Original Investigation | CLINICAL TRIAL

Phacopower Modulation and the Risk for Postoperative Corneal Decompensation
A Randomized Clinical Trial

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IMPORTANCE In compromised corneas, eg, patients with Fuchs endothelial dystrophy (FED), it is of utmost importance to use a phacotechnique that is the least traumatic to the corneal endothelium. Furthermore, preoperative patient selection is crucial, because unexpected corneal decompensation leads to dissatisfied patients.

OBJECTIVE To compare corneal thickness and corneal volume changes using torsional and longitudinal phacoemulsification in patients with Fuchs endothelial dystrophy (FED) and determine risk factors of postoperative corneal decompensation.

DESIGN, SETTING, AND PARTICIPANTS Prospective randomized clinical trial of all patients diagnosed with FED and planning to undergo cataract surgery for visually significant cataract at a university medical center from November 2008 to May 2010.

INTERVENTION Fifty-two eyes with FED and visually significant cataract underwent torsional (n = 26) or longitudinal (n = 26) phacoemulsification. Patients were evaluated preoperatively and 1 day, 1 week, 1 month, 3 months, and 6 months postoperatively. Visits included best spectacle-corrected visual acuity, anterior segment optical coherence tomography evaluating central corneal thickness (CCT) and peripheral corneal thickness (PCT), and Scheimpflug imaging calculating corneal volume (CV). Randomization took place according to stage of FED, nucleus density grade, and age. Intraoperatively, ultrasonography time and cumulative dissipated energy were recorded.

MAIN OUTCOMES AND MEASURES Central corneal thickness, PCT, and CV.

RESULTS Ultrasonography time and cumulative dissipated energy were significantly lower in the torsional group for harder nucleus density grades compared with the longitudinal group (P = .009 and P = .002, respectively). Peripheral corneal thickness at the 6-o'clock position, CCT, and CV were significantly smaller in the torsional group 1 day postoperatively (P = .002; P = .03; and P = .004, respectively). Changes in PCT at the 12-o'clock position and best spectacle-corrected visual acuity were not significantly different between the 2 groups (P > .05). Preoperative CCT was the only significant predictor of corneal decompensation postoperatively (P < .001). Preoperative CCT of 620 μm corresponded to an odds ratio of 1, meaning no increased risk of developing corneal decompensation. For each 10-μm increase in preoperative CCT, the odds of developing corneal decompensation increased 1.7 times.

CONCLUSIONS AND RELEVANCE Torsional phacoemulsification effectively reduces ultrasonography time and cumulative dissipated energy compared with longitudinal phacoemulsification in patients with FED. However, there were only significant differences in corneal thickness and CV changes at 1 day postoperatively in favor of the torsional group. Central corneal thickness more than 620 μm, measured by noncontact pachymetry, leads to an increased risk for corneal decompensation after phacoemulsification in patients with FED.

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Fuchs endothelial dystrophy (FED) is a progressive, bilateral disease of the corneal endothelium that develops after the age of 40 years and eventually leads to corneal decompensation.[1] Central endothelial guttae form the main clinical sign, together with decreased vision and pain.[2]

After several years of conservative treatment, visual acuity will decrease and corneal transplant, usually Descemet stripping automated endothelial keratoplasty (DSAEK), becomes the only option to improve vision. Descemet stripping automated endothelial keratoplasty can be performed simultaneously with cataract extraction and intraocular lens insertion when visually significant cataract is present. In patients with an early stage of FED and cataract, cataract extraction alone may be preferable. The selection of patients who may undergo a successful phacoemulsification procedure is crucial, because unexpected corneal decompensation leads to dissatisfied patients. Seitzman et al[3] calculated a preoperative central corneal thickness (CCT) cutoff point of 640 μm, measured using ultrasound (US) pachymetry, in patients with FED. They suggested that many patients with FED and CCT less than 640 μm can undergo cataract surgery without postoperative corneal decompensation. Others stated that the decision to perform cataract surgery should not be based on corneal thickness measurements exclusively and preoperative evaluation should also include endothelial cell density, symptoms of early-morning decompensation, presence of epithelial edema, and cataract density.[4-6]

