e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com doi: 10.25258/ijpqa.16.10.34

International Journal of Pharmaceutical Quality Assurance 2025; 16(10); 209-213

Original Research Article

Analysis of Macular Thickness Variations after Cataract Surgery with OCT

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Received: 12-09-2025 / Revised: 08-10-2025 / Accepted: 28-10-2025
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Conflict of interest: Nil

Abstract:

Background: Cataract is the most common reversible cause of blindness worldwide, with phacoemulsification and intraocular lens implantation being the gold standard treatment. Postoperative changes in the retina, especially those that are assessed in terms of changes in the macular thickness, may affect visual recovery, so it is important to assess these changes clinically.

Aim: To assess the impact on macular thickness following uncomplicated cataract surgery using Optical Coherence Tomography (OCT).

Methodology: This prospective as interventional study consists of 80 eyes of 80 patients who were undergoing routine phacoemulsification in the Regional Institute of Ophthalmology (RIO), IGIMS, Patna, India. Retinal and choroidal thickness was assessed by spectral-domain OCT before cataract surgery, then at 1 week postoperatively and at 1 month postoperatively. All patients received standard anti-inflammatory treatment in the postoperative period. Statistical analysis involved paired t-tests where $p < 0.05$ was considered significant.

Results: Retinal thickness increased significantly from 305.12 ± 16.21 µm preoperatively to 308.89 ± 16.75 µm at week 1 ($p = 0.012$) and 313.79 ± 17.02 µm at 1 month ($p < 0.001$), indicating progressive postoperative thickening. Choroidal thickness remained largely unchanged (240.35 ± 80.42 µm preoperatively vs. 231.47 ± 81.12 µm at 1 month, $p = 0.42$). Vertical scan measurements also disclosed a similar pattern. These changes represent mild postoperative inflammation and transient disruption of the blood-retinal barrier without progression to clinically significant macular edema.

Conclusion: It can be concluded that uncomplicated phacoemulsification results in measurable retinal thickening within the first month with stability in choroidal thickness. Non-invasive OCT facilitates the detection of early postoperative changes in the retina and helps in the proper management of postoperative conditions.

Keywords: Cataract, Phacoemulsification, Macular Thickness, Optical Coherence Tomography, Retinal Changes, Postoperative Inflammation.

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Introduction

Cataract remains one of the most prevalent forms of reversible blindness throughout the world and the most prevalent reason for eye surgery. Cataract is characterized by the progressive opacification of the crystalline lens that results in gradual visual decline. With the development of microsurgical techniques, cataract extraction, and especially phacoemulsification cataract surgery and intraocular lens (IOL) insertion, has become a very successful surgery, restoring great visual results in most patients. However, sometimes complications can still happen even with a seemingly uncomplicated postoperative course. Recently, there has been more recognition of subtle changes in macular morphology and thickness as postoperative consequences given the potential effect on vision [1].

The macula, essential for centre vision and high-resolution visual activities, is especially susceptible to surgical damage and postoperative inflammation. Even subtle subclinical changes in macular thickness may affect visual quality. After cataract surgery, an inflammatory cascade may occur and is exacerbated by the breakdown of the blood-retinal barrier, causing vascular permeability to increase and fluid to accumulate in the macula [2]. Subclinical macular edema may occur in mild, asymptomatic forms, but when it grows more pronounced and symptomatic, this is referred to as cystoid macular

edema (CME), which is well established as the reason for delayed visual recovery.

In the past few years, advances in the imaging of the retina have improved our ability to assess these minute structural changes accurately and without invasion. Optical Coherence Tomography (OCT) has become an integral diagnostic tool to ophthalmology, producing high-resolution images of the retina layers in cross-section. OCT provides a way to quantitatively measure macular thickness and visualize early macular changes that may not be evident on slit-lamp bio microscopy or fundus examination [3]. Thus, technology has become irreplaceable in the evaluation of retinal integrity pre and post cataract surgery.

