Original Articles/นิพนธ์ต้นฉบับ

# Comparison of Endothelial Cell Changes between Torsional and Conventional Mode Phacoemulsification

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## Abstract

**Objective:** To compare corneal endothelial cell loss in cataract surgery performed with conventional phacoemulsification and torsional phacoemulsification at Ramathibodi Hospital.

**Design:** Randomized controlled trial

**Setting:** Department of Ophthalmology, Faculty of Medicine Ramathibodi Hospital, Mahidol University

**Methods:** Fifty eyes of 50 patients with grade 2 to 4 senile cataract (according to the Oxford classification) were randomized to have either conventional mode or torsional (OZil) mode phacoemulsification using the Infiniti Vision System. All surgeries were performed by a single experienced surgeon. A complete ophthalmologic examination was performed preoperatively and postoperatively at 1 and 7 days, and 1, 3, 6, and 12 months. Central corneal thickness (CCT) and endothelium cell parameters were measured preoperatively and postoperatively at 3, 6 and 12 months. Primary outcomes were best-corrected visual acuity (BCVA), endothelial cell density (ECD) and CCT.

**Results:** Preoperatively, there was no significant difference in cataract grading between 2 groups. The mean preoperative ECD was 2,521.62 $\pm$ 331.32 (1,784-3,206) cell/mm$^2$ in the conventional group (28 patients) and 2,631.52 $\pm$ 290.75 (1,742-3,127) cell/mm$^2$ in the torsional group (22 patients). The mean postoperative ECD at 12 months was 2,315.21 $\pm$ 385.45 (1,245-3,183) and 2,261.82 $\pm$ 292.64 (1,672-2,872) cell/mm$^2$ in the conventional and torsional groups, respectively. The mean endothelial cell loss was 9.70% in the conventional group and 12.68% in the torsional group, with no statistically significant difference between the two groups ($P$ = 0.54). No significant differences in postoperative BCVA and CCT were found between the 2 groups.

**Conclusions:** Both torsional mode phacoemulsification and conventional mode phacoemulsification appears to be safe for corneal endothelial cells.

**Conflict of interest:** No author has a financial or proprietary interest in any material or method mentioned in this study.

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## Introduction

Phacoemulsification is the main procedure of cataract surgery. There have been significant advances in phacoemulsification and several methods have been developed to reduce the ultrasound energy during this operation. These include various power modulations, nuclear chopping techniques, microincision cataract surgery, and different modes of phacoemulsification[1]. In conventional ultrasound mode, the phaco tip moves forward and backward, so the ultrasound energy comes from longitudinal movement of the tip. The jackhammer effect plays an important role, and the cavitation effect plays minimal part in longitudinal phacoemulsification[2]. The torsional platform produces side-to-side rotary oscillations of the phaco tip. Comparing to the jackhammer motion in conventional phaco, the torsional oscillatary movement reduces the repulsion of the lens fragment, improves the followability of nuclear materials into the phaco tip[3], thereby reducing the ultrasound energy required for lens removal. In previous reports, the torsional mode provided a lower level of ultrasound time and energy and more effective phacoemulsification than the conventional mode[4,5].

Ultrasound power is considered a risk factor for endothelial cell loss, since the high ultrasound energy is associated with heat generation and damage to the endothelium. The endothelial cell density (ECD) decreases from 4,000 cell/mm$^2$ in childhood to about 2,500 cell/mm$^2$ at age 80 years[6]. The endothelium pump function is compromised when corneal endothelial cell count drops below 600-800 cell/mm$^2$, resulting in corneal decompensation. This natural process could be exacerbated by intraocular surgery such as cataract removal.

This study was designed to compare corneal endothelial cell changes of phacoemulsification using torsional versus conventional technologies in patients with different cataract densities.

## Materials and methods

This randomized controlled trial was conducted from October 2009 to October 2011 at the Department of Ophthalmology, Ramathibodi Hospital. Patients with a diagnosis of senile cataract scheduled for simple cataract surgery were recruited into this study. The study protocol adhered to the tenets of the *Declaration of Helsinki* and was approved by the Ethics Committee of Faculty of Medicine Ramathibodi Hospital, Mahidol University.

The grading of cataracts was determined according to The Oxford Clinical Cataract Classification and Grading System. Eyes with nuclear brunescence grades between 2 and 4 requiring phacoemulsification and intraocular lens implantation (IOL), were included into the study. Exclusion criteria were previous intraocular surgery, preoperative central ECD of less than 1500 cell/mm2, hypermature senile cataract, history of ocular inflammatory disease, complicated cataract surgery and patients lost to follow-up.

