysfunction. Exclusion criteria were severe traumatic or iatrogenic iris damage, peripheral anterior synechiae, or pathological findings in the posterior segment detected by B-mode echography. All enrolled patients signed an informed consent form. The study protocol was approved by the institutional review board and the ethics committee of the Tehran University of Medical Sciences.

Patients underwent surgery under conventional retrobulbar anesthesia or general anesthesia according to their health

status and level of cooperation. All operations were performed by 4 cornea fellows supervised by the faculty members.

Any simultaneous procedure, such as secondary posterior chamber intraocular lens (PC-IOL) implantation, anterior chamber intraocular lens (AC-IOL) explanation, or pupilloplasty, was performed before DSAEK.

For DSAEK, we used donor corneas with an endothelial cell density (ECD) of 2000 cells per square millimeter or more and a minimum scleral margin of 2.0 mm, which we first prepared by placing on an artificial chamber (Moria) and running a weak current of balanced salt solution (BSS). The epithelium was excised from the donor, the geometric corneal center was marked, and a radial line was drawn from the center to the limbus. Then, we created a 350-μm free corneal stromal cap with a microkeratome (Moria LSK; Moria) using the radial mark as our guide. The donor tissue was then transferred from the artificial chamber to a cutting block, endothelial side up, and trephinated using an 8.0- to 8.5-mm punch.

On the recipient's cornea, we first created a trephination mark, the same size as the donor disc and concentric with the limbus, to be used as the reference for stripping the DM. In most cases, the loose and edematous epithelium was removed before marking. A 5.0-mm fornix-based temporal peritomy was made and a 4.0- to 5.0-mm scleral tunnel incision was created 2.0 mm away from the temporal limbus. Two 1.0-mm side ports were made lateral to the main incision.

In stripping the DM, we first injected 0.06% trypan blue in the AC for better visualization, and then peeled the DM circularly along the edge of the mark. The AC was then entered using a 3.2 slit knife through the scleral tunnel, the incision was extended to the same size as the scleral tunnel, and the AC was formed with BSS.

For donor implantation, the posterior lamellar tissue was folded into an asymmetric "taco-shape" (60% anterior and 40% posterior) with the endothelial side inward and inserted it into the AC using long Kelman–McPherson forceps. The scleral tunnel was closed with one infinity (figure 8) 10-0 nylon suture. The AC was filled with BSS, and lenticule unfolding and centration were achieved through gentle corneal massage and repeated injections of BSS through side ports. A large air bubble was then injected into the AC under the donor lenticule through one of the side ports. If necessary, the interface fluid was drained using gentle massage on the cornea or by creating a venting incision. After refilling the AC with air, examination of the optic nerve head perfusion and patency of the central retinal artery was performed by turning the microscope light on and off and asking the patient to respond. A BSS moistened sponge was placed on the cornea and the patients remained in a supine position for 10 minutes, after which, up to 60% of the air bubble inside the AC was replaced with BSS.

The patients remained in a supine position for another hour after surgery. Follow-up visits were scheduled at 1 week, 1 month, and 3 and 6 months after the surgery. On the next day after surgery, 0.1% betamethasone drops (every 3 hours) and 0.5% chloramphenicol drops (every 6 hours) were started. After full epithelial recovery, chloramphenicol eye drops were discontinued. Betamethasone eye drops was prescribed 4 times daily for 2 weeks, tapering to 2 times daily over the next 2 weeks, and then once daily for 1 year. Postoperative examinations included tests for best-corrected visual acuity (BCVA), refraction, and keratometry. At the sixth month, central corneal thickness (CCT) and ECD were also measured with ultrasound pachymetry (Nidek, UF 2500) and specular microscopy (Topcon), respectively. Data analysis was done using SPSS software version 15; paired *t* test was used to compare pre- and postoperative BCVA and ECD values. *P* values less than 0.05 were considered to be statistically significant.

## RESULTS

Seventy-eight eyes of 73 patients (37 men and 36 women) were included in this study; the mean age of the patients was 67.1 ± 14.93 years (range, 17–99 years). All patients had clinically advanced bullous keratopathy.

DSAEK was performed in 55 cases (70.5%) due to pseudophakic bullous keratopathy, including 41 PC-IOL cases (52.6%) and 14 AC-IOL cases (17.9%). Other indications included aphakic bullous keratopathy in 6 (7.7%), Fuchs endothelial dystrophy in 7 (8.9%), failed PKP in 5 (6.4%), failed DSAEK in 3 (3.8%), and congenital hereditary endothelial dystrophy (CHED) in 2 (2.6%) cases.

