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Assessment of Nerve Fiber Layer and Ganglion Cell Complex Thickness Changes after Uncomplicated Phacoemulsification by Optical Coherence Tomography

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ABSTRACT

Background: Phacoemulsification is considered one of the most prevalent surgical techniques in ophthalmologic practice. The thickness measurements of the retinal layer may be altered following easy surgery for cataracts due to the presence of lens opacity, which can lead to inaccurate measures of the retinal layer's thickness.

Aim and objectives: This study aimed to evaluate the alterations in the nerve fiber layer & ganglion cell layer thickness measurements following uncomplicated phacoemulsification.

Patients and methods: This pre-post quasi-experimental research was performed on 51 cases with cataracts who received uncomplicated phacoemulsification in the Ophthalmology Outpatient Clinic, Suez Canal University Hospitals, Ismailia.

Results: At baseline, the average thickness of the retinal nerve fiber layer (RNFL) was 88.32 ± 16.3 µm, and the mean ganglion cell layer (GCL) thickness was 77.36 ± 5.88 µm. A significant raise observed in visual acuity (VA), retinal nerve fiber layer thickness, and GCL thickness postoperatively. A significant association was observed among visual acuity and RNFL thickness. **Conclusion:** There was an increase in layer of retinal nerve fiber & ganglion cell layer thickness evaluated by 3D optical coherence tomography associated with a rise in the visual acuity of patients experiencing uncomplicated phacoemulsification surgery.

Keywords: Phacoemulsification, Optical coherence tomography, BCVA, VA**.**

INTRODUCTION

Phacoemulsification is widely regarded as one of the most performed surgical operations in the Departments of Ophthalmology [(1)]. The thickness estimations of the retinal layer may be altered following easy surgery for cataracts due to the lens opacity associated with cataracts, which can result in inaccurate measures of the retinal layer's thickness [(2)]. According to **El-khiat *et al***. [(3)], the alterations in the measurement of retinal layer thickness following phacoemulsification operation are due to enhancements in the transmission and reflectivity of the layer boundaries resulting from the removal of the opacified lens, rather than genuine changes in thickness following surgery for cataracts.

Optical coherence tomography (OCT) was widely recognized as a viable procedure for examining the structure of the retina. Due to its noninvasive characteristics, OCT has been established as a critical tool for identifying retinal diseases. OCT allows for imaging of the retinal layers & macula without the need for physical contact or noninvasive procedures. OCT utilizes an interferometer and near-infrared low-coherence light to attain a resolution of approximately five micrometers in the eye [(4)].

Before the onset of functional visual field (VF) loss, a significant decline was observed in the structural strength of the GCL & NFL. OCT is particularly valuable in cases of preperimetric illness. Optical coherence tomography can directly assess and measure the thickness of the RNFL & GCL. The repeatability of OCT data is normally high, although some factors like the existence of cataracts, the level of corneal dryness, and pupillary dilation can impact both the quality of the image & the repeatability of subsequent optical coherence tomography estimations [(5)].

Phacoemulsification is a surgical procedure that can be affected by multiple factors that can impact the tissue structure of the eyeball. Fluidics and ultrasonic energy, unlike other movements, induce mechanical impacts that result in an inflammatory response, hypoxia, and compression of the eyeball tissue [(6)]. Phacoemulsification induces mechanical forces that cause damage to the iris during operation, lens epithelial cells, & ciliary body. This trauma results in the release of phospholipids, which in turn stimulates the production of prostaglandins or other inflammatory mediators. Inflammatory mediators disrupt the blood-retinal barrier by diffusing through the vitreous, leading to the accumulation of serum in the retina and causing macular edema [(7)]. The purpose of this research was to assess the variations in the thickness of the layer of ganglion cell & layer of nerve fiber measurements following uncomplicated phacoemulsification.

PATIENTS AND METHODS

This pre-post-quasi-experimental research was performed on 51 cases of cataract undergoing uncomplicated phacoemulsification in the Ophthalmology Outpatient Clinic, Suez Canal University Hospitals, Ismailia.

