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Article

Corneal Endothelial Changes After Phacoemulsification Using the Eight-Chop Technique in Patients with Diabetes

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Abstract: **Background:** To investigate corneal endothelial changes and intraocular pressure (IOP) after phacoemulsification using the eight-chop technique and intraoperative parameters in patients with diabetes. **Methods**: This study included eyes of patients with cataracts who had undergone phacoemulsification. Cataract surgery was performed using the eight-chop technique. The operative time, phaco time, aspiration time, cumulative dissipated energy, and volume of fluid used were measured. The best-corrected visual acuity, IOP, corneal endothelial cell density (CECD), coefficient of variation (CV), percentage of hexagonal cells (PHC), and central corneal thickness (CCT) were measured pre- and post-operatively. **Results**: Overall, 181 eyes of 138 patients with cataracts were evaluated. The diabetes group showed CECD loss rates of 5.1%, 3.9%, and 2.1% at 7 weeks, 19 weeks, and 1 year postoperatively, respectively. The control group showed CECD loss rates of 2.8%, 2.6%, and 1.2% at 7 weeks, 19 weeks, and 1 year postoperatively, respectively. Significant differences in the CV and PHC were observed preoperatively and postoperatively between the diabetes and control groups ($p < .01$ or $p = .01$, 0.2). Furthermore, significant differences were observed between the CV and PHC preoperatively and that at 19 weeks and 1 year postoperatively in the diabetes and control groups ($p < .01$). The IOP reduction rates were 8.0% and 11.2% in the diabetes and control groups, respectively, at 1 year postoperatively. **Conclusion**: CECD loss in the eight-chop technique was minimal. The repair and healing mechanisms of the endothelium may have increased by phacoemulsification using the eight-chop technique postoperatively. The IOP reduction was maintained in both groups postoperatively.

Keywords: cataract surgery; phacoemulsification; corneal endothelial cell; diabetes mellitus; eight-chop technique

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Background

Patients with diabetes develop cataracts at a high rate, and diabetes also causes many other complications in addition to cataracts [1,2]. In particular, in patients with diabetes, high blood sugar is associated with an increase in the accumulation of TGF-β-induced proteins and the formation of advanced glycation end products in corneal endothelial cells [3]. Furthermore, components of the extracellular matrix such as vitronectin and fibronectin are markedly increased along the Descemet membrane-stromal interface [3]. In addition, the activity of Na^+/K^+-ATPase, which plays an important role in the maintenance of the cornea, is reduced and corneal endothelial cells in patients with diabetes are structurally and functionally impaired [4].

Several studies have shown that patients with diabetes have higher intraocular pressure (IOP) than healthy participants [5,6]. It has also been reported that patients with diabetes are more likely to develop glaucoma than normal individuals [5]. Therefore, it is important to investigate changes in intraocular pressure after cataract surgery in patients with diabetes, who have a high incidence of glaucoma. However, many studies have shown that IOP decreases after cataract surgery in patients with and without diabetes, though the results varied.

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Although advances in phacoemulsification have improved the safety and efficiency of cataract surgery, there is still a need to work on protecting corneal endothelial cells. Even now, cataract surgery reduces corneal endothelial cell density (CECD) [7–10]. However, the results regarding the reduction of CECD after surgery are not consistent [11–15] and the phacoemulsification techniques used in surgery are mixed. In addition, intraoperative measurement of parameters is an important indicator for analysis of the effects of surgery, but there are few studies that have investigated the relationship between these parameters and postoperative CECD loss.

In the eight-chop technique, the nucleus is divided manually under an ophthalmic viscosurgical device before phacoemulsificatio [16]. Compared with conventional grooving, divide-and-conquer, and phaco-chop techniques, the eight-chop technique reduces the total ultrasound energy, aspiration time, and volume of the fluid used [16]. Furthermore, the CECD loss after cataract surgery is 0.9–1.0% if the nucleus is not hard [16]. From the perspective of corneal endothelial cell protection, the eight-chop technique is an ideal surgical method.

