

Stromal Support for Descemet's Membrane Endothelial Keratoplasty

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Purpose: To evaluate the use of a peripheral stromal support to facilitate and improve the outcomes of Descemet's membrane endothelial keratoplasty (DMEK).

Design: Prospective case series.

Participants: Ten patients with Fuchs' endothelial dystrophy.

Intervention: Pneumatic dissection was used to detach the central part of the Descemet's membrane and endothelium from the deep stroma. Endothelial grafts including a peripheral stromal support were obtained by eccentric punching of donor tissue and used to perform DMEK surgery in 10 patients.

Main Outcome Measures: Operative time, graft attachment rate, best spectacle-corrected visual acuity (BSCVA), endothelial cell loss, refraction, and complications.

Results: In all cases the surgical time was ≤ 1 hour. The postoperative course was uneventful in all but 2 cases, which required rebubbling owing to early graft detachment. Final attachment rate was 100%. The average follow-up was 8.4 months (range, 6–12). Postoperative BSCVA was $\geq 20/40$ in all cases and no substantial change in refraction was recorded. Postoperative endothelial cell loss averaged 24.1% (range, 8%–34.9%).

Conclusions: Stromal support facilitates surgery, reduces complications, and appears to maintain the favorable outcomes of DMEK.

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Descemet's membrane endothelial keratoplasty (DMEK) represents the most recent development in posterior lamellar keratoplasty. As opposed to Descemet's stripping endothelial keratoplasty (DSAEK), donor stromal tissue is not transplanted. This avoids formation of a corneal interface and therefore may optimize visual outcome and speed of postoperative visual rehabilitation.¹ However, the presence of a thin stromal layer in DSAEK allows for ease of harvesting, handling, and delivery of the donor tissue. Furthermore, absence of the stromal layer would not allow marking, thus making identification of the endothelial side questionable. For these reasons, DMEK has not gained widespread popularity to date.

We have previously described how pneumatic dissection can be used to separate the endothelium/Descemet's complex from deep stroma.² In our experience, this method substantially simplifies preparation and storage of endothelial grafts without the need for excessive tissue handling and stripping, while minimizing wastage.

We have described herein how a donor graft consisting of endothelium together with a peripheral "sickle" of deep stroma can be prepared from such tissue. Because the central portion of this type of graft does not include any stromal tissue, the optimal optics of DMEK is maintained while incorporating all the advantages of DSAEK surgery. We

report the preliminary results of this novel technique in 10 patients.

Methods

Ten pseudophakic patients with Fuchs' endothelial dystrophy were recruited into a prospective study aimed at evaluating the results of "sickle" DMEK surgery. The study followed the tenets of the 1964 Declaration of Helsinki and detailed informed consent approved by the Institutional Review Board was obtained from all participants. Patients were scheduled to be seen 1, 3, 6, and 12 months after surgery. Data collected included patient demographics, surgical time, pre- and postoperative Snellen best spectacle-corrected visual acuities (BSCVA), pre- and postoperative refraction, and endothelial cell count, as well as complications.

Operative Technique

All procedures were performed under sedation with intravenous droperidol 3-ml administered immediately before peribulbar local anesthetic injection (50% mixture of 2% lidocaine and 0.5% bupivacaine).

Each donor cornea was placed on an artificial chamber (ALTK System, Moria, Antony, France). Microkeratome-assisted removal of approximately two thirds of the anterior corneal stroma from the

