Endothelial Cell Loss: Comparison between Torsional and Longitudinal Phacoemulsification

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To compare the postoperative outcomes of longitudinal phacoemulsification and torsional phacoemulsification this randomized clinical trial was done in the Department of Ophthalmology, National institute of Ophthalmology & Hospital. Eyes with senile cataract were randomized to have phacoemulsification using the Infiniti Vision System and the torsional mode (OZil) or conventional longitudinal mode. Primary outcomes were corrected by distance visual acuity (CDVA) and central endothelial cell density (ECD). Postoperative follow-up was at 3 months. The mean preoperative CDVA was 0.41 logMAR in the torsional group and 0.38 logMAR in the longitudinal group, improving to 0.07 logMAR postoperatively in both groups. The mean ECD loss was 7.2% SD 4.6% in the torsional group (72 patients) and 7.1% SD 4.4% in the longitudinal group (76 patients), with no statistically significant differences. The torsional mode was as safe as the longitudinal mode in phacoemulsification for age-related cataract.

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Introduction

There have been significant advances in cataract surgery in last 3 decades, and improvements are ongoing. Studies have evaluated several methods to reduce the amount of ultrasound (US) energy intraoperatively; these include various power modulations,[1] nuclear chopping techniques,[2] microincision cataract surgery,[3] and infusion and irrigation systems.[4] Ultrasound power is considered a risk factor for endothelial cell loss,[5] and the use of high US energy is associated with heat generation and damage to the endothelium.[6]

The corneal endothelium is a single layer of polygonal cells on the posterior surface of the cornea. Corneal transparency is controlled by the activity of endothelial ionic pumps, which maintain a low level of stromal hydration.[3] The endothelial cell density (ECD) in the human eye decreases from 4000 cells/mm^2 in childhood to approximately 2500 cells/mm^2 at age 80 years, assuming a normal loss of 0.5% per year.[7]

When the endothelial cell count (ECC) drops below 600 to 800 cells/mm^2 corneal edema, corneal decompensation, and decreased visual acuity occur as a result of the compromised pump function. Endothelial cells are nonreplicative, and cell loss is compensated by enlargement, migration, and increasing heterogeneity of residual cells. These changes increase the thickness of the cornea.[3] This naturally occurring process is exacerbated when there is additional cell loss resulting from intraocular surgery, such as cataract removal.

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In this study, we sought to determine whether there is a difference between longitudinal phacoemulsification and torsional phacoemulsification in protecting the corneal endothelium. Both techniques are regularly used in modern cataract surgery.

Methods

This prospective interventional consecutive series comprised eyes having cataract surgery with intraocular lens (IOL) implantation between August 2012 and December 2013 at the National Institute of Ophthalmology & Hospital, Dhaka. All patients gave informed consent at the preoperative examination. The study was approved by the Local Ethical Committee. The patients were randomly assigned to have torsional phacoemulsification or longitudinal phacoemulsification.

To be included, patients had to have senile cataract with grade 2 or grade 3 nuclear sclerosis. The nucleus density was scored according to the Oxford Clinical Cataract Classification and Grading System.[16] Exclusion criteria were previous intraocular ocular surgery, corneal disease (dystrophy, corneal scarring), pseudoexfoliation syndrome or other severe ocular comorbidity (eg, trauma), and hypermature senile cataract. Patients with an ECC (Endothelial cell count) lower than 1900 cells/mm2 were also excluded.

Patient Assessment

All patient assessments were performed by examiners masked to the phacoemulsification group. Preoperatively all patients had a comprehensive ophthalmologic examination including slitlamp and retinal evaluation. The central ECD was determined using a slitlamp-mounted noncontact specular microscope.

The examiner determined the area of analysis manually choosing the best image and examination field. A minimum analysis frame size was maintained by software incorporated into the microscope. The automatic cell counts are by a fixed-frame technique; therefore, at least 50 cells were required to reduce sampling errors. According to the microscope's manufacturer, the standard deviation of the cell density is SD 2.5%. The corrected distance visual acuity (CDVA) was measured using a Snellen chart; the values were converted to logMAR notation.

The postoperative examination was performed at approximately 3 months. It included CDVA, anterior segment slitlamp evaluation, and endothelial microscopy. Endothelial cell loss was calculated as follows: Endothelial cell loss (%) = ([postoperative ECD_ preoperative ECD]/preoperative ECD) _ 100.

Surgical Technique

The same experienced surgeon performed all procedures using coaxial phacoemulsification through a clear corneal incision (CCI) created with a 2.75 mm keratome. Peribulbar anesthesia of lidocaine 2.0% mixed with bupivacaine 0.5%, and an ocular compression bandage were used in all cases. Mydriasis was achieved with phenylephrine and tropicamide eye drops.

The conjunctival sac was rinsed with povidone iodine. One side ports were created for the use of second instrument at 11 O'clock or 5 O'clock. Carboxy methyl cellulose was injected to fill the anterior chamber and to protect structures such as the corneal endothelium. A capsulorhexis was created with a 27-gauge needle. A self-sealing limbal incision was made at the 3 or 9 O'clock position to prepare the corneal tunnel. The anterior lens capsule was removed and hydrodissection performed for better maneuverability during phacoemulsification.