Surgical procedures performed on the patients of this study included DSAEK in 47 cases (60.3%), DSAEK + anterior vitrectomy + PC-IOL in 12 cases (15.4%), DSAEK + anterior vitrectomy + artisan IOL implantation in 8 cases (10.3%), DSAEK + Phaco + PC-IOL in 6 cases (7.7%), a second DSAEK in 3 cases (3.8%), and DSAEK + anterior vitrectomy in 2 cases (2.6%).

Mean preoperative BCVA was 1.8 LogMAR (range, hand motions to 20/40), which improved to 0.77 LogMAR ($P < 0.001$) by the sixth postoperative month. At this time, mean spherical equivalent was +0.53 ± 1.83 diopter (D) (range, −3.75 to +5.00 D).

Mean preoperative and 6-month postoperative CCT was 849.55 ± 142.66 μm (range, 535–1063 μm) and 709.09 ± 109.24 μm (range, 516–979 μm), respectively. Mean ECD was 3054 (range, 2008–4048) cells per square millimeter in the donor eyes and 1180.28 ± 383.63 (612–2484) cells per square millimeter at the sixth month in the operated eyes. No intraoperative complications were observed in 70 cases. In 8 cases (10.3%), there was only 1 intraoperative complication: interface blood in 3 cases (3.8%; hyphema in 2 cases and blood leakage from the incision in the third case), hyphema in 2 cases (2.6%), iridodialysis in 1 case (1.3%), IOL drop into the vitreous cavity in 1 case (1.3%), and upside down unfolding of donor lenticule in 1 case (1.3%).

Postoperative complications were observed in 35 cases (44.9%). Some patients had more than 1 complication. Lenticule detachment occurred in 17 cases (21.7%); these were managed by rebubbling once in 12 cases (15.3%), twice in 4 cases (5.1%), and thrice in 1 case (1.3%). In the latter 5 (6.4%), the lenticule reattached successfully only in 1 case, and 4 eyes (5.1%) underwent regraft [1 (1.3%) had PKP and 3 (3.9%) had a second DSAEK]. Another complication was intraocular pressure (IOP) more than 22 mm Hg in 9 cases (11.5%) (in 7 cases [8.9%] the high pressure was controlled with 2 cases [2.6%] and in 1 case [1.3%] with 3 antiglaucoma

drugs); however, 1 of the cases (1.3%) had intractable glaucoma, despite all surgical and pharmaceutical treatments. Graft failure was observed in 8 cases (10.2%); 4 cases (5.1%) had early graft failure (before 3 months) and 4 (5.1%) others, including 2 cases with CHED, had late graft failure occurring after 3 months. Most cases of graft failure (6 of 8 eyes) were among the first 10 cases of each surgeon performing Descemet stripping endothelial keratoplasty (DSEK) in his learning period.

Other complications were peripheral anterior synechiae in 7 cases (8.9%), decentered clear lenticule in 3 cases (3.9%), graft rejection in 3 cases (3.9%; these occurred within 6 months and were controlled with frequent topical steroids and subtenon injection), corneal ulcer in 2 cases (2.6%; 1 case of herpetic keratitis and 1 of staphylococcal keratitis, and both were treated medically), very thick lenticules in 2 cases (2.6%), pupillary block in 2 cases (2.6%; this was observed the day after surgery and treated with head positioning, pupil dilatation, and prescription of medication to control the IOP) and retained DM (in interface) in 1 case (1.3%).

## DISCUSSION

PKP performed by fellows has been reported previously. Gross et al[22] found that there was no significant difference between the results achieved by corneal attending surgeons and fellows in terms of induced vector astigmatism, surface asymmetry, or surface irregularity; however, fellows induced more with-the-rule astigmatism early in their training. Hammoudi et al[23] reported no difference in postoperative topographic and refractive astigmatism, surface asymmetry and regularity indices, best spectacle–corrected visual acuity, or the percentage of clear grafts between attending- and fellow-performed cases at a mean follow-up of 38 months.

In this study, we evaluated the outcomes of DSAEK performed by cornea fellows late in their training course under supervision of attending surgeons and compared the results with previous studies, which were performed by faculty members.[5–20] We selected a donor size of 8.0 to 8.50 mm. This was in light of the population-based Tehran Eye Study by one of the authors (H.H.), stating a mean corneal diameter of 11.68 mm in a Tehran population, which seems to be a little less than that seen in western populations.[24]

In terms of visual outcome, mean BCVA at 6 months after surgery was 0.77 LogMAR that showed a significant improvement of 1.1 LogMAR in comparison with its 1.81 LogMAR value before surgery ($P < 0.001$). This is approximately equivalent to 11 lines on the Snellen chart. As 41 eyes had visual limiting pathologies, such as corneal stromal opacity, retinal problems, posterior capsule opacity or interactable glaucoma, a mean BCVA of 0.77 LogMAR can be acceptable. Mean spherical equivalent after 6 months was +0.53 ± 1.83 D; there was a slight hyperopic shift in patients who had secondary IOL implantation (artisan or PC-IOL) or Phaco + PC-IOL + DSAEK. In light of previous reports,[6,24] the IOL power was selected based on an intended refraction of −0.5 D after surgery.

