Descemet membrane endothelial keratoplasty: graft rejection, failure and survival

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CHAPTER 3

Endothelial Survival after Descemet Membrane Endothelial Keratoplasty Effect of Surgical Indication and Graft Adherence Status

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ABSTRACT

Objective: To determine endothelial survival and its association with the indication for surgery and/or partial graft detachment in DMEK.

Design, Setting, Participants: Retrospective cross-sectional study of data collected from August 8, 2006, until June 17, 2015, at a tertiary referral center. A total of 352 eyes were evaluated up to 8 years after DMEK for Fuchs endothelial corneal dystrophy (FECD; n = 314), bullous keratopathy (BK; n = 31), and failed previous endothelial graft (n=7), of which 314 eyes had complete graft attachment and 38 eyes had partial graft detachment (one-third of the graft surface area or less). Endothelial cell density was measured with specular microscopy, and Kaplan-Meier survival estimates were based on eyes with endothelial failure. Endothelial survival was followed up to 8 years after DMEK.

Main outcomes and Measures: Endothelial cell density, endothelial failure, and endothelial survival.

Results: Endothelial cell density decreased to a mean (SD) of 952 (366) and 771 (321) cells/mm^2 at 7 and 8 years postoperatively, respectively. Higher endothelial cell densities were found in eyes with FECD compared with those with BK (estimated mean difference, 261 cells/mm^2; 95% CI, 118-404; P = .003) and in eyes with attached grafts compared with those with partially detached grafts (estimated mean difference, 330 cells/mm^2; 95% CI, 208-452; P < .001), until 8 years. In 11 eyes (3.1%) that had concomitant ocular pathology, endothelial failure occurred within 4 years after DMEK. The overall graft survival probability was 0.96 at 5 and 8 years (95% CI, 0.94-0.99). At 8 years, better survival rates were found in eyes with FECD than in those with BK (survival probability, 0.97 [95% CI, 0.95-0.99] vs 0.84 [95% CI, 0.70-0.99], respectively); until the same follow-up, survival probabilities in eyes with attached and partially detached grafts were 0.97 (95% CI, 0.95-0.99) and 0.91 (95% CI, 0.82-0.99), respectively.

Conclusions and Relevance: Endothelial decay was higher in eyes with a partial graft detachment than in those with attached grafts and lower in eyes with FECD than in those with BK. Endothelial failure only occurred in eyes with concomitant ocular pathology. These results suggest that eyes with DMEK that have undergone surgery for FECD with a completely attached graft may have an excellent prognosis.

INTRODUCTION

Since its introduction in 1998, endothelial keratoplasty has become increasingly popular and evolved from deep lamellar endothelial keratoplasty to Descemet stripping endothelial keratoplasty (DSEK) and Descemet stripping automated endothelial keratoplasty (DSAEK), and most recently to Descemet membrane endothelial keratoplasty (DMEK).[1]

Although DMEK provides excellent visual acuity recovery of 20/25 or even better in about three-quarters of the eyes,[2-4] there is not yet any indication of long-term graft survival (i.e., ≥10 years) in DMEK or earlier endothelial keratoplasty techniques. We recently reported an 84% graft survival rate at 10 years in our first deep lamellar endothelial keratoplasty cohort.[5] For DSEK/DSAEK, survival rates up to 5 years postoperatively seem to resemble midterm graft survival rates after penetrating keratoplasty (PK).[6-14]

Midterm evaluation of endothelial cell density (ECD) after DMEK showed a 7% annual decrease that may mimic that of earlier endothelial keratoplasty techniques, while the decrease appears to be slower than after PK.[15-17] This may hint toward a higher endothelial survival probability after DMEK. If so, not only faster visual rehabilitation but also higher long term endothelial survival would be important considerations for surgeons to choose DMEK over PK as a preferred treatment method in corneal endothelial disease.

The aim of this study was to assess midterm endothelial survival by evaluating ECD decay and endothelial graft failures in the first DMEK cohort worldwide and to evaluate its association with the indication for surgery (Fuchs endothelial corneal dystrophy [FECD] vs bullous keratopathy [BK]) and the presence of a partial graft detachment.

