Simple, Inexpensive, and Effective Injector for Descemet Membrane Endothelial Keratoplasty

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Purpose: We describe an inexpensive, simple, and effective endothelium–Descemet membrane (EDM) graft injector assembled from regular operating room supplies in Descemet membrane endothelial keratoplasty (DMEK).

Methods: To assemble the injector, standard intravenous tubing was cut approximately 2 inches from the Luer lock end, leaving a steep bevel. The cut end of the tubing was firmly wedged bevel up and advanced into the back of an Alcon IOL B cartridge. The Luer lock end of the tubing was then attached to a 5- or 10-mL syringe filled with BSS Plus. The EDM graft was then placed into a Petri dish filled with BSS. After the graft was sucked into an injector with bevel-side up under the surgical microscope, the graft was then inserted into the anterior chamber with the injector through the main incision in the superotemporal quadrant.

Results: In seven eyes of seven patients with Fuchs endothelial corneal dystrophy treated with DMEK using our injector, clear attached grafts and improved visual acuity were achieved.

Conclusions: This simple, inexpensive, and effective injector is a safe and viable device to facilitate this part of DMEK surgery.

Key Words: corneal endothelium, Descemet membrane, Descemet membrane endothelial keratoplasty, DMEK injector

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Endothelial keratoplasty has become an alternative to penetrating keratoplasty in the management of corneal endothelial disorders in the last decade.[1,2] Endothelial keratoplasty procedures, in particular Descemet stripping (automated) endothelial keratoplasty, have become preferred over penetrating keratoplasty because the absence of corneal surface incisions or sutures decreases postoperative astigmatism and increases safety.[1] Descemet membrane endothelial keratoplasty (DMEK) may provide faster and more complete visual rehabilitation in a majority of cases, potentially higher graft survival with larger-diameter transplants, a more efficient use of donor corneal tissue, and a lower graft rejection rate than does Descemet Stripping Automated Endothelial Keratoplasty (DSAEK).[3,4] Despite excellent outcomes of DMEK, technical issues associated with both donor preparation and insertion of endothelium–Descemet membrane (EDM) grafts and intraocular manipulation make the transition from DSAEK to DMEK challenging.[5]

Previous reports describe the efforts to ameliorate these technical issues.[6,7] Studeny et al[6] reported the preparation and transplantation of posterior corneal lamellae consisting of the endothelium and bare Descemet membrane (DM) with a stromal rim (DMEK-S) to prevent EDM scroll formation. However, loss of donor corneas occurred at a relatively high rate (5%–10%).[6] Dapena et al[7] described a "no-touch" technique for DMEK, facilitating implantation, orientation, unrolling, centering, and apposing of DMEK grafts using a glass injector and the Dapena maneuver.

Despite the growing number of reports describing the intraocular manipulation of DMEK graft tissue, there is a relative paucity of information describing methods of graft insertion, particularly addressing the difficulties arising from inadequate fluid control and volume as occur when encountering positive pressure during graft insertion. Thus, we describe a novel, simple, inexpensive, and safe EDM injector for the insertion of DMEK graft tissue into the anterior chamber.

SURGICAL TECHNIQUE

Operations were performed under sub-Tenon anesthesia by a single surgeon (A.S.J.). Previous steps of the procedure were performed through a 2.75-mm clear corneal keratome incision and included the scoring of the DM at 8.0 mm, removal of the DM, and scraping of the peripheral recipient stromal bed as described previously.[8] All patients underwent an intraoperative inferior peripheral iridectomy. In 6 out of 7 cases, combined phacoemulsification with intraocular lens (IOL) implantation was performed before any steps of the DMEK procedure.

To assemble the injector, standard intravenous tubing (part number MX451FL; Smiths Medical, Dublin, OH) was cut using drape scissors approximately 2 in. from the Luer lock

