Symposium

Descemet stripping automated endothelial keratoplasty

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Endothelial keratoplasty is at present the gold standard for surgical treatment of corneal endothelial pathologies not associated with significant corneal scar. Tremendous progress has been made in recent years in improving the technology of endothelial keratoplasty techniques, such as descemet stripping automated endothelial keratoplasty (DSAEK) and descemet membrane endothelial keratoplasty. In this review, we discuss the current techniques and outcomes of DSAEK.

Key words: Bullous keratopathy, corneal edema, corneal endothelial dystrophy, descemet stripping automated endothelial keratoplasty, endothelial keratoplasty

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Endothelial keratoplasty has evolved significantly in the past few decades. It has now become the surgery of choice for endothelial failure without stromal scarring. At its inception, endothelial keratoplasty was performed from the anterior route, and now, the approach is gradually shifted toward the posterior route. The first case of posterior lamellar keratoplasty (PLK) was performed by Tillett in 1956 using manual lamellar dissection of posterior recipient stroma and attachment of donor lenticule with sutures and air tamponade.[1] Melles *et al*. were first to describe endothelial keratoplasty through the posterior approach, and this technique was known as PLK.[2] A 9 mm scleral tunnel was made to dissect posterior stroma, descemet membrane (DM), and endothelium and same-sized posterior donor lenticule were implanted with air tamponade without suture fixation.[3] PLK was introduced in the United States by Terry and Ousley, who called it as deep lamellar endothelial keratoplasty (DLEK).[4] Later, Melles *et al*. described technique, in which the dissection of diseased DM (descemetorrhexis) was done without dissecting posterior stroma and transplanting donor's DM through 5 mm incision.[5,6] However, maintaining apposition of graft in anterior chamber (AC) was difficult with rolling of the graft. In 2005, Price and Price. performed refined technique wherein the recipient's DM was dissected using Melles' technique and donor tissue was manually dissected similar to PLK/DLEK technique and donor posterior lenticule with DM was folded 60/40 over fold and transplanted through 5-mm incision. The posterior graft was apposed using air tamponade without sutures.[7] This technique was known as descemet stripping endothelial keratoplasty (DSEK). As the technique involved manual dissection, obtaining uniformly thick and smooth surface of donor posterior stroma was surgically challenging. This issue was solved by Gorovoy, who modified DSEK technique using automated microkeratome to dissect donor lenticule, and this technique was popularized as descemet stripping automated endothelial keratoplasty (DSAEK).[8] As per Eye Bank Association of America, DSAEK is the most frequently utilized keratoplasty procedure in the United States.[9] This article reviews the current indications, surgical techniques, and outcomes of DSAEK with an aim to provide up-to-date information to the experienced as well as beginners of endothelial keratoplasty (EK).

Indications

Patients with endothelial dysfunction causing visual loss or visual disability in the form of glare and fluctuating vision affecting day-to-day activities such as reading, writing, or driving are suitable candidates for EK. The only absolute contraindication is significant corneal scarring and high irregular astigmatism. The diseases where DSAEK is indicated are summarized in Table 1.[7-12]

Surgical Technique

The surgery involves three principal steps, which includes donor preparation, recipient preparation, and donor lenticule

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Table 1: Indications of descemet stripping automated endothelial keratoplasty

Groups	Examples
Endothelial dystrophies	FED PPCD CHED ICE
Postcataract surgery	PBK ABK
Endothelial decompensation following other intraocular surgeries	Vitreo-retinal surgery Postglaucoma surgery
Posttraumatic endothelial decompensation	
Failed keratoplasty	Failed PKP Failed DSAEK
Postinfective keratitis	Postrecurrent herpetic endothelitis
Others	Aniridia, buphthalmos

FED: Fuchs endothelial dystrophy, PPCD: Posterior polymorphous corneal dystrophy, CHED: Congenital hereditary endothelial dystrophy, ICE: Iridocorneal endothelial syndrome, DSAEK: Descemet stripping automated endothelial keratoplasty, PKP: Penetrating keratoplasty, PBK: Pseudophakic bullous keratopathy, ABK: Aphakic bullous keratopathy

insertion.[10] Various techniques have been described in literature for these three major steps.

Donor preparation

The aim of the surgeon in donor preparation is to achieve the thinnest lenticule possible. All the methods described for donor cut employ the use of an artificial AC which the corneoscleral rim is mounted. The central corneal thickness (with the epithelium on) of the donor tissue is measured using an ultrasonic pachymeter.[13] The donor tissue can be prepared in the following manner.

Manual method

Preset depth calibrated blades are used to make a vertical lamellar incision in the cornea at the desired depth. The dissection is then carried out at this depth to create an interface between the anterior and posterior layers of the cornea. This technique avoids the use of expensive equipment. However, uniformity of the dissection is difficult to reproduce, often leading to an irregular stromal bed and a reduced final visual acuity.

Automated microkeratomes

Donor lenticule is prepared using a microkeratome with the cutting head of 350 or 400 μm. Different types of microkeratomes are available in the market. The microkeratome head is either passed straight or in a rotational manner over the mounted cornea. The Moria Surgical (Antony, France) offers two types of blade attachments; one has a rotational and the other has a translational effect. Gebauer SLc Original and SLc Expert Microkeratomes offer to provide ultrathin lenticules (<100 μm) with a single-pass or double-pass technique.

Single-pass technique

Vajpayee *et al*. using a 400 μm microkeratome head slowed the speed of the pass to achieve a thinner donor lenticule without any complications during the donor preparation.[13] A single, slow pass of 400 μm microkeratome yielded thin donor lenticules in all the cases, and the mean graft thickness achieved at the end of 6 months was 111 ± 17.62 μm (range 70–134 μm). Excellent visual outcomes were obtained in the majority of the patients.

Nahum *et al*. have described a nomogram for choosing the appropriate microkeratome head size in single pass microkeratome-assisted dissection of donor tissue.[14] The authors reported mean postoperative donor graft central thickness of 63 ± 29 μm in 42 eyes using this nomogram. Thus, creation of ultra-thin DSAEK lenticules has been made possible with a single microkeratome pass.

Double-pass technique

In this technique, an initial debulking cut is performed using a microkeratome with a 300-μm head. A second cut (refinement cut) is carried out from the direction opposite to the one of the first cut.[15] The size of the head used for this step is selected such that a residual bed with a central thickness of approximately 100 μm is left. Intraoperative pachymetry or anterior segment optical coherence tomography helps in deciding the residual stromal thickness during the procedure.

The double-pass technique, in experienced hands and when successful, results in excellent outcome.[15] However, it has some issues such as the potential higher risk of donor tissue perforation (microkeratome is passed twice), difficult manipulation of a thinner graft which may lead to increased endothelial loss, prolonged time for second cut, chances of second pass creating a smaller diameter cut, and unpredictability when donor thickness exceeds 600 μm.[13,15,16]

Precut tissue

Tissue preparation is done either in advance by the operating surgeon or by an eye bank technician before surgery.[17,18] This precut tissue is then shipped to surgeons when needed. This has the advantage of reducing the cost as well as the time of surgery. Moreover, in countries like India where every corneal surgeon does not have the microkeratome, it will be extremely useful.

