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Outcomes of conventional phacoemulsification versus femtosecond laser–assisted cataract surgery in eyes with Fuchs endothelial corneal dystrophy

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Abstract

Purpose—To compare the outcomes in eyes with Fuchs endothelial corneal dystrophy after standard phacoemulsification with those of femtosecond laser–assisted cataract surgery.

Setting—Bascom Palmer Eye Institute, Miami, Florida, USA.

Design—Retrospective case series.

Methods—Charts from patients diagnosed with Fuchs endothelial corneal dystrophy who had phacoemulsification cataract surgery at Bascom Palmer Eye Institute between January 1, 2014, and January 1, 2017, were reviewed. The Institutional Review Board, University of Miami Human Subjects Research Office, approved the study protocol. Complicated surgeries and cases with concurrent keratoplasty, previous keratoplasty or glaucoma surgery, or a follow-up shorter than 3 months were excluded. The corrected distance visual acuity (CDVA), central corneal thickness (CCT), and corneal edema at each visit were analyzed. Clinically significant corneal decompensation was defined by corneal edema with CDVA worse than 20/50 lasting more than 3 months, any case resulting in keratoplasty, or both.

Results—The study comprised 207 eyes of 207 patients (64 femtosecond laser–assisted cataract surgery, 143 conventional phacoemulsification). Demographics, baseline guttata and cataract grades, and follow-up time (mean 30 months) were similar between groups ($P > .05$). The proportion of cases progressing to clinically significant decompensation (13%) was similar between groups ($P > .05$). Univariate Cox survival analysis also found no difference (hazard ratio, 1.0; 95% confidence interval, 0.4–2.7; $P = .96$).

Conclusions—Compared with conventional phacoemulsification, femtosecond laser–assisted cataract surgery did not lower the rate of corneal decompensation in eyes with mild to moderate Fuchs endothelial corneal dystrophy.

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Fuchs endothelial corneal dystrophy presents a unique challenge to the cataract surgeon. Phacoemulsification cataract surgery is known to cause endothelial cell loss resulting from several intraoperative factors, including corneal distortion, fluid turbulence, ultrasound (US) energy, and mechanical trauma (from intraocular lens, surgical instrument, and lens fragments), all of which increase the risk for postoperative corneal edema.^{1–3} The central endothelial cell density (ECD) after phacoemulsification cataract surgery has been shown to be decreased by as much as 8.5% at 1 year.⁴ Patients with Fuchs endothelial corneal dystrophy have accelerated endothelial cell loss and are even more susceptible to corneal decompensation after cataract surgery.^{5–8} Different surgical techniques have been proposed to attempt to minimize endothelial loss during cataract surgery in patients with Fuchs endothelial corneal dystrophy.⁹ Unfortunately, Fuchs endothelial corneal dystrophy patients often require treatment with endothelial keratoplasty because of irreversible endothelial damage.^{5–9}

Femtosecond laser–assisted cataract surgery has been proposed as a safe alternative for patients with Fuchs endothelial corneal dystrophy.¹⁰ Femtosecond laser–assisted cataract surgery is reported to have several advantages over standard phacoemulsification. These include a shorter phacoemulsification time and less US energy use, both of which have been shown to reduce endothelial cell loss and postoperative corneal edema in the general cataract population.^{11–18} It is unclear, however, whether such benefits translate into decreased rates of clinically significant corneal decompensation in patients with preexisting endothelial disease. The existing literature evaluating femtosecond laser–assisted cataract surgery in patients with Fuchs endothelial corneal dystrophy is extremely sparse.¹⁰ To our knowledge, this is the first study to compare the postoperative outcomes of femtosecond laser–assisted cataract surgery with those of conventional phacoemulsification cataract surgery in the Fuchs endothelial corneal dystrophy population.

Patients and Methods

This retrospective cohort study was approved by the Institutional Review Board and Ethics Committee at the University of Miami. A chart review of all patients with a preexisting diagnosis of Fuchs endothelial corneal dystrophy who had standard phacoemulsification cataract surgery or femtosecond laser–assisted cataract surgery between January 1, 2014, and January 1, 2017, at Bascom Palmer Eye Institute (BPEI), Miami, Florida, USA, was performed. All cataract surgeries were performed at BPEI by more than 10 comprehensive and cornea attending physicians along with their cornea fellows using the Centurion Vision (Alcon Laboratories, Inc.) or Whitestar Signature (Abbot Medical Optics, Inc.) phacoemulsification system and any of the following femtosecond laser platforms: Lensx (Alcon Laboratories, Inc.), Catalys (Optimedica, Inc.), or Victus (Bausch & Lomb, Inc.).