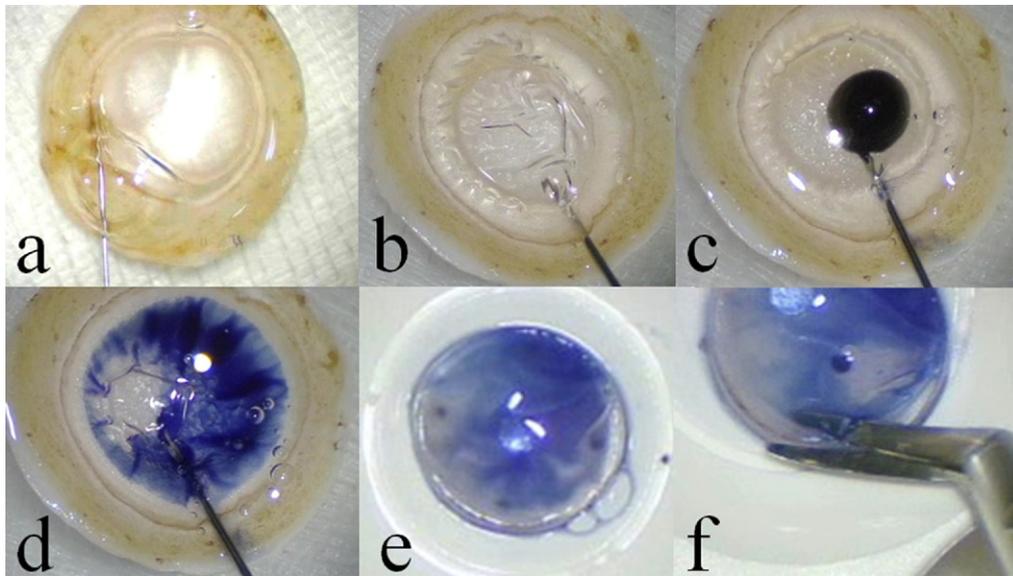


Figure 1. A, Pneumatic dissection of Descemet's membrane and endothelium. B, Partial bubble collapse achieved by aspirating a small amount of air with a 25-gauge needle. C, Trypan blue is injected into the residual air bubble using the same needle. D, The remaining air is aspirated allowing the trypan blue to delineate the area of pneumatic dissection. E, Eccentric punching of the donor results in a peripheral "sickle" of stromal tissue. F, The "sickle" is dissected free from the underlying stroma using curved scissors.

