

Evaluation of Corneal Curvature Changes and its Correlation with Area of Pterygium Following Pterygium Surgery

Shreya Thatte*, Shlok O Singh, Garvesh Modi and Priyanshu Kaushal

Sri Aurobindo Medical College and PG Institute, Indore.

*Correspondence:

Dr. Shreya Thatte, Professor and Head of Department, Department of Ophthalmology, Sri Aurobindo Medical College and PG Institute, Indore, Madhya Pradesh, India, Tel: 9302104864.

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ABSTRACT

Purpose: To assess the changes in corneal curvature indices following pterygium surgery and its correlation with total, triangular (corneal) part, trapezoidal (bulbar conjunctival) part of area of pterygium.

Background: Pterygium, a fibrovascular growth on the ocular surface, frequently induces change in corneal curvature leading to astigmatism. This effect is due to mechanical traction and tear film pooling. (10). This induced astigmatism increases with increase grade of pterygium. (11) It was our observation that in the same grade of pterygium there is substantial variability in corneal curvature changes, which suggests that some other factor which can induce traction on the corneal surface is also responsible for pterygium induced astigmatism. Hypothetically we thought of surface area of pterygium may have effect of mechanical traction the corneal surface. Therefore, this study was conducted to evaluate effect of surface area of anatomical subdivision of pterygium, corneal triangle as well as conjunctival trapezoid to induce corneal astigmatism by measuring this area and co relating with postoperative corneal curvature changes (induced astigmatism) in patients undergoing pterygium excision.

Methods: A cross-sectional, non-interventional study was conducted on 80 patients with primary pterygium. Surface area was calculated using standard geometrical formulas for triangular (corneal) and trapezoidal (bulbar conjunctival) regions. Keratometric readings (K1 and K2) were obtained preoperatively and three months post pterygium surgery. Data were statistically analyzed to assess correlations between both surface area and keratometric changes.

Results: The mean increase in K1 and K2 values showed a statistically significant progressive trend with increasing pterygium grades ($p < 0.05$). However, both total surface area and its anatomical parts demonstrated significant correlations with keratometric increases. Specifically, higher total area, triangular area, and trapezium area were associated with greater postoperative keratometric shifts ($p < 0.001$ in most subgroups).

Conclusion: The extent of change in corneal curvature in pterygium is not only affected by grade of the pterygium but surface area of pterygium its variables as total, corneal triangular and conjunctival trapezoid anatomical subdivisions also play a vital role in inducing astigmatism. Both the triangular and trapezium components contribute significantly to astigmatic refractive changes. Quantitative area of pterygium assessment should complement grading to assess amount of induced astigmatism.

Keywords

Pterygium, Corneal Curvature, Keratometry, Surface Area, Astigmatism.

Introduction

Pterygium, a triangular fibrovascular proliferation extending onto the corneal surface, is known to disrupt corneal architecture and induce significant refractive changes, particularly astigmatism [1,2]. There are two primary mechanisms are described in literature

for this induced astigmatism: pooling of the tear film at the apex of the pterygium and mechanical traction exerted by the pterygium on the corneal surface, resulting tension flattens the corneal surface and alters its curvature [1].

A direct relationship has been demonstrated between the clinical grade of pterygium and the extent of corneal topographic alteration [3]. However, notable variation was observed in astigmatic severity even among pterygia within the same grade. This discrepancy was also detected in a parallel investigation, examining pterygium area in relation to dry eye severity [4]. In this study reported data show that in Grade 2 pterygia, K1 values ranged from 0.05 to 2.63 diopters and K2 values from 0.01 to 2.74 diopters, indicating that factors beyond clinical grading contribute to corneal distortion.

Biomechanically, the tractional force exerted by the pterygium is likely influenced by its surface area, as force correlates proportionally with tissue size [1]. Hence, it can be hypothesized that a larger area exerts greater force on the cornea, resulting in more pronounced curvature changes and astigmatism.

Pterygium anatomy includes two distinct regions: the triangular corneal portion and the trapezoid bulbar conjunctival component. While both may influence corneal biomechanics, their individual contributions to curvature alteration and refractive error remain inadequately understood.

Therefore, the present study was aimed to quantitatively assess corneal curvature changes following pterygium surgery and to explore their correlation with pterygium area—both in total and in its distinct anatomical parts (triangular and trapezoid). These findings may contribute to more refined clinical grading systems and inform surgical planning, thereby enhancing visual outcomes in patients undergoing pterygium surgery.

