Archives of
Ophtalmological Research

Original Article

DOI: 10.51271/AOR-0038

Impact of phacoemulsification on choroidal and ganglion cell complex thickness assessed by spectral-domain optical coherence tomography

Kadriye Demir[1], Erkan Çelik[2]

[1]Department of Ophthalmology, Faculty of Medicine, Sakarya University, Sakarya, Turkiye
[2]Department of Ophthalmology, Sakarya Dünyagöz Hospital, Sakarya, Turkiye

Cite this article: Demir K, Çelik E. Impact of phacoemulsification on choroidal and ganglion cell complex thickness assessed by spectral-domain optical coherence tomography. *Arch Ophthalmol Res.* 2025;2(4):58-62.

Received: 01/09/2025 ◆ **Accepted:** 13/10/2025 ◆ **Published:** 30/10/2025

ABSTRACT

Aims: To investigate the effects of phacoemulsification on subfoveal choroidal thickness (SFCT) and ganglion cell complex thickness (GCCT), using spectral-domain optical coherence tomography (SD-OCT).

Methods: This retrospective study included 40 eyes of 40 patients who underwent phacoemulsification with intraocular lens implantation for senile cataract. Preoperative examinations included best-corrected visual acuity, slit-lamp biomicroscopy, intraocular pressure, central corneal thickness, and axial length. Operative time and effective phaco time were recorded. SFCT, GCCT, central macular thickness (CMT), and peripapillary retinal nerve fiber layer thickness (pRNFLT) were measured preoperatively and at 1 month using SD-OCT.

Results: At one month postoperatively, all parameters showed statistically significant increases ($p<0.001$): SFCT (298.6±41.3 µm to 304.6±40.8 µm), GCCT (83.2±4.4 µm to 91.4±6.1 µm), CMT (244.6±16.6 µm to 248.3±17.4 µm), and pRNFLT (95.3±5.1 µm to 100.9±5.8 µm). No significant associations were found between changes in SFCT or GCCT and demographic or clinical factors.

Conclusion: Phacoemulsification may induce mild inflammatory changes that affect posterior segment structures, even in uneventful cases. SFCT, GCCT, CMT, and pRNFLT should therefore be re-evaluated postoperatively to establish new baselines for accurate monitoring. Larger, long-term studies are warranted to clarify the clinical relevance of these changes.

Keywords: Subfoveal choroidal thickness, ganglion cell complex thickness, phacoemulsification, cataract surgery

INTRODUCTION

The choroid, located between the sclera and the retinal pigment epithelium, contains a dense vascular network that supplies oxygen and nutrients to the outer third of the retina.[1] Due to its close anatomical relationship with the outer retina, it plays a central role in the pathogenesis of various ocular diseases, including choroidal neovascularization, central serous chorioretinopathy, and polypoidal choroidal vasculopathy.[2-4] Choroidal thickness is regarded as an indirect marker of choroidal vascular status and is influenced by multiple factors such as age, sex, axial length, refractive status, and circadian rhythm.[5,6] The development of the enhanced depth imaging (EDI) mode in spectral-domain optical coherence tomography (SD-OCT) has enabled non-invasive, high-resolution visualization of deep ocular structures, allowing for reliable and reproducible choroidal measurements.[7]

The ganglion cell complex (GCC)-comprising the inner plexiform layer, ganglion cell layer, and retinal nerve fiber layer, which correspond to the dendrites, cell bodies, and axons of retinal ganglion cells-has also been shown to undergo subtle but statistically significant transient thickness changes after uncomplicated phacoemulsification surgery. These changes, demonstrated in recent SD-OCT studies, are thought to reflect postoperative inflammatory responses or biomechanical alterations.[8,9] Beyond GCC changes, phacoemulsification has been associated with other retinal complications, such as progression of diabetic retinopathy and pseudophakic cystoid macular edema, although the mechanisms underlying its effects on the posterior segment remain incompletely understood.[10,11]

The present study aimed to evaluate changes in ganglion cell complex thickness (GCCT) and subfoveal choroidal thickness (SFCT) following cataract surgery. In addition, alterations in peripapillary retinal nerve fiber layer thickness (pRNFLT) and central macular thickness (CMT) were assessed. Although

Corresponding Author: Kadriye Demir, kadriye_dmr@hotmail.com

postoperative changes in choroidal thickness have been widely investigated, data regarding GCC alterations remain limited. Therefore, this study provides an insight into the early structural effects of uncomplicated phacoemulsification on the posterior segment.