Inclusion criteria: Both sexes (males and females), age from 40 to 70 years old and patients with cortical or nuclear cataracts not more than grade III so we can still do OCT.

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Exclusion criteria: Cases who have systemic illnesses like diabetes mellitus and uncontrolled hypertension, cases who take systemic drugs that may cause retinopathy like chloroquine (which is utilized to treat malaria), cases with systemic inflammation like inflammatory bowel disease, as well as hepatitis C or B, cases with a history of macular pathology like macular hole, senile macular degeneration, or epiretinal membrane, cases with retinopathies like retinal dystrophy and retinal vascular obstruction, cases with previous eye illnesses like glaucoma, severe dry eye, and uveitis, and cases with a history of intraocular operation, ocular trauma, and laser therapy.

METHODS

All cases have been exposed to the following: Full history taking**,** medical inspection, slit-lamp biomicroscopic inspection of the anterior segment of each eye (Topcon-Japan), and intra-ocular pressure measurement using Goldman applanation tonometry (Shin-Nippon). OCT measurements: The Swept Source Optical Coherence Tomography (SS-OCT) instrument, specifically the Topcon 3D OCT 2000 software (version 4.1) was utilized to quantify the central macular thickness & the peripapillary retinal nerve fiber layer prior to the phacoemulsification procedure. These measurements were repeated one week and one month following the procedure. Additionally, a fundus examination was conducted using an indirect ophthalmoscope by Appasmy Associates. Volk lens with a power of +90 diopters

Preoperative preparation: The pupil was dilated with tropicamide one percent one hour prior to operation. Peribulbar anesthesia was implemented in each case. The operation was performed using the following technique: The periocular epidermis was sterilized with ten percent povidone iodine, and the conjunctival sac was washed with five percent povidone iodine for three minutes.

Anesthetic technique: The peri-bulbar anesthesia technique used for all cases with sub-tenon anesthesia of lidocaine (xylocaine) was utilized to give anesthesia & moderate akinesia throughout the operation.

Surgical technique: A corneal incision that was both accurate and clear was made with the use of a disposable metal keratome measuring 2.8 millimeters in diameter and featuring two side ports that were spaced ninety degrees apart. The anterior chamber was then filled with hydroxypropyl methylcellulose after the procedure was completed. Subsequently, capsulorhexis was performed utilizing capsulorhexis forceps. The OVD was evacuated, and the nucleus was rotated and hydrodissected. The procedure of phacoemulsification was performed, during which various parameters were measured. Phaco one was utilized to create the trench, Phaco two was employed for quadrant removal, & the EPT was documented. The stop and chop strategy were used in all cases. The cortical material was separated from the capsular bag by utilizing a tangential stripping approach combined with gentle centripetal movements during bimanual I/A. Ultimately, the process of sealing the wound was carried out. Following the completion of the surgical procedure, a 0.1-milliliter dose of cefuroxime was administered into the anterior part of the eye.

Postoperative examination: Patients were also evaluated during the follow-up on the first postoperative day, following one week, following one month, & following three months. In each visit, the following was recorded: The BCVA was recorded. Anterior segment & posterior segment examinations were repeated.

Optical coherence tomography: After one and three months, OCT was done. Pupils were dilated for optical coherence tomography assessment in all patients with one percent tropicamide (Mydrapid).

Postoperative medications: All cases were administered moxifloxacin 0.5 percent & prednisolone acetate one percent eye drops at a frequency of five times per day for a duration of two weeks, followed by a gradual reduction over a duration of two weeks. The follow-up period for all cases lasted for three months.

Ethical considerations: All the procedures of the research were approved by The Radiology Department and The Investigation Ethics Committee, Faculty of Medicine, Suez Canal University. Administrative consents required were taken. This study was conducted on humans in compliance with The Declaration of Helsinki, the code of ethics of the World Medical Association.

