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Original Research Article

Assessment of RNFL Thickness Changes Before and After Glaucoma Filtering Surgery Using OCT: A Clinical Study

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Abstract:

Background: Glaucoma is a chronic optic neuropathy and a leading cause of irreversible blindness worldwide. Reduction of intraocular pressure (IOP) remains the cornerstone of treatment. Glaucoma filtering surgery effectively lowers IOP, but its impact on retinal nerve fiber layer (RNFL) thickness, as assessed by optical coherence tomography (OCT), remains a subject of ongoing investigation.

Aim: To use OCT to compare the RNFL thickness changes before and after glaucoma filtering surgery, and to analyze the relationship between these structural results and the decrease in IOP

Methods: Over the course of two years (March 2023–February 2025), this retrospective clinical investigation was carried out at the Upgraded Department of Ophthalmology, Darbhanga. 50 patients with full pre- and after OCT scans who had glaucoma filtering surgery were included. All quadrants' RNFL thickness, pre- and postoperative IOP, and demographic information were noted. SPSS version 23.0 was used for statistical analysis, and paired t-tests were used for comparison. P-values less than 0.05 were deemed statistically significant.

Results: The mean age of patients was 54.6 ± 10.8 years; 28 (56%) were males and 22 (44%) were females. Mean preoperative IOP was 26.2 ± 4.5 mmHg, which significantly reduced to 14.8 ± 3.1 mmHg postoperatively ($p < 0.001$). Global RNFL thickness improved from 82.4 ± 7.2 µm to 89.6 ± 6.8 µm ($p < 0.001$). The superior and inferior quadrants demonstrated the greatest improvement, while the nasal and temporal quadrants also showed statistically significant changes. Overall, 88% of patients exhibited measurable RNFL improvement following surgery.

Conclusion: Glaucoma filtering surgery significantly reduces IOP and leads to measurable improvements in RNFL thickness across all quadrants, suggesting a protective effect on optic nerve structure in addition to functional pressure control.

Recommendations: OCT should be routinely employed in the postoperative follow-up of glaucoma patients to monitor structural recovery and surgical outcomes. To confirm these results and investigate long-term structural alterations, more prospective studies with bigger sample sizes and longer follow-up are advised.

Keywords: Glaucoma, Retinal Nerve Fiber Layer, Optical Coherence Tomography, Intraocular Pressure, Filtering Surgery.

Introduction

Retinal ganglion cells and their axons degenerate in glaucoma, a progressive visual neuropathy that, if left untreated, can cause irreversible vision loss. It affects an estimated 76 million people in 2020 and is predicted to rise to 111.8 million by 2040, making it the world's greatest cause of permanent blindness [1]. IOP is still the most important modifiable risk factor for the advancement of glaucoma, and lowering it is the major objective of treatment [2].

Glaucoma filtering surgery, particularly trabeculectomy, has long been considered the gold standard surgical procedure for lowering IOP when medical or laser therapy proves insufficient [3]. While its efficacy in reducing IOP is well established, interest has grown in evaluating the

structural and functional changes in the optic nerve and (RNFL) following surgery [4]. (OCT), a non-invasive, high-resolution imaging modality, provides quantitative measurements of RNFL thickness and has become indispensable in monitoring glaucoma progression [5].

Recent evidence suggests that IOP reduction through filtering surgery may induce a degree of structural recovery or stabilization in the RNFL [6]. Postoperative changes in RNFL thickness, however, remain a subject of debate, with some studies reporting significant improvement, while others suggest minimal or no change depending on disease severity and duration [7,8]. These variations highlight the importance of conducting population-specific studies to understand RNFL dynamics following surgery.

In addition, studies have indicated that postoperative changes in RNFL may correlate with the extent of IOP reduction, suggesting a possible relationship between mechanical decompression of the optic nerve head and structural preservation of axonal fibers [9]. Understanding these structural responses is crucial, as they may provide early indicators of surgical success beyond IOP control alone. Furthermore, documenting RNFL alterations post-surgery can aid in refining surgical indications, predicting prognosis, and optimizing patient counseling.

The current study was conducted on a cohort of patients from the Upgraded Department of Ophthalmology, Darbhanga, to evaluate changes in RNFL thickness using OCT before and after glaucoma filtering surgery. This study intends to add to the expanding body of knowledge regarding the significance of surgical intervention in both structural preservation of optic nerve health and functional IOP control by examining structural outcomes in addition to IOP reduction.

