Clinical outcomes of modern lamellar keratoplasty techniques

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Chapter 3

Incidence of irregular astigmatism eligible for contact lens fitting after Descemet membrane endothelial keratoplasty

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ABSTRACT

Purpose. To evaluate the incidence and causes of anterior corneal surface irregularities after successful Descemet membrane endothelial keratoplasty (DMEK) and the efficacy of contact lens fitting in these cases.
Setting. Tertiary referral center.
Design: Retrospective study of prospectively collected data.
Methods. Eyes with a subnormal visual outcome or monocular diplopia after successful DMEK were fitted with a contact lens. These cases were evaluated with Pentacam rotating Scheimpflug camera imaging preoperatively and 6 months postoperatively, and outcomes were compared with those in a randomly selected DMEK control group.
Results. In a series of 262 surgeries, 23 eyes (21 patients) were fitted with contact lenses; the control group comprised 23 eyes. Indications for contact lens fitting included (1) obvious corneal surface irregularities due to preexisting corneal scarring, (2) surface irregularities associated with longstanding preoperative stromal edema, and (3) undetectable optical imperfections. The postoperative corrected distance visual acuity (CDVA) with spectacles improved after contact lens correction ($P<.001$). Preoperative and postoperative irregularity indices were significantly higher in the contact lens group than in the DMEK control group ($P<.05$). Positive correlations were found between the duration of preoperative stromal edema and postoperative Scheimpflug camera indices ($P<.02$).
Conclusions. After successful DMEK, 23 of 262 eyes (9%) showed subnormal spectacle CDVA and/or monocular diplopia due to corneal scarring, surface irregularities, or undetectable optical imperfections that could be managed by contact lens fitting. Prolonged preoperative corneal edema for more than 12 months may be a risk factor for diffuse irregular astigmatism after DMEK.

Keywords: Astigmatism, contact lens fitting, Descemet membrane endothelial keratoplasty, endothelial keratoplasty, corneal transplantation, visual acuity, corneal surface irregularities, stromal edema

INTRODUCTION

Since 1998, we have introduced various techniques for endothelial keratoplasty, popularized as 'deep lamellar endothelial keratoplasty' (DLEK), and 'Descemet stripping (automated) endothelial keratoplasty' (DSEK/DSAEK). More recently, we described a technique for selective replacement of Descemet membrane, currently referred to as Descemet membrane endothelial keratoplasty (DMEK).[1-3]

One of the major advantages of endothelial keratoplasty over penetrating keratoplasty (PK) may be that corneal sutures and surface incisions are not required in DLEK, DSEK/DSAEK, or DMEK.[4,5] Consequently, the anterior corneal curvature is not compromised and the optical quality of the refractive surface of the eye is largely preserved. After DMEK, most patients are able to continue wearing their existing glasses until a stable postoperative refraction is reached and new glasses can be prescribed, usually three to six months after surgery.[6]

With DMEK, the majority of eyes reach a corrected distance visual acuity (CDVA) with spectacles of 20/25 (0.8) ot better at six months postoperatively. In the remaining eyes, a lower visual acuity level is often explained by a dysfunctional transplant, maculopathy in an elderly age group, or other concomitant ocular pathology.[7] However, in DSEK/DSAEK, irregular astigmatism has also been recognized as a potential cause for incomplete visual rehabilitation,[8] and although easy to manage, it may also be easily overlooked.

The purpose of this study, therefore, was to evaluate the incidence of anterior corneal surface irregularities associated with visual complaints after successful DMEK, and the efficacy of contact lens fitting in these cases.

MATERIAL AND METHODS

This study comprised eyes that had DMEK for endothelial dysfunction. A group of the eyes were fitted with contact lenses 6 months postoperatively because of subnormal spectacle CDVA or visual complaints. All patients signed an IRB-approved informed consent. The study was conducted according to the Declaration of Helsinki and registered on the U.S. National Institutes of Health Clinical Trials site.[A]

All DMEK surgeries were performed following protocol.[9] In short, from corneo-scleral buttons stored by organ culture at 31° C for one week, the Descemet membrane (DM) was stripped off, so that a 9.5 mm diameter sheet of posterior DM with its endothelial monolayer was obtained. Due to the elastic properties of the membrane, a 'Descemet-roll' formed spontaneously with the endothelium on the outer side. Each Descemet–roll was then stored 'free-floating' in organ culture medium until the time of transplantation.[10]

