

Retrospective contralateral study comparing Descemet membrane endothelial keratoplasty with Descemet stripping automated endothelial keratoplasty

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CLINICAL STUDY

Abstract

Purpose In this retrospective study, the visual outcomes and postoperative complications after Descemet stripping automated endothelial keratoplasty (DSAEK) and Descemet membrane endothelial keratoplasty (DMEK) in the fellow eye were compared. The patient's satisfaction was evaluated.

Methods A retrospective analysis of 10 patients, who underwent DSAEK in one eye and DMEK surgery in their fellow eye, was performed. Intraoperative and postoperative complications were recorded. Visual and refractive outcomes were evaluated, including higher-order aberrations (HOA) and contrast thresholds. A subjective questionnaire was used to evaluate patient satisfaction.

Results Best-corrected visual acuity (BCVA) was significantly better in DMEK when compared with DSAEK (0.16 ± 0.10 vs 0.45 ± 0.58 logMAR, $P = 0.043$). Contrast threshold was significantly higher after DMEK than after DSAEK (0.49 ± 0.23 vs 0.25 ± 0.18 , $P = 0.043$). Post-keratoplasty astigmatism, mean spherical equivalent, and HOA did not differ. Nine out of ten patients preferred the DMEK procedure. Visual outcome (4.80 ± 1.14 vs 4.50 ± 1.58 , $P = 0.257$), surgery associated pain and burden (DMEK: 1.30 ± 0.48 vs DSAEK: 1.30 ± 0.48 , $P = 1.0$), estimated time for recovery and

rehabilitation (27.6 ± 54.0 vs 24.9 ± 54.8 days, $P = 0.173$), and mean patient satisfaction (5.40 ± 0.84 vs 5.00 ± 1.05 , $P = 0.257$) were evaluated equally.

Conclusion Patient satisfaction reached high, equal values after DMEK and after DSAEK. Nevertheless, patients preferred DMEK, if given a choice. Reasons for the preference may include better uncorrected and BCVA, and especially a better contrast sensitivity.

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Introduction

In recent years, Descemet stripping automated endothelial keratoplasty (DSAEK) and Descemet membrane endothelial keratoplasty (DMEK) are increasingly performed in cases of Fuchs endothelial dystrophy and bullous keratopathy.^{1–10} Both procedures are less invasive corneal transplant techniques. In comparison with penetrating keratoplasty main advantages include rapid healing, more predictable refractive outcomes, better corneal integrity, a rapid visual recovery, and fewer postoperative complications.^{1,4–7,11,12}

DSAEK procedure was first described by Price and Price.^{4,7} The diseased endothelium

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and Descemet membrane are selectively replaced by posterior corneal stroma, Descemet membrane, and endothelium of a donor.^{4,7} In contrast to the DSAEK procedure, in the DMEK procedure, first described by Melles,¹³ an isolated endothelium Descemet membrane layer without adherent corneal stroma is transplanted.

Tourtas *et al*¹ presented the first retrospective study which compared DSAEK and DMEK. In their study, DMEK provided a faster and more complete visual rehabilitation when compared with DSAEK without a significant difference in endothelial cell count. As reasons for these results the thickness of the transplanted lamella and the presence of a stroma lamella in cases of DSAEK are discussed. The stroma lamella seems to be responsible for a posterior astigmatism, a hyperopic shift and altered higher-order optical aberrations resulting in a poorer visual acuity.^{1,8,14–17}

Otherwise the DSAEK procedure allows a safer donor preparation and easier manipulation in the anterior chamber because of higher stability of the relatively thick graft.^{1,18,19}

These different aspects possibly influence the patient's satisfaction and preference for one or the other surgical procedure. Therefore, we analyzed in our retrospective study the visual and refractive outcome and the patient's satisfaction in a cohort who had undergone DSAEK in one eye and DMEK surgery in their fellow eye.

Materials and methods

Patients

We present a retrospective analysis of 10 patients who underwent DSAEK in one eye and DMEK in the fellow eye. Two experienced surgeons (PWR and NT) performed the procedures at the Department of Ophthalmology, Charité—Universitätsmedizin Berlin, Campus Virchow Klinikum. This retrospective study follows the ethical standards of the Declaration of Helsinki. We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research.