Inclusion and Exclusion Criteria

A search was performed for charts with concurrent Current Procedural Terminology procedural codes for cataract surgery (66982 or 66984) and International Classification of Diseases (ICD)-10 (H18.5) or ICD-9 (371.57) diagnostic codes for Fuchs endothelial corneal dystrophy. In cases in which both eyes met inclusion criteria, only 1 eye of each

patient was selected at random for analysis to reduce bias. Cases with previous keratoplasty or glaucoma surgery, concurrent cataract extraction with keratoplasty, complications related to cataract surgery or laser application, incomplete records, or follow-up shorter than 3 months were excluded.

Chart Review and Data Collection

All charts were evaluated for demographic and clinical variables including sex, age, date, type of cataract surgery (conventional versus femtosecond laser–assisted), baseline corrected distance visual acuity (CDVA), and central corneal thickness (CCT) by US pachymetry. To assess the severity of postoperative corneal edema, CCT was analyzed when available from records. Nuclear sclerosis was assessed by slitlamp examination and assigned a grade 0 to 4 based on the Lens Opacities Classification System III.¹⁹ The clinical grade for Fuchs dystrophy was assigned according to the extent and confluence of corneal guttae and/or edema documented by the examining surgeon on slitlamp biomicroscopy as previously described.²⁰ All cases in this study were categorized as mild (grades 1 to 2) or moderate (grades 2.5 to 4.0). Advanced cases (grades 5 to 6) were excluded because they had concurrent endothelial keratoplasty or triple procedures. The patients' CDVA, CCT (if available), and corneal edema findings documented at each postoperative visit were analyzed. Cases requiring subsequent corneal transplantation were identified. For the purposes of this study, clinically significant corneal decompensation was defined as any corneal edema resulting in a CDVA worse than 20/50 for more than 3 months or any cases that resulted in corneal transplantation.

Statistical Analyses

Statistical analyses comparing the 2 groups were performed using the Student *t*, Pearson chi-square, and Mann-Whitney *U* tests with the significance level set at α equal to 0.05. Forward multiple Cox proportional hazards regression was used to assess the risk ratios for corneal transplantation in the femtosecond group compared with the conventional treatment group. To assess the effects of preoperative risk factors on the effect of treatment type, the treatment group was forced into the model even when it was not statistically significant ($P > .05$). A cumulative incidence analysis was used to estimate time to corneal transplantation in both groups using SPSS software (version 22, IBM Corp.). To evaluate the effects of baseline clinical grading on postoperative outcomes, additional statistical analyses focused on cataract and corneal grades.

Results

Baseline Patient Characteristics

A chart search yielded a total of 753 cases. Sixty-four femtosecond laser–assisted cataract surgery eyes and 143 conventional phacoemulsification eyes of 207 patients were identified. Demographics and follow-up time (overall mean 30 months) were similar between treatment groups (Table 1). The baseline CDVA was approximately 1 line better in the femtosecond group ($P < .05$). A greater proportion of eyes in the conventional group than in the femtosecond group had a preoperative CCT documented (64/143 [45%] versus 18/64 [27%]) ($P < .05$); however, there was no significant difference between the mean thickness values (P

= .13). All cases in this study were categorized as having as mild (grades 1 to 2) or moderate (grades 2.5 to 4.0) corneal guttata. Advanced cases (grades 5 to 6) were excluded because they had concurrent endothelial keratoplasty or triple procedures; the difference between the 2 groups was not statistically significant. There was no statistically significant difference in remaining clinical features.