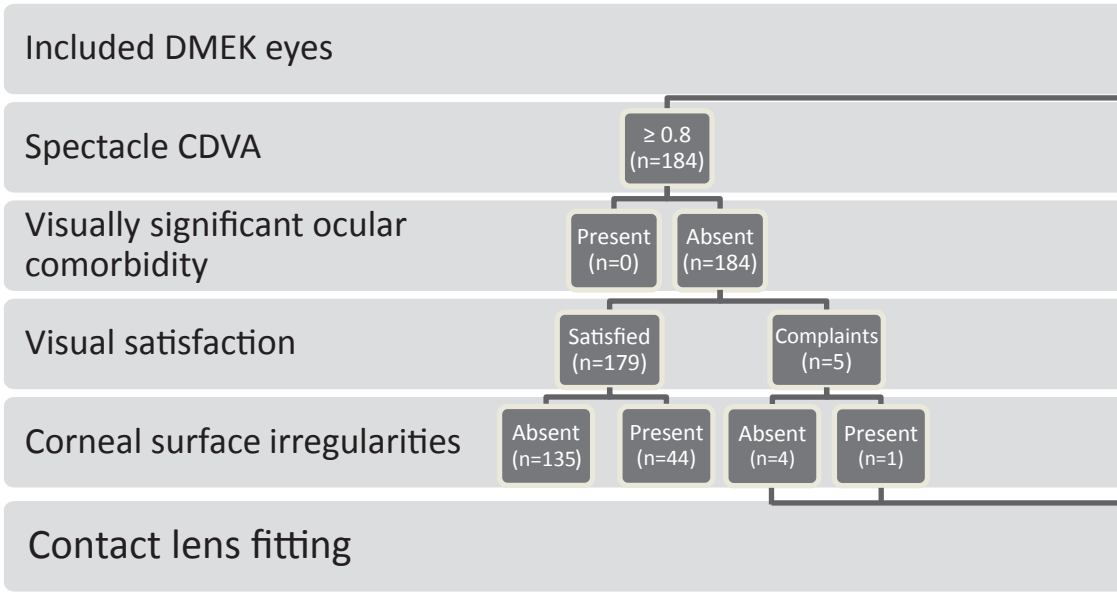
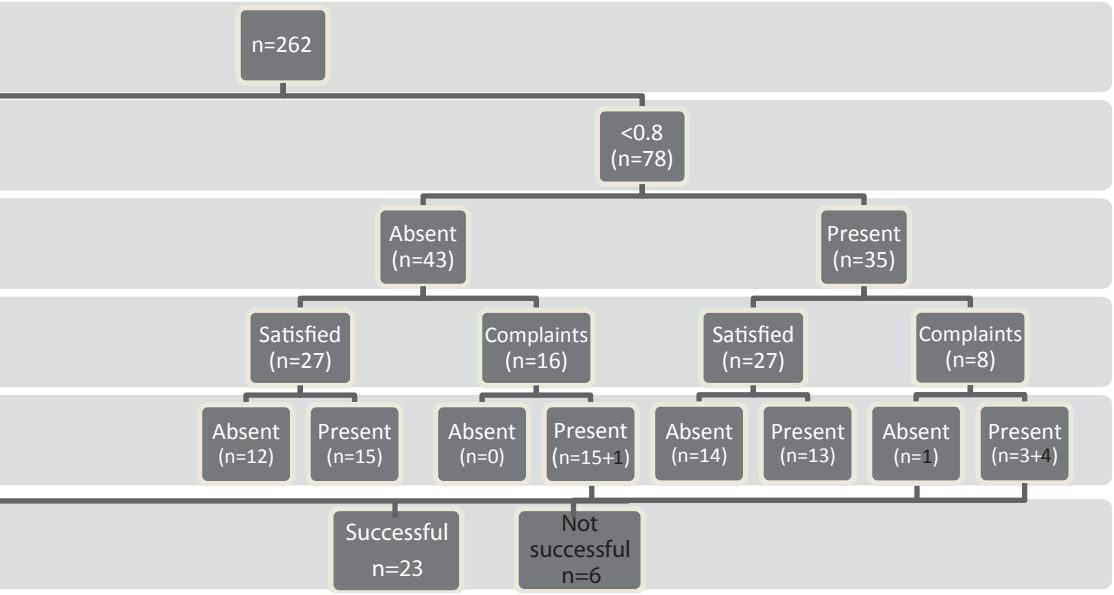


Figure 1. Incidence of corneal surface irregularities in eyes after successful DMEK and the decision tree for contact lens fitting (CDVA = corrected distance visual acuity; DMEK = Descemet membrane endothelial keratoplasty).

In recipient eyes, a circular portion of DM was scored and stripped from the posterior stroma to create a 9.0-mm diameter 'descemetorhexis.' In eyes with prior endothelial graft failure, the previous transplant was carefully separated from the recipient posterior stroma. Then, the donor Descemet-roll was stained with a 0.06% trypan blue solution (VisionBlue™, D.O.R.C. International, Zuidland, The Netherlands), and sucked into a custom-made pipette (D.O.R.C. International).[9,11] The donor roll was then injected into the anterior chamber, unfolded, and positioned endothelial side down (facing the iris) onto the recipient posterior stroma by careful, indirect manipulation of the tissue with air and fluid. The anterior chamber was completely filled with air for 60 minutes, followed by an air-liquid exchange to pressurize the eye.[9] All surgeries were recorded on DVD (Pioneer DVR-RT601H-S, Tokyo, Japan).

The DMEK eyes were examined before, and at one, three and six months after surgery. The clinical outcome was evaluated by comparing the preoperative to 6-month postoperative spectacle CDVA, contact lens CDVA and slit-lamp biomicroscopy (Topcon Medical Europe BV). Corneal surface topography maps (Pentacam, Oculus, Wetzlar, Germany) were used to analyze the index of surface variance (ISV), which is a general measure of surface irregularity; index of vertical asymmetry (IVA), which displays the difference between the superior and inferior corneal curvature; index of height asymmetry (IHA), which is similar to the IVA but based on corneal elevation; and index of height decentration (IHD), which is a quantification of the degree of vertical decentration calculated with Fourier analysis (Table 1).[B] To compare these indices to a control group, Pentacam



examinations of the 23 study eyes were compared to a randomly selected, group of 23 successful DMEK eyes with a spectacle CDVA of 20/25 (0.8) or better, matched for patient age (*P*=.739), preoperative pachymetry (*P*=.138), and preoperative spectacle CDVA (*P*=.131). The control eyes were selected from the group of 179 eyes with satisfying spectacle CDVA 20/25 (0.8) or better (Figure 1).

Table 1. Scheimpflug camera index limit values.

