

# Experience and 12-Month Results of Descemet-Stripping Endothelial Keratoplasty (DSEK) with a Small-Incision Technique

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**Purpose:** To report our clinical experience and 12-month results of small-incision Descemet-stripping endothelial keratoplasty (DSEK).

**Methods:** Prospective study of 11 eyes of 9 patients who had DSEK. The DSEK technique consisted of stripping the Descemet membrane and endothelium from the recipient cornea. The donor button was prepared by manual dissection and inserted through a 5-mm incision. Air, sulfur hexafluoride (SF<sub>6</sub>), or perfluoropropane (C<sub>3</sub>F<sub>8</sub>) was used both at the end of surgery and in subsequent dislocations to promote donor tissue adherence.

**Results:** Mean age was 79.6 years (range, 66–91 years), and minimum follow-up was 12 months (range, 12–18 months). Nine eyes had donor tissue dislocation postoperatively, 8 of which received intervention with either SF<sub>6</sub> (n = 4) or C<sub>3</sub>F<sub>8</sub> (n = 4). In 1 patient with repeat dislocation, Tisseel glue in combination with C<sub>3</sub>F<sub>8</sub> was used. Preoperative best-corrected visual acuity (BCVA) was 6/24 or worse in all patients. Postoperatively, 6/11 eyes (55%) achieved a BCVA of 6/12 at last follow-up. Mean preoperative cylinder was 1.875 ± 0.906 D (range, 1–3 D) and postoperatively was 1.5 ± 1.157 D (range, 0.25–3.25 D). At last follow-up, 6 grafts were clear and 5 had failed. Mean endothelial cell count in the clear grafts at 12-month follow-up was 1078 ± 507 cells/mm<sup>2</sup>.

**Conclusions:** DSEK provided excellent refractive and reasonable visual outcomes in our limited series, but there were frequent problems with dislocation of the donor tissue, and the graft failure rate was high. The graft failures may be linked to excessive endothelial damage, and the high dislocation rate may be linked to not filling the anterior chamber totally with air after insertion of the donor. Further development of the procedure is necessary.

**Key Words:** Descemet-stripping endothelial keratoplasty, deep lamellar endothelial keratoplasty, posterior lamellar keratoplasty, corneal transplant, graft dislocation

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Deep lamellar endothelial keratoplasty (DLEK) is a method of treatment of corneal disease where the pathology is confined to the endothelium. DLEK was initially described by Melles et al,<sup>1</sup> and subsequently by Terry and Ousley,<sup>2</sup> and involves posterior lamellar keratectomy (PLK) in the recipient cornea—removing the posterior stroma, Descemet membrane (DM), and endothelium—with subsequent insertion of a similarly prepared donor endothelial through a posterior stromal lamellar button.

More recently, interest has grown in a Descemet-stripping endothelial keratoplasty technique (DSEK), where only DM and the endothelium are removed from the recipient cornea.<sup>3–5</sup> Melles et al<sup>3</sup> described this concept in 2004, the advantage being that only the pathologic tissue is removed, sparing the normal cornea, and better preserving structural integrity. Furthermore, the technique is much easier and quicker to perform, and the resultant recipient corneal interface is smoother than would be achieved with lamellar dissection, with potentially improved visual results.

Published results of DLEK, where recipient posterior stromal resection was performed, are comparable to those achieved with penetrating keratoplasty, with superior refractive outcomes, although follow-up is limited to 2 to 3 years.<sup>6–8</sup>

Endothelial keratoplasty using DSEK is new, and there are few published data: Price and Price<sup>5</sup> recently published their early results in 50 eyes and reported good refractive and visual outcomes at 6-month follow-up, comparable to prior DLEK reports.

We report visual and refractive outcomes and problems encountered in the first UK series of DSEK.

## MATERIALS AND METHODS

After local ethics committee approval, patients suitable for inclusion were invited to take part in the study. All patients underwent small-incision DSEK. Where patients had significant lens opacity, the surgery was combined with phacoemulsification and intraocular lens implantation.

Data were collected prospectively and included patient demographics, indication for surgery, pre- and postoperative refraction, visual acuity, adverse events, and endothelial cell counts.

