Descemet’s membrane endothelial keratoplasty (DMEK): outcomes after three years of experience

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OBJECTIVE: Three-year evaluation of outcomes after Descemet’s membrane endothelial keratoplasty (DMEK).

SETTING: Hospital Son Llàtzer and Unidad Oftalmológica Balear in Palma de Mallorca, Spain.

METHOD: Prospective analysis of 85 DMEKs in 70 eyes of 57 patients with Fuchs’ dystrophy and postoperative bullous keratopathy performed from October 2009 to January 2013.

RESULTS: Mean best corrected visual acuity (BCVA) in 48 eyes with no ocular comorbidity was 0.65 at 3 months; 85.42% achieved BCVA ≥ 0.5, and 39.58% achieved BCVA ≥ 0.8. At 3 months, mean cell density was 1455.98 ± 557.91 cells/mm² with mean loss of 47.2% ± 19.29% relative to preoperative graft cell density. Mean cell density was 1224.30 ± 528.11 cells/mm² and 980.79 ± 425.86 cells/mm² at 1- and 2-year follow up, respectively, with mean loss of 55.94 ± 18.35% and 65.03 ± 14.39%. Graft detachment occurred in 19 cases (22.35%). In 10 of these (52.63%) it was reattached by means of air injected into the anterior chamber, while in the remaining 9 cases (47.37%) reattachment was unsuccessful, resulting in total detachment of the transplanted tissue. The reoperation rate in the 70 eyes studied was 17.14% (12 eyes) ± 2.05%, with 46.67 ± 12.05% requiring at least one intervention in the first year, 20.83 ± 4.25% in the second, and none in the third year.

CONCLUSION: DMEK is our treatment of choice for corneal endothelial diseases, enabling us to achieve better visual rehabilitation that has improved steadily over time.

J Emmetropia 2014; 5: 191-199

Posterior lamellar keratoplasty (PLK) has been shown to be superior to penetrating keratoplasty in terms of patient benefits, since it involves selective-tissue corneal transplantation which preserves the patient’s normal corneal architecture. The outcome is rapid visual rehabilitation that eliminates irregular astigmatism, refractive surprises and complications associated with wound healing. Various techniques have been described, including posterior lamellar keratoplasty (PLK), deep lamellar endothelial keratoplasty (DLEK)1, Descemet’s stripping endothelial keratoplasty or Descemet’s stripping automated endothelial keratoplasty (DSAEK)2. These have been shown to be superior to penetrating keratoplasty3 and have steadily evolved over the past 10 years until Descemet’s membrane can be harvested for selective transplantation with its endothelial cells and no stromal tissue.

Pioneered by Gerrit Melles, Descemet’s membrane endothelial keratoplasty (DMEK)4,5 has several indications (shown in Table 1). This technique replaces the diseased Descemet-endothelial layer with a healthy donor Descemet-endothelial layer with no stromal tissue. As a result, visual rehabilitation is faster, and as donor-recipient interface is free of stromal tissue, almost normal visual acuity should be
achieved. The technique, however, has its drawbacks, mainly its complexity. We discuss the most common complication, graft detachment, and analyze the strategies used to resolve this and the outcomes obtained.

In this study, we present our experience in DMEK procedures performed since October 2009 to January 2013 in the Hospital Son Llàtzer and the Unidad Oftalmológica Balear in Palma de Mallorca.

MATERIAL AND METHODS

A total of 85 DMEK endothelial keratopathy procedures performed on 70 eyes from 57 patients with Fuchs’ endothelial dystrophy and/or secondary bullous keratopathy were studied. The patient population comprised 23 men (40.35%) and 34 women (59.65%) with a mean age of 72 (range 52-90). Mean follow up time was 15.04 ± 9.97 months (3-38 months). Inclusion criteria were: Fuchs’ endothelial dystrophy or bullous keratopathy secondary to trauma, prior surgery and angle closure. Patients with stromal opacities compromising visual rehabilitation were excluded. As far as surgical indications were concerned, 49 patients presented Fuchs’ endothelial dystrophy, 19 had postoperative bullous keratopathy and 2 had presumptive herpes simplex endothelitis. Transplant-quality grafts were determined to be donor tissue with an endothelial cell density of over 2400 cells/mm²; transplantation was performed on the same day donor Descemet’s membrane was stripped.

