SURGICAL OUTCOME OF COAXIAL PHACOEMULSIFICATION WITH TORSIONAL ULTRASOUND AFTER A 2.4 MM VERSUS 3.2 MM CLEAR CORNEAL TEMPORAL INCISION

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ABSTRACT

Purpose: This study aimed to evaluate and compare outcomes of phacoemulsification surgery with purely torsional ultrasound in coaxial small incision procedures.

Methods: This study was a prospective observational series of 50 eyes of 50 patients with age-related cataracts. There were two groups each with 25 eyes. Group 1 eyes were treated with microcoaxial phacoemulsification using a 2.4 mm temporal clear corneal incision; group 2 eyes were treated with phacoemulsification using a 3.2 mm temporal clear corneal incision. Both groups underwent a standardised surgical procedure using purely torsional ultrasound. Outcome measures were best corrected visual acuity, percentage increase in postoperative corneal thickness, and surgically-induced astigmatism assessed at day 1, week 1, month 1 and month 3 postoperatively.

Results: Both groups were comparable with respect to age, cataract grading and intraoperative parameters such as cumulative dissipated energy and irrigation volume. The only statistically significant outcome difference was surgically induced astigmatism at postoperative day 1 (higher in group 2). Intraoperative and early postoperative complications were similar in both groups.

Conclusions: Coaxial phacoemulsification with purely torsional ultrasound produced satisfactory results for 2.4 mm and 3.2 mm incisions. There were no differences in outcomes between groups.

KEY WORDS

Small incision cataract surgery, micro-incision cataract surgery, torsional ultrasound, coaxial phacoemulsification, surgically-induced astigmatism

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INTRODUCTION

Phacoemulsification surgery continues to employ smaller incision sizes as newer generation machines provide better modulation of ultrasound (US) power and fluidics control (1). Smaller incisions may improve intraoperative fluidics, decrease corneal endothelial trauma, decrease postoperative wound leakage and endophthalmitis, improve wound sealing, and cause less surgically induced astigmatism; these features may allow more rapid visual recovery (2).

Microincision phacoemulsification surgery, which was initially introduced as a bimanual technique using two incisions smaller than 1.5 mm (one for the sleeveless phaco probe and the second for the irrigated chopper), has demonstrated effectiveness in cataract surgery (3). Nevertheless, most cataract surgeons do not use this bimanual approach because of its limitations: 1) poor fluidics causing anterior chamber instability; and 2) necessity of incision enlargement for intraocular lens (IOL) implantation. Additionally, angular movement of instruments through small incision sites may cause excessive mechanical trauma to the cornea. The procedure also has a steep learning curve for the surgeons who are familiar with coaxial surgery (3).

Microcoaxial surgery had been developed to overcome these difficulties. The recently introduced torsional US aims to decrease US energy while increasing efficiency. In combination with the microcoaxial technique, torsional US allows microcoaxial phacoemulsification (MCPE) using smaller incisions whilst preserving the advantages of classical coaxial surgery (4-6). Consequently, MCPE has a more gradual learning curve.

Small incision surgery that is performed using an incision of 2.4 mm or less but does not differ much from conventional, which uses an incision of 3.2 mm or less. It requires a particular sleeve over the phaco tip to allow sufficient fluid flow through the same coaxial incision and an injection system to allow IOL insertion without incision enlargement (6).

The aim of this study was to evaluate and to compare the effectiveness and the outcomes of coaxial phacoemulsification with purely torsional US in both 2.4 and 3.2 mm small incision cataract surgeries.

METHODS

Study design

This was a prospective observational series of 50 eyes of 50 patients (aged 50 to 80 years) with age-related cataracts. Patients were eligible if they had cataracts with grade 3 or 4 nuclear or nucleocortical opacity, according to the Lens Opacities Classification System III (LOCS III) scale (7). Exclusion criteria were: 1) coexisting ocular disease; 2) use of tamsulosin; 3) pupillary dilation smaller than 5 mm; 4) traumatic or subluxated cataract with grade 1, 2, 5 or 6 nuclear and nucleocortical opacity; or 5) corneal astigmatism greater than 1.5 diopters.

