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ORIGINAL ARTICLE

Evaluation of central macular thickness and ganglion cell complex analysis following uncomplicated phacoemulsification surgery

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ABSTRACT

Objective: To evaluate the changes in central macular thickness (CMT) and macular ganglion cell complex (GCC) thickness measured by optical coherence tomography (OCT) before and after uncomplicated phacoemulsification cataract surgery.

Material and Methods: This retrospective study included 40 eyes from 33 patients who underwent uncomplicated phacoemulsification at Istanbul Education and Research Hospital Eye Clinic over a nine-month period. Eyes were further categorized based on cataract morphology. Best corrected visual acuity (BCVA), CMT, GCC thickness, and OCT image quality were recorded preoperatively and postoperatively at day 1, week 1, month 1, and month 3.

Results: The mean age of the patients was 66.7±10.3 years. The mean preoperative CMT was 209.59±25.14 µm. Postoperative CMT values were 220.54±27.20 µm (day 1), 226.26±28.01 µm (week 1), 244.56±23.57 µm (month 1), and 240.29±21.78 µm (month 3). Preoperative mean GCC thickness was 89.78±5.42 µm, while postoperative values were 96.03±6.67 µm (day 1), 101.60±9.22 µm (month 1), and 102.83±8.22 µm (month 3). Statistically significant increases in CMT, GCC thickness, and OCT image quality were observed at all postoperative time points compared to preoperative measurements ($p<0.001$).

Conclusion: OCT is a valuable tool for detecting and monitoring morphological changes and macular edema following cataract surgery. Postoperatively, improved OCT image quality enables more reliable measurements of CMT and GCC thickness.

Keywords: Central macular thickness, ganglion cell complex thickness, optical coherence tomography, phacoemulsification.

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INTRODUCTION

Age-related cataracts remain the leading cause of visual impairment worldwide. Of the estimated 35–40 million individuals who are blind globally, nearly half of these cases are attributed to cataracts.[1,2] Phacoemulsification combined with intraocular lens (IOL) implantation is currently the most effective surgical treatment.[3] Despite advances in surgical techniques, cystoid macular edema (CME) can still occur following uncomplicated cataract surgery and may hinder optimal visual recovery.[4] The incidence of CME has significantly decreased—from 5–10% in earlier techniques such as intracapsular cataract extraction to approximately 1% in healthy eyes undergoing modern, uncomplicated procedures.[5,6]

Pseudophakic CME, also known as Irvine-Gass syndrome, is primarily caused by disruption of the blood-aqueous barrier, which leads to the release of inflammatory mediators and the accumulation of fluid in the fovea.[7] Surgical trauma may further contribute to the development of CME by inducing perifoveal capillary leakage, increasing prostaglandin levels, and compromising the integrity of the blood-retinal barrier.[8]

Optical coherence tomography (OCT) is a widely used, non-invasive imaging modality for assessing macular changes following intraocular surgeries. OCT generates high-resolution, cross-sectional tomographic images of the retina and optic nerve using light at a wavelength of approximately 800 nm.[9,10] It allows for detailed visualization of retinal layers and provides quantitative measurements of central macular thickness (CMT), ganglion cell complex (GCC) thickness, and retinal nerve fiber layer (RNFL) thickness.[11]

MATERIAL AND METHODS

This retrospective, observational clinical study included 40 eyes from 33 patients who underwent uncomplicated phacoemulsification surgery at the Istanbul Education and Research Hospital Eye Clinic over a period of nine consecutive months. Patients with ocular conditions that could result in secondary cataract—such as corneal pathologies, uveitis, glaucoma, diabetic retinopathy, or hypertensive retinopathy—were excluded. Additionally, patients with ocular or systemic diseases associated with a risk of cystoid macular edema, or those with a history of systemic medication use known to have ocular side effects, were not included.

Preoperative demographic data, including age, sex, and the operated eye, were recorded for all participants. Best-corrected visual acuity (BCVA) was measured preoperatively and postoperatively using the Snellen chart and converted to logMAR values for analysis. A comprehensive ophthalmologic examination was performed on all patients prior to surgery, including slit-lamp biomicroscopy of the anterior segment. The cataract type—categorized as nuclear, nucleocortical, posterior subcapsular, or cortical—was noted for each patient.

All eyes were pharmacologically dilated using 2.5% phenylephrine (Mydfrin, Alcon, Switzerland) and 0.5% tropicamide (Tropamid, Bilim, Türkiye) eye drops. A detailed fundus examination was then conducted using indirect ophthalmoscopy with a +90 diopter lens. Preoperative and postoperative keratometric measurements and refractive assessments for BCVA were performed using the KR-7000P™ autorefractometer (Topcon, Japan).