Routine cataract surgery has been shown to induce an endothelial cell density loss of 6.3% to 12.8% because of the lack of US power necessary for phacoemulsification.[7-10] In compromised corneas, eg, patients with FED, it is of utmost importance to use a technique that is the least traumatic to the corneal endothelium. To reduce the amount of energy during phacoemulsification, new phacoemulsification techniques have been described, eg, phaco-chop[11] and new phacopower modulation technologies have been developed. In conventional longitudinal phacoemulsification, where US power is generated by the longitudinal excursions of the phacoemulsification needle, the risk for endothelial cell loss and damage has been described in previous studies.[12-14] In 2006, a torsional emulsification mode was introduced where the handpiece produces rotary oscillations of the phacoemulsification tip with a frequency of 32 kHz, contrary to the forward-backward movement of the tip in longitudinal phacoemulsification, which might reduce US power, because it limits repulsion and breaks up the cataract by shearing forces and not by the conventional jackhammer effect.[15] Three recent studies compared torsional and longitudinal US in normal eyes with different stages of cataract. They reported a significantly lower use of US power and cumulative dissipated energy (CDE), smaller increases of CCT 1 and 7 days postoperatively, faster visual recovery, and less endothelial cell loss in the torsional group.[15-17] To our knowledge, there are no studies comparing these 2 phacoemulsification modes in patients with FED, who might benefit the most from a reduction in endothelial cell damage.

The purpose of this study was to compare corneal thickness and corneal volume (CV) changes using torsional and longitudinal phacoemulsification in patients with FED and determine preoperative and intraoperative risk factors for corneal decompensation after phacoemulsification. The effect of torsional and longitudinal phacoemulsification on intraoperative and postoperative outcome parameters was analyzed to compute a prediction model, calculating the risk of corneal decompensation after phacoemulsification.

Methods

Patient Population and Study Design

This prospective randomized clinical trial included a total of 52 eyes of 48 patients and was conducted from November 2008 to May 2010 at the Maastricht University Medical Center. Institutional review board approval was obtained from the Academic Hospital Maastricht. All patients diagnosed with FED and planning to undergo cataract surgery because of visually significant cataract were included in the study, regardless of endothelial cell counts and corneal thickness. Patients were excluded if they had a history of previous corneal or intraocular surgery, already needed a combined surgical procedure (eg, triple procedure), or had other visually significant ocular diseases.

After patients were informed about the study and provided their informed consent, they were randomized to receive either torsional (n = 26) or longitudinal (n = 26) phacoemulsification using a computer-based randomization system. This system used permuted blocks for the stage of FED,[1] nucleus density grade (according to the Lens Opacities Classification System II[18] [LOCS II]), and age of the patient. An independent investigator conducted the randomization prior to surgery. Therefore, the patient, evaluating investigator, and surgeon were all masked for treatment allocation. Both phacoemulsification modes are integrated in the Infiniti Vision System (Alcon).

Main Outcome Measures

Preoperatively, nucleus density grade using the LOCS II[18] and stage of FED (stage 1-4 as described by Adamis et al[1]) were evaluated during slitlamp examination. Postoperatively, patients were evaluated 1 day, 7 days, 1 month, and 3 and 6 months after the surgery. All visits included measurement of best spectacle-corrected visual acuity (BSCVA) using the Early Treatment Diabetic Retinopathy Study chart, slitlamp evaluation, anterior segment optical coherence tomography (AS-OCT) (Visante OCT; Carl Zeiss Meditec) to evaluate CCT and peripheral corneal thickness (PCT), and Scheimpflug imaging (Pentacam HR; Oculus) to calculate CV. Corneal decompensation was defined as decreased visual acuity attributable predominantly to increased corneal thickness and corneal edema visible during slitlamp examination and resulting in DSAEK surgery.

Anterior Segment Optical Coherence Tomography

The AS-OCT images were made using the Visante OCT Model 1000 with software version 2.0. At each visit, 1 enhanced anterior segment scan was obtained on the horizontal meridian in an unaccommodated state under the same light conditions (50 lux). The “chamber function” was used to evaluate anterior chamber depth. To evaluate corneal thickness at differ-

ent locations, 3 consecutive global pachymetric maps were made (composed of 16 scans on 16 meridians). Mean (of 3 consecutive scans) CCT and mean PCT at the 6 (opposite to incision site)- and 12 (at incision site)-o'clock positions were used for analysis.

Scheimpflug Imaging

The Pentacam HR type 70900 is a noncontact device that can calculate CV using a rotating Scheimpflug camera. The patient was asked to fixate on a blue light target in the center of the camera, which obtained 25 slitlamp images of the anterior segment. At each visit, 3 consecutive images were obtained to evaluate CV (mean was used for statistical analysis).

