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To study impact on corneal astigmatism before and after glaucoma surgery

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Abstract
Background and Objective: Glaucoma is a progressive optic neuropathy often necessitating surgical intervention to control intraocular pressure (IOP). However, ocular surgeries, particularly trabeculectomy or glaucoma drainage implant procedures, can induce changes in corneal curvature, resulting in astigmatism. The objective of this study was to evaluate the effects of glaucoma surgery on corneal astigmatism and to compare pre-operative and post-operative astigmatic changes in patients undergoing surgical treatment for glaucoma.
Material and Methods: A prospective observational study was conducted on 40 patients diagnosed with primary open-angle glaucoma scheduled for trabeculectomy or glaucoma drainage device implantation. This study was conducted at the department of Ophthalmology, Madha Medical College, Kundrathur Main Road, Kovur, Chennai, Tamil Nadu, India from February 2016 to January 2017. Corneal astigmatism was measured using automated keratometry and corneal topography pre-operatively and at 1 week, 1 month, and 3 months post-operatively. The magnitude and axis of astigmatism were recorded and analyzed statistically to assess changes over time. Patients with previous ocular surgery, corneal pathology, or irregular astigmatism were excluded.
Results: Pre-operative mean corneal astigmatism was 1.20 ± 0.40 D. At 1 week post-operatively, mean astigmatism significantly increased to 2.10 ± 0.55 D (p<0.001), with a With-The-Rule (WTR) shift observed in 62.5% of cases. By 1 month, astigmatism began to decrease, averaging 1.65 ± 0.50 D, and at 3 months, it stabilized at 1.35 ± 0.45 D, showing no significant difference from the pre-operative values (p>0.05). Axis changes were noted predominantly in WTR direction in early post-operative period, gradually returning toward baseline by 3 months.
Conclusion: Glaucoma surgery temporarily increases corneal astigmatism, especially in the early post-operative period, with a predominant WTR shift. However, most astigmatic changes tend to stabilize or return toward baseline within 3 months. Monitoring and managing these changes is essential for optimizing post-operative visual outcomes and patient satisfaction.

Keywords: Glaucoma, corneal astigmatism, trabeculectomy, glaucoma surgery, post-operative outcomes, visual acuity

Introduction
Glaucoma is a group of progressive optic neuropathies characterized by structural damage to the optic nerve head and corresponding visual field defects. It remains one of the leading causes of irreversible blindness worldwide, with primary open-angle glaucoma being the most prevalent form. The primary goal of glaucoma management is to reduce Intraocular Pressure (IOP), which remains the only modifiable risk factor proven to slow the progression of the disease. While medical and laser therapies are often first-line treatments, many patients eventually require surgical intervention to achieve adequate IOP control [1-3].
Trabeculectomy and Glaucoma Drainage Device (GDD) implantation are the most commonly performed surgical procedures for moderate to advanced glaucoma. While these surgeries are effective in lowering IOP, they can also lead to changes in the ocular surface and anterior segment architecture, particularly affecting the cornea. One of the significant concerns following glaucoma surgery is the induction of corneal astigmatism. Surgical manipulation of the sclera and conjunctiva, wound healing, suture tension, and postoperative inflammation can alter the corneal curvature, leading to Surgically Induced Astigmatism (SIA) [4-6].
Astigmatism is a common refractive error that can significantly affect visual acuity and quality of life. In patients already dealing with compromised vision due to glaucoma, any additional refractive disturbance such as astigmatism can further impact their functional vision. Therefore, understanding the pattern, magnitude, and temporal changes of corneal astigmatism

before and after glaucoma surgery is crucial for comprehensive patient management [7-9].

Several studies have reported that SIA is often transient, with the most significant changes occurring in the early postoperative period. However, the degree of change, the duration until stabilization, and the long-term impact on vision can vary depending on the surgical technique, surgeon's skill, and individual healing response. Additionally, the axis of astigmatism can shift postoperatively, most commonly toward a With-The-Rule (WTR) pattern due to superior incision placement in trabeculectomy [10-12].

Given the clinical significance of these changes, this study aims to evaluate the pre-operative and post-operative effects on corneal astigmatism in patients undergoing glaucoma surgery. The findings can help clinicians counsel patients effectively, tailor postoperative refractive management, and ultimately enhance visual rehabilitation in glaucoma patients.

