Use of Pentacam in Assessment of Corneal Changes after Pterygium Excision

Running Title: *Use of Pentacam in assessment of corneal changes after pterygium excision*

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Abstract

Introduction: Pterygium, a common ocular surface condition, is characterized by the growth of fibrovascular tissue from the conjunctiva onto the cornea. This growth disrupts the visual axis and induces changes in corneal topography, leading to astigmatism and other refractive errors.

Objective: This work aims to assess corneal changes induced by pterygium and the effect of pterygium surgery on these changes using the Pentacam system.

Patients and Methods: This prospective interventional study included 30 eyes of 30 patients with primary pterygium undergoing pterygium removal surgery. Complete ophthalmological examination, uncorrected (UCVA) and best corrected visual acuity (BCVA), and Pentacam imaging were performed preoperatively and 3 months postoperatively. Pterygium was graded preoperatively. Outcome measures included changes in UCVA, BCVA, subjective refraction, and Pentacam-derived corneal parameters after pterygium excision.

Results: Postoperatively, there was insignificant improvement in UCVA ($p=0.106$) and BCVA ($p=0.724$). The mean postoperative subjective cylinder-D was significantly ($p=0.008$) lower (-0.98 ± 0.1) than the preoperative value (-2.03 ± 0.4). Pentacam astigmatism showed significant improvement postoperatively ($p=0.032$). Changes in logMAR BCVA, subjective cylinder, and Pentacam astigmatism were significantly correlated with pterygium grade ($p < 0.001$ for all).

Conclusion: Pterygium surgery improved visual, refractive, and corneal topographic parameters. The magnitude of improvement was proportional to the pterygium grade. Pentacam was useful in quantifying the corneal changes pre- and postoperatively. Further studies with longer follow-ups are warranted to evaluate long-term outcomes.

Keywords: Pterygium, Pentacam, corneal topography, Astigmatism, Visual acuity.

Introduction:

Pterygium is a common ocular surface disease characterized by triangular fibrovascular growth of bulbar conjunctiva encroaching onto the cornea, typically on the nasal side (1). The leading cause is believed to be ultraviolet (UV) exposure, making it more prevalent in tropical climates, outdoor workers, and older adults (2). In Egypt, pterygium surgery rates range from 9-30% due to increased UV exposure from sunlight and hot, dry khamsin winds (3).

Patients experience foreign body sensation, tearing, inflammation, and blurred vision as pterygium progresses.

Advanced pterygium can induce significant astigmatism

and obscure the optical center, reducing visual acuity (4). The fibrovascular growth is hypothesized to cause corneal flattening by disrupting tear film and exerting pressure on the cornea (5). Histologically, pterygium demonstrates elastotic collagen degeneration and fibrovascular proliferation under an epithelial covering (1).

Pterygium management ranges from lubricants and anti-inflammatory medications to surgical excision using bare sclera, conjunctival autografts with or without mitomycin-C (MMC), and amniotic membrane grafts (6). Although primarily done for symptomatic or cosmetic relief, surgery has improved corneal topography and refractive parameters (7). However, outcomes vary based on surgical approach and pterygium morphology (8).

Corneal topography mapping allows corneal shape, elevation, thickness, and refractive power analysis. Systems like Pentacam (Oculus Optikgeräte GmbH) use rotating Scheimpflug cameras to image anterior segment anatomy from the corneal surface to the posterior lens (9). High-resolution elevation and pachymetry maps are extremely useful in grading ectatic diseases, planning refractive surgery, and evaluating corneal disorders (10).

Prior studies have evaluated corneal changes before and after pterygium surgery using Scheimpflug imaging. However, limited research compares outcomes between different excision techniques or correlating results with pterygium size and morphology. Quantifying surgically induced modifications with Pentacam can guide future refractive treatments and long-term management (11).

Therefore, this study aimed to assess corneal changes caused by varying grades of pterygium and the effect of simple excisional surgery on these changes using preoperative and postoperative Pentacam imaging parameters.

Patients and Methods:

This prospective interventional study enrolled 30 eyes of 30 adult patients undergoing primary pterygium excision at the Ophthalmology Department of Assiut University Hospital from January 2019 to December 2021.

The inclusion criteria were adults with primary unilateral pterygium. **Exclusion criteria** were recurrent pterygium, ocular media opacities, prior ocular surgery/trauma, contact lens use, other corneal diseases, and dry eye.

A complete ophthalmological examination was performed before and 3 months after surgery. Uncorrected (UCVA) and best corrected visual acuity (BCVA) were tested using a Snellen chart and converted to LogMAR values. Slit lamp biomicroscopy, intraocular pressure measurement, and dilated fundus examination were done. Corneal topography and pachymetry were evaluated by the Oculus Pentacam (Pentacam HR, V.1.15r4 n7; Oculus Optikgeräte GmbH, Wetzlar, Germany).