Femtosecond laser-assisted endothelial keratoplasty

Femtosecond laser-assisted EK is another addition to the existing techniques of EK donor lenticule preparation. In this technique, the donor cornea undergoes a lamellar cut from the epithelial side with the femtosecond laser at the desired depth. This may be followed by excimer laser photoablation of the stromal tissue to achieve a smooth surface. While femtosecond laser dissection yields a thin and reproducible endothelial graft cut with a high level of safety and accuracy, excimer photoablation provides a smooth, high-quality interface.[19,20]

Few studies have shown disappointing results when the grafts have been cut from the epithelial side using femtosecond laser.[21,22] This has been attributed to the attenuation of the laser beam in a swollen donor cornea and an uneven surface when applanated from the epithelial side. These can be alleviated by mounting the graft endothelial side up on the artificial AC (ZeimerPort, Switzerland) followed by creation of the lenticule with femtosecond laser cut by applanating the surface from the endothelial side.[23] One of the major concerns with this technique is the endothelial cell loss attributed to direct applanation of the endothelial side. This can be minimized

by the use of visco dispersive agent (Viscoat) as the interface fluid.[24]

Recipient preparation

The donor can be inserted either through a scleral tunnel or clear corneal incision.

Scleral tunnel

A limited fornix-based peritomy is fashioned in the superotemporal or superonasal quadrant. A "reverse smile" scleral tunnel of 3.5 mm length partial scleral thickness incision is created such that it is 1.5 mm from the limbus centrally and 3.0 mm from the limbus at the edges and extends 1.0 mm into the clear cornea.

Clear corneal incision

A clear corneal incision of 4 mm in width is fashioned either nasally or temporally by first making a corneal tunnel with the help of crescent blade followed by AC entry with keratome.

Donor insertion

Numerous techniques have been described for the insertion of donor lenticule within the eye. They can either be categorized into "push-in" or "pull-through" techniques.

"Pull-through" techniques

In pull-through techniques, the donor is docked into the main incision and pulled within the eye from the opposite small clear corneal incision with the help of forceps/suture. One of the most commonly performed pull-through techniques is the use of Busin glide (Asico, Westmont, IL, USA). The glide with the donor tissue is docked into the scleral tunnel/clear corneal incision. The donor lenticule is pulled into the AC by grasping the edge of the donor lenticule with a bent disposable 23-gauge vitreous forceps from the opposite side port. After the donor lenticule gets unfolded, AC is filled with air.

The other pull-through technique used often is the "suture pull-through" technique, in which a prolene suture is passed through the graft before inserting it and pulling it within the eye. The suture is then hitched on to the recipient cornea.

Push-in techniques

In push in techniques, the donor is pushed in through the main incision with forceps/glides and injectors. The various donor insertion techniques include forceps: Taco with 60/40 over fold, trifold, 40/60 under fold, glides: Busin glide, Sheets glide, Tan EndoGlide and inserters: Endoserter (Winston-Salem, NC, USA), Endoshield/Endoinjector (Keramed, San Jose, CA, USA), Neusidl Corneal Inserter (Fischer Surgical, Arnold, MO, USA).[10,25-28] In general, these glides allow better maintenance of AC during the procedure, better unfolding, and being bimanual allow the surgeon for better hold during the procedure.[28-32] Endoserter requires 4–5.5 mm incision size and no AC maintainer is needed. Reported endothelial loss at 6 months is 13%–33%.[33] Endoglide is based on pull-in and pull-out technique. It requires 4–5.0 mm incision size and an AC maintainer. Reported endothelial loss at 6 months with Endoglide is 13%–26%.[34] In a randomized study comparing these two insertion devices, in 20 cases of fuchs endothelial corneal dystrophy and PBK, no difference was seen in the endothelial loss at 12 months. The mean endothelial cell loss, including that in the rebubbled eyes, was 41.2% and 31.4% at 12 months in the Tan EndoGlide and EndoSerter groups, respectively.[35]

Outcomes of Descemet Stripping Automated Endothelial Keratoplasty

The outcomes and complications of DSAEK reported from various studies are summarized in the Table 2.[35-72] Figs. 1 and 2 show the postoperative outcomes after DSAEK and ultrathin DSAEK, respectively. Fig. 3 shows intraoperative optical coherence tomography showing complete attachment of the donor lenticule.

Graft survival

Graft clarity

The reported long-term graft clarity of DSAEK reported in studies, including a large number of cases with follow-up ranging from 6 months to 3 years ranges from 90% to 99%.[10,38,49,69]

Primary graft failure

Primary graft failure (PGF) is characterize by the clinical situation, in which a corneal graft does not clear as expected after surgery usually by 2 months. It can result mostly from poor quality donor tissue, unhealthy recipient circumstances (blood, interface foreign bodies, infection, and flat chamber), or poor surgical technique.[10] The published studies showed rates from 0% to 29%, with an average PGF rate of 1%.[10,42,73]

Late graft failure

Late endothelial failure is due to progressive endothelial cell loss. Analysis of the available studies suggests endothelial cell loss in the range of 25%–61% at 3-year follow-up.[10,35,44,72,73] At 5 years follow-up, it has been reported to be around 51.9%.[52]

Functional outcomes

Visual acuity

The greatest advantage of DSAEK over penetrating keratoplasty (PKP) is early and predictable visual recovery. The procedure is usually sutureless and the anterior corneal surface is not affected. Both these factors allow for rapid and better uncorrected as well as best-corrected visual acuity (BCVA).

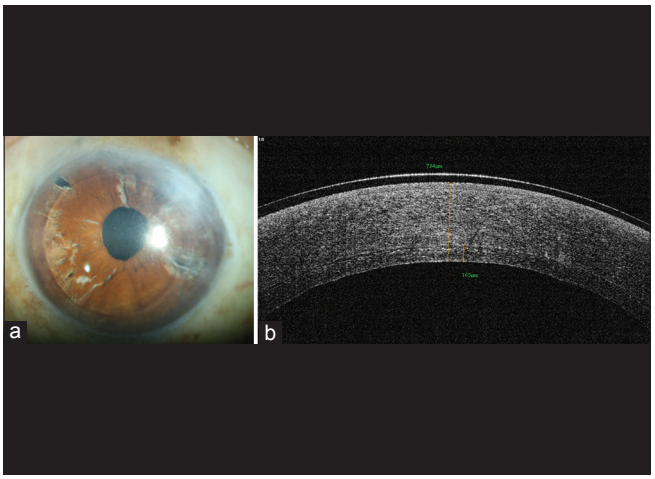

Figure 1: (a) Postoperative photograph of a patient 1 month after descemet stripping automated endothelial keratoplasty with a clear graft. (b) The anterior segment optical coherence tomography shows a postoperative graft thickness of 165 μm at 1 month

Table 2: Outcomes and complications of descemet stripping automated endothelial keratoplasty

