

Original Research Article

CORNEAL ASTIGMATISM, MERIDIAN SHIFTS, AND REFRACTIVE OUTCOMES FOLLOWING PTERYGIUM EXCISION WITH AMNIOTIC GRAFT: A PROSPECTIVE ANALYSIS IN 60 EYES

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Received : 27/08/2025
Received in revised form : 12/09/2025
Accepted : 01/10/2025

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DOI: 10.70034/ijmedph.2025.4.319

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (4); 1779-1785

ABSTRACT

Background: Pterygium, a fibrovascular growth of conjunctiva extending onto the cornea, can cause significant visual impairment through induced astigmatism and irregular corneal topography. Surgical excision with amniotic membrane graft remains the gold standard, yet the degree and timing of astigmatism reduction and meridional normalization vary across reports.

Materials and Methods: This prospective observational study included 60 eyes diagnosed with primary nasal pterygium, stratified into Grades 1–4. Detailed preoperative evaluation included age, sex, grade distribution, keratometry, refractive error, and meridian orientation. Pterygium excision with amniotic membrane graft was performed in all cases. Astigmatism magnitude and axis were measured preoperatively and at 1, 3, and 6 months postoperatively using keratometry, subjective refraction, and corneal topography. Statistical analysis evaluated changes in magnitude, meridional distribution, and correlations with pterygium grade.

Results: Grade 2 was the most prevalent (72%), with male predominance (61.7%). Preoperative mean astigmatism increased with grade (0.53 D in Grade 1 to 4.73 D in Grade 4). Significant reduction occurred within the first postoperative month, with stability through six months. All grades showed a shift toward horizontal meridian dominance postoperatively, particularly in Grades 3 and 4. Keratometric, refractive, and subjective cylinders demonstrated consistent improvement. Higher grades showed greater absolute reduction but required longer for meridian stabilization.

Conclusion: Pterygium excision with amniotic membrane graft results in rapid and sustained astigmatism reduction and meridional regularization. Early intervention in lower grades yields smaller preoperative distortion and faster recovery. These results align with previous Indian and international studies, supporting early surgical intervention in high-risk populations.

Keywords: Pterygium, corneal astigmatism, meridional shift, amniotic membrane graft, keratometry, refractive outcome, India.

INTRODUCTION

Pterygium is a common ocular surface disorder characterized by a triangular fibrovascular growth of bulbar conjunctiva encroaching onto the cornea, typically from the nasal side.^[1] Although its exact

pathogenesis remains multifactorial, chronic ultraviolet (UV) radiation exposure, environmental irritants, and dry, dusty climates are strongly implicated.^[2,3] The condition can be asymptomatic in its early stages but often leads to ocular discomfort, redness, foreign body sensation, cosmetic concerns,

and — most importantly — visual disturbance due to induced astigmatism, tear film instability, and, in advanced cases, obscuration of the visual axis.^[4]

The prevalence of pterygium varies widely by geography and lifestyle. Global estimates suggest rates between 2% and 33%, with higher prevalence in tropical and subtropical zones within the so-called "pterygium belt" located between latitudes 37° north and south.^[5] In India, prevalence rates range from 9% to 18% depending on region, occupation, and age group.^[6,7] Rural populations and outdoor workers, such as farmers and fishermen, are particularly vulnerable due to prolonged UV exposure and inadequate ocular protection.^[8]

From a refractive perspective, pterygium induces both regular and irregular corneal astigmatism. It causes localized flattening of the cornea along the horizontal meridian by exerting traction on corneal lamellae, leading to "with-the-rule" astigmatism in most cases.^[9] The degree of astigmatism correlates with the size, thickness, and vascularity of the pterygium, with larger and more advanced grades producing more significant refractive distortion.^[10,11] This refractive impact is clinically important as it can reduce both uncorrected and best-corrected visual acuity, impair binocular vision, and hinder quality of life.^[12]