METHODS

This was a retrospective cross-sectional study of data that had been collected from August 8, 2006, until June 17, 2015, of 500 consecutive eyes that underwent DMEK in 395 patients (including the learning curve of the first 25 DMEK procedures).

Table 1. Demographic Characteristics and Exclusions

	Characteristic	Value
Included DMEK eyes	Included Eyes after DMEK / Patients, No.	352 / 352
	Sex, No. (%)	
	Male	154 (43.8)
	Female	198 (56.2)
	Recipient´s age, mean (SD) [range], y	68 (13) [20-96]
	Participation time, mean (SD) [range], mo[a]	42 (22) [0-96]
	Lens status, No. (%)	
	Phakic	91 (25.8)
	Pseudophakic	259 (73.6)
	Aphakic	2 (0.6)
	Indication, No. (%)	
	Fuchs endothelial corneal dystrophy[b]	314 (89.2)
	Bullous keratopathy	31 (8.8)
	Pseudophakic bullous keratopathy	14
	Aphakic bullous keratopathy	1
	Congenital glaucoma	4
	Phakic intraocular lens[c]	11
	After trauma	1
	Regraft after DSEK/DSAEK	7 (2.0)
	Graft adherence status at 6 mo postoperatively, No. (%)	
	Attached	314 (89.2)
	Partially detached[d]	38 (10.8)
Included Donors for DMEK	Donors	
	No.	352
	Age, mean (SD) [range], y	65 (10) [41-85]
	Sex, No. (%)	
	Male	219 (62.2)
	Female	133 (37.8)
	Cause of death, No. (%)	
	Cerebrovascular, cardiac/stroke	176 (50.0)
	Cancer	97 (27.6)
	Respiratory	57 (16.2)
	Trauma	6 (1.7)
	Other	16 (4.5)
	Time from death to preservation, mean (SD) [range], h	22 (7) [7-39]
	Time from preservation to surgery, mean (SD) [range], d	13 (4) [6-25]
	Preoperative endothelial cell density, mean (SD), cells/mm^2	2533 (216)

Table 1. Demographic Characteristics and Exclusions *(continued)*

	Characteristic	Value
Excluded DMEK eyes	Excuded eyes, (n = 148)	
	Second fellow eyes, No.	106
	DMEK after penetrating keratoplasty, No.	2
	Graft detachment greater than one-third of surface area, No.[e]	40
	Cases 1-25, learning curve	9
	Cases 26-100	13
	Cases 101-500	18

DMEK=Descemet membrane endothelial keratoplasty; DSAEK=Descemet stripping automated endothelial keratoplasty; DSEK=Descemet stripping endothelial keratoplasty.
[a]Time from surgery until the last available visit with a successful graft or a failed graft necessitating regrafting.
[b]Including 1 eye with a posterior polymorphous endothelial dystrophy and 1 aphakic eye.
[c]Phakic intraocular lens was removed in 6 eyes.
[d]One-third of the graft surface area or less.
[e] Eyes in which reliable endothelial cell density measurements could not always be obtained.

Of each patient with bilateral DMEK, the second eye that underwent surgery was excluded from the analysis (n = 106). Because reliable ECD measurements could not always be obtained in eyes with a larger graft detachment (more than one-third of the graft surface area), only eyes with a detachment of one-third of the graft surface area or less (partially detached) were determined as a cutoff point for inclusion in the study. Hence, 40 eyes with a larger detachment were excluded, as were 2 eyes with DMEK performed as a secondary procedure after PK. Thus, 352 unilateral eyes that underwent DMEK in 352 patients were included in our study (Table 1).

Of these 352 eyes, 314 underwent DMEK for FECD, 31 underwent DMEK for BK (pseudophakic BK, aphakic BK, congenital glaucoma, phakic intraocular lens, or trauma), and 7 underwent DMEK as a secondary procedure to manage low visual outcome or graft failure after DSEK/DSAEK (Table 1). Sixteen eyes (4.5%) had preexisting glaucoma (FECD, n = 7; BK, n = 8; failed DSEK/DSAEK, n = 1), of which 4 had congenital glaucoma. In total, 314 eyes had an attached graft and 38 had a partially detached graft (Table 1). The mean (SD) participation time after DMEK was 42 (22) months (range, 0-96 months) (Table 1).