Table 1: Distribution of descriptive characteristics and cataract type

	n	%
Age, Mean±SD (years)	33	66.7±10.3
Gender		
Male	23	70
Female	10	30
Eye		
Right	21	52
Left	19	47
Cataract type		
Nucleocortical	15	37.5
Nuclear	12	30
Posterior subcapsuler	8	20
Cortical	5	12.5

SD: Standard deviation.

Central macular thickness (CMT) and ganglion cell complex (GCC) measurements were obtained using optical coherence tomography (OCT) (TOPCON 3D OCT-2000FA Plus, Ver. 8.11, Japan). Imaging was conducted by the same physician during both preoperative and postoperative evaluations, following pupil dilation with 0.5% tropicamide. The Image Quality Factor (QF), provided by the Topcon OCT system, was used to ensure scan quality; a QF value of 45 or higher was considered adequate for analysis.

Ethical approval for the study was obtained from the Ethics Committee of Istanbul Education and Research Hospital (Date: September 4, 2015; Approval No: 706). All participants were thoroughly informed about the potential intraoperative and postoperative risks associated with cataract surgery, and written informed consent was obtained. The study adhered to the principles outlined in the Declaration of Helsinki.

Statistical Analysis

Statistical analysis was performed using SPSS software, version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables with a normal distribution—such as age, central macular thickness (CMT), and ganglion cell complex (GCC) thickness—were expressed as mean±standard deviation, while non-normally distributed variables, such as best-corrected visual acuity (BCVA), were presented as median values.

The normality of the data was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests, along with visual inspection of histograms and probability plots. Paired-sample t-tests were used to compare preoperative and postoperative measurements for normally distributed variables, whereas the Wilcoxon signed-rank test was used for non-normally distributed data. Differences between subgroups based on cataract type were analyzed using the Kruskal-Wallis test.

Table 2: Comparison of central macular thickness and best corrected visual acuity values according to preoperative values

	CMT (μm)	Average difference in CMT in accordance with preoperative CMT (μm)	BCVA (logMAR) Median (min–max)	p
Preoperative	209.15±25.61		0.5 (0.4–0.7)	
Postoperative 1st day	219.85±27.23	10.70±10.67	0.2 (0.1–0.52)	<0.001
Postoperative 1st week	226.78±27.84	17.62±18.72	0.1 (0–0.52)	<0.001
Postoperative 1st month	247.10±37.18	37.95±44.01	0 (0–0.40)	<0.001
Postoperative 3rd month	243.15±29.14	34.00±27.95	0 (0–0.40)	<0.001

CMT: Central macular thickness; BCVA: Best corrected visual acuity.

Table 3: Comparison of macular ganglion cell complex thickness and macular ganglion cell complex OCT measurement quality factor values

	Macular GCC- OCT quality factor value	Superior Macular GCC (μm)	Inferior Macular GCC (μm)	Total Macula GCC (μm)	p
Preoperative	47.72±4.92	89.03±5.65	90.91±5.84	89.78±5.42	
Postoperative 1st day	62.44±4.30	95.10±6.60	97.08±6.95	96.03±6.67	<0.001
Postoperative 1st week	64.96±4.05	97.88±7.76	99.70±7.85	98.85±7.70	<0.001
Postoperative 1st month	66.05±4.48	101.80±8.43	102.235±9.50	101.60±9.22	<0.001
Postoperative 3rd month	66.60±3.20	101.05±7.85	104.03±8.16	102.83±8.22	<0.001

GCC: Ganglion cell complex; OCT: Optical coherence tomography.

A 95% confidence interval was used for all statistical tests, and a p-value of<0.05 was considered statistically significant.

RESULTS

Forty eyes of 33 patients, 23 (70%) male and 10 (30%) female, diagnosed with senile cataract were included in the study. Patient characteristics are given in Table 1.

Mean change in CMT in OCT preoperatively and after uncomplicated cataract surgery is presented in Table 2. There were statistically significant differences between pre- and postoperative values of CMT and BCVA (p<0.001, p<0.001; respectively). BCVA improved following surgery from the first day toward the 3-month control. Although there was a statistically significant increase in CMT starting from the postoperative first day, the most prominent increase was detected at the postoperative first-month visit. There was a statistically significant difference in postoperative first-day CMT compared to values at postoperative first week, first month, and third month (Table 2).

There was a statistically significant difference between the preoperative and postoperative 1st day, 1st week, 1st month, and 3rd month measurements of superior, inferior, and total macular ganglion cell complex thickness and the quality value (p<0.001). Although the increase in superior, inferior, and total macular ganglion cell complex thickness started on postoperative 1st day, the most significant increase was detected in the measurements performed at postoperative 3rd month (Table 3).