Surgical Procedure

All surgeries were performed by the same experienced cataract surgeon (R.M.M.A.N). In both groups, the same phacoemulsification procedure was followed using the divide and conquer nucleofractis technique,[19] the same phacoemulsification tip (45° mini flared Kelman tip with 0.9-mm Ultra Sleeve; Alcon), and Intrepid FMS tubing (Alcon). The only difference was the application of phacoemulsification energy through the phacoemulsification needle either by a torsional energy mode delivery or a longitudinal energy mode. For detailed surgical information, see the eAppendix in the Supplement.

Intraoperatively, we measured total US time in minutes, which represents the foot pedal time in position 3; CDE; aspiration time in minutes; balanced salt solution use during the different surgical steps (sculpt, quadrant removal, and irrigation/aspiration); and total operating time in minutes. Total US time, CDE, and aspiration time were all automatically calculated by the phacoemulsification machine. Intraoperatively, the balanced salt solution bottle was attached to a scale that measured the balanced salt solution consumption during the different operating steps. The occurrence of surgical complications during cataract surgery was documented.

Statistical Analysis

All data were collected in an Excel database and exported to SPSS (SPSS for Windows, version 15.0; SPSS Inc) for data analysis. All categorical data are presented as percentages and continuous variables as means and standard deviations with ranges. The primary outcome parameter was the change in corneal thickness and CV 1 day and 1 week after cataract surgery, meaning the change from baseline to postoperatively. Our sample size calculation was based on changes in CCT from baseline to 1 day and 1 week after cataract surgery. Therefore, the a priori agreed times were 1 and 7 days postoperatively. The mean change of corneal thickness and CV in the torsional group was compared with the mean change of corneal thickness and CV in the longitudinal group. Significance and 95% confidence intervals were tested using a linear mixed model analysis to correct for repeated measures, as were all other mentioned outcome measurements. Paired t tests were used to evaluate the within-group changes. Correlations were assessed using the Pearson or Kendall tau correlation coefficient, depending on the outcome variable. Logistic regression analyses were performed to assess the data's predictive ability in determining the occurrence of corneal decompensation needing DSAEK surgery. Using this analysis, we present a mathematical model to quantify the risk of corneal decompensation after phacoemulsification. A P value <.05 was considered significant.

In this study, we compared the increase in corneal thickness after cataract surgery of 2 groups: group 1 was treated with the torsional US mode and group 2 was treated with the longitudinal US mode. Zeng et al[16] compared torsional US with longitudinal US in eyes with hard nucleus cataract. They reported an SD of 12 µm in the difference between preoperative and postoperative corneal thickness measurements in both groups. The increase in corneal thickness was expected to be 12 µm larger in group 2 than in group 1, which was the mean difference between the torsional and longitudinal groups on days 1 and 7 postoperatively in the Zeng et al study. Sample size calculation (independent study design) for a .05 level of significance with 90% power and the earlier-mentioned values indicated 22 eyes in each group.[20] The loss to follow-up was expected to be around 15%, which resulted in 26 eyes in each group.

Results

Patient Population

Preoperative patient demographics are summarized in **Table 1**. **Figure 1** shows the Consolidated Standards of Reporting Trials flowchart of the participants. Mean (SD) CCT of the total study group was 592 (50) µm (range, 460-720 µm), with 593 (50) µm (range, 480-660 µm) for the longitudinal group and 591 (52) µm (range, 460-720 µm) for the torsional group. There were no statistically significant differences between the torsional and longitudinal groups for all preoperative variables (all P > .19). No intraoperative complications such as posterior capsule rupture, bleeding, zonulolysis, or dropped nucleus were reported for either group. Two eyes in the longitudinal group needed 1 suture (nylon 10-0) to close the main incision because of thermal injury of the cornea. One of those eyes had a very hard nucleus (LOCS II grade 4), which resulted in a long US time and high CDE. The other eye had a LOCS II grade 3 nucleus with a CDE and US time comparable with others in the LOCS II grade 3 group.

Intraoperative Parameters

Table 2 shows the comparison of all intraoperative parameters between the torsional and longitudinal groups. Overall, mean CDE and total US time were significantly lower in the torsional group when compared with the longitudinal group (P = .001 and P = .003, respectively). Mean CDE values and total US time for each nucleus density grade are shown in **Figure 2** for both groups.