Author	Technique	Number of eyes	Follow-up	Indication	Final BCVA	Graft rejection (number of eyes/%)	Graft failure (number of eyes/%)	Endothelial cell loss	Graft dislocation (number of eyes/%)	Complication
Vajpayee *et al.*[12]	Thin lenticule DSAEK	15	6 months	PBK, FED, CHED, failed graft	0.109±0.11 logMAR	1	Nil	26.33±1.34%	Nil	Interface fluid=1
Pedersen *et al.*[36]	DSAEK	78	4 years	PBK, trauma, uveitis, other causes*	-	4	7	-	-	-
Nakatani *et al.*[37]	DSAEK	22	3 years	ALI-BK	0.15 logMAR	9.1	1 eye	46.5%	Nil	Posterior synechiae=31.8%
Ang *et al.*[30]	DSAEK Group 1 (endoglide) Group 2 (sheets glide)	Group 1=100 Group 2=119	3 years	PBK FED	-	-	Group 1=2.1 Group 2=13.5	Group 1=29.7%±20.9% Group 2=38.5±24%	-	-
Nakagawa *et al.*[38]	DSAEK with precut tissue	134	3 years	ALI-BK, FED, glaucoma surgery, PBK, ABK, graft failure	0.22±0.19 logMAR	2.2	PGF=0.7 Late failure=3.7	51%	8.9	Pupillary block=2.2% infection=0.7%
Titiyal *et al.*[39]	DSAEK with internal air tamponade	27	6 months	-	6/18–6/9		Nil	18.19%	Nil	-
Sacthre *et al.*[40]	DSAEK	40	6 months	-	-	-	-	29.65%	7.5	-
Beltz *et al.*[41]	DSAEK	12	4 years	Buphthalmos	0.74±0.66 logMAR	-	Late=1	40.5±8.9%	2 cases	Glaucoma progression=1
Price *et al.*[42]	DSAEK	173	3 years	FED PBK	-	9	Graft survival in FED 96, 86 in non-FED cases	46% in FED, 59% in nonfuchs cases	-	Unsatisfactory visual outcome in 1.7%
Khor *et al.*[43]	DSAEK	100	1 years	FED, PBK	20/40	2.6	PGF=1 eye Late failure=1 eye	14.9%	2 eyes	Glaucoma/ocular hypertension=34.1%
Terry *et al.*[35]	DSAEK Group 1 - forceps Group 2 - neusidl inserter	100	-	FED	-	-	Late failure=1	In Group 1=25% in Group 2=33%	2 in Group 2	-

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Table 2: Contd...

Author	Technique	Number of eyes	Follow-up	Indication	Final BCVA	Graft rejection (number of eyes/%)	Graft failure (number of eyes/%)	Endothelial cell loss	Graft dislocation (number of eyes/%)	Complication
Foster *et al.*[44]	DSAEK	175 (105 small incision forceps, 70 with injector)	6 months	BK FED	≥20/4; 74% injector, 72% forceps	-	1.4 - injector 6.5 - forceps	28.3% - injector 44.1% forceps	5.7 - injector 27.6 - forceps	-
Wu *et al.*[45]	DSAEK	353	3 years	PBK, FED, intraocular surgery, ABK	-	22	Late failure 8 cases	-	-	-
Jangi *et al.*[46]	DSAEK	30	3 months	Failed PK	Increased BCVA in 19	1 eye	PGF=1 Late failure=4	-	16.7	Graft detachment=5
Li *et al.*[47]	DSAEK	108	3 years	PBK FED	20/25	-	-	-	-	-
Phillips *et al.*[48]	DSAEK	100	6 months	FED, PBK, failed PK, trauma, ICE	20/29	1	Nil	16%	2	CME=2% PAS=1%, glaucoma 24%
Wendel *et al.*[49]	DSAEK Group 1 - forceps, Group 2 - injector	179 N1=143 N2=36	1 year	Phakic and pseudophakic corneal edema	Group 1=0.171±0.015 Group 2=0.253±0.039	-	Group 1; PGF=3.5, late failure=1.4 Group 1; PGF=2.8	Group 1=42.5±23% Group 2=51.4±26%	Group 1=19.6 Group 2=27.8	-
Tsui *et al.*[50]	DSAEK	10	1 years	FED	20/24	-	1 eye	-	-	Cataract=40% Pupillary block=3 eyes
Clements *et al.*[51]	DSAEK	97	6 months	Failed PK	0.55 logMAR	-	PGF=2	-	Dislocation=31	-
Khor *et al.*[34]	DSAEK	25	1 years	PBK, FED, PPCD, ALI-PBK	12 eyes ≥20/40	-	Nil	15.6%	Nil	PED - 1eye, glaucoma=2 cases
Ratanasit *et al.*[52]	DSAEK	51	5 years	PBK, ABK FED, failed PKP	20/20-20/40 in 75% eyes	1 eye	PGF-1 Late failure-3	51.4%	-	Epithelial down growth=3 case
Busin *et al.*[53]	DSAEK	15	15.9 months	CHED	8 eyes ≥20/40	-	-	30%	4	-
Chen *et al.*[54]	DSAEK	305	1 years	Endothelial dysfunction	-	-	-	27%	-	-
Esquenazis *et al.*[55]	DSAEK	25	2 years	ACIOL	-	Nil	-	28±13%	1	-
Allen *et al.*[56]	DSAEK	68	11.3±7.8 months	-	-	-	-	-	-	Increased IOP in=54%

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Table 2: Contd...

Author	Technique	Number of eyes	Follow-up	Indication	Final BCVA	Graft rejection (number of eyes/%)	Graft failure (number of eyes/%)	Endothelial cell loss	Graft dislocation (number of eyes/%)	Complication
Koeing *et al.*[57]	DSAEK in phakic eyes	6	9.1 months	FED, amantadine toxicity	20/28	Nil	Graft failure=2 (amantadine-induced)	-	-	-
Phillips *et al.*[58]	DSAEK with previous glaucoma filtering surgeries	28	-	Endothelial dysfunction	-	-	PGF=0	-	3.6	Decentered graft=3.6%
Price *et al.*[59]	DSAEK (5 and 3.2 mm incision)	167 Group 1=64 (5 mm) Group 2=103 (3.2 mm)	1 years	FED PBK	-	Group 1=8 Group 2=4	Group 1=98 Group 2=97	Group 1=31±19% Group 2=44±22%	Group 1=3 Group 2=8	Raised IOP Group 1=20%, Group 2=14%
Price *et al.*[60]	DSAEK	173	1 years	PBK FED	-	5	PGF=0, regraft rate 2.3	38±22%	5.8	-
Shih *et al.*[61]	DSAEK	126	2 years	Endothelial dysfunction	-	2	12	-	22.4	Choroidal effusion=2, epithelial growth=2, endophthalmitis=1, papillary block=1
Terry *et al.*[62]	DSAEK	DSAEK=315, DSAEK triple=149	1 years	FED	20/32	-	PGF=0	32±15%	DSAEK=4 DSAEK triple=1.8	Pupillary glaucoma=1
Chen *et al.*[68]	DSAEK (donor cornea with scar)	42	6 months	FED PBK Other	20/33	5.2	PGF=0	32%	2.4	No pupillary block
Chen *et al.*[64]	DSAEK Group 1 - attending surgeons Group 2 - fellows	327 Group 1=235 Group 2=92	6 months	FED PBK Other	Group 1=20/37 Group 2=20/36	-	- PGF=0	Group 1=32% Group 2=35%	In Group 1=2 In Group 2=1	No pupillary block
Terry *et al.*[65]	DSAEK	350	1 year	PBK, FED, other	-	-	PGF=0	36%	Dislocation=2.6	-
Mehta *et al.*[29]	DSAEK	10	7.5 months	PBK, FED	0.38 logMAR	-	Nil	25.3%	Nil	-

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Table 2: Contd...