METHODS

This retrospective study included 40 eyes of 40 patients who underwent uncomplicated phacoemulsification with intraocular lens implantation for grade 1-3 senile cataracts at Sakarya University Faculty of Medicine between 2018 and 2021. The study adhered to the tenets of the Declaration of Helsinki, and Ethical approval was obtained from the Sakarya University Ethics Committee (Date: 02.06.2022, Decision No: E-71522473-050.01.04-136949).

Preoperative assessments included best-corrected visual acuity (BCVA, LogMAR), intraocular pressure (IOP, Goldmann applanation tonometry), axial length (AL, optical biometry; Nidek Co., Japan), and intraocular lens (IOL) power. SFCT was measured using the Cirrus EDI-OCT system (Carl Zeiss Meditec AG, Germany), while GCCT was assessed with the macular cube 512×128 protocol. Only scans with a signal strength ≥6 were included.

SFCT was determined at the subfoveal point using the linear caliper tool, defined as the vertical distance from the outer border of the retinal pigment epithelium-Bruch's membrane complex to the inner scleral surface (Figure). Measurements were performed by two independent observers; if interobserver variability exceeded 10%, scans were repeated and averaged values were recorded. To minimize the effects of pharmacological mydriasis and diurnal variation, all OCT scans were acquired without dilation between 2:00 and 4:00 p.m. GCCT was automatically analyzed by the OCT software.

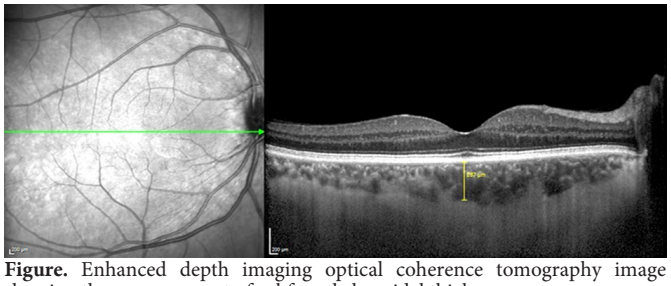

Figure. Enhanced depth imaging optical coherence tomography image showing the measurement of subfoveal choroidal thickness

Additional parameters, including CMT, pRNFLT, operative time (OT), and effective phaco time (EPT) were also recorded. All OCT acquisitions were performed by an experienced technician who was independent of the study team and masked to the study objectives.

Surgical Technique and Exclusion Criteria

All surgeries were performed by a single experienced surgeon using the INFINITI Vision System (Alcon Inc., Fort Worth, TX, USA). A foldable hydrophobic acrylic intraocular lens was implanted in the capsular bag in all eyes. No intraoperative or postoperative complications were observed. Postoperatively, patients received topical moxifloxacin 0.5% (eight times daily for 1 week) and prednisolone acetate 0.1% (eight times daily, tapered over 4 weeks). Follow-up visits were scheduled on postoperative day 1, week 1, and month 1. For this study, preoperative and 1-month postoperative data, including comprehensive ophthalmologic examinations and OCT measurements obtained after pharmacologic pupil dilation, were analyzed.

Exclusion criteria included a history of intraocular surgery or laser treatment; ocular pathologies such as retinal disorders, glaucoma, uveitis, diabetic retinopathy, age-related macular degeneration, or central serous chorioretinopathy; high refractive error (≥±6.00 D); poor fixation during imaging; severe cataracts precluding OCT acquisition (grade 4-5, Oxford Cataract Classification System); or systemic use of prostaglandin analogs, steroids, or diuretics that could affect retinal or choroidal thickness.