Table 1. Indications for DMEK

- Fuchs’ endothelial dystrophy
- Aphakic and pseudophakic bullous keratopathy
- Posterior polymorphous dystrophy
- Congenital hereditary endothelial dystrophy
- Iridocorneal endothelial syndrome
- Endothelial failure due to trauma, prior surgery and angle closure
- Failed penetrating keratoplasty
  (if acceptable refractive results were achieved)
- Failed DSAEK

Statistical analysis

Descriptive analysis of variables was performed using SPSS 190 (SPSS Inc. Chicago, IL, USA). Quantitative variables were expressed as mean ± standard deviation. Categorical variables were expressed as frequencies and/or percentages.

Surgical technique

Corneas were received directly from the Fundació Banc de Sang i Teixits de les Illes Balears (FBSTIB) blood and tissue bank in the Balearic Islands. These corneas have a corneo-scleral rim of 18 mm and have been stored in EUSOL-C at 4 °C for no longer that 1 week (2-7 days) prior to surgery. We verified the endothelial cell count previously performed by the tissue bank, where endothelial cell morphology was studied using Konan Specular Microscope. Grafts with over 50% hexagonal cells and mean density > 2500 were accepted for transplantation. Transplant-quality grafts were determined to be donor tissue with an endothelial cell density of over 2400 cells/mm²; transplantation was performed on the same day donor Descemet’s membranes (DM) were stained for 10 seconds with trypan blue 0.06% (VisionBlueTM, D.O.R.C International), after which the supernatant was removed with a sponge and membrane dissection was performed using a crescent knife, pulling the membrane away from the corneo-scleral ring of the donor button, as described by Melles et al. Donor corneas were partially trephined using an 8.5 to 9 mm Barron trephine, and once the membrane had been completely removed, the Descemet’s roll was placed in balanced salt solution (BSS). It was then loaded into a glass pipette and set aside.

Sub-Tenon’s anesthesia was administered with 1 ml of 5% lidocaine combined with 1% intracameral anesthesia. Using a 15° knife, 3 paracentesis sites were created at the 10, 2 and 7 o’clock positions in the right eye, or at 5 o’clock in the left. The desired descemetorhexis diameter was marked using an 8-9 mm Janach DSAEK marker (J2296.20). A flat 30G cannula was inserted through 1 paracentesis to fill the anterior chamber with air, and descemetorhexis was performed using a John DMEK-DSAEK dexatome spatula (Asico, Westmont, IL, USA, AE 2872). If the anterior chamber could not be stabilized with air, descemetorhexis was performed under low continuous flow irrigation using a Janach irrigation/aspiration cannula (J2238.2).

The main 2.75 mm incision was made at the 12 o’clock position and the Descemet’s roll was inserted into the anterior chamber through a glass pipette. We initially used a 2 mm-tip pipette (VWR Co), but more recently switched to the pipettes included in the Melles set (DORC, DO50.2200). The graft was positioned using air and BSS, checking its orientation by means of the Moutsouris sign, and a small bubble of air was injected on top of the membrane, inside one of the rolls. The graft was then unrolled and centered using the Dapena maneuver. Once unrolled and centered, the bubble on
the Descemet’s membrane was aspirated, maintaining the cannula in the center of the bubble, and then with the cannula under the donor membrane a small air bubble was injected to elevate the membrane and bring it into contact with the posterior stroma of the recipient eye. The air bubble was gradually enlarged, taking care to prevent the edges from folding in on the recipient stroma. The edges can be unrolled by making small indentations with the cannula on the corneal surface overlapping the edge. Finally, the anterior chamber completely was filled with air.

