Corneal endothelial cell changes following Femtosecond laser - assisted cataract surgery versus phacoemulsification

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The aim
Is to compare the safety of femtosecond laser-assisted cataract surgery versus conventional phacoemulsification on the corneal endothelial cell changes.
Method
Prospective, randomized study of 30 eyes underwent femtosecond laser-assisted cataract surgery and 30 eyes underwent conventional phacoemulsification between January and September 2016 at a private ophthalmology clinic in Alexandria. Femtosecond laser-assisted cataractsurgery involved cornealincision, anteriorcapsulotomy, and lens fragmentation based on optical coherence tomography-guided treatment mapping. Conventional procedure involved manual continuous curvilinear capsulorrhexis. Both procedures were completed by means of standard phacoemulsification and insertion of an intraocular lens. Endothelial cell count was measured with a Tommy EM 3000 Specular microscope preoperatively and 1 and 3 month postoperatively.
Results
Central corneal thickness in femtosecond lasr assisted cataract surgery (FLACS) group was 545.87±29.045 μm, whereas in phaco group was 541.43±36.606 μm, with no statistically significant difference between the two groups preoperatively and 1 week postoperatively. Effective phacoemulsification time was reduced by 52% in the FLACS group ($P<0.0001$), and cumulative dissipated energy was reduced by 45% in FLACS group ($P<0.0001$). A larger amount of fluid was used in conventional haco surgery (CPS) more than FLACS, with a statistically significant difference (regarding using divide-and-conquer technique in conventional phaco group in phaco one step) ($P<0.05$). There was no significant change in corneal endothelial cell count between the two groups.
Conclusions
Femtosecond laser-assisted cataract surgery appears to be as safe as conventional cataract surgery regarding central corneal thickness and corneal endothelial cell count with lower effective phacoemulsification time and cumulative dissipated energy in femtosecond laser-assisted cataract surgery.

Keywords:
corneal endothelium, femtosecond laser-assisted cataract surgery, phacoemulsification

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Introduction

With the advent of femtosecond laser-assisted cataract surgery, a highly controlled and reproducible capsulotomy, efficient lens fragmentation or liquefaction, and precise creation of a corneal incision became possible [1,2]. Corneal edema is one of the most frequent early postoperative complications of phacoemulsification, which can sometimes lead to permanent and serious visual disturbances. Postoperative corneal swelling and endothelial cell loss are related to many factors, including phacoemulsification time and energy, cataract density, corneal pathology, anterior chamber depth, axial length, ocular trauma, mechanical and heat injury, phacoemulsification technique, experience of the surgeon, and use of a viscoelastic material [3].

In this study, we aimed to report the effective phacoemulsification time and cumulative dissipated energy and analyze the postoperative central corneal thickness and the postoperative endothelial cell count, following femtosecond laser-assisted phacoemulsification compared with conventional phacoemulsification.

Patients and methods

This prospective comparative randomized interventional study was performed at a private ophthalmology clinic in Alexandria, Egypt, between January 2016 and September 2016.

The study was designed in accordance with the rules of Alexandria University's ethical committee. Overall, 60

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eyes of 52 patients with cataract who were candidates for cataract surgery and intraocular lens implantation and met the inclusion and exclusion criteria were enrolled after informed consent was obtained.

The inclusion criteria were as follows: age between 50 and 75 years, nuclear cataract of grade 2–3 (nuclear opalescence 3–4) according to the Lens Opacity Classification System (LOCS III) classification, and corneal endothelial cell count greater than 1700/mm^2.

The exclusion criteria were as follows: patients with corneal pathology; patients on medications that affect corneal healing or ability to fight infection, such as systemic steroid; patients with systemic diseases affecting cornea, such as collagen vascular diseases; patients with glaucoma or ocular hypertension; patients with poor pupillary dilatation less than 7 mm; patients with synechiae or history of uveitis; diabetic patients (endothelial cell polymegathism); patients who show low cooperation, dense cataract (grade≥4), and white cataract; patients with intraoperative or postoperative complications; and patients who needed toric intraocular lenses. The enrolled patients were divided into two groups: the femtosecond laser-assisted cataract surgery group, which included 30 eyes of 25 patients (the femtolaser group), and the conventional phacoemulsification, which included 30 eyes of 27 patients (the phaco group).