Although cataract surgery alone does not cause corneal endothelial cell dysfunction, the CECD loss after cataract surgery needs to be kept to a minimum in consideration of the effects of potential complications such as glaucoma and vitreous surgery.

In this study, we aimed to measure the changes of corneal endothelial cells and IOP and intraoperative parameters in patients with diabetes using the eight-chop technique.

Methods

This study included the eyes of patients with cataracts who underwent phacoemulsification and posterior chamber intraocular lens (IOL) implantation between June 2019 and July 2022. This study enrolled patients with cataract who visited our clinic. Exclusion criteria included corneal disease or opacity, uveitis, diabetic retinopathy, poorly dilated pupils (< 5.0 mm), all-white cortical cataract, preoperative CECD < 2,000 cells/mm^2, severe weak zonules, and previous ocular trauma or surgery.

The study protocol adhered to the guidelines of the Declaration of Helsinki and was approved by the review board. Informed consent for participation in this study was obtained from each patient after explaining the nature and possible consequences of the study. Preoperatively, all patients underwent slit-lamp and retinal examinations, and their best-corrected visual acuity (BCVA) and IOP were measured. The patients were diagnosed with diabetes based on the Hemoglobin A1c level within 6 months prior to surgery.

The CECD (cells/mm^2), coefficient of variation (CV), percentage of hexagonal cells (PHC), and central corneal thickness (CCT) were analyzed using a non-contact specular microscope (EM-3000, Topcon, Hasunumacho). The firmness of the nucleus was graded using the Emery classification [17]. The same surgeon, experienced in the eight-chop technique, performed phacoemulsification using the phacoemulsification unit (Centurion®, Alcon Labs Inc) in all patients.

New surgical instruments have been designed and developed to perform the eight-chop technique [16]. Our research team designed eight choppers and requested a manufacturing company to produce them. Eight-chopper I (SP-8193; ASICO) has a smaller tip than the conventional prechopper, with a length and width of 3.2 mm and 1.4 mm, respectively, and a sharper leading edge. Eight-chopper II (SP-8402; ASICO) has a smaller angular tip (2.5 mm long and 0.8 mm wide) that can be inserted vertically into the lens nucleus.

In all surgeries, a temporal, clear corneal incision was made using a 3.0-mm steel keratome. After injecting sodium hyaluronate into the anterior chamber, a 6.2–6.5-mm continuous curvilinear capsulorrhexis was created using capsule forceps. The soft-shell technique [7] was used in the grade III group. Hydrodissection was performed using a 27-G cannula; however, hydrodelineation was not performed. The lens nucleus was cracked into eight segments using an Eight-chopper I or II in the grade II and III groups. The eight segments were phacoemulsified and aspirated at the depth of the iris plane. The capsular bag was aspirated with an irrigation/aspiration tip to remove the cortical materials. The ophthalmic viscosurgical device was injected and a foldable IOL (Alcon Labs Inc.) with polymethyl methacrylate haptics was inserted into the capsular bag using an injector system.

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Subsequently, the ophthalmic viscosurgical device was aspirated. The phacoemulsification unit was used in all cases and had a flow rate of 32 mL/min, maximum ultrasound power of 80%, and 1.1-mm tip. If necessary, the wound was sealed with stromal hydration. The anterior chamber was replaced with a balanced salt solution containing moxifloxacin (0.5 mg/mL) postoperatively.

The intraoperative outcome measures included the operative time (min), phaco time (s), aspiration time (s), cumulative dissipated energy (CDE), volume of fluid used (mL), and rate of intraoperative complications. The operative time was calculated from the beginning of the corneal incision to the end of the ophthalmic viscosurgical device aspiration. All surgeries were recorded using a camera (MKC-704KHD, Ikegami, Tokyo, Japan), and video images were stored on a hard disc drive.

Patients were followed up on postoperative days 1 and 2; at weeks 1, 3, 7, and 19; and at year 1. The postoperative outcome measures were the BCVA, IOP, CCT, CV, PHC, and CECD obtained at 7 and 19 weeks and 1 year postoperatively.