Pentacam Index limit values		
Index	Abnormal	Pathological
ISV	≥37	≥41
IVA	≥0.28	≥0.32
IHA	≥19	>21
IHD	≥0.014	>0.016

IHA = index of height asymmetry; IHD = index of height decentration; ISV = index of surface variance; IVA = index of vertical asymmetry

To compare the contact lens group with the DMEK control group, unpaired Student t-tests and Fisher exact tests were applied for continuous and categorical variables, respectively. In addition, to correct for case mix at baseline, multiple linear regression models were fitted, whereby the postoperative indices were taken as response versus all baseline characteristics, and the group indicator as covariates. For comparison within each group, paired Student t-tests were used. Pearson correlations (r) were used to estimate relations between logMAR spectacle CDVA and Pentacam indices within each group. The effect size of this relation was assessed using the coefficient of determination (r^2) and the classification established by Cohen (1992).[12] A *P*-value <.05 was considered statistically significant (not corrected for multiple testing). All analyses were performed using the statistical software R (2.14.0) and the statistical package SAS (version 9.2).

RESULTS

From a larger group of 300 consecutive eyes (63 phakic, 237 pseudophakic) of 248 patients with a mean age of 67 years (±13), 262 were included in the study. Thirty-eight eyes were excluded because of primary graft failure (2 eyes), partial graft detachment (27 eyes), or loss to follow-up (9 eyes). Of the 262 eyes studied, 23 eyes (6 phakic, 17 pseudophakic) of 21 patients with a mean age of 61 (±12) years were fitted with contact lenses 6 months postoperatively because of subnormal spectacle CDVA or visual complaints. Indications for DMEK surgery in this group were Fuchs endothelial dystrophy (15 eyes), bullous keratopathy (3 eyes), and previous endothelial graft failure (5 eyes) (Table

Table 2. Characteristics of eyes in the contact lens study group

STUDY GROUP				PREOPERATIVE				
#	Age	Indication	Eye OD/OS	Spectacle CDVA	Irregular Astigmatism	Pachymetry (μm)	Corneal Swelling*/ Increasing since	Corneal Scarring
1	62	FED	OS	20/50 (0.4)	yes	658	41% / >17M	yes
2	74	FED	OD	20/133 (0.15)	yes	614	31% / >17M	yes
3	49	post DSAEK	OD	CF	yes	769	n.a. / 10M	yes
4	73	FED	OS	20/200 (0.1)	yes	583	21% / >5M	no
5	63	FED	OS	20/100 (0.2)	yes	618	10% / n.a.	no
6	74	Re-DMEK	OD	20/40 (0.5)	yes	745	35% / >15M	no
7	67	FED	OD	20/60 (0.3)	yes	615	16% / n.a.	no
8	77	FED	OS	20/100 (0.2)	yes	637	23% / 12M	no
9	64	Re-DMEK	OD	20/400 (0.05)	yes	859	62% / 12M	no
10	69	FED	OD	20/100 (0.2)	mild	676	29% / >12M	no
11	74	PPBK	OS	20/200 (0.1)	yes	714	27% / >12M	no
12	67	FED	OS	20/400 (0.05)	yes	790	59% / ±12M	no
13	30	BK	OD	20/100 (0.2)	yes	761	34% / ±120M	no
14	72	Re-DMEK	OD	20/60 (0.3)	yes	763	62% / 31M	no
15	42	BK	OS	20/200 (0.1)	yes	n.a.	n.a.	no
16	58	FED	OS	20/100 (0.2)	yes	808	62% / n.a.	no
17	69	FED	OS	20/40 (0.5)	no	649	29% / 3M	no
18	53	FED	OD	20/50 (0.4)	mild	654	22% / 4M	no
19	62	Re-DMEK	OD	20/60 (0.3)	no	719	32% / 6M	no
20	61	FED	OS	20/40 (0.5)	no	626	12% / n.a.	no
21	55	FED	OS	20/60 (0.3)	no	678	33% / n.a.	no
22	46	FED	OD	20/20 (1.0)	no	569	15% / n.a.	no
23	42	FED	OS	20/25 (0.8)	no	558	13% / n.a.	no

BK = bullous keratopathy; CDVA = corrected distance visual acuity; CL = contact lens; CME = cystoid macular edema; DMEK = Descemet membrane endothelial keratoplasty; DSAEK = Descemet-stripping automated endothelial keratoplasty; FED = Fuchs endothelial dystrophy; HSV = herpes simplex virus;

2). Figure 1 shows the incidence of corneal surface irregularities in eyes after successful DMEK and the decision tree for contact lens fitting.

Of the 262 successful DMEK cases, 184 eyes (70%) had a spectacle CDVA of 20/25 (0.8) or better at six months after DMEK. All patients in this group were satisfied with the visual outcome, except for five cases that reported ghost images and/or monocular diplopia (Figure 1). In the remaining (262-184=) 78 eyes with a postoperative spectacle CDVA less than 20/25 (<0.8) at six months, an additional 24 eyes had visual complaints and/or a lower visual outcome than explained by ocular comorbidity (Figure 1). In 18 of these 24 eyes, a contact lens could be fitted successfully to improve vision (Figure 1). In 6 eyes, no visual improvement could be obtained with contact lenses.

