Comparison of the effect of torsional and transversal phacoemulsification modes on corneal endothelial health

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ABSTRACT

Purpose: To evaluate the effects of torsional and transverse phacoemulsification modes on corneal endothelial health.

Material and Methods: Forty-nine eyes of 49 patients who were operated for cataracts were randomized into two groups. 27 patients in the first group were operated in the torsional phacoemulsification mode, and 22 patients in the second group were operated using the transversal mode. Preoperative, postoperative first day and postoperative first month; endothelial cell density (ECD), coefficient of variation (CV), hexagonality (HEX) and central corneal thickness (CCT) were analyzed.

Results: The mean age was 67.89 ± 9.98 years in the first group and 66.77 ± 10.78 years in the second group. There was no significant difference between the groups in terms of mean age and ultrasound power (p=0.71 and p=0.26). While CCT increased significantly on the postoperative first day in both groups (p<0.001 and p=0.002), it returned to baseline at the postoperative first month. Although ECD decreased significantly at postoperative first month in both study groups (p<0.001 and p=0.005), it was above 1400 cells/µ2 in all cases. When the ECD, CV, 6A and CCT measurements performed before the operation, on the postoperative first day and at the postoperative first month were compared between the groups, it was observed that there was no significant difference.

Conclusion: It was evaluated that phaco surgery performed with both modes is safe in terms of corneal thickness and endothelial health. However, it should be considered that phaco surgery slightly reduces the endothelial number and endothelial health should be evaluated before surgery.

Keywords: corneal endothelium, torsional mode phacoemulsification, transversal mode pseudoemulsification, specular microscopy

INTRODUCTION

Phacoemulsification (phaco) surgery is currently the most commonly used surgical method for cataract treatment. The aim of this surgery is to remove the lens opacified, particularly without causing damage to the corneal endothelium, and to achieve the best possible visual outcome by implanting an intraocular lens. [1,2]

The surgical procedure must prioritize maintaining the integrity of the capsule and corneal transparency. Postoperatively, the long-term transparency of the cornea is contingent upon the morphological stability and functional integrity of the endothelium. The endothelium, situated on Descemet's membrane, is composed of a monolayer of hexagonal cells.[3] Maintaining a sufficient endothelial cell count is critical for preventing postoperative complications and preserving long-term corneal health. [4]

The assessment of endothelial cell loss or a reduction in endothelial cell density is achievable through specular microscopy. This technique involves directing light over the corneal tissue surface using a slit lamp, and capturing the endothelial image by reflecting light onto a film plane. In the analysis of endothelial cell morphology using specular microscopy, several parameters are considered: cell area (µm2, CA), cell density (cells/mm2, CD), polymegathism (coefficient of variation, CV), and pleomorphism (percentage of hexagonal cells).[5]

Factors including ultrasound power, fluid turbulence, movement of nucleus fragments, and the production of free

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oxygen radicals induce stress on the corneal endothelium.[6] In modern phacoemulsification technology, the primary goal is to minimize ultrasound power while enhancing overall efficiency. Advances in nucleus fragmentation techniques, pump systems, and vacuum-assisted phacoemulsification modes have collectively contributed to a reduction in the amount of energy needed for emulsifying cataracts. In conventional phacoemulsification, ultrasound energy is obtained at the tip of the phacoemulsification hand-piece through high-frequency (40 MHz) longitudinal reciprocating motion, creating a pushing effect on the nucleus that decreases the efficient use of ultrasound energy.[7] Torsional and transversal phaco technologies that create different movement have been developed to use ultrasound energy in a more effective manner. In torsional phacoemulsification mode, nucleus emulsification is achieved using a lower frequency (32 kHz) back-and-forth movement rather than the forward-backward movement in the conventional mode.[8] Transversal phacoemulsification, on the other hand, operates at a frequency of 38 kHz, producing simultaneous back-and-forth and right-to-left movements, aiming to maximize maximize ultrasound efficiency by emulsifying lens material in multiple directions with an ellipsoid movement of the phaco tip.[9] In our study, we aimed to compare the effects of torsional and transversal phacoemulsification modes on endothelial health using specular microscopy.