Statistical analyses were performed to compare the results of the diabetes and control groups using unpaired *t*-tests. Paired *t*-tests were used to compare the preoperative BCVA, IOP, CV, PHC, CCT, and CECD at each postoperative time point. Statistical significance was set at $p <. 05$. Chi-square test was used to determine any differences in sex and incidence of diabetes mellitus between the diabetes and control groups.

Results

This study included 181 eyes of 138 patients with cataract who underwent phacoemulsification and posterior chamber IOL implantation. Table 1 shows the patient characteristics and intraoperative parameters. No significant differences were observed in the mean age ($p = .71$) or sex ($p = .12$) between the diabetes and control groups. Furthermore, no significant differences were observed in the operative time, phaco time, aspiration time, CDE, and volume of fluid used between the diabetes and control groups ($p = .14$, .15, .83, .14, and .65, respectively).

Table 2 shows the preoperative and postoperative changes in the CECD. No significant differences were observed in the CECD preoperatively and at 7 and 19 weeks and 1 year postoperatively between the diabetes and control groups ($p = .61$, .24, .73, and .99, respectively). Significant differences were observed between the CECD preoperatively and that at 7 weeks postoperatively; between the CECD preoperatively and that at 19 weeks postoperatively; and between the CECD preoperatively and that at 1 year postoperatively in the diabetes and control groups (all $p < .01$).

Table 3 shows the preoperative and postoperative changes in the CCT, CV, and PHC. No significant differences were observed in the CCT preoperatively and at 7 and 19 weeks and 1 year postoperatively between the diabetes and control groups ($p = .59$, .09, .26, and .24, respectively). Significant differences were observed between the CCT preoperatively and that at 7 weeks postoperatively and between the CCT preoperatively and that at 19 weeks postoperatively in the diabetes group ($p < .01$ and $p = .03$, respectively); however, no significant differences were observed between the CCT preoperatively and that at 1 year postoperatively in the diabetes group ($p = .38$). No significant differences were observed between the CCT preoperatively and that at 7 weeks postoperatively and between the CCT preoperatively and that at 19 weeks postoperatively in the control group ($p = .27$ and .86, respectively); however, significant differences were observed between the CCT preoperatively and that at 1 year postoperatively in the control group ($p < .01$). Significant differences were observed in the CV preoperatively and at 7 and 19 weeks and 1 year postoperatively between the diabetes and control groups ($p < .01$ or $p = .01$). No significant differences were observed between the CV preoperatively and that at 7 weeks postoperatively in the diabetes ($p = .13$) and control ($p = .43$) groups; however, significant differences were observed between the CV preoperatively and that at 19 weeks postoperatively and between the CV preoperatively and that at 1 year postoperatively in the diabetes and control groups (all $p < .01$). Significant differences were observed in the PHC preoperatively and at 7 and 19 weeks and 1 year postoperatively between the

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diabetes and control groups ($p < .01$ or $p = .02$). No significant differences were observed between the PHC preoperatively and that at 7 weeks postoperatively in the diabetes ($p = .11$) and control ($p = .34$) groups; however, significant differences were observed between the PHC preoperatively and that at 19 weeks postoperatively and between the PHC preoperatively and that at 1 year postoperatively in the diabetes and control groups (all $p < .01$).

Table 4 shows the changes in IOP. No significant differences were observed in IOP preoperatively and at 7 and 19 weeks and 1 year postoperatively between the diabetes and control groups (p = .06, .49, .20, and .36, respectively). Significant differences were observed between IOP preoperatively and that at 7 and 19 weeks and 1 year postoperatively in the diabetes and control groups (all $p < .01$).

Table 5 shows the changes in BCVA. Significant differences were observed in the preoperative BCVA between the diabetes and control groups ($p = .02$). Moreover, significant differences were observed in the BCVA at 7 and 19 weeks and 1 year postoperatively between the diabetes and control groups (all $p < .01$). Significant differences were observed between the BCVA preoperatively and that at 7 weeks postoperatively; between the BCVA preoperatively and that at 19 weeks postoperatively; and between the BCVA preoperatively and that at 1 year postoperatively in the diabetes and control groups (all $p < .01$).