POSTOPERATIVE (6 months follow up)						Remarks
Spectacle CDVA	CL CDVA	CL	Irregular Astigmatism	Pachymetry (μm)	Corneal Scarring	
20/50 (0.4)	20/28 (0.7)	scleral	yes	467	yes	RK / LASIK / Myopic fundus
20/60 (0.3)	20/28 (0.7)	RGP	yes	467	yes	Pre op HSV / Myopic fundus
20/60 (0.3)	20/20 (1.0)	RGP	yes	427	yes	Corneal thinning paracentral due to ulcer
20/60 (0.3)	20/28 (0.7)	RGP	yes	482	yes	Myopic fundus
20/100 (0.2)	20/50 (0.4)	scleral	yes	563	yes	Macular Pucker
20/133 (0.15)	20/23 (0.9)	scleral	yes	551	yes	
20/28 (0.7)	20/23 (0.9)	RGP	yes	530	yes	Verticillata
20/60 (0.3)	20/25 (0.8)	scleral	yes	517	no	
20/20 (1.0)	20/20 (1.2)	RGP	yes	530	no	Large refractive cylinder
20/40 (0.5)	20/25 (0.8)	RGP	yes	525	no	
20/40 (0.5)	20/25 (0.8)	scleral	yes	562	yes	Glaucoma
20/28 (0.7)	20/20 (1.0)	RGP	yes	498	yes	
20/40 (0.5)	20/25 (0.8)	RGP	yes	567	yes	
20/60 (0.3)	20/28 (0.7)	RGP	yes	471	yes	
20/80 (0.25)	20/28 (0.7)	RGP	yes	n.a.	no	Glaucoma / CME
20/40 (0.5)	20/23 (0.9)	scleral	yes	500	yes	
20/33 (0.6)	20/25 (0.8)	scleral	mild	503	no	Macular RPE changes
20/40 (0.5)	20/28 (0.7)	RGP	no	538	no	Optic neuritis
20/40 (0.5)	20/25 (0.8)	scleral	no	544	no	
20/25 (0.8)	20/25 (0.8)	scleral	no	558	no	Monocular double vision without CL
20/23 (0.9)	20/20 (1.0)	scleral	no	511	no	High refractive cylinder
20/23 (0.9)	20/20 (1.0)	SCL	no	495	no	Ghost images without CL
20/20 (1.0)	20/20 (1.0)	SCL	no	496	no	Ghost images without CL

LASIK = laser in situ keratomileusis; n.a. = not available; PPBK = pseudophakic bullous keratopathy; RGP = rigid gas permeable; RK = radial keratotomy; RPE = retinal pigment epithelium; SCL = soft contact lens
*Percentage of corneal swelling with postoperative pachymetry as a reference

Hence, a total of 23 eyes (5+18; contact lens study group) were fitted with a scleral contact lens (10 eyes); a rigid gas permeable contact lens (11 eyes) or a soft silicone hydrogel lens (2 eyes) (Figure 1 and Table 2). After excluding three eyes with low visual potential (Cases 5, 15, 19), the average LogMAR CDVA improved from 0.30 (±0.22) with spectacles to 0.07 (±0.06) with a contact lens, (an improvement in Snellen visual acuity from 20/40 (0.5) to 20/23 (0.9)). All patients in this group subjectively had better vision with a contact lens than with spectacles and reported a noticeable decrease in monocular double vision and/or ghost images, if present before.

To determine the cause of visual complaints and/or a relatively poor spectacle CDVA after DMEK, rotating Scheimpflug camera imaging and biomicroscopy were used and 3

Table 3. Characteristics of eyes in control group

CONTROL GROUP				PREOPERATIVE				
#	Age	Indication	Eye OD/OS	Spectacle CDVA	Irregular Pentacam	Pachymetry (μm)	Corneal swelling* / Increasing since	Corneal Scarring
1	62	PPBK	OD	20/50 (0.4)	yes	783	45% / n.a.	no
2	63	FED	OD	20/100 (0.2)	mild	702	39% / n.a.	no
3	54	FED	OS	20/50 (0.4)	yes	768	40% / 7M	no
4	82	FED	OS	20/100 (0.2)	mild	661	31% / n.a.	no
5	31	BK	OD	CF	yes	929	84% / 8M	no
6	50	re DMEK	OD	20/50 (0.4)	mild	719	41% / 3M	no
7	45	FED	OS	20/60 (0.3)	yes	785	34% / n.a.	no
8	68	FED	OS	20/25 (0.8)	yes	659	32% / n.a.	no
9	59	FED	OD	20/50 (0.4)	yes	691	39% / n.a.	no
10	66	FED	OD	20/60 (0.3)	mild	807	48% / n.a.	no
11	48	FED	OS	20/40 (0.5)	mild	539	9% / n.a.	no
12	46	FED	OD	20/60 (0.3)	mild	785	34% / n.a.	no
13	75	FED	OS	20/50 (0.4)	no	618	25% / n.a	no
14	68	FED	OD	20/60 (0.3)	no	665	25% / 4M	no
15	80	PPBK	OD	20/100 (0.2)	no	871	74% / 8M	no
16	75	FED	OD	20/100 (0.2)	no	709	47% / ±9M	no
17	63	FED	OS	20/60 (0.3)	no	643	16% / n.a.	no
18	58	FED	OD	20/40 (0.5)	no	666	21% / n.a.	no
19	74	FED	OS	20/33 (0.6)	no	572	15% / n.a.	no
20	48	FED	OD	20/33 (0.6)	no	624	33% / n.a.	no
21	57	FED	OD	20/50 (0.4)	no	865	74% / n.a.	no
22	62	FED	OD	20/25 (0.8)	no	630	10% / n.a.	no
23	41	FED	OD	20/28 (0.7)	no	580	18% / n.a.	no

BK = bullous keratopathy; CDVA = corrected distance visual acuity; CF = counting fingers;
DMEK = Descemet membrane endothelial keratoplasty; FED = Fuchs endothelial dystrophy;
NA = not available; PPBK = pseudophakic bullous keratopathy; RGP = rigid gas permeable;

subgroups were recognized as follows: (1) corneal surface irregularities due to evident pre-existing corneal scarring (Cases 1 to 3 Group 1; Table 2)*;* (2) postoperative corneal surface irregularities without pre-existing scarring (Cases 4 to 17 Group 2; Table 2), with 8 eyes (Cases 6 and 8 to 14) having longstanding preoperative stromal edema (≥12 months); and (3) optical imperfections of the cornea that could not be detected with biomicroscopy and/or Pentacam imaging (Cases 18 to 23 Group 3; Table 2) (Figure 2).