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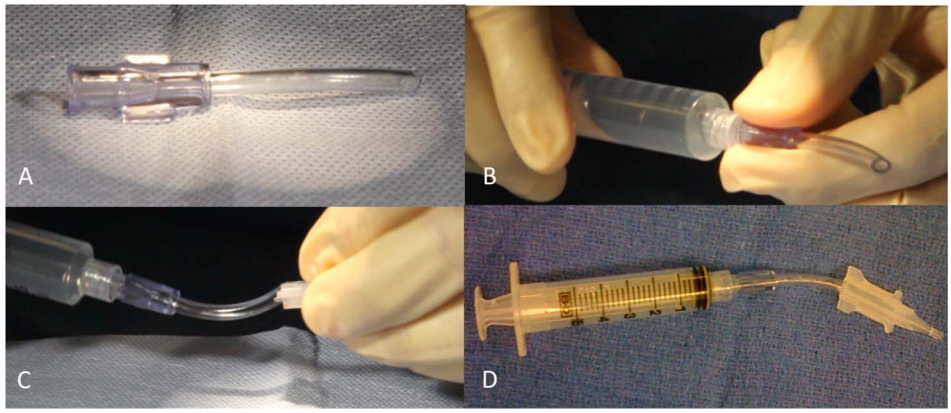

FIGURE 1. DMEK injector assembly. A, The intravenous tubing was cut with drape scissors approximately 2 to 3 in from the Luer lock end. B, The syringe filled with BSS Plus was connected to the tubing. C, Appearance after the cut end of the tubing was wedged into the back of an Alcon IOL B cartridge. D, Assembled injector.

end, leaving a steep (~30° from the vertical) bevel (see video, Supplemental Digital Content 1, http://links.lww.com/ICO/A218). The thumb and index finger were used to compress the tubing bevel to reduce its vertical height, and the cut end of the tubing was briefly dipped into saline and then firmly wedged bevel up into the back of an Alcon IOL B cartridge (Alcon, Fort Worth, TX; Fig. 1). The tubing was advanced as far as possible into the B cartridge. The Luer lock end of the tubing was then attached to a 5- or 10-mL syringe filled with BSS Plus (Alcon). The tubing and the IOL cartridge were irrigated with BSS Plus by depressing the syringe plunger. This allowed space in the syringe for aspiration of the graft in a subsequent step. Because individual syringes can vary in how easily the plunger moves, at this point, it is advisable to use the device to aspirate and irrigate the pathologic DM (either as an intact or as a smaller portion), which had been removed from the patient and placed aside in a reservoir of sterile saline. If the resistance to the plunger movement does not allow the tissue to load and unload in a slow, controlled fashion, a new syringe should be used.

DMEK donor tissue, which had been predissected inside Schwalbe line except for a 1- to 2-o'clock-hour area of attachment, was obtained from Lions VisionGift (Portland, OR). After trephination at an 8-mm diameter using a standard disposable trephine system, the graft was grasped at its edge with smooth tying forceps, peeled completely from the underlying corneoscleral rim, and stained in trypan blue for 10 seconds. The graft was then placed into a Petri dish filled