The air was left in the chamber for 45-60 minutes to prevent detachment of the graft, after which 50% was replaced with BBS. After surgery, patients were instructed to remain in a supine position for 24 hours.

Postoperative care

Topical postoperative care included administration of combination antibiotic plus corticosteroid (tobramycin/ dexamethasone) eye drops (1 drop every 8 hours) for the first month, followed by 0.1% fluorometholone (1 drop every 8 hours) for at least 1 year, based on the corneal clearance and provided secondary ocular hypertension was absent.

Patients were followed up 1 day post-surgery, then at 3 days, 1 week, 1 month, 3 months and every 6 months thereafter. At each follow up best corrected visual acuity (BCVA) was measured and, biomicroscopy, tomometry and funduscopy were performed, together with corneal endothelial microscopy with a Topcon SP-2000P specular microscope (Topcon Corp. Tokyo, Japan). Whenever required, a corneal examination was carried out in the immediate postoperative period by means of anterior segment optical coherence tomography (RTvue, Optovue Inc, Fremont, CA USA).

RESULTS

Visual acuity

Of the 70 eyes studied, 22 (31.42%) had an ocular comorbidity that compromised the visual outcome: 4 with age-related macular degeneration (ARMD), 3 with optic neuropathy, 3 with advanced glaucoma, 1 with maculopathy due to myopia magna, 1 with injury-related macular alteration, 2 with retinal detachment, 6 with DMAE, 1 with epiretinal membrane, and 1 with amblyopia. In the 48 eyes with no ocular comorbidity, of which 29 were from women and 19 from men (mean age 67 years; range 45-85), visual acuity gradually improved over the course of the first year post-surgery, achieving a BCVA of 0.65 on the decimal scale at three months, 0.71 at 6 months, and 0.77 at 12 months (range 0.03-1.00). This visual acuity was maintained in the 9 patients undergoing 3-year follow up (Figure 1), of which 39.58% achieved BCVA ≥ 0.8 at three months, 50% at six months, and 64.52% at 1 year (Figure 2), while 85.42% obtained BCVA ≥ 0.5 at 3 months, and more than 90% during the first year. Table 2 shows visual acuity obtained over the 3-year follow up period.

Cellular density

Of the 64 eyes suitable for cellular density (CD) measurement, mean donor CD was 2811.30 ± 280.58 cells/mm², with a mean cell count of 1455.98 ± 577.91 cells/mm² at 3 months post-surgery, giving a cell density loss rate of 48.22% (Figure 3). Mean CD was 1224.30 ± 528.11 cells/mm² and 980.79 ± 425.86 cells/mm² at 1- and 2-year follow up, respectively, giving a mean loss of 55.94% and 65.03%. Table 3 shows the evolution of endothelial cell density.

<table>
<thead>
<tr>
<th>Table 2. BCVA during follow up</th>
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<tbody>
<tr>
<td><strong>BCVA (mean ± error)</strong></td>
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<tr>
<td>Pre-surgery</td>
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<tr>
<td>1 week</td>
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<tr>
<td>1 month</td>
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<td>3 months</td>
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<td>6 months</td>
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<td>12 months</td>
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<tr>
<td>18 months</td>
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<tr>
<td>24 months</td>
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<tr>
<td>30 months</td>
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</table>

BCVA: Best Corrected Visual Acuity, n: number of cases
Postoperative complications

Graft detachment

Of 85 procedures performed, graft detachment occurred in 19 cases (22.35%). In 10 (11.76%) of these (52.63%) it was reattached by means of air injected into the anterior chamber, while in the remaining 9 cases (10.59%) reattachment was unsuccessful, resulting in total loss of the graft. In these cases, the DMEK procedure was repeated in a new operation (Figure 4). In general, 84.21% of Descemet's membrane (DM) detachment occurred in the first 30 cases.
DM detachment is usually seen under slit lamp examination. However, in the presence of a corneal edema large enough to obstruct visualization, the examination was performed by anterior segment optical coherence tomography, which revealed the site of the detachment, facilitating the choice of the most appropriate strategy.