This study was approved by the institutional review board of the Netherlands Institute for Innovative Ocular Surgery as a retrospective data review. All patients signed an institutional review board–approved informed consent form. The study was conducted according to the Declaration of Helsinki.[18]

Donor Tissue

Harvesting of the Descemet membrane graft was performed as previously described.[19,20] In short, corneoscleral buttons from donor globes were obtained post-mortem and stored in organ culture medium at 31°C.In the eye bank, endothelial cell morphology and viability were evaluated and the corneoscleral buttons were mounted endothelial side up on a custom-made holder so that a 9.5-mm-diameter Descemet membrane sheet with its endothelium could be stripped from the posterior stroma. Due to the elastic tissue properties, a Descemet roll formed spontaneously with the endothelium on the outside. Descemet rolls were then stored in organ culture medium until the day of transplantation (Table 1).

Surgery

A circular 9.0-mm-diameter descemetorhexis was performed under air by scoring and stripping the Descemet membrane from the posterior stroma with a reversed Sinskey hook (D.O.R.C.International).In eyes that underwent DMEK as a secondary procedure, the primary DSEK/DSAEK graft was carefully removed from the recipient posterior stroma with a reversed Sinskey hook.

The donor Descemet roll was stained with 0.06% Trypan blue solution (VisionBlue; D.O.R.C. International), sucked into a custom-made injector (DMEK inserter; D.O.R.C. International), and injected through a 3.0-mm limbal tunnel incision into the recipient anterior chamber. The graft was oriented with the endothelial side facing the recipient iris and with the donor Descemet membrane facing the recipient stroma. After complete graft unfolding over the iris through indirect manipulation by an air bubble, by flushing with balanced salt solution, and by gentle strokes on the corneal surface, an air bubble was injected under the graft to attach and fixate it onto the recipient posterior stroma. The anterior chamber was then completely filled with air for 60 minutes followed by an air/liquid exchange, leaving a 30% to 50% air bubble.[21]

Postoperative medication included topical antibiotics for 2 weeks and a steroid regimen of dexamethasone sodium phosphate, 0.1%, eyedrops 4 times daily for 4 weeks, followed by fluorometholone eyedrops 4 times daily, tapered to once daily until 1 year postoperatively and thereafter once daily or once every other day.[22]

Data Collection

Donor ECD was measured preoperatively in vitro using an inverted light microscope Axiovert 40; Zeiss) and postoperatively every 6 months up to 8 years with an SP3000p noncontact autofocus specular microscope (Topcon Medical Europe BV). At the same time intervals, all eyes had routine examinations, including biomicroscopy, anterior segment optical coherence tomography (Heidelberg Engineering GmbH), and Scheimpflug imaging (Pentacam; Oculus).

Analysis of ECD was done by multiple trained technicians. For every image, the automatically delineated cell borders were carefully checked. If they were not correctly assigned by the program, a manual correction was applied to correctly assign the cell borders. Three central images were analyzed per eye and follow-up point and results were averaged. For every analysis, the largest possible part of the image was used.

Endothelial graft failure was diagnosed with slit-lamp biomicroscopy, revealing corneal edema that necessitated repeat keratoplasty. Primary graft failure was defined as absent corneal clearance after surgery despite full graft attachment; secondary graft failure was defined as a corneal decompensation after a postoperative interval with a clear cornea.

To determine whether the indication for surgery affected the outcomes, the FECD subgroup was compared with the BK subgroup (Figure 1B and Figure 2B).

For each eye, graft adherence status was categorized as either completely attached or partially detached. These 2 subgroups were compared with each other to determine whether partial graft detachment affected ECD decay and endothelial survival (Figure 1C and Figure 2C).

Statistical Analysis

Participation time of an eye was defined as the time from surgery until the last visit with a successful graft or a failed graft necessitating repeat keratoplasty.