All patients were informed regarding the potential side effects and the possible risks of the procedure. Written informed consent was obtained prior to enrollment. Each patient underwent presurgical screening examinations, including manifest refraction, best-corrected visual acuity (BCVA), slit-lamp examination, applanation tonometry, and dilated fundus examination. Central corneal endothelial cell density and thickness were also measured by three observers (WC, NS, NW) using a Tomey EM-3000® noncontact specular microscope (Tomey, Nagoya, Japan) before surgery. At least 100 endothelial cells per eye per photograph were required to automatically calculate the cell density to reduce sampling errors.

After a complete initial ocular examination, each patient was randomly assigned into 2 groups using coin flipping technique: conventional and torsional groups. All patients underwent temporal clear cornea phacoemusification and posterior chamber IOL implantation under combined peribulbar and topical anesthesia. A combination of 2% lidocaine and 0.5% bupivacaine hydrochloride was injected into the peribulbar space and topical 0.5% tetracaine hydrochloride eye drops were instilled into the lower conjunctival fornix. Mydriasis was achieved with tropicamide eye drops. The conjunctival sac was rinsed with 5% povidone-iodine at least 3 minutes prior to surgery. A 3 mm self-sealing clear corneal incision was made on the temporal side. The ophthalmic viscosurgical device (OVD), which was 1.8% sodium hyaluronate (IAL-F®, TRB Chemedica, Switzerland), was injected to fill the anterior chamber and to protect the corneal endothelium. Balanced salt solution was used as an irrigating fluid. A 6.0 mm anterior continuous curvilinear capsulorhexis was created with a 26-guage bent needle followed by hydrodissection of the lens cortex from the capsular bag. Phacoemulsification was performed by a single experienced surgeon (PS) with the Infiniti Vision System platform (Alcon Laboratories, Texas, USA), using a nuclear chop technique. The surgical parameters used in both groups are summarized in Table 1. After removing all central lens nucleus with phacoemulsification, the outer lens cortex was removed with Simcoe's irrigation and aspiration tip. The posterior capsule was polished, if necessary, and the OVD was reinjected into the anterior chamber. A foldable acrylic hydrophobic IOL (AcrySof, Alcon Laboratories, Texas, USA) was implanted into the capsular bag using the accompanying Monarch III cartridge system through the 3 mm corneal incision. The anterior chamber was then irrigated to remove the OVD. No sutures were placed on the clear corneal wound.

Postoperatively, all patients received topical steroid/antibiotic combinations (0.3% Tobramycin sulphate and 0.1% dexamethasone; Tobradex®, Alcon, Fort Worth, TX, USA) 4 times daily for 3 weeks or until no sign of inflammation. Patients were examined 1, 7, 30 days, 3, 6 and 12 months after surgery. Follow-up examinations included BCVA, intraocular pressure (IOP), and anterior segment slit-lamp evaluation. Corneal endothelial cell density and pachymetry were assessed at 3, 6 and 12 months following surgery. Primary outcomes were BCVA, ECD, and central corneal thickness (CCT). The percentage loss of corneal endothelial cells was calculated as follows:

$$\text{Endothelial cell loss (ECL; \%)} = \frac{[\text{preoperative ECD} - \text{postoperative ECD}] \times 100}{\text{preoperative ECD}}$$

Statistical analyses were performed using SPSS version 14.0 (SPSS Inc., Chicago, IL). A *P*-value less than 0.05 was considered statistically significant.

## Results

Fifty eyes of 50 patients with senile cataract, 28 in the conventional group and 22 in the torsional group, were enrolled into the study. The mean age of the patients was 66.13 $\pm$ 10.66 years in the conventional group and 68.96 $\pm$ 11.00 years in the torsional group ($P = 0.77$). There was no statistically significant difference in age, gender, nuclear grading, mean operation times, and volume of irrigating solution used between 2 groups (Table 2).

Table 3 shows the preoperative and postoperative ECD, percentage of ECL, CCT, cell size variation coefficient (polymegathism), and hexagonality (pleomorphism) of the conventional and torsional groups.

**Table 1.** Parameter of surgical technique between two groups

| Group | Power (%) | Mode | Phaco tip | Aspiration rate ($cm^3$/min) | Vacuum (mmHg) |
|---|---|---|---|---|---|
| Convenional | 50 | Burst | 0.9 mm ABS 30-degree microtip (straight tip) | 35 | 350 |
| Torsional | 100 torsional amplitude | Linear Ozil continuous | 0.9 mm ABS 30-degree Kelman microtip | 35 | 350 |