Statistical Analysis

All data analyses were conducted using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as means±standard deviations. The normality of data distribution was assessed using the Shapiro-Wilk test. Pearson correlation analysis was employed to explore associations between continuous variables. One-way analysis of variance (ANOVA) regression was used to evaluate differences in pre- and postoperative measurements. p-value <0.001 was considered statistically significant in all analyses.

RESULTS

A total of 40 patients [21 males (52.5%) and 19 females (47.5%)] with a mean age of 63.4±4.7 years were included in the study (Table 1). The mean preoperative BCVA was 0.38±0.18 LogMAR, which significantly improved to 0.05±0.39 LogMAR at postoperative month 1 (p<0.001). AL and CCT were 22.6±0.5 mm (range, 21.5-24.1 mm) and 553.5±24.3 µm, respectively. The mean surgical duration was 8.9±2.3 minutes, and the mean EPT was 7.1±2.3 seconds (Table 2). At postoperative month 1, statistically significant increases were observed in all OCT parameters compared with baseline values. Mean SFCT increased from 298.6±41.3 µm (range, 201-356 µm) to 304.6±40.8 µm (range, 231-367 µm) (p<0.001). Mean GCCT increased from 85.0 ± 4.4 µm (range, 78-94 µm) to 89.2±5.3 µm (range, 81-99 µm) (p<0.001). Similarly, mean pRNFLT increased from 95.3±5.1 µm (range, 87-110 µm) to 100.9±5.8 µm (range, 91-113 µm), and mean CMT increased from 244.6±16.6 µm (range, 211-280 µm) to 248.3±17.4 µm (range, 213-278 µm), both with statistical significance (p<0.001 for all).

Table 1. Demographic characteristics of the patients

Parameter	Value
Age (years)	63.4±4.7
Sex (male/female)	21/19
Operated eye (right/left)	18/22

Table 2. Ocular and surgical parameters

Parameter	Value
Preoperative BCVA (LogMAR)	0.38±0.18
Postoperative BCVA (LogMAR)	0.05±0.39
Axial length (mm)	22.6±0.5
Central corneal thickness (µm)	553.5±24.3
Operation time (minutes)	8.9±2.3
Effective phaco time (seconds)	7.1±2.3

BCVA: Best-corrected visual acuity

No significant correlations were found between changes in SFCT, GCCT, pRNFLT, or CMT and demographic or surgical parameters, including age, sex, AL, CCT, OT, or EPT (Table 3).

Table 3. Preoperative and postoperative month 1 OCT parameters

OCT parameter (µm)	Preoperative (mean±SD)	Postoperative month 1 (mean±SD)	p-value
SFCT	298.6±41.3	304.6±40.8	<0.001
GCC	83.2±4.4	91.4±6.1	<0.001
CMT	244.6±16.6	248.3±17.4	<0.001
pRNFLT	95.3±5.1	100.9±5.8	<0.001

OCT: Optical coherence tomography, SFCT: Subfoveal choroidal thickness, GCC: Ganglion cell complex thickness, CMT: Central macular thickness, pRNFLT: Peripapillary retinal nerve fiber layer thickness, SD: Standard deviation

