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Cataract Surgery in Pseudoexfoliation Syndrome Using the Eight-Chop Technique

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Article

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Abstract

Objectives: To evaluate the safety and efficacy of the eight-chop technique in cataract surgery in patients with pseudoexfoliation (PEX) syndrome and assess the intraoperative parameters, changes in corneal endothelial cells, intraocular pressure (IOP), and intraoperative complications. **Methods:** This technique was applied in patients with and without PEX syndrome. Best-corrected visual acuity, IOP, corneal endothelial cell density (CECD), coefficient of variation, percentage of hexagonal cells, and central corneal thickness were assessed pre- and postoperatively. Operative time, phaco time, aspiration time, cumulative dissipated energy (CDE), and volume of fluid used were recorded intraoperatively. **Results:** We analyzed 219 eyes from 150 patients (mean age, 75.5 ± 5.7 years; 58 men, 92 women). In the PEX group, the mean operative time, phaco time, aspiration time, CDE, and volume of fluid used were 6.5 min, 16.8 s, 83.8 s, 6.67, and 32.9 mL, respectively, demonstrating favorable surgical metrics. In addition, CECD loss was 1.1% and 0.5% at 7 and 19 weeks, respectively, with no significant decrease observed post-surgery in the PEX group. No eye in the PEX group required a capsular tension ring due to zonular dialysis. **Conclusion:** The eight-chop technique in cataract surgery demonstrates excellent intraoperative parameters in patients with PEX, is effective against zonular weakness, and does not require the use of a capsular tension ring. This technique will aid in establishing personalized treatment strategies and improve cataract management and treatment.

Keywords: cataract surgery; corneal endothelial cell; eight-chop technique; phacoemulsification; pseudoexfoliation syndrome

1. Introduction

Pseudoexfoliation (PEX) syndrome is an age-related fibrillopathy characterized by the accumulation and deposition of white fibrillar exfoliation material in ocular and extraocular tissue [1,2]. Pseudoexfoliative materials comprise various extracellular matrix components such as fibrillin-1, elastin, fibronectin, and cross-linked glycoproteins [3–5]. PEX deposits are located extracellularly around blood vessels and in the connective tissues around the heart, lungs, and brain [6]. It has been definitively linked to Alzheimer's disease, cerebral atrophy, ischemic heart disease, renal artery stenosis, aortic aneurysms, and systemic hypertension, among other conditions [1,6]. PEX has been detected on the ocular surface and in the anterior segment of the eye [1,2,6].

PEX frequently causes PEX glaucoma, accounting for 25–70% of glaucoma cases worldwide, making it the primary cause of open-angle glaucoma [2]. Other studies have demonstrated that patients with PEX have lower corneal endothelial cell density (CECD) [7–9] and their pupils are 21% smaller than those of healthy individuals [10]. Additionally, in patients with PEX, pseudoexfoliative deposits form in the zonules and zonular lamellae, leading to zonular weakness and lens subluxation [1]. Furthermore, high incidences of intraoperative floppy iris syndrome and zonular rupture have been reported [11]. In a large-scale study, patients with PEX had a 2.68-fold higher risk of developing complications during cataract surgery; zonular weakness in PEX may lead to complications, such as zonular rupture, vitreous loss, and posterior capsule rupture [12].

Reportedly, the eight-chop technique for cataract surgery requires shorter surgical and phaco time, less cumulative dissipated energy (CDE), shorter aspiration time, and less volume of fluid than other surgical techniques. In addition, postoperative corneal endothelial cell loss is extremely low, and postoperative intraocular pressure (IOP) decreases [13–17]. Furthermore, even in cases with poor pupil dilation or a shallow anterior chamber depth, the postoperative reduction in corneal endothelial cell count was superior to that of conventional surgical techniques, IOP reduction was maintained, and the incidence of intraoperative complications was extremely low [14,17]. Therefore, the eight-chop technique may be effective in PEX cases with a high risk of intraoperative complications during cataract surgery due to the possibility of corneal endothelial cell loss and IOP elevation.