Pentacam imaging was standardized using dim illumination, proper alignment, and fixation. The following parameters were analyzed - flat and steep keratometry (K1, K2), maximum K, mean K, anterior corneal astigmatism, pachymetry at the thinnest location, and Q-value.

Pterygium morphology was graded preoperatively based on translucency and corneal encroachment in grades 1 (atrophic), 2 (intermediate), and 3 (fleshy) (1).

All surgeries were performed by the same surgeon using pterygium excision with conjunctival flap technique under local anesthesia. After excision, the bare sclera was covered by mobilizing a conjunctival flap secured with interrupted sutures. Figure 1 shows the Pterygium Excision Steps.

Postoperatively, topical antibiotic-steroid drops were prescribed 4 times daily with gradual tapering over 4 weeks. In addition, all patients were prescribed topical lubricants after surgery to facilitate healing and comfort.

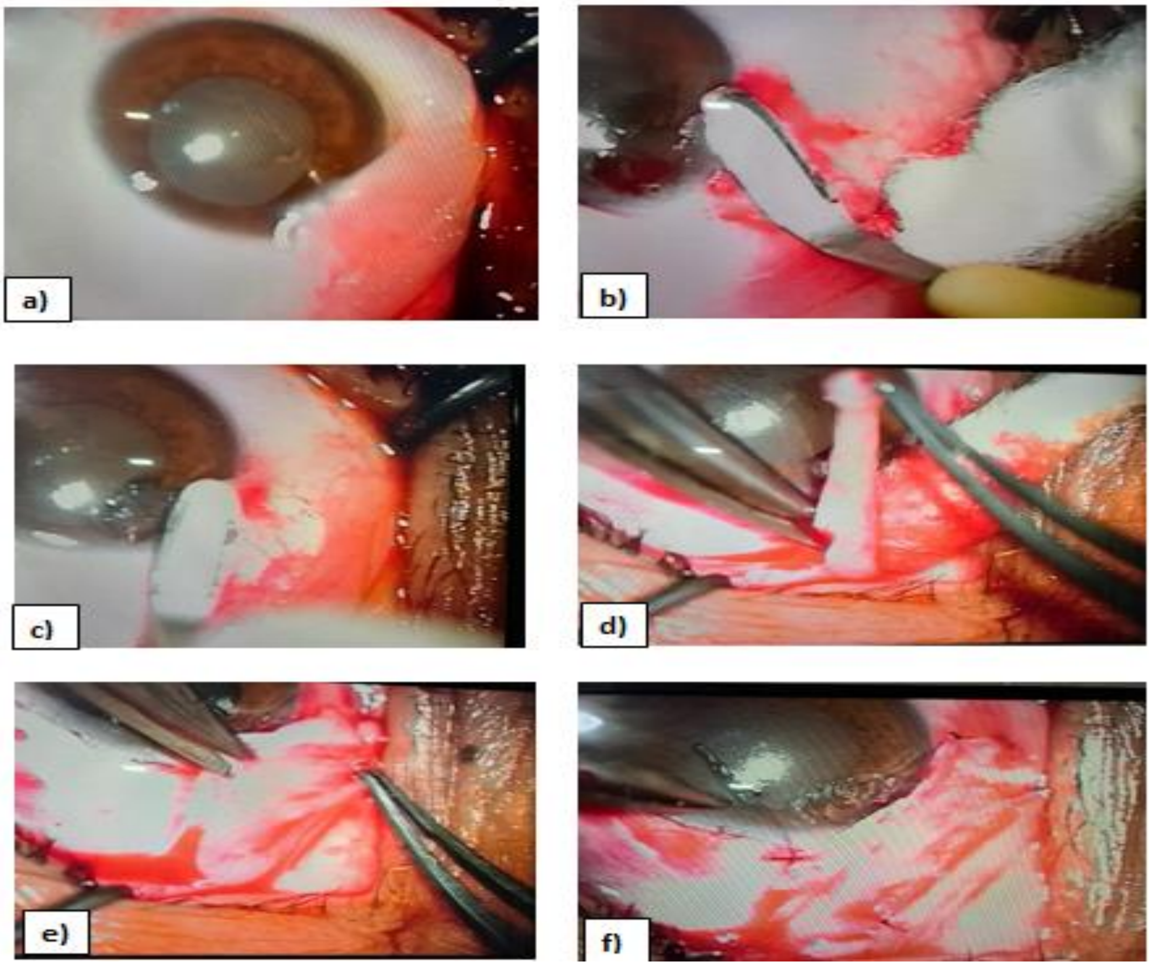

Figure 2: Pterygium Excision Steps—(a, b) Pterygium head removal, (c) adjacent conjunctival and Tenon's tissue excision, and (d, e) conjunctival flap coverage, finalized by (f) suture placement.

