Fellow Eye Comparison of Corneal Thickness and Curvature in Descemet Membrane Endothelial Keratoplasty and Descemet Stripping Automated Endothelial Keratoplasty

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Purpose: To compare posterior corneal curvature in the fellow eye of the same patients after Descemet membrane endothelial keratoplasty (DMEK) and Descemet stripping automated endothelial keratoplasty (DSAEK).

Methods: This retrospective, case series comparative study included consecutive patients who underwent DSAEK in one eye and DMEK in the fellow eye. Each eye underwent corneal evaluation with Pentacam HR (Oculus, Wetzlar, Germany). Postoperative corneal curvature, corneal thickness, and visual acuity were assessed.

Results: Twenty eyes of 10 patients (5 women and 5 men) aged 72.5 ± 13.5 (range, 42–87) years were included. No significant differences were observed between front flat K's (43.01 ± 1.6 vs. 43.5 ± 0.9, $P = 0.27$) and front steep K's (44.17 ± 1.5 vs. 44.52 ± 0.7, $P = 0.39$) in DMEK vs. DSAEK eyes, accordingly. Posterior curvature was statistically significantly flatter in DMEK compared with DSAEK eyes; back flat K's (−6.30 ± 0.2 vs. −6.84 ± 0.6, $P = 0.012$), back steep K's (−6.64 ± 0.1 vs. −7.2 ± 0.3, $P = 0.03$), and back Km (−6.45 ± 0.1 vs. −6.99 ± 0.4, $P = 0.005$), accordingly. Corneas in DMEK eyes were significantly thinner than in DSAEK eyes (541.0 ± 61 vs. 627.9 ± 70 μm, $P = 0.007$).

Conclusions: Eyes that underwent DSAEK surgery have thicker corneas with steeper posterior corneal curvature than fellow eyes that underwent DMEK. This difference may explain the hyperopic shift commonly observed after DSAEK and should be considered when choosing an intraocular lens for cataract surgery.

Key Words: Descemet membrane endothelial keratoplasty, Descemet stripping automated endothelial keratoplasty, Pentacam, corneal curvature

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Posterior lamellar corneal transplants have become the choice surgical treatment option for patients with corneal endothelial pathologies.[1] The treatment aims to replace diseased host endothelium with a lamellar donor graft bearing healthy endothelial cells. Different techniques of endothelial keratoplasty vary in the preparation of donor tissue and in the way it is introduced and handled inside the recipient eye.

Descemet stripping automated endothelial keratoplasty (DSAEK) uses an automated microkeratome to prepare a donor disc consisting of the endothelial layer, Descemet membrane, and a thin layer of posterior stroma.[2]

Descemet membrane endothelial keratoplasty (DMEK) involves manual preparation of donor grafts consisting only of endothelium and Descemet membrane.[3]

Differences in size of the corneal incisions used for introducing DSAEK and DMEK grafts into the recipient anterior chamber (AC) and different thickness of these grafts may result in different postoperative refractive changes. The aim of our study was to characterize and compare corneal thickness and anterior and posterior corneal curvature in fellow eyes of a cohort of patients who underwent DSAEK and DMEK. Our literature review showed that the present study is the first to report these observations.

METHODS

A retrospective medical chart review of patients who underwent DSAEK in 1 eye and DMEK in the fellow eye secondary to Fuchs corneal endothelial dystrophy at Toronto Western Hospital was performed. This retrospective observational case series received Research Ethics Board approval by the University Health Network (Toronto Western Hospital, Toronto, Ontario, Canada) and was conducted in compliance with the tenets of the Declaration of Helsinki. Corneal evaluation was performed with the Pentacam HR (Oculus, Wetzlar, Germany). Postoperative corneal curvature, corneal thickness, and visual acuity were assessed.

All donor tissues we used were stored in corneal storage solution (Optisol; Bausch & Lomb, Rochester, NY) and received from the Eye Bank of Canada, Ontario division.

DSAEK donor preparation was performed immediately before transplantation, as previously described.[4] Briefly, the donor disc was cut with the Moria ALTK microkeratome system equipped with a 300-mm head and associated artificial AC (Moria, Antoney, France). After dissection and 8.5-mm

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punch with a corneal trephine, an anchoring 10/0 Prolene stitch on a long curved needle (CIF-4; Ethicon) was placed in the donor disc at the 6-o'clock position and used to insert the donor into the AC. The AC was filled with air for 10 minutes and then part of the air was removed and replaced with balanced salt solution.