Author	Technique	Number of eyes	Follow-up	Indication	Final BCVA	Graft rejection (number of eyes/%)	Graft failure (number of eyes/%)	Endothelial cell loss	Graft dislocation (number of eyes/%)	Complication
Busin *et al*.[66]	DSAEK with glide technique	10	2 years	-	-	-	-	26.4±2.7%	-	-
Sarnicola *et al*.[67]	DSAEK with suture	16	1 year	PBK, FED	≥20/40 in 38%	-	-	30%	6.25	-
Chen *et al*.[68]	DSAEK (Group 1=60/40 over fold, Group 2=40/60 under fold	148 (Group 1=112, Group 2=36)	6 months	-	20/38 in 97%	-	-	Group 1=36%, Group 2=26%	-	-
Kaiserman *et al*.[69]	DSAEK (suture or forceps)	28 (8=suture, 20=forceps)	6 months	PBK, FED, other	Suture=0.30±0.14, forceps=0.25±0.16 logMAR	Suture=nil, forceps=5	PGF; suture=12.5, forceps=0 Late failure; nil	Suture=39.4±21%, forceps=37.8±16.5%	Suture=12.5, forceps=10	Interface opacity; suture=12.5%, forceps=10% Glaucoma=15%, CME=5%
Suh *et al*.[70]	DSAEK	118	-	FED, PBK, ABK, DSAEK failure	-	6	Graft failure=17 PGF=6 eyes	-	23	RD=4% CME=5% Pupillary block=2% SCH=1% Epithelial ingrowth=1%
Van Cleynenbreugel *et al*.[71]	DSAEK	12	6 months	-	20/42	-	-	Mean count - 1614 cells/mm2	0	-
Hashemi *et al*.[72]	DSAEK	78	6 months	PBK, ABK, FED, failed PKP/DSAEK, CHED	0.77 logMAR	3.9	Graft failure=10.2	61%	21.8	Raised IOP=11.5%, keratitis=2.6%

*Other causes; ABK, ICE, and prior failed PK grafts. DSAEK: Descemet stripping automated endothelial keratoplasty, BCVA: Best-corrected visual acuity, FED: Fuchs endothelial dystrophy, PBK: Pseudophakic bullous keratopathy, ABK: Aphakic bullous keratopathy, CHED: Congenital hereditary endothelial dystrophy, ALI: Argon laser trabeculoplasty induced, logMAR: Logarithm of the minimum angle of resolution, PKP: Penetrating keratoplasty, BK: Bullous keratopathy, PGF: Primary graft failure, ICE: Iridocorneal endothelial syndrome, PAS: Peripheral anterior synechiae, PPCD: Posterior polymorphous corneal dystrophy, IOP: Intraocular pressure, ACIOL: Anterior chamber intraocular lenses, PK: Penetrating Keratoplasty, RD: Retinal Detachment, SCH: Subconjunctival Hemorrhage, CME: Cystoid Macular Edema, PED: Persistent Epithelial Defect

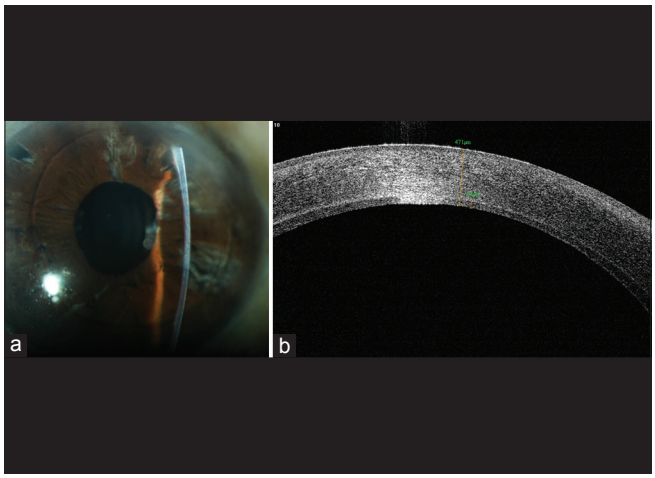

Figure 2: (a) Postoperative photograph of a patient 1-month after ultrathin descemet stripping automated endothelial keratoplasty (double-pass technique) with a clear graft. (b) The anterior segment optical coherence tomography shows a postoperative graft thickness of 57 μm at 1 month

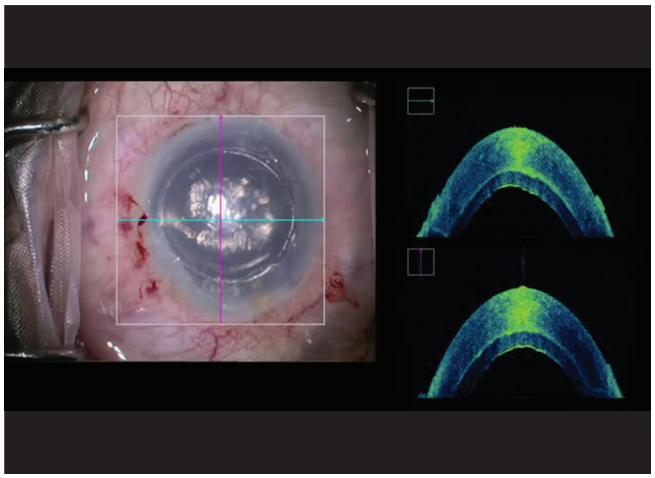

Figure 3: Intraoperative optical coherence tomography showing complete attachment of the donor lenticule

Mean BCVA of 20/40 or better is achieved in more than 70% of cases.[51-54,73-75]

Hyperopia

The hyperopia induced ranges from 0.7 to 1.5 D with an average induced hyperopia of 1 D.[10,37,76] The induced hyperopia is primarily due to nonuniform thickness profiles of donor lenticules.[10,50] Donor lenticules prepared with the microkeratome are thinner centrally and thicker in the periphery, resulting in a reduced radius of curvature of the posterior corneal surface and reduced effective corneal power.[73,76] The hyperopic shift from DSAEK must be considered while calculating intraocular lens (IOLs) power in cases undergoing triple procedure. Target refraction should be aimed at 0.5–1.0 D of myopia in these cases.

Astigmatism

The average postoperative astigmatism after DSAEK is 1.5 D.[10,52,73] The amount of astigmatism often depends on the type of incision.