Ethical Considerations:

The `Medical Ethics Committee, Assiut Faculty of Medicine, approved and monitored the study. IRB# **04-2024-200738**. All patients provided informed consent to take part in this study. Furthermore, all authors have examined and agreed to the copyright policies within our research system.

Statistical Analysis:

The data analysis was executed using the statistical software SPSS, version 19.0, from SPSS Inc., located in Chicago, Illinois, USA. Standard data summaries such as means, standard deviations, medians, and ranges were calculated. Normality tests were conducted to check if the continuous variables were normally distributed using appropriate tests. Chi-square tests were used to compare differences in frequency distributions between groups. Paired t-tests or related samples Wilcoxon signed rank tests examined differences in means or medians of repeated measurements. One-way ANOVA with Bonferroni post-hoc tests evaluated mean differences between groups with more than two categorical, continuous variables. Statistical significance was set at $p < 0.05$.

Results:

This study included 30 patients with primary pterygium. The median age was 43 (range 26-59), and most were males (93.3%). The right eye was affected in 46.7% of cases and the left eye in 53.3% of cases. Based on grading, 40% had grade 1, 46.7% had grade 2, and 13.3% had grade 3 pterygium (Tables 1)

Table (1): Baseline Characteristics of the Studied Cohort

Variable	Category	n = 30
Age/years	• Mean ± SD	44.53 ± 8.1
	• Median (Range)	43 (26 – 59)
Sex	• Female	2 (6.7%)
	• Male	28 (93.3%)
Eye	• Right	14 (46.7%)
	• Left	16 (53.3%)
Grade of Pterygium	• Grade I	12 (40%)
	• Grade II	14 (46.7%)
	• Grade III	4 (13.3%)

SD: Standard deviation

There was a slight improvement in uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA) after surgery, but it was statistically insignificant (Table 2). The postoperative median UCVA was 0.6 versus 0.5 preoperatively (p=0.106), while the mean BCVA changed from 0.907 to 0.920 (p=0.724).

Table (2): Effect of Operation on the Patient's Visual Acuity

	Time (n=30)		P-value
	Preoperative	**Postoperative**	
UCVA			
• **Mean SD**	0.587 ± 0.3	0.660 ± 0.2	= 0.106*
• **Median (Range)**	0.5 (0.2 – 1.0)	0.6 (0.4 – 1.0)	
BCVA			
• **Mean SD**	0.907 ± 0.2	0.920 ± 0.1	= 0.724**
• **Median (Range)**	1.0 (0.5 – 1.0)	1.0 (0.5 – 1.0)	

UCVA: Uncorrected visual acuity, **BCVA**: Best corrected visual acuity, **SD**: Standard deviation

However, the study found significant changes in refractive parameters (Table 3). However, median sphere power was unchanged (p=0.789), and the mean subjective cylinder reduced significantly from -2.03D preoperatively to -0.98D postoperatively (p=0.008). Unlikely, the mean postoperative subjective spherical equivalent was insignificantly (p = 0.390) higher (-0.18 ± 0.3) than the preoperative value (-0.55 ± 0.3).

Table (3) Effect of Operation on the Patient's Refractive Parameters

	Time (n=30)		P-value
	Preoperative	**Postoperative**	
Spherical Power			
• **Mean SD**	0.476 ± 0.3	0.301 ± 0.3	= 0.789*
• **Median (Range)**	(-2.0 – 4.0)	0.5 (-2.0 – 4.0)	
Subjective Cylinder-D			
• **Mean SD**	-2.033 ± 0.4	-0.983 ± 0.1	= 0.008**
• **Median (Range)**	-1.5 (-8.0 – 0)	-1.0 (-2.0 – 0)	
Subjective Spherical Equivalent			

• **Mean SD**	-0.550 ± 0.3	-0.183 ± 0.3	= 0.390*
• **Median (Range)**	0 (-3.5 – 3.0)	0.25 (-3.0 – 2.5)	

SD: Standard deviation, D: Diopters

Pentacam-measured corneal astigmatism also improved significantly, with the median changing from -1.4D to -0.2D (p=0.032). However, the surgery did not substantially impact corneal curvature overall, as evidenced by the insignificant changes in keratometry readings, including K1, K2, K-max, and K-mean (p>0.05) (Table 4) (Fig.2).