DISCUSSION

In our study, a statistically significant increase in SFCT and GCCT was observed in the early postoperative period following cataract surgery. Although fundus changes following uncomplicated phacoemulsification have not been fully elucidated, proposed mechanisms include vitreomacular traction, vascular instability, ocular hypotony, and intraoperative light exposure; postoperative inflammation has also been shown in recent studies to play a significant role in these structural alterations.[12,13] However, the precise mechanism underlying changes in choroidal thickness remains unclear. Current evidence suggests that choroidal thickness tends to increase by approximately 5-30 µm, typically beginning as early as the third postoperative day, with values often returning to baseline by the third month.[14] Historically, choroidal evaluation was limited to angiography and ultrasonography, both of which lacked the resolution to detect subtle morphological changes in choroidal thickness. With advances in OCT, non-invasive and reproducible imaging of the choroid has become feasible. In 2008, Spaide et al.[15] introduced the EDI technique using conventional OCT systems, enabling detailed visualization of the choroid. Our findings align with those of Falcão et al.,[16] who investigated the impact of uncomplicated phacoemulsification on retinal and choroidal structures using EDI-OCT. In their study, a statistically significant increase in retinal macular thickness was observed one month postoperatively, which was attributed to inflammatory responses following surgery. However, unlike our study, no significant alterations were detected in SFCT. When evaluating previous studies examining the relationship between choroidal thickness and cataract surgery, Aslan Bayhan et al.[17] and Pierru et al.[18] also reported an increase in SFCT at the first postoperative month. In Pierru's study, this thickening was observed to return to baseline levels by the third postoperative month. These studies suggest that inflammation in the anterior segment caused by cataract surgery may also affect the posterior segment. Surgical trauma and disruption of the blood-aqueous barrier are believed to initiate this inflammatory process.[19] An experimental animal study demonstrated that the inflammatory response is induced by surgical stress, and that proinflammatory cytokines increase within the choroid and inner retinal layers.[20] In another study evaluating SFCT, it was reported that SFCT peaked on postoperative day 7 and gradually decreased by the third month, returning close to baseline levels.[21] These findings are partially consistent with the current study, in which a significant increase in subfoveal choroidal thickness was observed at the first postoperative month. However, as measurements were limited to a single subfoveal point and follow-up did not extend beyond the first month, it remains uncertain whether this increase represents a transient inflammatory response or a more sustained structural change. In line with this, Yilmaz et al.[22] reported in a prospective study that although central macular thickness returned to baseline levels within 6 months after cataract surgery, subfoveal choroidal thickness remained slightly elevated even at 12 months. This suggests that postoperative choroidal alterations may persist beyond the early inflammatory phase, potentially indicating longer-term remodeling or subclinical vascular changes. Additionally, Icoz[23] demonstrated that subfoveal, nasal, and temporal choroidal thickness significantly increased at the first postoperative month and returned to baseline at the third month, while the Choroidal Vascular Index (CVI) remained elevated. These findings indicate that vascular changes may persist even after structural normalization, providing further insight into postoperative choroidal physiology.

Neurodegenerative eye diseases, particularly glaucoma, predominantly target the GCC. The GCC is anatomically composed of the RNFL, the ganglion cell layer, and the inner plexiform layer, which respectively contain the axons, cell bodies, and dendritic connections of retinal ganglion cells.[9,24] Because these layers directly reflect the structural integrity of ganglion cells, alterations in their thickness are considered reliable markers of neuroaxonal loss. Recent investigations have demonstrated that assessment of macular GCCT is at least as effective as peripapillary RNFLT in detecting glaucomatous damage.[25,26] Moreover, these studies have emphasized that GCC analysis may capture early neurodegenerative changes even when RNFL alterations are minimal, thereby offering an additional diagnostic advantage. In the present study, a significant increase in GCCT and pRNFLT was observed in the early postoperative period following cataract surgery. Previous research has indicated that cataract surgery may alter GCC and peripapillary RNFL thickness measurements, highlighting the importance of considering such changes during postoperative follow-up.[27-29] In one of these studies evaluating early postoperative changes, a decrease in pRNFLT and GCCT was observed on postoperative day 1; however, by the first week, values had exceeded baseline levels and peaked at one month.[29] Moreover, the increase in these layers began earlier than the increase in total retinal thickness. Another study comparing femtosecond laser-assisted cataract surgery (FLACS) with conventional phacoemulsification reported that, although no statistically significant differences were found between the two groups, both GCCT and pRNFLT showed a significant increase from baseline in each surgical group.[30] Based on these observations, the authors suggested the importance of establishing a new postoperative baseline for GCCT and pRNFLT to accurately monitor future structural changes. Similarly, the increase observed in our study, despite being statistically significant, may reflect transient postoperative alterations rather than true pathological progression. Thus, follow-up evaluations should consider the influence of recent cataract surgery when interpreting OCT-based measurements of inner retinal structures. Another secondary finding of our study was the increase in CMT observed at postoperative month 1. Numerous studies in literature have reported similar increases in CMT following uncomplicated cataract