Patient eyes were divided into two groups. Each group included 25 eyes of 25 patients. Group 1 eyes underwent 2.4 mm temporal clear corneal incisions and group 2 eyes underwent 3.2 mm temporal clear corneal incisions. Postoperative follow-up was 3 months.

Patients were recruited following hospital ethics committee approval. Written informed consent was obtained at least 24 hours prior to surgery. The study followed the ethical principles of the Declaration of Helsinki.

Surgery

All eye surgeries were performed by a single surgeon (MSK) using a standardised procedure. Coaxial torsional phacoemulsification was performed using the Infiniti Vision System phaco machine (Alcon Laboratories Inc., Fort Worth, Texas, USA). In all cases, pre-surgical pupillary dilation was achieved by topical tropicamide and phenylephrine drops. A standardised surgical technique was performed with topical anaesthesia using topical proxymetacaine hydrochloride drops. A 2.4 mm or 3.2 mm biplanar clear corneal incision was made temporally using a steel trapezoidal knife advanced 1.5 mm into the cornea prior to anterior chamber entry. Two paracenteses were made in superior and inferior quadrants using a 20-gauge MVR knife. The ophthalmic viscosurgical device (OVD) (2% sodium hyaluronate) was injected into the anterior chamber, and a continuous curvilinear capsulorhexis of 5 to 6 mm was created by cystotome or Utrata forceps. Following hydrodissection, coaxial phacoemulsification was performed using the stop and chop technique and a 20- gauge chopper. In group 1, torsional phacoemulsification was performed using a 0.9 mm 30-degree-angled Kelman microtip and a small-diameter infusion ultrasleeve. For group 2, a 1.1 mm 30-degree-angled Kelman tip with a standard sleeve was used. Bimanual irrigation and aspiration of cortical remnants and OVD were performed through separate cannulas. The capsular bag was filled with an OVD (1.4% sodium hyaluronate). Acrylic IOL insertion (5.75 mm x 12 mm) (Softec I, Lenstec Inc. St. Petersburg, Florida, USA) was performed by using a cartridge-injection system without enlarging the incisions (Viscoject 2.2 cartridge set for group 1; Viscoject 2.7 cartridge set for group 2; Medicel AG, Wolfhalden Switzerland). The cartridge tip was not advanced into the anterior chamber; the IOL was injected transcorneally. The phaco incision and paracentesis were inflated with Balanced Salt Solution (BSS), and cefuroxime (1 mg / 0.1 mL) was injected into the anterior chamber. The incision was tested with a sponge wick to confirm the integrity of the self-sealing incision. No eyes required suturing for leaks.

Torsional US energy as cumulative dissipated energy (mean phaco time x mean ultrasonic power x 0.4), and total intraoperative BSS irrigation volume were measured for each individual eye. Topical antibiotic and corticosteroid drops were given for four weeks postoperatively.

Examination and data evaluation

Routine and standard clinical examinations were performed preoperatively and at day 1, month 1, month 3, and month 6 by a separate ophthalmologist (EG). Best corrected visual acuity for distance was measured by the Snellen chart using decimal notation. Central corneal thickness (CCT) was assessed by ultrasonic pachymetry UP-1000 (Nidek Corp., Gamagori, Japan). The ultrasound probe was placed perpendicular to the central cornea without excessive pressure. The mean of three similar measurements to the nearest 5 μm was recorded. The percentage increase in corneal thickness was calculated for each eye using the following formula: [(postoperative thickness – preoperative thickness) / preoperative thickness] × 100.

Computerised corneal topography was determined by the Color Mapping 32 program 1.24 of KR-8100PA (Topcon Corp., Tokyo, Japan); this technique was used to analyse the degree of preoperative and postoperative corneal astigmatism and the corneal surface. Keratometric results and simulated K-values from corneal topography were used to analyse phaco surgery-induced keratometric and topographic astigmatism. Surgically induced astigmatism (SIA) was calculated using a vectorial analysis formula.

Groups were compared with respect to age, cataract grading and intraoperative parameters such as cumulative dissipated energy (CDE) and BSS irrigation volume (Table I).