Material and Methods

This cross-sectional, non-interventional study was conducted in 80 patients diagnosed with primary pterygium of varying grades, selected according to predefined inclusion and exclusion criteria. The primary aim was to evaluate corneal curvature changes following pterygium surgery and to analyze their correlation with the surface area of the pterygium and its anatomical subdivisions. Ethical clearance was obtained from the Institutional Ethics Committee, and written informed consent was taken from all participants in accordance with the Declaration of Helsinki.

Inclusion and Exclusion Criteria

Patients of either gender and of any age group, clinically diagnosed with primary pterygium and willing to undergo surgical excision and come for follow up for a 3-month postoperatively, were included in the study. Exclusion criteria comprised patients with prior ocular surgeries, history of ocular trauma, corneal scars, use of contact lenses, diagnosed corneal diseases, or co-existing ocular pathologies such as glaucoma and uveitis. Patients with any systemic or ocular condition likely to affect corneal curvature were also excluded.

Methodology

Patient Evaluation and Preoperative Assessment

A detailed demographic and clinical profile were documented for each participant, including past medical and surgical history. All patients underwent comprehensive ocular examination, including slit-lamp biomicroscopy, visual acuity testing, and keratometric assessment using a standard autorefractor-keratometer or corneal topographer. The surface area of the pterygium was assessed in terms of its total area and its two anatomical components—the triangular-shaped corneal part and the trapezoid-shaped bulbar conjunctival part.

Surface Area Calculation

Standard geometrical formulae were used for surface area estimation (Figure 1)

- **Corneal (triangular) component:**

$$\text{Area} = \frac{1}{2} \times \text{Base (L)} \times \text{Height (C)}$$

where L is the limbal length and C is the extent of corneal encroachment.

- **Conjunctival (trapezoidal) component:**

$$\text{Area} = \frac{1}{2} \times (L+W) \times H$$

where W is the width at the medial canthus and H is the maximal distance from the limbus to the medial canthus in temporal gaze, approximated at 6 mm. These calculations allowed estimation of the mechanical influence of each anatomical part of the pterygium as depicted in Figure (2&3).

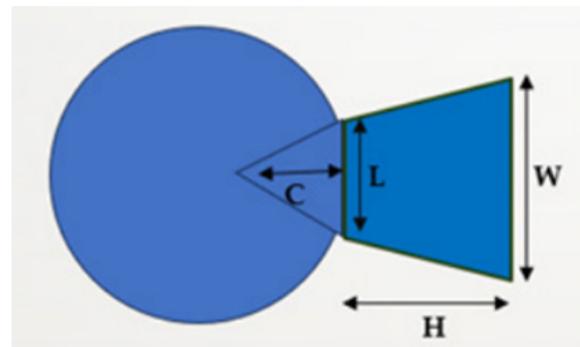


Figure 1: Diagram illustrating various parameters to calculate area of pterygium.

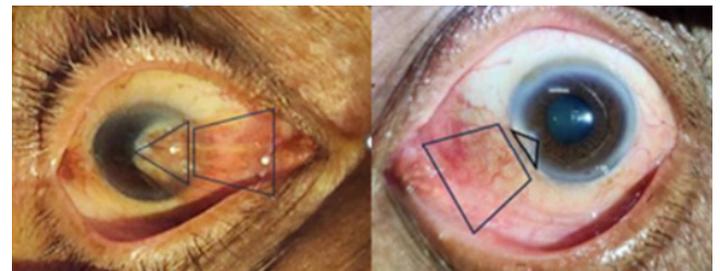


Figure 2: Grade 4 Nasal Pterygium. **Figure 3:** Grade 2 Nasal Pterygium.

Surgical Procedure and Follow-Up

All patients underwent standard pterygium excision with conjunctival limbal autograft under aseptic precautions.

Postoperative care was administered as per protocol. At 3 months postoperatively, repeat keratometric readings were obtained to assess corneal curvature stabilization.

Postoperative keratometric indices—including K1, K2, and corneal astigmatism—were statistically analyzed and correlated with the measured surface area of the pterygium. Comparisons were also drawn between the grades of pterygium and corneal curvature changes to determine effect and relation of both grade and surface area of pterygium on change in corneal curvature.