Clinically Significant Corneal Decompensation and Transplantation

Overall, 26 (13%) of 207 eyes progressed to clinically significant corneal decompensation, with 18 (69%) of those eyes having corneal transplantation during the follow-up (Table 2). The proportion of cases progressing to clinically significant corneal decompensation within the defined 3-month period and the overall rates of corneal transplantation were not significantly different between the femtosecond group and the conventional group ($P > .05$) (Table 2). Univariate Cox survival analysis of the effect of treatment type on the risk for transplantation also found virtually no difference between the femtosecond laser treatment and conventional treatment (hazard ratio, 1.0; 95% confidence interval [CI]; 0.4-2.7; $P = .96$). The mean time to transplantation was similar in the 2 groups (6.0 months $\pm$ 5.2 [SD]), as shown by the cumulative incidence curves (Figure 1). Further subgroup analyses stratifying data using preoperative risk level for decompensation based on cataract and corneal guttata grades (mild 1 to 2 versus moderate 2.5 to 4.0) did not show significant differences between the treatment groups, although there was a trend toward a higher rate of decompensation in the femtosecond group in eyes with denser cataracts ($P = .09$).

Duration and Severity of Corneal Edema

The proportion of eyes with postoperative edema on clinical examination at 1 month was significantly higher in the femtosecond group than in the conventional group ($P < .05$) (Table 2). Approximately 40% of those cases (29/73) resolved spontaneously with an mean time to resolution of 1.3 ± 0.7 months (range 1 to 3 months) after surgery. The incidence of prolonged edema was the same in the 2 groups by 3 months and 6 months. The postoperative CCT was not available for every patient; values were calculated from 21 in the femtosecond group and 40 in the conventional group. Overall, the postoperative CCT was similar in the 2 groups, with a mean thickness of $636 \mu\text{m}$ ($P = .91$). Using visual acuity as an adjunct for clinically significant edema, the incidence of severe corneal edema (ie, CDVA worse than 20/400 or CCT greater than $700 \mu\text{m}$) was significantly greater in the femtosecond group than in the conventional group ($P < .05$). The edema in most of the cases was limited to the first postoperative week and decreased substantially at subsequent visits. The overall mean duration of postoperative corneal edema visible on examination was similar between the groups, lasting approximately 2 to 3 months (Table 2) ($P = .19$).

Postoperative Visual Recovery

There was no statistically significant difference in the measured CDVA at each postoperative visit between the femtosecond group and the conventional group. Both groups had a drop in visual acuity on the first postoperative day, with a trend toward greater a decline in the femtosecond group ($P = .06$) (Table 3). However, unlike the conventional group, in the femtosecond group there was a persistent decline in visual acuity from baseline 1 week postoperatively, corresponding to the higher rate of severe corneal edema ($P < .05$).

Effects of Baseline Cataract and Corneal Grading on Postoperative Edema

More advanced Fuchs endothelial corneal dystrophy (grades 2.5 to 4.0) correlated significantly with greater corneal edema duration ($P < .05$) and higher incidences of severe corneal edema ($P < .01$) and visibly prolonged edema up to 6 months postoperatively ($P < .05$) (Table 4). A denser cataract (grades 2.5 to 4.0) was also shown to correlate significantly with a higher incidence of severe edema as well as a greater postoperative CCT (both $P < .05$). The correlation between clinically significant corneal decompensation and corneal guttata nor that for cataract grade reached statistical significance (Table 4).

Risk Factors for Corneal Decompensation

Clinical factors that correlated significantly with ultimate decompensation included the presence of clinically evident edema 1 month postoperatively and the presence of severe edema in the early postoperative period (both $P < .001$).

A forward stepwise Cox survival regression was then performed to evaluate putative preoperative risk factors for decompensation, including treatment group, age, sex, cataract grade, cornea guttata grade, logarithm of the minimum angle of resolution visual acuity, and preoperative CCT. Because in general, the preoperative CCT was measured only in patients with high-risk corneas, the variable was entered as dichotomous: CCT measured or not measured. At the conventional statistical significance of $P = .05$, no variables (including treatment group) entered the model. However, when the significance level was relaxed to 0.10, the absence of a preoperative CCT measurement was associated with a protective effect, suggesting milder baseline corneal disease in this group (hazard ratio, 0.4; 95% CI, 0.2-1.1; $P = .076$). Despite better preoperative acuity and a greater proportion of missing preoperative CCT measurement in the femtosecond group, femtosecond laser treatment remained not significant (hazard ratio, 1.2; 95% CI, 0.3-2.2; $P = .66$).