Table (4) Effect of the Operation on the Pentacam Parameters

	Time (n=30)		**P-value**
	Preoperative	**Postoperative**	
Pentacam Astigmatism			**= 0.032***
• **Mean SD**	-1.500 ± 0.3	-0.787 ± 0.3	
• **Median (Range)**	-1.4 (-5.6 – 0)	-0.2 (-4.4 – 1.8)	
K1			= 0.307**
• **Mean SD**	42.92 ± 2.6	43.49 ± 2.3	
• **Median (Range)**	43.5 (37 – 47)	44 (39.5 – 47)	
K2			= 0.507**
• **Mean SD**	44.43 ± 1.8	44.72 ± 1.7	
• **Median (Range)**	44 (42 – 47)	44 (42.5 – 47)	
K-Max			= 0.495**
• **Mean SD**	46.19 ± 1.7	46.48 ± 1.6	
• **Median (Range)**	46.6 (42.5 – 49)	46.5 (43 – 49)	
K-Mean			= 0.344**
• **Mean SD**	43.65 ± 2.2	44.11 ± 1.9	
• **Median (Range)**	43.5 (40 – 47)	44 (41.5 – 47)	
Pachymetry at the Thinnest Location			= 0.657*
• **Mean SD**	515.93 ± 37.4	514.40 ± 36.5	
• **Median (Range)**	524 (447 – 592)	519 (447 – 590)	
Q-value			= 0.343*
• **Mean SD**	-0.098 ± 0.05	-0.055 ± 0.05	
• **Median (Range)**	-0.2 (-0.6 – 0.4)	-0.2 (-0.4 – 0.4)	

SD: Standard deviation, D: Diopters

Interestingly, the improvements in logMAR BCVA, subjective cylinder, and Pentacam astigmatism had significant positive correlations with pterygium grade (Table 6). The changes were greatest for higher grade 3 versus grades 1 and 2 (p < 0.001 for all).

Table (5) Relationship between Pterygium Grade and Ophthalmic Parameter Changes

	Grade I (n = 12)	**Grade II (n = 14)**	**Grade III (n = 4)**	**P-value**
Log-MAR BCVA Change	0.0 ± 0.0	0.0 ± 0.0	0.05 ± 0.01	< 0.001*
P-value	I vs. II = 1.000	II vs. III <0.001	I vs. III <0.001	
Subjective Cylinder-D Change	0.333 ± 0.2	0.679 ± 0.1	4.500 ± 0.8	< 0.001*
P-value	I vs. II = 0.262	II vs. III <0.001	I vs. III <0.001	
Pentacam Astigmatism-D Change	0.100 ± 0.01	0.657 ± 0.3	2.750 ± 0.7	< 0.001*
P-value	I vs. II = 0.163	II vs. III <0.001	I vs. III <0.001	