Statistical analysis

SPSS 22.0 for Windows (SPSS Inc., Chicago, IL, USA) was utilized to collect, tabulate, & perform statistical analyses of all data. The Shapiro-Wilk test was used for assessing the normality of the data. Frequencies & relative percentages were used for presenting qualitative information. As indicated, the Chi square test (χ^2) and Fisher exact were utilized to determine the variation among qualitative variables. Quantitative data have been presented as mean ± SD for parametric data and median and range for non-parametric statistics. The independent T test & Mann-Whitney test were utilized to determine the distinction among quantitative variables in both groups for parametric & non-parametric variables, correspondingly. All statistical comparisons were two-tailed and statistically significant. A P- values ≤ 0.05 was significant, ≤ 0.001 was greatly significant and > 0.05 was non-significant.

RESULTS

Table (1): showed that 62.7% of the cases were women with average age of 60.5± 7.29 years.

Table (1): Demographic distribution of the experimented cases

		All cases (n=51 eyes)
Age (years) Mean ± SD		60.5 ± 7.29 43–70
Sex	Female	32 (62.7%)
	Male	19 (37.3%)

Table (2) illustrated that there was a significant increase in VA postoperatively.

Table (2): Visual acuity (VA) findings of the studied patients

	All cases (n=51 eyes)			P
	Preoperative	one month post	3 months post	
VA Mean ± SD	0.312 ± 0.072	0.574 ± 0.083	0.574 ± 0.83	< **0.001****

** Highly significant difference.

Table (3) showed that at baseline, the mean RNFL thickness was 88.32 ± 16.3 µm with mean GCL thickness was 77.36 ± 5.88 µm.

Table (3): Thickness of RNFL and GCL before operation of the studied patients

	All cases (n=51 eyes)
RNFL thickness (µm) Mean ± SD	89.7 ± 14.31
GCL thickness (µm) Mean ± SD	77.36 ± 5.88

Table (4) illustrated that a significant increase was observed in thickness of RNFL and GCL thickness postoperatively.

Table (4): Postoperative findings of the studied patients

	All cases (n=51 eyes)			P
	Preoperative	one month post	3 months post	
RNFL thickness (µm) Mean ± SD	89.7 ± 14.31	109.1±11.73	107.1 ± 11.51	<**0.001****
GCL thickness (µm) Mean ± SD	77.36 ± 5.88	87.88± 5.82	85.8 ± 5.88	<**0.001****

** Highly significant difference.

Table (5) illustrated a significant association was observed among visual acuity and RNFL thickness.

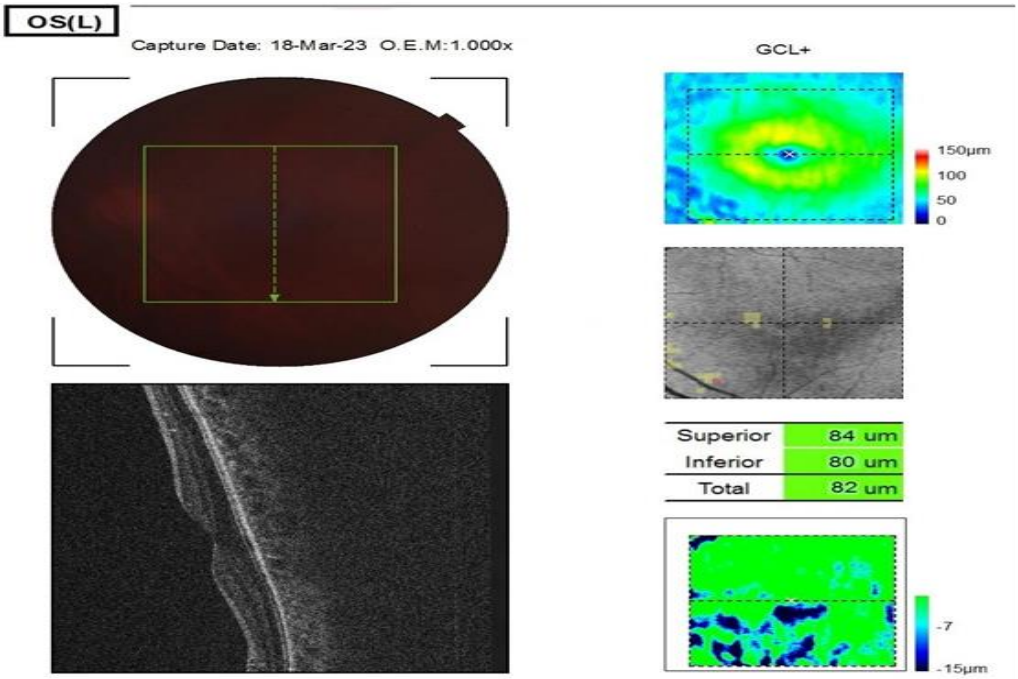
Table (5): Correlation among visual acuity with RNFL & GCL thickness among the studied patients