Linear mixed models were used to identify possible differences in ECD outcomes over 8 years between the different subgroups, FECD vs BK and attached vs partially detached grafts, while controlling for possible confounders of the patient (age, sex, lens status, preoperative glaucoma), the donor (cause of death, sex, age), and the donor and graft processing times (times from death to preservation, preservation to preparation, preparation to surgery). Examination of the

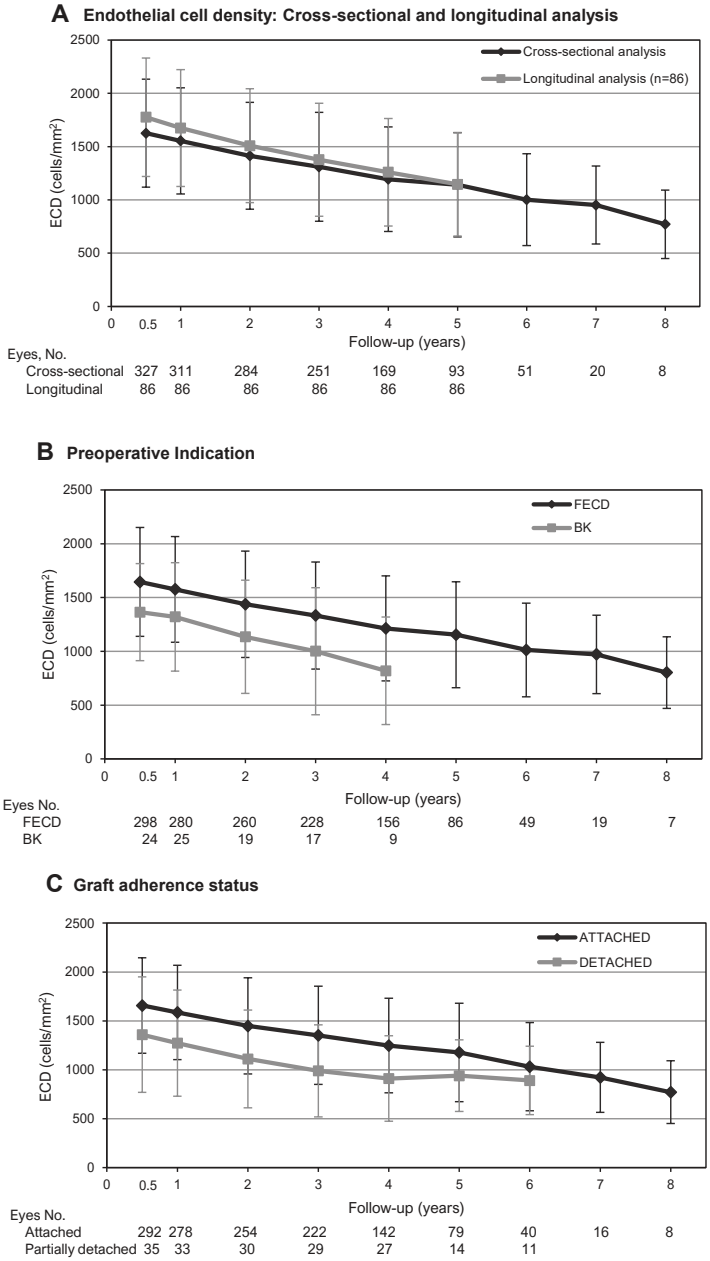

Figure 1. Mean Endothelial Cell Density (ECD) up to 8 years after Descemet Membrane Endothelial Keratoplasty. (A) Mean ECD by cross-sectional analysis of the entire cohort for each follow-up point and longitudinal analysis from 6 months until 5-year follow-up. (B) Mean ECD by preoperative indication of Fuchs endothelial corneal dystrophy (FECD) vs bullous keratopathy (BK). (C) Mean ECD by graft adherence status of attached grafts vs partially detached grafts. Error bars indicate standard deviation.