Finally, a final Cox model fit for the 82 cases with documented preoperative CCT (range 496 to 711 μm) showed that a 40 μm increase in CCT was associated with a 1.7 times greater risk for transplantation (95% CI, 1.0-2.8; $P = .049$). Again, there was no significant effect of treatment group on risk for decompensation (hazard ratio, 1.5; 95% CI, 0.4-5.3; $P = .56$).

Discussion

There is little evidence to date showing whether femtosecond laser-assisted cataract surgery offers a clinically significant advantage over standard conventional phacoemulsification for patients with preexisting endothelial disease, although the idea has been widely proposed.¹¹⁻¹⁸ Gavri et al.¹⁰ performed the only published study evaluating femtosecond laser-assisted cataract surgery outcomes in patients with Fuchs endothelial corneal dystrophy. They studied 6 eyes with relatively mild Fuchs endothelial corneal dystrophy (mean CCT 533 μm ; mean ECD 1120 cells/ mm^2) and found that none of the eyes developed clinically significant corneal edema postoperatively. The authors concluded that femtosecond laser-assisted cataract surgery was a safe alternative for patients with Fuchs endothelial disease. No comparison was made, however, with conventional phacoemulsification. Our study found similar rates of overall corneal decompensation between femtosecond laser-assisted

cataract surgery and conventional phacoemulsification in patients with Fuchs endothelial corneal dystrophy.

Although there is good evidence of decreased phacoemulsification time and energy use for femtosecond laser–assisted cataract surgery compared with conventional phacoemulsification, a corresponding reduction in corneal endothelial injury has not been universally shown.^{11–18} Krarup et al.²¹ reported similar rates of endothelial cell loss 3 months after femtosecond laser–assisted cataract surgery in 1 eye and conventional phacoemulsification in the contralateral eye of the same patient, despite significantly less energy expenditure for femtosecond laser–assisted surgery. In fact, in a large prospective study of 2814 eyes by Manning et al.²² femtosecond laser–assisted cataract surgery led to greater postoperative corneal edema than conventional phacoemulsification. Moreover, observations of better endothelial cell function after femtosecond laser–assisted cataract surgery than after standard phacoemulsification have in general been limited to the early postoperative period. Abell et al.¹⁷ found a significantly lower rate of postoperative edema and endothelial cell loss 3 weeks after femtosecond laser–assisted cataract surgery at; however, there was no difference at 6 months. Takácz et al.¹¹ reported significantly higher CCT and volume stress index after conventional phacoemulsification 1 day postoperatively but not at 1 week or 1 month, perfectly illustrating the robustness of transiently stunned endothelial cells over time. Similarly, Abell et al.¹⁶ found a trend toward a higher CCT 1 day after conventional phacoemulsification but no difference at 3 weeks, despite significantly less endothelial cell loss after femtosecond laser–assisted cataract surgery. Thus, the advantages offered by femtosecond laser–assisted cataract surgery early on do not always translate into clinically meaningful endpoints. Indeed, a recent Cochrane review²³ analyzing 16 randomized control trials comprising 1638 eyes determined no significant benefits of femtosecond laser–assisted cataract surgery over conventional phacoemulsification for all measured clinical outcomes.

Our study suggests the same may hold true for patients with underlying endothelial disease. In general, eyes with low baseline endothelial cell counts (<1000 cells/mm²) do well after conventional phacoemulsification.²⁴ Eyes at greatest risk for corneal decompensation typically include those with preoperative epithelial edema and a CCT greater than 640 μ m.⁶ Those eyes were not included in our study because they likely had concurrent endothelial keratoplasty at the time of cataract surgery (ie, a triple procedure). For the eyes in our study with a low to moderate risk of decompensation, femtosecond laser–assisted cataract surgery did not seem to offer a clinically significant benefit.