	Visual acuity	
	r	P
RNFL thickness (µm)	**.355**	**.011***
GCL thickness (µm)	.143	.323

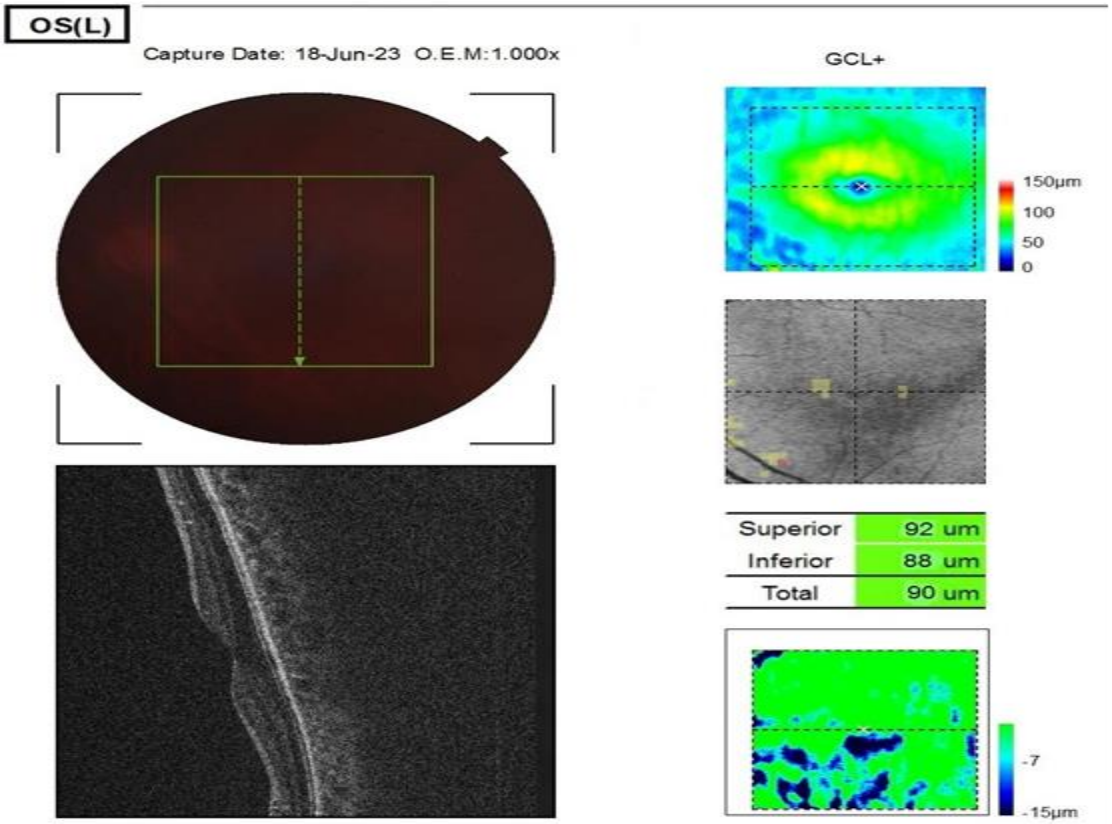
* Significant difference

