Descemet-stripping Automated Endothelial Keratoplasty—A Review

Anita M Hwang, MD[1] and Jimmy K Lee, MD[2]

1. Clinical Instructor of Cornea, External Diseases, and Refractive Surgery at Doheny Eye Institute, University of Southern California Keck School of Medicine;
2. Director of Cornea and Refractive Surgery, and Assistant Professor of Ophthalmology, Yale University School of Medicine

Abstract

Descemet-stripping automated endothelial keratoplasty (DSAEK) has become the procedure of choice to treat corneal endothelial dysfunction. The technique involves replacing the diseased host endothelium with a graft consisting of a thin layer of posterior stroma, Descemet membrane, and endothelium. In comparison to penetrating keratoplasty (PK), DSAEK confers quicker visual and structural recovery with absence of corneal surface incisions or sutures, and limits astigmatism. DSAEK has been proved to successfully achieve favorable visual acuity and graft clarity in bullous keratopathy, posterior polymorphous dystrophy, and failed PK grafts. This article discusses various DSAEK surgical techniques, short- and long-term post-surgical results, complications, and comparisons with other types of keratoplasty. With the advent of Descemet membrane endothelial keratoplasty (DMEK), in which only Descemet membrane is transplanted, visual rehabilitation may be attained sooner.

Keywords

Descemet-stripping automated endothelial keratoplasty (DSAEK), Descemet-stripping endothelial keratoplasty (DSEK), corneal transplant

Disclosure: The authors have no conflicts of interest to declare.
Received: August 31, 2010 **Accepted:** February 24, 2011 **Citation:** *US Ophthalmic Review*, 2011;4(1):80–2 *DOI: 10.17925/USOR.2011.04.01.80*
Correspondence: Jimmy K Lee, MD, Yale Eye Center, 40 Temple Street 3B, New Haven, CT 06510. E: jimmy.k.lee@yale.edu

Descemet-stripping automated endothelial keratoplasty (DSAEK) has become the procedure of choice to treat corneal endothelial dysfunction. Developed by Melles et al.[1] and modified by others,[2] DSAEK evolved from posterior lamellar keratoplasty (PLK) and deep lamellar endothelial keratoplasty (DLEK). The host Descemet membrane is removed and a graft consisting of posterior stroma, Descemet membrane, and endothelial layer is inserted.[3] Initially, the grafts were manually dissected and the procedure was known as Descemet-stripping endothelial keratoplasty (DSEK). Most grafts are now pre-dissected with microkeratomes. DSAEK is preferred over penetrating keratoplasty (PK) in treating corneal decompensation from endothelial disease as it confers quicker visual and structural recovery with absence of corneal surface incisions or sutures, and limits astigmatism.[4] With the advent of Descemet membrane endothelial keratoplasty (DMEK), in which only Descemet membrane is transplanted, visual rehabilitation may be attained earlier.

Indications

DSEK/DSAEK has been described to successfully achieve favorable visual acuity and graft clarity in bullous keratopathy[5] secondary to Fuch's dystrophy, cataract surgery,[6] posterior polymorphous dystrophy, iridocorneal endothelial (ICE) syndrome,[7] and failed PK grafts.[8] Although visual rehabilitation after DSAEK is quicker than with PK, the endothelial cell loss is higher (20–57% at six-month and one-year follow-up).[3,6,8–16] Various studies reported best-corrected visual acuity (BCVA) ≥20/40 (logMAR 0.3) ranging from 28 to 100% at six months[6,10,12,14,15,17] and 66 to 100% at one year.[3,8,11,18] BCVA ≥20/25 (0.1) was also noted to range from 0 to 20% at both six months[6,10,12,14,15,17] and one year.[3,18]