Reoperation

Of the 70 eyes undergoing DMEK, reoperation was required in 17.14 ± 2.05% of eyes. In all cases, DMEK was repeated and was successful after a single intervention in 10 of the 12 eyes. Reoperation was required due to primary graft failure in 5 eyes, and due to complete MD detachment in 7 eyes.

Analyzed by years, the reoperation rate was 46.67 ± 12.05% in the 15 eyes treated the first year, 20.83 ± 4.25% in the 24 eyes treated in the second year, and zero (0%) in the 31 treated in the final 18 months (Figure 5).

Allograft rejection

Keratic precipitates were observed in 2 cases, in the first at 1 month post-surgery, and in the second at 18 months. Precipitates were attributed to allograft rejection, and in both cases, it was resolved with corticoid therapy (fluorometholone), which was maintained as preventive treatment twice a day. It is important to note that visual acuity was not impaired in either case.

### Table 3. Evolution of Endothelial Cell Density

<table>
<thead>
<tr>
<th></th>
<th>CD</th>
<th>MAX</th>
<th>MIN</th>
<th>SD</th>
<th>ERROR</th>
<th>n</th>
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<td><strong>DONOR</strong></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Mean CD</td>
<td>1455.98</td>
<td>2739</td>
<td>509</td>
<td>557.91</td>
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<td>% CD loss</td>
<td>48.22%</td>
<td>84.19%</td>
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<td>19.29%</td>
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<td>Mean CD</td>
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<td>433</td>
<td>582.42</td>
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<td>% CD loss</td>
<td>52.91%</td>
<td>84.45%</td>
<td>-27.38%</td>
<td>19.91%</td>
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<td>% CD loss</td>
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<td>18.35%</td>
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<td>Mean CD</td>
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<td>2259</td>
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<td>23.47%</td>
<td>18.11%</td>
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<td>Mean CD</td>
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<td>65.03%</td>
<td>88.09%</td>
<td>37.83%</td>
<td>14.39%</td>
<td>3.85%</td>
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<tr>
<td>Mean CD</td>
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<td>1681</td>
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<td>435.52</td>
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<tr>
<td>% CD loss</td>
<td>66.16%</td>
<td>89.66%</td>
<td>39.45%</td>
<td>14.86%</td>
<td>4.95%</td>
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<tr>
<td>Mean CD</td>
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<td>904</td>
<td>470</td>
<td>201.76</td>
<td>100.88</td>
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<td>74.26%</td>
<td>84.58%</td>
<td>67.62%</td>
<td>7.85%</td>
<td>3.92%</td>
<td>4</td>
</tr>
</tbody>
</table>

DC: Cell Density, MAX: maximum sample value, MIN: minimum sample value, SD: standard deviation, n: number of cases, % CD loss: percentage cell density loss
**Other complications**

The most noteworthy among the complications observed were: one case in which traces of the recipient DM were found in the donor DM interface, although this did not impair final visual acuity or graft survival; two cases of cystoid macular edema, most probably secondary to the surgical procedure. All these were resolved with intravitreal triamcinolone. After these two cases, we currently use 1 drop of 0.1% diclofenac sodium every 8 hours for 6 weeks in the immediate postoperative period. In 5 cases, peripheral folds or extensions were observed that were not really a complication; a local edema was observed at the detachment site, and was ultimately resolved. One case of late failure was found in a patient with a previous trabeculectomy who during the DMEK post-operative period presented decompensation of intraocular pressure that required a repeat trabeculectomy, which ultimately caused late failure of the DMEK at 6 months post-surgery. In this case, a repeat DMEK was performed, with no further complications. Two cases of increased intraocular pressure were observed due to pupillary block in the 24-hour postoperative period; the air was successfully burped through the paracentesis.