Corneal Thickness and CV Changes

Within-Group Results

Table 3 and **Table 4** show the postoperative changes in CV, CCT, and PCT for the torsional and longitudinal groups. In the longitudinal group, CV and PCT at the 6- and 12-o'clock positions stabilized between 3 and 6 months postoperatively (paired t test

Table 1. Preoperative Patient Demographics[a]

Preoperative Variable	Mean (SD) Torsional (n = 26)	Longitudinal (n = 26)	Total Population (n = 52)
Age, y	71.8 (8.1)	73.0 (7.6)	72.4 (7.8)
No. of females	17	15	32
Stage of FED	1.7 (0.8)	1.8 (0.8)	1.8 (0.8)
LOCS II nucleus density grade	2.6 (0.9)	2.8 (0.9)	2.7 (0.9)
ACD, mm	2.60 (0.43)	2.45 (0.34)	2.53 (0.39)
CCT, µm	591 (52)	593 (50)	592 (50)
PCT at the 6-o'clock position, µm	639 (53)	642 (43)	640 (48)
PCT at the 12-o'clock position, µm	685 (65)	695 (49)	690 (57)
Corneal volume, mm^3	60.8 (5.2)	60.6 (4.3)	60.7 (4.7)
BSCVA, logMAR	0.40 (0.20)	0.38 (0.34)	0.39 (0.27)

Abbreviations: ACD, anterior chamber depth; BSCVA, best spectacle-corrected visual acuity; CCT, central corneal thickness; FED, Fuchs endothelial dystrophy; LOCS II, Lens Opacities Classification System II; PCT, peripheral corneal thickness.

[a] Independent-samples *t* test for torsional vs longitudinal groups: all *P* > .19.

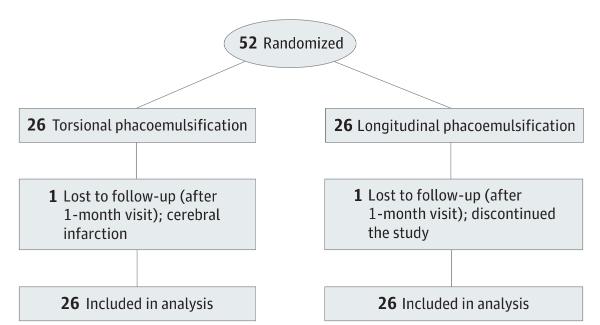
Table 2. Comparison Intraoperative Parameters

Intraoperative Variable	Mean (SD) Torsional (n = 26)	Longitudinal (n = 26)	*P* Value[a]
BSS use sculpt mode, mL	17.7 (7.4)	21.3 (9.0)	.13
BSS use quad removal, mL	44.8 (18.0)	64.5 (32.8)	.01
BSS use cortex removal, mL	38.5 (22.0)	37.1 (26.4)	.83
Total BSS use, mL	117.4 (36.9)	138.0 (56.5)	.13
Total US time, min:s	00:57 (00:25)	01:29 (00:44)	.003
CDE	11.5 (6.1)	24.4 (16.7)	.001
Aspiration time, min:s	05:19 (01:38)	06:07 (02:19)	.15
Operating time, min:s	10:26 (03:08)	11:58 (04:09)	.14

Abbreviations: BSS, Balanced Salt Solution Plus (Alcon Laboratories); CDE, cumulative dissipated energy; US, ultrasonography.

[a] Independent *t* test.

Figure 1. Consolidated Standards of Reporting Trials Flowchart of Study Participants



of 3 vs 6 months postoperatively; *P* = .54; *P* = .13; and *P* = .64, respectively). The CCT remained stable from 1 month to 6 months postoperatively in the longitudinal group (*P* = .06). In the torsional group, stabilization of CCT and PCT at the 6-o'clock position was already seen at 1 week postoperatively (all *P* > .054). **Figure 3**A shows CCT over the course of the study for both groups.

Between-Group Results

The increases in PCT at the 6-o'clock position, CCT, and CV were significantly smaller in the torsional group compared with the longitudinal group at 1 day postoperatively (*P* = .002; *P* = .03; and *P* = .004, respectively). All other changes in CCT, CV, and PCT were not statistically significant between the 2 groups (all *P* > .05).

Changes in Visual Acuity

Within-Group Results

Figure 3B shows BSCVA over the course of the study for both groups. The BSCVA did not change between 1 month and 6 months after surgery, with *P* = .14 in the longitudinal group and *P* = .70 in the torsional group. Two eyes had cystoid macular edema with a BSCVA of 0.56 and 0.28 logMAR at 3 months postoperatively, and 1 eye had macrophages on the intraocular lens optic with a BSCVA of 0.94 logMAR (all in the torsional group). When excluding these 3 eyes in the torsional group, the increase in BSCVA was even more significant at 1, 3, and 6 months (*P* = .006; *P* = .01; and *P* = .006, respectively).