DMEK grafts were prepared as previously described.[3] Briefly, after preparation, the 8.5-mm donor DM was loaded into an Emerald intraocular lens (IOL) cartridge (Abbott Medical Optics, St. Andrew Place, CA) and inserted into the AC through a clear corneal (2.8 mm) incision. Tapping technique together with intracameral short bursts of balanced salt solution was used to unfold and position the graft.[5] The AC was then filled with air and 1 drop of cyclopentolate hydrochloride 1% (Minims Cyc 1.0; Chauvin Pharmaceuticals Ltd) and of phenylephrine hydrochloride 10% (Minims PHNL 10; Chauvin Pharmaceuticals Ltd) were instilled to prevent pupillary block.

All patients stayed strictly supine for 2 hours and then "as much as possible" at home until the next morning. All patients were examined 2 hours after surgery, and if necessary, some of the air was released if the bubble was completely filling the AC and pupillary block was deemed to be likely. All eyes underwent pressure-patching overnight. The following day, 0.1% dexamethasone sodium phosphate and 0.3% tobramycin antibiotic (Tobradex; Alcon, Mississauga, Ontario, Canada) eye drops were administered 4 times daily for 1 month. Then, the antibiotic component was discontinued and 0.1% dexamethasone sodium phosphate (Maxidex, Alcon) eye drops were tapered down to once daily during a 3-month period.

Statistical Analysis

The data are presented as mean ± SD. The paired 2-tailed Student *t*-test was used to assess differences in respective parameters. The distributions of values within each data set were evaluated graphically. A $P < 0.05$ was selected for the threshold of statistical significance. Analyses were performed using Excel (Microsoft Corp, Redmond, WA).

RESULTS

Twenty eyes of 10 patients (5 women and 5 men) aged 72.5 ± 13.5 (range, 42–87) years were included. All patients were previously diagnosed with Fuchs endothelial dystrophy. In 4 eyes undergoing DMEK and in 3 eyes undergoing DSAEK, a cataract was present and was removed at the time of surgery. Four eyes that underwent DMEK and 4 eyes that had DSAEK were pseudophakic with posterior chamber IOL. Two eyes in the DMEK group and 3 eyes in the DSAEK group were phakic without cataract.

Table 1 presents characteristics of both study groups. Table 2 shows postoperative corneal characteristics as evaluated by Pentacam in both groups. Posterior curvature was statistically significantly flatter in eyes with DMEK compared with eyes with DSAEK; back flat K's (−6.30 ± 0.2 vs. −6.84 ± 0.6, $P = 0.012$), back steep K's (−6.64 ± 0.1 vs. −7.2 ± 0.3, $P = 0.03$), and back Km (−6.45 ± 0.1 vs. −6.99 ± 0.4, $P = 0.005$), accordingly (Fig. 1). The mean difference between DMEK back Km and DSAEK back Km was 0.36 ± 0.4 diopters (D). No significant differences were observed between front flat K's (43.01 ± 1.6 vs. 43.5 ± 0.9, $P = 0.27$) and front steep K's (44.17 ± 1.5 vs. 44.52 ± 0.7, $P = 0.39$) in eyes with DMEK versus eyes with DSAEK, accordingly (Fig. 2). No significant differences were observed between anterior and posterior astigmatism or Q values in eyes with DMEK versus eyes with DSAEK (Table 2). Corneas that underwent DMEK surgeries were statistically significantly thinner than in eyes with DSAEK (541.0 ± 61 vs. 627.9 ± 70 μm, $P = 0.007$).

TABLE 1. Characteristics of Study Groups

Parameters	DMEK Eye Mean ± SD	DSAEK Eye Mean ± SD	*P*
Preoperative BSCVA, logMAR	0.68 ± 0.5	0.47 ± 0.1	0.2
Follow-up time, months	9.6 ± 2.2	36.5 ± 15.4	0.001
Donor size, mm	8.6 ± 0.2	8.5 ± 0.3	0.6
Postoperative BSCVA, logMAR	0.23 ± 0.1	0.32 ± 0.2	0.2
SE (D)	−0.14 ± 0.9	1.0 ± 3.0	0.4

BSCVA, best spectacle-corrected visual acuity.