**DMEK and cataract surgery**

Whenever possible, we first performed microincisional bimanual phacoemulsification and then DMEK, thus circumventing the use of viscoelastics that could affect graft attachment and must therefore be carefully removed when phacoemulsification and DMEK are performed in the same procedure. Nine cases underwent combined surgery in this study. In eyes with crystalline lens, 2% topical policarpine or 1% intracameral acetylcholine was applied to induce myosis and prevent damage.

**DISCUSSION**

Endothelial keratoplasty techniques have steadily improved since PLK was first described by Melles in 1998. As a result of Terry’s work on DLEK and the development of DSEK and DSAEK, these procedures have become mainstream, and penetrating keratoplasty is, or should be, no longer an option in patients meeting the criteria for endothelial keratoplasty. While DSAEK, due to its simplicity, reproducibility and positive outcomes, is now performed by most corneal surgeons, DMEK has not achieved the same popularity, despite better visual acuity and similar endothelial survival rates. This is no doubt due to the difficulties involved in obtaining donor DM and the complexity of intracameral graft placement, which can affect the reproducibility of the technique. In this study, we describe our 3-year experience with DMEK.

In the cases discussed here, a steady improvement in BCVA was observed in patients with no ocular comorbidity; mean BCVA at 3 months post-surgery was 0.65, and 0.71 and 0.77 at 6 and 12 months, respectively. Visual recovery rates were similar to those reported by Kruse, and slightly inferior to those of Melles and Price. According to Melles and Price, visual benefits were superior to DSAEK, with 26% of eyes achieving 20/20 vision and 63% 20/25 vision at only 3 months post-surgery. In this study, 39.58% of patients with no prior pathology achieved BCVA ≥ 20/25 at 3 months.

Other studies claim that 95% of patients can now achieve BCVA ≥ 0.5, and 75% achieve BCVA ≥ 0.8 at 6 months post-surgery. In this study, 92.50% of patients with no ocular comorbidity achieved BCVA ≥ 0.5 at 6 months, and 90.32% achieved BCVA ≥ 0.5 at 1 year. Since a visual acuity of 1.0 is frequently observed 1 week after surgery, this procedure can often provide rapid visual recovery.

The endothelial cell population gradually declines with age, a loss that is further exacerbated by injury or corneal surgery that can damage the endothelium. Since mitosis practically ceases after birth, the endothelial cells adjacent to the damaged area become enlarged in order to occupy the space left by dying cells. In individuals with no prior pathology or corneal surgery, around 0.6% of endothelial cells are lost each year. In adults, therefore, endothelial cell density loss (ECD loss) is estimated to be around 2,400-3,200 cells/mm², far in excess of the minimum 300-600 cells/mm² density needed for a healthy cornea.

Studies have reported ECD loss in DMEK procedures. Guerra et al. reported a mean loss rate of 36% in 1 year. Some endothelial cells are lost during Descemet’s membrane dissection. Unlike Bowman’s membrane, DM is easily separated from the stroma due to its randomly arranged collagen fibers that scarcely penetrate the thin non-banded layer of the DM. Using Melles’ technique, in which the DM is pulled away from the corneo-scleral ring of the donor button, ECD loss is calculated to be around 3.4% of the damaged surface area.

Comparing donor vs patient endothelial cell count at 3 months postsurgery, ECD loss is around 48.22%. As with other keratoplasty techniques, DMEK could be associated with a loss of endothelium cell density in the immediate post-operative period. Guerra et al. reported an 86% ECD loss during the first 3 months after surgery due to donor tissue preparation, intraoperative manipulation and possible rebubbling. Correct observation of the procedure, i.e. no direct intraoperative contact with the membrane, can minimize endothelial cell loss, resulting in a cell density.
of approximately 1,800-2,000 cells/mm² at 6 months post-DMEK, in other words, 20%-25% loss of pre-operative cell density. In this study, like that of the Melles group, found that ECD loss was not affected in any way by the learning curve. Dividing the total number of patients from whom a cell count could be obtained into 2 groups (23 early patients, and 23 late patients), it can be seen that the rate of cell loss is similar for both groups, namely, 49% in the first group and 47% in the second.