Higher order aberration

DSAEK does not change the anterior corneal curvature but the posterior corneal curvature is altered due to differences in curvatures between the host and the donor lenticule as well as an uneven thickness of donor lenticule. These changes can induce posterior corneal higher order aberrations after DSAEK.[77,78]

Complications

The complications of DSAEK can be categorized into intraoperative and postoperative complications and are summarized as follows:

Graft detachment and dislocation

Early postoperative graft detachment/dislocation remains one of the most common complications of DSAEK surgery. It manifests as interface fluid, significant graft displacement, or a graft that is completely dislocated into the AC. The reported average dislocation rate is around 14.5% [Table 1].[10,73]

Graft rejection

The incidence of graft rejection following DSAEK is relatively less compared to PKP. The reported rates range from 0% to 45.5% with an average rate of 10% with follow-up ranging from 3 months to 2 years.[10,36,37,73] The factors accounting for this low incidence are limited exposure of donor cells to host immune surveillance, absence of graft sutures, a lesser donor derived antigen presenting cells, and less disruption to the blood-aqueous barrier compared to PKP.[79,80]

Symptoms are relatively less serious such as small drop in vision or mild photophobia or at times patient may be completely asymptomatic.[80,81] The signs also differ and include scattered keratic precipitates unlike an endothelial rejection line, a localized corneal edema, or simple conjunctival hyperemia.[81]

Endothelial cell loss

Endothelial cell loss is still a major concern in DSAEK. Surgical trauma related to graft insertion appears to be the primary cause for this loss. The endothelial loss reported from larger series (involving ≥100 eyes) ranges from 14.9% to 59% with follow-up ranging from 6 months to 3 years [Table 1].[10,35,45]

Raised intraocular pressure and glaucoma

Glaucoma following DSAEK can occur due to pupillary block, inflammation, or steroid use.[10,73,82] The reported incidence of glaucoma after DSAEK ranges from 0% to 15%, with an average rate of 3.0%.[10,73] Pupillary block is a rare but serious immediate postoperative complication after DSAEK, with a reported incidence of 0%–10%.[39,43,57]

Epithelial ingrowth

Epithelial ingrowth is a rare complication of DSAEK.[83] The source of these epithelial cells can be host epithelial cells transported during donor insertion, donor epithelial cells transferred after eccentric trephination that has included full-thickness tissue beyond the microkeratome dissection and epithelial ingrowth related to the use of mid-peripheral full-thickness venting incisions.[10,83-86]

Infectious keratitis

Bacterial, fungal and herpetic, all form of keratitis have been reported following DSAEK.[87,88] The most commonly isolated

causative organism is *Candida albicans*.[10] Source of infection is often the donor tissue and rarely from late inoculation from conjunctiva and adnexa microflora. The infiltrate at the onset is often small and involves the donor lenticule or the interface. In addition, the effectiveness of topical antifungal agents may be reduced by posterior lamellar location of infiltrate. All these factors result in a poor prognosis of such cases. Majority of cases may require the removal of the lenticule with a therapeutic PKP.[87-89]

Interface haze

Interface abnormalities can occur in any form of lamellar keratoplasty, including DSAEK. The source of interface haze may include blood, retained ophthalmic viscoelastic, inflammatory cells, debris, and irregular cut of the donor tissue by the microkeratome, retained fragments of DM, microkeratome-generated plastic particles, and epithelial cells.[10,90,91] Most such cases cause minimal effect on BCVA or resolve with time, repeat DSAEK is required for the treatment of refractory cases.[91]

Other less-common complications

Other less frequent complications of DSAEK include endophthalmitis[92] and folds in donor tissue.[92,93]

Descemet Stripping Automated Endothelial Keratoplasty in Special Situations

Descemet stripping automated endothelial keratoplasty in the presence of anterior chamber intraocular lens

The primary concerns of performing DSAEK in the presence of an anterior chamber intraocular lens (ACIOL) are increased tissue manipulation, reduced AC depth (ACD), difficulty in graft manipulation, more difficult air-bubble management, and intermittent postoperative IOL touch.[56] In the presence of a well-centered ACIOL and an ACD >3 mm, DSAEK can be performed successfully in such cases.[56]

Descemet stripping automated endothelial keratoplasty in aphakia

The difficulties in performing DSAEK in aphakic eyes are difficulty of air retention in the AC, migration of air posteriorly, chances of graft dislocation into vitreous cavity, and chances of host DM dislocation posteriorly. The various modifications that can be employed to overcome these difficulties are simultaneous DSAEK and IOLs implantation,[94] insertion of an infusion cannula through pars plana route,[95] or placement of temporary anchor sutures to prevent donor dislodgement and improve graft adherence.[96]

Descemet stripping automated endothelial keratoplasty in aniridia

Congenital aniridia or aniridia associated with trauma along with aphakia poses a risk of posterior migration of air into vitreous cavity. This problem can be overcome by performing an aniridia IOLs implantation followed by DSAEK in stepwise manner or placing an anchor suture in the peripheral edge of the donor tissue and securing it to the overlying recipient cornea.[93]

Descemet stripping automated endothelial keratoplasty with previous trabeculectomy or tube shunt implantation

The problems encountered in such cases includes loss of the remaining field of vision due to the transient intraocular pressure (IOP) rise, difficulty in surgery due to presence of tube of the glaucoma valve, tube position contributing to corneal decompensation, and possibility of air escaping through the sclerostomy or tube or large iridotomy.[10,97] The various technical modifications that can be helpful in such cases include trimming of the tube if it extends centrally,[97] placement viscoelastic between the graft and the iris to block the escape of air from the AC,[98] suture closure of the iridotomy opening and meticulous monitoring of IOP.[10]

With the recent advancements in the techniques of EK, the surgery has become faster and safer with better visual outcomes. Further, an early rehabilitation of patients with DSAEK has made it the procedure of choice over full-thickness PKP to be used in patients with endothelial dysfunction. The creation of ultra-thin lenticules has further led to a reduction in the interface haze with improved visual outcomes and results close to those of DM endothelial keratoplasty. With the added advantages of DSAEK such as a lower rate of graft rejection, preservation of ocular surface, absence of suture-related problems, and the broader spectrum of ocular disorders where it can be safely used, DSAEK will surpass PKP as the first-line surgical treatment modality for cases with endothelial disorders.

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Conflicts of interest

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References

1. Tillett CW. Posterior lamellar keratoplasty. Am J Ophthalmol 1956;41:530-3.
2. Melles GR, Eggink FA, Lander F, Pels E, Rietveld FJ, Beekhuis WH, *et al*. A surgical technique for posterior lamellar keratoplasty. Cornea 1998;17:618-26.
3. Melles GR, Lander F, Beekhuis WH, Remeijer L, Binder PS. Posterior lamellar keratoplasty for a case of pseudophakic bullous keratopathy. Am J Ophthalmol 1999;127:340-1.
4. Terry MA, Ousley PJ. Deep lamellar endothelial keratoplasty in the first United States patients: Early clinical results. Cornea 2001;20:239-43.
5. Melles GR, Wijdh RH, Nieuwendaal CP. A technique to excise the descemet membrane from a recipient cornea (descemetorhexis). Cornea 2004;23:286-8.
6. Melles GR, Lander F, Rietveld FJ. Transplantation of Descemet's membrane carrying viable endothelium through a small scleral incision. Cornea 2002;21:415-8.
7. 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.
8. Gorovoy MS. Descemet-stripping automated endothelial keratoplasty. Cornea 2006;25:886-9.
9. Eye Bank Association of America. Eye Banking Statistical Reports. Washington, DC: Eye Bank Association of America; 2005-2011.
10. Anshu A, Price MO, Tan DT, Price FW Jr. Endothelial keratoplasty: A revolution in evolution. Surv Ophthalmol 2012;57:236-52.
11. Duman F, Kosker M, Suri K, Reddy JC, Ma JF, Hammersmith KM, *et al*. Indications and outcomes of corneal transplantation in geriatric patients. Am J Ophthalmol. 2013;156:600-7.e2.
12. Tan JC, Holland SP, Dubord PJ, Moloney G, McCarthy M, Yeung SN. Evolving indications for and trends in keratoplasty in British Columbia, Canada, from 2002 to 2011: A 10-year review. Cornea 2014;33:252-6.

