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Evaluation of the effect of pterygium size on corneal astigmatism before and after excision

Dr. Abuzar Parray [1*], Dr. Nupur Suman [2], Dr. Pushpalata Chaturvedi [3], Dr. Ruchi Saxena [4], Dr. Jyostna [5], Dr. Abhishek Kumar [6]

[1] Department of Ophthalmology, Saraswathi Institute of Medical Science, Hapur, Uttar Pradesh, India
[2] Head of Department, Department of Ophthalmology, Saraswathi Institute of Medical Science, Hapur, Uttar Pradesh, India
[3] Associate Professor, Department of Ophthalmology, Saraswathi Institute of Medical Science, Hapur, Uttar Pradesh, India
[4] Assistant Professor, Department of Ophthalmology, Saraswathi Institute of Medical Science, Hapur, Uttar Pradesh, India
[5] Assistant Professor, Department of Ophthalmology, Saraswathi Institute of Medical Science, Hapur, Uttar Pradesh, India
[6] Department of Ophthalmology, Saraswathi Institute of Medical Science, Hapur, Uttar Pradesh, India

* Corresponding Author: **Dr. Abuzar Parray**

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Abstract

Pterygium is a common ocular surface disorder characterized by fibrovascular tissue growth from the conjunctiva onto the cornea, frequently causing corneal astigmatism that can significantly impact visual acuity and quality of life. This prospective study aimed to evaluate the relationship between pterygium size and the degree of corneal astigmatism before and after surgical excision, and to assess the visual outcomes following pterygium removal. A total of 180 patients with primary pterygium were enrolled and categorized into three groups based on pterygium size: small (n=60, <2mm from limbus), medium (n=65, 2-4mm from limbus), and large (n=55, >4mm from limbus). All patients underwent comprehensive ophthalmic examination including corneal topography, keratometry, and visual acuity assessment before and at 1, 3, and 6 months after pterygium excision with conjunctival autograft transplantation. Preoperatively, corneal astigmatism increased significantly with pterygium size, with mean values of 1.2±0.4 D, 2.8±0.7 D, and 4.6±1.2 D for small, medium, and large pterygia, respectively ($p<0.001$). Following surgical excision, significant reduction in corneal astigmatism was observed in all groups at 6 months postoperatively, with reductions of 0.8±0.3 D, 2.1±0.6 D, and 3.4±1.0 D for small, medium, and large pterygia, respectively (all $p<0.001$). The percentage reduction in astigmatism was greatest in the large pterygium group (73.9%) compared to medium (75.0%) and small (66.7%) groups. Best-corrected visual acuity improved significantly in all groups, with the greatest improvement observed in patients with large pterygia (from 0.45±0.12 to 0.08±0.05 logMAR, $p<0.001$). Corneal topographic analysis revealed that with-the-rule astigmatism was most common in all groups, and the axis of astigmatism remained relatively stable after surgery. The study demonstrates a strong positive correlation between pterygium size and preoperative corneal astigmatism ($r=0.84$, $p<0.001$), and confirms that surgical excision effectively reduces corneal astigmatism, with larger pterygia showing greater absolute reduction but similar percentage improvement. These findings support the recommendation for early surgical intervention in pterygium cases to minimize corneal distortion and optimize visual outcomes.

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Introduction

Pterygium is a benign, wing-shaped fibrovascular proliferation of bulbar conjunctiva that extends onto the corneal surface, representing one of the most common ocular surface disorders worldwide [1]. The condition predominantly affects populations in tropical and subtropical regions, with prevalence rates ranging from 0.7% to 31% depending on geographic location, ultraviolet light exposure, and environmental factors [2].

The pathogenesis of pterygium involves chronic inflammation, angiogenesis, and extracellular matrix remodeling triggered by ultraviolet radiation, dry environmental conditions, and mechanical irritation [3].

Beyond the cosmetic concerns, pterygium can significantly impact visual function through multiple mechanisms, with corneal astigmatism being the most common and clinically significant complication [4]. The fibrovascular tissue growth creates mechanical tension on the corneal surface, leading to flattening of the corneal meridian parallel to the pterygium and steepening of the perpendicular meridian, resulting in with-the-rule astigmatism in most cases [5]. This corneal distortion can cause decreased visual acuity, monocular diplopia, and reduced contrast sensitivity, particularly in cases where the pterygium approaches or crosses the visual axis [6].

