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RESEARCH

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Retrospective evaluation of changes in choroidal thickness after cataract surgery

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Abstract

In this retrospective study, we investigated the changes in choroidal thickness (CT) using enhanced depth imaging spectral domain–optical coherence tomography (EDI–OCT) and intraocular pressure (IOP) following phacoemulsification. Twenty eyes of 18 patients who underwent phacoemulsification and intraocular lens implantation were included in this study. All patients underwent a detailed ophthalmologic examination. EDI–OCT was used to measure CT preoperatively, and postoperatively at days 3 and 10, and months 1, 3, and 6. CT was measured at the fovea and at points 1.5 mm and 3.0 mm nasal and temporal to the fovea. The data were compared using one-way analysis of variance. The correlation between the changes in the CT and IOP in all sectors was analyzed. There was statistically significant change in IOP after cataract surgery ($P=0.000$). The IOP reached a minimum (10.43 ± 1.64 mmHg) at 6 months postoperatively. Postoperatively CT increased significantly at three sectors: the subfovea ($P=0.019$), 1.5 mm nasal to the fovea ($P=0.003$), and 3 mm nasal to the fovea ($P=0.000$), and gradually thickened over time, reaching a peak (288.87 ± 67.70 µm) at 6 months postoperatively. The CT increase was negatively correlated with the decrease in IOP within 6 months after surgery ($P<0.05$). This study demonstrated that after cataract surgery, the IOP decreased and the choroid thickened, lasting up to 6 months. Studying the changes in CT and IOP after cataract surgery will help deepen the understanding of fundus diseases associated with cataract surgery and will also play a guiding role in solving clinical complications.

Keywords Choroidal thickness, Cataract surgery, Enhanced depth imaging spectral domain–optical coherence tomography, Intraocular pressure

Introduction

Phacoemulsification has become the most commonly used procedure for the treatment of cataracts. Studies have shown that abnormal changes in macular retinal and CT may occur after cataract surgery [1], and lesions of the macula are one of the main causes of poor visual recovery after cataract surgery [2]. CT varies greatly with the degree of blood vessel filling. Abnormal choroidal blood vessels and blood volume can cause many retinochoroidal diseases, such as central serous chorioretinopathy, age-related macular degeneration, and polypoidal choroidal vasculopathy [3, 4]. Therefore, studying changes in CT after cataract surgery will also help to further increase our understanding about the pathogenesis of macular disease, and ultimately improve postoperative vision quality.

In existing clinical studies [5, 6], CT after cataract surgery has only been followed-up for less than 3 months and was found to be thickened. However, the mechanism of change in CT in the 6 months following cataract surgery and the time required for CT to stabilize remain unknown. Therefore, in this study, EDI SD–OCT was used to measure the CT of the fovea and certain adjacent areas within 6 months after cataract surgery to further

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explore the impact of phacoemulsification on CT and provide evidence for the occurrence of clinically related diseases. Moreover, IOP changes following cataract surgery were measured to explore the correlation between changes in CT and IOP.

Materials and methods

General information

This was a retrospective study that enrolled a total of 20 eyes from 18 patients with a mean age of (67.8 ± 5.3) years who underwent phacoemulsification surgery from July 2016 to December 2019 at the Beijing Friendship Hospital. All patients enrolled were evaluated preoperatively. We excluded the patients with cataracts combined with other ocular complications, including glaucoma, retinal vascular disorders, diabetic retinopathy and macular degeneration. Patients with systemic chronic diseases and a history of smoking were excluded. In addition, patients with complications such as intraoperative posterior capsule rupture, persistent postoperative corneal edema, and significant postoperative anterior chamber reaction were excluded. The grade of lens opacities was determined preoperatively using the Lens Opacities Classification System III [7]. Best-corrected visual acuity, slit-lamp examination, fundus exam, IOP, and EDI SD–OCT (Heidelberg, Germany) were performed in all patients preoperatively and 3 days, 10 days, 1 month, 3 months, and 6 months postoperatively. The study was approved by the ethics committee of the Beijing Friendship Hospital (number: 2022-P2-003-01).

Operation method

The operations were performed by the same experienced ophthalmologist using a phacoemulsification machine (Alcon Infiniti, United States). Phacoemulsification surgery was performed via a 3.0 mm clear corneal incision. An intraocular monofocal aspheric lens (Rayner, UK) was implanted; the same type and brand of lens was used in all cases. No complications occurred during the operations. All patients were prescribed postoperative antibiotic and prednisolone acetate eye drops four times daily and tapering by one drop every week for 4 weeks.