Technique

Donor Dissection

In DSAEK, the graft is dissected with a microkeratome. In a randomized, prospective, double-masked clinical trial, Price et al. found that manually dissected grafts and eye bank pre-cut grafts possessed similar endothelial cell loss, visual and refractive outcomes, and detachment rates.[14] Donor lenticule thickness <350µm measured with slit-lamp optical coherence tomography (SL-OCT) one week after transplantation correlated with >98% success in achieving anatomically attached, clear recipient corneal stroma, and donor lenticule compatible with good vision two months after surgery.[19] Similarly, Terry et al. found that pre-cut tissue was similar to donor tissue cut intra-operatively. At six- and 12-month follow-up, differences in best spectacle-corrected visual acuity (BSCVA), refractive astigmatism, and pachymetry were not statistically significant between the two preparations. Visual improvement was not significantly influenced by donor thickness, death to preservation time, death to surgery time, or eye bank cutting time to surgery time.[15] Furthermore, an eye bank survey of surgeons showed that pre-cut tissue was not associated with increased risk for complications. Rather, success rates have been correlated with surgeon experience, lenticule adherence after injection of an anterior chamber air bubble, lack of venting incisions to release interface fluid, and presence of corneal deturgescence.[20,21]

Grafts stored with anterior lamellar corneal tissue (ALCT)-on corneas had less endothelial damage and edema than those stored without the stroma for 24 hours in Optisol GS. This is thought to be due to the

Bowman layer barrier preventing edema and a loose Descemet membrane that could easily detach from stroma.[22] Central anterior cap thickness of pre-cut grafts were compared and found to be dependent on depth plate, eye bank, and pre-dissection thickness. As with laser *in situ* keratomileusis (LASIK) flap thickness, thicker corneas led to deeper cuts.[23] Thickness and curvature coefficient derived from the graft thickness profile are known to alter refractive shift.[24]

Femtosecond laser is another modality used to cut DSAEK grafts. The laser performed deep posterior stromal ablations to achieve accurate, intended measurements of corneal thickness and diameter of corneal buttons in an *ex vivo* study.[25] Femtosecond-cut grafts are purported to produce minimal change in refractive astigmatism and cause a mild hyperopic shift in refraction.[26,27]

Surgical Technique and Donor Positioning

In DSAEK, the diseased endothelium is replaced with a graft consisting of a thin layer of posterior stroma, Descemet membrane, and endothelium.[28] Atraumatic graft insertion is one of the main challenges. The techniques involve pushing or pulling the graft into the anterior chamber. Initially, graft insertion was performed using McPherson forceps to position a folded donor posterior corneal disk into a taco-like formation over a plastic glide into the recipient anterior chamber.[29] Busin described a technique in which the donor tissue is pulled into the anterior chamber with a microincision forceps through the opposite limbus to reduce trauma to the graft and limit endothelial loss compared with forceps insertion.[9,10] Using a 10-0 monofilament suture on a long straight needle to pull the graft through is another technique that was found to have similar post-operative visual acuity, complications, and endothelial cell counts compared with forceps-assisted DSAEK.[11,12,30] Needle graft insertion techniques are also cost-effective.[28] Intraocular lens cartridges have also been used in *ex vivo* studies, where the graft is 'rolled' into a compact shape to avoid compressive, deleterious forces that occur from folding.[31,32] Modifications of the glide and forceps techniques to reduce endothelial injury during insertion are currently under investigation.[29,33]

Roughening the host peripheral stromal edges has demonstrated better graft adherence.[34] Pre-soaking the grafts in balanced salt solution (BSS) Plus also significantly reduced graft detachment rates in DSEK patients.[35] LASIK rollers have been used to center donor grafts and remove interface fluid.[36] Others have shown that air–fluid exchange can be used to control anterior chamber pressure and effectively tamponade the graft against the host stroma.[37]