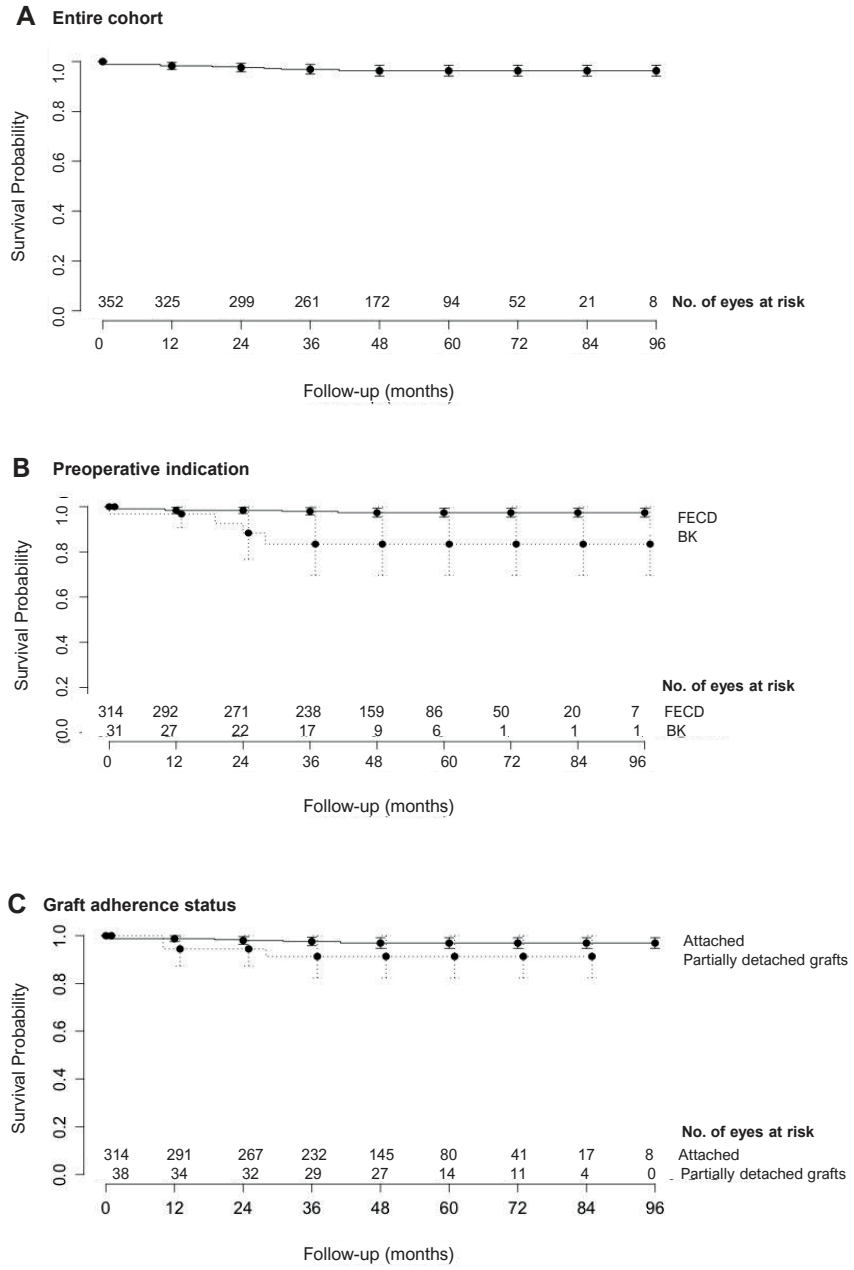

Figure 2. Kaplan-Meier survival curves up to 8 Years after Descemet Membrane Endothelial Keratoplasty (A,B,C) Survival probabilities and 95% confidence intervals for the overall group (A), for those with preoperative indication of Fuchs endothelial corneal dystrophy (FECD) vs bullous keratopathy (BK; B), and for those with attached grafts vs partially detached grafts (C).

residuals did not reveal violations of the assumptions (normality, homoscedasticity, outliers). There were a few eyes with high standardized residuals (between 3.5 and 4.0), for which the model does not fit well. Because 17 of 352 eyes did not have any follow-up ECD value at 6 months and onward, only the remaining 335 eyes could be included in the linear mixed model ECD analysis.