Table 4: Comparison of the percentage difference of OCT measurement values in preoperative period and postoperative 3rd month according to cataract morphology

Differences between groups according to cataract type	p*
BCVA percentage	0.268
CMT percentage	0.848
Total macular GCC percentage	0.941
CMT image quality factor percentage	0.752
Macular GCC image quality factor percentage	0.641

*: Kruskal Wallis Analysis; BCVA: Best corrected visual acuity; CMT: Central macular thickness; GCC: Ganglion cell complex; OCT: Optical coherence tomography.

There was no statistically significant difference between cataract subtype groups in terms of BCVA, CMT, and macular GCC thickness measurements preoperatively and at the postoperative 3rd month. In addition, the image quality factor did not change at postoperative 3rd month when compared to preoperative values (Table 4).

Among the patients included in the study, clinically significant CME was detected in 1 (2.5%) patient at postoperative 1st month. In the postoperative 1st month, cystoid changes and a significant

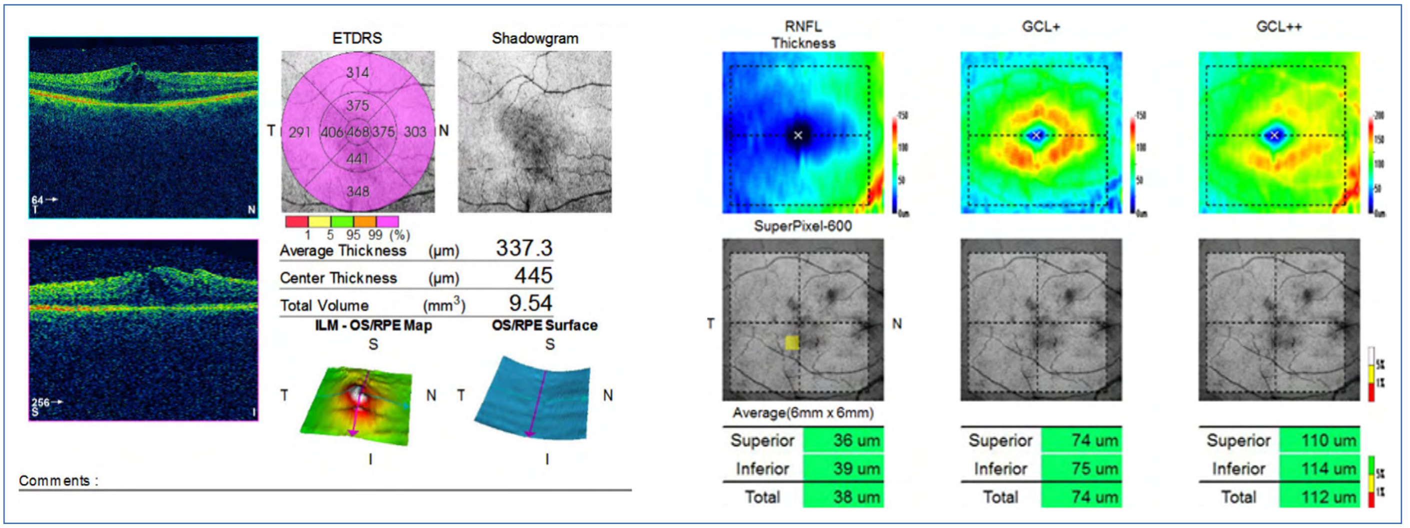

Figure 1: Postoperative 1st month Optical coherence tomography image of the patient who developed Cystoid macular edema.

increase in the thickness of the central macula were detected in this patient. Preoperative and postoperative 1st month CMT were 162μm and 445μm, respectively (Fig. 1). BCVA on postoperative 1st day and 1st week was 0.3 (logMAR), while it was 0.52 (logMAR) at the postoperative 1st month control. 0.1% Nepafenac drops 4x1 were started, and the CMT decreased to 235μm in the 3rd month follow-up. The medication was stopped upon improvement of CME. After the treatment, CME regressed, and at the postoperative 3rd month follow-up, the BCVA improved to 0 (logMAR).

DISCUSSION

In our study, an increase in macular thickness was observed from the first postoperative day to the third month following uncomplicated phacoemulsification, as measured by OCT. While early increases in macular thickness (first day and first week) did not correlate with best-corrected visual acuity (BCVA), a positive correlation was found between macular thickness and visual acuity at the first and third postoperative months. Cystoid macular edema (CME) was diagnosed in two patients, both of whom experienced a decrease in visual acuity.