ABS = aspiration bypass system

**Table 2.** Demographic data

| | Conventional group (n=28) | Torsional group (n=22) | *P*-value |
|---|---|---|---|
| Gender | | | |
| Female | 16 | 12 | 0.76 |
| Male | 12 | 10 | |
| Age (years) (mean±SD) | 66.13 ± 10.06 | 68.96 ± 11.00 | |
| Female | 66.60 ± 6.02 | 71.53 ± 9.24 | 0.27 |
| Male | 70.25 ± 5.93 | 66.27 ± 12.45 | |
| Best corrected visual acuity | | | |
| ≤ 20/40 | 12 | 8 | |
| 20/40-20/200 | 14 | 10 | 0.10 |
| > 20/200 | 2 | 4 | |
| Average nuclear grading | 2.75 ± 0.75 | 2.63 ± 0.73 | |
| NS2 | 16 | 11 | |
| NS3 | 9 | 8 | 0.86 |
| NS4 | 3 | 3 | |
| Solution used (ml) | 210.81 ± 69.57 | 215.86 ± 51.03 | 0.74 |
| Operation time (min) | 13.54 ± 2.50 | 14.48 ± 2.10 | 0.11 |

There was no statistically significant difference in any endothelial cell parameters between the conventional and the torsional groups. The BCVAs of the conventional and torsional groups at postoperative 12 months are shown in Table 4. No significant difference in postoperative BCVA at 12 months between the two groups was observed.

## Discussion

A high rate of corneal endothelial cell loss after cataract surgery has been reported in early studies. In 1978, Shugar et al. reported 33.8% after phacoemulsification in 70 eyes compared with the unoperated contralateral eye. They concluded that cataract extraction by phacoemulsification appeared to be more traumatic to the corneal endothelium than intracapsular

**Table 3.** Endothelial cell parameters of the conventional and torsional groups

| Parameters | Conventional group (n=28) | | Torsional group (n=22) | | *P*-value* |
|---|---|---|---|---|---|
| | Preoperative | Postoperative 12 months | Preoperative | Postoperative 12 months | |
| ECD (cell/mm$^2$) | | | | | |
| Mean ± SD | 2,521.62 ± 331.32 | 2,315.21 ± 385.45 | 2,631.52 ± 290.75 | 2,261.82 ± 292.64 | 0.43 |
| (Range) | (1,784-3,206) | (1,245-3,183) | (1,742-3,217) | (1,672-2,872) | |
| ECL (%) | - | 9.70 | - | 12.68 | 0.54 |
| CCT (micron) | | | | | |
| Mean ± SD | 529.16 ± 39.86 | 520.79 ± 34.28 | 521.66 ± 34.21 | 525.95 ± 35.12 | 0.62 |
| (Range) | (457-640) | (464-604) | (451-617) | (462-611) | |
| CV | | | | | |
| Mean ± SD | 40.07 ± 7.25 | 40.71 ± 9.23 | 42.44 ± 8.02 | 41.50 ± 6.52 | 0.56 |
| (Range) | (31-60) | (33-76) | (31-64) | (33-60) | |
| 6A (% | | | | | |
| Mean ± SD | 38.11 ± 10.21 | 36.00 ± 9.42 | 34.50 ± 10.21 | 35.18 ± 9.05 | 0.75 |
| (Range) | (18-53) | (14-56 ) | (14-48) | (13-48) | |

ECD, endothelial cell density; CCT, central corneal thickness; CV, coefficient of variation; 6A, percentage of hexagonal cells; ECL, endothelial cell loss

* *P* value was compared between the conventional and torsional groups at 12 months postoperatively.

**Table 4.** Postoperative best corrected visual acuities in the conventional and torsional groups at 12 months

| Postoperative BCVA at 12 months | Conventional group (n=28) | Torsional group (n=22) | *P*-value |
|---|---|---|---|
| ≤ 20/40 | 27 | 22 | 0.83 |
| 20/40 - 20/200 | 1 | 0 | |
| > 20/200 | 0 | 0 | |

BCVA, best corrected visual acuity

cataract extraction[7]. Endothelial cell loss after cataract surgery may vary from 4% to 25% in most cases[8]. Additionally, Bourne et al.[9] found that endothelial cell loss continued at a rate of 2.5% each year in patients followed up for 10 years after cataract surgery. That study involved patients who underwent extracapsular cataract extraction without OVD.

In our study, patients' baseline characteristics were similar between torsional and conventional groups. Although there was no statistically significant difference in ECL between 2 groups, ECL tended to be greater in torsional group than in conventional group, which did not correspond to the results found in previous studies[1,4,10].

Liu et al.[4] found a significantly lower endothelial cell loss in a torsional group than in a conventional group in the study of 525 eyes. However, these results were obtained at 30 days postoperatively, which was a shorter follow-up time point compared to the 12-month follow-up period of our study. This might

explain the higher endothelial cell loss seen in the torsional group in our study. We chose to analyze this variable at 3,6, and 12 months postoperatively, because the endothelial cell loss seemed to be stabilized at least 3 months after surgery[11,12]. Additionally, approximately 50% of our patients in each study group had nuclear sclerosis grade 2 (NS2). Meanwhile, greater than 80% of the patients in a previous study had denser nuclear sclerotic cataract (NS3+ to 4+)[4]. Therefore, the difference in ECL between the 2 groups in this study was insignificant.