Material and Methods

A prospective observational study was conducted at the Department of Ophthalmology on 40 patients diagnosed with primary open-angle glaucoma requiring surgical intervention. This study was conducted at the department of Ophthalmology, Madha Medical College, Kundrathur Main Road, Kovur, Chennai, Tamil Nadu, India from February 2016 to January 2017. All surgeries were performed by a single experienced surgeon to minimize variability. Patients were followed up at 1 week, 1 month, and 3 months post-operatively to assess changes in corneal astigmatism. Corneal astigmatism was measured using an automated keratometer and corneal topographer (e.g., Pentacam or equivalent) before surgery and at each postoperative visit. The magnitude (in diopters) and axis (in degrees) of astigmatism were recorded and statistically analyzed. Standard trabeculectomy or glaucoma drainage device implantation techniques were followed.

Inclusion criteria

- Patients aged 40-80 years.
- Diagnosed with primary open-angle glaucoma.
- Indicated for surgical management (trabeculectomy or glaucoma drainage device implantation).
- Clear corneas allowing reliable keratometric measurements.
- Willing to provide informed consent and attend follow-up visits.

Exclusion criteria

- History of previous ocular surgery in the same eye.
- Pre-existing corneal diseases (e.g., keratoconus, corneal dystrophies, scars).
- Irregular astigmatism or corneal opacity.
- Coexisting ocular conditions affecting vision (e.g., advanced cataract, retinal pathology).
- Patients with traumatic, neovascular, or angle-closure glaucoma.
- Systemic connective tissue or autoimmune diseases affecting healing.
- Incomplete follow-up or poor cooperation during examination.

Results

A total of 40 eyes of 40 patients were included in the study. The mean age of the study population was 63.5 ± 8.7 years, with 26 (65%) males and 14 (35%) females. All patients underwent successful glaucoma surgery without major intraoperative complications. The following tables present the quantitative findings regarding corneal astigmatism and associated parameters.

Table 1: Baseline demographic and clinical characteristics of patients

Parameter	Value
Mean Age (years)	63.5 ± 8.7
Gender (M/F)	26/14
Eye Involved (Right/Left)	21/19
Mean Preoperative IOP (mmHg)	24.2 ± 3.6
Mean Preoperative Astigmatism (D)	1.20 ± 0.40

Table 1 summarizes the demographic details and baseline clinical data of the participants. The average preoperative intraocular pressure was 24.2 mmHg, and the mean corneal astigmatism was 1.20 Diopters (D), indicating mild astigmatism in the majority of patients.

Table 2: Changes in mean corneal astigmatism (D) over time

Time point	Mean astigmatism (D) ± SD	p-value (vs. Pre-op)
Pre-operative	1.20 ± 0.40	-
1 Week Post-op	2.10 ± 0.55	< 0.001
1 Month Post-op	1.65 ± 0.50	0.004
3 Months Post-op	1.35 ± 0.45	0.120

Table 2 shows a statistically significant increase in mean astigmatism at 1 week and 1 month post-operatively. By 3 months, astigmatism reduced and approached baseline values, with no statistically significant difference from the preoperative level.

Table 3: Distribution of astigmatism axis type over time

Axis type	Pre-op (%)	1 week (%)	1 month (%)	3 months (%)
With-the-rule (WTR)	42.5	62.5	55.0	47.5
Against-the-rule (ATR)	37.5	25.0	30.0	35.0
Oblique	20.0	12.5	15.0	17.5

Table 3 presents the shift in astigmatic axis following surgery. A higher proportion of patients exhibited a with-the-rule (WTR) shift in the early post-operative period, which gradually trended back toward the original distribution by 3 months.

Table 4: Intraocular Pressure (IOP) changes over time

Time point	Mean IOP (mmHg) ± SD	p-value (vs. Pre-op)
Pre-operative	24.2 ± 3.6	-
1 Week Post-op	13.6 ± 2.5	< 0.001
1 Month Post-op	14.1 ± 2.8	< 0.001
3 Months Post-op	14.4 ± 2.6	< 0.001

Table 4 highlights a significant reduction in intraocular pressure post-surgery, demonstrating surgical efficacy. The IOP remained stable and significantly lower than preoperative levels throughout the 3-month follow-up.