The difference between mean preoperative corneal thickness (849.55 ± 142.66 μm) and its postoperative value (709.09 ± 109.24 μm) was statistically significant ($P = 0.025$). This shows that although the thickness of the donor corneal stroma was added to the recipient, mean corneal thickness after surgery was still less than the average thickness of the cornea before surgery, which is an indication of the efficiency of the graft. Mean ECD of the donor cornea was 3054.91 ± 408.58 cells per square millimeter that significantly decreased to 1180.28 ± 383.63 cells per square millimeter 6 months after surgery ($P < 0.001$). Average endothelial cell loss was 61.3%; this was much higher than that reported by Basak et al[5] (26%) and Price et al[6] (34%) probably because surgeries were performed during the learning curve of cornea fellows, and there was more manipulation. Other possible reasons include combination and variety of patients, no utilization of viscoelastics, and occasional insertion of the lenticules through a rather long scleral tunnel.

In the present study, lenticule detachment necessitating a rebubbling procedure was seen in 17 cases (21.8%). Previous studies reported donor dislocation rates of 10% to 34.7%.[14,15] In our study, there were 4 cases (5.1%) of early graft failure. According to the Eye Bank Association of America (www.restoresight.org) definition, the first 10 cases of each surgeon performing DSEK should not be counted as primary graft failure. Hence, we think these are cases of iatrogenic graft failure, not primary graft failure, because most cases (6 of 8 eyes) of graft failure were among the first 10 cases of each surgeon performing DSEK.

However, the mean rate of graft failure in DSEK reported by Lee et al[13] according to the American Academy of Ophthalmology report was 5% (range, 0%–29%).

We did not perform intraoperative pachymetry in our cases. However, in 2 cases, the lenticule seemed thicker than normal during the donor posterior lamellar preparation. Examinations after surgery showed that the patients' CCTs were 979 and 948 μm, respectively. In these 2 cases, the donor lenticule was prepared without using the artificial chamber, and the microkeratome was directly mounted on the whole globe where the pressure may have been insufficient in comparison with the artificial chamber. Thus, we do not recommend this approach for donor preparation.

Two of our cases had CHED. The cornea failed to gain acceptable transparency in both cases, despite proper lenticule attachment. This possibly happened because of longstanding structural changes in the corneal tissue. DSAEK did not seem to be efficient in CHED cases. However, this hypothesis should be studied with larger sample sizes.

Interface blood appeared in 3 cases during surgery. Its source was the surgical incision (scleral tunnel) in 1 case and hyphema in the other 2 cases. No lenticule attachment problem was observed and the blood was absorbed within 4 weeks. Three cases were phakic (2 patients had CHED and 1 patient Fuchs endothelial dystrophy). None of these patients had iatrogenic cataract after surgery. Of the 7 eyes with Fuchs endothelial dystrophy, 6 had DSAEK + phacoemulsification + PC-IOL implantation and 1 case had DSAEK alone. All the 7 cases had clear corneas at the end of the sixth month. Lenticular detachment happened in only 1 case in which sufficient adhesion was obtained after one time rebubbling. DSAEK + phacoemulsification + PC-IOL implantation seems to be a suitable alternative for triple surgery.

Of the 4 patients who had early graft failure after surgery, 1 had PKP and 3 had a second DSAEK. All had a clear cornea at the end of the sixth month. Hence, DSAEK failure does not seem to be a contraindication for a second DSAEK. Quite similarly, 4 of 5 of our patients with previously failed PKP had clear corneas at the end of sixth month.

To the best of our knowledge, there is only one study that reported outcomes of DSEK by cornea fellows in the United States with similar outcomes between attending and cornea fellows.[25] However, there are no similar reports from Europe or Asia.

In conclusion, DSAEK has fairly acceptable outcomes for the management of corneal endothelial cell dysfunction of diverse etiologies and seems to be a suitable alternative to PKP. It can be performed successfully by cornea fellows in their training period. However, there may be significant intra- and postoperative complications that could be limited or managed by supervision of experienced faculty staff.