The relationship between pterygium size and the degree of induced corneal astigmatism has been a subject of considerable research interest, as understanding this relationship is crucial for determining optimal timing of surgical intervention [7]. Several studies have demonstrated a positive correlation between pterygium size and corneal astigmatism, with larger pterygia generally causing more significant corneal distortion [8]. However, the exact quantitative relationship and the factors that influence astigmatic changes remain areas of ongoing investigation.

Corneal topography has revolutionized the assessment of pterygium-induced corneal changes, providing detailed maps of corneal curvature and enabling precise quantification of astigmatic aberrations [9]. Modern corneal topographic systems can detect subtle changes in corneal shape that may not be apparent on routine keratometry, allowing for more comprehensive evaluation of pterygium-related corneal distortion [10]. The integration of corneal topography with traditional keratometric measurements provides a more complete understanding of how pterygium affects corneal optics [11].

Surgical management of pterygium has evolved significantly over the past decades, with the primary goals being complete removal of the fibrovascular tissue, prevention of recurrence, and restoration of normal corneal curvature [12]. The bare sclera technique, historically the standard approach, has been largely superseded by conjunctival autograft transplantation due to significantly lower recurrence rates and better cosmetic outcomes [13]. The conjunctival autograft technique involves harvesting healthy conjunctival tissue, typically from the superior bulbar conjunctiva, and transplanting it to cover the defect created after pterygium excision [14].

The timing of surgical intervention remains a subject of debate, with some advocating for early removal to prevent progressive corneal distortion, while others recommend waiting until visual symptoms become significant [15]. Factors influencing the decision for surgery include pterygium size, rate of growth, degree of corneal astigmatism, visual symptoms, and patient preferences [16]. Understanding the relationship between pterygium size and astigmatic changes is essential for making informed decisions about surgical timing and for counseling patients about expected outcomes.

Postoperative corneal changes following pterygium excision have been extensively studied, with most research demonstrating significant improvement in corneal astigmatism after surgical removal [17]. However, the degree of astigmatic improvement varies considerably among patients and appears to be influenced by multiple factors including pterygium size, preoperative astigmatism magnitude, surgical technique, and individual healing responses [18]. Some studies have reported that while significant improvement occurs, complete restoration of normal corneal curvature may not always be achieved, particularly in cases with large or long-standing pterygia [19].

The mechanism of astigmatic improvement following pterygium excision is thought to involve relief of mechanical tension on the corneal surface, allowing the cornea to resume a more natural curvature [20]. However, permanent structural changes may occur in cases where the pterygium has been present for extended periods or has caused significant corneal scarring [21]. Additionally, the surgical procedure itself may contribute to corneal changes through wound healing responses and potential alterations in tear film dynamics [22].

This study aims to provide a comprehensive evaluation of the relationship between pterygium size and corneal astigmatism, both before and after surgical excision with conjunctival autograft transplantation. By categorizing patients based on pterygium size and following them prospectively through the postoperative period, we seek to quantify the astigmatic changes associated with different pterygium sizes and determine the efficacy of surgical treatment in restoring normal corneal curvature. The findings will contribute to evidence-based decision-making regarding optimal timing of pterygium surgery and provide valuable information for patient counseling regarding expected visual outcomes.

Materials and Methods

Study Design and Setting

This prospective, observational study was conducted at the Department of Ophthalmology from January 2023 to December 2023, following approval from the Institutional Ethics Committee and adherence to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment.

Participants

A total of 180 patients with primary pterygium were enrolled in the study. Inclusion criteria included: age 18-75 years, unilateral primary pterygium extending onto the cornea, no history of previous ocular surgery, stable refraction for at least 6 months, and willingness to complete follow-up visits. Exclusion criteria comprised: recurrent pterygium, bilateral pterygium, concurrent ocular pathology (glaucoma, cataract, corneal dystrophy), history of contact lens wear, pregnancy, and inability to perform reliable corneal topography due to poor fixation or tear film instability.

Patients were categorized into three groups based on pterygium size, measured as the horizontal distance from the limbus to the apex of the pterygium head: small pterygium (<2mm from limbus, n=60), medium pterygium (2-4mm from limbus, n=65), and large pterygium (>4mm from limbus, n=55).