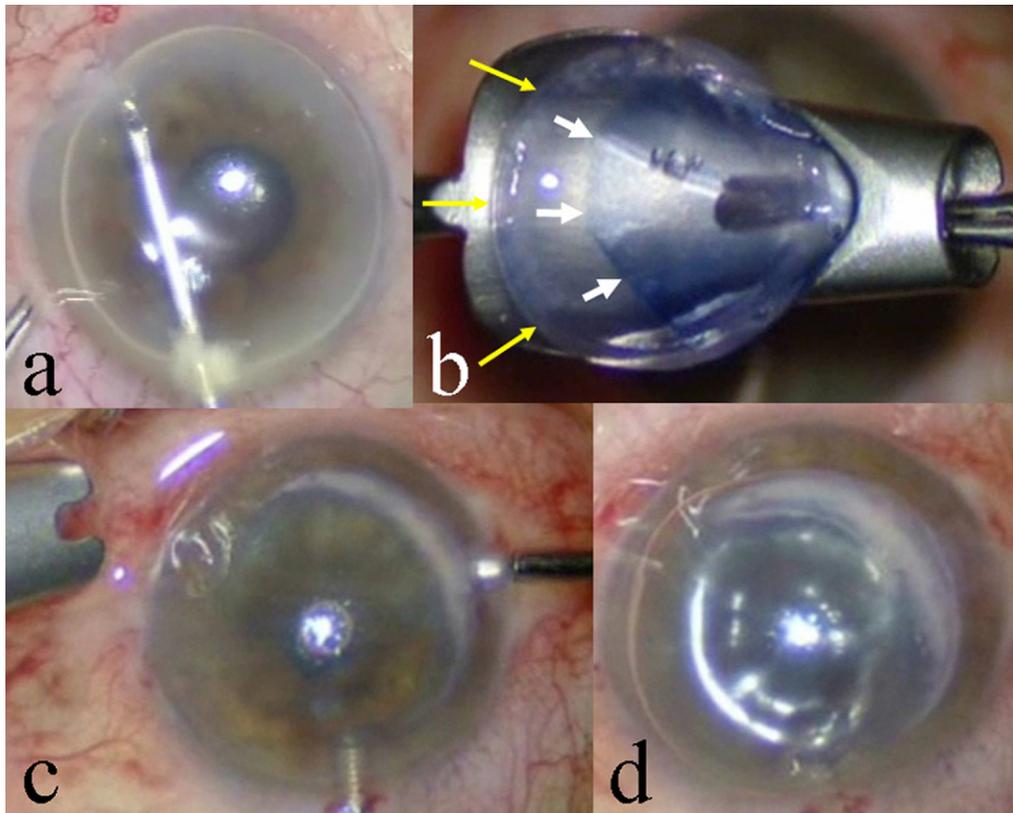


Figure 2. A, Descemetorhexis with air-filled anterior chamber. B, The endothelial graft (white arrows) is selectively grasped with the forceps leaving behind the underlying stromal support (yellow arrows). C, The graft unfolds spontaneously before disengagement of the forceps. D, Air fill before suturing of the corneal wounds.

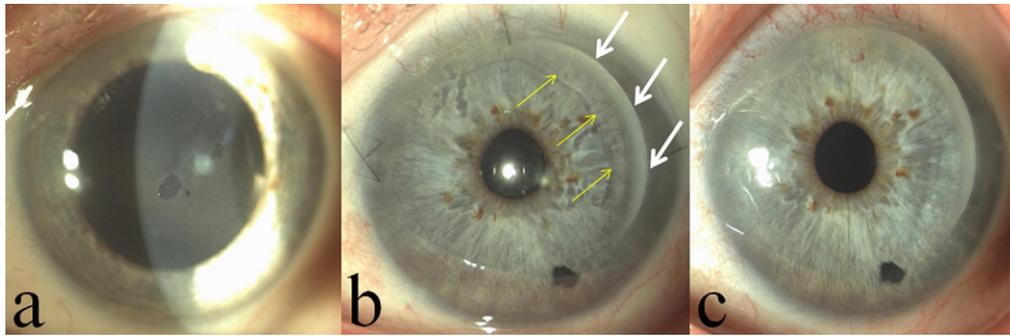


Figure 3. A, Preoperative appearance with bullous keratopathy. B, Two weeks postoperative appearance with visible “sickle” edge (white arrows) and transition edge between stroma and Descemet’s/endothelium (yellow arrows). C, Six weeks postoperatively, only the “sickle” edge remains faintly visible.

donor cornea was carried out using the 300- μm microkeratome head (as for DSAEK surgery). Pneumatic dissection was used to detach Descemet’s membrane and endothelium from the overlying stroma (Fig 1A).² The ensuing steps are also illustrated in the video (available online at <http://aaojournal.org>). After pneumatic dissection, part of the air bubble was aspirated by means of a 25-gauge needle mounted on an empty syringe until a partial collapse was achieved (Fig 1B). The same needle was used to inject a small amount of trypan blue into the bubble (Fig 1C) and



Figure 4. The central portion consisting of Descemet’s membrane and endothelium is detached (arrows) whereas the peripheral ring of stroma remains attached.

subsequently the residual air in the bubble was aspirated (Fig 1D). As a result of the total bubble collapse, the trypan blue stains and hence outlines the portion of detached Descemet’s membrane. This allowed precise punching of the donor tissue.

An appropriately sized trephine was then used to punch the detached Descemet’s and endothelium in an eccentric fashion so as to include a sickle of stroma (Fig 1E). The “sickle” of stroma was then carefully dissected from the underlying stroma using curved scissors (Fig 1F). The recipient eye was prepared as per routine DMEK surgery. A descemetorhexis (Fig 2A) and peripheral iridotomy were carried out and an anterior chamber maintainer placed at the 12 o’clock position.