Preoperative management

All patients underwent a complete ophthalmologic evaluation, including careful history taking (age, sex, and duration of cataract); assessment of best-corrected visual acuity; routine ophthalmic examinations [anterior segment examination (cataract grade assessment Cataract grade, nuclear density, and opalescence using the LOCS III [4] were reported using a BQ 900 slit-lamp ‘Haag-Streit AG’) and posterior segment examination]; intraocular lens (IOL) power calculations, performed using noncontact partial coherence laser interferometry (IOL Master; Carl Zeiss Meditec AG); and specular microscopy, which was done (Tommy EM-3000) and repeated three times for every patient in all visits.

Surgical procedures

All operations were performed under topical and sedation anesthesia, pupillary dilation was achieved with the instillation of one drop of tropicamide 0.5% every 15 min for 1 h, and topical NSAIDs were given four times daily preoperatively for 1 day to maintain intraoperative pupil dilatation.

One experienced surgeon performed both femtosecond laser-assisted and conventional phaco procedures.

Femtosecond laser-assisted phacoemulsification was done using LENSX platform (Alcon laboratories) for doing main incision, side ports, capsulorrhexis, and nuclear division, and then the operation was completed by conventional phacoemulsification (INFINITI OZiL Vision System; Alcon Laboratories).

The setting parameters for the primary corneal incision were a two-plane corneal incision at 120° with an incision width of 2.4 mm and incision length of 2.0 mm. An energy setting of 6.50 μJ, a spot separation of 5 μm, and a layer separation of 4 μm were used. The setting parameters of the secondary incision were one-plane corneal incision at 40° with an incision width of 1.0 mm. An energy setting of 7.0 μJ, a spot separation of 4 μm, and a layer separation of 4 μm were used. The capsulotomy diameter was 5 mm. The upper and lower deltas of the capsule were set at 330 μm. The energy was 13 μJ with a spot separation of 3 μm and a layer separation of 3 μm. The lens was fragmented using cubes (using energy of 15 μJ with a spot separation of 6 μm and a layer separation of 6 μm). The anterior and posterior offsets for lens fragmentation were 500 and 800 μm, respectively. The corneal incisions were opened with a blunt spatula, and the anterior chamber was filled with viscoelastic material (Healon, Abbott Laboratories Pharmaceutical Company, Chicago, Illinois, United States). The edge of the laser-dissected anterior capsule was checked for complete separation with a cystotome, and the dissected capsule was pulled out of the eye with a forceps. Following hydrodissection, standard phacoemulsification was used to remove the four quadrants of the nucleus.

Conventional phacoemulsification was done using INFINITI OZil Vision System; Alcon Laboratories Inc., in which, two-plane corneal incision (at ∼120°) was made with a disposable keratome knife (2.4 mm Clear Cut dual-bevel; Alcon Laboratories Inc.), with a 2.4-mm width. The secondary incision was a one-plane corneal incision, located at ∼40°, with an incision width of 1.0 mm. The manual capsulorhexis was performed using the continuous curvilinear capsulorhexis technique with an intended diameter ranging between 5.0 and 5.5 mm. In all cases, lens fragmentation was performed with a ‘divide-and-conquer’ technique.

In both groups, Intelligent phaco (INFINITI OZIL) with torsional amplitude was used. The Infiniti phaco system was used (Alcon Laboratories Inc.), with vacuum of 380 mmHg fixed, aspiration rate of 35 ml/min fixed, and bottle height of 110 cm. After cortex removal and implantation of the one-piece hydrophobic IOL Tecnis ZCB00, the viscoelastic material was completely removed by irrigation-aspiration. Gentle hydration of the main corneal incision was performed in both groups.

The following data were collected in this step: amount of fluid (Ringer Lactate), duration of surgery, effective phaco time, which is measured in seconds and represents the total phacoemulsification time multiplied by the average percentage power used, and Phaco energy [cumulative dissipated energy (CDE)].