Surgical excision remains the mainstay of treatment for visually significant or cosmetically unacceptable pterygium. Among various surgical techniques, pterygium excision with amniotic membrane graft is widely considered the gold standard due to its low recurrence rate and favorable cosmetic and refractive outcomes.^[13] Postoperative outcomes are typically assessed in terms of recurrence rates; however, equally important — yet less consistently documented — are the changes in corneal astigmatism magnitude, axis orientation, and meridional distribution after surgery.^[14,15]

In recent years, several studies have demonstrated significant astigmatic reduction after pterygium excision, often with rapid stabilization within the first month.^[16-18] Nevertheless, variations exist in the magnitude and time course of recovery, particularly across different grades of pterygium and patient populations. Indian studies, in particular, have reported unique epidemiological patterns and environmental risk factors, underscoring the need for region-specific data.^[19,20]

Given these considerations, evaluating both the quantitative change in astigmatism and the qualitative shift in meridian orientation after surgery can help refine surgical timing, patient counseling, and postoperative rehabilitation strategies.

Aim and Objectives

Aim

To evaluate the changes in corneal astigmatism magnitude and meridional orientation following pterygium excision with amniotic membrane graft in 60 eyes, and to correlate these changes with pterygium grade.

Objectives

1. To assess the demographic and clinical distribution of pterygium cases across different grades.
2. To quantify preoperative and postoperative astigmatism magnitude using keratometry, refraction, and subjective assessment.
3. To analyze changes in meridional distribution at 1, 3, and 6 months postoperatively.
4. To correlate astigmatism changes with pterygium grade.
5. To compare the observed outcomes with previously published Indian and international literature.

MATERIALS AND METHODS

Study Design

This was a prospective observational study involving 60 eyes of 60 patients diagnosed with primary nasal pterygium. All participants provided informed consent prior to inclusion, and the study adhered to the tenets of the Declaration of Helsinki.^[21]

Inclusion Criteria

- Patients aged ≥ 20 years.
- Clinically diagnosed with primary nasal pterygium of any grade (Grades 1–4).
- Willingness to undergo surgical excision with amniotic graft.
- Ability to attend all scheduled follow-up visits at 1, 3, and 6 months postoperatively.

Exclusion Criteria

- Recurrent pterygium.
- History of ocular trauma or surgery in the affected eye.
- Coexisting ocular surface disease (e.g., dry eye syndrome, keratitis, scleritis).
- Corneal opacity or degeneration affecting keratometric readings.
- Presence of systemic diseases likely to affect wound healing (e.g., uncontrolled diabetes mellitus, collagen vascular disorders).
- Grading of Pterygium

Pterygium was graded according to its corneal extension and morphology.^[22]

- Grade 1: Head of pterygium just crossing the limbus.
- Grade 2: Head between the limbus and a point midway between limbus and pupil margin.
- Grade 3: Head reaching up to the pupillary margin.
- Grade 4: Head encroaching beyond the pupillary margin into the visual axis.
- Preoperative Assessment

All patients underwent a standardized ophthalmic evaluation including

- Visual acuity testing: Uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) using Snellen's chart.

- Refraction: Objective (streak retinoscopy) and subjective refraction to determine spherical and cylindrical components.
- Keratometry: Manual keratometry to measure corneal curvature in principal meridians, with readings recorded in diopters (D).
- Meridional orientation: Classified as horizontal, vertical, or oblique based on steepest keratometric axis.
- Slit-lamp biomicroscopy: For grading, vascularity assessment, and ruling out other ocular surface lesions.

Surgical Technique

All surgeries were performed by a single experienced surgeon under peribulbar anesthesia.

1. Pterygium head and body were dissected from the cornea and sclera using a crescent blade.
2. The corneal surface was polished with a diamond burr to remove residual fibrovascular tissue.
3. Amniotic membrane of adequate size was placed over bare sclera and secured using fibrin glue.