Methodology

Study Setting: The study was carried out in the Upgraded Department of Ophthalmology, Darbhanga, over a period of two years, from March 2023 to February 2025. The hospital caters to a large population, thus providing a suitable sample for retrospective data analysis.

Participants: The study comprised 50 patients with available preoperative and postoperative OCT scans who undergone glaucoma filtering surgery. Patients were only deemed eligible for inclusion if they had accurate and comprehensive medical records.

Inclusion Criteria

1. Patients diagnosed with primary or secondary glaucoma requiring filtering surgery.
2. Patients who had undergone OCT evaluation of RNFL thickness both before and after surgery.
3. Patients aged 18 years and above.
4. Patients with complete follow-up records for at least 3 months postoperatively.

Exclusion Criteria

1. Patients with media opacities such as corneal opacity or dense cataract that hindered OCT image quality.
2. Patients with retinal or neurological diseases affecting RNFL thickness (e.g., optic neuritis, retinal detachment, diabetic retinopathy).
3. Patients with incomplete medical records or inadequate OCT scans.

Bias: Selection bias was minimized by including all eligible patients meeting the inclusion criteria within the defined period. By making sure data extraction was carried out from consistent OCT reports and operational records, information bias was decreased. To reduce observer bias, all OCT scans were interpreted based on machine-generated values without subjective grading.

Data Collection: Relevant demographic, clinical, and surgical details were retrieved from patient records, including age, gender, diagnosis, type of glaucoma, surgical notes, and follow-up OCT findings. RNFL thickness values were specifically recorded for preoperative and postoperative periods to analyze changes over time.

Procedure: All patients included in the study had undergone glaucoma filtering surgery as per departmental protocol. Standard preoperative and postoperative OCT scans were performed using the same machine to ensure uniformity. Data regarding RNFL thickness in all quadrants were extracted and recorded systematically.

Statistical Analysis: Microsoft Excel was used to enter the data, and SPSS version 23.0 was used for analysis. For baseline characteristics, descriptive statistics were used. RNFL thickness values before and after surgery were compared using paired t-tests. P-values less than 0.05 were regarded as statistically significant.

Results

Fifty individuals who met the inclusion criteria and had glaucoma filtering surgery were examined. Participants' ages ranged from 34 to 72 years old, with a mean age of 54.6 ± 10.8 years. There were 22 (44%) ladies and 28 (56%) males among them. 14 patients (28%) had primary angle-closure glaucoma (PACG), whereas the majority of patients (36, 72%) had primary open-angle glaucoma (POAG).

Table 1: Baseline Demographic and Clinical Characteristics (n = 50)

Parameter	Value
Mean age (years) ± SD	54.6 ± 10.8
Gender (Male/Female)	28 (56%) / 22 (44%)
Type of glaucoma	POAG: 36 (72%) / PACG: 14 (28%)
Mean preoperative IOP (mmHg) ± SD	26.2 ± 4.5
Mean postoperative IOP (mmHg) ± SD	14.8 ± 3.1

The baseline clinical and demographic characteristics are summarized in Table 1. The majority of patients in the study group were diagnosed with POAG, and the gender distribution was balanced. After surgery, a notable decrease in IOP was noted.

Changes in RNFL Thickness

At the 3-month surgical follow-up, the mean worldwide RNFL thickness had improved to 89.6 ± 6.8 μm from its preoperative mean of 82.4 ± 7.2 μm. All quadrants showed statistically noteworthy increases in RNFL thickness.

Table 2: Comparison of RNFL Thickness Before and After Surgery

Quadrant	Preoperative (μm) Mean ± SD	Postoperative (μm) Mean ± SD	p-value
Superior	104.3 ± 10.6	112.5 ± 9.8	<0.001
Inferior	101.7 ± 9.5	109.2 ± 8.7	<0.001
Nasal	69.5 ± 8.2	73.8 ± 7.9	0.002
Temporal	54.1 ± 6.4	59.0 ± 6.1	0.001
Global	82.4 ± 7.2	89.6 ± 6.8	<0.001

The superior and inferior quadrants had the most improvement in RNFL thickness, as indicated by Table 2. Even while the absolute thickness was still lower than in the other quadrants, the temporal quadrant also shown a notable recovery.

IOP

After surgery, the mean IOP dropped from 26.2 ± 4.5 mmHg to 14.8 ± 3.1 mmHg. A statistically significant decrease was seen ($p < 0.001$).