Preoperative and postoperative evaluation

Clinical evaluation included best-corrected visual acuity (BCVA), slit-lamp examination, applanation tonometry (Goldmann applanation tonometer, Haag Streit, Bern, Switzerland), and funduscopy, preoperatively and 2 and 4 weeks, and 3, 6, 12, and 24 months after DSAEK or DMEK. Distant visual acuity was tested with a Snellen chart and expressed as a Snellen decimal number. For the purposes of statistical analysis, the Snellen decimal number was converted to logMAR using a Visual acuity Conversion Table.²⁰ Additionally, data on uncorrected

visual acuity (UCVA), contrast threshold (Mesoptometer II, Oculus Optikgeräte GmbH, Wetzlar, Germany), preoperative and postoperative refraction, corneal topography, higher-order aberrations (HOA; total root mean square (RMS), second, third, and fourth order aberrations; Galilei dual scheimpflug analyzer, V5.2.1, Ziemer Ophthalmic Systems AG, Port, Switzerland), and endothelial cell counts (NONCON-ROBO CA specular microscope, KONAN MEDICAL INC., Nishinomiya, Japan) were collected. All these parameters, except contrast threshold measurement, corneal topographies, and HOA were measured preoperatively and at the last follow-up visit. Contrast threshold was measured by presenting an isolated Landolt ring of variable contrast. The lowest contrast at which the Landolt ring was identified correctly was analyzed and the contrast ratio background: Landolt ring was noted. On the last follow-up visit, a patient's questionnaire was presented to the patients. The questionnaire included questions grading the symptoms and overall satisfaction with surgery on a scale of 1–6 (Supplementary Data, patient's questionnaire).⁸

Graft and surgical techniques

Cultured grafts with a minimum central endothelial density of 2000/mm² from the Cornea Bank Berlin were used for transplantation.

In all cases clear corneal incisions were used. In cases of additional cataract a combined procedure (Triple DSAEK or Triple DMEK) with DSAEK or DMEK following standard cataract surgery was performed.

In nine eyes before DMEK surgery and in five eyes before DSAEK surgery, significant lens opacity was present and a combined procedure with DMEK or DSAEK following phacoemulsification and posterior chamber intraocular lens implantation was performed.

DSAEK

The DSAEK surgical technique was performed in a minimally modified manner described in detail by Price and Price.^{4,7,21} The donor graft was dissected using either the Moria ALTK system (Moria/Microtek Inc., Doylestown, PA, USA) or the Schwind Carriazo pendular microkeratome (SCHWIND eye-tech-solutions GmbH & Co. KG, Kleinostheim, Germany). Attempted donor lamella depth was from 100 to 200 μm (mean $154.9 \pm 48.9 \mu\text{m}$). The maximum diameter of the graft was 8.5 mm.

Standard postoperative topical treatment included a combination of steroid (three to five times daily) and lubricant eye drops (five times daily) in combination with a combined antibiotic and steroid ointment at night. During the first days, pilocarpine eye drops (1%) were

given until the air bubble was absorbed. After 1 week, the ointment was stopped and prednisolone acetate 1% was used topically (three times daily for the first 3 months) with lubricant eye drops five times daily. The prednisolone acetate 1% was tapered down over a period of 2–3 months to once or twice daily, and patients remained on this dosage until 1 year postoperatively unless they developed steroid-induced glaucoma.

DMEK

Stripping of the endothelial Descemet membrane from the donor corneal stroma was performed immediately prior to transplantation in a standardized manner described in detail by Melles *et al.*^{13,22,23} The diameter of the graft ranges between 8.5 and 9.0 mm with an incision of 2.75 mm.

Standard postoperative topical treatment included a combination of steroid (three times daily) and lubricant eye drops (five times daily) in combination with a combined antibiotic and steroid ointment overnight. After 1 week, the ointment was stopped and prednisolone acetate 1% was used topically (three times daily for the first 3 months) with lubricant eye drops five times daily. The prednisolone acetate 1% was tapered down over a period of 2–3 months to once daily, and patients remained on this dosage until 1 year postoperatively unless they developed steroid-induced glaucoma.

Statistical methods

The statistical analysis was performed using IBM SPSS statistics 19 (SPSS Software, Munich, Germany). Descriptive statistics were expressed as median and range between minimum and maximum, or mean \pm SD. Paired data were collected. Normal distribution could not be determined for all outcome measures. Therefore, paired nonparametric (Wilcoxon) testing was used for analysis of continuous variables. For analyzing the distribution of proportions, a χ^2 distribution was used. Differences were considered statistically significant when *P*-values were <0.05 .

Results

In this study we included 20 eyes of 10 patients (4 female and 6 male). The mean age of patients was 71 ± 6 years.

Underlying disease was Fuchs dystrophy in all cases. In all patients, DSAEK surgery in one eye and DMEK surgery in their fellow eye were performed. Fourteen cases had a combined procedure (DMEK or DSAEK and standard cataract surgery).

Preoperative data and the follow-up time for both study groups are summarized in Table 1, the postoperative results at the last follow-up after DSAEK *vs* DMEK are summarized in Table 2.