13. Vajpayee RB, Maharana PK, Jain S, Sharma N, Jhanji V. Thin lenticule Descemet's stripping automated endothelial keratoplasty: Single, slow pass technique. Clin Exp Ophthalmol 2014;42:411-6.
14. Nahum Y, Leon P, Busin M. Postoperative graft thickness obtained with single-pass microkeratome-assisted ultrathin Descemet stripping automated endothelial keratoplasty. Cornea 2015;34:1362-4.
15. Busin M, Madi S, Santorum P, Scorcia V, Beltz J. Ultrathin Descemet's stripping automated endothelial keratoplasty with the microkeratome double-pass technique: Two-year outcomes. Ophthalmology 2013;120:1186-94.
16. Hsu M, Hereth WL, Moshirfar M. Double-pass microkeratome technique for ultra-thin graft preparation in Descemet's stripping automated endothelial keratoplasty. Clin Ophthalmol 2012;6:425-32.
17. Terry MA, Shamie N, Chen ES, Phillips PM, Hoar KL, Friend DJ. Precut tissue for Descemet's stripping automated endothelial keratoplasty: Vision, astigmatism, and endothelial survival. Ophthalmology 2009;116:248-56.
18. Chen ES, Terry MA, Shamie N, Hoar KL, Friend DJ. Precut tissue in Descemet's stripping automated endothelial keratoplasty donor characteristics and early postoperative complications. Ophthalmology 2008;115:497-502.
19. Vetter JM, Holtz C, Vossmerbaeumer U, Pfeiffer N. Irregularity of the posterior corneal surface during applanation using a curved femtosecond laser interface and microkeratome cutting head. J Refract Surg 2012;28:209-14.
20. Trinh L, Saubaméa B, Auclin F, Denoyer A, Lai-Kuen R, El Hamdaoui M, *et al.* Femtosecond and excimer laser-assisted endothelial keratoplasty (FELEK): A new technique of endothelial transplantation. J Fr Ophtalmol 2014;37:211-9.
21. Cheng YY, Schouten JS, Tahzib NG, Wijdh RJ, Pels E, van Cleynenbreugel H, *et al.* Efficacy and safety of femtosecond laser-assisted corneal endothelial keratoplasty: A randomized multicenter clinical trial. Transplantation 2009;88:1294-302.
22. Phillips PM, Phillips LJ, Saad HA, Terry MA, Stolz DB, Stoeger C, *et al.* "Ultrathin" DSAEK tissue prepared with a low-pulse energy, high-frequency femtosecond laser. Cornea 2013;32:81-6.
23. McKee HD, Jhanji V. Ultrathin descemet stripping automated endothelial keratoplasty using a femtosecond laser to cut grafts from the endothelial side. Clin Exp Ophthalmol 2016;44:136-8.
24. Liu YC, Teo EP, Adnan KB, Yam GH, Peh GS, Tan DT, *et al.* Endothelial approach ultrathin corneal grafts prepared by femtosecond laser for descemet stripping endothelial keratoplasty. Invest Ophthalmol Vis Sci 2014;55:8393-401.
25. Terry MA, Shamie N, Chen ES, Hoar KL, Friend DJ. Endothelial keratoplasty a simplified technique to minimize graft dislocation, iatrogenic graft failure, and pupillary block. Ophthalmology 2008;115:1179-86.
26. Elbaz U, Yeung SN, Lichtinger A, Zauberman NA, Goldich Y, Ziai S, *et al.* EndoGlide versus EndoSerter for the insertion of donor graft in descemet stripping automated endothelial keratoplasty. Am J Ophthalmol 2014;158:257-62.e1.
27. Letko E, Price DA, Lindoso EM, Price MO, Price FW Jr. Secondary graft failure and repeat endothelial keratoplasty after Descemet's stripping automated endothelial keratoplasty. Ophthalmology 2011;118:310-4.
28. Mehta JS, Por YM, Beuerman RW, Tan DT. Glide insertion technique for donor cornea lenticule during Descemet's stripping automated endothelial keratoplasty. J Cataract Refract Surg 2007;33:1846-50.
29. Mehta JS, Por YM, Poh R, Beuerman RW, Tan D. Comparison of donor insertion techniques for descemet stripping automated endothelial keratoplasty. Arch Ophthalmol 2008;126:1383-8.
30. Ang M, Saroj L, Htoon HM, Kiew S, Mehta JS, Tan D. Comparison of a donor insertion device to sheets glide in Descemet stripping endothelial keratoplasty: 3-year outcomes. Am J Ophthalmol 2014;157:1163-9.e3.
31. Toyama T, Honda N, Usui T, Amano S. New graft inserter for descemet stripping automated endothelial keratoplasty. Cornea 2014;33:432-5.
32. Kobayashi A, Yokogawa H, Sugiyama K. Clinical results of the Neusidl Corneal Inserter®, a new donor inserter for Descemet's stripping automated endothelial keratoplasty, for small Asian eyes. Ophthalmic Surg Lasers Imaging 2012;43:311-8.
33. Gangwani V, Obi A, Hollick EJ. A prospective study comparing EndoGlide and Busin glide insertion techniques in descemet stripping endothelial keratoplasty. Am J Ophthalmol 2012;153:38-43.e1.
34. Khor WB, Mehta JS, Tan DT. Descemet stripping automated endothelial keratoplasty with a graft insertion device: Surgical technique and early clinical results. Am J Ophthalmol 2011;151:223-32.e2.
35. Terry MA, Straiko MD, Goshe JM, Shamie N, Shah A, Alqudah AA, *et al.* Endothelial keratoplasty: Prospective, randomized, masked clinical trial comparing an injector with forceps for tissue insertion. Am J Ophthalmol 2013;156:61-8.e3.
36. Pedersen IB, Ivarsen A, Hjortdal J. Graft rejection and failure following endothelial keratoplasty (DSAEK) and penetrating keratoplasty for secondary endothelial failure. Acta Ophthalmol 2015;93:172-7.
37. Nakatani S, Murakami A. Three-year outcome of Descemet stripping automated endothelial keratoplasty for bullous keratopathy after argon laser iridotomy. Cornea 2014;33:780-4.
38. Nakagawa H, Inatomi T, Hieda O, Sotozono C, Yokoi N, Iliakis B, *et al*. Clinical outcomes in descemet stripping automated endothelial keratoplasty with internationally shipped precut donor corneas. Am J Ophthalmol 2014;157:50-5.e1.
39. Titiyal JS, Tinwala SI, Shekhar H, Sinha R. Sutureless clear corneal DSAEK with a modified approach for preventing pupillary block and graft dislocation: Case series with retrospective comparative analysis. Int Ophthalmol 2015;35:233-40.
40. Saethre M, Drolsum L. The role of postoperative positioning after DSAEK in preventing graft dislocation. Acta Ophthalmol 2014;92:77-81.
41. Beltz J, Madi S, Santorum P, Scorcia V, Busin M. Descemet stripping automated endothelial keratoplasty for endothelial decompensation in buphthalmos. Am J Ophthalmol 2013;156:608-15.e1.
42. Price MO, Gorovoy M, Price FW Jr., Benetz BA, Menegay HJ, Lass JH. Descemet's stripping automated endothelial keratoplasty: Three-year graft and endothelial cell survival compared with penetrating keratoplasty. Ophthalmology 2013;120:246-51.
43. Khor WB, Han SB, Mehta JS, Tan DT. Descemet stripping automated endothelial keratoplasty with a donor insertion device: Clinical results and complications in 100 eyes. Am J Ophthalmol 2013;156:773-9.
44. Foster JB, Swan KR, Vasan RA, Greven MA, Walter KA. Small-incision Descemet stripping automated endothelial keratoplasty: A comparison of small-incision tissue injector and forceps techniques. Cornea 2012;31:42-7.
45. Wu EI, Ritterband DC, Yu G, Shields RA, Seedor JA. Graft rejection following descemet stripping automated endothelial keratoplasty: Features, risk factors, and outcomes. Am J Ophthalmol 2012;153:949-57.e1.
46. Jangi AA, Ritterband DC, Wu EI, Mehta VV, Koplin RS, Seedor JA. Descemet stripping automated endothelial keratoplasty after failed penetrating keratoplasty. Cornea 2012;31:1148-53.
47. Li JY, Terry MA, Goshe J, Davis-Boozer D, Shamie N. Three-year visual acuity outcomes after Descemet's stripping automated