DISCUSSION

This study shows that eyes that underwent DSAEK surgery have statistically significantly thicker corneas and steeper posterior corneal curvature than fellow eyes that underwent DMEK.

Both procedures aimed to replace the diseased host endothelium with minimal donor tissue carrying healthy endothelial cells. The principal difference between DSAEK and DMEK is in thickness and shape of the graft and size of the corneal incision potentially influencing both anterior and posterior corneal curvatures.

Theoretically, producing smaller corneal incisions should produce less or no astigmatism as compared with larger

TABLE 2. Pentacam Parameters

Parameters	DMEK Eye Mean ± SD	DSAEK Eye Mean ± SD	*P*
Front flat K (D)	43.01 ± 1.6	43.5 ± 0.9	0.27
Front steep K (D)	44.17 ± 1.5	44.52 ± 0.7	0.39
Front Km (D)	43.58 ± 1.5	44.00 ± 0.8	0.28
Front astigmatism (D)	1.21 ± 0.7	1.06 ± 0.5	0.69
Front Q value	−0.27 ± 0.3	−0.26 ± 0.3	0.88
Back flat K (D)	−6.30 ± 0.2	−6.84 ± 0.6	0.012
Back steep K (D)	−6.64 ± 0.1	−7.2 ± 0.3	0.003
Back Km (D)	−6.45 ± 0.1	−6.99 ± 0.4	0.005
Back astigmatism (D)	0.47 ± 0.1	0.54 ± 0.3	0.48
Back Q value	−0.07 ± 0.4	−0.13 ± 0.4	0.74
Pachymetry—pupil center, μm	541.0 ± 61	627.9 ± 70	0.007
Pachymery—apex, μm	541.9 ± 59	627.8 ± 71	0.008
Pachymetry—thinnest local, μm	531.7 ± 54	614.3 ± 72.4	0.005

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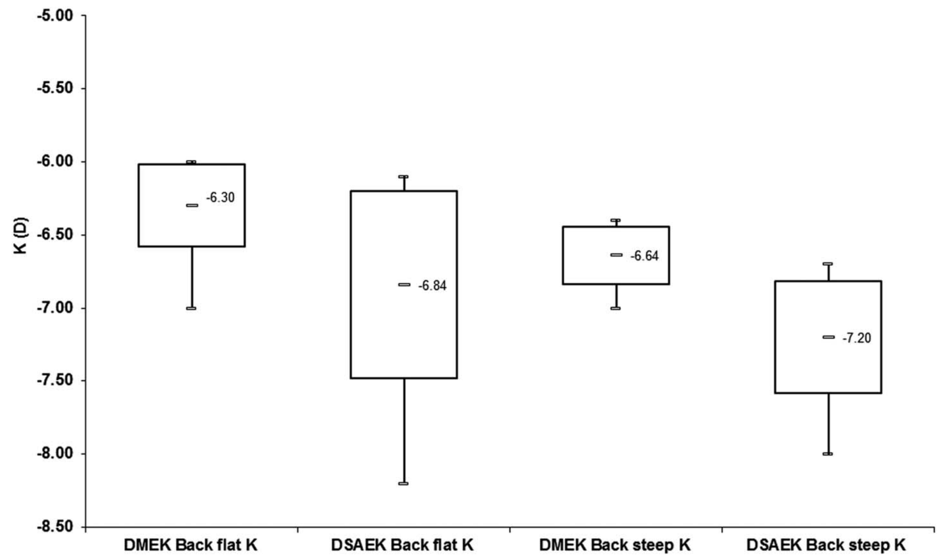

FIGURE 1. Box (mean ± SD) and whisker (smallest and largest values) plots showing steepest and flattest meridian keratometry (D) of posterior corneal surface in DMEK and DSAEK study groups.

incisions. We used 5-mm limbal corneal incisions for DSAEK and 2.8-mm clear corneal incisions for DMEK. No significant postoperative difference was found in anterior corneal curvature parameters between eyes with DMEK and eyes with DSAEK in our study. Previous studies that investigated corneal changes caused by DMEK and DSAEK reported stable preoperative and postoperative keratometry values.[6,7] Lack of postoperative differences between these techniques may lead to a conclusion that any induced refractive differences originate from differences in the posterior corneal surface.