surgery.[31-34] The authors observed a slight increase in foveal thickness following cataract surgery without affecting visual acuity and suggested that this change could be attributed to both subclinical alterations and the influence of improved media clarity on measurement accuracy. Surgical and biometric parameters such as EPT, and AL were not found to be associated with the degree of macular thickening, which is consistent with the findings of our study. In another study that examined all retinal layers, a decrease in retinal thickness was observed on the first postoperative day, followed by a significant increase at one month, and a subsequent reduction at three months after surgery. These findings support the hypothesis that the inflammatory response following uncomplicated cataract surgery, characterized by thickening of the retinal layers, peaks around the first postoperative month and gradually subsides thereafter. Based on these results, the authors suggested that additional treatment for cystoid macular edema may not be necessary as early as the first month in mild cases.[35]

Limitations

The primary limitations of this study include its relatively small sample size and the short duration of follow-up. Measurements were limited to a single time point at one month postoperatively, which prevents assessment of the long-term structural changes in choroidal and retinal layers. In addition, choroidal thickness was only measured at the subfoveal region; regional variations across the posterior pole were not evaluated. Furthermore, the retrospective design of the study limits the ability to control for potential confounding factors.

CONCLUSION

Although the main limitations of our study are the small sample size and lack of long-term follow-up, we observed a significant increase in SFCT and GCCT one month after uncomplicated cataract surgery in a homogeneous patient group operated on by the same surgeon under similar ocular and surgical parameters. Increases in pRNFLT and CMT were also recorded. While these changes may be transient, clinicians should be aware that SFCT, GCCT, or pRNFLT measurements may vary during the early postoperative period. This should be considered when monitoring patients with chronic diseases affecting the choroid and retinal layers, and when adjusting treatment parameters in individuals who have recently undergone cataract surgery.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Sakarya University Ethics Committee (Date: 02.06.2022, Decision No: E-71522473-050.01.04-136949).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Campos A, Campos EJ, Martins J, Ambrósio AF, Silva R. Viewing the choroid: where we stand, challenges and contradictions in diabetic retinopathy and diabetic macular oedema. *Acta Ophthalmol.* 2017;95(5):446-459. doi:10.1111/aos.13210
2. Gomi F, Tano Y. Polypoidal choroidal vasculopathy and treatments. *Curr Opin Ophthalmol.* 2008;19:208-212. doi:10.1097/ICU.0b013e3282fb7c33
3. Cheung CMG, Lai TYY, Teo KYC, et al. Macular neovascularization and polypoidal choroidal vasculopathy: phenotypic variations, pathogenic mechanisms and implications in management. *Eye (Lond).* 2024;38:659-667. doi:10.1038/s41433-023-02764-w