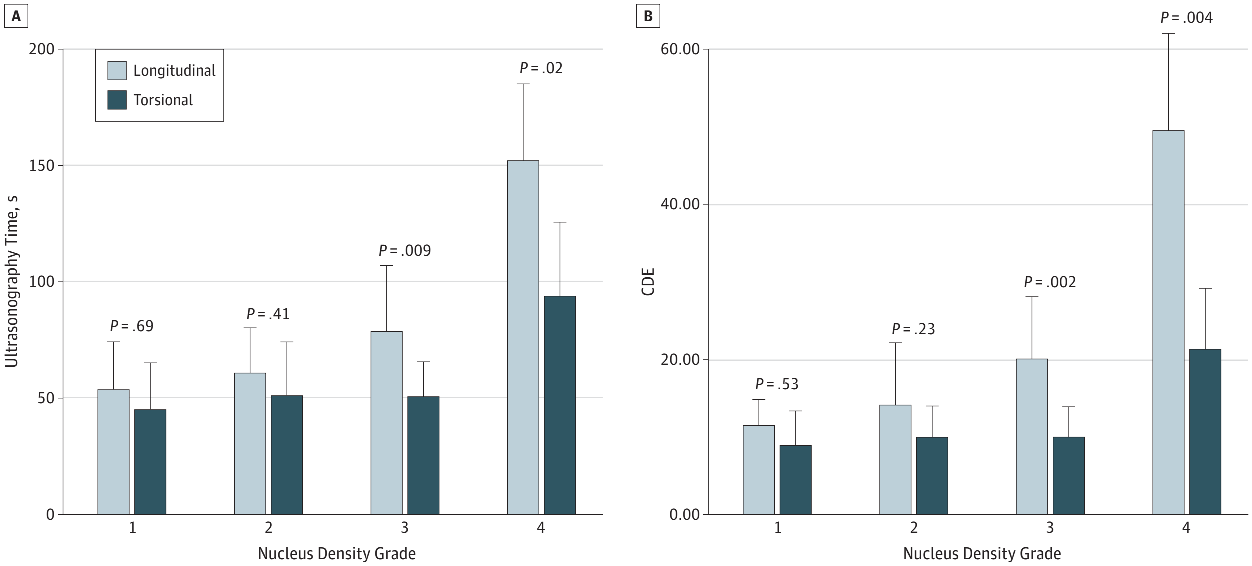
Between-Group Results

There were no significant differences in BSCVA between the 2 groups for all postoperative visits (all *P* > .05). A higher postoperative increase of CCT at 1 day was correlated with a lower BSCVA 1 day postoperatively in both groups, with a higher correlation in the torsional group (*r* = 0.522; *P* = .006) compared with the longitudinal group (*r* = 0.365; *P* = .07).

Correlation of Preoperative Corneal Thickness and Other Outcome Parameters

When evaluating both groups together, a higher preoperative CCT was associated with a more advanced stage of FED

Figure 2. Ultrasonography Time (A) and Cumulative Dissipated Energy (CDE) (B) for Each Nucleus Density Grade in the Longitudinal and Torsional Groups



P values: independent-samples *t* test between the 2 groups.

Table 3. Postoperative Changes in CCT and CV

	Mean (SD) Change			
	CV,[a] mm^3		CCT, µm	
Visit	Torsional	Longitudinal	Torsional[a]	Longitudinal
1 d	10.1 (4.2)	12.8 (5.7)	86 (38)	111 (58)[a]
1 wk	6.2 (3.7)	6.0 (3.2)	22 (27)	32 (32)[a]
1 mo	2.7 (2.4)	3.0 (2.2)	14 (24)	19 (23)[a]
3 mo	1.9 (2.1)	1.7 (2.7)	11 (24)	5 (25)[b]
6 mo	1.3 (1.6)	1.9 (2.2)	10 (19)	9 (25)[b]

Abbreviations: CCT, central corneal thickness; CV, corneal volume.

[a] Paired *t* test comparing preoperative with postoperative values: all $P < .03$.

[b] Paired *t* test comparing preoperative with postoperative values not significant.

Table 4. Postoperative Changes in PCT

	Mean (SD) Change, µm			
	PCT at the 6-o'clock Position		PCT at the 12-o'clock Position[a]	
Visit	Torsional	Longitudinal	Torsional	Longitudinal
1 d	44 (35)[a]	74 (46)[a]	180 (85)	160 (67)
1 wk	21 (31)[a]	27 (30)[a]	105 (61)	89 (49)
1 mo	12 (29)[a]	19 (30)[a]	57 (61)	55 (49)
3 mo	17 (42)[b]	6 (27)[b]	39 (46)	33 (39)
6 mo	14 (21)[b]	11 (21)[a]	22 (48)	30 (35)

Abbreviation: PCT, peripheral corneal thickness.