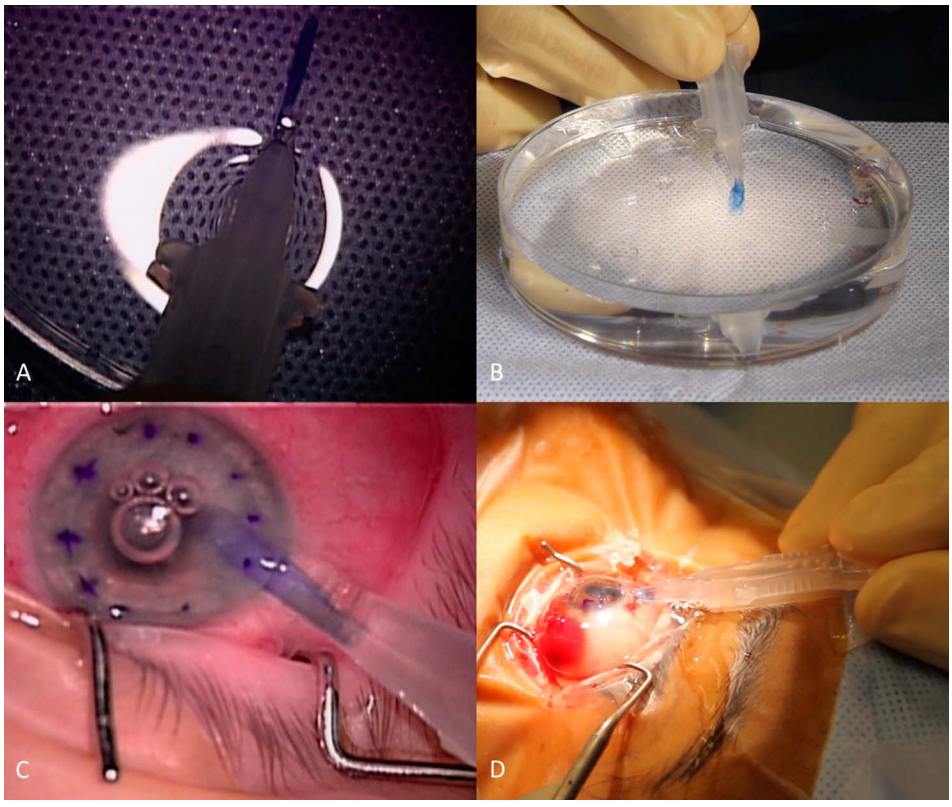

FIGURE 2. Loading the graft into the injector and inserting into the anterior chamber. A and B, Using a gentle negative pressure on the syringe, the EDM graft was aspirated into the injector with the bevel side up. C and D, The injector is inserted fully into the main wound, and with a gentle depression of the syringe plunger, the EDM graft is irrigated into the anterior chamber.

momentarily with BSS Plus. Under the surgical microscope, the open end of the injector was placed bevel up in line with the graft at one end, and the graft was gently aspirated into the IOL cartridge (Fig. 2). Ideally, this was done in a slow and controlled fashion taking care to keep the graft closer to the anterior half of the IOL cartridge. If the graft assumed a position toward the posterior end of the IOL cartridge (closer to the syringe), gentle irrigation would be performed to advance the graft into the anterior half closer to the open end. Once the graft was positioned appropriately within the IOL cartridge, care would be taken to keep the IOL cartridge below the level of the syringe (ie, "right side up") and to not inadvertently depress the plunger.

After repositioning the surgical microscope over the eye and ensuring a deep saline-filled anterior chamber, the injector was inserted into the main wound, which had been enlarged slightly (0.1–0.2 mm) to allow a snug but easy entry (Fig. 2). Once the injector was fully inside the eye (ie, beyond the inner os of the wound, the anterior chamber may have appeared shallow during this step), gentle pressure was applied to the syringe plunger to deepen the anterior chamber and deliver the graft into the eye. Once the graft was inside the eye, additional gentle plunger pressure (ie, irrigation) was applied to prevent reflux of the graft while the injector was quickly removed from the wound. During graft insertion and removal of the injector, care should be taken to not overfill the anterior chamber, which can lead to graft ejection. At this point, a single interrupted suture was placed across the main wound. The graft was unfolded and attached using air and saline as previously described.[7] After a 10-minute waiting period during which the anterior chamber was completely filled with air and the intraocular pressure was estimated to be 20 to 30 mm Hg by palpation, a small amount of air was released to maintain a full air fill but to reduce the intraocular pressure to approximately 10 to 20 mm Hg by palpation. The patient was taken to the recovery room and kept supine for 2 hours and was kept upright for 10 minutes, after 1 hour. The patient was then discharged home and instructed to remain supine for 48 hours other than the specified 10-minute periods during which the patient was kept upright to prevent pupillary block. Starting at the postoperative day 1 visit, standard postoperative topical corticosteroids and antibiotics were applied to the operated eye.

RESULTS

In the first 7 eyes of 7 patients with Fuchs endothelial corneal dystrophy treated with DMEK using our injector, clear attached grafts and improved visual acuity were achieved. All eyes achieved a best spectacle-corrected visual acuity (BCVA) of 20/25 or better, and 71% (5 eyes) reached 20/20 after surgery. The mean percentage of endothelial cell loss was 28% ± 16% (follow-up range, 3–11 months, Table 1). Patients 2 and 7 associated with a higher endothelial cell loss were noted to have longer times for intraoperative unfolding and attachment resulting in more surgical manipulation. Four of 7 eyes (57%) resulted in partial detachments requiring additional air injection and supine positioning, and no eyes required >1 repositioning procedure to achieve complete corneal clearing and attachment of the DMEK graft.

DISCUSSION

DMEK can provide better visual recovery and more predictable refractive outcomes with comparable endothelial cell loss when compared with DSAEK.[9] However, DSAEK is preferred by some surgeons because donor preparation, insertion, and intraocular manipulation can be difficult to learn and perform. Regarding graft insertion, a custom-made injector (Hippocratech, Rotterdam, the Netherlands) has been described for the insertion of EDM grafts into the anterior chamber by Melles et al.[10] An injector cartridge for the implantation of IOLs has commonly been used by several surgeons.[5,11] However, these methods have various shortcomings, including times when the graft tissue is unsupported by surrounding fluid and comes into direct contact with the surface of the injector. In addition, difficulties arising from inadequate fluid control and volume as occur when encountering positive pressure during graft insertion can result in the incomplete insertion of the graft tissue, requiring substantially greater contact with the graft tissue as it is manipulated into the eye.