endothelial keratoplasty. Ophthalmology 2012;119:1126-9.

48. Phillips PM, Phillips LJ, Much JW, Maloney C. Descemet stripping endothelial keratoplasty: Six-month results of the first 100 consecutive surgeries performed solo by a surgeon using 1 technique with 100% follow-up. Cornea 2012;31:1361-4.
49. Wendel LJ, Goins KM, Sutphin JE, Wagoner MD. Comparison of bifold forceps and cartridge injector suture pull-through insertion techniques for Descemet stripping automated endothelial keratoplasty. Cornea 2011;30:273-6.
50. Tsui JY, Goins KM, Sutphin JE, Wagoner MD. Phakic descemet stripping automated endothelial keratoplasty: Prevalence and prognostic impact of postoperative cataracts. Cornea 2011;30:291-5.
51. Clements JL, Bouchard CS, Lee WB, Dunn SP, Mannis MJ, Reidy JJ, *et al.* Retrospective review of graft dislocation rate associated with descemet stripping automated endothelial keratoplasty after primary failed penetrating keratoplasty. Cornea 2011;30:414-8.
52. Ratanasit A, Gorovoy MS. Long-term results of Descemet stripping automated endothelial keratoplasty. Cornea 2011;30:1414-8.
53. Busin M, Beltz J, Scorcia V. Descemet-stripping automated endothelial keratoplasty for congenital hereditary endothelial dystrophy. Arch Ophthalmol 2011;129:1140-6.
54. Chen ES, Phillips PM, Terry MA, Shamie N, Friend DJ. Endothelial cell damage in descemet stripping automated endothelial keratoplasty with the underfold technique: 6- and 12-month results. Cornea 2010;29:1022-4.
55. Esquenazi S, Schechter BA, Esquenazi K. Endothelial survival after Descemet-stripping automated endothelial keratoplasty in eyes with retained anterior chamber intraocular lenses: Two-year follow-up. J Cataract Refract Surg 2011;37:714-9.
56. Allen MB, Lieu P, Mootha VV, Bowman RW, Petroll WM, Tong L, *et al.* Risk factors for intraocular pressure elevation after descemet stripping automated endothelial keratoplasty. Eye Contact Lens 2010;36:223-7.
57. Koenig SB. Descemet stripping automated endothelial keratoplasty in the phakic eye. Cornea 2010;29:531-3.
58. Phillips PM, Terry MA, Shamie N, Chen ES, Hoar K, Dhoot D, *et al.* Descemet stripping automated endothelial keratoplasty in eyes with previous trabeculectomy and tube shunt procedures: Intraoperative and early postoperative complications. Cornea 2010;29:534-40.
59. Price MO, Bidros M, Gorovoy M, Price FW Jr., Benetz BA, Menegay HJ, *et al.* Effect of incision width on graft survival and endothelial cell loss after Descemet stripping automated endothelial keratoplasty. Cornea 2010;29:523-7.
60. Price MO, Gorovoy M, Benetz BA, Price FW Jr., Menegay HJ, Debanne SM, *et al.* Descemet's stripping automated endothelial keratoplasty outcomes compared with penetrating keratoplasty from the Cornea Donor Study. Ophthalmology 2010;117:438-44.
61. Shih CY, Ritterband DC, Rubino S, Palmiero PM, Jangi A, Liebmann J, *et al.* Visually significant and nonsignificant complications arising from Descemet stripping automated endothelial keratoplasty. Am J Ophthalmol 2009;148:837-43.
62. Terry MA, Shamie N, Chen ES, Phillips PM, Shah AK, Hoar KL, *et al.* Endothelial keratoplasty for Fuchs' dystrophy with cataract: Complications and clinical results with the new triple procedure. Ophthalmology 2009;116:631-9.
63. Phillips PM, Terry MA, Shamie N, Chen ES, Hoar KL, Stoeger C, *et al.* Descemet's stripping automated endothelial keratoplasty (DSAEK) using corneal donor tissue not acceptable for use in penetrating keratoplasty as a result of anterior stromal scars, pterygia, and previous corneal refractive surgical procedures. Cornea 2009;28:871-6.
64. Chen ES, Terry MA, Shamie N, Hoar KL, Phillips PM, Friend DJ. Endothelial keratoplasty: Vision, endothelial survival, and complications in a comparative case series of fellows vs. attending surgeons. Am J Ophthalmol 2009;148:26-31.e2.
65. Terry MA, Shamie N, Chen ES, Hoar KL, Phillips PM, Friend DJ. Endothelial keratoplasty: The influence of preoperative donor endothelial cell densities on dislocation, primary graft failure, and 1-year cell counts. Cornea 2008;27:1131-7.
66. Busin M, Bhatt PR, Scorcia V. A modified technique for descemet membrane stripping automated endothelial keratoplasty to minimize endothelial cell loss. Arch Ophthalmol 2008;126:1133-7.
67. Sarnicola V, Toro P. Descemet-stripping automated endothelial keratoplasty by using suture for donor insertion. Cornea 2008;27:825-9.
68. Chen ES, Terry MA, Shamie N, Phillips PM, Friend DJ, McLeod SD. Descemet-stripping automated endothelial keratoplasty: Insertion using a novel 40/60 underfold technique for preservation of donor endothelium. Cornea 2008;27:941-3.
69. Kaiserman I, Bahar I, McAllum P, Slomovic AR, Rootman DS. Suture-assisted vs. forceps-assisted insertion of the donor lenticula during Descemet stripping automated endothelial keratoplasty. Am J Ophthalmol 2008;145:986-90.
70. Suh LH, Yoo SH, Deobhakta A, Donaldson KE, Alfonso EC, Culbertson WW, *et al.* Complications of Descemet's stripping with automated endothelial keratoplasty: Survey of 118 eyes at one institute. Ophthalmology 2008;115:1517-24.
71. Van Cleynenbreugel H, Hillenaar T, Remeijer L. Graft insertion during Descemet-stripping automated endothelial keratoplasty: Pulling the graft inward. J Cataract Refract Surg 2008;34:534-6.
72. Hashemi H, Asghari H, Amanzadeh K, Behrooz MJ, Beheshtnejad A, Mohammadpour M. Descemet stripping automated endothelial keratoplasty performed by cornea fellows. Cornea 2012;31:974-7.
73. Lee WB, Jacobs DS, Musch DC, Kaufman SC, Reinhart WJ, Shtein RM. Descemet's stripping endothelial keratoplasty: Safety and outcomes: A report by the American Academy of Ophthalmology. Ophthalmology 2009;116:1818-30.
74. Patel SV, Baratz KH, Hodge DO, Maguire LJ, McLaren JW. The effect of corneal light scatter on vision after descemet stripping with endothelial keratoplasty. Arch Ophthalmol 2009;127:153-60.
75. 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.
76. Dupps WJ Jr., Qian Y, Meisler DM. Multivariate model of refractive shift in Descemet-stripping automated endothelial keratoplasty. J Cataract Refract Surg 2008;34:578-84.
77. Muftuoglu O, Prasher P, Bowman RW, McCulley JP, Mootha VV. Corneal higher-order aberrations after Descemet's stripping automated endothelial keratoplasty. Ophthalmology 2010;117:878-84.e6.
78. Hindman HB, McCally RL, Myrowitz E, Terry MA, Stark WJ, Weinberg RS, *et al.* Evaluation of deep lamellar endothelial keratoplasty surgery using scatterometry and wavefront analyses. Ophthalmology 2007;114:2006-12.
79. Price MO, Jordan CS, Moore G, Price FW Jr. Graft rejection episodes after Descemet stripping with endothelial keratoplasty: Part two: The statistical analysis of probability and risk factors. Br J Ophthalmol 2009;93:391-5.
80. Allan BD, Terry MA, Price FW Jr., Price MO, Griffin NB, Claesson M. Corneal transplant rejection rate and severity after endothelial keratoplasty. Cornea 2007;26:1039-42.
81. Jordan CS, Price MO, Trespalacios R, Price FW Jr. Graft rejection episodes after Descemet stripping with endothelial keratoplasty: Part one: Clinical signs and symptoms. Br J Ophthalmol 2009;93:387-90.
82. Vajaranant TS, Price MO, Price FW, Wilensky JT, Edward DP.