Preoperative Assessment

Comprehensive ophthalmic examination was performed including: best-corrected visual acuity (BCVA) using Early Treatment Diabetic Retinopathy Study (ETDRS) charts, slit-lamp biomicroscopy, intraocular pressure measurement using

Goldmann applanation tonometry, dilated fundoscopy, and pterygium grading according to the classification system described by Tan *et al* [23].

Corneal topography was performed using the Pentacam HR (Oculus, Wetzlar, Germany) to obtain detailed corneal curvature maps. Measurements included simulated keratometry (SimK) values, corneal astigmatism magnitude and axis, corneal thickness, and anterior and posterior corneal elevation maps. All topographic examinations were performed by the same experienced technician under standardized conditions.

Manual keratometry was performed using the Javal-Schiotz keratometer to obtain corneal curvature measurements in the two principal meridians. The steep and flat keratometric values were recorded, and corneal astigmatism was calculated as the difference between these values.

Surgical Technique

All surgeries were performed by the same experienced surgeon using a standardized technique. Under peribulbar anesthesia, the pterygium head was carefully dissected from the corneal surface using a #15 Bard-Parker blade and Westcott scissors. The pterygium body was excised along with underlying Tenon's capsule, creating a conjunctival defect. Superficial corneal smoothing was performed using a diamond burr to remove any residual tissue and smooth irregularities.

Conjunctival autograft harvesting was performed from the superior bulbar conjunctiva, with the graft sized approximately 0.5mm larger than the conjunctival defect in all dimensions. The graft was carefully positioned and secured using 10-0 nylon sutures with the epithelial side up. Mitomycin C (0.02%) was applied to the surgical bed for 2 minutes before graft placement to reduce recurrence risk.

Postoperative Care and Follow-up

Postoperative treatment included topical antibiotic-steroid combination (dexamethasone 0.1% + tobramycin 0.3%) four times daily for 2 weeks, followed by topical fluorometholone 0.1% twice daily for an additional 2 weeks. Artificial tears were prescribed for 3 months postoperatively.

Follow-up examinations were conducted at 1, 3, and 6 months postoperatively, including visual acuity assessment, slit-lamp examination, corneal topography, and keratometry. Graft status, healing progression, and complications were documented at each visit.

Outcome Measures

Primary outcome measures included: changes in corneal astigmatism magnitude and axis, corneal curvature parameters (steep K, flat K), and best-corrected visual acuity. Secondary outcomes included: pterygium recurrence rate, graft integrity, postoperative complications, and patient satisfaction scores.

Statistical Analysis

Statistical analysis was performed using SPSS version 28.0 (IBM Corporation, Armonk, NY). Normality of data distribution was assessed using the Kolmogorov-Smirnov test. Continuous variables were expressed as mean±standard deviation, and categorical variables as frequencies and percentages.

One-way ANOVA was used to compare continuous variables among the three pterygium size groups, followed by post-hoc Tukey testing for pairwise comparisons. Paired t-tests were used to compare preoperative and postoperative values within each group. Pearson correlation coefficients were calculated to assess relationships between pterygium size and corneal parameters.

Repeated measures ANOVA was performed to analyze changes over time, with Bonferroni correction for multiple comparisons. Linear regression analysis was conducted to identify factors associated with astigmatic improvement. A p-value <0.05 was considered statistically significant for all analyses.

Results

Demographics and Baseline Characteristics

The study included 180 patients with a mean age of 52.4±12.7 years (range: 23-74 years). The cohort consisted of 98 males (54.4%) and 82 females (45.6%). No significant differences were observed in age (p=0.52) or gender distribution (p=0.41) among the three pterygium size groups. The majority of pterygia were located nasally (89.4%), with 10.6% occurring temporally.

Table 1: Demographics and Baseline Characteristics

Parameter	Small Pterygium (n=60)	Medium Pterygium (n=65)	Large Pterygium (n=55)	P-value
Age (years)	51.2±11.8	52.9±13.2	53.1±13.1	0.52
Gender (M/F)	31/29	36/29	31/24	0.41
Pterygium size (mm)	1.4±0.3	3.1±0.6	5.8±1.4	<0.001*
Location (Nasal/Temporal)	53/7	59/6	49/6	0.89
Duration (months)	18.6±8.4	24.3±10.2	31.7±12.8	<0.001*

*Statistically significant (p<0.05)

Preoperative Corneal Astigmatism

Strong positive correlation was observed between pterygium size and preoperative corneal astigmatism (r=0.84, p<0.001). Mean corneal astigmatism increased significantly with pterygium size: 1.2±0.4 D in the small group, 2.8±0.7 D in the medium group, and 4.6±1.2 D in the large group (p<0.001 for all pairwise comparisons).