Phacoemulsification was performed using the Infiniti Vision System platform (Alcon, Inc.). The height of the infusion bottle was 90 to 100 cm depending on the program used. The aspiration/flow rate was 40 ml/min and the vacuum level 350 to 400 mm Hg. In the torsional group an OZil torsional handpiece, 0.9 mm Advanced Bypass System tip (30-degree bevel Kelman configuration) and continuous mode were used. The tip of the handpiece oscillates in longitudinal waves as in the conventional mode but also has a side-to-side motion to emulsify the lens. A 0.9 mm Advanced Bypass System straight needle with a flared tip (30-degree bevel) and US hyper pulse mode were used in the longitudinal group. The divide-and-conquer technique was used for initial fracture of the trenches, after which the technique was modified according to the surgeon's expertise. After the cortex was aspirated the ophthalmic viscosurgical device (OVD) was again injected into the anterior chamber. A foldable acrylic hydrophobic IOL (AcrySof, Alcon, Inc.) was implanted in the capsular bag through the limbal incision. The OVD was aspirated and a balanced salt solution injected into the anterior chamber.

Eye drop moxifloxacin 4 times daily and prednisolone 6 times daily were used for 1 month. All patients had a 1st day postoperative examination.

Outcome Measures

The primary outcome measures were preoperative and postoperative ECD and CDVA.

Statistical Analysis

The statistical analysis was performed using SPSS for Windows software (version 17.0, SPSS, Inc.). Mann-Whitney U, chi-square, and independent-samples t tests were used to compare categorical and continuous variables, where appropriate. A "p" value less than 0.05 was considered statistically significant.

Results

Of the 200 patients enrolled and randomized, 192 (98 torsional group, 94 eyes longitudinal group) had surgery; the data from these patients were used in the analysis. The mean age of the patients was 72.3 years 8.1 (SD) (range 51 to 89 years). There was no statistically significant difference between the torsional group and the longitudinal group in age (P = .474) or sex (P = .379). The mean time of the postoperative examination was 13.0, 2.2 (SD) weeks in the torsional group and 13.3, 2.4 (SD) weeks in the longitudinal group.

One hundred eighty-two patients (91 in each group) completed the follow-up. There were 18 dropouts (9 torsional groups, 9 longitudinal groups). Thirty-four patients (19 torsional groups, 15 longitudinal group) were excluded from the analysis of final endothelial cell parameters because of measurement errors resulting from poor-quality endothelial cell images. The secondary analysis of actual data included 72 eyes in the torsional group and 76 eyes in the longitudinal group.

Table I shows the preoperative and postoperative ECD and the postoperative endothelial cell loss calculated in the secondary analysis (i.e, using actual data). Table II shows the mean endothelial cell loss calculated in the primary analysis (ie, using substituted data).

There was no statistically significant difference in any endothelial cell parameter between the torsional group and the longitudinal group (P = .342, primary analysis; P=.906 in the secondary analysis).

Table I: Endothelial cell parameters using actual data (secondary analysis)

	Torsional Group (n=72)		Longitudinal Group (n=76)	
Parameter	Preop	Postop	Preop	Postop
ECD (Cells/mm^2)	2426.5 to 2593.5	2232.3 to 2437.0	2365.3 to 2566.0	2202.8 to 2389.0
Mean ± SD	2507.4 ± 134.8	2326.0 ± 141.8	2467.4 ± 150.7	2292.1 ± 167.3
ECL	_	259.75 to _82.00	_	250.75 to _84.00
Mean ± SD (%)	_	-7.2 ± 4.6	_	-7.1 G 4.47.1 ± 4.4

ECD = endothelial cell density; ECL = endothelial cell loss

The mean preoperative CDVA was 0.41 logMAR in the torsional group and 0.38 logMAR in the longitudinal group, improving to 0.07 logMAR postoperatively in both groups. There was no statistically significant difference in postoperative CDVA between the groups (P = 0.945).

Table II: Endothelial cell loss using substituted data (primary analysis)

ECL	Torsional Group (n = 100)	Longitudinal Group (n = 100)
Cells		
Median	_164.0	_160.5
Range	_198.8 to _116.8	_215.3 to _122.0
Mean ± SD	_176.5 G 101.4	_171.7 ± 94.9

Discussion

Early studies report a high rate of ECD loss after cataract surgery. In 1978 Sugar et al.[8] reported a 33.8% loss in 70 eyes compared with the ECD in the unoperated eye. They concluded that phacoemulsification was more traumatic than intracapsular cataract extraction. Storr-Paulsen et al.[9] found a loss of 20% to 30% after phacoemulsification; the main reason was luxation of the nucleus into the anterior chamber. Since then, there has been research and progress in ways to protect the endothelium in phacoemulsification.