Statistical Analysis

All data collected during the study were systematically compiled and entered into Microsoft Excel and subsequently analyzed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as mean ± standard deviation (SD) for continuous variables such as keratometric indices, and as frequencies and percentages for categorical variables such as gender and pterygium grade. The distribution of data was assessed using the Shapiro-Wilk test to determine normality. For normally distributed variables, comparisons between preoperative and postoperative keratometric values were made using the paired t-test. For non-normally distributed data, the Wilcoxon signed-rank test was applied.

Correlation analyses between the surface area of the pterygium (total area, corneal triangular part, and conjunctival trapezoidal part) and the changes in keratometric readings (K1, K2) were performed. Pearson’s correlation coefficient was used for parametric data, while Spearman’s rank correlation was employed for non-parametric data. The strength of the correlation was interpreted based on standard thresholds, ranging from very weak ($r = 0.00-0.19$) to very strong ($r = 0.80-1.00$). A p-value of less than 0.05 was considered statistically significant in all analyses.

Results

The study included a total of 80 patients diagnosed with primary pterygium. The mean age of the participants was 50.75 ± 12.40 years, with the youngest patient aged 24 years and the oldest 84

years, indicating that pterygium affects a broad adult age range. A female predominance was observed in the study, with 50 females (62.5%) and 30 males (37.5%), resulting in a male-to-female (M:F) ratio of 1:1.6. Regarding clinical grading, the majority of cases belonged to **Grade 2** (65%), followed by **Grade 3** (25%), while **Grade 1** and **Grade 4** were less common, comprising 3.8% and 6.3% respectively. This suggests that a significant proportion of patients presented with moderate-grade pterygium, indicating a possible delay in seeking medical attention or faster progression in certain individuals (Table 1).

Table 1: Clinico-Demographic Profile of Study Participants (n = 80).

Variable	Subcategory	Frequency (n)	Percentage (%)
Age (years)	Mean ± SD	-	50.75 ± 12.40
	Minimum	-	24
	Maximum	-	84
Gender	Male	30	37.5%
	Female	50	62.5%
	M:F Ratio	-	1 : 1.6
Pterygium Grade	Grade 1	3	3.8%
	Grade 2	52	65.0%
	Grade 3	20	25.0%
	Grade 4	5	6.3%

The keratometric differences (K1 and K2) showed an increasing trend with advancing grades of pterygium, with Grade 4 exhibiting the highest mean differences (K1 = 1.45, K2 = 1.60). Notably, these variations were statistically significant ($p = 0.008$ for K1, $p = 0.004$ for K2), indicating a meaningful association between pterygium grading and corneal curvature changes. This suggests that higher-grade pterygia are more likely to cause significant corneal distortion, reinforcing the need for timely clinical intervention and highlighting the utility of keratometric evaluation in guiding management decisions (Table 2).

The mean total surface area and both triangular and trapezoid components were highest in Grade 4 pterygium. Grades 2 and 3 had comparable mean areas, suggesting substantial fibrovascular proliferation even in intermediate grades (Table 3).

Table 2: Keratometric (K1 and K2) Differences Across Pterygium Grades.

Grade	Frequency (%)	K1 Diff				K2 Diff			
		Mean	SD	Min	Max	Mean	SD	Min	Max
Grade 1	3(3.8%)	0.30	0.15	0.15	0.50	0.40	0.20	0.20	0.60
Grade 2	52(65%)	0.75	0.35	0.20	1.60	0.78	0.40	0.20	1.70
Grade 3	20(25%)	1.05	0.40	0.40	1.80	1.20	0.50	0.50	2.00
Grade 4	5(6.3%)	1.45	0.50	0.80	2.20	1.60	0.55	0.90	2.30
p value		0.008				0.004			

Table 3: Pterygium Surface Area (Total, Triangle, Trapezium) by Grade.