Table 1. Preoperative Characteristics and Intraoperative Parameters.

Characteristics/Parameters	Diabetes group	Control group	*P* value
Number of eyes	94	87	
Age (years)	74.6 ± 6.8	74.3 ± 5.5	.71[a]
Sex Male	43 (46%)	30 (34%)	.12[b]
Female	51 (54%)	57 (66%)	
Operative time (min)	4.63 ± 1.24	4.91 ± 1.38	.14[a]
Phaco time (s)	15.5 ± 6.0	14.2 ±6.3	.15[a]
Aspiration time (s)	68.1 ± 16.7	67.6 ± 20.4	.83[a]
CDE	6.45 ± 2.30	5.91 ± 2.61	.14[a]
Volume of fluid used (mL)	27.0 ± 7.7	26.5 ± 8.1	.65[a]

Values are expressed as means ± standard deviations or as numbers with percentages, unless otherwise stated. CDE: cumulative dissipated energy. [a]No significant differences among groups (unpaired *t*-test). [b]No significant differences among groups (chi-square test).

Table 2. Pre- and Post-Operative CECD Values.

	Mean CECD ± SD (% Decrease)						
Time period	Diabetes group (n = 94)		Control group (n = 87)		*P* value		
Preoperatively	2670 ± 294	-	2652 ± 211	-	.61[a]		
7 weeks postoperatively	2533 ± 272	5.1	2576 ± 207	2.8	.24[a]	< .01[b]	< .01[c]
19 weeks postoperatively	2570 ± 294	3.9	2583 ± 221	2.6	.73[a]	< .01[b]	< .01[c]
1 year postoperatively	2620 ± 306	2.1	2620 ± 214	1.2	.99[a]	< .01[b]	< .01[c]

CECD: corneal endothelial cell density; SD: standard deviation. [a]No significant difference between the groups (unpaired *t*-test). [b]Significant difference between the preoperative and the respective time values in the diabetes group (paired *t*-test). [c]Significant difference between the preoperative and the respective time values in the control group (paired *t*-test).

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Table 3. Pre- and Post-Operative Endothelial CCT, CV, and PHC.

Time period	Diabetes group (n = 94)	Control group (n = 87)	*P* value		
CCT	Mean ± SD				
Preoperatively	538 ± 34.0	536 ± 34.1	.59[a]		
7 weeks postoperatively	547 ± 36.2	537 ± 34.0	.09[a]	< .01[c]	.27[f]
19 weeks postoperatively	542 ± 33.3	536 ± 32.7	.26[a]	.03[c]	.86[f]
1 year postoperatively	537 ± 35.0	531 ± 33.6	.24[a]	.38[d]	< .01[e]
CV	Mean ± SD				
Preoperatively	42.3 ± 5.5	39.8 ± 6.9	< .01[b]		
7 weeks postoperatively	41.3 ± 5.6	39.1 ± 5.2	< .01[b]	.13[d]	.43[f]
19 weeks postoperatively	39.3 ± 6.0	36.4 ± 4.9	< .01[b]	< .01[c]	< .01[e]
1 year postoperatively	37.6 ± 5.0	35.7 ± 4.9	.01[b]	< .01[c]	< .01[e]
PHC	Mean ± SD				
Preoperatively	39.7 ± 6.9	44.7 ± 5.6	< .01[b]		
7 weeks postoperatively	41.0 ± 6.5	45.5 ± 6.7	< .01[b]	.11[d]	.34[f]
19 weeks postoperatively	44.5 ± 7.1	48.1 ± 6.2	< .01[b]	< .01[c]	< .01[e]
1 year postoperatively	46.4 ± 6.7	48.8 ± 7.0	.02[b]	< .01[c]	< .01[e]

CCT: central corneal thickness; CV: variation in the size of endothelial cells; PHC: percentage of hexagonal cells; SD: standard deviation

[a]No significant difference between the groups (unpaired *t*-test). [b]Significant difference between the groups (unpaired *t*-test). [c]Significant difference between the preoperative and the respective time values in the diabetes group (paired t-test). [d]No significant difference between the preoperative and the respective time values in the diabetes group (paired t-test). [e]Significant difference between the preoperative and the respective time values in the control group (paired t-test). [f]No significant difference between the preoperative and the respective time values in the control group (paired t-test).