We searched the recent literature for studies of endothelial cell loss that were comparable to ours (i.e, coaxial phacoemulsification through a 2.75 mm CCI with a 3-month postoperative examination). The reported cell loss ranged from 4% to 23%.[9] The risk factors for endothelial cell loss included older age, small pupil, high nuclear grade, large nucleus, greater infusion volume, type of IOL implanted, firmness of the nucleus, irrigation procedure, rubbing of nuclear material against endothelial cells, surgical technique, incision size, OVD type.[9] In our study, these parameters were similar in both groups, making them homogeneous. Demographic data and endothelial cell parameters were similar between the torsional group and longitudinal group, showing that there was no bias resulting from the randomization. In addition, we used peribulbar anesthesia in all patients to reduce bias from different anesthesia methods.

Several studies[10] report ECD stabilization within 3 months. A study by Kohlhaas et al.[11] agrees, finding no further endothelial cell loss after 4 weeks. Price et al.[12] also found that most cell loss occurred within the first month after surgery. Our postoperative examination was scheduled based on these results. Some authors[7] point out that the central ECC does not represent the entire cornea and that the loss is greatest near the incision. Corneal cells migrate to cover the loss, which takes 3 to 6 months or longer.[7,13] Bourne et al.[14] found continuing endothelial cell loss 10 years after cataract extraction. Thus, we cannot speculate on the long-term effects of longitudinal phacoemulsification and torsional phacoemulsification. However, our study was designed to outline potential differences between the 2 techniques, and this was possible after 3 months of follow-up.

The phaco platform we used has a conventional US mode and a torsional mode. The torsional tip has side to side movement. Recent studies[15,16] found that torsional US is more efficient and safe in cataract removal. Han and Miller[17] report that torsional phacoemulsification created less heat than longitudinal phacoemulsification and based on this, suggest that the torsional mode provides thermal protection intraoperatively.

It has been postulated that longer phaco time and higher US power (cumulative dissipated energy) are associated with endothelial cell loss.[5,15] Walkow et al.[16] found a significant correlation between phaco time and central endothelial cell loss, but not between phaco energy and cell loss. O'Brien et al.[5] found a significant association between phaco time, mean US power and endothelial cell loss. Other studies found no correlation.[18] In our study, we evaluated 2 phacoemulsification technologies and the effect of energy and time. There was a 30 statistically significant correlation between the phaco parameters and endothelial cell loss. In addition, the cell loss was not significantly different between the 2 groups.

However, we excluded patients with an ECD lower than 1900 cells/mm^2 and our ECD results are comparable to those in an U.S. population in the same age group.[19] There was no significant difference in central endothelial cell loss between the torsional group and longitudinal group in our study and our results in each group are similar to those in a study by Bozkurt et al.[20] (4.2% ± 5.7%, torsional group; 6.7% ± 3.3%, conventional group). Bozkurt et al. conclude that the torsional mode appears to cause less loss of corneal endothelial cells, although not statistically significantly so. Their results are from the second postoperative month in 100 eyes with a nucleus density of grade 2 to grade 5 on the Lens Opacities Classification System II.[21] In our study, we used slitlamp grading and included cataracts with a grade of 2 to 3 according to the Oxford Clinical Cataract Classification and Grading System.[22] Another difference is that Bozkurt et al. used a stop-and-chop technique for cataract removal and surgery was performed by 3 surgeons. Nevertheless, these differences might not be the reason for the slightly greater endothelial cell loss in our study, as Storr-Paulsen et al.[9] suggest. They compared the divide-and-conquer and phaco-chop techniques and found both to be safe and with the same amount of endothelial cell loss. In their study of 525 eyes, Liu et al.[23] found a significantly lower cell decrease (12.5%) in a torsional group than in a conventional US group (19.1%). These results were from 30 days postoperatively, shorter than the 3 month evaluation in our study. This could explain the higher endothelial cell loss because specular microscopy should be performed when the loss has stabilized (at least 3months postoperatively).[9] Another difference is that Liu et al. used a different method of cataract removal. They used a quick-chop technique for grade 2 and 3 nuclei rather than non-chopping rotation and axial rotation techniques; the quick-chop technique seems to have higher endothelial cell loss, as recently reported.[24]

Cataract extraction is the most frequently performed surgery in the world and patient comfort, visual quality and fast and stable rehabilitation are major concerns. Therefore, we used corrected distance visual acuity (CDVA) to evaluate the quality and efficiency of the surgery. The torsional group and the longitudinal group both had better CDVA postoperatively; the improvement was similar in the 2 groups, with no significant differences. This result is comparable to those in other studies.[9]

Conclusion

Our results indicate that torsional phacoemulsification and longitudinal phacoemulsification are both safe methods of removing uncomplicated senile cataract. Because a healthy endothelium is able to maintain pump function and corneal dehydration over a large range of cell counts, our results are important to consider when planning surgery in eyes with a low ECC (1000 cells/mm^2). The CDVA results were also similar between groups, showing that both procedures are safe and homogenous, leading to fast rehabilitation and good visual quality.

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