Combined Procedures

Combined procedures or 'triple procedures' include concomitant cataract extraction and intraocular lens (IOL) implantation with DSAEK.[38] Intraocular lens calculations can be performed with consideration of the expected hyperopic shifts (1.25–1.50 diopters) that occur with DSAEK. In Fuchs' dystrophy patients, statistical comparison of post-operative visual acuity showed no significant difference between those who underwent DSAEK only and those who had a triple procedure. The DSAEK-only group showed a larger hyperopic shift from the pre-operative spherical equivalent than the triple procedure group. No significant difference in endothelial cell loss between the two groups was noted. Iatrogenic graft failure or primary graft failure was defined as persistent post-operative corneal edema that failed to clear within two months in a well-apposed graft. This was not observed in either of the groups.[39] Case reports of a triple procedure in Fuchs' dystrophy patients involving anterior chamber IOL implantation have been successful in patients with an anterior chamber depth >3mm.[40]

New Surgeons

New surgeons are encouraged to start performing DSAEK on patients who have an intact iris–lens diaphragm in order to prevent donor dislocation.[41] There is a relatively steep learning curve to DSEK/DSAEK; however, a recent study comparing surgical results from attendings and fellows showed that vision, endothelial loss, and complications were not statistically different at six-month follow-up.[17]

Comparisons

Comparisons between DSAEK and other types of keratoplasty have been favorable. In comparing PK and DSAEK, BCVA ≥20/40 (0.3) was 70–80% in DSAEK and 25% in PK patients, and ≥20/25 (0.1) was 6–20% in DSAEK and 0% in PK patients at one-year follow-up.[15,18] Although PK is known to have a longer course of visual rehabilitation, BCVA of DSAEK at one-year follow-up was superior to PK at two- to three-year follow-up (PK patients ≥20/40 [0.3] was 55% and ≥20/25 [0.1] in 20%).[18] However, primary graft failure was more common in DSAEK at one-year follow-up.[13,18] This may be attributed to surgical technique. In a patient survey comparing deep lamellar endothelial keratoplasty (DLEK) and DSAEK, perception of quicker visual recovery was higher with DSAEK even though post-operative visual acuity was not significantly different between the two groups. This may be attributed to fewer higher-order aberrations and limitation of surgery-induced hyperopia in DSAEK.[42] Endothelial cell loss between DSEK and DSAEK demonstrated no statistical significance at six or 12 months.[16]

Case reports of DSAEK in children have shown a more predictable refractive outcome with less astigmatism and quicker recovery crucial for amblyopia therapy, in comparison with PK.[43–45] Structural integrity is also enhanced due to the absence of sutures between the host and graft in DSAEK.

Complications

Graft dislocation is the most common complication in DSAEK, ranging from 1 to 50% in the literature,[3,6,8,10–15,34,46,47] and may be related to proper positioning of the graft with appropriate pressurization to maintain apposition. Terry et al. reported that roughening the peripheral edges of the host stroma decreased the graft dislocation rate to 4%. Post-operative repositioning or re-injecting an air bubble (rebubbling) can achieve graft reattachment in most cases.[46] A slit-lamp technique of draining fluid at the wound interface successfully reattached the donor disc in five cases.[48]

Primary graft failure ranges from 0.5 to 5%,[49] with loss of endothelium as the prominent factor in histopathologic evaluation of grafts.[50,51] As stated above, endothelial cell loss ranged from 20 to 57% in several studies.[3,6,8–16] This may be explained by many factors, including surgical experience, inadvertent epithelial implantation during lenticule preparation, retained Descemet membrane in the graft, epithelial ingrowth, fluid or material accumulation at the wound interface (viscoelastic, neovascularization,

calcification),[52,53] decentered grafts with full-thickness corneal layers at one edge, or chronic stromal changes from chronic corneal edema.[54,55] Cases of epithelial downgrowth have been treated successfully with lenticule exchange, mechanical scraping, and irrigation and aspiration of residual epithelial cells.[56–58]

Other complications include pupillary block, steroid-induced glaucoma, suprachoroidal hemorrhage, infectious donor-to-host transmission of fungal pathogen, cystoid macular edema, and retinal detachment. Air bubble trauma to endothelial cells has also been described in an *ex vivo* study.[59]