MATERIALS AND METHODS

Our study included 49 eyes of 49 patients who were diagnosed with cataracts and underwent phacoemulsification surgery with posterior chamber intraocular lens (IOL) implantation between October 2021 and December 2021. The study was approved by Ethics Committee of Gulhane Training and Research Hospital, Health Sciences University (approval#21.04.2022/150). The study was conducted in accordance to tenets of Helsinki Declaration. The study protocol was retrospective in design. Patients were randomly divided into two groups. The cases undergoing phaco-surgery using torsional mode technology with the Centurion device (OZil handpiece, Alcon Laboratories, Fort Worth, USA) were included in first group. The second group included cases undergoing phaco-surgery with transversal mode technology using the Whitestar Signature Pro device (Ellips® FX handpiece, Abbott Medical Optics Inc, Santa Ana). Before surgery, best-corrected visual acuity, intraocular pressures as measured by Goldmann applanation tonometry, detailed biomicroscopy, and dilated fundoscopy were evaluated. Cataract density was determined by the Lens Opacities Classification System III (LOCS III) classification. Specular microscopy (Rexxam, SPM-700, Kandatsukasa-machii, Chiyoda-ku, Tokyo, 101-0048, Japan) was used to measure endothelial cell density (ECD), coefficient of variation (CV), hexagonality (HEX) and central corneal thickness (CCT) at baseline and on day 1 and at month 1 after surgery. In all patients, a single-piece

Foldable monofocal hydrophobic intraocular lens injection was performed in a similar manner. The inclusion criteria were age ≥40 years, visual acuity < 5/10, and nuclear cataract grade between 2-4 according to LOCS III classification. Exclusion criteria included a diagnosis of glaucoma, previous corneal surgery, corneal opacities, suspected or known Fuchs dystrophy, macular degeneration or retinopathy, previous posterior segment surgery, a history of ocular inflammation, poor pupillary dilation, ECD <1500 cells/mm3, CCT ≥600 µm, and a diagnosis of hypertension and/or diabetes. Posterior capsule rupture, zonular dialysis, and complicated surgeries with dropped nucleus were defined as intraoperative exclusion criteria.

Surgical Technique

All surgeries were performed by two experienced surgeons (GÖ, ÖA). At least 3 minutes before the surgery, the conjunctival sac was washed using 5% povidone-iodine. The surgery was performed under topical anesthesia by instilling 0.5% proparacaine hydrochloride eye drops (Alcaine, Alcon Laboratories). In all cases, corneal side ports were created at the 3-9 o'clock positions using a 20 G MVR blade. The anterior chamber was filled with 3% sodium hyaluronate (Protectalon, VSY Biotechnology). Corneal access was achieved using 2.65 mm blade at 12 O'clock position. Hydro-dissection and hydro-delineation were performed after capsulorhexis. The nucleus was emulsified using the 'divide & conquer' technique. The remaining cortical material was cleaned with bimanual cannula. Sodium hyaluronate 1% (Protectalon, VSY Biotechnology) was injected into the anterior chamber and capsule. A foldable posterior chamber IOL was implanted into the capsular bag from 12 O'clock. Sodium hyaluronate in the anterior chamber was cleaned with bimanual cannula. The incision was hydrated, and 0.1 ml cefuroxime axetil was injected into the anterior chamber. At the end of the operation, the total ultrasound time (TUS) indicated on the screens of the phaco devices was recorded. For all patients, 5mg/1mg moxifloxacin + dexamethasone (Moxidexa, Abdi İbrahim İlaç Sanayi ve Ticaret A.Ş., Istanbul) was used four times a day over 10 days while 0.1% nepafenac (Apfecto, World Medicine İlaç ve San. Ve Tic., Istanbul) was used four times a day over one month after surgery.

Statistical Analysis

Statistical analysis was performed using SPSS 15.0. Normal distribution was evaluated with the Kolmogorov-Smirnov test. Fisher's exact test and independent t-test were used to compare data between independent groups. Repeated measures ANOVA test was used to analyze preoperative, postoperative 1st day, and 1-month specular microscopy measurements at baselin on day 1 and at month 1 after surgery. A p-value < 0.05 was considered statistically significant.

RESULTS

Of the 49 eyes included, 27 were in the first group while 22 were in the second group. Table 1 shows demographic data, cataract stages according to the LOCS III classification, and ultrasound duration in the cases included. Table 2 shows The preoperative, postoperative first day, and first- month specular microscopy measurements at baseline, on day 1 and at month 1 after surgery in both groups2. The central corneal thickness on postoperative day 1 was increased by 4% in the first group and 6.9% in the second group when compared to baseline measurements, indicating significant difference in both groups. However, no significant difference was found between groups. It was shown that there was a significant reduction in endothelial cell density in both groups at month 1 when compared to baseline. However, there was no significant difference between the groups. At month 1 after surgery, the change in endothelial cell density was -257.51±236.04 cells/mm2 in the first group and -181.50±238.51 cells/ mm2 in the second group. No significant difference was noted between the groups (p=0.27). The change in central corneal thickness was -7.70±61.62 µm in the first and -13.18±66.64 µm in the second group. There was no significant difference between the groups (p=0.76). No significant difference was found in the coefficient of variation and hexagonality within group or between the groups.