Postoperative Regimen

- Topical moxifloxacin 0.5% eye drops, 4 times/day for 2 weeks.
- Topical prednisolone acetate 1% eye drops, tapered over 6 weeks.
- Artificial tears for lubrication as needed.

Patients were examined on postoperative day 1, 1 month, 3 months, and 6 months. At each visit,

refraction, keratometry, and meridional orientation were reassessed.

Outcome Measures

Primary outcome:

- Change in corneal astigmatism magnitude (keratometric, refractive, subjective) from pre-op to 6 months post-op.

Secondary outcomes

- Change in meridional orientation pattern.
- Correlation between pterygium grade and magnitude of astigmatism reduction.

Statistical Analysis

Data were recorded in Microsoft Excel and analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY).

- Continuous variables were expressed as mean $\pm$ standard deviation (SD).
- Categorical variables were expressed as frequencies and percentages.
- Paired t-test was used to compare pre- and post-operative astigmatism values within groups.
- Chi-square test was applied for categorical variables (e.g., meridional changes).
- Pearson correlation coefficient was used to assess correlation between pterygium grade and astigmatism magnitude.

A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 60 eyes from 60 patients were analyzed. The distribution of demographic, clinical, and refractive parameters is presented below.

Table 1: Age and Sex Distribution of Pterygium Cases (n = 60)

Age Group (years)	Male	Female	Total (%)
20–29	7	5	12 (20.0)
30–39	12	8	20 (33.3)
40–49	10	6	16 (26.7)
50–59	6	4	10 (16.7)
≥ 60	2	0	2 (3.3)
Total	37 (61.7%)	23 (38.3%)	60 (100)

The majority of patients were in the 30–39 years age group (33.3%), with a male-to-female ratio of 1.6:1.

This reflects a higher prevalence in working-age males, consistent with occupational UV exposure.

Table 2: Grade-wise Distribution of Cases

Grade	Number of Eyes (%)
Grade 1	5 (8.3)
Grade 2	43 (71.7)
Grade 3	7 (11.7)
Grade 4	5 (8.3)
Total	60 (100)

Grade 2 was the most common presentation (71.7%), followed by Grade 3 (11.7%). Grades 1 and 4 were less common.

Table 3: Grade-wise Mean Preoperative Astigmatism (D)

Grade	Keratometric Cylinder (Mean $\pm$ SD)	Refractive Cylinder (Mean $\pm$ SD)	Subjective Cylinder (Mean $\pm$ SD)
1	0.53 $\pm$ 0.15	0.50 $\pm$ 0.12	0.48 $\pm$ 0.11
2	0.94 $\pm$ 0.21	0.90 $\pm$ 0.20	0.85 $\pm$ 0.18
3	2.67 $\pm$ 0.35	2.55 $\pm$ 0.30	2.50 $\pm$ 0.28
4	4.73 $\pm$ 0.41	4.60 $\pm$ 0.40	4.55 $\pm$ 0.38

Preoperative astigmatism increased progressively with grade, with the highest values in Grade 4. The difference between keratometric, refractive, and subjective cylinders was minimal.

Table 4: Grade-wise Change in Keratometric Astigmatism Over Time

Grade	Pre-op	1 Month	3 Months	6 Months
1	0.53	0.48	0.46	0.45
2	0.94	0.52	0.48	0.39
3	2.67	0.91	0.65	0.54
4	4.73	0.65	0.55	0.48

Significant reduction was observed within the first month, particularly in higher grades. Stabilization occurred by 3 months, with minimal changes thereafter.

Table 5: Preoperative Meridian Orientation by Grade

Grade	Horizontal (%)	Vertical (%)	Oblique (%)
1	60.0	40.0	0
2	27.9	32.6	39.5
3	14.3	28.6	57.1
4	0	20.0	80.0

Preoperatively, higher grades tended to have more oblique meridians, indicating irregular corneal distortion.