Postoperative measurement

Follow-ups were in four visits on 1 day, 1 week, 1, and 3 months postoperatively for assessment of best correted visual acuity (BCVA) slit-lamp examination and corneal edema, and specular microscopy was used to assess the central corneal endothelial cell count at 1 and 3 months postoperatively.

Results

Patient demographics were similar in both groups. The mean age was 55.90±5.641 years (range: 49–71 years) in the femtosecond lasr assisted cataract surgery (FLACS) group and 57.00±11.253 years (range: 47–73 years) in the phaco group (P>0.05). We included patients with similar cataract density (LOCS III, grade 1–3). Nuclear opalescence was not significantly different between the two groups.

Effective phacoemulsification time (EFT) was reduced by 52% in the FLACS group (P<0.0001), and CDE was reduced by 45% in FLACS group (P<0.0001; Table 1).

Table 1 EFT and CDE comparison

Groups	EFT	CDE	P value
FLACS	1.38±0.65	9.54±2.657	<0.05
Phaco	2.93±1.29	19.69±5.459	<0.05

FLACS, femtosecond lasr assisted cataract surgery.

Table 2 Central corneal thickness comparison

Groups	Preoperative	One week postoperative
FLACS	545.87±29.045	554.70±27.750
Phaco	541.43±36.606	555.17±37.663

FLACS, femtosecond lasr assisted cataract surgery.

Regarding central corneal thickness measured preoperatively and 1 week postoperatively, we found no statistically significant difference between the two groups, but with a statistically significant difference regarding the percentage of changes in central corneal thicknes (CCT) (Table 2).

In this study, we found a larger amount of fluid was used in conventional haco surgery (CPS) more than FLACS, with a statistically significant difference (regarding using divide-and-conquer technique in conventional phaco group) (P<0.05; Table 3).

The central corneal endothelial cell number and cell density and co-efficient of variation preoperatively, 1 and 3 month postoperatively were measured and compared. Postoperatively, there were no statistically significant decrease in central corneal endothelial cell count or in cell density and co-efficient of variation in both groups compared with preoperative values (P>0.05; Tables 4–6).

Visual acuity and BCVA increased in both groups postoperatively during follow-up period with

Table 3 Amount of fluid

Groups	FLACS	Phaco
	56.03±5.605 P<0.05	62.70±9.931 P<0.05

FLACS, femtosecond lasr assisted cataract surgery.

Table 4 Corneal endothelial cell number comparison

Groups	Preoperatively	One month postoperative	Three month postoperative
FLACS	234.70 ±23.899	221.61±24.599	220.45±23.332
Phaco	227.03 ±30.153	222.28±32.010	223.51±20.129

Table 5 Cell density comparison

Groups	Preoperatively	One month postoperative	Three month postoperative
FLACS	2575.79 ±187.192	2519.27±346.859	2424.08±167.444
Phaco	2589.84 ±232.179	2501.65±203.625	2489.87±231.142

FLACS, femtosecond lasr assisted cataract surgery.

Table 6 Co-efficient of variation comparison

Groups	Preoperatively	One month postoperative	Three month postoperative
FLACS	30.04±4.236	39.37±4.367	39.22±3.699
Phaco	38.80±4.647	38.87±4.304	38.35±3.913

FLACS, femtosecond lasr assisted cataract surgery.

nonstatistically significant difference in between ($P>0.05$). However, a slightly significant difference between the two groups was noticed at early follow-up period in the femtolaser group in the first day postoperative.

Discussion

Femtosecond lasers may revolutionize the way cataract surgery is performed, with promising preliminary results showing precise and self-sealing corneal incisions; consistently accurate capsulorrhexis [1], which optimizes adequate centration and positioning of an IOL; decreased phacoemulsification energy; effective phaco time; and decreased incidence of endothelial cell loss [4–6].

In this study, the comparison of femtosecond laser fragmentation with the cubicle pattern and traditional phacoemulsification with divide-and-conquer technique resulted in a 45% reduction in CDE and a 52% reduction in phacoemulsification time using the Infiniti (Alcon Laboratories Inc.) phacoemulsification machine. We evaluated the reduction of phacoemulsification time and power after femtosecond laser lens treatment and traditional phacoemulsification. The mean CDE was significantly reduced in the femtosecond laser group with a reduction in phacoemulsification time, which is in agreement with Palanker *et al*. [5], who reported a 39% decrease in CDE in FLACS in relation to CPS.