Intraocular pressure measurements following Descemet stripping endothelial keratoplasty. Am J Ophthalmol 2008;145:780-6.

83. Prasher P, Muftuoglu O, Hsiao ML, Bowman RW, Hogan RN, Mootha VV. Epithelial downgrowth after descemet stripping automated endothelial keratoplasty. Cornea 2009;28:708-11.
84. Koenig SB, Covert DJ. Early results of small-incision Descemet's stripping and automated endothelial keratoplasty. Ophthalmology 2007;114:221-6.
85. Gorovoy MS, Ratanasit A. Epithelial downgrowth after Descemet stripping automated endothelial keratoplasty. Cornea 2010;29:1192-4.
86. Phillips PM, Terry MA, Kaufman SC, Chen ES. Epithelial downgrowth after Descemet-stripping automated endothelial keratoplasty. J Cataract Refract Surg 2009;35:193-6.
87. Kitzmann AS, Wagoner MD, Syed NA, Goins KM. Donor-related Candida keratitis after Descemet stripping automated endothelial keratoplasty. Cornea 2009;28:825-8.
88. Prasher P, Muftuoglu O. Herpetic keratitis after descemet stripping automated endothelial keratoplasty for failed graft. Eye Contact Lens 2009;35:41-2.
89. Araki-Sasaki K, Fukumoto A, Osakabe Y, Kimura H, Kuroda S. The clinical characteristics of fungal keratitis in eyes after Descemet's stripping and automated endothelial keratoplasty. Clin Ophthalmol 2014;8:1757-60.
90. Vira S, Shih CY, Ragusa N, Sheyman A, Feder R, Weisenthal RW, *et al*. Textural interface opacity after descemet stripping automated endothelial keratoplasty: A report of 30 cases and possible etiology. Cornea 2013;32:e54-9.
91. Kim K, Alder B, Vora GK, Carlson AN, Afshari NA, Kuo AN, *et al*. Textural interface opacity after Descemet-stripping automated endothelial keratoplasty. J Cataract Refract Surg 2014;40:1514-20.
92. Chew AC, Mehta JS, Li L, Busmanis I, Tan DT. Fungal endophthalmitis after descemet stripping automated endothelial keratoplasty – A case report. Cornea 2010;29:346-9.
93. Price MO, Price FW Jr., Trespalacios R. Endothelial keratoplasty technique for aniridic aphakic eyes. J Cataract Refract Surg 2007;33:376-9.
94. Sinha R, Shekhar H, Sharma N, Tandon R, Titiyal JS, Vajpayee RB. Intrascleral fibrin glue intraocular lens fixation combined with Descemet-stripping automated endothelial keratoplasty or penetrating keratoplasty. J Cataract Refract Surg 2012;38:1240-5.
95. Titiyal JS, Sachdev R, Sinha R, Tandon R, Sharma N. Modified surgical technique for improving donor adherence in DSAEK in the aphakic vitrectomized eye. Cornea 2012;31:462-4.
96. Huang T, Wang YJ, Luo Y, Huan DN, Chen JQ. Effect of temporary anchor sutures on Descemet stripping endothelial keratoplasty in aphakic eyes. Zhonghua Yan Ke Za Zhi 2010;46:233-7.
97. Sansanayudh W, Bahar I, Rootman D. Novel technique in preparing a donor DSAEK lenticule in a patient with a glaucoma drainage device. Br J Ophthalmol 2009;93:1267-9.
98. Peng RM, Hao YS, Chen HJ, Sun YX, Hong J. Endothelial keratoplasty: The use of viscoelastic as an aid in reattaching the dislocated graft in abnormally structured eyes. Ophthalmology 2009;116:1897-900.