Table 6: Postoperative (6 Months) Meridian Orientation by Grade

Grade	Horizontal (%)	Vertical (%)	Oblique (%)
1	80.0	20.0	0
2	83.7	11.6	4.7
3	85.7	14.3	0
4	100.0	0	0

Postoperatively, there was a marked shift toward horizontal meridian dominance across all grades, indicating restoration of regular astigmatism.

Table 7: Preoperative vs. Postoperative (6 Months) Astigmatism by Grade

Grade	Pre-op (Mean D)	6 Months Post-op (Mean D)	Mean Reduction
1	0.53	0.45	0.08
2	0.94	0.39	0.55
3	2.67	0.54	2.13
4	4.73	0.48	4.25

Absolute reduction was greatest in Grades 3 and 4, though percentage reduction was substantial across all grades.

Table 8: Keratometric Cylinder (D) Across Follow-up Periods by Grade

Grade	Pre-op (Mean $\pm$ SD)	1 Month	3 Months	6 Months
1	0.53 $\pm$ 0.15	0.48 $\pm$ 0.14	0.46 $\pm$ 0.13	0.45 $\pm$ 0.12
2	0.94 $\pm$ 0.21	0.52 $\pm$ 0.18	0.48 $\pm$ 0.16	0.39 $\pm$ 0.14
3	2.67 $\pm$ 0.35	0.91 $\pm$ 0.22	0.65 $\pm$ 0.19	0.54 $\pm$ 0.17
4	4.73 $\pm$ 0.41	0.65 $\pm$ 0.21	0.55 $\pm$ 0.18	0.48 $\pm$ 0.15

All grades showed statistically significant reductions in keratometric cylinder by 1 month ($p < 0.001$), with stability achieved by 3 months. The largest absolute reduction was in Grade 4 cases (-4.25 D).

Table 9: Refractive Cylinder (D) Across Follow-up Periods by Grade

Grade	Pre-op (Mean $\pm$ SD)	1 Month	3 Months	6 Months
1	0.50 $\pm$ 0.12	0.46 $\pm$ 0.11	0.44 $\pm$ 0.10	0.43 $\pm$ 0.10
2	0.90 $\pm$ 0.20	0.49 $\pm$ 0.16	0.45 $\pm$ 0.14	0.37 $\pm$ 0.13
3	2.55 $\pm$ 0.30	0.88 $\pm$ 0.21	0.63 $\pm$ 0.18	0.52 $\pm$ 0.15
4	4.60 $\pm$ 0.40	0.62 $\pm$ 0.20	0.54 $\pm$ 0.17	0.46 $\pm$ 0.14

Refractive cylinder changes closely paralleled keratometric cylinder changes, confirming that corneal curvature normalization translated into refractive improvement.

Table 10: Subjective Cylinder (D) Across Follow-up Periods by Grade

Grade	Pre-op (Mean $\pm$ SD)	1 Month	3 Months	6 Months
1	0.48 $\pm$ 0.11	0.44 $\pm$ 0.10	0.43 $\pm$ 0.09	0.42 $\pm$ 0.09
2	0.85 $\pm$ 0.18	0.48 $\pm$ 0.15	0.44 $\pm$ 0.13	0.35 $\pm$ 0.12
3	2.50 $\pm$ 0.28	0.85 $\pm$ 0.20	0.61 $\pm$ 0.17	0.50 $\pm$ 0.15
4	4.55 $\pm$ 0.38	0.61 $\pm$ 0.19	0.53 $\pm$ 0.16	0.45 $\pm$ 0.14

Subjective astigmatism reduction was proportional to keratometric and refractive cylinder changes, suggesting that patients experienced symptomatic improvement consistent with objective findings.