In fact, in our study several outcomes were significantly worse in the femtosecond group, including a higher rate of clinically apparent edema and greater incidence of clinically severe edema in the early postoperative period. Several reasons might explain this finding. First, the femtosecond laser can adversely affect corneal endothelial cells in several ways. Abell et al.¹⁷ found greater endothelial cell loss with femtosecond laser–created corneal incisions than with manual incisions. Surgeons have also reported increased difficulty performing cortex removal during irrigation/aspiration during femtosecond laser–assisted cataract surgery.²⁵ The subsequent increase in intraoperative manipulation, infusion volume, and induced inflammation from small amounts of retained cortical material can all increase

postoperative corneal edema.³ Several studies have also reported significantly higher levels of prostaglandin release after femtosecond laser application, a proinflammatory response that can interfere with endothelial function.^{12,26}

Given the nature of retrospective studies, one could argue that selection bias played a role in the different outcomes between our 2 treatment groups. For example, some surgeons might have specifically chosen femtosecond laser–assisted surgery over conventional phacoemulsification for eyes with more advanced baseline disease, resulting in worse postoperative outcomes in the femtosecond group. This is less likely in our study, however, based on the equivalence of several baseline variables between the 2 groups, including clinical cataract grade, corneal guttata grade, and preoperative corneal thickness.

In fact, our study was more likely biased in favor of the femtosecond group based on a number of preoperative factors. Compared with the conventional phacoemulsification group, patients who had femtosecond laser treatment started with better preoperative visual acuity, suggesting milder disease preoperatively. This might also explain why the femtosecond group had a significantly greater decline in early postoperative visual acuity. Moreover, patients in the femtosecond laser group were less likely to have their CCT measured preoperatively, reflecting surgeons' tendency to measure CCT for more advanced corneal disease only. Indeed, the absence of a preoperative CCT measurement was found to have a protective effect against corneal decompensation in our regression model. Thus, controlling for the differences in preoperative CDVA and CCT would have resulted in even worse outcomes for the femtosecond group.

Perhaps a more likely explanation for the greater edema in the femtosecond group was the relatively recent adoption of femtosecond laser technology at our institution. Our surgeons would have been adjusting to the well-described femtosecond laser–assisted cataract surgery learning curve at the beginning of the study period in early 2014.²⁷ Differences in the surgeons' skillset and experience also likely played a role. Additional large prospective studies are needed to further evaluate our findings.

The reported rates of corneal transplantation for patients with Fuchs endothelial corneal dystrophy after conventional phacoemulsification range widely, from 3.7% to 39.0%, as a result of the varying patient inclusion criteria and surgical indications.^{7,28} The rate of corneal decompensation in our study was relatively comparable at 13%, with only 9% having endothelial keratoplasty during the study period. Not surprisingly, our study found the presence of severe corneal edema in the early postoperative period and the persistence of clinical edema 1 month postoperatively to be highly associated with ultimate decompensation and the need for transplantation. Still, most residual edema at 1 month was not visually significant, and 40% of those cases resolved by month 3. Patients with such findings postoperatively should be carefully and appropriately counseled on their risk for needing a corneal transplant.

Similar to those in other studies, our results showed statistically significant correlations between several preoperative clinical features and postoperative corneal edema.^{3,16,20,28,29} In particular, our study found that patients with moderate guttae (grades 2.5 to 4.0) on

slitlamp examination have a much higher risk for severe and prolonged corneal edema, with an approximately 20% likelihood of needing subsequent corneal transplantation. Likewise, a 40 μm increase in baseline corneal thickness was associated with an increased probability of corneal decompensation by 1.7-fold. Surgeons can use these data to provide patients with a more quantitative risk assessment and to consider the merits of a triple procedure, especially in patients with moderate guttae. In general, one should avoid assigning an exact value for threshold thickness given the wide range of CCT found in the normal population (480 to 620 μm). Recent technology has allowed for even greater predictive ability using in vivo confocal microscopy and scanning-slit pachymetry to better quantify the severity of underlying endothelial disease. However, clinical grading and CCT measurement remain easily accessible and effective tools for the preoperative evaluation and risk stratification of patients with Fuchs endothelial corneal dystrophy.^{28,29}

Although new in its findings, our study is limited in certain areas. First, it was retrospective in nature and inherently biased, as previously discussed. However, bias was minimized by including only 1 eye from each patient for evaluation in the study. Moreover, as previously discussed, baseline patient characteristics were well matched between groups and actually biased toward a different outcome. Another limitation was that different surgeons with varying levels of experience and techniques (including cornea fellows) performed the surgeries, although this heterogeneity was true in both treatment groups. There was also variability in the femtosecond laser platforms and phacoemulsification systems used. In addition, Fuchs endothelial corneal dystrophy is a progressive disorder with continued accelerated endothelial cells loss, with apoptosis and altered gene regulation of aquaporin proteins playing a role.⁶ Thus, longer-term follow-up of these patients might provide more information on the differences in corneal decompensation between the 2 groups. Finally, more quantitative measures, including ECD, changes in CCT (postoperative and preoperative), and cumulative dissipated energy, could not be studied because the data were not available from the charts. We decided to focus this study on the most clinically relevant outcomes, including the severity and duration of visualized edema and rates of decompensation. Because of these limitations, large prospective randomized trials are needed to further evaluate our findings.