Table 4. Mean IOP (mmHg) and Mean Decrease (%) in the IOP (mmHg) Over time.

	Mean IOP ± SD (% Decrease)						
Time period	Diabetes group (n = 94)		Control group (n = 87)		*P* value		
Preoperatively	14.0 ± 1.9	-	14.5 ± 2.0	-	.06[a]		
7 weeks postoperatively	11.9 ± 2.3	13.2	12.1 ± 1.8	16.1	.49[a]	< .01[b]	< .01[c]
19 weeks postoperatively	12.3 ± 2.2	10.7	12.6 ± 1.8	12.4	.20[a]	< .01[b]	< .01[c]
1 year postoperatively	12.6 ± 2.1	8.0	12.9 ± 1.9	11.2	.36[a]	< .01[b]	< .01[c]

IOP: intraocular pressure; SD: standard deviation. [a]No significant difference between groups (unpaired *t*-test). [b]Significant difference between the preoperative and respective time values in the diabetes group (paired *t*-test). [c]Significant difference between the preoperative and respective time values in the control group (paired *t*-test).

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Table 5. BCVA Over time.

Time period	BCVA				
	Diabetes group (n = 94)	**Control group (n = 87)**	***P* value**		
Preoperatively	0.031 ± 0.030	0.074 ± 0.011	0.02[a]		
7 weeks postoperatively	-0.040 ± 0.0049	-0.065 ± 0.00095	< .01[b]	< .01[c]	< .01[d]
19 weeks postoperatively	-0.037 ± 0.0038	-0.0664 ± 0.00086	< .01[b]	< .01[c]	< .01[d]
1 year postoperatively	-0.039 ± 0.0042	-0.064 ± 0.0010	< .01[b]	< .01[c]	< .01[d]

Values are expressed as means ± standard deviation. BCVA: best-corrected visual acuity; IOP: intraocular pressure. [a]No significant difference between groups (unpaired *t*-test). [b]Significant difference between groups (unpaired *t*-test). [c]Significant difference between the preoperative and respective time values in the diabetes group (paired *t*-test). [d]Significant difference between the preoperative and respective time values in the control group (paired *t*-test).

Discussion

This study revealed that the eight-chop technique had an operative time of 4.63–4.91 min in the diabetes and control groups, significantly less than that in other techniques (10–19 min) [7,9,18,19]. Furthermore, the phaco time and CDE were reduced, and the volume of fluid used was only one-third to one-fourth of that used by other technique [7,9,20]. In the eight-chop technique, the nucleus is mechanically divided into eight pieces prior to phacoemulsification. This results in a reduction in the use of ultrasonic oscillation energy and an efficient removal of the fragmented nucleus, which can lead to a drastic reduction in the phaco time and CDE. The idea of the eight-chop technique may be shared with femtosecond laser-assisted cataract surgery in that the lens nucleus is divided without the use of ultrasonic oscillation energy.

According to two meta-analyses, the preoperative CECD in patients with diabetes was lower than in the healthy population [21,22], on the other hand, Yang et al. [23] reported that there was no difference and no agreement. In this study, no significant differences were observed in the CECD preoperatively between the diabetes and control groups.