EDI SD–OCT examination

CT was defined as the vertical distance between the outer edge of the retinal pigment epithelium and the inner boundary of the sclera [8]. EDI SD–OCT was used to scan the macula and measure the CT at the fovea and at points 1.5 mm and 3 mm nasal and temporal to the fovea, using the system's measuring tools (Fig. 1). The IOP was measured three times with an applanation tonometer, and the mean value was used in the analysis. All examinations and measurements were completed by two physicians, and the results were verified for reproducibility.

Statistical analysis

Version 26.0 IBM SPSS Statistics for Windows (IBM Corp., Armonk, N.Y., USA) software was used for statistical analysis. The research data are expressed as mean ± standard deviation. The differences between preoperative and postoperative data were compared by one-way analysis of variance. The relationship between CT and IOP changes was analyzed using Pearson correlation, and statistical significance was set as $P < 0.05$.

Results

For this study, we enrolled a total of 20 eyes from 18 patients (7 men, 11 women) with a mean age ± standard deviation of 71.36 ± 8.23 years (range, 65–85 years).

Changes in IOP before and after cataract surgery

Pairwise comparison results of preoperative and postoperative IOP showed a gradual decrease (Fig. 2), and the

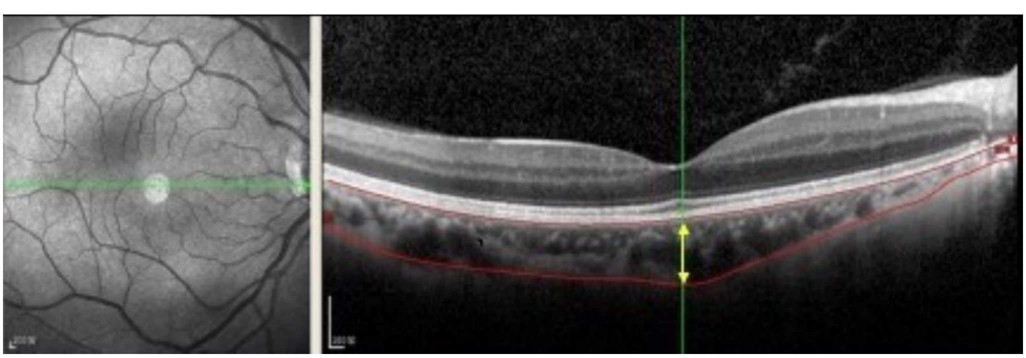

Fig. 1 Length of the yellow double-headed arrow is the CT at the fovea

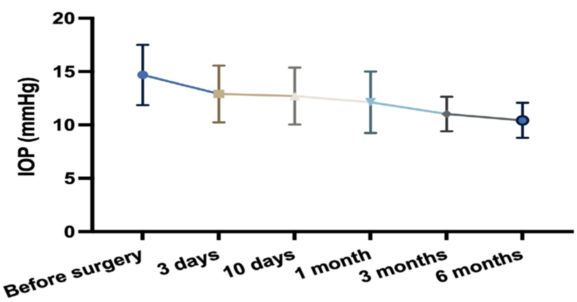

Fig. 2 IOP showed a gradual decrease following cataract surgery

difference in IOP between the two groups was statistically significant (P< 0.05) (Table 1).

Changes in CT following cataract surgery

Pairwise comparison of the preoperative and postoperative CT showed a gradual increase (Fig. 3). The CT at the subfoveal, 1.5 mm and 3.0 mm nasal to the fovea, had statistically significant differences at different timepoints (P< 0.05) (Table 2).

Correlation between decrease in IOP and change in CT at different timepoints after surgery

Within 6 months after cataract surgery, the increase in CT at all regions measured by EDI SD–OCT was negatively correlated with the decrease in IOP (P< 0.05), as shown in Table 3 and Fig. 4; meanwhile, there were no statistically significant changes in CT and IOP within the first postoperative month (P> 0.05).

Discussion

The results of this study show that IOP gradually decreased for 6 months after cataract surgery, reaching the lowest value at the end of this period. Handzel et al. [9] have found that corneal thickening can occur in the short term after cataract surgery. Although corneal thickening can lead to high IOP measurements, the multiple factors that cause IOP to drop are much greater than the effect of corneal thickness on IOP. This may be related to the removal of the compression on Schlemm's canal, and the trabecular meshwork caused by the cataractous lens. In addition, the use of viscoelastic agents and continuous infusion of fluid into the anterior chamber during the operation plays a role in opening the anterior chamber angle, thereby deepening the anterior chamber after the operation and causing a trend toward a further decrease in IOP. As early as 1945, a study [10] had proposed the theory that cataract surgery would cause a drop in IOP. Cataract surgery can also reduce the secretory function of the ciliary body, an increase in the release of endogenous prostaglandins, and changes in the postoperative blood–aqueous barrier function, all of which can lead to a decrease in postoperative IOP [11]. From this study, it is evident that the gradual decrease in IOP after cataract surgery is statistically significant (P< 0.05).