Table 3: IOP Before and After Surgery

Parameter	Mean ± SD (mmHg)	p-value
Preoperative IOP	26.2 ± 4.5	
Postoperative IOP	14.8 ± 3.1	<0.001

Glaucoma filtering surgery significantly reduced intraocular pressure, which correlated with improvement in RNFL thickness, suggesting both structural and functional benefits.

Outcomes

- RNFL improvement observed in 44 (88%) patients, while 6 (12%) patients showed no significant change.
- Postoperative IOP control achieved in 46 (92%) patients.
- No major postoperative complications affecting OCT readings were recorded.

Discussion

The mean age of participants in this retrospective clinical research of 50 patients who had glaucoma filtering surgery was 54.6 years, and there were somewhat more men than women (56%). The most common diagnosis was primary open-angle glaucoma (72%), which was followed by primary angle-closure glaucoma (28%). IOP was found to have significantly decreased, with mean values falling from 26.2 mmHg before surgery to 14.8 mmHg after ($p < 0.001$).

In every quadrant, there was a noticeable improvement in the (RNFL) thickness. Preoperatively, the mean global RNFL thickness was 82.4 μm; postoperatively, it was 89.6 μm ($p < 0.001$). Among the quadrants, the superior and inferior regions demonstrated the greatest gains in thickness, while the temporal quadrant, though showing smaller absolute values, also improved significantly.

Overall, 88% of patients demonstrated measurable improvement in RNFL thickness following surgery, while IOP control was achieved in 92% of cases. No major postoperative complications were reported that could affect OCT imaging or the study outcomes.

According to the study's findings, glaucoma filtering surgery may help preserve or restore the RNFL's structural integrity, as determined by OCT, in addition to reducing intraocular pressure. The reduction in RNFL thickness, especially in the superior and inferior quadrants, suggests that

lowering IOP may improve axoplasmic flow and alleviate axonal stress, protecting the integrity of the optic nerve.

The postoperative increase in global RNFL thickness challenges the traditional belief that RNFL loss in glaucoma is irreversible. Instead, these results support the possibility of partial reversibility or artifact-related apparent thickening due to improved optic nerve head morphology after surgery. Furthermore, the high rate of IOP control observed emphasizes the functional success of the surgical intervention in preventing further glaucomatous damage.

Taken together, the study highlights the dual benefit of glaucoma filtering surgery—both in pressure control and in potential structural protection of the optic nerve fibers. These findings underscore the importance of early surgical intervention in advanced or uncontrolled glaucoma cases to preserve vision and optic nerve health.

Recent clinical studies have consistently shown that (RNFL) and ganglion cell complex (GCC) thickness decrease after glaucoma filtering surgery, especially in the first few months postoperatively. Kanamori et al. reported that both RNFL and macular GCC thickness decreased significantly within 6 months following trabeculectomy, likely reflecting structural remodeling and resolution of preoperative edema rather than glaucomatous progression [10]. Similarly, Miki et al. observed substantial RNFL thinning within the first 6 months after trabeculectomy, which then stabilized, suggesting an early postoperative effect rather than ongoing neurodegeneration [11]. Choi et al. evaluated RNFL and ganglion cell-inner plexiform layer (GCIPL) changes after glaucoma drainage implant surgery and found that thinning occurred mainly in the first 3 months, correlating with the degree of (IOP) reduction [12]. This suggests that postoperative structural changes may reflect mechanical decompression rather than true disease progression. Other longitudinal investigations confirmed this pattern of early thinning followed by stabilization. Several studies emphasized that OCT remains a sensitive tool for detecting these postoperative changes but clinicians must interpret early thinning cautiously to avoid overestimating glaucomatous progression [12].

More recent work also compared trabeculectomy and non-penetrating deep sclerectomy, reporting similar early RNFL thinning patterns, again attributed to IOP-related structural remodeling rather than progression [13]. Another study highlighted that the magnitude of thinning was proportional to the preoperative IOP reduction, reinforcing the role of biomechanical changes after filtration surgery [14]. Overall, evidence from multiple studies indicates that RNFL and GCC thinning in the early months after glaucoma filtering surgery is a common and expected phenomenon, largely due to postoperative tissue and biomechanical changes, with thickness stabilizing thereafter.

Conclusion

Glaucoma filtering surgery significantly reduced intraocular pressure and led to measurable improvement in RNFL thickness across all quadrants. These findings suggest that surgical intervention not only provides effective pressure control but also contributes to structural preservation of the optic nerve, highlighting the value of OCT in monitoring postoperative outcomes

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