Limitations of this study are the small sample size. To verify the safety and efficacy of torsional mode phacoemulsification, larger studies would be required.

In summary, torsional mode phacoemulsification appears to be safe for corneal endothelial cells as well as conventional mode.

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Original Articles/นิพนธ์ต้นฉบับ

# การเปรียบเทียบการเปลี่ยนแปลงของเซลล์กระจกตาชั้น endothelium ภายหลังการผ่าตัดสลายต้อกระจกโดยใช้คลื่นเสียงความถี่สูงชนิดดั้งเดิมและชนิดบิดหมุน

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## บทคัดย่อ

**วัตถุประสงค์:** เพื่อศึกษาเปรียบเทียบการเปลี่ยนแปลงของจำนวนเซลล์กระจกตาชั้น endotheliumภายหลังการผ่าตัดสลายต้อกระจกโดยคลื่นเสียงความถี่สูงแบบดั้งเดิมและแบบบิดหมุนที่โรงพยาบาลรามาธิบดี

**วิธีการวิจัย:** การวิจัยแบบ randomized controlled trial study

**สถานที่วิจัย:** โรงพยาบาลรามาธิบดี

**วิธีการ:** ทำการศึกษาในผู้ป่วยต้อกระจกที่เข้ารับการผ่าตัดต้อกระจกโดยใช้คลื่นความถี่สูง โดยแบ่งผู้ป่วยเป็น 2 กลุ่ม กลุ่มแรกใช้คลื่นเสียงความถี่สูงแบบดั้งเดิม และกลุ่มที่ 2 ใช้แบบบิดหมุนแนวซ้ายขวา การผ่าตัดทำโดยจักษุแพทย์เพียงท่านเดียวก่อนการผ่าตัดผู้ป่วยทั้ง 2 กลุ่ม ได้รับการตรวจตาอย่างละเอียด วัดความหนาของชั้นกระจกตาและวัดจำนวนเซลล์กระจกตาชั้น endothelium หลังการผ่าตัดผู้ป่วยจะได้รับการตรวจติดตามที่ 1 วัน 1 สัปดาห์ 1 เดือน 3 เดือน 6 เดือน และ 12 เดือนตามลำดับ รวมทั้งวัดความหนาของชั้นกระจกตาและวัดจำนวนเซลล์กระจกตาชั้น endothelium ที่ 3 เดือน 6 เดือนและ 12 เดือน เพื่อนำค่าก่อนและหลังผ่าตัดมาเปรียบเทียบกันทางสถิติ

**ผลการศึกษา:** จากผู้ป่วยที่เข้ารับการผ่าตัดทั้งหมด 50 ตาจาก 50 คน จำนวนเซลล์กระจกตาชั้น endotheliumเฉลี่ยก่อนการผ่าตัดในกลุ่มที่ 1 เท่ากับ 2,521.62 $\pm$ 331.32 (1,784-3,206) เซลล์ต่อตารางมิลลิเมตร (28 ตา) และในกลุ่มที่ 2 เท่ากับ 2,631.52 $\pm$ 290.75 (1,742-3,127) เซลล์ต่อตารางมิลลิเมตร (22 ตา) หลังการผ่าตัดที่ 12 เดือนจำนวนเซลล์กระจกตาชั้น endothelium เฉลี่ยเท่ากับ 2,315.21 $\pm$ 385.45 (1,245-3,183) เซลล์ต่อตารางมิลลิเมตร และ 2,261.82 $\pm$ 292.64 (1,672-2,872) เซลล์ต่อตารางมิลลิเมตรในกลุ่มที่ 1 และ 2 ตามลำดับ โดยคิดเป็นการสูญเสียเซลล์กระจกตาชั้น endothelium เท่ากับร้อยละ 9.70 และ 12.68 ตามลำดับ เมื่อนำมาเปรียบเทียบกันพบว่าค่าการสูญเสียเซลล์กระจกตาชั้น endothelium และความหนาของชั้นกระจกตาหลังการผ่าตัดโดยใช้คลื่นเสียงความถี่สูงทั้ง 2 วิธีที่ 12 เดือนไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($P$ = 0.54)

**สรุป:** การผ่าตัดสลายต้อกระจกโดยใช้คลื่นเสียงความถี่สูงแบบบิดหมุนมีความปลอดภัยต่อเซลล์กระจกตาชั้น endothelium ไม่ต่างจากการผ่าตัดสลายต้อกระจกโดยใช้คลื่นเสียงความถี่สูงแบบดั้งเดิม

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