[a] Paired *t* test comparing preoperative with postoperative values: all $P < .03$.

[b] Paired *t* test comparing preoperative with postoperative values not significant.

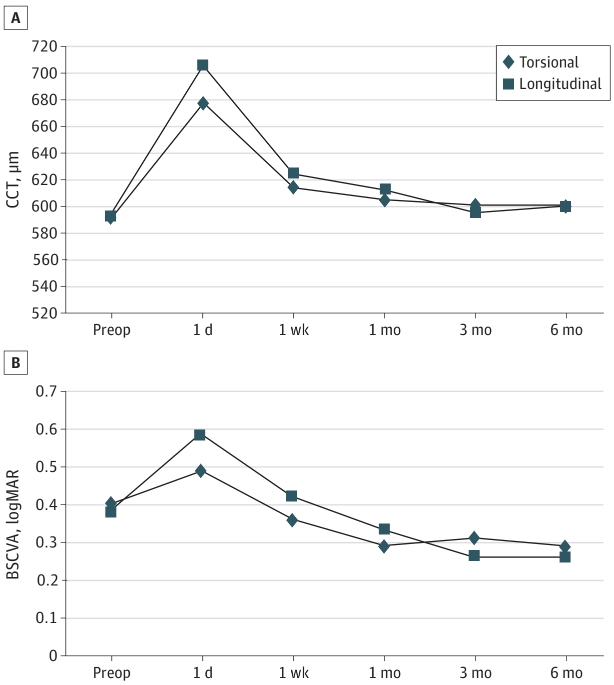
($r = 0.427$; $P = .002$). Furthermore, a higher preoperative CCT was associated with a larger postoperative increase in CCT ($r = 0.460$; $P = .001$) (**Figure 4**), PCT at incision site ($r = 0.309$; $P = .03$), PCT at the 6-o'clock position ($r = 0.356$; $P = .01$), and CV ($r = 0.308$; $P = .03$) 1 day postoperatively.

Preoperatively, there was no correlation between BSCVA and CCT. However, a higher preoperative CCT was correlated with a lower postoperative BSCVA at all follow-up visits (all $r > 0.344$; $P < .02$) (**Figure 5**). There was no correlation between CV and stage of FED or any of the other outcome parameters.

Risk Factors for and Timing of Eventual DSAEK Surgery

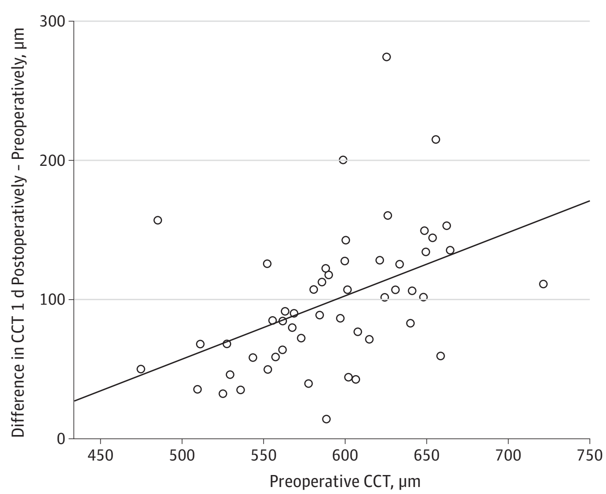
A total of 16 of 50 eyes (30.8%), 8 in the torsional and 8 in the longitudinal group, required DSAEK surgery because of corneal decompensation 6 months postoperatively. **Figure 6** shows the distribution of eyes having DSAEK surgery as a function of their preoperative CCT. Mean preoperative CCT, PCT at the 6- and 12-o'clock positions, and CV were significantly higher in the group that needed DSAEK surgery when compared with the group that did not need DSAEK surgery (**Table 5**) (all $P \le .02$). After logistic regression analysis, only preoperative CCT was a significant predictor of needing DSAEK surgery postopera-

Figure 3. Central Corneal Thickness (CCT) (A) and Best Spectacle-Corrected Visual Acuity (BSCVA) (B) at Each Follow-up Visit for the Longitudinal and Torsional Groups



Preop indicates preoperatively.