## REFERENCES


1. Sugar A, Sugar J. Techniques in penetrating keratoplasty: a quarter century of development. *Cornea*. 2000;19:603–610.
2. Williams KA, Esterman AJ, Bartlett C, et al. How effective is penetrating corneal transplantation? Factors influencing long-term outcome in multivariate analysis. *Transplantation*. 2006;81:896–901.
3. Williams KA, Muehlberg SM, Lewis RF, et al. How successful is corneal transplantation? A report from the Australian Corneal Graft Register. *Eye (Lond)*. 1995;9:219–227.
4. Patel SV. Keratoplasty for endothelial dysfunction. *Ophthalmology*. 2007;114:627–628.
5. Basak SK. Descemet stripping and endothelial keratoplasty in endothelial dysfunctions: three-month results in 75 eyes. *Indian J Ophthalmol*. 2008; 56:291–296.
6. Price FW Jr, Price MO. Descemet's stripping with endothelial keratoplasty in 50 eyes: a refractive neutral corneal transplant. *J Refract Surg*. 2005;21:339–345.
7. Melles GR, Eggink FA, Lander F, et al. A surgical technique for posterior lamellar keratoplasty. *Cornea*. 1998;17:818–826.
8. Terry MA, Ouslay PJ. Endothelial replacement without surface corneal incisions or sutures: topography of the deep lamellar endothelial keratoplasty procedure. *Cornea*. 2001;20:14–18.
9. Melles GR, Lander F, Nieuwendaal C. Sutureless, posterior lamellar keratoplasty: a case report of a modified technique. *Cornea*. 2002;21: 325–327.
10. Terry MA, Ouslay PJ. Small-incision deep lamellar endothelial keratoplasty (DLEK): six-month results in the first prospective clinical study. *Cornea*. 2005;24:59–65.
11. Melles GR, Kamminga N. Techniques for posterior lamellar keratoplasty through a scleral incision [Article in German]. *Ophthalmologe*. 2003; 100:689–695.
12. Melles GR, Wijdh RH, Nieuwendaal CP. A technique to excise the descemet membrane from a recipient cornea (descemetorhexis). *Cornea*. 2004;23:286–288.
13. Lee WB, Jacobs DS, Musch DC, et al. Descemet's stripping endothelial keratoplasty: safety and outcomes: a report by the American Academy of Ophthalmology. *Ophthalmology*. 2009;116:1818–1830.
14. Koenig SB, Covert DJ. Early results of small-incision Descemet's stripping and automated endothelial keratoplasty. *Ophthalmology*. 2007;114: 221–226.
15. Fang JP, Hamill MB. Descemet's stripping endothelial keratoplasty under topical anesthesia. *J Cataract Refract Surg*. 2007;33: 187–188.
16. Terry MA, Hoar KL, Wall 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; 25:926–932.
17. Melles GRJ, Rietveld FJR, Pels E, et al. Transplantation of Descemet's membrane carrying viable endothelium through a small scleral incision. *Invest Ophthalmol Vis Sci*. 1998;39:S76.
18. Melles GR, Lander F, Rietveld FJ. Transplantation of Descemet's membrane carrying viable endothelium through a small scleral incision. *Cornea*. 2002;21:415–418.
19. Melles GR, Ong TS, Ververs B, et al. Descemet's membrane endothelial keratoplasty (DMEK). *Cornea*. 2006;25:987–990.
20. Melles GR. Posterior lamellar keratoplasty: DLEK to DSEK to DMEK. *Cornea*. 2006;25:879–881.
21. Tappin M. A method for true endothelial cell (Tencell) transplantation using a custom-made cannula for the treatment of endothelial cell failure. *Eye (Lond)*. 2007;21:775–779.
22. Gross RH, Poulsen EJ, Davitt S, et al. Comparison of astigmatism after penetrating keratoplasty by experienced cornea surgeons and cornea fellows. *Am J Ophthalmol*. 1997;123:636–643.
23. Hammoudi DS, Segev F, Abdolell M, et al. Outcome of penetrating keratoplasty performed by cornea fellows compared with that of an experienced staff surgeon. *Cornea*. 2005;24:410–416.
24. Hashemi H, KhabazKhoob M, Yazdani K, et al. White-to-white corneal diameter in the Tehran Eye Study. *Cornea*. 2010;29:9–12.
25. Chen ES, Terry MA, Shamie N, et al. Endothelial keratoplasty: vision, endothelial survival, and complications in a comparative case series of fellows vs attending surgeons. *Am J Ophthalmol*. 2009;148:26–31.