With the injector described here, we were able to load the device while avoiding any moments when the graft was unsupported by surrounding fluid. Further, the "closed" system and the attached syringe provide increased fluid control and volume to allow the simultaneous and prolonged

TABLE 1. Preoperative and Postoperative Characteristics in DMEK

Patient	Age	Sex	Eye	Preoperative Visual Acuity	Postoperative Visual Acuity	Specular Microscopy Date (Postoperative), mos	Preoperative Donor Endothelial Cell Count (cells/mm²)	Postoperative Patient Endothelial Cell Count (cells/mm²)	Preoperative Cell Count, %	Repositioned
1	69	F	OD	BCVA, 20/200	BCVA, 20/25	5	3333	3115	93.5	Yes
2	65	M	OD	UCVA, 20/70	UCVA, 20/20	9	3413	1560	45.7	Yes
3	59	M	OD	BCVA, 20/25	BCVA, 20/20	4	3425	2571	75.1	No
4	61	F	OS	UCVA, 20/70	UCVA, 20/20	8	2833	2135	75.4	Yes
5	63	F	OD	BCVA, 20/40	BCVA, 20/25	3	2770	2273	82.1	Yes
6	46	F	OS	BCVA, 20/30	BCVA, 20/20	11	3096	2320	74.9	No
7	62	F	OS	BCVA, 20/60	BCVA, 20/20	3	2674	1555	58.2	No

OD, right eye; OS, left eye; UCVA, uncorrected visual acuity.

deepening of the anterior chamber with a reduced likelihood of incomplete insertion. Although our study is of a small scale, our results compare well with those of a larger published series of DMEKs, with all our cases reaching a BCVA of 20/25, and 71% (5 eyes) reaching 20/20 after surgery. In addition, our mean endothelial cell loss value of 28% ± 16% compares favorably with others' results. Guerra et al[12] reported an endothelial cell loss of 36% ± 20% at 1 year, with most of the loss being observed during the first 3 months after surgery. Price et al[11] reported a reinjection rate of 63% in a series of 60 eyes. In our patients, reinjection of air with repeat positioning occurred in 57% of eyes, which compares well with that in the Price et al series.

Although some surgeons feel strongly that glass injectors reduce endothelial cell loss compared with plastic injectors, information available from the literature may inadequately address this issue for a variety of reasons. First, published reports include different surgical techniques, different points on the surgeon learning curve, and different types of injectors of either material. Perhaps of greater importance than the material of the injector is whether a closed or open fluid system is used. Some widely described plastic injectors are modified IOL inserters that do not allow the continuous support of the graft tissue by fluid or even use a plunger that makes direct contact with the graft. Our device described here uses a closed system as do previously described glass injectors, in which contact between the graft and injector material is minimized. Supporting this possibility is the 28% endothelial cell loss presented in our series, which, although admittedly small, compares well with the 19% to 29% cell loss at 6 months presented in a larger series using a glass injector by Ham et al.[13]

The potential pitfalls of our device derive from the lack of a complete seal between the tubing and the IOL cartridge, which is reduced by inserting the tubing as far into the cartridge as possible. This incomplete seal creates a small amount of leakage or backflow current, which can become problematic if the inserter is positioned "upside down," with the IOL cartridge above the syringe after loading the graft, or if the graft assumes a location in the posterior half of the cartridge. In the latter case, the graft tissue can get caught in the backflow current of the fluid leaking between the cartridge and the tubing as the plunger is depressed, and as a result, the graft can move in a retrograde fashion during attempted insertion.

Despite these shortcomings and the likely commercial availability of DMEK injectors that use a closed system and a larger volume reservoir to allow "no-touch" loading and avoid incomplete insertions, we feel that our device is and will remain a good option for surgeons. In particular, it is inexpensive and is assembled from items readily available in an ophthalmic surgery facility. Furthermore, it is easy to use, and endothelial cell counts seem comparable with those obtained in other techniques. Although it is difficult to directly compare methods of graft insertion, we believe that our simple, inexpensive, and effective injector is a viable device to facilitate this part of DMEK surgery.

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