4. Sato Kuroda K, Ikuno Y, Yasuno Y, et al. Choroidal thickness in central serous chorioretinopathy. *Retina.* 2013;33(2):302-308. doi:10.1097/IAE.0b013e318263d11f
5. Tuncer I, Karahan E, Zengin MO, Atalay E, Polat N. Choroidal thickness in relation to sex, age, refractive error, and axial length in healthy Turkish subjects. *Int Ophthalmol.* 2015;35(3):403-410. doi:10.1007/s10792-014-9962-4
6. Zhu H, Liu C, Gao M, et al. Choroidal thickness in relation to diopter and axial length among myopic children. *Front Med.* 2023;10:1241352. doi:10.3389/fmed.2023.1241352.
7. Spaide RF, Koizumi H, Pozzoni MC. Enhanced depth imaging spectral-domain optical coherence tomography. *Am J Ophthalmol.* 2008;146(4):496-500. doi:10.1016/j.ajo.2008.05.032
8. Abdelghany AA, Sallam MA, Ellabban AA. Assessment of ganglion cell complex and peripapillary retinal nerve fiber layer changes following cataract surgery in patients with pseudoexfoliation glaucoma. *J Ophthalmol.* 2019;2019:8162825. doi:10.1155/2019/8162825
9. Nakatani Y, Higashide T, Ohkubo S, Takeda H, Sugiyama K. Effect of cataract and its removal on ganglion cell complex thickness and peripapillary RNFL thickness by Fourier-domain OCT. *J Glaucoma.* 2013;22(6):447-455. doi:10.1097/IJG.0b013e3182478ac3
10. Lobo C. Pseudophakic cystoid macular edema. *Ophthalmologica.* 2012;227(2):61-67. doi:10.1159/000331277
11. Hayashi K, Igarashi C, Hirata A, Hayashi H. Changes in diabetic macular oedema after phacoemulsification surgery. *Eye (Lond).* 2009;23:389-396. doi:10.1038/sj.eye.6703022
12. Kim H, Kang JW, Chung H, Kim HC. Morphologic changes in retinal layers after uncomplicated phacoemulsification: a swept-source optical coherence tomography study. *Sci Rep.* 2021;11:19927. doi:10.1038/s41598-021-99440-4
13. Georgopoulos GT, Papaconstantinou D, Niskopoulou M, Moschos M, Georgalas I, Koutsandrea C. Foveal thickness after phacoemulsification as measured by optical coherence tomography. *Clin Ophthalmol.* 2008;2:817-820. doi:10.2147/opth.s4031
14. Jiang H, Li Z, Sun R, Liu D, Liu N. Subfoveal choroidal and macular thickness changes after phacoemulsification using enhanced depth imaging optical coherence tomography. *Ophthalmic Res.* 2018;60(4):243-249. doi:10.1159/000480240
15. Spaide RF, Koizumi H, Pozzoni MC. Enhanced depth imaging spectral-domain optical coherence tomography. *Am J Ophthalmol.* 2008;146(4):496-500. doi:10.1016/j.ajo.2008.05.032
16. Falcão MS, Gonçalves NM, Freitas-Costa P, et al. Choroidal and macular thickness changes induced by cataract surgery. *Clin Ophthalmol.* 2013;8:55-60. doi:10.2147/OPTH.S53989
17. Aslan Bayhan S, Bayhan HA, Muhafiz E, Kirboga K, Gurdal C. Evaluation of choroidal thickness changes after phacoemulsification surgery. *Clin Ophthalmol.* 2016;10:961-967. doi:10.2147/OPTH.S94096
18. Pierru A, Carles M, Gastaud P, Baillif S. Measurement of subfoveal choroidal thickness after cataract surgery in enhanced depth imaging optical coherence tomography. *Invest Ophthalmol Vis Sci.* 2014;55(8):4967-4974. doi:10.1167/iovs.14-14172
19. Sheppard JD. Topical bromfenac for prevention and treatment of cystoid macular edema following cataract surgery: a review. *Clin Ophthalmol.* 2016;10:2099-2111. doi:10.2147/OPTH.S86971