Based on the observed survival times of all eyes up to 8 years, survival distributions were estimated using the Kaplan Meier estimator. Survival times were assessed with Cox regression while taking possible risk factors (age, preoperative ECD, etc.) into account, to evaluate whether preoperative indication (FECD vs BK) and graft adherence status (attached vs partially detached) have an effect on survival time. Survival analysis for the entire group comprised 352 eyes; survival analysis for the subgroups comprised 345 eyes because the small regraft group (n = 7) was not included.

Statistical analyses were performed with R version 3.1.3 statistical software (R Foundation for Statistical Computing) using the package "survival," "rms," and "nlme."

RESULTS

Endothelial Survival in Terms of Endothelial Decay

In the cross-sectional analysis of 352 eyes, the mean (SD) ECD was 1626 (507) cells/mm^2 at 6 months (n = 327), 1554 (498) cells/mm^2 at 12 months (n = 311), 1414 (502) cells/mm^2 at 24 months (n = 284), 1310 (511) cells/mm^2 at 36 months (n = 251), 1194 (491) cells/mm^2 at 48 months (n = 169), 1142 (490) cells/mm^2 at 60 months (n = 93), 1002 (431) cells/mm^2 at 72 months (n = 51), 952 (366) cells/mm^2 at 84 months (n = 20), and 771 (321) cells/mm^2 at 96 months (n = 8) after DMEK (Figure 1A). Of the available eyes with survived (clear) grafts 7 years after DMEK, 5.0% had an ECD of less than 500 cells/mm^2 and 45.0% had an ECD of 1000 cells/mm^2 or more (Table 2).

In the longitudinal ECD analysis of 86 eyes with available ECD at each point from 6 months until 5-year follow-up, the mean (SD) ECDs at 6, 12, 24, 36, 48, and 60 months after DMEK were 1776 (555), 1674 (549), 1508 (534), 1377 (530), 1259 (504), and 1145 (483) cells/mm^2, respectively (Figure 1A).

Table 2. Availability of Endothelial Cell Density at each follow-up point after DMEK

Variable	Follow-up time (years)									
	Pre-operative	0.5	1	2	3	4	5	6	7	8
DMEK eyes, No.	352	352	352	352	349	252	159	79	36	15
Eyes with missing data, No.	0	9	14	16	21	15	10	3	5	--
Eyes lost-to follow-up, No. (%)	NA	12 (3.4)	21 (6.0)	45 (12.8)	68 (19.5)	57 (22.6)	52 (33.3)	21 (22.7)	7 (19.4)	4 (26.7)
Failure or reoperation,No.	NA	4	6	7	9	11	4	4	4	3
Failures per interval, No.	NA	4	2	1	2	2	0	0	0	0
Eyes available for ECD analysis, No.	352	327	311	284	251	169	93	51	20	8
Eyes with ECD <500 cells/mm^2, No. (%)	0	4 (1.2)	5 (1.6)	9 (3.2)	12 (3.4)	6 (2.4)	4 (4.3)	4 (7.8)	1 (5.0)	1 (6.7)
Eyes with ECD >1000 cells/mm^2, No. (%)	352 (100)	283 (86.6)	258 (82.3)	217 (76.4)	170 (67.7)	99 (57.9)	51 (54.8)	23 (45.1)	9 (45.0)	1 (6.7)

DMEK=Descemet membrane endothelial keratoplasty; ECD=Endothelial cell density; NA=not applicable

Up to 8 years, a significantly higher ECD was found in eyes with FECD than in those with BK (estimated mean difference, 261 cells/mm^2; 95% CI, 118-404; P = .003) (Figure 1B),

and eyes with attached grafts had a significantly higher ECD than those with partially detached grafts (estimated mean difference, 330 cells/mm^2; 95% CI, 208-452; P < .001) (Figure 1C). The graft was partially detached in 35 of 314 eyes with FECD (11.1%) and in 3 of 31 eyes with BK (9.7%).