The graft was loaded onto the Busin glide (Moria) for insertion as previously described.³ However, in this case the Descemet’s membrane and endothelium are selectively grasped by the stromal edge with microforceps, leaving behind the stromal support (Fig 2B). After the spontaneous unfolding of the graft (Fig 2C), the anterior chamber maintainer was removed and the graft centered by either gentle tapping or manipulating the graft using a blunt cannula in the interface. Air was injected posterior to the graft (Fig 2D) and all wounds secured with 10.0 nylon sutures. Finally, a 30-gauge needle was used to achieve a complete air fill. At the end of surgery, gentamicin (40 mg) and methylprednisolone acetate (40 mg) were injected subconjunctivally.

Postoperatively, all patients received 2 hourly tobramycin 0.3% and dexamethasone 0.1% combination drops, which were gradually tapered to once daily over 4 to 6 months. In all patients with glaucoma, topical antihypertensive treatment was adjusted as required to maintain an adequate level of intraocular pressure. Sutures were removed between 4 and 6 weeks postoperatively.

Results

The average age of the 10 patients (7 females, 3 males) was 63 years. All patients had had previous uneventful phacoemulsification with implantation of a posterior chamber intraocular lens. A single surgeon (MB) performed all DMEK procedures according to the technique described. Preoperative best spectacle-corrected visual acuity was $\leq 20/100$ in all patients. The average operating time was 50.7 minutes (range, 43–60). All surgeries were uneventful and complete attachment of the endothelial graft was achieved at the end of the procedure in all patients.

On the first postoperative day, detachment of the endothelial part of the graft was seen in 2 of 10 patients and reattachment was achieved by renewed air bubble injection into the anterior chamber.

The average follow-up was 8.4 months (range, 6–12). No significant change in refractive spherical equivalent was noted

Table 1. Patient Demographics, Operative Time, Pre- and Postoperative Data, and Follow-up

Patient No	Age/Gender	Preoperative BSCVA	Preoperative ECC	Preoperative SE	Operative Time (min)	Postoperative BSCVA	Postoperative ECC	Postoperative SE	Follow-up (mos)
1	62/M	20/200	2500	-2.5	47	20/25	1876	-2.25	12
2	59/F	20/400	2600	-1.5	60	20/25	1820	-1.5	6
3	66/F	20/200	2700	0.5	44	20/25	1783	0	6
4	61/F	20/100	2300	0	47	20/30	1849	0.25	12
5	58/F	20/120	2900	1.0	51	20/25	1888	0.75	6
6	62/F	20/400	2600	-1.75	57	20/40	1765	-1.5	9
7	58/M	20/200	2600	3.0	43	20/25	1990	3.25	6
8	65/F	20/100	2700	-0.25	55	20/20	2001	0	6
9	67/M	20/100	2500	-2.0	48	20/20	2298	-1.5	9
10	72/F	20/120	2500	1.0	55	20/30	2307	1.0	12

BSCVA = best spectacle-corrected visual acuity; ECC = endothelial cell count; F = female; M = male; SE = spherical equivalent.

(-0.10 ± 0.29 diopters; $P = 0.31$). After suture removal, BCVA was $\geq 20/30$ in 9 of 10 patients and 20/40 in 1 patient. In all cases, the absolute value of astigmatism was within 0.5 diopters of the preoperative value. The average endothelial cell loss 6 months postoperatively was $22.1 \pm 10.3\%$ and $24.1 \pm 9.79\%$ at final follow-up. Figure 3A–C shows the pre- and postoperative appearances. Results of the case series are summarized in Table 1.

Discussion

We have demonstrated in the past that pneumatic dissection can be used to obtain donor grafts consisting purely of Descemet's membrane and endothelium.² With this method, the donor endothelium, although detached, cannot roll onto itself because its periphery remains attached to the deep stroma until the time of surgery. In addition, linear, focal, and irregular peripheral loss of endothelial cells, which have been all documented after stripping of the endothelium, is avoided.^{4,5} After the donor graft is punched to the desired size, the underlying stroma is still instrumental in providing a cushion while transporting the endothelium from the preparation site to the point of delivery into the eye. However, upon removal from the stromal carrier and insertion into the eye, the donor tissue maintains its tendency to roll onto itself making proper positioning and fixation difficult. If prolonged manipulation is required, identification of the endothelial side may also become impossible.