Modern phaco machines can record various critical parameters during cataract surgery, including CDE, phaco time, aspiration time, volume of fluid used, and duration of the surgical procedure. Limited studies have analyzed intraoperative parameters in patients with PEX syndrome undergoing phacoemulsification surgery [18]. Therefore, we aimed to evaluate the efficacy of the eight-chop technique in patients with PEX syndrome who underwent cataract surgery. We examined intraoperative parameters, changes in corneal endothelial cells and IOP, as well as intraoperative complications.

2. Materials and Methods

2.1. Ethical Considerations

The institutional review board reviewed and approved the study protocol for use, with adherence to the tenets of the Declaration of Helsinki. After carefully articulating the study's nature and potential outcomes, consent to participate was obtained for each patient (approval number 20140901).

2.2. Study Population

This study included patients with cataracts who underwent phacoemulsification and posterior chamber intraocular lens (IOL) implantation between November 2014 and July Subsequently, these patients visited the Sato Eye Clinic in Matsudo City, Chiba Prefecture, Japan. The presence of PEX materials in the anterior segment was determined by observing fibrillary deposits on the pupillary margin, anterior lens capsule, or both, using a slit lamp microscope. We excluded patients with corneal disease or opacity, uveitis, diabetic retinopathy, white cataracts, preoperative CECD < 2,000 cells/mm², severely weak zonules, and a history of ocular trauma or surgery.

2.3. Preoperative Assessment

All patients were examined using a slit-lamp and retinal biomicroscopy. Best corrected visual acuity (BCVA) and IOP were evaluated preoperatively. CECD (cells/mm²), central corneal thickness (CCT), coefficient of variation (CV), and percentage of hexagonal cells (PHC) were analyzed using a non-contact specular microscope (EM-3000; Topcon Corporation, Tokyo, Japan). The hardness of the nucleus was evaluated using the Emery classification [19]. All patients were treated by the same surgeon, experienced in the eight-chop technique using the phacoemulsification system (Centurion®; Alcon Laboratories, Inc., Irvine, CA, USA).

2.4. Surgical Technique

For each case, a 3.0 mm steel keratome was employed to create a temporal clear corneal incision. Next, sodium hyaluronate was injected into the anterior chamber, and a 6.2–6.5 mm continuous curvilinear capsulorrhexis was created using capsule forceps. Hydrodissection was successfully performed using a 27-G cannula. The lens nucleus was divided into eight sections with an Eight-chopper I or II in the grade II and III groups. At the level of the iris plane, the eight sections were carefully phacoemulsified and aspirated. Then, the capsular bag was carefully extracted with an irrigation/aspiration tip to remove the cortical materials. The ophthalmic viscosurgical device was administered, and a foldable three-piece IOL (Acrysof® MN60AC; Alcon Laboratories, Inc., Fort Worth, TX, USA) with polymethyl methacrylate haptics was carefully placed into the capsular bag through a precise injection process. Next, the ophthalmic viscosurgical device was carefully removed. Post-surgery, the anterior chamber was replaced with a balanced salt solution containing moxifloxacin (0.5 mg/mL).

Intraoperative outcome measures included operative time in minutes, phaco time in seconds, aspiration time in seconds, CDE, volume of fluid used in milliliters, and incidence of intraoperative complications. The operative time was carefully measured from the start of the corneal incision to the conclusion of the aspiration of the ophthalmic viscosurgical device. All surgeries were recorded using a camera (MKC-704KHD, Ikegami Tsushinki Co., Ltd., Tokyo, Japan), and video images were stored on a hard disk.

2.5. Intraoperative Signs of Zonular Weakness

Zonular weakness was diagnosed if two or more of the following findings are observed during surgery: prominent striated changes in the anterior capsule during continuous curvilinear capsulorrhexis preparation, eccentric displacement of the lens nucleus during phacoemulsification,

difficulty in rotating the lens nucleus, striated changes in the posterior capsule, and difficulty in aspiration during cortical removal [20].