Grade	Frequency (Percentage)	TOTAL				TRIANGLE				TRAPEZIUM			
		Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Grade 1	3(3.8%)	45.33	7.51	41.00	54.00	4.33	1.15	3.00	5.00	41.00	8.66	36.00	51.00
Grade 2	52(65%)	65.42	22.45	29.00	140.00	13.78	8.02	5.00	39.37	51.64	16.42	24.00	112.00
Grade 3	20(25%)	63.54	18.71	35.00	106.50	13.61	7.33	5.00	29.25	49.83	13.22	30.00	84.00
Grade 4	5(6.3%)	73.75	21.58	41.25	100.00	12.80	6.60	7.50	20.00	60.95	21.34	32.25	92.50
p value		0.326				0.234				0.354			

As, Grade 2 pterygium showed variable range of keratometric changes (K1, K2) and different surface area's (total, triangular and trapezoid) with minimum and maximum values. We analyzed the correlation between various surface area's and keratometric changes within the same grade to determine the contribution of surface area of pterygium in induced corneal astigmatism.

Keratometric increases (both K1 and K2) showed a positive correlation with the total pterygium area within same grade (grade 2) cases. Groups with larger surface areas (>80 mm²) exhibited significantly higher mean increases in corneal curvature (K1 and K2) compared to those with smaller areas (<40 mm²). The association was statistically significant (p < 0.001 for both K1 and K2 increases), highlighting that larger total pterygium encroachment contributes meaningfully to corneal distortion (Table 4).

The triangle area of the pterygium also showed a statistically significant correlation with keratometric changes within same grade (grade 2) cases. As, the triangular area increased from Group 1 to Group 3, the mean increase in K1 and K2 also rose significantly (p < 0.001 and 0.002 respectively). However, baseline keratometric values (Pre K1 and Pre K2) were not significantly different, suggesting that the triangular component of pterygium predominantly affects corneal curvature without influencing baseline readings (Table 5).

In the analysis of the trapezium area, a clear increasing trend in both K1 and K2 differences was observed with increasing area groupings within same grade (grade 2 cases). Particularly, Group 6 (trapezium area 70–80 mm²) showed the highest increases in

keratometric values (K1 = 1.58, K2 = 1.50). The results were statistically significant (p < 0.001 for both K1 and K2 differences), supporting the notion that broader trapezoidal extension of pterygium contributes substantially to corneal distortion (Table 6).

Discussion

This study comprehensively evaluated the effect of primary pterygium on corneal curvature using keratometric indices (K1 and K2), while examining its correlation with surface area and anatomical subtypes of the pterygium. The results affirm the clinical observation that pterygium induces significant astigmatic changes in the cornea, particularly as the lesion progresses in grade and surface coverage.

The mean age of the study population was 50.75 years, consistent with global literature suggesting pterygium predominantly affects middle-aged and older adults due to cumulative UV exposure and environmental irritants. The observed female predominance (62.5%) is notable and may reflect greater cosmetic concerns or healthcare-seeking behaviour among women. However, this finding varies across geographic regions and studies, where male predominance has also been reported due to occupational sun exposure.

The keratometric differences (K1 and K2) progressively increased with advancing grades of pterygium, with Grade 4 showing the highest mean values, indicating a stronger association between lesion grading and corneal distortion. The differences were statistically significant across grades (p = 0.008 for K1 and p = 0.004 for K2), suggesting a meaningful correlation between the extent of pterygium and its impact on corneal curvature. These findings

Table 4: Total Area Correlation with Mean Keratometric Increase (K1 and K2) in Grade 2 pterygium.

Variables	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	p value
	<40 (n=6)	40-50 (n=15)	50-60 (n=15)	60-70 (n=18)	70-80 (n=7)	80-90 (n=8)	90-100 (n=7)	>100 (n=4)	
Pre K1	43.14 ± 0.95	43.93 ± 1.65	43.09 ± 1.40	43.54 ± 1.35	43.75 ± 1.50	44.25 ± 2.77	41.61 ± 2.67	43.31 ± 1.66	0.13
Pre K2	44.09 ± 1.31	44.98 ± 2.13	43.93 ± 1.30	44.85 ± 1.66	44.26 ± 1.93	45.34 ± 2.79	43.57 ± 1.88	44.23 ± 1.28	0.437
Mean increase in K1	0.15 ± 0.19	0.40 ± 0.12	0.74 ± 0.31	0.90 ± 0.38	1.09 ± 0.15	1.19 ± 0.38	1.25 ± 0.87	1.75 ± 0.58	<0.001
Mean increase in K2	0.31 ± 0.48	0.42 ± 0.37	0.76 ± 0.37	1.02 ± 0.18	1.08 ± 0.11	0.87 ± 0.40	1.20 ± 0.81	1.82 ± 0.60	<0.001

Table 5: Triangle Area Correlation with Keratometric Parameters in Grade 2 pterygium.