Table 1 Comparison of intraocular pressure

Time after surgery	IOP (mmHg)	*F*	*P*
Before surgery	14.69 ± 2.83	5.722	**0.000**
3 days	12.90 ± 2.66		
10 days	12.71 ± 2.66		
1 month	12.13 ± 2.89		
3 months	11.03 ± 1.62		
6 months	10.43 ± 1.64		

Values are presented as mean ± standard deviation

IOP, intraocular pressure

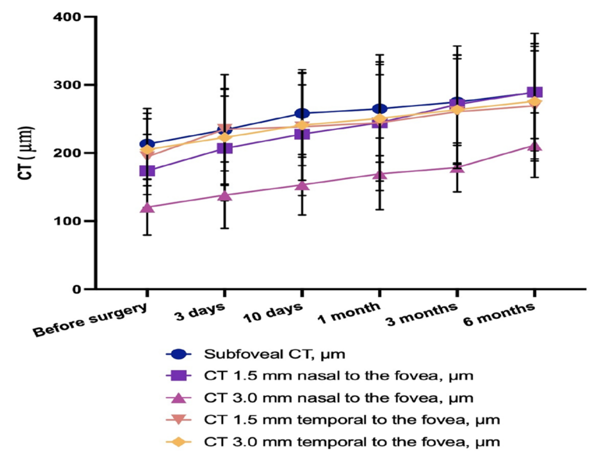

Fig. 3 CT showed a gradual increase following cataract surgery

In this study, statistically significant changes were observed in CT after cataract surgery. The CT increased gradually starting 3 days after surgery and peaked 6 months postoperatively. However, the increase in CT varied among the anatomical regions measured. The mechanism of and factors influencing the changes in CT after cataract surgery remain unclear [12]. Clinical studies have shown that the CT of the macular fovea preoperatively and postoperatively are significantly correlated with each other, while the changes in CT are not significantly correlated with age, axial length, or surgery duration [13]. We speculate that surgical mechanical damage and ultrasound energy cause the release of a large amount of inflammatory mediators, which destroy the blood–retinal barrier, leading to increased vascular permeability, and ultimately, to choroidal thickening. Research [14] has found that femtosecond laser-assisted cataract surgery has less impact on choroidal function than traditional surgery. It also showed that reducing

Table 2 Choroidal thickness measurements before and after cataract surgery

	Subfoveal CT, µm	CT 1.5 mm nasal to the fovea, µm	CT 3.0 mm nasal to the fovea, µm	CT 1.5 mm temporal to the fovea, µm	CT 3.0 mm temporal to the fovea, µm
Before surgery	213.20 ± 52.10	173.87 ± 53.56	120.67 ± 41.06	194.53 ± 55.59	205.07 ± 53.18
3 days after surgery	234.07 ± 60.37	206.80 ± 76.73	138.20 ± 48.67	234.73 ± 80.59	222.93 ± 70.49
10 days after surgery	258.13 ± 64.23	227.80 ± 90.21	153.33 ± 44.40	238.53 ± 78.59	240.87 ± 59.23
1 month after surgery	264.93 ± 68.96	244.53 ± 99.67	169.40 ± 52.52	244.47 ± 85.50	250.80 ± 64.26
3 months after surgery	274.87 ± 63.54	271.27 ± 85.90	178.80 ± 35.89	260.67 ± 83.27	263.67 ± 80.13
6 months after surgery	288.87 ± 67.70	289.53 ± 86.07	211.47 ± 47.31	269.20 ± 80.89	276.00 ± 84.60
F	2.891	3.876	7.506	1.672	2.124
P	**0.019**	**0.003**	**0.000**	0.150	0.070

Values are presented as mean ± standard deviation

CT, choroidal thickness

Table 3 Correlation between changes in intraocular pressure and choroidal thickness within 6 months following cataract surgery

	Change in IOP	
	r	*P*
Subfoveal CT	− 0.965	**0.002**
CT 1.5 mm nasal to the foveal	− 0.989	**0.000**
CT 3.0 mm nasal to the foveal	− 0.959	**0.003**
CT 1.5 mm temporal to the foveal	− 0.987	**0.000**
CT 3.0 mm temporal to the foveal	− 0.983	**0.000**

CT, choroidal thickness; IOP, intraocular pressure

mechanical manipulations during surgery can reduce the release of inflammatory factors and prostaglandins, thereby reducing damage to the blood–retinal barrier [14]. Under normal circumstances, the inflammatory response after cataract surgery lasts for about 1 month [15], but the results from this study showed that the CT gradually increased for 6 months after cataract surgery, demonstrating that there are other factors that affect the changes in CT. Some scholars believe that the expression of specific genes after cataract surgery can also cause changes in choroidal function. Related animal experiments have shown that extracapsular lens removal can cause a significant increase in the gene expression of vascular endothelial growth factor and fibroblast growth factor in the choroid. Thus, the permeability of the choroidal capillaries increases, which leads to thickening of the choroid [16]. The existing clinical studies [6, 17, 18] have shown a significant increase in SFCT after cataract surgery, which is the same as the results of the present study. Although the peaks of postoperative changes in SFCT were not exactly the same in all studies [19], postoperative increases in SFCT were observed over a longer period of time. It is worth noting that most of the studies only examined changes in CT at 3 months after cataract surgery, and the follow-up period was limited. In the present study, CT did not return to preoperative levels after 6 months of follow-up.