CASE PRESENTATION

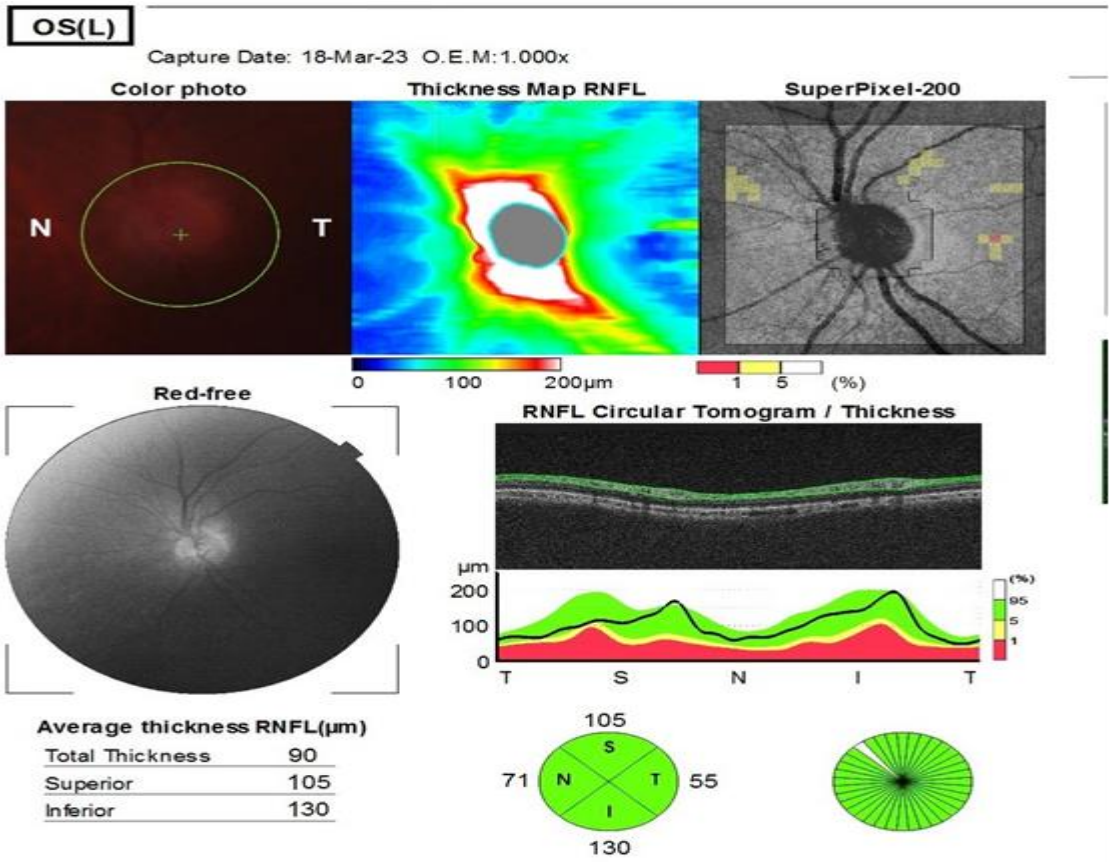
Male patient 69 years old had VA of 0.3 and had no history of chronic diseases.