Figure 4. Scatterplot of Relationship Between Preoperative Central Corneal Thickness (CCT) and Change in CCT Between Baseline and 1 Day Postoperatively (Pearson Correlation Coefficient $r = 0.460$; $P = .001$)



tively ($P < .001$). An increase in preoperative CCT resulted in an increased risk of corneal decompensation postoperatively. All other preoperative and intraoperative parameters, including torsional and longitudinal phacoemulsification, did not significantly contribute to the risk of corneal decompensation postoperatively. Based on estimated coefficients, the following logistic regression equation was determined to estimate the probability (*P*) of developing corneal decompensation in relation to preoperative corneal thickness: $P(\text{DSAEK}) = 1/(1 + e^{-[-31.6 + 0.051\,(\text{preCCT})]})$. In this equation, preoperative CCT is measured in units of 1 μm. The model predicts that for each 10-μm increase in preoperative CCT the probability of development of corneal decompensation increased, with an odds ratio of 1.7 (95% CI, 1.3-2.2; $P < .001$). A preoperative CCT of 620 μm corresponds to an odds ratio of 1, meaning no increased risk of developing corneal decompensation.

The model correctly identified 12 of the 16 eyes (75% sensitivity) having DSAEK surgery and 30 of 34 eyes (88.2% specificity) not having DSAEK surgery, with an overall accuracy of the model of 84%.

Figure 5. Scatterplot of Relationship Between Preoperative Central Corneal Thickness (CCT) and Best Spectacle-Corrected Visual Acuity (BSCVA) 1 Day Postoperatively (Pearson Correlation Coefficient $r = 0.369$; $P = .007$)

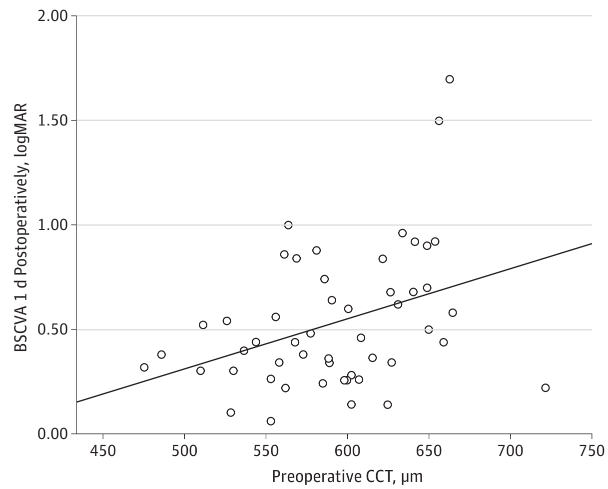


Figure 6. Histogram Representing Patients With Fuchs Endothelial Dystrophy Needing Descemet Stripping Automated Endothelial Keratoplasty (DSAEK) Surgery After Cataract Extraction vs Patients Not Needing DSAEK Surgery, Arranged According to Their Preoperative Central Corneal Thickness (CCT)

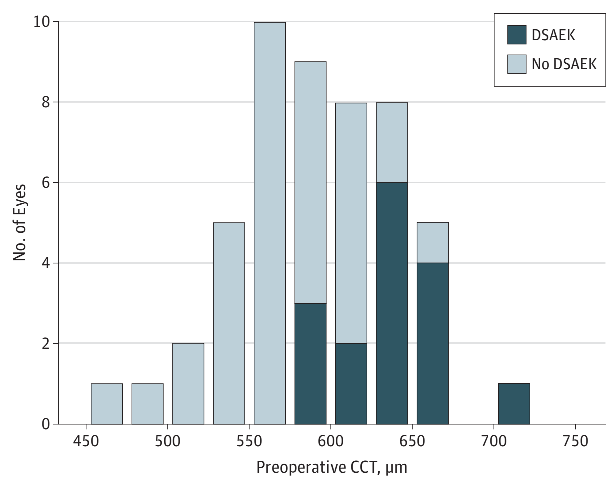


Table 5. Preoperative Factors and Postoperative Corneal Decompensation

Preoperative Variable	Corneal Decompensation, Mean (SD) Yes (n = 16)	No (n = 34)	*P* Value[a]
BSCVA, logMAR	0.45 (0.20)	0.37 (0.30)	.33
CCT, μm	637 (35)	569 (42)	<.001
PCT at the 6-o'clock position, μm	662 (33)	624 (45)	.004
PCT at the 12-o'clock position, μm	714 (41)	675 (60)	.02
Corneal volume, mm^3	62.9 (3.4)	59.3 (4.8)	.01

Abbreviations: BSCVA, best spectacle-corrected visual acuity; CCT, central corneal thickness; PCT, peripheral corneal thickness.

[a] Independent *t* test.