Conclusion

Descemet membrane endothelial keratoplasty (DMEK) is under investigation.[60] This procedure involves implantation of isolated Descemet membrane and endothelial cells in the host cornea through a self-sealing 3.5mm clear corneal incision. A study of 50 DMEK procedures by Ham et al. conveyed promising results: >95% had BCVA better than 20/40 (≥0.5); 75% had BCVA better than 20/25 (≥0.8). They also showed faster visual rehabilitation (within one to three months) and less refractive shift.[61] As these procedures are refined with innovative advances in tissue handling, the sole replacement of cultured endothelial cells, with faster visual rehabilitation, may be soon. ■

1. Melles GRJ, et al., Preliminary clinical results of posterior lamellar keratoplasty through a sclerocorneal pocket incision, *Ophthalmology*, 2000;107(10):1850–6.
2. Terry MA, et al., A prospective study of endothelial cell loss during the 2 years after deep lamellar endothelial keratoplasty, *Ophthalmology*, 2007;114(4):631–9.
3. Gorovoy MS, Descemet-stripping automated endothelial keratoplasty, *Cornea*, 2006;25(8):886–9.
4. Price MO, Price FW, Descemet's stripping endothelial keratoplasty, *Curr Opin Ophthalmol*, 2007;18(4):290–4.
5. Basak S, Descemet stripping and endothelial keratoplasty in endothelial dysfunctions: three-month results in 75 eyes, *Indian J Ophthalmol*, 2008;56:291–6.
6. Koenig SB, et al., Visual acuity, refractive error, and endothelial cell density six months after Descemet stripping and automated endothelial keratoplasty (DSAEK), *Cornea*, 2007;26(6):670–4.
7. Bahar I, et al., Descemet's stripping with endothelial keratoplasty in iridocorneal syndrome, *Ophthalmic Surg Lasers Imaging*, 2008;39(1):54–6.
8. Covert DJ, Koenig SB, Descemet stripping and automated endothelial keratoplasty (DSAEK) in eyes with failed penetrating keratoplasty, *Cornea*, 2007;26(6):692–6.
9. Bahar I, et al., Busin guide vs forceps for the insertion of the donor lenticule in Descemet stripping automated endothelial keratoplasty, *Am J Ophthalmol*, 2009;147(2):220–6.e1.
10. Busin M, et al., A modified technique for Descemet membrane stripping automated endothelial keratoplasty to minimize endothelial cell loss, *Arch Ophthalmol*, 2008;126(8):1133–7.
11. Sarnicola V, Toro P, Descemet-stripping automated endothelial keratoplasty by using suture for donor insertion, *Cornea*, 2008;27(7):825–9.
12. Kaiserman I, et al., Suture-assisted vs forceps-assisted insertion of the donor lenticula during Descemet stripping automated endothelial keratoplasty, *Am J Ophthalmol*, 2008;145(6):986–90.
13. Bahar I, et al., Retrospective contralateral study comparing Descemet stripping automated endothelial keratoplasty with penetrating keratoplasty, *Cornea*, 2009;28(5):485–8.
14. Price MO, et al., Randomized, prospective comparison of precut vs surgeon-dissected grafts for Descemet stripping automated endothelial keratoplasty, *Am J Ophthalmol*, 2008;146(1):36–41.
15. Terry MA, et al., Precut tissue for Descemet's stripping automated endothelial keratoplasty: vision, astigmatism, and endothelial survival, *Ophthalmology*, 2009;116(2):248–56.
16. Terry MA, et al., Endothelial cell loss after Descemet's stripping endothelial keratoplasty in a large prospective series, *Ophthalmology*, 2008;115(3):488–96.
17. Chen ES, et al., Endothelial keratoplasty: vision, endothelial survival, and complications in a comparative case series of fellows vs attending surgeons, *Am J Ophthalmol*, 2009;148(1):26–31.e2.