As DSAEK does not pose these problems, we attempted to develop a procedure incorporating its advantages with the optimal optics of DMEK with pneumatic dissection. As a result, we conceived the idea of a donor graft consisting of 2 parts: (1) A peripheral portion made of deep stroma, Descemet's, and endothelium that serves the purpose of maintaining the advantages of DSAEK (ease of manipulation and delivery, as well as possibility of marking) and (2) a central, optical portion of only Descemet's and endothelium not different from the donor tissue used in DMEK.

In 2006, we prepared 5 endothelial grafts, 9 mm in diameter, with a central 6 mm portion of pure Descemet's and endothelium and a peripheral ring of stroma 1.5 mm in width. A similar type of graft, although of a different size, has been described by Studeny in 2008 (didactic course at the annual

American Academy of Ophthalmology meeting in Atlanta). The use of this type of graft has also been reported recently by McCauley et al.⁶ In our series, all grafts were attached initially, but the central area (endothelium and Descemet's) detached within 1 to 2 days of surgery, when most of the air was reabsorbed and the tamponading effect was lost. Repeat attempts at reattaching the central portion of the graft by rebubbling failed in all cases (Fig 4). We thus improvised on this technique to develop the "sickle"-shaped peripheral stromal support, which is technically easier to prepare and maintains all the advantages of the original concept.

No complications were encountered in preparing the graft with pneumatic dissection. When the bubble extends into the periphery further than desired, trephination must be carried out more eccentrically, possibly including the corneoscleral region. The resulting "sickle" would hence be more evident, especially in the early postoperative period, but fade away over the following 2 to 3 weeks. However, as opposed to conventional DMEK procedures, eccentric punching of the donor tissue includes the peripheral endothelium, which has a higher density than the central portion. Therefore, a higher density of endothelium is transplanted.

None of the patients in this series experienced any visual complaints owing to the presence of the peripheral "sickle." However, the surgeon may wish to rotate the graft to ensure that the "sickle" is positioned superiorly, thus minimizing possible visual disturbances. The stromal support also allows the surgeon to mark the graft to aid orientation, which reduces the likelihood of excessive manipulation and upside down transplantation, both of which may cause donor failure.⁷

In all cases, the handling, insertion, and attachment of the tissue was similar to that experienced in DSAEK surgery. The frame of stromal support ensured that the graft remained flat throughout preparation and delivery and allowed the graft to unfold spontaneously upon insertion into the eye.

Two patients required rebubbling to achieve graft attachment. Both patients had a complete air fill 2 hours postoperatively and required partial release of the air to avoid a pupillary block and Urrets Zavalía syndrome. Thus, inadequate tamponade may have led to the early detachment in these patients. All patients eventually had successful postoperative attachment of the graft and improvement in best

spectacle-corrected visual acuity at final follow-up. No significant change in refractive spherical equivalent was noted. Also, visual rehabilitation and outcomes were equivalent to those of conventional DMEK surgery.¹

This technique is considerably quick; preparation of donor tissue is simplified and the tissue handling and insertion is similar to that of DSAEK. Although no comparable data exist on operating time for DMEK surgery, in our experience DMEK without stromal support requires at least 1.5 to 2 hours. The shorter surgical time favors the use of local anesthesia, which in addition to allowing a swift postoperative recovery, also allows the procedure to be offered to patients unsuitable for general anesthesia.

Endothelial cell loss at final follow-up was comparable to that reported at 6 months for conventional DMEK and lower than earlier endothelial keratoplasty techniques.⁸ The cell loss may be attributable to numerous factors, although it is expected to improve as the surgeon surpasses the learning curve phase.

We expect that the above advantages and the ease with which the technique can be carried out would facilitate uptake of DMEK surgery.

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Footnotes and Financial Disclosures

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