Multiple studies have shown that there is a very mild, intermittent increase in central macular thickness following an uncomplicated phacoemulsification. Generally, these findings are self-limiting, resolving over a few weeks to months. However, knowing the pattern and timing of macular changes is important to identify normal postoperative inflammatory response versus pathological edema warranting treatment [4]. An early identification of macular changes may help the clinicians to inform therapeutic doses of anti-inflammatory treatment, especially in high-risk populations, such as diabetic patients or patients already with retinal disease.

There are different possible causes for thickening of the macula after cataract surgery that can be seen as part of the same process. The surgical manipulation of the eye with a phacoemulsification hand piece, ultrasonic energy transfer, and light exposure in the eye can cause mild trauma to intraocular tissues. As a result of these stimulations, vascular endothelial growth factors, cytokines, and prostaglandins are released, which in turn increases the permeability of perifoveal capillaries [5]. Biochemical changes are typically limited in duration, but chronic, or exaggerated, inflammatory responses may result in cystoid changes that affect visual recovery after surgery.

OCT-based evaluation has several benefits over traditional imaging techniques like fluorescein angiography. It is non-invasive, repeatable, and provides objective quantitative data about retinal thickness in different macular regions. Monitoring change over time extends the utility for postoperative follow up and may allow for a more efficient time frame for treating the patient [6]. Advances in technology, such as SD-OCT and SS-OCT allow for better image resolution and scanning speeds and provided more detailed analysis of the microstructure of the retina.

Considering the clinical importance of measurement of change to the macula during the postoperative phase, systematic monitoring of change is important. Measurement of macular thickness at various time points after cataract surgery will provide greater understanding of the time course of retinal recovery and may also lead to refinement of our perioperative management protocol, in particular use of topical steroids and/or NSAIDs to mitigate postoperative inflammation, which may be associated with the best visual recovery [7].

Therefore, using optical coherence tomography, this study will examine variations in macular thickness following successful cataract surgery. This will clinically assess the retinal changes over time and help provide an all-encompassing understanding of the subclinical inflammatory response because of cataract extraction that affects postoperative recovery. In summary, this study may enable clinicians to make more proper evaluations of the visual prognosis and form the basis of evidence-based approaches for postoperative monitoring and assessment by means of OCT.

Methodology

Study Design: This is a prospective interventional case series study that was conducted using OCT to evaluate variations in macular thickness after cataract surgery. The study aimed to assess the postoperative variations in the thickness of the retina and choroid at varied time intervals to understand the structural changes that occur after phacoemulsification.

Study Area: The research was conducted at the Regional Institute of Ophthalmology (RIO), Department of the Indira Gandhi Institute of Medical Sciences in Patna, Bihar, India for 12 months.

Study Participants

Inclusion Criteria

- Patients diagnosed with age-related uncomplicated cataract.
- Individuals scheduled for routine phacoemulsification surgery with posterior chamber intraocular lens implantation.
- Patients providing informed written consent for participation.
- Eyes exhibiting transparent ocular media, facilitating high-quality OCT imaging.

Exclusion Criteria

- Patients with existing ocular conditions like diabetic retinopathy, macular degeneration, retinal diseases and glaucoma.
- Previous history of trauma or ocular surgery.
- High refractive errors (> ±6 diopters).
- Systemic diseases affecting retinal microvasculature, such as diabetes mellitus or hypertension.
- Intraoperative or postoperative complications.

Sample Size: A total of 80 eyes of 80 patients fulfilling the inclusion and exclusion criteria were included in the study.