Endothelial cell densities are similar in DMEK to those obtained by penetrating keratoplasty or DSAEK. Guerra et al. found no difference in CD in patients undergoing DMEK in one eye and DSAEK in the other, while Tourtas et al. found that 6-month mean cell density in DMEK (1,520) is similar to that of DSAEK (1,532). In DMEK, initial donor cell density declines by approximately 30% at 6 months, a rate similar to pre- and post-operative cell loss in other keratoplasty procedures.

DMEK cannot be compared with DSAEK in terms of complications and reoperation rates, although it is important to bear in mind that is a DMEK comparatively novel procedure that has a significant learning curve and is also still largely under development.

This study also shows the DMEK learning curve. Breaking down the reoperation rate by years shows that the overall 3-year rate was 17.14%; however, when analyzed by year it can be seen that the reoperation rate in the first year was 46.67%, in the second year 20.83 %, while in the third it had been reduced to zero. This clearly shows the need to perform a number of procedures before mastering the technique.

After the initial learning curve, DMEK is a highly cost-effective procedure. The main drawback of this technique lies in the number of surgical steps: failure to perform each step correctly could result in tearing donor DM during dissection, which in turn would lead to graft detachment in the immediate post-operative period. It is important, therefore, to minimize this risk, and in our series this was achieved by the end of the learning curve. In our department, we dissect donor DM intraoperatively, thereby avoiding additional costs, although a reliable source of precut grafts from tissue banks would have prevented the risk of tearing that often occurs at the start of the learning process. Some studies have shown that iatrogenic destruction of donor tissue occurs in 8% of cases, compared with 0% in precut grafts for DSAEK.

Mastery of the technique and the results obtained after a number of operations have shown that visual prognosis improves with corneal edema with no stromal alternation and DMEK at an early stage of the disease, while fibrotic changes in the corneal stroma caused by long-standing preoperative edema, together with scarring, will give a worse prognosis. Stromal or subepithelial opacity is often irreversible, although in our experience this is not a contraindication for DMEK in most cases. Unobstructed intraoperative visualization of the graft is, however, essential for the success of the DMEK procedure.

Comparing DMEK with DSAEK shows that DSAEK still has a number of drawbacks: poor visual acuity and relatively slow visual rehabilitation, limited access to the procedure due to the expense of the equipment needed or of the pre-dissected tissue, and loss of donor endothelial cells in the immediate post-operative period. In DMEK, meanwhile, almost full visual recovery is achieved in a shorter time, and the instruments needed to prepare donor tissue are simpler; however, a longer training period is required before consistent results are achieved. In terms of visual rehabilitation, BCVA was ≥ 0.8 at 3 months in 39.58% of cases with no prior ocular pathology. DMEK can potentially deliver better clinical results than DSAEK, with 75% of patients achieving BCVA ≥ 0.8 in 1-3 months, according to other studies, which is why corneal surgeons should consider going the extra mile and performing DMEK instead of DSAEK.

Several studies have shown the advantages of DMEK over DSAEK. Like DSAEK, DMEK grafts can measure 9-10 mm in diameter, nearly the entire endothelial layer, and therefore improve long-term graft survival rates. We prefer grafts of 8.5-9 mm, as we have observed that this size facilitates manipulation. Furthermore, DMEK requires an incision of only 2.75 mm, compared with 4 to 5 mm in DSAEK.

With regard to surgical technique, in 2004 Melles described the descemetorhexis approach, consisting in excision of DM from the recipient cornea to prepare a homogeneous stromal bed. The descemetorhexis procedure must be carefully monitored to ensure that no trace of recipient Descemet's membrane remains, since this can impair final visual acuity and/or graft attachment to the posterior stroma. The use of air to inflate the anterior chamber seems to improve visualization of the DM during descemetorhexis. In this study, air-assisted descemetorhexis was performed in the first few cases, but then it was found that continuous irrigation gives better results, with only 1 case, in the early months of the study, where DM traces were found the interface.