20. Xu H, Chen M, Forrester JV, Lois N. Cataract surgery induces retinal pro-inflammatory gene expression and protein secretion. *Invest Ophthalmol Vis Sci.* 2011;52(1):249-255. doi:10.1167/iovs.10-6001
21. Ibrahim AM, Elgouhary SM, Nassar MK, El Batanony AH. Changes in choroidal thickness after cataract surgery. *Semin Ophthalmol.* 2018; 33(5):664-670. doi:10.1080/08820538.2017.1416410
22. Yilmaz T, Karci AA, Yilmaz I, Yilmaz A, Yildirim Y, Sakalar YB. Long-term changes in subfoveal choroidal thickness after cataract surgery. *Med Sci Monit.* 2016;22:1566-1571. doi:10.12659/msm.898714
23. Icoz M. Evaluation of structural and vascular changes in the choroid after uneventful phacoemulsification surgery. *Rom J Ophthalmol.* 2023; 67(1):50-56. doi:10.22336/rjo.2023.9
24. Mwanza JC, Oakley JD, Budenz DL, Chang RT, Knight OJ, Feuer WJ. Macular ganglion cell-inner plexiform layer: automated detection and thickness reproducibility with spectral domain-optical coherence tomography in glaucoma. *Invest Ophthalmol Vis Sci.* 2011;52(11):8323-8329.
25. Kim NR, Lee ES, Seong GJ, Kim JH, An HG, Kim CY. Structure-function relationship and diagnostic value of macular ganglion cell complex measurement using Fourier-domain OCT in glaucoma. *Invest Ophthalmol Vis Sci.* 2010;51(9):4646-4651.
26. Seong M, Sung KR, Choi EH, et al. Macular and peripapillary retinal nerve fiber layer measurements by spectral domain optical coherence tomography in normal-tension glaucoma. *Invest Ophthalmol Vis Sci.* 2010;51(3):1446-1452.
27. Roh HC, Park CY, Kim M. Changes of the macular ganglion cell-inner plexiform layer thickness after cataract surgery in glaucoma patients. *J Ophthalmol.* 2016;2016:9785939. doi:10.1155/2016/9785939
28. Sari ES, Ermis SS, Yazici A, Koytak A, Sahin G, Kilic A. The effect of intracameral anesthesia on macular thickness and ganglion cell-inner plexiform layer thickness after uneventful phacoemulsification surgery: prospective and randomized controlled trial. *Graefes Arch Clin Exp Ophthalmol.* 2014;252(3):433-439. doi:10.1007/s00417-013-2557-3
29. Zhou Y, Zhou M, Wang Y, et al. Short-term changes in retinal vasculature and layer thickness after phacoemulsification surgery. *Curr Eye Res.* 2020;45(1):31-37. doi:10.1080/02713683.2019.1649703
30. Sánchez-Sánchez C, Rementería-Capelo LA, Carrillo V, Pérez-Lanzac J, Contreras I. Changes in ganglion cell complex and peripapillary retinal nerve fiber layer after femtosecond laser-assisted cataract surgery compared to manual phacoemulsification in patients receiving a trifocal intraocular lens. *J Ophthalmol.* 2020;2020:8626495. doi:10.1155/2020/8626495
31. Mojzis P, Studeny P, Penkova L. Macular thickness after uneventful cataract surgery determined by optical coherence tomography. *Graefes Arch Clin Exp Ophthalmol.* 2007;245(12):1765-1771. doi:10.1007/s00417-007-0605-6
32. Guliani BP, Agarwal I, Naik MP. Effect of uncomplicated cataract surgery on central macular thickness in diabetic and non-diabetic subjects. *J Ophthalmic Vis Res.* 2019;14(4):442-447. doi:10.18502/jovr.v14i4.5447
33. Perente I, Utine CA, Ozturker C, et al. Evaluation of macular changes after uncomplicated phacoemulsification surgery by optical coherence tomography. *Curr Eye Res.* 2007;32(3):241-247. doi:10.1080/02713680601160610
34. Akbulut S, Pekel G. Effects of uncomplicated phacoemulsification surgery on retinal vascular diameters, subfoveal choroidal and central macular thickness. *Int Ophthalmol.* 2025;45(1):262. doi:10.1007/s10792-025-03638-8
35. Großpötzl M, Malle EM, Riedl M, et al. Changes of individual retinal layer thickness post-uneventful cataract surgery determined by spectral-domain optical coherence tomography over a 3-months period. *Heliyon.* 2024;10(15):e35096. doi:10.1016/j.heliyon.2024.e35096