The risk factor preoperative ECD had an effect on the outcome ECD: for each additional 100 cells/mm^2 before DMEK, the final ECD outcome at 8 years post-operatively increased by an average of 86 cells/mm^2 (95% CI, 69-104; P < .001). Among the donor death causes (cancer, cardiac or stroke, respiratory, and trauma or other), cancer was associated with the highest ECD outcome until 8 years. When compared with the baseline category cardiac or stroke, the estimated mean difference was 133 cells/mm^2 (95% CI, 43-224; P = .01).

Endothelial Survival in Terms of Primary and Secondary Graft Failures

Endothelial failure occurred in 11 of 352 eyes (3.1%) within 4 years after DMEK; 4 eyes were diagnosed as having primary graft failure and 7 were diagnosed as having secondary graft failure. All of these eyes had concomitant ocular pathology, including partial graft detachment.

Based on the number of primary and secondary graft failures in the entire cohort, the estimated survival probability was 0.97 (95% CI, 0.95-0.99) at 3 years and 0.96 (95% CI, 0.94-0.99) at 5 and 8 years (Figure 2A). Survival probabilities were higher in eyes with FECD than in those with BK at 3 years (0.98 [95% CI, 0.96-0.99] vs 0.84 [95% CI, 0.70-0.99], respectively) as well as at 5 and 8 years (0.97 [95% CI, 0.95-0.99] vs 0.84 [95% CI, 0.70-0.99], respectively) (Figure 2B). In eyes with attached grafts and partially detached grafts, survival probabilities at 8 years were 0.97 (95% CI, 0.95-0.99) and 0.91 (95% CI, 0.82-0.99), respectively (Figure 2C). The baseline hazard risk for failure was 0.02 (average number of expected failures per eye per 12-month interval). Preoperative indication BK significantly increased the (baseline) hazard risk of failure by a factor of 5 (hazard ratio = 5.09 [95% CI, 1.24-20.83]; P = .02). The graft adherence status of detached increased the hazard risk of failure by a factor of approximately 3, but not significantly (hazard ratio = 2.79 [95% CI, 0.73-10.68]; P = .13). The possible risk factors such as baseline ECD did not have a significant effect on the hazard risk of failure.

Graft Failure and Other Postoperative Complications

Of the 4 eyes with a primary graft failure, 3 were within the learning curve. The remaining eye developed BK after ocular trauma with corneal perforation.

Of the 7 eyes with a secondary graft failure, 2 had a DMEK performed for BK after phakic intraocular lens removal associated with glaucoma episodes necessitating filtering surgery. One eye that had DMEK for corneal decompensation due to congenital glaucoma in the presence of a brunescent cataract and a Baerveldt shunt developed graft failure after phacoemulsification 9 months after DMEK. Two eyes developed secondary graft failure after allograft rejection, and 2 eyes had an ECD less than 500 cells/mm^2 in the presence of a partial graft detachment at 6 months.

All other corneas with postoperative complications potentially affecting endothelial cell survival remained clear throughout the study period: reversible allograft rejection (n = 6), rebubbling (n = 4), postoperative glaucoma (n = 14), pars plana vitrectomy (n = 1), and phacoemulsification (n = 10).

DISCUSSION

In PK and DSEK/DSAEK, graft survival has been described to vary with factors such as the indication for surgery, re-transplantation, comorbidity (e.g., glaucoma), complications (e.g., allograft rejection), and donor characteristics.[10,13,14,23,24] To determine the causes associated with graft longevity in DMEK, we evaluated endothelial survival in terms of ECD decay and endothelial failure in a first DMEK cohort up to 8 years postoperatively.

However, comparisons between studies require caution because graft survival may vary per region, demographic characteristics, and surgical setting and because various studies used different inclusion and exclusion criteria, causing varying survival outcomes.[25,26] A complicating factor is the terminology used: graft survival may not mirror graft failure because technical failures may not provide information on graft viability (e.g., grafts positioned upside down have been shown to carry healthy endothelial cells).[27] Similarly, a common indication for repeat DMEK is graft detachment, but microscopic analysis of explanted grafts showed a normal and viable endothelial cell layer.[27] For that reason, we did not define our outcome measurements in terms of success rate or graft survival

but instead based our analysis on ECD decay and on eyes with endothelial graft failure.