The presence of intraoperative vitreous pressure is one of the main causes of complications in the intraoperative management of donor DM because it causes a narrowing of the anterior chamber, which in turn hampers intracameral manipulation of the graft, particularly in terms of orientation and unrolling. This is why it is essential to maintain hypotony during the procedure.

A slightly off-center graft is acceptable, although it must cover the center of the cornea since clinically the
space between the de-centered graft and the recipient Descemet’s membrane is often repopulated by donor or recipient endothelial cells\textsuperscript{33}.

One of the most complications most frequently encountered in this technique is partial graft detachment during the immediate post-operative period. In our case, the DM detachment rate was 22.35%, of which 11.76% involved partial detachment, which was resolved by re-bubbling (repeat injection of air in the anterior chamber), while 0.59% required reoperation. If these patients are divided evenly into 2 groups, 1 comprising the first (earlier) patients and the other the second (later) group, it can be seen that the reoperation rate fell from 33.3% to 3.45 %, a clear indication of the importance of the learning curve in this surgical technique. Price et al.\textsuperscript{11} reported 63% of dislocations due to interface fluid requiring re-bubbling in DMEK compared to 1.8% of re-bubbling in a larger DSAEK series\textsuperscript{34}. Although this could advise against DMEK in favor of DSAEK, we consider re-bubbling less as a serious complication and more as part of the post-operative treatment to correct cases where the bubble has not survived in the anterior chamber long enough for complete graft attachment. We believe that patients should be carefully monitored in the immediate post-operative period, using a slit lamp or OCT to detect the slightest dislocation of the DM, in which case re-bubbling should be performed to prevent further progression and ultimately total detachment of the graft. These complications can be prevented to a great extent by avoiding viscoelastics. Guerra et al. reported a 62% rebubbling rate in their prospective study of interventions involving lens cartridges containing viscoelastics\textsuperscript{19}, and Feng et al. recently reported a rebubbling rates of 14% in the absence of viscoelastics\textsuperscript{6}. Laser et al. published a study in which 74% of DMEK procedures (45 out of 61) combined with phacoemulsification required at least 1 rebubbling procedure\textsuperscript{6}. We recommend leaving the air in the chamber for at least 45-60 minutes after surgery, taking care to totally eliminate all traces of recipient membrane in the interface, and avoiding the formation of folds around the edge.

It is important to note that aphakic eyes, with or without vitrectomy, in which the capsular bag is ruptured or absent, extensive iridectomies, glaucoma drainage devices and/or a relatively narrow anterior chamber are high risk for graft detachment, since they hamper pressurization of the anterior chamber during the final surgical step. Unlike DSAEK in phakic eyes (above all in young patients) with a narrow chamber, there is no need for phacoemulsification.

Graft rejection is a rare complication of DMEK. This may be due to the low level of antigenic stimulation caused by the absence of donor stromal tissue. Dapena et al. reported 1 case (0.8%) of graft rejection from a series of 120 patients, with a 2-year follow up, receiving a 9-10 mm DMEK graft. Rejection can be resolved with the administration of topical corticoids. Anshu et al. reported a rejection rate of 0.7% in DMEK and 9% in DSAEK.

In conclusion, DMEK is a surgical technique that requires a learning curve with a high rate of reoperation in the early surgery. It requires training in specific surgical and tissue manipulation techniques, but once it has been mastered the rate of complications and reoperations significantly declines as the surgeon’s expertise increases. In our department, DMEK is the treatment of choice for Fuchs endothelial dystrophy and bullous keratopathy, and has shown very positive results in terms of visual recovery. Additionally, DMEK is accessible to most corneal surgeons, and does not require major investments. For all these reasons, we believe the DMEK will become the procedure of choice to treat corneal endothelial dysfunctions requiring tissue transplantation.

**REFERENCES**