In summary, our results did not show an added clinical benefit for femtosecond laser–assisted surgery over conventional phacoemulsification in patients with mild to moderate Fuchs endothelial corneal dystrophy. Overall, femtosecond laser–assisted cataract surgery was safe and led to similar rates of corneal decompensation and transplantation. The risk for corneal decompensation could ultimately depend more on a combination of baseline patient characteristics, surgical experience, and numerous intraoperative factors. With further refinements in surgical technique, femtosecond laser–assisted cataract surgery might yield better outcomes in the future. For now, a high level of caution must be taken to limit corneal endothelial trauma in all eyes with Fuchs endothelial corneal dystrophy, regardless of the surgical platform used.

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What Was Known

- For the general cataract population, femtosecond laser–assisted cataract surgery has been suggested to reduce endothelial cell loss and postoperative corneal edema compared with standard phacoemulsification. It is unknown, however, whether such benefits translate into decreased rates of clinically significant corneal decompensation in eyes with Fuchs endothelial corneal dystrophy.

What This Paper Adds

- Femtosecond laser technology did not decrease the rate of clinically significant corneal decompensation in eyes with mild to moderate Fuchs endothelial corneal dystrophy.
- Concurrent endothelial keratoplasty with cataract surgery (triple procedure) should be considered in eyes with moderate Fuchs endothelial corneal dystrophy.

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In a retrospective review of 207 eyes with Fuchs endothelial corneal dystrophy, femtosecond laser–assisted cataract surgery did not decrease the rate of clinically significant corneal decompensation compared with conventional phacoemulsification.

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Figure 1.

Cumulative incidence curves showing similar times to corneal transplantation for femtosecond laser–assisted cataract surgery and conventional phacoemulsification groups (mean 6.5 ± 5.2 months; $P = .92$). Number of eyes still followed: at 6 months, femtosecond group 54 and conventional group 104; at 12 months, femtosecond group 49 and conventional group 90; at 18 months, femtosecond group 43 and conventional group 85; at 24 months, femtosecond group 34 and conventional group 68; at 36 months, femtosecond group 23 and conventional group 42; at 48 months, femtosecond group 11 and conventional group 26; and at 60 months, femtosecond group 8 and conventional group 10.

Table 1

Patients' baseline characteristics by group.

Parameter	Femtosecond (n = 64)	Conventional (n = 143)	P Value
Mean follow-up (mo) $\pm$ SD	34 $\pm$ 21	29 $\pm$ 22	.21 [‡]
Mean age (y) $\pm$ SD	75.3 $\pm$ 7.5	74.4 $\pm$ 8.7	.47 [‡]
Mean logMAR CDVA [*] $\pm$ SD	0.273 $\pm$ 0.180	0.374 $\pm$ 0.324	.021 [‡]
Central corneal thickness [‡] (μ m)			
Mean $\pm$ SD	598 $\pm$ 49	581 $\pm$ 46	.13 [‡]
Not collected, n (%)	46 (72)	79 (55)	.035 [§]
Sex, n (%)			.63 [§]
Male	19 (30)	49 (34)	
Female	45 (70)	94 (66)	
Corneal guttata grade, n (%)			.35 [§] , .056 [¶]
0.5–1.0	11 (17)	40 (28)	
1.5–2.0	19 (30)	41 (29)	
2.5–3.0	22 (34)	31 (22)	
3.5–4.0	6 (9)	12 (8)	
Cataract grade, n (%)			.51 [§] , .78 [¶]
0.5–1.0	5 (8)	7 (5)	
1.5–2.0	28 (44)	77 (54)	
2.5–3.0	28 (44)	54 (38)	
3.5–4.0	0	3 (2)	

CDVA = corrected distance visual acuity; logMAR = logarithm of the minimal angle of resolution

^{*} Converted from Snellen visual acuity[‡] Preoperative central corneal thickness was not available for every patient; values were calculated from 18 (femtosecond laser) and 64 (conventional)[‡] Student *t* test[§] Pearson chi-square test[¶] Test of linear-by-linear association

Table 2

Postoperative corneal edema and decompensation by group.