2.6. Data Collection and Statistical Analysis

Patients were carefully followed up on postoperative days 1 and 2 and weeks 1, 3, 7, and Postoperative outcome measurements included BCVA, IOP, CCT, CV, PHC, and CECD at 7 and 19 weeks postoperatively.

Statistical analyses were performed using the Mann–Whitney U test to compare the results obtained from the two groups. The pre- and postoperative BCVA, IOP, CV, PHC, CCT, and CECD values were compared using a paired t-test. The chi-square test was used to determine whether sex-related differences were observed between the PEX and control groups. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Characteristics of the Participants

In this study, we examined 219 eyes of 150 patients with cataract who underwent phacoemulsification and IOL implantation. Table 1 presents patient characteristics and intraoperative parameters. No significant differences were observed between the PEX and control groups in terms of mean age, sex distribution, anterior chamber depth, and lens hardness ($p = 0.40$, $p = 0.93$, $p = 0.49$, and $p = 0.50$, respectively). However, the two groups differed significantly in terms of preoperative pupil size, operative time, phaco time, aspiration time, CDE, and volume of fluid used ($p = 0.03$, $p < 0.01$, $p = 0.01$, $p = 0.01$, $p = 0.02$, and $p < 0.01$, respectively). Glaucoma was detected in 30 eyes in the PEX group.

Table 1. Preoperative characteristics and intraoperative parameters.

Characteristic/Parameter	PEX Group	Control Group	*p*-value
Number of eyes	109	110	
Age (y)	75.7 ± 6.7	75.8 ± 3.3	0.40 [a]
Gender: Men	40 (36.7%)	41 (37.2%)	0.93 [b]
Women	69 (63.3%)	69 (62.8%)	
Glaucoma	30 (27.5%)	0	
Anterior chamber depth (mm)	3.31 ± 0.33	3.26 ± 0.36	0.49 [a]
Preoperative pupil size (mm)	6.2 ± 1.0	6.9 ± 0.5	<0.01 [c]
Lens hardness	2.3 ± 0.3	2.3 ± 0.3	0.50 [a]
Operative time (min)	6.5 ± 3.4	4.5 ± 0.8	<0.01 [c]
Phaco time (s)	16.8 ± 7.2	14.2 ± 3.7	0.01 [c]
Aspiration time (s)	83.8 ± 24.8	63.82 ± 12.3	<0.01 [c]
CDE	6.67 ± 2.66	5.79 ± 1.53	0.02 [c]
Volume of fluid used (mL)	32.9 ± 10.3	25.3 ± 5.4	<0.01 [c]

Values are expressed as mean ± standard deviation or percentages, unless otherwise noted. [a] No significant differences were found between the groups using the Mann–Whitney U test. [b] No significant differences were found between the groups using the chi-square test. [c] Significant differences were found between the groups using the Mann–Whitney U test. PEX, pseudoexfoliation; CDE, cumulative dissipated energy.

3.2. Changes in CECD

Table 2 shows the pre- and postoperative changes in CECD. CECD differed significantly between the PEX and control groups preoperatively ($p = 0.01$). However, no significant differences were observed at 7 and 19 weeks postoperatively ($p = 0.10$ and $p = 0.27$, respectively). Regarding the percentage decrease in CECD, significant differences were observed between the two groups at 7

weeks postoperatively (p = 0.02); however, no significant differences were observed at 19 weeks postoperatively (p = 0.27).

Table 2. Pre- and postoperative CECD values.

Time period	Mean CECD ± SD (% Decrease)		
	PEX group (*n* = 67)	Control group (*n* = 110)	*p*-value
Preoperatively	2579 ± 291	2694 ± 240	0.01 [a]
7 weeks postoperatively	2547 ± 286 [b]	2622 ± 236 [c]	0.10 [d]
% Decrease	1.1 ± 5.1	2.6 ± 2.4	0.02 [a]
19 weeks postoperatively	2563 ± 285 [b]	2655 ± 248 [c]	0.06 [d]
% Decrease	0.5 ± 4.9	1.4 ± 2.1	0.27 [d]

Values are presented as mean ± standard deviation. [a] Significant differences were found between groups using the Mann–Whitney U test. [b] No significant differences were found between the preoperative and respective time values using a paired *t*-test. [c] Significant differences were found between the preoperative and respective time values using a paired *t*-test. [d] No significant differences were found between the groups using the Mann–Whitney U test. CECD, corneal endothelial cell density; SD, standard deviation; PEX, pseudoexfoliation.