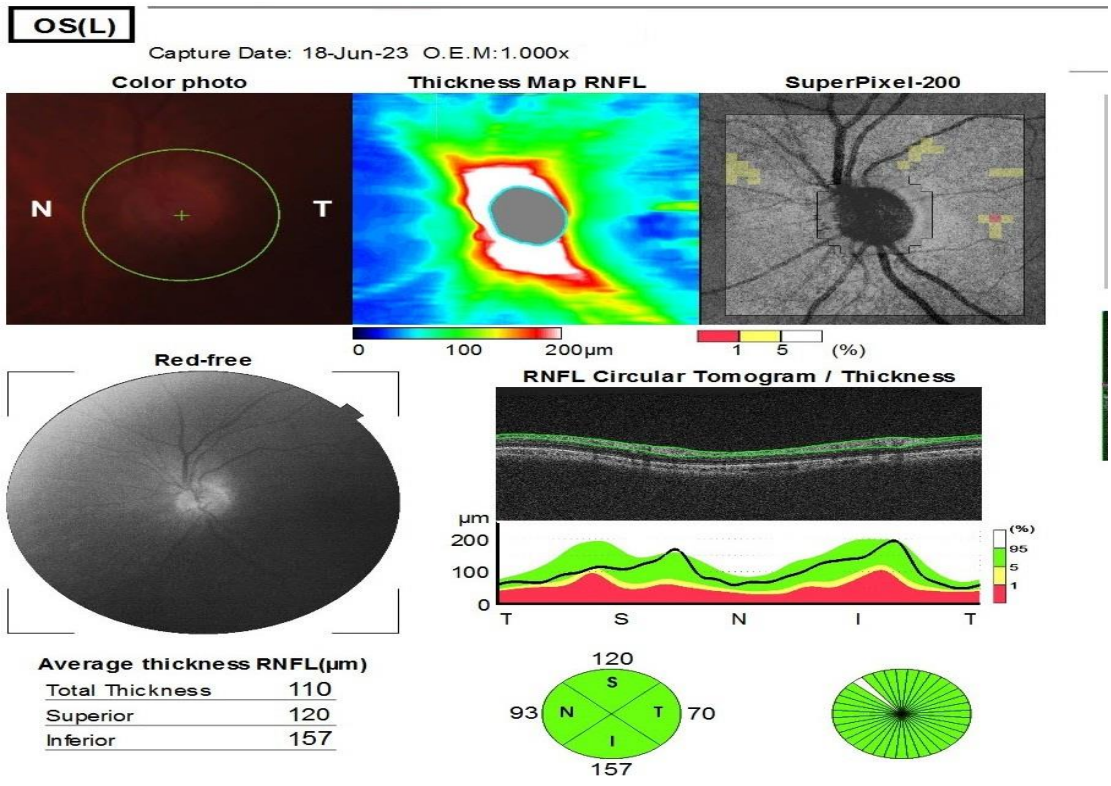
(A): GCL preoperatively.



(B): GCL three months postoperatively.



(C): NFL preoperatively.



(D): NFL three months postoperatively.

Figure (1): Photo of case presentation.

DISCUSSION

This investigation involved 51 eyes in cases with cataracts undergoing uncomplicated phacoemulsification; 62.7% of the cases were women with an average age of 60.5 ± 7.29 years. Additionally, **Sánchez-Sánchez *et al*.** [8] assessed the alterations in ganglion cell complex (GCC) values following femtosecond laser-assisted cataract surgery (FLACS) and compared them to the alterations observed following conventional phacoemulsification. The investigation involved a total of 171 cases, each with one eye, resulting in a total of 171 eyes. Out of these, seventy-four eyes received FLACS (FLACS group) & ninety-seven eyes underwent "classic" phacoemulsification (Phaco group). The FLACS group had a greater proportion of women (58 / 74 eyes, 78.4%) compared to the Phaco group (67 /97, 69.1%), while the distinction didn't reach statistical significance. The mean age was comparable between the two groups, with an average of 67.12 ± 7.80 years for the FLACS group and 67.74 ± 7.93 years for the Phaco group.

Our study revealed an important increase in visual acuity following the surgery. Prior to the operation, the VA was measured at 0.312 ± 0.072 logMar. However, one month following the surgery, the VA increased to 0.574 ± 0.083 logMar, and this improvement remained at 0.574 ± 0.83 logMar for the for the following three months. In addition, **Mahmoud *et al*.** [9] discovered a statistically significant distinction in both IOP and BCVA among the normal & glaucoma groups.

