RESEARCH PAPER

Evaluation of Structural Changes in Retinal Nerve Fiber Layer and Ganglion Cell Complex Layer Post Minimally Invasive Glaucoma Surgery

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ABSTRACT

Purpose: To evaluate postoperative structural changes in the retinal nerve fiber layer (RNFL) and ganglion cell complex (GCC) following minimally invasive glaucoma surgery (MIGS) using optical coherence tomography (OCT).

Study Design: Retrospective observational study.

Methods: A total of 51 eyes with mild to moderate open-angle glaucoma undergoing MIGS were included. Preoperative and postoperative OCT measurements of RNFL and GCC were analysed at baseline, 1 week, and 1 month. Only high-quality scans were included. Statistical analysis was performed using paired tests with significance set at $p < 0.05$.

Results: RNFL thickness showed mild postoperative variation: superior quadrant decreased from (94.9→91.8→92.0) µm, while nasal (76.4→79.6→80.3 µm), inferior (79.8→82.5→83.9 µm), and temporal (70.4→71.0→71.3 µm) quadrants showed slight increases (all $p < 0.001$ vs baseline). GCC thickness demonstrated a significant postoperative increase, with superior GCC rising from 84.0→88.1→88.6 µm and inferior GCC from 83.5→86.9→87.2 µm ($p < 0.001$). No significant differences were observed between 1 week and 1 month (RNFL: $p = 0.854$ 0.603, 0.212, 0.738; GCC: $p = 0.199$, 0.475), indicating early stabilization. No progressive thinning was observed.

Conclusion: RNFL and GCC remained structurally stable following MIGS, with mild postoperative changes likely attributable to transient physiological effects. OCT is useful in monitoring early postoperative changes; however, findings should be interpreted cautiously

Keywords: *Glaucoma, Minimally Invasive Glaucoma Surgery, Retinal Nerve Fiber Layer, Ganglion Cell Complex, Optical Coherence Tomography*

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Clinical Significance

MIGS procedures demonstrate short-term structural safety with no evidence of progressive retinal damage. OCT-based monitoring of RNFL and GCC can aid clinicians in distinguishing true disease progression from transient postoperative changes. These findings support the use of MIGS as a safe surgical option in glaucoma management. distinguishing true diseases progression from transient postoperative changes. These findings support the use of MIGS as a safe surgical option in glaucoma management.

List of Abbreviations

RNFL – Retinal Nerve Fiber Layer

GCC – Ganglion Cell Complex

MIGS – Minimally Invasive Glaucoma Surgery

OCT – Optical Coherence Tomography

INTRODUCTION

Glaucoma is a term describing a group of ocular disorders with multi-factorial etiology united by a clinically characteristic intraocular pressure-associated optic neuropathy.[1] Primary Open-Angle Glaucoma (POAG) and Primary Angle-Closure Glaucoma (PACG) represent the predominant forms of glaucoma.[2] Initial management involves topical hypotensive medications, often requiring

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multiple daily instillations.[3,4] Minimally Invasive Glaucoma Surgery (MIGS) aims to lower intraocular pressure (IOP) and reduce medication burden through a minimally invasive internal approach targeting aqueous outflow pathways such as Schlemm's canal, the suprachoroidal space, and the subconjunctival space.[5–9] MIGS may be performed alone or with cataract surgery.[10–12]

Structural assessment of glaucoma has been enhanced by Optical Coherence Tomography, enabling evaluation of the retinal nerve fiber layer (RNFL) and ganglion cell complex (GCC). [13] RNFL thinning reflects axonal loss, while GCC provides macular inner retinal assessment.[14–16] Structural changes often precede functional loss on perimetry, making these parameters important for early diagnosis and monitoring.[17–21] Progressive thinning correlates with disease severity and visual field deterioration.[22–26]

Although MIGS effectively reduces IOP and medication use, its impact on structural progression remains unclear.[27,28] Some studies report continued postoperative thinning suggesting disease progression, while others attribute early changes to biomechanical effects of IOP reduction rather than true neural loss.[29]

Understanding postoperative RNFL and GCC changes is important for distinguishing true progression from measurement variability or remodelling effects.[30] This study aimed to evaluate changes in RNFL and GCC following MIGS by comparing pre- and postoperative OCT parameters to clarify structural outcomes and its role in glaucoma management.