3.3. Changes in CCT, CV, and PHC

Table 3 shows the pre- and postoperative changes in CCT, CV, and PHC. No significant differences were observed in CCT preoperatively and at 7 and 19 weeks postoperatively between the PEX and control groups (p = 0.59, p = 0.81, and p = 0.99, respectively). Significant differences were observed in CV at 7 and 19 weeks postoperatively (p < 0.01 and p = 0.01, respectively); however, no significant differences were observed preoperatively (p = 0.07) between the PEX and control groups. Significant differences were observed in PHC between the PEX and control groups at 7 and 19 weeks postoperatively (all p < 0.01); however, no significant differences were observed between the two groups preoperatively (p = 0.17).

Table 3. Pre- and postoperative endothelial CCT, CV, and PHC.

Time period	PEX group (*n* = 82)	Control group (*n* = 110)	*p*-value
CCT	Mean ± SD		
Preoperatively	529 ± 33.4	532 ± 30.2	0.59 [a]
7 weeks postoperatively	537 ± 38.7 [c]	535 ± 27.9 [d]	0.81 [a]
19 weeks postoperatively	532 ± 34.8 [d]	531 ± 29.0 [d]	0.99 [a]
CV	Mean ± SD		
Preoperatively	41.2 ± 7.2	39.5 ± 6.6	0.07 [a]
7 weeks postoperatively	41.1 ± 5.2 [d]	38.8 ± 5.4 [d]	< 0.01 [b]
19 weeks postoperatively	39.7 ± 6.6 [d]	37.2 ± 5.4 [c]	0.01 [b]
PHC	Mean ± SD		
Preoperatively	43.3 ± 8.2	45.3 ± 6.1	0.17 [a]
7 weeks postoperatively	41.3 ± 7.1 [c]	45.8 ± 6.4 [d]	< 0.01 [b]
19 weeks postoperatively	43.5 ± 7.9 [d]	47.7 ± 5.9 [c]	< 0.01 [b]

Values are presented as mean ± standard deviation. [a] No significant differences were found between the groups using the Mann–Whitney U test. [b] Significant differences were found between the groups using the Mann–

Whitney U test. [c] Significant differences between the preoperative and respective time values were found using a paired *t*-test. [d] No significant differences were found between the preoperative and respective time values using a paired *t*-test. CCT, central corneal thickness; CV, coefficient of variation; PHC, percentage of hexagonal cells; PEX, pseudoexfoliation; SD, standard deviation.

3.4. Changes in IOP

Table 4 shows the changes in IOP. No significant differences were observed in the IOP preoperatively or at 7 and 19 weeks postoperatively between the PEX and control groups ($p = 0.15$, $p = 0.20$, and $p = 0.51$, respectively). In the PEX and control groups, significant decreases were observed at 7 and 19 weeks postoperatively (all $p < 0.01$). Regarding the percentage decrease in IOP, no significant differences were observed between the two groups at 7 weeks postoperatively; however, significant differences were observed at 19 weeks postoperatively ($p = 0.72$ and $p = 0.03$, respectively).

Table 4. Mean IOP (mmHg) and mean decrease (%) in the IOP (mmHg) over time.