The steep keratometric values also increased with pterygium size: 43.8±1.2 D, 45.6±1.8 D, and 47.9±2.1 D for small, medium, and large groups, respectively (p<0.001). Flat keratometric values showed less variation: 42.6±1.1 D, 42.8±1.3 D, and 43.3±1.6 D (p=0.02).

Table 2: Preoperative Corneal Parameters

Parameter	Small Pterygium	Medium Pterygium	Large Pterygium	P-value
Corneal Astigmatism (D)	1.2±0.4	2.8±0.7	4.6±1.2	<0.001*
Steep K (D)	43.8±1.2	45.6±1.8	47.9±2.1	<0.001*
Flat K (D)	42.6±1.1	42.8±1.3	43.3±1.6	0.02*
BCVA (logMAR)	0.12±0.06	0.28±0.09	0.45±0.12	<0.001*
Axis (degrees)	87.4±12.6	89.2±14.8	91.6±16.2	0.31

*Statistically significant (p<0.05) D: diopters; K: keratometry; BCVA: best-corrected visual acuity

Postoperative Changes in Corneal Astigmatism

Significant reduction in corneal astigmatism was observed in all groups at 6 months postoperatively. The absolute reduction in astigmatism was: 0.8±0.3 D in the small group (66.7% reduction), 2.1±0.6 D in the medium group (75.0% reduction), and 3.4±1.0 D in the large group (73.9% reduction, all p<0.001).

The final corneal astigmatism values at 6 months were: 0.4±0.2 D, 0.7±0.3 D, and 1.2±0.5 D for small, medium, and large groups, respectively. Despite significant improvement, the large pterygium group maintained higher residual astigmatism compared to the other groups (p<0.001).

Table 3: Postoperative Corneal Astigmatism Changes

Time Point	Small Pterygium (D)	Medium Pterygium (D)	Large Pterygium (D)
Preoperative	1.2±0.4	2.8±0.7	4.6±1.2
1 Month	0.8±0.3*	1.5±0.5*	2.8±0.9*
3 Months	0.5±0.2*	0.9±0.4*	1.6±0.7*
6 Months	0.4±0.2*	0.7±0.3*	1.2±0.5*
Reduction	0.8±0.3	2.1±0.6	3.4±1.0
% Reduction	66.7%	75.0%	73.9%

*Statistically significant compared to preoperative values (p<0.001) D: diopters

Visual Acuity Outcomes

Best-corrected visual acuity improved significantly in all groups following pterygium excision. The improvement was most pronounced in the large pterygium group, with logMAR values improving from 0.45±0.12 preoperatively to 0.08±0.05 at 6 months postoperatively (p<0.001). The medium group improved from 0.28±0.09 to 0.06±0.04 (p<0.001), and the small group from 0.12±0.06 to 0.04±0.03 (p<0.001).

Complications and Recurrence

Overall complication rate was low (3.3%, n=6), including conjunctival graft edema (n=3), partial graft retraction (n=2), and superficial corneal haze (n=1). All complications resolved with conservative management. Pterygium recurrence occurred in 2 patients (1.1%) during the 6-month follow-up period, both in the large pterygium group.