Outcomes in the contact lens study group were compared with those in a control group of uneventful DMEK eyes (n=23) with a spectacle CDVA of 20/25 (0.8) or better (Table 3). The mean postoperative logMAR spectacle CDVA in the control group was -0.03 (± 0.07), representing a Snellen spectacle CDVA of 20/18 (1.1). This was significantly higher than CDVA

POSTOPERATIVE (6 months follow-up)				Remarks
Spectacle CDVA	Irregular Pentacam	Pachymetry (μm)	Corneal Scarring	
20/23 (0.9)	mild	540	yes	
20/20 (1.0)	yes	505	no	
20/20 (1.0)	mild	550	no	
20/23 (0.9)	mild	504	no	
20/25 (0.8)	no	505	no	
20/17 (1.2)	no	509	no	
20/17 (1.2)	no	584	no	Folds in Tx at paracentral area
20/17 (1.2)	no	499	no	
20/20 (1.0)	no	497	no	Small peripheral detachment
20/17 (1.2)	no	546	no	
20/17 (1.2)	no	494	no	
20/13 (1.5)	no	584	no	
20/20 (1.0)	no	493	no	
20/20 (1.0)	no	530	no	Ablatio retinae, RGP contact lens pre-op
20/20 (1.0)	no	500	no	
20/17 (1.2)	no	482	no	
20/20 (1.0)	no	553	no	
20/20 (1.0)	no	550	no	
20/20 (1.0)	no	497	no	
20/13 (1.5)	no	469	no	
20/25 (0.8)	no	498	no	Small horse-shoe-tear peripheral retina
20/17 (1.2)	no	574	no	
20/17(1.2)	no	490	no	