Previous studies have reported 10.2–18.5% and 5.0–18.4% decreases in the CECD following cataract surgery in the first few postoperative months in patients with diabetes and normal patient [8–10,21,22]. However, in this study, the decrease was only 5.1%, 3.9%, and 2.1% at 7 weeks, 19 weeks, and 1 year postoperatively, respectively, in the diabetes group and 2.8%, 2.6%, and 1.2% at 7 weeks, 19 weeks, and 1 year postoperatively, respectively, in the control group. Diabetes increases the risk of damage and dysfunction of the corneal endothelium following surgical stress [24]. Compared with patients without diabetes, those with diabetes show differences in greater CECD loss following cataract surgery [21,23,25]. however, no significant difference was observed in the postoperative decrease in the CECD between the diabetes and control group. The low surgical invasiveness of the eight-chop technique may have prevented the fragility of the corneal endothelial cell function of patients with diabetes from causing a difference in the CECD loss.

CECD loss during phacoemulsification is inevitable. This is mainly because of the confined space (anterior chamber) in which the surgery is performed. The corneal endothelium comes into direct contact with the instruments several times during the procedure, making it susceptible to damage from the high ultrasound energy of the phaco tip [26]. Despite the potential benefits of phacoemulsification, the CECD after phacoemulsification remains a major concern. CECD assessment is crucial for comparing various techniques because it represents the true summation of intraocular insult during surgery [7,27].Our results indicate that the eight-chop technique may be advantageous for minimizing the surgical involvement of intraocular tissues, including the

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trabecular meshwork and Schlemm's canal. The aim of modern cataract surgery is not only to improve vision but also to minimize the damage to corneal endothelial cells, especially in patients with cataracts and diabetes. This study revealed that, in patients with diabetes, the CECD loss after cataract surgery is greater than in normal patients, but the loss is minimal, and if the eight-chop technique is used, even in patients with diabetes, the rate of decrease one year after surgery is the same as the average annual rate of decrease over 10 years after surgery in normal patients, which has been reported in the past, at 2.5% [28].

The CCT is used as a marker of corneal endothelial function [25]. In this study, there was no significant difference in the preoperative and postoperative CCT between the diabetes and control groups. However, significant differences were observed between the CCT preoperatively and that at 7 weeks postoperatively and between the CCT preoperatively and that at 19 weeks postoperatively in the diabetes group, while in the control group, no significant differences were observed. This result shows that there is a possibility of corneal endothelial cell dysfunction in the diabetes group at 19 weeks postoperatively compared to the control group.

The CV is an indicator of the uniformity in the size of endothelial cells, which indicates the repair and healing mechanisms of the endothelium after damage. Previous studies have demonstrated significant and non-significant differences in CV changes between patients with diabetes and normal patients after cataract surgery [11,21,23,29]. In this study, the CV in the diabetes group was higher than in the control group preoperatively and the CVs decreased significantly in both groups at 1 year preoperatively, there was no significant difference between the two groups.

Hexagonality indicates the variability in hexagonal cell shape, such as the CV, and it represents the healing response after damage [25]. Previous studies have demonstrated significant and non-significant differences in PHC changes between patients with diabetes and normal patients after cataract surgery [11,21,23,29]. In this study, the PHC in the diabetes group was lower than in the control group preoperatively and the PHCs increased significantly in both groups at 1 year preoperatively, there was no significant difference between the two groups. These results of CV and PHC suggest that the repair and healing mechanisms of the endothelium may be reduced in the diabetes group preoperatively, although its activity may have increased in both groups postoperatively becasuse of the low surgical invasiveness of the eight-chop technique.

Many investigators have reported a decrease in IOP following phacoemulsification, cataract extraction, and IOL implantation in patients with cataracts [30,31]. Previous reports have demonstrated IOP reductions of 4–10% [32–34]. Changes in the postoperative IOP are proportional to the preoperative IOP. However, Poly et al. [34,35] reported an increase in IOP in the primary open-angle glaucoma (POAG) and normal groups at 1 year compared with the preoperative levels. Therefore, there are conflicting perspectives on IOP reduction after phacoemulsification cataract surgery. In this study, the IOP reduction rates were 8.0% and 11.2% in the diabetes and control groups, respectively, at 1 year postoperatively, which were higher than the previously reported data in both groups. The greater IOP reduction could be attributed to the superiority of the eight-chop technique over other techniques in minimizing surgical involvement of the intraocular tissues.