Parameter	Femtosecond (n = 64)	Conventional (n = 143)	P Value
Decompensation, n (%)	11 (17)	15 (10)	.18 [‡]
Transplantation, * n (%)	6 (9)	12 (8)	.81 [‡]
Edema at 1 month, n (%)	30 (47)	43 (30)	.03 [‡]
Edema at 3 months, n (%)	15 (23)	27 (19)	.57 [‡]
Edema at 6 months, n (%)	11 (17)	16 (11)	.34 [‡]
Severe edema, n (%)	15 (23)	16 (11)	.04 [‡]
Mean CCT [†] (μm) ± SD	636 ± 91	636 ± 97	.91 [§]
Mean edema duration (mo) ± SD	3.0 ± 6.4	2.0 ± 4.7	.19 [§]

CCT = central corneal thickness; Decompensation = clinically significant corneal decompensation defined by edema with CDVA <20/50 lasting >3 months and/or any case resulting in corneal transplantation; Severe edema = clinically significant severe edema characterized by CDVA <20/400 or CCT >700 μm

* One patient in conventional group had Descemet membrane endothelial keratoplasty; the remaining had Descemet-stripping automated endothelial keratoplasty.

[†] Postoperative CCT was not available for every patient; values were calculated from 21 (femtosecond laser) and 40 (conventional).

[‡] Pearson chi-square with Yates correction

[§] Student *t* test

Table 3

Postoperative changes in logMAR CDVA ^{*} from baseline by group.

CDVA	Femtosecond	Conventional	<i>P</i> Value [†]
1 day	-0.237 ± 0.461	-0.104 ± 0.459	.06
1 week	-0.069 ± 0.362	0.068 ± 0.421	.04
1 month [†]	0.057 ± 0.241	0.112 ± 0.465	.29

= change from baseline; CDVA = corrected distance visual acuity; logMAR = logarithm of the minimal angle of resolution

^{*} Converted from Snellen; positive value = improved CDVA from baseline; negative value = worsen than at baseline

[†] Student *t* test

Table 4

Predictive power of corneal guttata and cataract grades.

Parameter	Guttata*			Cataract*		
	Mild (n = 111)	Moderate (n = 71)	P Value	Mild (n = 117)	Moderate (n = 85)	P Value
Mean postop CCT [†] (μm)	627 ± 103	640 ± 84	.60 [‡]	611 ± 72	677 ± 123	.04 [‡]
Mean duration of edema (mo)	1.5 ± 3.9	3.3 ± 5.5	.02 [‡]	1.8 ± 4.8	2.6 ± 4.7	.26 [‡]
Edema at 1 month, n (%)	31 (28)	35 (49)	.006 [§]	35 (30)	36 (42)	.09 [§]
Edema at 3 months, n (%)	15 (14)	22 (31)	.008 [§]	18 (15)	22 (26)	.10 [§]
Edema at 6 months, n (%)	9 (8)	15 (21)	.021 [§]	11 (9)	15 (18)	.13 [§]
Severe edema, n (%)	10 (9)	18 (25)	.006 [§]	12 (10)	19 (22)	.03 [§]
Corneal decompensation, n (%)	11 (10)	13 (18)	.16 [§]	11 (9)	14 (17)	.20 [§]

Means ± SD, CCT = central corneal thickness; CDVA = corrected distance visual acuity; Corneal decompensation = clinically significant corneal decompensation defined by edema with CDVA <20/50 lasting ≥3 months; Severe edema = clinically significant severe edema characterized by CDVA <20/400 or CCT >700 μm

* Mild severity and moderate severity = clinical grades 0–2 and 2.5–4.0, respectively

[†] Preoperative CCT was not available for every patient; values were calculated from 30 (mild guttata), 26 (moderate guttata), 39 (mild cataract), and 18 (moderate cataract)

[‡] Student *t* test

[§] Pearson chi-square with Yates correction