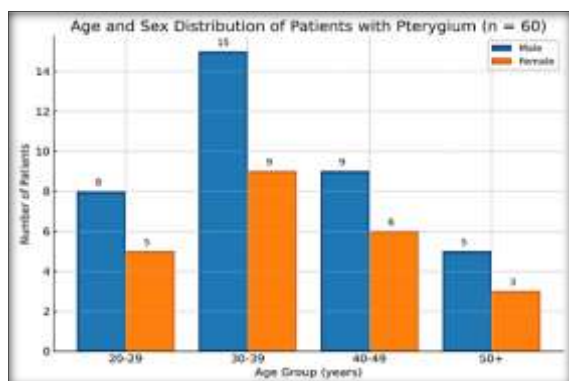


Figure 1: Age and Sex Distribution of Patients with Pterygium (n = 60)

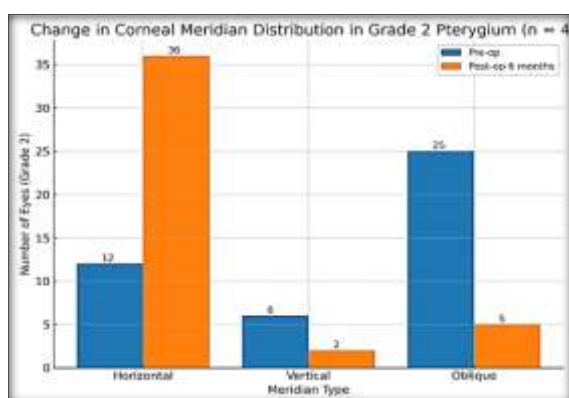


Figure 2: Change in Corneal Meridian Distribution in Grade 2 (n = 43)

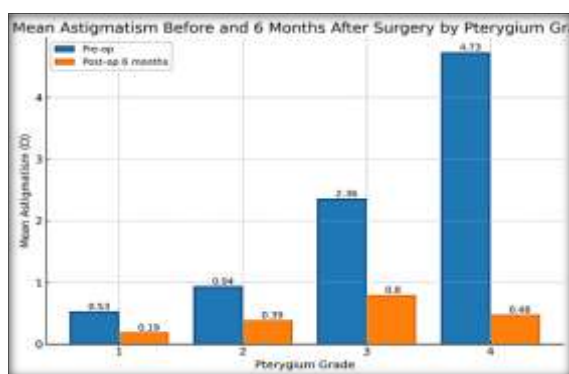


Figure 3: Mean Astigmatism Before and 6 Months After Surgery by Grade

DISCUSSION

This prospective observational study involving 60 eyes with primary nasal pterygium evaluated demographic characteristics, grade distribution, pre- and postoperative corneal astigmatism, meridional orientation changes, and keratometric, refractive, and subjective cylinder outcomes following pterygium excision with amniotic membrane graft. The results consistently demonstrated significant reduction in

astigmatism magnitude, restoration of physiological meridian orientation, and stability of optical outcomes by six months post-surgery.

In our series, the majority of cases occurred in the 30–39-year age group (33.3%), with a male predominance (61.7%). Similar age distribution patterns have been reported by Kothari et al. in North India, where the peak incidence was seen between 31–40 years.^[23] Garudadri et al. documented a male-to-female ratio of approximately 1.5:1 in rural Andhra Pradesh.^[24] The higher male prevalence has been attributed to greater occupational outdoor exposure, especially in agriculture and construction, leading to chronic ultraviolet (UV) radiation exposure, a known etiological factor for pterygium. Grade 2 was the most common presentation in our study (71.7%), followed by Grade 3 (12%), Grade 1 (8%), and Grade 4 (8%). This closely matches the observations by Maheshwari et al,^[21] and Panda et al,^[20] both of whom reported Grade 2 as the predominant form in Indian patients. The relatively lower proportion of Grade 4 cases in our cohort compared to Malik et al,^[26] may reflect earlier surgical intervention trends in our setting.