Endothelial Survival in Terms of Primary and Secondary Graft Failure

For DSAEK, a 3-year graft survival rate of 87% to 97% has been reported[6,7]; for DSEK, a 5-year survival rate of 93% has been reported.[8] After PK, survival rates may vary from 75% to 95% at 3 and 5 years.[6,7,9,10] The overall DMEK survival probability in our cohort was 0.96 at 5 and 8 years postoperatively.

Interestingly, all 11 endothelial graft failures in our study seemed to only be associated with surgical error, comorbidity, or postoperative complications. Of the 4 eyes that showed a primary graft failure, 3 were within the first 25 DMEK operations (learning curve), and these eyes may have undergone reoperation too early when the cornea failed to clear within 3 weeks. We later learned that in the presence of a completely attached graft, some transplanted corneas may need a longer time to clear.[28] The remaining eye with primary graft failure had a history of BK after penetrating ocular trauma. Eyes that developed a secondary graft failure had a partial graft detachment with a low ECD, BK after phakic intraocular lens implantation (and removal) complicated by glaucoma episodes, congenital glaucoma, or allograft rejection preceding the transplant failure. These findings would suggest that, overall, mainly eyes with comorbidity are at risk for graft failure or, in other words, that endothelial survival probability would be high in eyes that have undergone DMEK without complication.

Compared with PK, survival probabilities with DMEK may have improved owing to elimination of suture-related complications (suture loosening, sterile inflammation, stromal melt), lower incidence of allograft rejection, better preservation of the anterior chamber angle anatomy, and faster tapering of steroids (reducing the risk of glaucoma and cataract formation).[22,29,30]

When stratified by the indication for surgery, graft survival probability in terms of endothelial failure until 8 years after DMEK was better in eyes with FECD than in those with BK (0.97 vs 0.84, respectively). This finding may agree with studies on DSEK/DSAEK and PK, in which eyes with FECD consistently showed better graft longevity.[7–10,17,23]

When analyzed for graft adherence status, the graft survival probability in eyes with a completely attached graft was higher than in those with a partial detach-

ment (0.97 vs 0.91, respectively). Still, partial graft detachment did not seem to be significantly associated with higher risk of endothelial graft failure. This could be attributed to the relatively low number of eyes with endothelial failure in our cohort. Larger series in longer follow-up studies may be required to evaluate whether partial graft detachment is associated with a higher risk of endothelial failure.

It stands to reason that in both BK and partial graft detachment, a relative depletion of cells and/or the underlying pathology relates to lower endothelial survival rates. If so, partial graft detachment - albeit visually insignificant – could benefit from (earlier) surgical intervention, although repeat rebubbling has also been associated with lower ECDs.[31]

Furthermore, the distribution of endothelial graft failures over time may be of interest: 6 of the 11 failures occurred within the first postoperative year. This may suggest that if the early postoperative course after DMEK is uneventful, the graft may have an excellent prognosis on long-term survival, especially in eyes with FECD, because late-onset secondary graft failure was consistently associated with comorbidity unrelated to the transplant itself. However, identification of risk factors was limited by the relatively small number of failures in our cohort combined with the amount of censored observations.

Endothelial Survival in Terms of ECD Decay

In addition to visual outcomes surpassing those of PK and DSEK/DSAEK, the relatively low number of endothelial failures in our study may suggest that DMEK also has the advantage of longer graft longevity. To further substantiate this hypothesis, we evaluated the decay in ECD during the first 8 years in an attempt to calculate how many eyes that underwent DMEK would have an ECD less than 500 cells/mm^2, an ECD that may be associated with impending graft failure.[17,32] Within the entire cohort of survived clear grafts, fewer than 10% of eyes had an ECD less than 500 cells/mm^2 at each follow-up point. Any predictions of a time at which low ECD may result in graft failure and whether a certain ECD constitutes a threshold related to graft failure seem unreliable because the long-term sample size was relatively small. A larger data set may be necessary to allow a reliable prediction on long-term endothelial survival after DMEK.[33]

CONCLUSIONS

This study shows that until 8 years after DMEK, endothelial survival may be promising. In particular eyes with FECD and a completely attached graft may have an excellent prognosis in the longer term.

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