## Operative Technique

All surgeries were performed by either C.K.R. or M.A.Q. Both surgeons are experienced anterior lamellar graft

surgeons and had undergone wet-laboratory DSEK training, and one had assisted in DSEK surgery with another surgeon before the study. Before starting surgery on the patient, the donor button was prepared using a Moria artificial anterior chamber, using a manual stromal dissection technique. A calibrated diamond knife set at 350 microns was used to create a peripheral incision in the donor corneoscleral segment. Melles' spatula set (DORC International, The Netherlands) was used for the donor lamellar dissection. The corneoscleral segment was placed endothelial side up and trephined (mean diameter, 8.75 mm; range, 8.25–9.5 mm). The 2 punched lamellae were carefully separated, and the donor lamella of posterior stroma with its DM and endothelium was kept covered with its preservation medium. In 7 cases, the preservation medium was post-organ culture dextran transport medium, and in the remaining 4, it was Optisol-GS (Bausch & Lomb, Irvine, CA). Immediately before transplantation, the donor button was briefly stained with a drop of Vision Blue (DORC International) to check for any inadvertent endothelial damage.

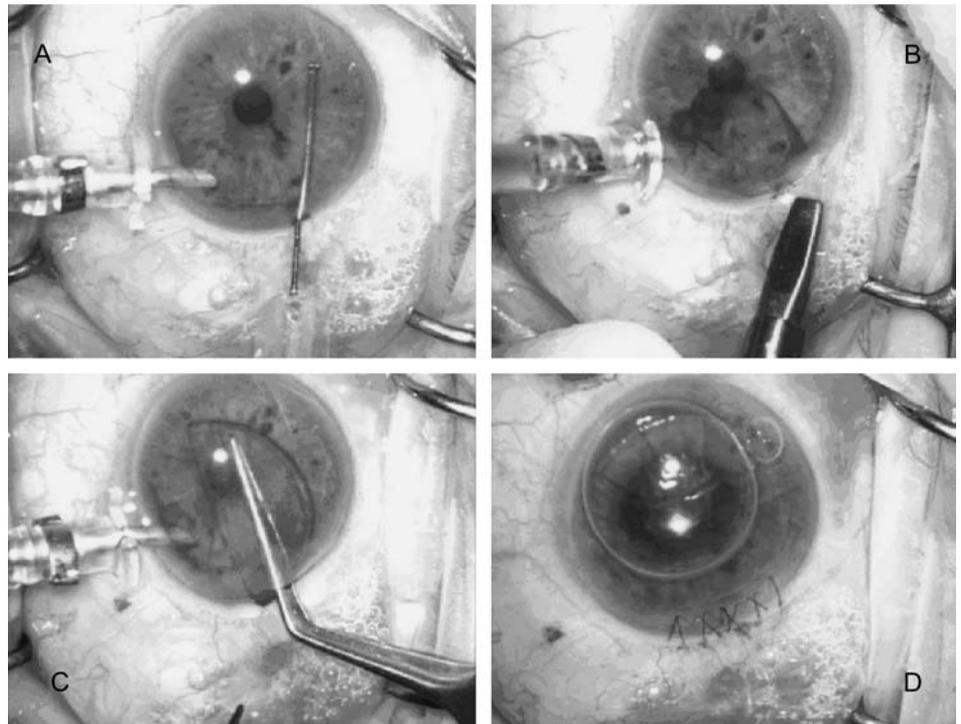
Surgery (Fig. 1) was performed under general anesthesia in 2 patients, and local peribulbar anesthesia was used for the remainder.

A superior paracentesis was made in the recipient cornea, followed by a temporal paracentesis. An anterior-chamber maintenance cannula was inserted through the superior paracentesis, and Vision Blue was used for better visualization of DM. Descemet stripping was performed aiming for a diameter of approximately 8.5 to 9 mm, using either a 25-gauge needle with a snapped, crushed, and bent end or a specially designed scraper (DORC International). The temporal incision was enlarged to 5 mm, and the DM was removed. The donor