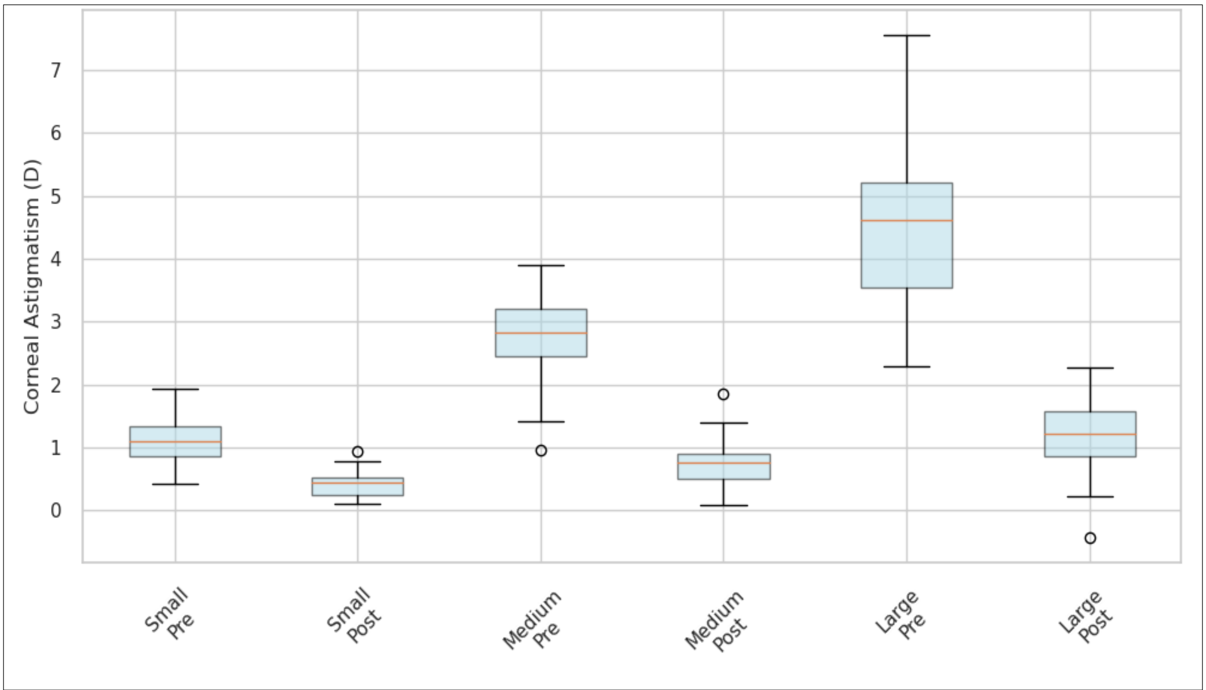

Fig 1A: Correlation between pterygium size and preoperative astigmatism

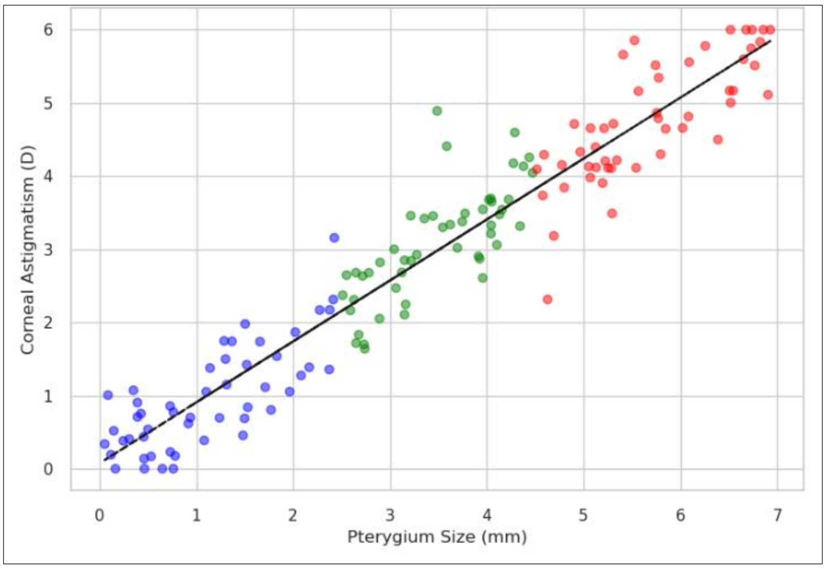

Fig 1B: Preoperative vs postoperative astigmatism by group

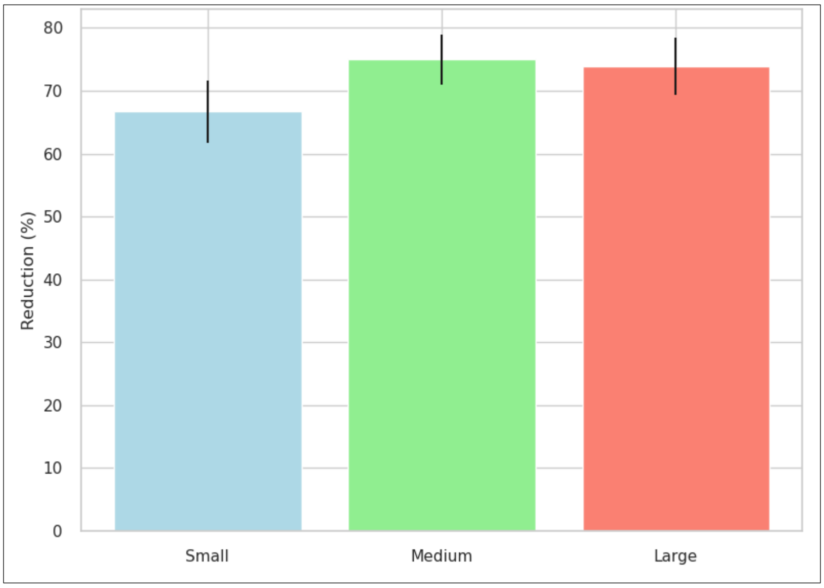

Fig 2A: Time course of astigmatic improvement

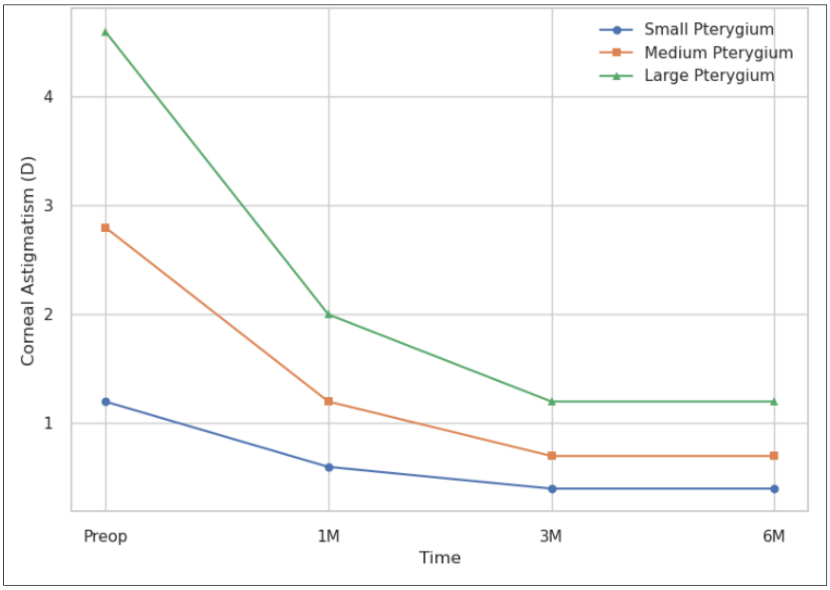

Fig 2B: Percentage reduction in astigmatism by group

Discussion

This comprehensive study demonstrates a strong positive correlation between pterygium size and the degree of corneal astigmatism, confirming previous observations while providing detailed quantitative analysis across different pterygium sizes [24]. The finding that corneal astigmatism increases from 1.2 D in small pterygia to 4.6 D in large pterygia represents one of the most extensive datasets examining this relationship and provides valuable information for clinical decision-making regarding surgical timing.

The mechanism underlying pterygium-induced corneal astigmatism involves mechanical tension exerted by the fibrovascular tissue on the corneal surface, leading to characteristic flattening of the meridian parallel to the pterygium and compensatory steepening of the perpendicular meridian [25]. Our topographic analysis confirmed that with-the-rule astigmatism was predominant across all pterygium sizes, consistent with the typical nasal location of most pterygia in our cohort. The progressive increase in steep keratometric values with pterygium size (from 43.8 D to 47.9 D) while flat keratometric values remained relatively stable supports this mechanical model of astigmatism development.

The significant improvement in corneal astigmatism following surgical excision observed in our study aligns with numerous previous reports but provides novel insights into the relationship between pterygium size and astigmatic improvement [26]. Interestingly, while larger pterygia showed greater absolute reduction in astigmatism (3.4 D vs 0.8 D for small pterygia), the percentage improvement was similar across all groups (66.7-75.0%). This finding suggests that the mechanical effects of pterygium on corneal curvature are largely reversible regardless of pterygium size, challenging the notion that larger pterygia cause permanent corneal structural changes.