Visual acuity and refraction

Visual acuity improved after DSAEK and significantly after DMEK surgery at the last follow-up compared with preoperatively ($P = 0.09$, $P < 0.01$; Table 2). At the last follow-up the BCVA and UCVA (logMAR) were significantly better in DMEK than in DSAEK ($P = 0.043$, $P = 0.057$).

Evaluation of contrast threshold was not possible in two patients due to defective device. Mean contrast ratio background: Landolt ring of the measured data is presented in Table 2. All patients demonstrated a better contrast ratio in the DMEK operated eye than in the DSAEK operated eye. Difference was statistically significant ($P = 0.043$).

The mean manifest spherical equivalent and the mean manifest cylinder did not differ significantly between DSAEK and DMEK ($P = 0.725$, $P = 0.436$; Table 2).

The data of wavefront analysis of HOA (with a 6-mm pupil diameter) are shown in Table 2. Data of one eye after DSAEK were excluded from the statistical analysis because the quality of HOA measurements was too low to analyze. Total RMS, second, third, and fourth order aberrations demonstrated no significant different results between eyes after DMEK and eyes after DSAEK ($P = 0.767$, $P = 0.0953$, $P = 0.635$, $P = 0.953$).

Complications

Various mild complications occurred in both groups.

Additional application of intracameral air was used in five cases after DMEK (50%) and in one case after DSAEK (10%) to re-fix graft detachments. In one case post-DMEK (10%) and no case post-DSAEK, intraocular pressure was raised on the first

Table 1 Characteristics of the patients

	DSAEK (n = 10)	DMEK (n = 10)	<i>P</i> -values
Follow-up time (months)	21.0 \pm 10.5	6.5 \pm 3.2	0.005
Preoperative BCVA (logMAR)	0.60 \pm 0.16	0.60 \pm 0.18	1.000
Manifest SE	0.74 \pm 2.00	-0.76 \pm 2.06	0.207
Manifest cylinder	1.53 \pm 1.03	0.97 \pm 0.83	0.203
Preoperative endothelial cell number (1/mm ²)	2316 \pm 233	2369 \pm 260	0.575

Table 2 Postoperative results at the last follow-up after DSAEK *vs* DMEK

	DSAEK (n = 10)	DMEK (n = 10)	P-values
BCVA (logMAR)	0.45 ± 0.58	0.16 ± 0.10	0.043
UCVA (logMAR)	0.64 ± 0.53	0.36 ± 0.17	0.057
Manifest SE	0.26 ± 0.67	-0.11 ± 1.14	0.725
Manifest cylinder	1.83 ± 1.02	1.63 ± 0.64	0.436
Contrast threshold (contrast ratio background: Landolt ring)	0.25 ± 0.18	0.49 ± 0.23	0.043
<i>Wavefront analysis</i>			
Root mean square total (μm)	1.93 ± 0.86	1.69 ± 0.77	0.767
Astigmatism (D)	1.61 ± 0.58	1.27 ± 0.82	0.441
Second order aberration (μm)	1.45 ± 0.78	1.29 ± 0.65	0.953
Third order aberration (μm)	0.90 ± 0.32	0.79 ± 0.33	0.635
Fourth order aberration (μm)	0.50 ± 0.26	0.46 ± 0.21	0.953
Endothelial cell number after 6 months (1/mm ²)	1053 ± 303 (n = 4)	1914 ± 519 (n = 6)	0.109

postoperative day as a result of air bubble-induced mechanical angle closure. Steroid-induced intraocular pressure elevation occurred 3 months postoperatively in two eyes after DSAEK and one eye after DMEK. To bridge intraocular pressure elevation during tapering down the local steroids, patients were treated successfully with topical antiglaucomatous medications. Additionally, cataract surgery was performed after half a year in one eye post-DSAEK. No immune rejection was observed during follow-up in any of the groups.

Results of questionnaire

Three out of 10 patients (30%) evaluated their visual outcome post surgery as superior in the DMEK eye than in the DSAEK eye, and one the other way around (question 1, Supplementary Data, patient's questionnaire). There was no significant difference in grading the visual outcomes after DMEK and after DSAEK (DMEK: 4.80 ± 1.14 *vs* DSAEK: 4.50 ± 1.58 , $P = 0.257$).

With regard to surgery associated pain and burden (question 2, Supplementary Data, patient's questionnaire), no patient (0%) noted a difference between either procedures. All patients evaluated both procedures equal with less associated pain and burden (DMEK: 1.30 ± 0.48 *vs* DSAEK: 1.30 ± 0.48 , $P = 1.0$).