Tx = Descemet membrane endothelial keratoplasty graft

*Percentage of corneal swelling with postoperative pachymetry as a reference

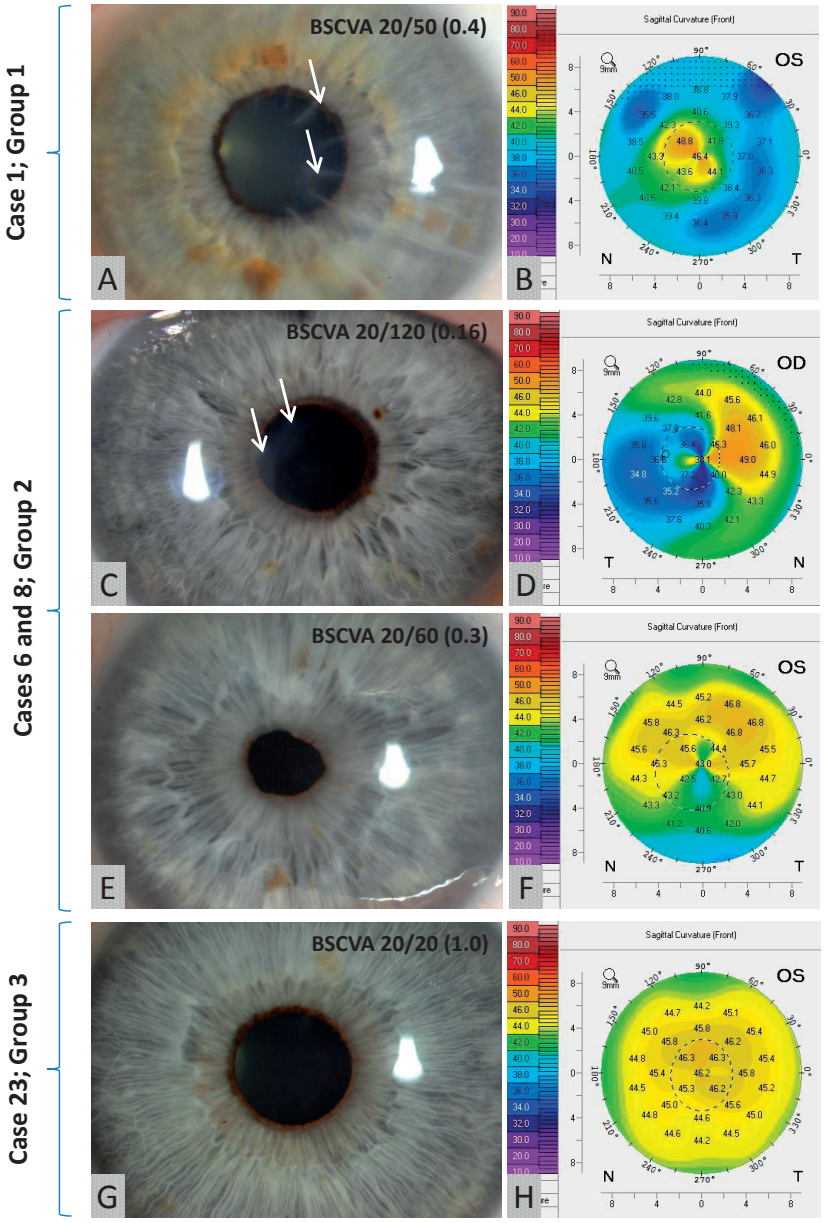


Figure 2. Slitlamp images and related topography images from the contact lens study group divided into 3 subgroups. A cornea containing old radial keratotomy scars (A and B, case 1). Corneas with unexpected surface irregularities in the presence of subepithelial fibrosis (C and D, case 6) or without subepithelial fibrosis (E and F, case 8). Cases 6 and 8 had a history of longstanding (≥12 months) preoperative corneal edema. Group 3 consisted of corneas with optical imperfections not detectable with biomicroscopy and/or corneal topography, for example a cornea with a normal topography, but still associated with ghost images, which disappeared after soft silicone hydrogel contact lens fitting (G and H, Case 23) (BSCVA = spectacle-corrected distance visual acuity; N = nasal; T = temporal).

Table 4. Preoperative and postoperative mean outcome of irregularity indices in the contact lens study group and the control group.

Pentacam indices	Study group		Control group		Significance (*P*)			
	Preop Mean (SD)	6M FU Mean (SD)	Preop Mean (SD)	6M FU Mean (SD)	Preop Study group – Control Group	6M FU Study group – Control Group	Study group Preop to 6M FU	Control group Preop to 6M FU
ISV	44.5 (±33.4)	39.7 (±21.0)	27.7 (±13.7)	23.0 (±6.04)	**0.033**	**0.001**	0.372	0.129
IVA	0.44 (±0.35)	0.38 (±0.21)	0.25 (±0.12)	0.22 (±0.07)	**0.017**	**0.001**	0.391	0.317
IHA	11.0 (±13.4)	9.32 (±9.66)	6.71 (±1.65)	5.93 (±4.35)	0.168	0.136	0.607	0.615
IHD	0.03 (±0.03)	0.02 (±0.02)	0.02 (±0.01)	0.01 (±0.01)	**0.048**	**0.007**	0.288	0.171
Anterior astigmatism	2.48 (±2.44)	2.76 (±2.38)	1.37 (±1.08)	1.33 (±0.83)	0.056	**0.011**	0.539	0.836

ISV = Index of surface variance
IVA = Index of vertical asymmetry
IHA = Index of height asymmetry
IHD = Index of height decentration
'Bold' = statistically significant
M = months
FU = Follow up
SD = standard deviation

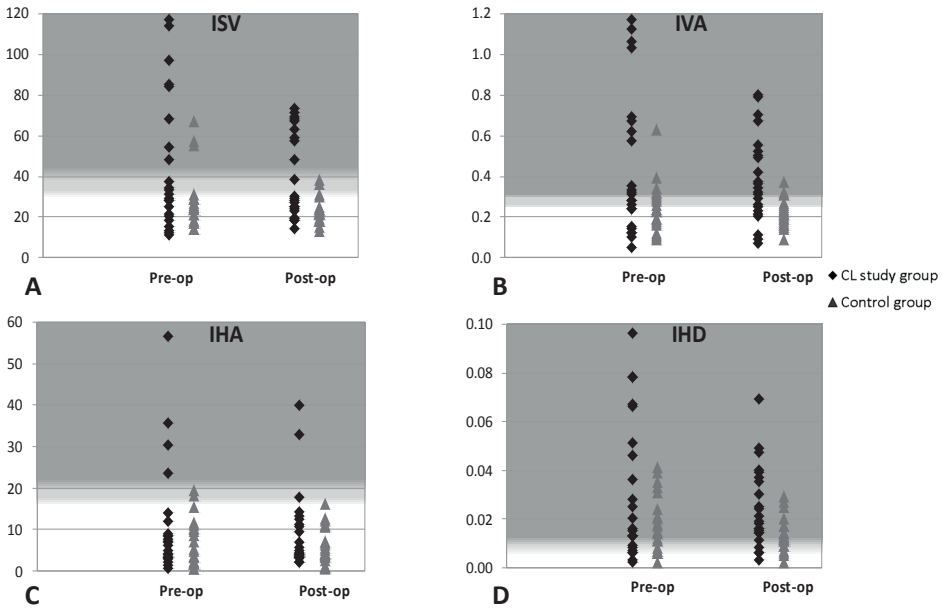


Figure 3. Difference in preoperative and 6-month postoperative ISV (A), IVA (B), IHA (C), and IHD (D) between the DMEK contact lens group and the DMEK control group. Note higher irregularity values in the DMEK contact lens group than in the DMEK control eyes preoperatively and postoperatively (CL = contact lens; IHA = index of height asymmetry; IHD = index of height decentration; ISV = index of surface variance; IVA = index of vertical asymmetry)

with spectacles and CDVA with contact lenses in the contact lens study group (*P*=.000). In the control group, the duration of preoperative edema could be tracked in 7 eyes. In these eyes, the edema was present for less than 10 months before surgery (Table 3).