Outcomes for both groups were defined as follows: 1) best corrected distance visual acuity (BCVA); 2) amount of corneal edema as the percentage increase in postoperative corneal thickness; 3) amount of surgically induced astigmatism; 4) intraoperative and early postoperative complications.

Statistics

Chi-square tests were used to compare the distribution of some of the patient characteristics (gender, eye operated, LOCS-grading) in the groups. Nonparametric Mann-Whitney test was used to determine significant differences between other patient characteristics (age) and study variables (CDE, BSS, BCVA, CCT, keratometric SIA, topographic SIA). The confidence interval was set at 95% with p values smaller than 0.05 considered statistically significant.

RESULTS

Preoperative and postoperative characteristics are summarised in Table I. There were no statistically significant differences in age, baseline BCVA, sex, side of operated eyes, distribution of cataract grading, mean CDE, or mean irrigation volume between groups. No statistically significant differences were observed in

Table I: *Characteristics and comparison of study groups.*

	GROUP 1 (N=25)	GROUP 2 (N=25)	*P
MEAN AGE	64.1±10.8 years	63±11.2 years	0.79
SEX (M/F)	12/13	10/15	CST=0.77
EYE (RIGHT/LEFT)	11/14	14/11	CST=0.57
LOCS GRADE III/GRADE IV	12/13	13/12	CST=0.97
CDE	13.4±10.2	10.8±12.3	0.12
BSS IRRIGATION VOL.(mL)	117.9±54.5	152.4±84.8	0.11
BCVA			
Preoperative	0.27±0.19	0.25±0.14	0.45
Day 1	0.47±0.30	0.44±0.25	0.76
Week 1	0.80±0.19	0.77±0.18	0.51
Month 1	0.85±0.14	0.79±0.17	0.17
Month 3	0.86±0.13	0.84±0.16	0.81
CCT (% INCREASE)			
Day 1	0.29±0.40	0.24±0.35	0.76
Week 1	0.04±0.09	0.03±0.04	0.52
Month 1	0.01±0.03	0.006±0.01	0.31
Month 3	0.00±0.01	0.00±0.005	0.83
KERATOMETRIC SIA			
Day 1	0.56±0.45	0.90±0.65	0.012
Week 1	0.40±0.28	0.52±0.41	0.43
Month 1	0.37±0.24	0.32±0.24	0.35
Month 3	0.39±0.21	0.34±0.17	0.42
TOPOGRAPHIC SIA			
Day 1	0.37±0.28	0.60±0.35	0.015
Week 1	0.40±0.22	0.48±0.35	0.72
Month 1	0.42±0.29	0.37±0.22	0.76
Month 3	0.30±0.20	0.30±0.18	0.98

***p: Mann-Whitney test,** *LOCS*: Lens Opacities Classification System; *CDE*: Cumulative Dissipated Energy; *BSS*: Balanced salt solution; *BCVA*: Best Corrected visual acuity; *CCT*: central Corneal Thickness; *SIA*: Surgically Induced astigmatism; *CST*: Chi-Square test

mean BCVA, or percentage increase in CCT at any time during the follow-up period.
Induced astigmatism was comparable between groups except on postoperative day 1 where astigmatism was lower in the group with the 2.4mm temporal corneal incisions compared to the 3.2mm incisions (Table I).

There were no intraoperative complications of wound burn, Descemet membrane detachment, posterior capsule rupture, zonular dialysis or iris trauma. In three out of the group 1 surgeries, a blockage of the phaco tip and tubing was experienced in grade 4 cataracts. This was remedied by handpiece re-priming. Because no incisional leaks occurred, corneal wounds and paracenteses were left to self-seal by hydration. Severe postoperative corneal oedema was observed in six eyes in group 1 and five eyes in group 2. Severe anterior chamber inflammation occurred in three eyes in each group. All complications were transient and improved spontaneously within 1 week. We did not observe any severe intraocular pressure rise, hypotonia, endophthalmitis, cystoid macular oedema or retinal detachment during follow-up.