Time period	Mean IOP ± SD (% Decrease)		
	PEX group (*n* = 107)	Control group (*n* = 110)	*p*-value
Preoperatively	14.6 ± 3.0	14.0 ± 2.1	0.15 [a]
7 weeks postoperatively	12.4 ± 2.8 [b]	11.9 ± 1.6 [b]	0.20 [a]
% Decrease	13.8 ± 17.2	14.4 ± 9.2	0.72 [a]
19 weeks postoperatively	12.4 ± 2.6 [b]	12.5 ± 1.8 [b]	0.51 [a]
% Decrease	13.7 ± 16.4	9.9 ± 10.6	0.03 [c]

Values are presented as mean ± standard deviation. [a] No significant differences were observed between the groups using the Mann–Whitney U test. [b] Significant differences were observed between the preoperative and respective time values using a paired *t*-test. [c] Significant differences were found between the two groups using the Mann–Whitney U test. IOP, intraocular pressure; SD, standard deviation; PEX, pseudoexfoliation.

3.5. Changes in BCVA Over Time

Table 5 shows the changes in the BCVA. No significant differences were observed in BCVA preoperatively and at 7 and 19 weeks postoperatively between the PEX and control groups ($p = 0.20$, $p = 0.09$, and $p = 0.11$, respectively). In the PEX and control groups, BCVA differed significantly between the preoperative period and both at 7 and 19 weeks postoperatively (all $p < 0.01$).

Table 5. Pre- and postoperative best-corrected visual acuity values.

Time period	Best-corrected visual acuity logMAR		
	PEX group (*n* = 87)	Control group (*n* = 110)	*p*-value
Preoperatively	0.110 ± 0.200	0.082 ± 0.108	0.20 [a]
7 weeks postoperatively	-0.058 ± 0.041 [b]	-0.066 ± 0.029 [b]	0.09 [a]
19 weeks postoperatively	-0.060 ± 0.035 [b]	-0.068 ± 0.028 [b]	0.11 [a]

Values represented as mean ± standard deviation. [a] No significant differences were found between the groups using the Mann–Whitney U test. [b] Significant differences were found between preoperative and respective time values using a paired *t*-test. logMAR, logarithmic minimum angle of resolution; PEX, pseudo-exfoliation.

3.6. Complications

No intraoperative complications or capsulorrhexis tears were observed in the PEX and control groups. During surgery, 17 (15.6%) eyes exhibited zonular weakness.

4. Discussion

In this study, the operative times for the PEX and control groups were 6.5 and 4.5 min, respectively. Reportedly, other surgical procedures take between 7.6 and 19.6 min [21,22], demonstrating that the eight-chop technique shortens the operative time. Furthermore, the phaco and aspiration times were minimal, and the CDE was low. The volume of fluid used in other studies ranged from 46 to 139 mL [18,22–24]; however, in this study, 32.9 and 25.3 mL were used in the PEX and control groups, respectively. The eight-chop technique involves mechanically dividing the nucleus into eight pieces before phacoemulsification. This reduces the amount of ultrasonic energy used and enables the efficient removal of fragmented nuclei, leading to shorter phaco and aspiration times, and a reduction in CDE [13–17]. The eight-chop technique is similar to femtosecond laser-assisted cataract surgery in that it divides the lens nucleus without using ultrasonic energy.

Statistically significant differences were observed in phaco time, aspiration time, and volume of fluid used between patients with and without PEX [25,26]. In the PEX group, zonule weakness and insufficient mydriasis created the need for more careful surgery. [25,26]. Significant differences were observed between the PEX and control groups in terms of operative time, phaco time, aspiration time, CDE, and the volume of fluid used. In the PEX group, 17 patients had zonular weakness. In these cases, rotation of the lens nucleus after hydrodissection was difficult, and some eccentric displacement occurred when the Eight-chopper was inserted into the lens nucleus, requiring careful manipulation. In addition, the posterior lens capsule appeared to be aspirated during lens cortex removal, which may have resulted in a longer procedure and an increase in the volume of fluid used. Furthermore, it appears that division of the lens nucleus and phacoemulsification required additional time because of poor mydriasis. In the PEX group, 22 patients required iris retractor hooks because of inadequate pupil dilation.