Discussion

This randomized clinical trial compared torsional and longitudinal phacoemulsification in patients with a compromised corneal endothelium (FED). Preoperative randomization ensured that age, nucleus density grade, and stage of FED were not significantly different between the 2 groups. Contrary to the previously reported benefits of the torsional mode in healthy eyes,[15,16] we only found significant differences in corneal thickness and CV changes at 1 day postoperatively, in favor of the torsional group. However, stabilization of CCT occurred faster in the torsional group than the longitudinal group. Furthermore, we found that during surgery both CDE and US time were reduced by 53% and 36% in the torsional group when compared with the longitudinal group, respectively. This is in accordance with previous reports comparing longitudinal and torsional phacoemulsification in healthy eyes.[15-17] An explanation for the discrepancy between our results and previous studies could be in our sample size calculation. We used an SD of 12 μm in CCT to calculate our sample size, the same as used in the study of Zeng et al[16] performed in healthy corneas. Unfortunately, there were no data available for patients with a compromised corneal endothelium at the start of this study. In our study, the SD of the change in CCT at 1 and 7 days postoperatively ranged from 27 to 58 μm, which is much larger than the 12 μm used for our sample size calculation. This might have resulted in a lower power than previously expected. However, we were not surprised to find a larger SD in these patients with FED, since we included a broad range of FED stages.

In longitudinal phacoemulsification, the phacoemulsification tip pushes the nucleus away during its forward stroke. This mechanism produces repulsion. Torsional phacoemulsification uses rotary oscillations of the phacoemulsification tip, which might reduce repulsion. The current study showed that PCT at the 6-o'clock position, which is opposite to the incision site, was significantly lower 1 day postoperatively in the torsional group. We believe this might be the result of less repulsion when using torsional phacoemulsification.

Furthermore, we prospectively investigated the preoperative risk factors for postoperative corneal decompensation in patients with FED. As mentioned, a retrospective study by Seitzman et al[3] suggested a preoperative corneal thickness less than 640 μm as a safe thickness for considering careful phacoemulsification in many patients with FED and visually significant cataract.[3] The presented prediction model in the current study demonstrated that a preoperative CCT more than 620 μm results in an increased risk of corneal decompensation needing DSAEK surgery 6 months after phacoemulsification. All values less than 620 μm have no increased risk of corneal decompensation after phacoemulsification, according to our model. This model suggests that the previously described safety limit of 640 μm might be too high for some patients. However, we measured CCT using AS-OCT, a noncontact method, whereas Seitzman et al measured CCT using US pachymetry, which is a contact method.[3] Two recent studies found that CCT measurements using AS-OCT were consistently lower than US measurements, with mean (SD) differences of 16.5 (11.7) μm and 26.3 (14.2) μm.[21,22] These mean differences correspond to the difference in CCT found in our study compared with the study by Seitzman et al.[3]

Unfortunately, there is a lack of data on normal CCT values in patients with FED. Therefore, it is difficult to advise an absolute cutoff value of CCT for corneas at risk of decompensation. Our model found a cutoff point of 620 μm, which is quite similar to the previous study by Seitzman et al,[3] when taking measurement differences into account. However, to increase the validity of the presented model, it should be applied to a second independent population for validation.

One of the limitations of a prediction model in general is the uncertainty of extrapolation of the data outside the ranges of the estimated values. Therefore, we included patients with FED in all stages to come up with a wide range of preoperative CCT and built a prediction model applicable to most patients with FED. However, this did result in quite a large rate of eyes eventually having DSAEK surgery (30.8%).

All important outcome parameters, ie, BSCVA and CCT, remained stable 1 month after cataract extraction. Therefore, when patients are not satisfied with their visual acuity postoperatively, ophthalmologists can advise them to wait until their 1-month visit and then decide whether to perform corneal transplant surgery. This decision does not have to be postponed to 3 or 6 months postoperatively.

In conclusion, torsional and longitudinal phacoemulsification show no long-term clinically significant differences in postoperative CCT, PCT, CV, and BSCVA. Only CCT stabilized faster in the torsional group when compared with the longitudinal group. The presented model calculates the risk for corneal decompensation after phacoemulsification in patients with FED using preoperative corneal thickness measured with

AS-OCT. Using AS-OCT, a CCT more than 620 µm leads to an increased risk for corneal decompensation after phacoemulsification in patients with FED. This information can assist us in optimalization of patient selection and counseling and prevent corneal decompensation after cataract surgery in patients with FED.

ARTICLE INFORMATION

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Study concept and design: Doors, Berendschot, Webers, Nuijts.
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