button was folded on itself in a taco shape (without viscoelastic), grasped with plain forceps, and inserted into the anterior chamber. A combination of balanced salt solution and air was used to unfold and manipulate the donor button into place. The wound was sutured with 10-0 Ethilon (Ethicon, Brussels, Belgium), and a 7- to 8-mm air bubble was left in situ for the first case. In subsequent cases (eyes 2–5), sulfur hexafluoride/air ( $\text{SF}_6$  20% concentration) was used at the end of surgery, and in eyes 6–11, perfluoropropane/air ( $\text{C}_3\text{F}_8$  20% concentration) was used because of continuing problems with graft dislocation. Subconjunctival betamethasone and gentamicin was administered at the end of surgery. Where patients had significant lens opacity, temporal clear-corneal phacoemulsification was carried out first, using a phaco-chop technique, with insertion of an Akreos Adapt (Bausch and Lomb) intraocular lens, followed by Miochol (acetylcholine) to constrict the pupil. Thereafter, the procedure was continued as above.

### Management of Dislocated Buttons

In the event of donor tissue dislocation postoperatively,  $\text{SF}_6$ /air was initially used (first 4 cases), and  $\text{C}_3\text{F}_8$ /air was used in all subsequent cases. The gas (7- to 8-mm bubble) was inserted into the anterior chamber through a paracentesis using a Rycroft cannula. In 1 patient, after repeat dislocation after  $\text{SF}_6$  injection, Tisseel glue was used in combination with  $\text{C}_3\text{F}_8$  to reposition the donor button. Glue placement was performed by first injecting the fibrinogen component in the interface between donor cornea and recipient, once the graft was appropriately positioned. The thrombin component was then injected into the anterior chamber to initiate the formation of then fibrin.



**FIGURE 1.** A, DM is scraped off with an angulated needle. B, The detached membrane, stained with Vision Blue, is removed through a 5-mm incision. C, The folded donor tissue "taco" is introduced. D, After wound closure, a gas bubble helps to maintain graft apposition.

## RESULTS

Eleven eyes of 9 patients had DSEK from March to November 2004, 4 of which were combined with phacoemulsification and intraocular lens implantation. The mean age was 79.6 years (range, 66–91 years), and minimum follow-up was 12 months (range, 12–18 months). Patient demographics, indication for surgery, pre- and postoperative vision, refractions, graft status, and endothelial cell counts are shown in Table 1.

One patient had posterior lens capsule rupture requiring vitrectomy and insertion of a sulcus-placed polymethylmethacrylate (PMMA) intraocular lens. There were no other intraoperative complications. Nine eyes had graft dislocation postoperatively, with 8 requiring intervention (1 had a partial dislocation that resolved spontaneously). The dislocations were noted on the first postoperative day in 1 patient, and all other primary dislocations were noted on postoperative days 4 to 14, typically when the gas bubble resorbed. In 2 patients, the donor button dislocated again despite secondary intervention at 3 and 4 weeks after surgery. Further treatment with  $C_3F_8$  was used in 1 case, and  $C_3F_8$  in combination with Tisseel glue (Baxter, Vienna, Austria) was used in the other. There were no further dislocations after these interventions. One patient had primary graft failure, and the procedure was repeated after 2 months.

Pre- and postoperative visual acuities are summarized in Table 2. Preoperative best-corrected visual acuity (BCVA) was 6/24 or worse in all patients. Postoperatively, 9/11 eyes (82%) achieved a BCVA of 6/24 or better, and 6/11 eyes (55%) achieved a BCVA of 6/12 at 6-month follow-up. At 12-month follow-up, 7/11 eyes (64%) were seeing 6/24 or better, and 6/11 eyes (55%) were seeing 6/12. No patients were seeing better than 6/12 at last follow-up.

Mean preoperative cylinder was  $1.875 \pm 0.906$  D (range, 1–3 D) and postoperatively was  $1.5 \pm 1.157$  D (range, 0.25–3.25 D). Mean preoperative spherical equivalent was  $0.063 \pm 2.8$  D (range, –4.75 to +2.875 D) and postoperatively was  $-0.406 \pm 0.746$  D (range, –1.375 to +1.00 D). At last follow-up, 6 grafts were completely clear, and 5 grafts had

failed. None of the failures were thought to be caused by graft rejection but rather because of poor endothelial function. The patient who had Tisseel glue as an intervention for donor button dislocation initially had a clear graft, but this subsequently began to fail at 6 months postoperatively, with a BCVA of 3/60 at last follow-up (12 months).