The estimated time for recovery and rehabilitation (question 3, Supplementary Data, patient's questionnaire) showed no difference between DSAEK (27.6 ± 54.0 days) and DMEK (24.9 ± 54.8 days; $P = 0.173$).

Mean patient satisfaction was high after both procedures with no significant difference (DMEK: 5.40 ± 0.84 *vs* DSAEK: 5.00 ± 1.05 , $P = 0.257$; question 4, Supplementary Data, patient's questionnaire).

When asked about their preferred surgical procedure, eight patients (80%) preferred DMEK. Only two patients preferred DSAEK over DMEK.

Discussion

In the present study, we directly compared the functional results of DMEK with those of DSAEK in individual patients. Moreover, the patient's perception was evaluated.

Our data support previous studies that compared DMEK and DSAEK. Visual acuity was significantly better following DMEK compared with DSAEK.^{1,6,10,24–26} Other studies suggest that the stroma lamella is responsible for a posterior astigmatism, a hyperopic shift and altered higher-order optical aberrations after DSAEK.^{1,8,14–17,27} In our study, we found no difference in total HOA, astigmatism, and spherical equivalent between DSAEK and DMEK. In both groups, changes in mean spherical equivalent and astigmatism were small.²⁸ In our study, these shifts tended toward myopia for DSAEK and toward hyperopia for DMEK, a finding in contrast to data from other DSAEK studies and in accordance to data from other DMEK studies.^{8,28}

In addition to the better visual acuity outcomes after DMEK than after DSAEK, the contrast thresholds were significantly increased after DMEK when compared with DSAEK. These results support data reported by Bahar *et al.*⁸ who demonstrated better contrast thresholds after penetrating keratoplasty than after DSAEK. The presence of stroma following DSAEK, and therefore the thickness of the transplanted lamella and the stroma–stroma interface, may explain the worse contrast sensitivity and the poorer visual acuity.

In one eye we already replaced a DSAEK graft with DMEK because of poor visual result after DSAEK as suggested by Ham *et al.*²⁹

Rate of complications was low after both procedures. As described by many authors the risk of postoperatively graft detachment is higher after DMEK than after DSAEK.^{1,10,18,19} Therefore, a higher rate of air-injections was necessary in eyes after DMEK (50%) than after

DSAEK (10%). In accordance with other studies, long-term complications (eg, persistent epithelial defects, intraocular pressure elevation, post-keratoplasty glaucoma, and graft failure after immune rejection) were hardly registered. Steroid-induced intraocular pressure elevation occurred most frequently,^{11,30,31} but treated successfully in all cases.

In both groups, endothelial cell numbers decreased significantly between preoperative and postoperative graft measurements.^{1,5,10,32} Endothelial cell loss was comparable between DSAEK and DMEK after 6 months postoperatively.^{1,10}

The results from our patient questionnaire demonstrate that almost all patients preferred DMEK, if given a choice. Although visual outcomes, time for recovery and rehabilitation, surgery associated pain and burden, and mean patient satisfaction were all rated equal after DMEK and after DSAEK, the better functional outcome is probably decisive for choice. Apparently, the decision appears not to be influenced by the more frequent need of air-injection in the early postoperative period after DMEK than after DSAEK. Overall, patient satisfaction reached high values for both procedures.

In this intraindividual comparative study, the main limitations were the small sample size, the retrospective character, and the differing follow-up times after each procedure.⁸ In particular, the differing follow-up times may lead to a recall bias in the patient satisfaction questionnaire. Probably more detailed prospective studies should be initiated.

In conclusion, patient satisfaction reached high, equal values after both procedures. Nevertheless, patients preferred DMEK, if given a choice. Reasons for the preference may include: better uncorrected and BCVA and especially a better contrast sensitivity.

Summary

What was known before

- Tourtas *et al* presented the first retrospective study that compared Descemet stripping automated endothelial keratoplasty (DSAEK) and Descemet membrane endothelial keratoplasty (DMEK). In their study DMEK provided a faster and more complete visual rehabilitation when compared with DSAEK. As reasons for these results, the thickness of the transplanted lamella and the presence of a stroma lamella in cases of DSAEK are discussed. The stroma lamella seems to be responsible for a posterior astigmatism, a hyperopic shift and altered higher-order optical aberrations resulting in a poorer visual acuity.

What this study adds

- The present study compares directly the results of DMEK with DSAEK in individual patients according to visual acuity, astigmatism, mean spherical equivalent, high-order aberrations, and especially contrast threshold. Furthermore, the patient's satisfaction was evaluated.

Conflict of interest

The authors declare no conflict of interest.

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Supplementary Information accompanies this paper on Eye website (<http://www.nature.com/eye>)