By statistically analyzing the relationship between the changes in CT at different anatomical regions after cataract surgery and with the decrease in IOP, we found that within 6 months after the operation, the increase in CT at the five measurement regions and the decrease in IOP were significantly negatively correlated. However, within 1 month after surgery, the changes in CT and IOP were not statistically significant. It is speculated that the

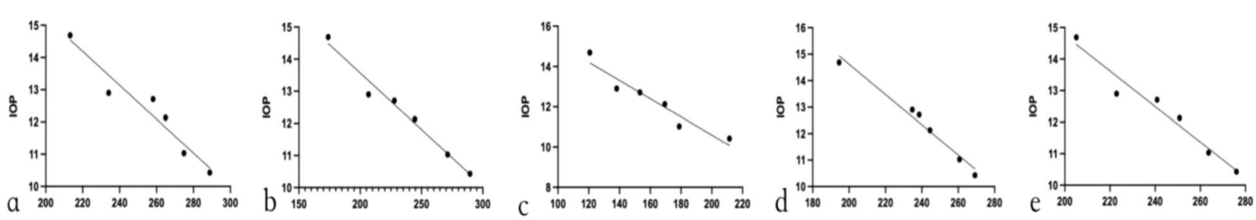

Fig. 4 Increase in CT was negatively correlated with a decrease in IOP. **a** SFCT and IOP; **b** CT 1.5 mm nasal to the foveal and IOP; **c** CT 3.0 mm nasal to the foveal and IOP; **d** CT 1.5 mm temporal to the foveal and IOP; **e** CT 3.0 mm temporal to the foveal and IOP. CT, choroidal thickness; SFCT, subfoveal choroidal thickness; IOP, intraocular pressure

increase in macular foveal CT at 3 months and 6 months after cataract surgery may be related to the increase in ocular perfusion pressure caused by the drop in IOP after cataract surgery. Various factors, including the increase of intraocular inflammatory mediators and prostaglandins, and the use of local drugs within a month after surgery, may influence the IOP and choroidal capillary blood flow; therefore, there is no statistical relationship between the changes in CT and IOP within a month after surgery. The study by Ohsugi et al. [20] showed that the changes in the SFCT and IOP after cataract surgery were significantly negatively correlated. Many studies have shown that the increase in macular CT is significantly related to ocular perfusion pressure [21–23], and the measurement of CT in the macular area may indirectly indicate the perfusion state of the blood vessels in the macular area. Therefore, studying the changes in CT after cataract surgery will also play a role in the diagnosis and treatment of macular diseases.

However, there were several limitations of this study. First, it is a single center study, which was designed retrospectively with relatively small sample size. Second, CT is a variable parameter and changes in thickness at specific sites. It does not reflect changes in the entire choroid. In addition, we still need to add more parameters to the study such as choroidal vascular index which will provide more valuable information to the literature.

Conclusions

Statistical analysis of changes in CT evaluated by EDI SD–OCT and IOP after cataract surgery via phacoemulsification will help deepen the understanding of the mechanism of fundus complications after cataract surgery. Meanwhile, CT measurement can predict the occurrence and development of postoperative complications, which is a guide for resolving postoperative complications and restoring postoperative visual function. In existing clinical studies, the postoperative follow-up time is generally less than 3 months. In this study, we followed all patients for up to 6 months after surgery and found that CT had still not stabilized. Our data clearly showed the trends in CT changes within 6 months after cataract surgery. This parameter can be used to evaluate the relationship between cataract surgery and diseases involving the choroid. This study is also noteworthy for being the population-based study. In future research, we will expand the sample size, extend the follow-up time, add more variables or control groups, and conduct further research and analysis on the changes in CT after cataract surgery.

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Author contribution
Wu Weizhen is responsible for writing original draft and review & editing. Songguo LI, Xiaolei Zhang, Luping Wang are responsible for formal analysis and data curation. Hongbin Wang is responsible for the conceptualization and Methodology.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval
The study was approved by the ethics committee of the Beijing Friendship Hospital, who waived the requirement for informed consent in consideration of the retrospective nature of the study. Ethics number: 2022-P2-003-01. We confirm that all methods were performed in accordance with the relevant guidelines.

Competing interests
The authors declare no competing interests.

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