Preoperatively and postoperatively, the ISV, IVA, and IHD indices were higher in the study group than in the control group (*P*<.05), and no significant change in these indices induced by the surgery was found in either group (*P*≥.05) (Figure 3 and Table 4). In the contact lens study group, significant correlations were found between postoperative logMAR spectacle CDVA and postoperative ISV (r=0.809, r^2=0.655, *P*=.000), IVA (r=0.776, r^2=0.602, *P*=.000), IHA (r=0.586, r^2=0.343, *P*=.007), and IHD (r=0.749, r^2=0.562, *P*=.000) (Figure 4), while no significant correlations were found for these indices in the DMEK control group. The preoperative logMAR spectacle CDVA was significantly correlated with the preoperative pachymetry in both groups (r=0.616, r^2=0.379, *P*=.005 [contact lens study group]; and r=0.669, r^2=0.448, *P*=.000 [control group]), while no correlation was found after surgery. Overall, no correlation was found between preoperative pachymetry and postoperative corneal surface irregularities. However, significant correlations were found between the duration of preoperative stromal edema and postoperative ISV (r=0.585, r^2=0.342, *P*=.007), IVA (r=0.602, r^2=0.362, *P*=.005) and IHD (r=0.544,

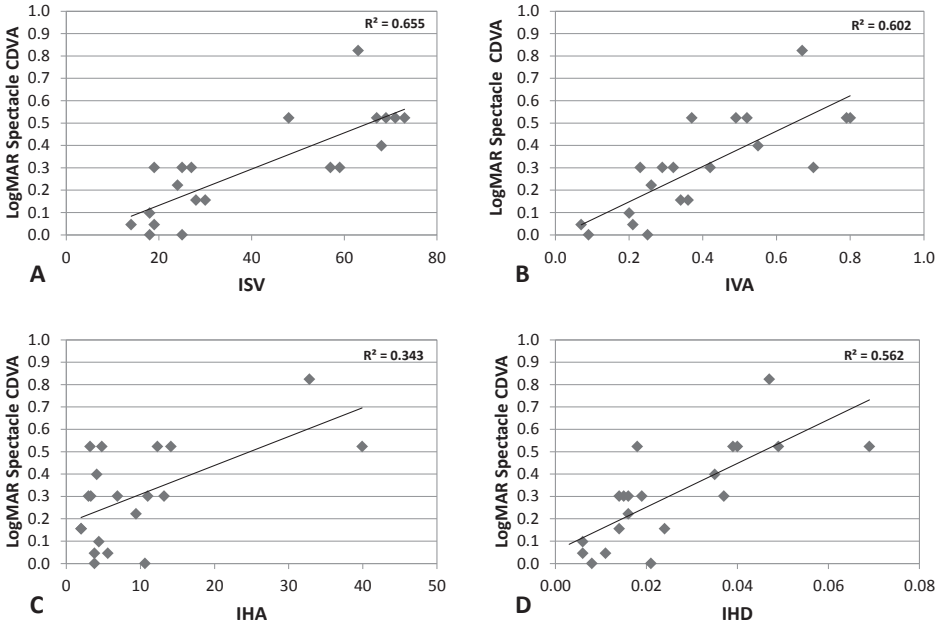


Figure 4. Correlation between logMAR spectacle CDVA and ISV (A), IVA (B), IHA (C), and IHD (D) at 6 months in the DMEK contact lens group. All correlations were significant, representing a large effect size (CDVA = corrected distance visual acuity; IHA = index of height asymmetry; IHD = index of height decentration; ISV = index of surface variance; IVA = index of vertical asymmetry).

r^2=0.296, *P*=.013), which represented medium to large effect sizes (Figure 5). Case 13 (contact lens study group) was excluded from this analysis because the extreme duration of preoperative edema (120 months) had a disproportional influence on the linear relationship between the duration of preoperative edema and the irregularity indices.

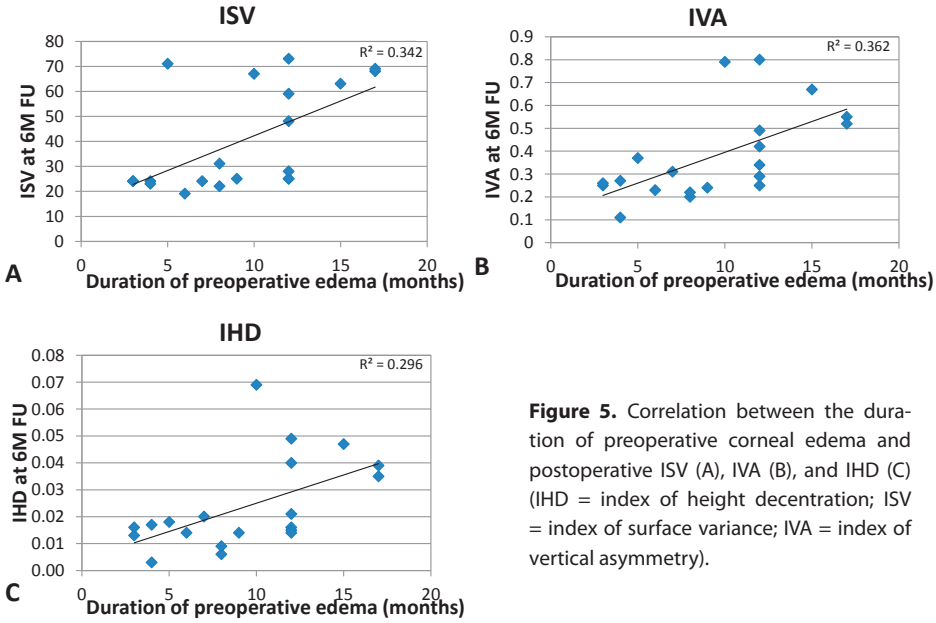


Figure 5. Correlation between the duration of preoperative corneal edema and postoperative ISV (A), IVA (B), and IHD (C) (IHD = index of height decentration; ISV = index of surface variance; IVA = index of vertical asymmetry).

DISCUSSION

After PK, contact lens fitting is commonly performed to correct high or irregular astigmatism. A major argument for corneal surgeons to make the switch from PK to endothelial keratoplasty is that in endothelial keratoplasty, the anterior part of the cornea is not compromised so the refractive surface of the eye remains stable[4,5] and visual rehabilitation can be obtained with spectacles only. In other words, when endothelial keratoplasty would be performed for endothelial dysfunction, contact lens fitting - a tedious process in this elderly age group - would no longer be required.