Preoperative endothelial cell counts in the donor buttons averaged  $2754 \pm 301$  cells/mm<sup>2</sup>. This finding compared with a postoperative level in the functioning grafts of  $1078 \pm 507$  cells/mm<sup>2</sup> at 12-month follow-up (Topcon SP2000 Specular microscope with IMAGEnet 2000 analysis software; Newbury, UK). The postoperative cell counts were obtained in 5 of 6 patients whose grafts remained clear at last follow-up (1 was unobtainable because of poor health) and represented a 61% reduction from preoperative levels.

## DISCUSSION

Since Melles et al<sup>1</sup> reported his technique in 1998, endothelial lamellar keratoplasty has been gaining rapidly in popularity. The advantages include minimal change in astigmatism and a tectonically stable globe.<sup>9</sup>

Interest in the DSEK approach as opposed to the recipient lamellar dissection method (DLEK) has been increasing in recent years, although published data are limited.<sup>3–5,10</sup>

During our series, the surgical technique was varied as we sought to find a method to avoid graft dislocations. During DM stripping, we used an anterior-chamber maintainer with Vision Blue to aid visualization. In all but 1 case, we made the scraper from a 25-gauge needle by breaking off the sharp tip and bending the end. We found this approach to be equally effective in stripping the DM as the specially designed Melles scrapers. Terry,<sup>11</sup> however, uses Healon in the anterior chamber without the aid of Vision Blue and has been using a reverse Sinskey hook for DM stripping. He has recommended that the area of stripped DM be the same size as the graft, whereas Price and Price<sup>5</sup> have suggested that it is better if the area is smaller.

**TABLE 1.** Demographic Data, Graft Status, Endothelial Cell Counts, and Pre- and Postoperative Visual Acuities and Refractions at 12 Months

Eye	Age	Indication for DSEK	Preoperative BCVA	Preoperative Refraction	Postoperative Refraction	BCVA	Graft Status	ECC (Mean)
1	66	Fuchs	6/24	+3.50/–1.25 × 115°	–1.25/–0.25 × 45°	6/12	Clear	781
2	79	Fuchs	6/60	0/2.50 × 66°	+1.50/–1.00 × 80°	6/12	Clear	1561
3	91	PBK	6/24	N/R	+2.00/+0.25 × 10°	6/36	Failed	N/R
4	90	PBK	6/36	+5.50/–5.75 × 90°	N/R	HM	Failed	N/R
5	78	Failed PKP for PBK	HM	0/–3.00 × 112°	+1.00/–3.00 × 140°	3/60	Failed	N/R
6	78	PBK	6/36	N/R	N/R	HM	Failed	N/R
7	66	Fuchs	6/36	+3.25/–1.00 × 75°	–0.50/–0.50 × 125°	6/12	Clear	644
8	78	Fuchs	6/24	+3.50/–3.00 × 80°	+1.00/–3.25 × 35°	6/24	Failed	N/R
9	79	Fuchs	6/24	–5.25/–1.00 × 1°	0/–2.00 × 170°	6/12	Clear	1691
10	81	Fuchs	6/24	+1.25/–1.00 × 46°	0/–0.50 × 122°	6/12	Clear	N/R
11	75	Fuchs	6/36	–1.75/–2.25 × 86°	+1.00/–1.50 × 110°	6/12	Clear	709

Eyes 1 and 7 are left and right eyes of the same patient, eyes 2 and 9 are right and left eyes of the same patient. Eyes 1, 7, 8, and 9 had combined phacoemulsification and lens implant. Eye 6 had primary graft failure and the procedure repeated after 2 months.

DSEK, Descemet-stripping endothelial keratoplasty; BCVA, best-corrected visual acuity; ECC, endothelial cell count; PKP, penetrating keratoplasty; PBK, pseudophakic bullous keratopathy; Fuchs, Fuchs endothelial dystrophy; HM, hand movements; N/R, not reported.