Von Jagow et al.[12] evaluated postoperative macular thickness using OCT in 33 patients without preexisting macular pathology who underwent uncomplicated phacoemulsification in one eye, with the fellow eye serving as a control. They reported a moderate, statistically significant increase in central macular thickness (CMT) on postoperative day one, week one, and week six compared to the control group. No patients developed CME, and no significant correlation was observed between CMT and visual acuity. The authors suggested that this moderate thickening could be attributed to subclinical changes or the resolution of media opacity following surgery.

In contrast, we detected CME in 2 eyes (5.0%)—one at postoperative month one and the other at month three. The CMT values in these patients were 445μm and 367μm, respectively. Among patients without CME, the average increase in CMT was 31μm at one month and 29μm at three months postoperatively. Although cataract surgery generally leads to improved visual acuity, CME can hinder this improvement. It has been reported that an increase in macular thickness on OCT is not always associated with a decline in visual acuity. For example, Bélair et al.[13] studied 52 eyes from 47 patients without ocular or systemic diseases and found a 304μm increase in two eyes at week four postoperatively. In those without CME, the mean increase was only 9μm. Similarly, Kim et al.[14] found that even an 80μm increase in CMT did not result in reduced visual acuity in their analysis of 130 patients.

These findings support the idea that OCT can detect moderate subclinical macular edema and minimal retinal thickening, even up to six months postoperatively.[15] In the study by Dabas et al.,[16] CMT peaked at six weeks post-surgery and returned to near-normal levels by the twelfth week. A significant correlation was also found between preoperative CMT and measurements at weeks one, six, and twelve. In another study, Yazici et al.[17] observed no significant difference in mean macular thickness between preoperative and postoperative measurements on the first day, first week, and sixth month, although a statistically significant difference was found between months one and three. Dad et al.[18] also reported a postoperative increase in macular thickness but noted continuous improvement in BCVA, with no associated visual decline.

CME remains one of the most important complications of cataract surgery and is classically known as Irvine-Gass syndrome.[19] Surgical trauma may cause excessive prostaglandin release, leading to CME. Additional contributing factors include anterior segment ischemia, increased oxidative stress due to elevated light exposure during surgery, and disruption of the blood-retinal barrier. Mechanical traction from vitreoretinal adhesion and accumulation of prostaglandins in the aqueous humor—penetrating the vitreous and increasing macular vascular permeability—can also result in extracellular fluid accumulation. Notably, CME has been observed even in eyes without posterior vitreous detachment or mechanical traction, further supporting the inflammatory pathway theory.[20,21]

Cataract, as a common cause of media opacity, can reduce image quality in imaging modalities such as OCT, potentially affecting measurement accuracy.[22] It is widely accepted that cataract impairs the acquisition of retinal nerve fiber layer (RNFL) images by lowering image quality.[23] However, the degree of this effect appears to vary depending on the cataract type.[24,25] Savini et al.[26] reported that posterior subcapsular cataracts had the greatest impact on OCT signal quality, while Kim et al.[22] found cortical cataracts to have the most significant effect. El-Ashry et al.[24] showed that cortical cataracts most strongly affected RNFL measurements, followed by posterior subcapsular and then nuclear cataracts. Lee et al.[27] reported similar findings.

In our study, all cataract subtypes demonstrated a significant postoperative increase in superior, inferior, and total macular GCC thickness, as well as in OCT image quality factor (QF). However, no significant differences were found between the cataract types in terms of GCC or QF changes. Bambo et al.[28] observed statistically significant increases in RNFL and CMT values one month after uncomplicated cataract surgery, using both time-domain and spectral-domain OCT ($p<0.05$). As cataract reduces signal strength and measurement reproducibility in OCT, improved image quality following surgery likely contributed to the postoperative increases we observed in GCC values.[29]

Although our findings are promising, this study is limited by a relatively small sample size, short follow-up duration, and a limited number of follow-up assessments, restricting our ability to assess long-term changes. Larger-scale studies with extended follow-up periods are needed to better understand the effects of cataract type on CMT and GCC measurements. We believe that future clinical trials incorporating advanced diagnostic technologies will be critical not only for early detection and monitoring of CME but also for clarifying its underlying pathophysiological mechanisms following uncomplicated cataract surgery.

CONCLUSION

Our findings indicate that macular edema can develop even after uncomplicated cataract surgery. Cataract removal significantly enhances OCT image quality, allowing for more accurate measurements of macular GCC and CMT. Therefore, when interpreting OCT results in elderly patients with clinically significant cataracts, it is important to consider that cataract-related media opacity may affect the reliability of these measurements.

Statement

Ethics Committee Approval: The Istanbul Training and Research Hospital Clinical Research Ethics Committee granted approval for this study (date: 04.09.2015, number: 706).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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