METHODS

Retrospective cross-sectional observational study was conducted to evaluate structural retinal changes following Minimally Invasive Glaucoma Surgery (MIGS) in patients with mild to moderate primary open-angle glaucoma. Patients attending the outpatient department of a tertiary care hospital who underwent MIGS, either as a standalone procedure or in combination with cataract surgery, were screened for eligibility. The study was approved by the Institutional Ethics Committee. Patients with advanced glaucoma, secondary glaucoma (including uveitic glaucoma), prior intraocular surgery, ocular trauma, or coexisting retinal or optic nerve pathology that could influence OCT measurements were excluded.

A total of eligible patients was included in the analysis. Preoperative baseline data were retrieved from medical records and imaging databases, including retinal nerve fiber layer (RNFL) thickness, and ganglion cell complex (GCC) thickness. Postoperative follow-up data were collected from the same sources at documented follow-up visits. All measurements were performed using Optical Coherence Tomography (spectral-domain OCT), ensuring consistency of imaging protocol across visits.

For OCT acquisition, peripapillary RNFL scans were obtained with a circular scan centered on the optic nerve head, providing global and quadrant-wise RNFL thickness values. GCC analysis was performed using macular cube scans encompassing the ganglion cell layer, inner plexiform layer, and retinal nerve fiber layer within the central macular region. All scans were carefully reviewed for image quality, and only those with adequate signal strength and absence of segmentation errors were included in the final analysis. A single experienced examiner performed or verified all OCT measurements to minimize inter-observer variability. The primary outcome measure was the change in RNFL and GCC thickness following MIGS. Structural and functional correlations were not included in the present analysis. All preoperative and postoperative values were tabulated for comparison.

Statistical analysis was performed using appropriate software. Continuous variables were expressed as mean ± standard deviation. Preoperative and postoperative RNFL, GCC values were compared using paired statistical tests after confirming normality assumptions. A p-value of < 0.05 was considered statistically significant. Additional subgroup analysis was performed where applicable to evaluate the influence of demographic variables on postoperative structural changes.

RESULTS

Retinal Nerve Fiber Layer (RNFL) Changes

RNFL thickness was analyzed in the superior, nasal, inferior, and temporal quadrants. Overall, all quadrants demonstrated a mild increase or stabilization in postoperative measurements difference was observed between 1 week and 1 month ($p = 0.854$), indicating early postoperative stabilization. compared to baseline, with statistically significant changes observed between preoperative and postoperative values.

Superior Quadrant

The mean superior RNFL thickness decreased slightly at 1 week but stabilized at 1 month. The overall change from baseline was statistically significant ($p < 0.001$), while no significant

Nasal Quadrant

The nasal RNFL showed a consistent increase from baseline to postoperative follow-ups, which was statistically significant ($p < 0.001$). However, no significant difference was observed between 1 week and 1 month ($p = 0.603$).

Table 1: RNFL Thickness (µm) – Superior and Nasal Quadrants

Parameter	*Pre-op*	*Post-op 1 Week*	*Post-op 1 Month*
Superior RNFL			
Superior RNFL			
Mean (µm)	*94.9*	*91.8*	*92*
Median (µm)	*91.5*	*90*	*90*
SD (µm)	*30.4*	*16.3*	*14.4*
Nasal RNFL			
Mean (µm)	*76.4*	*79.6*	*80.3*
Median (µm)	*76*	*79*	*83*

Inferior Quadrant

The inferior RNFL demonstrated a significant increase from preoperative to postoperative values ($p < 0.001$). The difference between 1 week and 1 month was not statistically significant ($p = 0.212$), indicating stability after early postoperative change.

Temporal Quadrant

The temporal RNFL showed a mild increase from baseline with statistical significance ($p < 0.001$). No significant difference was observed between postoperative visits ($p = 0.738$).