Research has shown that CECD decreases in PEX eyes compared to non-PEX eyes [22]. In this study, we confirmed that the PEX group showed a significant decrease in preoperative CECD compared to the control group. The reduction rates of CECD after cataract surgery were 9.0–11.4% and 3.4–8.1% in PEX eyes and non-PEX eyes, respectively [22,24], demonstrating a higher rate in PEX eyes. However, in the PEX group, this study showed a decrease of 1.1% and 0.5% at 7 and 19 weeks postoperatively, respectively. The control group showed a decrease of 2.6% and 1.4% at 7 and 19 weeks postoperatively, respectively. The reduction rate in PEX eyes was lower than that in non-PEX eyes. Furthermore, the reduction rates in both groups were extremely low compared with those reported in previous studies. The minimally invasive nature of the eight-chop technique may have suppressed the decrease in CECD due to the fragility of the corneal endothelial cells in PEX eyes. The eight-chop technique is relatively noninvasive, which may be attributed to the minimal ultrasonic energy required and the low volume of fluid used. The flow of fluid during surgery results in reduced loss or damage to corneal endothelial cells. This is consistent with the surgical results reported to date [13–17].

The anterior chamber, where the lens is removed, has limited space, making corneal endothelial cells susceptible to damage from ultrasound energy during surgery [27]. Thus, a decrease in CECD during phacoemulsification is unavoidable. Despite the advantages of phacoemulsification, postoperative CECD reduction remains a significant concern. In addition, assessing CECD reduction helps to compare surgical techniques because it reflects intraoperative damage to the intraocular tissues [28]. Our findings suggest that the eight-chop technique may be advantageous in minimizing surgical invasion of intraocular tissues, including the corneal endothelium, ciliary body, and Schlemm's canal. Considering that modern cataract surgery aims to improve vision and minimize damage to corneal endothelial cells in patients with cataracts complicated by other eye diseases, the eight-chop technique is a very useful surgical approach.

CCT is a clear indicator of corneal endothelial function [29]. Previous studies have reported that the rate of CCT increase in PEX eyes was higher than that in non-PEX eyes at 4 weeks postoperatively, but no significant difference was observed at 12 weeks postoperatively [22]. However, we found no significant difference in CCT between the PEX group and control groups before and after surgery.

CCT differed significantly between the preoperative period and at 7 weeks postoperatively in the PEX group, whereas no significant difference was observed in the control group. This result indicates that corneal endothelial cell function deteriorates in the PEX group at 7 weeks postoperatively, aligning with the findings reported by Hayashi et al [22]. CV indicates the uniformity of endothelial cell size, whereas PHC indicates variability in hexagonal cell shape, and both are hallmarks of healing responses after injury [29]. Previous studies have reported a tendency toward decreased PHC and increased CV in PEX eyes [30], whereas other reports have found no significant differences in PHC and CV between preoperative and postoperative measurements in cataract surgery [24]. This study definitively shows no significant differences in CV and PHC between the PEX and control groups preoperatively. However, significant differences in CV and PHC were observed at 7 and 19 weeks postoperatively. These results indicate that the endothelial repair and healing mechanisms may be impaired in the PEX group postoperatively.

Preoperative IOP was significantly higher in PEX eyes compared to non-PEX eyes [23,31], and IOP decreased by 10.5–30.6% and 2.3–3.9% in PEX and non-PEX eyes postoperatively, respectively [23,31]. Preoperative IOP predicts postoperative IOP reduction [32,33]. In this study, the preoperative IOP was significantly higher in the PEX group than in the control group. Postoperative IOP reduction rates were 13.7% and 9.9%, respectively, at 19 weeks postoperatively. These results are consistent with previous reports, and both groups showed a high rate of IOP reduction. This is likely because the eight-chop technique uses a small amount of fluid, which reduces the impact on the trabecular meshwork cells and Schlemm's canal cells. This maintains the normal function of the trabecular meshwork, resulting in a greater reduction in IOP.