However, in our study of DMEK cases, a relatively large percentage of eyes (9%) showed incomplete visual rehabilitation, resulting in visual complaints attributed to imperfections in the optical or refractive surface of the transplanted cornea. In the majority of eyes, these corneal abnormalities could be assessed with biomicroscopy and/or rotating Scheimpflug imaging; however, contact lens fitting also proved effective in some eyes in which no aberrations could be detected. Overall, 3 groups based on indications for contact lens fitting could be defined.

Group 1 had corneal surface irregularities due to preexisting corneal scarring detectable with biomicroscopy and Scheimpflug imaging. With these methods, 3 (13%) of 23 eyes (cases 1 to 3, Group 1) clearly showed corneal surface irregularities due to preexisting corneal scarring after radial keratotomy/laser in situ keratomileusis treatment, herpes simplex keratitis, or corneal ulcer. In these eyes, contact lens fitting was anticipated before surgery and would also have been indicated if no DMEK had been performed. These 3 eyes reached a CDVA with contact lens of 20/28 (0.7) or better. Because all these corneas showed preoperative abnormalities not related to the endothelial disorder or the corneal transplant, contact lens fitting after DMEK probably could not have been avoided. Hence, in such cases, performing PK instead might be considered by weighing the advantage of excising corneal scars in the visual axis versus the risk for high and/or irregular astigmatism and other complications specifically associated with PK.

Group 2 showed corneal surface irregularities without preexisting scarring, detectable with Scheimpflug imaging only. In 14 of 23 eyes (cases 4 to 17, Group 2), the need for contact lens fitting after DMEK was unexpected. Except for endothelial dysfunction, no corneal abnormalities were found with biomicroscopy before surgery and abnormal corneal topography was initially attributed to the endothelial disease. However, in retrospect, the ISV, IVA, and IHD indices were found to be significantly higher than in the DMEK control group before as well as after DMEK. It may therefore be important to anticipate the possibility of postoperative corneal surface irregularities when the ISV, IVA, and IHD indices are abnormal and to inform the patient that contact lens fitting may be required after surgery to optimize the visual outcome. However, approximately 17% of eyes (4/23, cases 1 to 4) in the DMEK control group showed postoperative abnormal indices without visual discomfort and while reaching good visual acuities.

To determine the cause of optical imperfections, we reviewed the ocular history of each patient. Why do some corneas with endothelial dysfunction develop such ocular surface irregularities while most corneas show an uncompromised refractive surface after DMEK? Our analysis found that a higher proportion of eyes in the contact lens group had longstanding preoperative stromal edema (≥12 months) than those in the DMEK control group. Furthermore, the duration of preoperative stromal edema was positively associated with the ISV, IVA, and IHD values. Hence, the presence of surface irregularities in these eyes seemed to have resulted from longstanding stromal edema, which may induce irreversible changes in the anterior stroma, such as subepithelial fibrosis.[13–15] If so, the presence and extent of corneal edema in corneas with endothelial disease may be considered as a parameter in the surgical planning. It may be important to avoid any secondary stromal or subepithelial changes caused by delayed surgical intervention, especially with DMEK, a procedure that may give full visual rehabilitation, with a majority of eyes reaching 20/25 (0.8) or better.[2,3,7]

Group 3 had optical imperfections not detectable with biomicroscopy and Scheimpflug imaging. The most difficult eyes to recognize to benefit from contact lens fitting were those that presented with good spectacle CDVA; that is, 20/25 (0.8) or better, without detectable corneal surface irregularities (cases 20 to 23, Group 3). However, subtle corneal aberrations and/or tear-film irregularities may cause visual discomfort with monocular diplopia and/or ghost images[16] and affect contrast sensitivity under mesopic conditions.[17–19] Paradoxically, these symptoms may occur more often with higher visual acuity levels, especially in relatively young patients with exigent visual demands who may be more sensitive to minor optical imperfections and/or changes.

The correlation between postoperative spectacle CDVA and abnormal ISV, IVA, and IHD values may indicate that in eyes without concomitant ocular pathology and with a functional DMEK graft, the final visual acuity is limited by anterior corneal surface irregularities. A similar effect of corneal surface irregularities on CDVA has been reported after DSEK.[8] In DMEK, the rule of thumb may be that the operated eye should reach a spectacle CDVA of 20/25 (0.8) or better within 3 months.[2,7] Lower visual acuity levels may warrant additional diagnostic evaluation including corneal topography.

In conclusion, visual discomfort and/or subnormal spectacle CDVA after DMEK may often be explained by corneal surface irregularities associated with preexisting corneal scarring or longstanding preoperative stromal edema. Patients with anterior corneal scarring and/or longstanding corneal edema may be counseled about postoperative contact lens requirement to obtain better visual rehabilitation.

SUMMARY

What was known before:

- After PK contact lens fitting is commonly performed to correct high or irregular astigmatism.
- With endothelial keratoplasty the anterior part of the cornea is not compromised, so the refractive surface of the eye remains stable and visual rehabilitation can be obtained with spectacles only.

What this paper adds:

- Incomplete visual rehabilitation after DMEK may often be explained by corneal surface irregularities, which may be associated with pre-existing corneal scarring or longstanding preoperative stromal edema.
- Patients with anterior corneal scarring and/or longstanding corneal edema may be counseled about postoperative contact lens requirement to obtain better visual rehabilitation.

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