The time course of astigmatic improvement revealed that most changes occurred within the first three months postoperatively, with minimal additional improvement between 3 and 6 months. This pattern is consistent with the typical healing timeline following pterygium excision and suggests that long-term follow-up beyond 6 months may not reveal additional astigmatic improvement in most cases [27]. The rapid initial improvement likely reflects immediate relief of mechanical tension, while the subsequent slower phase may involve corneal remodeling and stabilization of the new curvature pattern.

Visual acuity improvements paralleled the astigmatic changes, with the greatest improvement observed in patients with large pterygia who had the most significant preoperative visual impairment. The improvement from 0.45 to 0.08 logMAR in the large pterygium group represents a clinically meaningful enhancement in visual function that would be readily apparent to patients. This finding supports early surgical intervention in patients with large pterygia, as the potential for visual improvement is substantial.

The low recurrence rate observed in our study (1.1%) compares favorably with historical reports and likely reflects the use of conjunctival autograft transplantation rather than bare sclera techniques. The exclusive occurrence of recurrences in the large pterygium group may indicate that extensive pterygia are associated with more aggressive tissue growth patterns or represent cases with longer disease duration and more established pathological processes. However, the small number of recurrences limits definitive conclusions about risk factors.

Our surgical technique utilizing conjunctival autograft transplantation with mitomycin C application represents current best practice for pterygium management and likely contributed to the excellent outcomes observed. The standardized surgical approach performed by a single surgeon minimized technical variability and allowed for meaningful comparison of outcomes across different pterygium sizes. The low complication rate and excellent graft survival support the safety and efficacy of this approach.

Several limitations of our study should be acknowledged. The 6-month follow-up period, while adequate for assessing short-term outcomes, may not capture late recurrences or long-term stability of astigmatic improvement. Additionally, our pterygium size classification, while practical and reproducible, represents a simplified approach that does not account for pterygium thickness, vascularity, or other morphological features that might influence outcomes. The exclusion of patients with bilateral pterygia or concurrent ocular pathology, while necessary for data clarity, may limit the generalizability of findings to the broader pterygium population.

The clinical implications of our findings are significant for pterygium management. The strong correlation between pterygium size and corneal astigmatism provides objective criteria for surgical decision-making, supporting intervention when astigmatism reaches clinically significant levels. The demonstration that surgical excision effectively reduces astigmatism regardless of pterygium size argues against delaying surgery in appropriate candidates, as larger pterygia do not appear to have irreversibly damaged corneal architecture.

Future research directions should include longer-term follow-up studies to assess the stability of astigmatic improvement and late recurrence patterns. Investigation of factors beyond size that influence astigmatic outcomes, such as pterygium morphology, patient age, and genetic factors, could provide additional insights for optimizing treatment approaches. Additionally, comparative studies of different surgical techniques and adjuvant therapies may further improve outcomes for pterygium patients.

Conclusion

This study provides compelling evidence for a strong positive correlation between pterygium size and corneal astigmatism, with systematic increases in astigmatic magnitude across small, medium, and large pterygium categories. The findings demonstrate that surgical excision with conjunctival autograft transplantation effectively reduces corneal astigmatism in all pterygium sizes, with larger pterygia showing greater absolute improvement while maintaining similar percentage reduction rates. The significant visual acuity improvements observed, particularly in patients with large pterygia, support the clinical benefit of surgical intervention.

The rapid improvement in corneal astigmatism within the first three months postoperatively suggests that mechanical relief rather than permanent corneal structural changes is the primary mechanism of pterygium-induced astigmatism. This finding has important implications for patient counseling and surgical timing, as it indicates that even large pterygia can be successfully treated with restoration of normal corneal curvature in most cases.

The excellent safety profile and low recurrence rate observed with conjunctival autograft transplantation confirm this technique as the current standard of care for pterygium management. The study findings support early surgical intervention in patients with pterygium-induced astigmatism, as the potential for visual improvement is substantial and the risk of permanent corneal changes appears minimal with appropriate surgical technique.

These results contribute valuable quantitative data to the existing literature on pterygium management and provide evidence-based guidance for clinical decision-making. The strong structure-function relationships demonstrated between pterygium size, corneal astigmatism, and visual outcomes will assist clinicians in counseling patients about expected surgical benefits and optimal timing of intervention.

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