Table 2: RNFL Thickness (µm) – Inferior and Temporal Quadrants

Parameter	*Pre-op*	*Post-op 1 Week*	*Post-op 1 Month*
Inferior RNFL			
Mean (µm)	*79.8*	*82.5*	*83.9*
Median (µm)	*75*	*78*	*79*
SD (µm)	*17.6*	*19.8*	*18.3*
Temporal RNFL			
Mean (µm)	*70.4*	*71.0*	*71.3*
Median (µm)	*70*	*70*	*71*
SD (µm)	*13.7*	*10.1*	*9.4*

Ganglion Cell Complex (GCC)

Ganglion Cell Complex (GCC) Changes

GCC thickness showed a pattern similar to RNFL, with mild postoperative thickening and stabilization over time. No progressive thinning was observed.

Superior GCC

Mean superior GCC increased significantly from baseline to postoperative values ($p < 0.001$). No significant difference was observed between 1 week and 1 month ($p = 0.199$).

Inferior GCC

Inferior GCC thickness also showed a significant increase from preoperative to postoperative measurements ($p < 0.001$), with no significant change between postoperative visits ($p = 0.475$).

Table 3: GCC Thickness (µm)

Region	Pre-op Mean ± SD	Post-op 1 Week	Post-op 1 Month	p-value (Pre vs Post)	p-value (1W vs 1M)
Superior GCC	84.0 ± 10.1	88.1 ± 10.1	88.6 ± 10.3	<0.001	0.199
Inferior GCC	83.5 ± 9.58	86.9 ± 8.82	87.2 ± 8.15	<0.001	0.475

Early postoperative OCT showed no RNFL or GCC thinning after Minimally Invasive Glaucoma Surgery, with a mild but significant increase from baseline and no significant change between 1 week and 1 month, indicating early structural stabilization.

DISCUSSION

Minimally invasive glaucoma surgery (MIGS) has emerged as an effective approach for reducing intraocular pressure (IOP) with minimal tissue disruption and reduced dependence on topical medications. In the present study, early postoperative optical coherence tomography (OCT) evaluation demonstrated overall stability of retinal nerve fiber layer (RNFL) and ganglion cell complex (GCC) thickness at 1 week and 1 month following surgery, with no evidence of progressive structural deterioration.

Across RNFL quadrants, the superior quadrant showed a mild reduction in thickness, whereas the nasal, inferior, and temporal quadrants demonstrated slight increases. Similarly, GCC analysis showed significant postoperative increases in both superior and inferior regions. These findings suggest early structural changes after MIGS, without indicating glaucomatous progression.

Importantly, no significant differences were observed between 1 week and 1month values for either RNFL or GCC, indicating that these changes occur early and subsequently stabilize. The absence of continued thinning

supports the short-term structural safety of MIGS.[29,30] The mild postoperative increase in RNFL and GCC may reflect transient biomechanical and physiological effects following IOP reduction, such as improved axoplasmic flow, ocular perfusion changes, and tissue hydration shifts.[31] These reversible changes should not be interpreted as true neural recovery or disease progression.

The significant pre- and postoperative differences highlight the sensitivity of OCT in detecting subtle early structural variations.[32,33]However, early postoperative changes should be interpreted cautiously, as they may reflect reversible effects rather than permanent anatomical alterations.

Optical Coherence Tomography remains essential in glaucoma monitoring, helping distinguish true progression from postoperative variability. A key limitation is the short follow-up of one month; longer studies are needed to assess sustained structural stability after MIGS.

CONCLUSION

Minimally invasive glaucoma surgery (MIGS) provides effective intraocular pressure reduction while maintaining retinal structural integrity. Early postoperative OCT analysis demonstrated statistically significant changes in RNFL and GCC thickness compared to baseline; however, these changes were mild and stabilized by 1 month.

Importantly, no evidence of progressive RNFL or GCC thinning was observed, supporting the short-term structural safety of MIGS in patients with mild to moderate open-angle glaucoma. The observed changes are likely attributable to transient postoperative effects rather than true disease progression.

These findings support MIGS as a safe and effective surgical option. OCT remains a valuable tool for monitoring structural outcomes; however, early postoperative measurements should be interpreted with caution. Further long-term studies are necessary to confirm sustained structural preservation and long-term efficacy.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was conducted in accordance with the principles of the Declaration of Helsinki. As this was a retrospective study using anonymized patient data, formal ethical approval and informed consent were waived.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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