Variables	Group 1 (1–10, n=24)	Group 2 (10–20, n=15)	Group 3 (20–30, n=13)	p value
Pre K1	43.49 ± 1.41	43.34 ± 1.53	43.81 ± 2.41	0.768
Pre K2	44.53 ± 1.58	44.13 ± 1.83	44.61 ± 2.49	0.761
Mean increase in K1	0.48 ± 0.38	0.87 ± 0.40	1.20 ± 0.71	<0.001
Mean increase in K2	0.57 ± 0.43	0.89 ± 0.26	1.19 ± 0.72	0.002

Table 6: Trapezium Area Correlation with Keratometric Parameters in Grade 2 pterygium.

Variables	Group 1 (20–30, n=4)	Group 2 (30–40, n=10)	Group 3 (40–50, n=11)	Group 4 (50–60, n=13)	Group 5 (60–70, n=9)	Group 6 (70–80, n=5)	p value
Pre K1	43.56 ± 0.87	43.92 ± 1.86	43.57 ± 1.50	43.15 ± 1.05	43.75 ± 2.95	42.96 ± 1.37	0.884
Pre K2	44.73 ± 0.97	44.81 ± 2.20	44.47 ± 1.53	44.11 ± 1.37	44.75 ± 3.10	43.44 ± 1.00	0.794
Mean increase in K1	0.095 ± 0.10	0.44 ± 0.20	0.70 ± 0.432	0.83 ± 0.42	0.97 ± 0.39	1.58 ± 0.91	<0.001
Mean increase in K2	0.16 ± 0.30	0.534 ± 0.39	0.75 ± 0.40	0.93 ± 0.27	0.94 ± 0.36	1.50 ± 0.94	<0.001

highlight that higher-grade pterygia are more likely to induce significant corneal changes, reinforcing the importance of early intervention in advanced cases (Table 2). This aligns with findings by Mohammad-Salih and Sharif [5], who also noted increased corneal astigmatism in higher-grade pterygia, with statistical variability. Verma S et al. [6] highlighted those progressive and fleshy pterygia, categorized as Group B and C, were associated with more pronounced corneal surface irregularities, increased asymmetry, and significantly higher levels of astigmatism compared to the atrophic type (Group A). This suggests that the morphological characteristics and aggressiveness of the pterygium play a critical role in the extent of corneal distortion, thereby influencing visual outcomes.

Surface area analysis further revealed that both total area and its subcomponents (triangle and trapezium) increase with pterygium grade. While Grades 2 and 3 had comparable areas, Grade 4 pterygium showed the largest mean areas in all measurements, consistent with more extensive tissue proliferation. However, the lack of statistically significant differentiation between grades (Table 3) may suggest overlapping dimensions among intermediate lesions or variable tissue thickness and vascularity contributing to the corneal effect. Similarly, Verma et al. [6] also highlighted that total surface area correlated strongly with grade of pterygium.

The strongest correlations in this study were observed between total surface area and keratometric changes. Patients with pterygia larger than 80 mm² had significantly higher mean increases in K1 and K2, with values rising progressively across area groups. The results were statistically significant ($p < 0.001$), emphasizing that not just the grade but the physical extent of encroachment is a critical factor in inducing corneal distortion (Table 3). This finding is in agreement with studies by Kampitak et al. [7] and Avisar et al. [8], which highlighted surface area is also one of the predictors of corneal astigmatism along with clinical grading.

Similarly, in study by Abdussamad HM et al., [9] who also reported a strong positive correlation between the pterygium encroachment area and induced astigmatism ($r = 0.727$, $p < 0.001$), particularly when the pterygium extended >4 mm over the cornea ($r = 0.802$, $p < 0.001$), further supporting the role of surface area over mere clinical grading.

Additionally, Thatte S et al. [4] observed a significant correlation between increasing surface area of pterygium and severity of dry eye symptoms, with patients in the >85 mm² group showing moderate to severe dry eye disease. This complements our findings by further validating that larger surface area not only worsens corneal curvature but also affects ocular surface health, supporting the multifactorial visual impact of progressive pterygia.