DISCUSSION

US energy delivered to the eye and fluid dynamics may adversely affect ocular tissues. Decreased US energy and intraoperative fluid volume are associated with better visual outcomes and clear corneas following phacoemulsification surgery (8). Traditional phacoemulsification handpieces create longitudinal jackhammer movements at the tip, which push lenticular material away. In contrast, torsional phacoemulsification reduces repulsion of nuclear particles from the phaco tip because of its rotational motion with a 32 kHz frequency. In addition to improved followability, torsional US also increases the efficiency of lens removal. Reduced energy with torsional US is also safer and has a lower risk of wound burn compared to longitudinal phacoemulsification (9-11).

In this study, fixed, purely torsional US energy delivered to the eye (as reflected by CDE) was higher in group 1, but this difference was not statistically significant. Previous studies using phacoemulsification surgery with purely torsional US have demonstrated greater effectiveness compared to conventional longitudinal phacoemulsification. This difference is especially pronounced with high fixed torsional US power and high vacuum levels; CDE is significantly reduced when using pure torsional US or torsionalmixedwithlongitudinalUS(9,10).Blockage of the tip and tubing by nuclear material in group 1 of our study suggests that longitudinal power may be required in addition to torsional US, especially in cataract cases with harder nucleus with the use of a 0.9 mm phaco tip. Although the relationship between infusion volume and endothelial cell loss is controversial, it is thought that higher infusion volumes may be associated with increased endothelial cell loss (12,13). However, there were no differences in mean irrigation volume between our study groups.

Significant postoperative corneal swelling (as defined by increased pachymetry on postoperative day 1) has been demonstrated as an indicator of corneal endothelial cell trauma due to phacoemulsification (14). Thus, postoperative changes in corneal thickness indirectly reflect surgical quality. The percentage increase in CCT in this study was similar in both groups at day 1 and throughout follow-up.

Smaller incisions in cataract surgery cause less trauma and SIA, which lead to better outcomes (15). Self-sealing clear corneal incisions of 3 mm in temporal and supero-temporal quadrants produce minimal postoperative astigmatism (approximately 0.50 diopters of induced cylinder) (16,17). A recent study showed similar results for bimanual microphacoemulsification (1.2 mm incision) and microcoaxial phacoemulsification (2.2 mm incision), with both approaches producing optical neutrality (18). Some studies had found that SIA decreased significantly with smaller incisions, microcoaxial clear corneal incisions creating more astigmatism than larger clear corneal incisions (19-21). In contrast, a study comparing 1.8 mm and 2.2 mm microcoaxial phacoemulsification surgeries demonstrated similar SIA outcomes with both incision sizes (22).

In this study, both groups experienced similar SIA values, except at postoperative day 1, when keratometric and topographic SIA were greater in group 2 (3.2 mm incision) compared to group 1 (2.4 mm incision) ($p=0.012$ and $p=0.015$, respectively). This difference diminished over the course of follow-up, with similar mean SIA at 3 months (0.3 to 0.35 diopters of induced cylinder).

The difference of incision size between groups (0.8 mm) was similar to that observed by Masket et al (19). However, our results contrast with those of other researchers. Although the mean SIA value in the 2.4 mm incision group was comparable to those reported previously, our mean SIA for 3.2 mm incisions was small compared to previous studies (19-21).

One study showed that mechanical and thermal stress from the phacoemulsification tip destabilises and denatures stromal collagen fibres around corneal incisions, with poor wound sealing as result (23). Theoretically, coaxial surgery with torsional US minimises temperature increases near the wound, thereby maximising postoperative incision closure, reducing SIA, and reducing postoperative endophthalmitis. We believe that our lower SIA with the 3.2 mm incision is explained by our use of purely torsional US and transcorneal IOL injection without wound stretching, which resulted in preserved corneal incision integrity.

In conclusion, coaxial phacoemulsification with purely torsional US yielded satisfactory results for both 2.4 mm and 3.2 mm incisions. There were no important differences in clinical outcomes between the two methods. Our experience also supports the use of small incision phacoemulsification with a 1.1 mm tip over microcoaxial phacoemulsification with a 0.9 mm tip in cataracts with a hard nucleus because tip and tube blockage seems to be more likely with purely torsional US using smaller diameter tip.

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