The incidence of complications during PEX eye surgery is high, and the main complications include zonular instability, vitreous loss, poor mydriasis, and lens subluxation [12,18,34–36]. In PEX eyes, the frequency of using a capsular tension ring (CTR) due to zonular weakness was 3.96%, and the frequency of posterior capsule rupture was 5.40%, which are reported to be 30 and 13 times higher than those in non-PEX eyes, respectively [18]. In this study, zonular weakness was observed in 17 out of 107 PEX eyes, but no eyes required CTR due to zonular dialysis. With the eight-chop technique, the combined use of a nucleus sustainer and Lance-chopper allows phacoemulsification without stress on the zonules or posterior capsule, even in cases with a hard lens [13,15]. In the eight-chop technique, an Eight-chopper with a sharp tip is inserted into the lens nucleus and divided without striking the lens nucleus with an ultrasound tip, so only a small amount of force is required to push the lens nucleus. If zonule weakness is detected when inserting the Eight-chopper into the lens nucleus, zonular dialysis is prevented by using a nucleus sustainer along with the Lance-chopper. If the lens nucleus is divided into eight segments, phacoemulsification of the lens nucleus can be performed without a CTR. At this stage of the procedure, the ultrasonic tip is not inserted into the lens nucleus to avoid stress on the zonules or posterior lens capsule. In cases of zonule weakness alone within the continuous curvilinear capsulorrhexis, inserting a CTR did not improve the accuracy of refractive prediction [37]. Therefore, CTR should be used with caution. A shorter interval between cataract surgery and in-the-bag dislocation has been reported in eyes where a CTR was inserted [38–40]. The usefulness of CTR insertion for preventing late IOL dislocations remains unclear [41]. In addition, this study revealed that inserting a three-piece IOL into a capsular bag could be an effective strategy for preventing capsular bag eccentricity.

The prechop technique has the excellent feature of significantly reducing the amount of ultrasonic energy used and surgical trauma to intraocular tissues by mechanically dividing the lens into four segments before phacoemulsification [42]. This feature shares many similarities with the benefits of femtosecond laser-assisted cataract surgery. However, from a medical and economic perspective, it is far superior to femtosecond laser-assisted cataract surgery. Despite the numerous noteworthy features of the prechop technique, it is not widely adopted as a surgical technique because of the inherent challenges associated with operating the prechopper [13,43]. Hence, an enhanced version of the pre-chop technique, known as the eight-chop technique, has been shown to improve operational efficiency [13].

This study has some limitations. First, the surgical outcomes were not directly compared with the prechop technique, phaco-chop technique, or divide-and-conquer technique. This point must be carefully considered when evaluating the current results. However, numerous other studies using the phaco-chop technique or the divide-and-conquer technique have been conducted, and we are confident that our results can be evaluated by comparison with these studies. Second, we did not consider the severity of PEX or the presence of severely weak zonules. The observation period was short (19 weeks postoperatively); therefore, the incidences of pseudophakodonesis, anterior capsule contraction, and IOL decentration could not be evaluated.

5. Conclusions

The eighth-chop technique demonstrated excellent intraoperative parameters for cataracts with PEX, with only a slight decrease in CECD and a reduction in IOP. Other studies have reported a high incidence of intraoperative complications, such as zonular dehiscence and posterior capsule rupture. However, the present study used the eighth-chop technique, and no complications were reported. The eighth-chop technique is effective for zonular weakness and does not require a CTR. Research on the eighth-chop technique for cataracts with PEX will establish personalized treatment strategies and improve cataract management and treatment.

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Sato Eye Clinic (approval number 20140901, approval date: September 1, 2014).

Informed Consent Statement: Informed consent was obtained from all participants for sample collection and subsequent analyses.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author due to privacy and ethical restrictions.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

PEX	Pseudoexfoliation
IOP	Intraocular pressure
CECD	Corneal endothelial cell density
CDE	Cumulative dissipated energy
IOL	Intraocular lens
BCVA	Best-corrected visual acuity
CCT	Central corneal thickness
CV	Coefficient of variation
PHC	Percentage of hexagonal cells
SD	Standard deviation
CTR	Capsular tension ring

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