The differences in corneal pachymetry between DMEK and DSAEK were expected. Although DMEK grafts consist of a monolayer of endothelial cells and Descemet membrane only, the DSAEK graft invariably includes also layer of posterior stroma. As expected, we observed that corneas that underwent DSAEK were statistically significantly thicker than post-DMEK corneas. Although, from an optical perspective, thickness of the tissue by itself should not influence refractive power of the cornea, it is plausible that additional stromal tissue together with recipient–donor interface mismatch may explain increased higher-order aberrations in eyes that underwent DSAEK as compared with eyes that have had DMEK.[8,9] Beyond differences in thickness, the shape of the grafts differs too. Although the DMEK graft has homogeneous thickness, the DSAEK graft is concave meniscus–shaped.[10] This graft concavity is responsible for the increased posterior corneal curvature in DSAEK eyes that was observed in our study. Clinically, such a lenticle-shaped DSAEK meniscus causes an increase in posterior corneal curvature that correlates with the reported postoperative hyperopic shift.[10,11] Theoretically, the degree of difference between ultrathin DSAEK and DMEK should be smaller than differences that were observed in our study, but this comparison was beyond the scope of our study.

Although a possible limitation of our study is different follow-up times for the types of surgery, we do not think this difference influencing our observations as previous studies

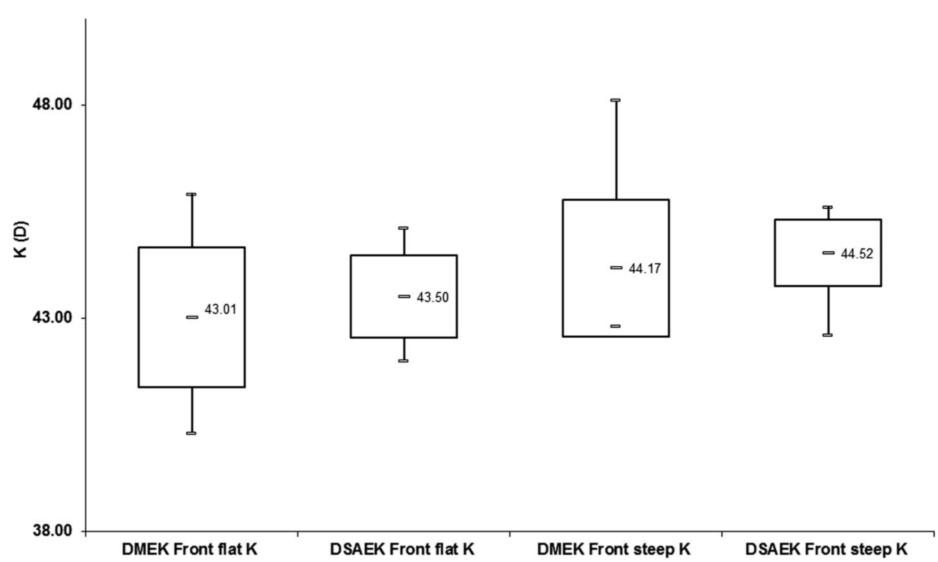

FIGURE 2. Box (mean ± SD) and whisker (smallest and largest values) plots showing steepest and flattest meridian keratometry (D) of anterior corneal surface in DMEK and DSAEK study groups.

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reported stabilization in central corneal thickness 3 months after DMEK and DSAEK.[12]

Posterior corneal curvature values (K_{steep}, K_{flat}, and K_{mean}) as measured in this study were statistically significantly lower in eyes with DMEK than in eyes with DSAEK with mean difference of 0.36 D and fell in concordance with previously reported values.[10,13]

Observed differences may be of clinical significance when patients are undergoing triple procedures with simultaneous phacoemulsification and IOL implantation, and the managing surgeon needs to take induced hyperopic changes into consideration when planning cataract surgery.

Although not measured in our study, DMEK has been reported to cause a postoperative hyperopic refractive shift averaging from 0.3 to 0.5 D caused by an increase in posterior K values by approximately 1 D.[13,14] The proposed explanation for this observation is postoperative corneal deturgescence when the degree of corneal thinning at the center is larger than at the periphery, thus, producing decrease in the radius of posterior curvature.[7,13,14]

CONCLUSIONS

This is the first study in contralateral eyes of the same patients showing that eyes that underwent DSAEK surgery have thicker corneas and steeper posterior corneal curvatures than fellow eyes that underwent DMEK. These differences should be considered when choosing IOLs for cataract surgery and powers adjusted according to the chosen corneal procedure.

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