**TABLE 2.** Pre- and Postoperative Visual Acuity

BCVA	Preoperative	6 Mo Postoperative	12 Mo Postoperative
<6/24	55% (n = 6)	18% (n = 2)	36% (n = 4)
6/24	45% (n = 5)	18% (n = 2)	9% (n = 1)
6/18	0	9% (n = 1)	0
6/12	0	55% (n = 6)	55% (n = 6)

In our series, we had significant problems with donor graft dislocation, with 9 of 11 grafts dislocating, 8 of which required intervention. In our first case, we used air at the end of surgery, but in subsequent cases, we first used sulfur hexafluoride (SF<sub>6</sub>), and later used perfluoropropane (C<sub>3</sub>F<sub>8</sub>), both at the end of surgery and later to reposition dislocated grafts. These agents have been used in the treatment of DM detachments and corneal hydrops, and for postoperative flat anterior chambers after trabeculectomy, with good effect and few side effects.<sup>12–16</sup> Our series is the first reported use of these gases for the prevention and treatment of endothelial graft dislocation.

One uncertainty is whether the gas causes damage to the corneal endothelium. Green et al<sup>17</sup> looked at the effects of these gases on the permeability of rabbit corneal endothelium. They concluded that the gases themselves were nontoxic but did disrupt normal physiologic functioning because of a physical effect.

Other animal studies have shown that SF<sub>6</sub> can cause transient corneal edema and that C<sub>3</sub>F<sub>8</sub> can induce persistent corneal edema and fibrin deposition on the endothelium. This was again thought to be caused by a physical barrier being created by the gas preventing aqueous from reaching the endothelium, thereby leading to nutritional deprivation,<sup>18–20</sup> but the relevance of this supposition to the human situation is unclear. Mitamura et al<sup>21</sup> showed significant endothelial cell loss when these agents were used in patients undergoing pars plana vitrectomy and total lensectomy, but again, it is uncertain how much the cell loss was caused by the gas. Cataract formation is also another potential side effect of gas.<sup>22</sup> However, in our cases, we used lower concentrations than would generally be the case for vitreoretinal surgery, and all our cases were ultimately pseudophakic.

Other methods that have been reported to try to prevent dislocation include stroking the cornea and peripheral corneal stab incisions in an effort to remove fluid in the interface between donor and recipient.<sup>5,10</sup> Another technique is roughening the peripheral recipient posterior stromal surface with a scraper after Descemet stripping.<sup>11</sup> Price and Price<sup>5</sup> have been completely filling the anterior chamber with air at the end of surgery for 5 to 8 minutes and replacing this with balanced salt solution, leaving a small air bubble. His patients are postured face-up for 1 hour. Interestingly, in his series of 50 eyes, he does not mention any dislocations, although he did modify his technique during the series, presumably with a view to improve some aspect of the outcome. In his second publication (series of 200 eyes), Price and Price<sup>10</sup> reported a dislocation rate of 50% in their first 10 cases and only 6% in their final 64 cases. The reduction in dislocation rate was

attributed to stroking the cornea and the use of peripheral corneal stab incisions with an anterior chamber full of air.

We did not completely fill the anterior chamber with air in any of our cases, and this may also be a factor in our high dislocation rate. Without totally filling the anterior chamber with air, one cannot be sure that the donor is pushed up against the recipient, and it follows that fluid in the interface may still remain despite techniques such as stroking the cornea and peripheral stab incisions. In view of this, it is remarkable that any of the donors stayed attached and shows how resilient the endothelium of the donor can be in that it can attach in some cases without a complete air fill.

In addition to the use of gas, we did use Tisseel glue in 1 patient after repeat dislocation, and although the graft remained adherent and functional after this intervention, corneal decompensation developed 6 months postoperatively. Tisseel glue is a commercially available 2-component adhesive system from human fibrinogen that is activated by thrombin. It has been used successfully in the treatment of epithelial ingrowth after laser in situ keratomileusis (LASIK),<sup>23</sup> for gluing anterior lamellar corneal grafts,<sup>24</sup> and in experimental epikeratophakia surgery.<sup>25</sup> In addition, it has been used for sealing corneal perforations<sup>26</sup> and in other ophthalmic indications such as in glaucoma surgery.<sup>27</sup> Furthermore, we used Tisseel successfully in the management of persistent double anterior chambers after deep anterior lamellar keratoplasty with no evidence of corneal toxicity or effect on corneal clarity.<sup>28</sup> However, there are potential problems with its use in this context because it could possibly cause irido- or lenticulo-corneal adhesions or even severe systemic adverse reaction.<sup>29</sup> It seems more likely that the glued graft in our patient failed secondary to multiple manipulations of the donor button rather than being related to the use of Tisseel.