DISCUSSION

Ultrasonic energy used during phacoemulsification can lead to serious complications including leakage at wound site, irregular astigmatism, and corneal endothelial insufficiency due to the generated heat.[10] Phacoemulsification has become safer owing to advances in phaco technology that reduce ultrasound energy and duration. Torsional, transversal, and longitudinal phaco modes have been developed to improve safety in phaco surgery. Torsional phacoemulsification is a specific mode of ultrasound technology used in cataract surgery, and its advantages have been highlighted in various research studies.[11,12]

In a study by Modis et al. comparing torsional and longitudinal phaco modes, it was reported that there was greater increase in CCT in the torsional group at month 1 after surgery when compared to the longitudinal group, but there was no significant difference between the groups.[13] In a study by Christaki PG et al., it was found that CCT was increased by 5.1% in torsional group while it was increased by 9.7% in longitudinal group and by 11.5% in longitudinal group.[14] In our study, there was an increase in CCT by 4% in the torsional group and by 6.9% in the transversal group on postoperative day 1, no significant difference was found between two modes.

In a study by Assaf and Roshdy, it was found that there was a reduction in ECD at month 1 after surgery when compared to baseline in torsional and transversal groups; however, there was no significant difference between groups. Authors proposed that both methods are safe

Table 1: *Demographic data, cataract grades and total duration of ultrasound during surgery*

	Group 1 (n=27)	Group 2 (n=22)	P
Sex			0.40*
F	16	10	
M	11	12	
Age (years)	67.98± 9.98	66.77±10.78	0.71**
F	70.63±9.54	68.90±9.53	
M	63.91	65.00±11.84	
LOCS III	2.37± 0.56	2.68±0.78	0.11**
TDU (sec)	69.30±26.37	83.73±58.56	0.26**

*Fisher's exact test, ** Independent samples t test
F: Female, M: Male, TDU: Total duration of ultrasound, LOCS III: Lens Opacities Classification System III,

Table 2: *Corneal thickness values and endothelial parameters before and after cataract surgery*

	Group 1 (n=27)	Group 2 (n=22)	P*
	Mean ± SD (min- maks)	Mean ± SD (min-maks)	
CCT (µm)			
Preoperative	522±34 (450-591)	520±24 (457-560)	>0.05
Postoperative day 1	543±47(440-659)	556±40 (489-637)	>0.05
P**	***<0.001***	***0.002***	
Postoperative month 1	525±36 (435-594)	520±25 (455-556)	>0.05
P**	>0.05	>0.05	
ECD (cell/mm2)			
Preoperative	2230±304 (1528-2999)	2283±216 (1845-2895)	>0.05
Postoperative day 1	2167±315 (1526-2835)	2199±379 (1101-2832)	>0.05
P**	0.86	0.99	
Postoperative month 1	1973±227 (1483-2523)	2102±279 (1518-2738)	>0.05
P**	***<0.001***	***0.005***	
CV			
Preoperative	44±8 (34-60)	45±5 (34-58)	>0.05
Postoperative day 1	45±13 (28-96)	48±8 (33-75)	>0.05
P**	>0.05	0.72	
Postoperative month 1	48±9 (33-72)	48±7 (38-62)	>0.05
P**	0.052	0.16	
HG			
Preoperative	38±7 (23-52)	36±9 (10-49)	>0.05
Postoperative day 1	34±7 (17-46)	36±9 (17-48)	>0.05
P**	0.062	>0.05	
Postoperative month 1	38±9 (26-58)	37±9 (23-58)	>0.05
P**	>0.05	>0.05	

*Independent samples t test, ** Repeated measurements ANOVA test
CCT: Central corneal thickness, ECD: Endothelial cell density, CV: Coefficient of variation, HG: Hexagonality, SD: Standard deviation, min: minimum, max: maximum.

with minimal corneal endothelial changes. Similarly, no significant difference was found between groups regarding ECD at postoperative month 1 despite significant decrease in ECD in both groups.[9]

In a study by Ataş M et al., it was reported that the changes in CCT and ECT on postoperative day 1 and at postoperative month 1 were comparable in both phaco modes when compared to baseline, indicating no significant difference.[15] Similarly, there was no difference in both CCT and ECD on postoperative day 1 and at postoperative month 1 in our study.

Bourne et al. reported no significant change in CV and HC during one-year follow-up.[16] In some studies, it was reported that CV and HC values returned baseline values at month 3 after surgery and stabilized thereafter.[17,18] However, in another study in the literature, it was reported that changes in endothelial cell morphology persisted on postoperative month 6.[19] In our study, no significant difference was found in postoperative CV and HC values when compared to preoperative values.

This study has some limitations including smaller sample size and shorter follow-up. We think that the finding of no significant difference in hexagonality and coefficient of variation might be resulted from limited sample size. There is need for larger studies to assess the effects of phacoemulsification surgery on corneal endothelial health. The shorter follow-up might hamper to observe ultimate changes in endothelial health.

In conclusion, our study indicates that both torsional and transversal phaco modes are safe for corneal endothelial health with minimal corneal changes.

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