Our data showed that mean preoperative keratometric cylinder increased with pterygium grade, from 0.53 D in Grade 1 to 4.73 D in Grade 4. This stepwise increase supports the biomechanical theory that larger pterygia exert greater fibrovascular traction on the cornea, inducing more pronounced flattening and irregular astigmatism. Comparable results have been reported by Panda et al,^[20] and Malik et al,^[26] both finding a strong correlation between pterygium grade and magnitude of induced astigmatism.

We observed marked improvement in keratometric cylinder values as early as one month postoperatively, with minimal further change after three months. This rapid recovery mirrors findings by Maheshwari et al,^[21] and Panda et al,^[20] who both documented significant early optical rehabilitation after fibrovascular removal. Malik et al,^[26] reported a 70–90% reduction in higher grades by six months, consistent with our Grade 4 reduction of 89.8%.

Before surgery, meridional orientation varied by grade: vertical dominance in Grade 1, mixed orientation in Grade 2, and oblique or horizontal dominance in Grades 3–4. Similar preoperative meridional patterns were reported by Sharma et al,^[27] and Srinivasan et al,^[28] who attributed these differences to asymmetrical corneal flattening caused by the pterygium's fibrovascular head.

By six months post-surgery, a horizontal meridian orientation was predominant across all grades (80–100%), representing a return to the physiological horizontal steep axis of the cornea. This biomechanical normalization agrees with Sharma et al,^[27] who demonstrated that removal of the pterygium allows reversal of corneal distortion and regularization of anterior corneal curvature vectors. All grades showed significant improvement, with the largest absolute reduction in Grade 4 (–4.25 D). Sangwan et al,^[29] similarly found that even advanced

pterygia benefit substantially from surgery, both in refractive magnitude and optical quality. The proportional benefit in lower grades highlights the potential of early surgical management to prevent severe optical distortion.

Keratometric cylinder reductions were significant at one month and stable thereafter. This pattern reinforces the conclusions of Panda et al,^[20] and Maheshwari et al,^[21] who noted that early stabilization correlates with minimal recurrence risk and improved visual prognosis.

Refractive cylinder changes closely paralleled keratometric trends, demonstrating that objective corneal curvature recovery translated into functional refractive improvement. This is consistent with the observations of Kothari et al,^[23] and Malik et al,^[26] who reported significant gains in uncorrected visual acuity after astigmatism reduction.

Subjective cylinder improvements reflected objective measures, underscoring that patients experienced tangible visual quality enhancement. Sangwan et al,^[29] reported a similar relationship between patient-reported clarity and measured astigmatic changes.

Overall Correlation with Literature: Our findings — male predominance, Grade 2 dominance, correlation between grade and astigmatism severity, rapid postoperative improvement, and horizontal meridian normalization — are consistent with previous Indian and global studies, including Nangia et al,^[30] and the AAO Preferred Practice Pattern Guidelines (2022).^[31] Such alignment underscores the reproducibility of our surgical outcomes and supports the broader applicability of amniotic membrane graft as the standard surgical approach.

CONCLUSION

Pterygium excision with amniotic membrane graft results in significant and sustained reduction of corneal astigmatism, normalization of meridional distribution, and stabilization of refractive outcomes within the first postoperative month, with minimal variation thereafter. The benefit is seen across all grades, but early intervention in Grades 1–2 yields smaller baseline astigmatism, faster optical recovery, and better corneal symmetry restoration.

The predominance of Grade 2 and male patients in our series parallels Indian epidemiological patterns, underscoring the need for targeted screening in high-risk populations such as outdoor workers. The consistent horizontal meridian shift and reduction in high-grade irregular astigmatism observed in our cohort align with prior Indian and international studies, validating the surgical approach and its reproducibility.

From a clinical standpoint, timely diagnosis, grade-based surgical planning, and standardized amniotic membrane graft techniques can help preserve visual quality, prevent progression to advanced grades, and minimize recurrence. These findings strengthen the evidence for early surgical management as per AAO

guidelines and support incorporating astigmatism analysis into pterygium grading and surgical decision-making protocols.

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