This is in agreement with previous studies conducted by Nagy *et al*. [1] and Abell *et al*. [7], who also reported a higher reduction in effective phacoemulsification time of almost 70% in their larger study on 200 eyes that underwent femtosecond laser cataract, with a decreased incidence of postoperative corneal endothelial cell loss.

Cataract surgery using traditional technique induces an increase in mean corneal thickness leading to corneal edema. Less corneal edema leads to a faster visual recovery after IOL implantation. Our study revealed an increase in CCT in both groups in the first day postoperative, which reflects the development of central corneal edema after surgery, with a statistically nonsignificant difference, but with a statistically significant difference in the percentage of change in 1 week postoperatively. This is in agreement with Jacob *et al*. [8] who reported that maximal increase occurred within 24 h following cataract surgery. Moreover, the study showed similarity with the studies by Bolz *et al*. [9] Ventura *et al*. [10] and Cheng *et al*. [11], where increases followed by gradual decreases in corneal thickness in the follow-up period were observed.

Palanker *et al*. [5], Nagy *et al*. [12], Roberts *et al*. [13], Masket *et al*. [4], Takacs *et al*. [14], and Reddy *et al*. [15] support the safety of the FLACS procedure. FLACS is associated with less corneal swelling in the immediate postoperative period and less trauma to corneal endothelial cells compared with ultrasound phacoemulsification procedures, as shown by CCT and ECL.

In this study, we focused on the effect of femtosecond laser on postoperative corneal endothelial count and co-efficient of variation. The use of a femtosecond laser followed by minimal US energy led to lower endothelial cell loss (ECL) than in conventional phaco group, but it was statistically insignificant either after 1 and 3 month postoperatively, despite the statistically significant reduced EFT and CDE level.

Another major advantage of FLACS rather than the reduction in EFT and CDE [15–17] is that it may lead to decreasing corneal ECL and corneal edema in the early postoperative phase, resulting in faster visual recovery [18].

Trikha *et al*. [19] reported an adverse effect to the corneal endothelial cells by FLACS incisions. However, Chang *et al*. [20] demonstrated a rather comparable ECL between CPS and FLACS ($P<0.001$).

In 2009, Grewal *et al*. [21] reported that corneal endothelial cell counts were lower in phaco group at all postoperative follow-ups, but differences were not statistically significant.

Takacs *et al*. [14] demonstrated less corneal swelling and endothelial cell damage in patients undergoing femtosecond laser-assisted cataract surgery than in those undergoing a conventional phacoemulsification technique at all visits.Mastropasqua *et al*. [22] also found a lower central endothelial cell loss at 7 and 30 days in the femtosecond laser CCI group compared with the manual CCI group. In addition, femtosecond laser showed a better morphology.

Visual rehabilitation is the most concerning problem for patients undergoing cataract surgery. Less corneal edema leads to a faster visual recovery after IOL implantation and therefore is beneficial for patients indicating that patients with FLACS can achieve rapid vision recovery. This was shown in our study in which the visual results only 1 day after surgery were significantly better in the FLACS than in the CPS, with no difference in the follow-up periods. This is in agreement with Conrad-Hengerer *et al.* [16] who reported no difference between the two groups in the long-term comparison.

Good visual and optical quality outcomes have been reported by several studies, but the differences between FLACS and CPS are not universally statistically significant, as reported by Mihaltz *et al.* [23] and Takacs *et al.* [14].

A meta-analysis of nine randomized, controlled trials and 15 cohort studies compared outcomes in 2861 eyes undergoing FLACS and 2072 undergoing CPS, and no significant differences were observed in the final BCVA [24].

Conclusion

This study revealed that the two cataract surgery techniques appear to be equally safe to the corneal endothelium. FLACS did not demonstrate clinically meaningful improvements in visual outcomes over conventional PCS, despite reduction of ultrasonic energy and lowering effective phacoemulsification time in FLACS.

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Conflicts of interest

There are no conflicts of interest.

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