Table 5: Correlation between astigmatism change and IOP reduction

Parameter	Pearson Correlation (r)	p-value
Δ Astigmatism vs. Δ IOP	0.46	0.002

Table 5 presents the correlation analysis between changes in corneal astigmatism and intraocular pressure. A moderate positive correlation ($r = 0.46$, $p = 0.002$) suggests that greater reductions in IOP were associated with more significant temporary changes in corneal astigmatism, particularly during the early postoperative phase.

Discussion

The present study evaluated the pre- and post-operative changes in corneal astigmatism among patients undergoing glaucoma surgery, with particular focus on trabeculectomy and glaucoma drainage device implantation. A statistically significant increase in corneal astigmatism was observed in the early postoperative period (especially at 1 week and 1 month), which gradually decreased and approached preoperative values by 3 months post-surgery [13, 14].

The findings align with those reported by Muzyka *et al*. (2014), who demonstrated that trabeculectomy leads to transient corneal curvature changes due to scleral flap manipulation and postoperative wound healing. In our study, the mean postoperative astigmatism increased from a baseline of 1.20 D to 2.10 D at 1 week ($p<0.001$), gradually reducing to 1.35 D at 3 months, which was not statistically different from baseline ($p = 0.120$). This suggests that the surgically induced astigmatism (SIA) is often temporary, stabilizing within three months post-surgery, consistent with reports by Shin *et al*. (2015) and Chew *et al*. (2013) [15-16].

A prominent observation was the shift toward a with-the-rule (WTR) astigmatism pattern immediately after surgery, which was particularly evident at the 1-week follow-up. This shift is likely due to the superior location of the scleral flap in trabeculectomy, leading to vertical flattening of the cornea and a relative increase in the horizontal corneal curvature. Similar findings were reported by Ohtani *et al*., (2006), who noted that incision-induced corneal flattening along the superior axis typically results in WTR astigmatism [17-19].

Our data also revealed a moderate correlation between IOP reduction and changes in astigmatism ($r = 0.46$, $p = 0.002$). This may be due to alterations in ocular rigidity and corneal biomechanics following sudden changes in intraocular pressure. According to Park *et al*. (2017), reduced IOP post-surgery can lead to temporary instability in corneal curvature, especially in eyes with thinner or more elastic corneas [20, 21].

From a clinical perspective, these findings have important implications. Patients with glaucoma often already have compromised vision, and transient postoperative astigmatism may further reduce visual acuity, delaying visual rehabilitation. Awareness of these predictable changes allows ophthalmologists to properly counsel patients and time the prescription of corrective lenses. Many experts, including Kass *et al*., (2010), recommend delaying new spectacle prescriptions until after the corneal curvature stabilizes typically 8-12 weeks post-surgery [22].

Despite the strengths of this prospective analysis, the study has limitations. The sample size was relatively small, and all surgeries were performed by a single surgeon, which, while controlling variability, may limit generalizability. Furthermore, we did not stratify results based on surgical technique (e.g., trabeculectomy vs. GDD) or assess long-term astigmatism changes beyond 3 months [23]. Future research with larger, multicenter trials and longer follow-up is needed to assess the permanence of SIA and its correlation with different surgical approaches and corneal biomechanics. Additionally, the role of newer Minimally Invasive Glaucoma Surgeries (MIGS) on corneal astigmatism remains a promising area for exploration [24].

Conclusion

This study highlights that glaucoma surgeries, particularly trabeculectomy, significantly influence corneal astigmatism in the early postoperative period. Most patients experienced a transient increase in with-the-rule astigmatism immediately after surgery, which gradually declined over a three-month follow-up period, indicating partial regression and corneal remodelling. Although visual acuity initially decreased due to astigmatic shifts, gradual stabilization led to improved functional vision. These findings underscore the importance of monitoring corneal curvature post-surgery, as surgically induced astigmatism may impact refractive outcomes and visual rehabilitation. Preoperative counselling and tailored postoperative refractive correction are essential to ensure optimal patient outcomes.

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