Trabecular meshwork cells, which are exposed to the same ultrasonic energy and turbulent currents as corneal endothelial cells during cataract surgery, are expected to decrease in number if the corneal endothelial cells decrease more severely. A decrease in the trabecular meshwork cells is associated with POAG and elevated IOP. POAG eyes contained fewer trabecular meshwork cells overall than normal eyes, indicating an average cell loss of 17.7% in glaucoma eyes [36]. Furthermore, trabecular meshwork cellularity was highly correlated with the maximum recorded IOP [36], supporting the notion that reduced trabecular meshwork cell density hampers the ability of the tissue to regulate IOP [36]. Therefore, increasing CECD loss may lead to trabecular meshwork cell loss, resulting in increased IOP.

In the eight-chop techniqque, the low volume of fluid used indicates that the ultrasound and irrigation/aspiration tips are inserted for a shorter period, which may have less impact on the trabecular meshwork and Schlemm's canal cells, including corneal endothelial cells. Therefore, we

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speculate that the eight-chop technique may result in less trabecular meshwork cell loss, and as a result, normal trabecular meshwork function may be maintained, leading in long-term IOP reduction.

The present study has several limitations. The first stems from the absence of the results with the prechop, phaco-chop, or divide-and-conquer techniques, and this should be fully considered when evaluating the present results. However, many other studies have been conducted using the phaco-chop and divide-and-conquer techniques, and we believe that the present results can be evaluated by comparing them with these results. Second, the correlation between intraoperative parameters, postoperative outcomes, and blood glucose levels, duration of diabetes, and type of diabetes has not been investigated. Furthermore, as cases with diabetic retinopathy were excluded, it is unknown how the CECD changes in patients with severe diabetes after cataract surgery.

The prechop technique has the excellent feature of being able to reduce the use of ultrasonic oscillation energy and the surgical invasion of intraocular tissue by mechanically dividing the crystalline lens into four segments before phacoemulsification [37]. This excellent feature is the same as the advantages of femtosecond laser-assisted cataract surgery. However, it is far superior to femtosecond laser-assisted cataract surgery in terms of medical economics.

Although the prechop technique has excellent features, it is rarely used as a surgical technique worldwide [16,38]. The reason for this is that the prechopper may not be easy to operate. However, the eight-chop technique, which is an improvement on the prechop technique, has been developed and the eight-chopper has improved usability [16]. Furthermore, by using the Lance-chopper, it is possible to perform phacoemulsification surgery on patients with hard nucleus cataracts or weak zonules [16]

The phaco time, aspiration time, CDE, volume of fluid used, and operative time should be measured when examining changes in IOP and CECD following phacoemulsification cataract surgery. However, to the best of our knowledge, few studies have reported the effects of phacoemulsification cataract surgery on IOP and CECD. To reduce postoperative CECD loss and maintain IOP reduction, surgical invasion of intraocular tissues should be analyzed using intraoperative parameters, and a phacoemulsification technique should be selected to minimize surgical invasion.

Conclusion

The eight-chop technique is a cataract surgery with a shorter operative time, less surgical invasion of intraocular tissues, and less fluid volume used than previous techniques. The CECD loss in the present study was minimal compared with that reported in previous studies. The changes of CV and PHC suggest that the repair and healing mechanisms of the endothelium may have increased postoperatively becasuse of the low surgical invasiveness of the eight-chop technique. The IOP reduction could be attributed to the superiority of the eight-chop technique in minimizing surgical involvement of the intraocular tissues.

List of abbreviations

IOP: intraocular pressure; CECD: corneal endothelial cell density; CV: endothelial cells; PHC: percentage of hexagonal cells; CCT: central corneal thickness； IOL: intraocular lens; BCVA: best-corrected visual acuity; CDE: cumulative dissipated energy

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Consent for publication: Not applicable.

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Authors' contributions: TS designed the study and collected and analyzed the data. TS wrote, read, and approved the final manuscript.

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