BCVA: Best corrected visual acuity, **SD**: Standard deviation, **D**: Diopters

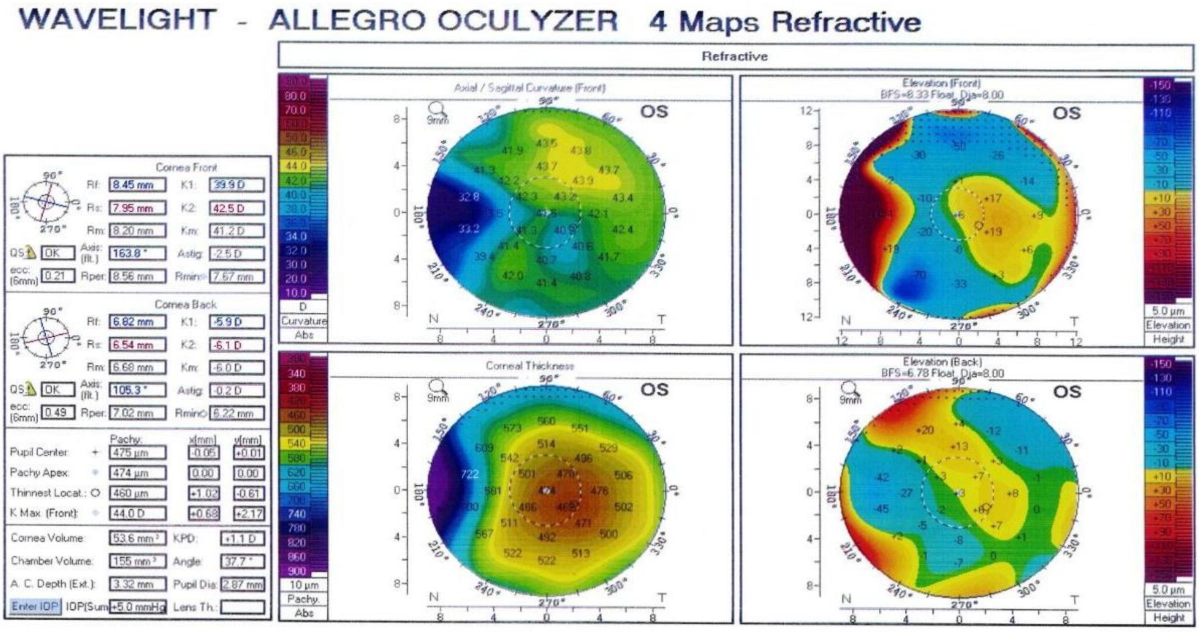

Figure 2: Pentacam before and after surgery

Discussion:

Pterygium, a fibrovascular growth on the cornea, causes significant corneal changes that may necessitate surgical removal, especially before refractive surgery. Understanding the impact of pterygium and its surgical excision on corneal topography is crucial for anticipating refractive outcomes.

Our study evaluated the corneal changes induced by pterygium and the subsequent effects of surgical removal using the Pentacam system. With its advanced Scheimpflug imaging, this system offers a detailed analysis of both the anterior and posterior corneal surfaces, providing valuable insights into the subtler aspects of corneal topography.

Our study encompassed 30 eyes from adult patients diagnosed with primary pterygium. Most participants were male (93.3%), aged 26 to 59. This distribution aligns with the literature, which commonly reports a higher incidence of pterygium in males within this age range (6, 90). However, we observed a slight deviation from the findings of Ghazaly et al. (12), who noted a higher average age and a female predominance in their study cohort. Such variations could be attributed to regional differences or sample size variations.

Postoperatively, our study observed negligible improvements in uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA), with the median postoperative UCVA and log-MAR UCVA showing insignificant improvement and median postoperative/preoperative log-MAR BCVA remaining unchanged. These findings stand in contrast to the significant improvements noted in the studies by Oltulu et al. (8) and Omar et al. (13), which could suggest that the impact of surgery on visual acuity may be more pronounced in certain patient populations or surgical techniques.

Regarding corneal parameters, we noted a significant increase in postoperative subjective cylinder power, while sphere power and subjective spherical equivalent remained unchanged. This finding is partially corroborated by Oltulu et al. (8), who did not observe significant changes in corneal parameters after pterygium surgery. On the other hand, Omar & Attaallah reported considerable reductions in corneal astigmatism, indicating that surgical intervention can lead to notable improvements in corneal topography for some patients (14).

The Pentacam assessments in our study revealed a significant improvement in astigmatism values post-surgery, yet K parameters and pachymetry readings exhibited no significant change. This outcome discrepancy underscores the complexity of corneal responses to pterygium surgery and suggests that while some corneal parameters may improve significantly, others may remain stable.

Furthermore, an analysis of the relationship between the grade of pterygium and changes in ophthalmic parameters demonstrated a significant correlation, with the greatest changes observed in patients with grade III pterygium. This supports the notion that more advanced pterygium may induce greater corneal changes, which can be substantially reversed post-surgery. Our results were supported by the study of İpek et al., who reported that ninety-eight patients with primary nasal pterygium were included in this comparative single-centered interventional study. All patients underwent pterygium surgery with either the conjunctival autograft (Group 1) or the anchored conjunctival rotational flap (Group 2). There was no statistically significant difference in pre- and postoperative keratometry (K) values between groups 1 and 2 and within each group. However, group 1 experienced a greater K-value reduction than group 2 (15).

The literature offers a spectrum of outcomes regarding the effects of pterygium excision on corneal topography. While some researchers like Omar & Attaallah (14) and Kheirkhah et al. (16) have found significant improvements in corneal astigmatism, others, such as Villalba et al. (17), report no significant change in astigmatism despite a reduction in corneal aberrations.

Conclusion

Pterygium surgery can induce variable topographical changes. While some studies show significant improvements in corneal astigmatism and keratometry, others report minimal or no significant changes. Factors such as pterygium grade and patient demographics may influence surgical outcomes. Future research should focus on a comparative analysis of different surgical techniques to establish guidelines for predicting refractive outcomes post-pterygium excision.

Its small sample size limits The study's conclusions, which may not accurately represent the broader population. The lack of randomization and absence of a control group raises concerns about potential biases affecting the study's validity. Additionally, the results are drawn from a single-center, short-term follow-up, which may not capture long-term effects or be generalizable to other settings.

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Conflict of interest:

The authors declare no conflicts of interest.

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