Anatomical component analysis showed that the triangular area, often indicative of the visible body of the pterygium on slit-lamp examination, was also significantly correlated with increases in K1 and K2 ($p < 0.001$ and $p = 0.002$, respectively). Interestingly, the preoperative K1 and K2 did not vary significantly across triangle

area groups, reinforcing the notion that the triangle segment affects induced rather than baseline curvature (Table 4). This supports the anatomical theory that fibrovascular advancement into the cornea exerts a tractional effect, steepening its curvature.

Similarly, the trapezium component—which extends deeper into the limbal and subconjunctival areas—was found to have the most consistent and pronounced effect on corneal curvature. The highest keratometric increases were observed in patients with trapezium areas between 70–80 mm², with statistically significant correlations for both K1 and K2 ($p < 0.001$ each) (Table 5). This emphasizes the influence of the deeper structural component on corneal biomechanics, possibly due to subepithelial fibrosis and chronic inflammation.

Overall, this study reinforces the clinical relevance of pterygium morphology and size in determining visual impact. While traditional grading provides a general sense of severity, quantification of surface area—especially the trapezoidal and triangular components—offers a more precise prediction of corneal distortion. These insights, are crucial in surgical planning, patient counseling, and anticipating refractive outcomes.

This study is subject to certain limitations. The relatively modest sample size and cross-sectional design constrain the ability to assess postoperative changes and long-term outcomes. Surface area quantification did not incorporate lesion depth or vascularity, which may have led to an underestimation of the true biomechanical impact of pterygium. Additionally, morphological characteristics such as thickness or vascular pattern were not evaluated. The lack of postoperative corneal topography and reliance on manual grading systems may have introduced measurement variability. To substantiate and refine these observations, future research with larger cohorts and longitudinal follow-up, incorporating advanced imaging modalities, is strongly recommended.

Conclusion

This study highlights a positive correlation between the surface area of pterygium—especially its triangular (corneal) and trapezoidal (conjunctival) components—and the degree of induced corneal curvature changes (K1 and K2). While clinical grading alone did not show statistically significant keratometric differences, surface area parameters—particularly in larger lesions—were significantly associated with greater keratometric increases and corneal distortion. These findings suggest that quantitative surface area assessment offers a more precise predictor of refractive impact than grade-based classification alone. Incorporating area-based evaluation into routine clinical assessment may enhance surgical planning and improve visual outcomes in patients undergoing pterygium excision.

References

1. Mahdy MA, Bhatia J. Treatment of primary pterygium: Role of limbal stem cells and conjunctival autograft transplantation. *Eur J Ophthalmol*. 2009; 19: 729-732.

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2. Youn J, Ryang W. The effect of pterygium surgery on contrast sensitivity and corneal topographic changes. *Clin Ophthalmol*. 2010; 4: 315-319.
 3. Yagmur M, Ozcan AA, Sari S, et al. Visual acuity and corneal topographic changes related with pterygium surgery. *J Refract Surgery*. 2005; 21: 166-170.
 4. Thatte S, O Singh S, Modi G. Correlation of Pterygium Induced Severity of Dry Eye Disease with Total Surface Area of Pterygium. *Mathews J Ophthalmol*. 2023; 7: 34.
 5. Mohammad-Salih PA, Sharif AF. Analysis of pterygium size and induced corneal astigmatism. *Cornea*. 2008; 27: 434-438.
 6. Verma S, Bhatkoti B, Chauhan R. Evaluation of corneal topographic changes following pterygium surgery and correlation with size of pterygium. *J Med Sci Health*. 2020; 6: 31-39.
 7. Kampitak K. The effect of pterygium on corneal astigmatism. *J Med Assoc Thai*. 2003; 86: 16-23.
 8. Avisar R, Loya N, Yassur Y, et al. Pterygium-induced corneal astigmatism. *Isr Med Assoc J*. 2000; 2: 14-15.
 9. Abdussamad HM, Joma AK. The relation between pterygium size and refractive astigmatism among a group of patients in Erbil city. *Zanco J Med Sci*. 2018; 22: 141-147.
 10. Stern G, Lin A. Effect of pterygium excision on induced corneal topographic abnormalities. *Cornea*. 1998; 17: 23-27.
 11. Seitz B, Gutay A, Kuchle M, et al. Impact of pterygium size on corneal topography and visual acuity a prospective clinical cross-sectional study. *Klin Mobil Augenheilkd*. 2001; 218: 609-615.