One of the main advantages of endothelial keratoplasty over penetrating keratoplasty is that postoperative levels of astigmatism are low, with little change from preoperative levels. In our series, there were no significant changes in spherical equivalent or cylinder at 6 or 12 months after surgery compared with preoperative levels. Our findings are similar to those of other reported series.<sup>5–7</sup>

In terms of visual acuity, 55% (6/11) of our patients achieved a BCVA of 6/12 at 6 and 12 months after surgery. In the Price and Price<sup>5</sup> series of DSEK patients with 6-month follow-up, they reported a figure of 62% (31/50) achieving this level of vision or better. Terry and Ousley,<sup>30</sup> in their prospective series of DLEK, reported 56% (14/25) of patients achieving this level of vision or better, which is comparable to ours. In addition, none of our patients needed contact lenses or had an intolerable refractive correction. However, none of our patients achieved BCVA of 6/9 or 6/6 at last follow-up.

In our series, 1 patient had primary graft failure and had repeat surgery 2 months after the original operation. At last follow-up, 5 grafts had failed, all thought to be caused by endothelial depletion rather than rejection. In the series reported by Price and Price,<sup>5</sup> there were 3 (6%) reported primary graft failures that were regrafted 1 week after the original surgery, and there were no further reported graft failures at last follow-up (6 months). In our series, mean endothelial counts in the clear grafts at last follow-up was

1078 ± 507 cells/mm<sup>2</sup>, which represented a 61% reduction from preoperative levels. Van Dooren et al<sup>8</sup> reported a comparable figure of 1216 ± 156 mm<sup>2</sup> at 12 months (n = 3) after PLK using a folded donor button technique, representing a 56% reduction from preoperative levels (but he did use viscoelastic in the folded tissue). Ousley and Terry<sup>7</sup> reported much higher figures at 12-month follow-up (2335 ± 468-mm<sup>2</sup>), but these were in those cases where he had used large incisions (9–9.5 mm) without folding of the donor button. He does report good results at 6-month follow-up of his small-incision cases where the donor button was folded (2122 ± 510 cells/mm<sup>2</sup>), and it would be interesting to compare his 12-month cell counts with ours.<sup>30</sup> Price and Price,<sup>5,10</sup> in the only reported series of DSEK to date, did not report endothelial cell counts, but it would be interesting to compare results in the future.

In our efforts to prevent donor button dislocation, it is possible that there was inadvertent damage to the corneal endothelium secondary to the use of SF<sub>6</sub> and C<sub>3</sub>F<sub>8</sub>, despite using low concentrations. This might explain not only our dislocation rate but also our low endothelial cell counts and high graft failure rate. However, our counts in the clear grafts were comparable to those in the series of Van Dooren et al,<sup>8</sup> and the results are more probably accounted for by the steep learning curve for the technique and damage to the endothelium occurring as a result of folding and grasping the donor tissue. Other factors possibly affecting graft adhesion are the duration of preservation and type of preservation medium of the donor and the size of the graft, but we were not able to define the effect, if any, of these parameters.

DSEK provided excellent refractive outcomes and reasonable visual outcomes in our series of patients, but there were significant problems with donor dislocation. This outcome may be linked to not totally filling the anterior chamber with air after insertion of the donor. Although C<sub>3</sub>F<sub>8</sub> and SF<sub>6</sub> may be helpful in the prevention and management of donor button dislocation, there is uncertainty as to their effect on the endothelium. Tisseel glue is yet to be evaluated in full as a method to prevent dislocation and may be an option, although not without risk. In conclusion, the technique used here resulted in an unacceptable rate of complications. Current and future modifications should improve the success of DSEK.

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Bruce Allan, FRCOphth, prepared the protocol and obtained ethics committee approval and Scott Hau, MCOptom, carried out the specular microscopy.

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