Procedure: After obtaining institutional ethical clearance and informed consent from all participants, each subject underwent a comprehensive preoperative ophthalmic examination. This included best-corrected visual acuity assessment, slit-lamp bio microscopy, intraocular pressure measurement using Goldmann applanation tonometry, and fundus evaluation to exclude other ocular pathologies. Preoperative macular imaging was performed using Spectral-Domain Optical Coherence Tomography (SD-OCT, Spectral is Heidelberg Engineering, Germany). Using the fovea as the center, horizontal and vertical macular scans were obtained, each averaged 100 times, along with a peripapillary circular scan for retinal nerve fiber layer (RNFL) evaluation. These scans were stored as baseline data and were used for exact positional reference during follow-up imaging using the "follow-up" function of the Spectral is system.

Each patient had a posterior chamber acrylic intraocular lens implanted in the capsular bag following routine phacoemulsification cataract surgery. There were no reported intraoperative problems. For three weeks following surgery, topical ofloxacin, flurbiprofen, and dexamethasone eye drops were given four times a day. A postoperative OCT scan was conducted for one week and four weeks following surgery. While choroidal thickness was measured from the outer edge of the RPE to the choroidal-scleral interface at the fovea and at distances of 500 µm, 1000 µm, and 1500 µm in the nasal, temporal, superior, and inferior orientations, retinal thickness was measured manually from the inner limiting membrane to the retinal pigment epithelium (RPE). The meaning of these measurements was calculated to obtain average retinal and choroidal thickness values for each eye.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 27 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean values and standard deviations. Paired t-tests were employed to compare preoperative and postoperative macular thickness. A p-value of less than 0.05 was deemed statistically significant.

Result

Table 1 summarizes changes in retinal and choroid thickness as determined by horizontal macular scans for 80 eyes prior to and during cataract surgery. The mean retinal thickness increased significantly from a preoperative value of 305.12 ± 16.21 µm to 308.89 ± 16.75 µm at week 1 ($p = 0.012$) and further to 313.79 ± 17.02 µm at month 1 ($p < 0.001$), indicating a progressive postoperative thickening. On the other hand, choroidal thickness showed a slight and non-significant decrease from 240.35 ± 80.42 µm preoperatively to 239.01 ± 78.95 µm at week 1 ($p = 0.87$) and 231.47 ± 81.12 µm at month 1 ($p = 0.42$), suggesting that cataract surgery did not produce meaningful changes in the choroid during the period of follow-up.

Table 1: Average differences in choroidal and retinal thickness in horizontal macular scans (n = 80 E)

Parameter	Preoperative	Week 1	P value	Month 1	P value
Retinal Thickness (µm)	305.12 ± 16.21	308.89 ± 16.75	0.012	313.79 ± 17.02	0
Choroidal Thickness (µm)	240.35 ± 80.42	239.01 ± 78.95	0.87	231.47 ± 81.12	0.42

Table 2 summarizes the mean changes in the thickness of the retina and choroid observed in 80 eyes after cataract surgery. The mean retinal thickness increase was mild and not significant 1 week after surgery (+1.85 µm, $p = 0.14$); however, it attained a significant increase at 1 month (+9.12 µm, $p = 0.001$), representing measurable thickening of the retina over time. The choroid was stable during this time because changes in choroidal thickness were negligible at one week after surgery (+0.55 µm, $p = 0.92$) and at one month after surgery (+4.45 µm, $p = 0.45$), with no statistical significance. Generally, these results indicate that cataract surgery causes a significant rise in retinal thickness one month later, while the thickness of the choroid remains unchanged.

Table 2: Average variation in choroidal and retinal thickness in vertical macular scans (n = 80)

Parameter	Preoperative	Week 1	P Value	Month 1	P Value
Retinal thickness	309.12 ± 15.03	+1.85 ± 4.50	0.14	+9.12 ± 7.25	0.001
Choroidal thickness	239.05 ± 77.20	+0.55 ± 26.10	0.92	+4.45 ± 21.00	0.45

Discussion

This current study investigates the changes in thickness of the retina and choroid after uncomplicated cataract surgery using optical coherence tomography. The results demonstrate that there is a significant increase in the thickness of the retina after one month postoperatively, while there were no statistical differences of the choroidal thickness in the early postoperative period. This information provides important structural changes after surgery of the posterior segment.