18. Hjortdal J, Ehlers N, Descemet's stripping automated endothelial keratoplasty and penetrating keratoplasty for Fuchs' endothelial dystrophy, *Acta Ophthalmologica*, 2009;87(3):310–4.
19. Shih CY, et al., The use of postoperative slit-lamp optical coherence tomography to predict primary failure in Descemet stripping automated endothelial keratoplasty, *Am J Ophthalmol*, 2009;147(5):796–800.
20. Kitzmann AS, et al., Eye bank survey of surgeons using precut donor tissue for Descemet stripping automated endothelial keratoplasty, *Cornea*, 2008;27(6):634–9.
21. Gorovoy MS, Precut tissue for Descemet stripping automated endothelial keratoplasty, *Cornea*, 2008;27(6):632–3.
22. Ide T, et al., Descemet-stripping automated endothelial keratoplasty: effect of anterior lamellar corneal tissue-on/-off storage condition on Descemet-stripping automated endothelial keratoplasty donor tissue, *Cornea*, 2008;27(7):754–7.
23. Price MO, et al., Central thickness variation in precut DSAEK donor grafts, *J Cataract Refractive Surg*, 2008;34(9):1423–4.
24. Dupps Jr WJ, et al., Multivariate model of refractive shift in Descemet-stripping automated endothelial keratoplasty, *J Cataract Refract Surg*, 2008;34(4):578–84.
25. Mehta JS, et al., Femtosecond laser creation of donor cornea buttons for Descemet-stripping endothelial keratoplasty, *J Cataract Refract Surg*, 2008;34(11):1970–5.
26. Cheng YYY, et al., Preliminary results of femtosecond laser-assisted Descemet stripping endothelial keratoplasty, *Arch Ophthalmol*, 2008;126(10):1351–6.
27. Soong HK, et al., Femtosecond laser-assisted lamellar keratoplasty, *Arquivos Brasileiros de Oftalmologia*, 2008;71:601–6.
28. Balachandran C, et al., Simple technique for graft insertion in Descemet-stripping (automated) endothelial keratoplasty using a 30-gauge needle, *J Cataract Refract Surg*, 2009;35(4):625–8.
29. Mehta JS, et al., Glide insertion technique for donor cornea lenticule during Descemet's stripping automated endothelial keratoplasty, *J Cataract Refract Surg*, 2007;33(11):1846–50.
30. van Cleynenbreugel H, et al., Graft insertion during Descemet-stripping automated endothelial keratoplasty: pulling the graft inward, *J Cataract Refract Surg*, 2008;34(4):534–6.
31. Kuo AN, et al., Novel delivery method to reduce endothelial injury in Descemet stripping automated endothelial keratoplasty, *Am J Ophthalmol*, 2008;145(1):91–6.
32. Macaluso C, Closed-chamber pulling-injection system for donor graft insertion in endothelial keratoplasty, *J Cataract Refract Surg*, 2008;34(3):353–6.
33. Ide T, et al., Descemet-stripping automated endothelial keratoplasty: effect of inserting forceps on DSAEK donor tissue viability by using an *in vitro* delivery model and vital dye assay, *Cornea*, 2007;26(9):1079–81.
34. Terry MA, 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(8):926–32.
35. Lee JK, et al., Presoaking donor corneas reduces graft detachment rates in Descemet stripping endothelial keratoplasty, *Am J Ophthalmol*, 2009;147(3):439–41.
36. Koenig SB, et al., External refinement of the donor lenticule during descemet's stripping and automated endothelial keratoplasty, *Ophthalmic Surg Lasers Imaging*, 2008;39(6):522–3.
37. Meisler DM, et al., Use of an air-fluid exchange system to promote graft adhesion during Descemet's stripping automated endothelial keratoplasty, *J Cataract Refrac Surg*, 2007;33(5):770–2.
38. Covert DJ, Koenig SB, New triple procedure: Descemet's stripping and automated endothelial keratoplasty combined with phacoemulsification and intraocular lens implantation, *Ophthalmology*, 2007;114(7):1272–7.