Our investigation revealed that initially, the average RNFL thickness was 88.32 ± 16.3 μm, whereas the ganglion cell layer mean thickness was 77.36 ± 5.88 μm. After surgery, there was a significant rise in thickness of GCL & RNFL. According to the research conducted by **Cheng *et al*.** [10], it was discovered that following cataract removal, the measures of the layer of retinal nerve fiber have been significantly greater in both the Cirrus optical coherence tomography (P 0.02) & Stratus OCT (P < 0.001) machines.

Pardianto *et al*. [11] discovered that there were statistically significant variations in macular thickness when comparing prior to surgery and after spectral domain OCT exams in nine specific regions involving macular volume. The thickness of 3/4 in the paracentral macular area showed a significant rise (superior P-value = 0.015; temporal P-value = 0.001; and nasal P-value = 0.023). The thickness of peripheral macular exhibited a significant rise in both the superior (P-value = 0.05) & temporal macular regions (P-value <0.001). The macular volume exhibited a statistically significant rise during phacoemulsification (P-value <0.001). Insignificant associations were observed among absolute or efficient macular cellular structures & phacoemulsification time (P > 0.05). However, a significant association (P = 0.011) has been identified among absolute phacoemulsification time & the alteration in macular volume.

Average pRNFL thickness was found to rise by a mean of 2.11 micrometers to 5.63 micrometers following traditional phacoemulsification utilizing a Cirrus-OCT [12].

The precise cause of the alterations in optical coherence tomography measurements following surgery for cataracts remains unclear. The cause appears to be a result of multiple factors, for example the inflammatory impact of the treatment, a reduction in the lens's OD, alterations in refraction post-operation, & the optical characteristics of the IOL [13].

Mahmoud *et al*. [9] discovered a statistically significant distinction in the mean values of the inferior, superior, & average RNFL and GCL complex among people with normal grades and those with glaucoma.

The utilization of trifocal intraocular lenses is progressively rising, requiring an assessment of their potential impact on optical coherence tomography results. **Celebi and Mirza** [14] examined the effect of aging on the RNFLT thickness around the optic nerve utilizing spectral domain optical coherence tomography (SDOCT) in a group of healthy adults. The researchers determined that the decline in RNFLT due to aging differed depending on the specific sector being examined. Any assessment of RNFLT should take into consideration the changes that occur with age. The normative database of Cirrus SD-optical coherence tomography takes into consideration the age-related changes that occur at the regional level.

Hondur *et al*. [15] used swept-source OCT to analyze the RNFLT (thickness) in the retinal periphery and found age-related changes**.** They suggested that when assessing glaucoma-associated variations in peripheral RNFL thickness, it is critical to consider the age-associated decrease.

Radwan *et al*. [7] investigated the impact of phacoemulsification on the RNFL and macula thickness, and the influence of phaco duration on macular thickness. The researchers determined that phacoemulsification results in a significant elevation of the central RNFL thickness, & the macular area thickness, after one week and one month following the operation as compared to the preoperative measurements. There is a direct association among macular thickness and phaco time.

Phacoemulsification surgery affects the retina due to the mechanical effects caused by ultrasonic energy and fluidics. This causes an inflammatory response, resulting in macular edema. Additionally, the removal of opacified media advances the reflectivity & transmittance of the retinal nerve fiber layer boundary, leading to a rise in RNFL thickness following phacoemulsification.

In their study, **Mahmoud *et al*.** [9] discovered that using SD-OCT to quantify GCC and RNFL was crucial in

identifying and evaluating glaucoma. A significant association was observed among RNFL & GCL complex thickness in cases having glaucoma. The imaging of the GCC exhibits similar diagnostic efficacy to measures of the RNFL and ONH in distinguishing among cases of glaucoma and people staying healthy.

CONCLUSION

We concluded that there was a rise in the GCL & RNFLT measured by three-dimensional OCT related to a rise in the visual acuity of patients experiencing uncomplicated phacoemulsification surgery.

DECLARATIONS

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Availability of data and material: Available

Conflicts of interest: No conflicts of interest.

Competing interests: None.

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