In horizontal macular scans, retinal thickness increased significantly compared to the pre-operative mean of 305.12 ± 16.21 µm to 308.89 ± 16.75 µm at week 1 ($p = 0.012$) and 313.79 ± 17.02 µm at month 1 ($p < 0.001$). The gradual thickness of the retina over time indicates a measurable or measurable postoperative retina response potentially caused by transient inflammatory change after surgery. The early increase at week 1, although statistically significant, was a small increase which suggests the retinal response is mild, but a more substantial insign of retinal response is observed at month 1. Nagy et al. (2012) [8] suggested a reduction of retinal macular thickness is less significant for individuals undergoing femtosecond-assisted cataract surgery, mostly attributed to the thickening of the outer nuclear layer.

In contrast, there was a slight reduction in choroidal thickness in the horizontal scans from 240.35 ± 80.42 µm preoperatively to 239.01 ± 78.95 µm at week 1, and 231.47 ± 81.12 µm at month 1 ($p = 0.87$, and $p = 0.42$, respectively). Overall, these changes were not statistically significant, suggesting that the choroid is reasonably robust to the effects of cataract surgery during the early postoperative period. The choroid's stability may be due to the strengths of vascular autoregulation and a reduced vulnerability to transient postoperative inflammation, compared to the retina. Lobo et al. (2004) [9] observed that significant isolated fluorescein leakage from the retina into the vitreous layer, resulting from a compromise of the blood-retinal barrier, correlated with increasing macular thickness.

Vertical macular scans indicated a comparable pattern with a little elevation in retinal thickness at one week +1.85 µm, $p = 0.14$) and a larger increase at one month (+9.12 µm, $p = 0.001$); the choroid showed no variations (+0.55 µm, $p = 0.92$ and +4.45 µm, $p = 0.45$). This furthers the horizontal scanning results to demonstrate that the retina does thicken consistently postoperatively, while the choroid remains unchanged, even by scanning orientation. Eriksson et al., (2011) [10] demonstrated approximately a scooter increase in macular thickness within the first and second postoperative months, but then between the months declined.

The thickening notes may result from a minor increase in postoperative inflammation and a transient disruption of the blood-retinal barrier, causing a tiny fluid buildup in the macula. While these variations were statistically significant, the degree of thickening remained within clinically acceptable limits for most subjects and did not automatically indicate cystoid macular edema. The absence of any appreciable choroidal changes provides further support for the argument that cataract surgery has an effect primarily on the retina during the early postoperative period. Degenring et al., (2007) [11] observed a statistically significant reduction in thickness of macular after a single month postoperatively.

In conclusion, this study demonstrates that uncomplicated cataract surgery results in a significant thickening of the retina just one month after surgery, and there are no effects on the choroid in the short term. Clinically significant changes for postoperative monitoring would support the impact that routine OCT assessment will enhance early detection of retaining changes and facilitate timely management if a significant thickening occurs. Additional studies should seek to follow patients for longer periods of time to assess if these changes either stabilize or regress over time.

Conclusion

The current research shows that uncomplicated phacoemulsification cataract surgery resulted in a slight increase in thickness of the retina within the first month postoperatively while choroidal thickness remained stable. Both horizontal and vertical macular scans showed a persistent thickening of the retina, which is most likely a temporary, moderate inflammatory response to the surgery and an acute disruption of the blood-retinal barrier with mild fluid buildup in the macula. Mount of fluid remained within clinically acceptable limits and progression to clinically significant cystoid macular edema did not occur in most patients. These observations demonstrate the importance of OCT testing as a non-invasive, highly sensitive method of monitoring the retina post-operatively allowing for early recognition of retinal structural changes to assist with management of optimum visual recovery.

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