39. Terry MA, et al., Endothelial keratoplasty for Fuchs' dystrophy with cataract: complications and clinical results with the new triple procedure, *Ophthalmology*, 2009;116(4):631–9.
40. Esquenazi S, Safety of DSAEK in pseudophakic eyes with anterior chamber lenses and Fuchs endothelial dystrophy, *Br J Ophthalmol*, 2009;93(4):558–9.
41. O'Brien PDF, et al., Endothelial keratoplasty: case selection in the learning curve, *Cornea*, 2008;27(10):1114–8.
42. Bahar I, et al., Posterior lamellar keratoplasty—comparison of deep lamellar endothelial keratoplasty and Descemet stripping automated endothelial keratoplasty in the same patients: a patient's perspective, *Br J Ophthalmol*, 2009;93(2):186–90.
43. Jeng BH, et al., Descemet stripping automated endothelial keratoplasty in a 2-year-old child, *J AAPOS*, 2008;12(3):317–8.
44. Colby K, Changing times for pediatric keratoplasty, *J AAPOS*, 2008;12(3):223–4.
45. Fernandez MM, Buckley EG, Afshari NA, Descemet stripping automated endothelial keratoplasty in a child, *J AAPOS*, 2008;12(3):314–6.
46. Suh LH, et al., Complications of Descemet's stripping with automated endothelial keratoplasty: survey of 118 eyes at one institute, *Ophthalmology*, 2008;115(9):1517–24.
47. Terry MA, Precut tissue for Descemet stripping automated endothelial keratoplasty: complications are from technique, not tissue, *Cornea*, 2008;27(6):627–9.
48. Srinivasan S, Rootman DS, Slit-lamp technique of draining interface fluid following Descemet's stripping endothelial keratoplasty, *Br J Ophthalmol*, 2007;91(9):1202–5.
49. Price JFW, 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(3):411–8.
50. Oster SF, et al., A clinicopathologic series of primary graft failure after Descemet's stripping and automated endothelial keratoplasty, *Ophthalmology*, 2009;116(4):609–14.
51. Mehta JSF, et al., Primary graft failure after Descemet-stripping automated endothelial keratoplasty: clinico-pathological study, *Cornea*, 2008;27(6):722–6.
52. Ebrahimi KB, et al., Donor corneal stroma and host–donor interface vascularization after Descemet's membrane stripping with automated endothelial keratoplasty, *Acta Ophthalmologica*, 2010;88(2):e7–8.
53. Ebrahimi KB, et al., Calcareous degeneration of host–donor interface after Descemet membrane stripping with automated endothelial keratoplasty, *Cornea*, 2009;28(3):342–4.
54. Grossniklaus HE, Lessons from the pathology laboratory: hints to improve outcomes, *Ophthalmology*, 2009;116(4):601–2.
55. Suh LH, et al., Histopathologic examination of failed grafts in Descemet's stripping with automated endothelial keratoplasty, *Ophthalmology*, 2009;116(4):603–8.
56. Phillips PM, et al., Epithelial downgrowth after Descemet-stripping automated endothelial keratoplasty, *J Cataract Refract Surg*, 2009;35(1):193–6.
57. Koenig SB, Covert DJ, Epithelial ingrowth after Descemet-stripping automated endothelial keratoplasty, *Cornea*, 2008;27(6):727–9.
58. Walker BM, et al., Epithelial downgrowth following Descemet's-stripping automated endothelial keratoplasty, *Arch Ophthalmol*, 2008;126(2):278–80.
59. Hong A, et al., Air bubble-associated endothelial trauma in Descemet stripping automated endothelial keratoplasty, *Am J Ophthalmol*, 2009;148(1):26-31.e2.
60. Dapena I, et al., Endothelial keratoplasty: DSEK/DSAEK or DMEK—the thinner the better? *Curr Opin Ophthalmol*, 2009;20(4):299–307.
61. Ham L, et al., Descemet membrane endothelial keratoplasty (DMEK) for Fuchs endothelial dystrophy: review of the first 50 consecutive cases, *Eye (Lond)*, 2009;23(10):1990–8.