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Changes in corneal curvature and visual acuity in North Indian adults after pterygium excision with modified sutureless, glueless limbal-conjunctival autograft

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Purpose: To identify the exact time point during after following pterygium excision with a modified technique of sutureless, glueless limbal-conjunctival autograft, when stabilization of the change in corneal curvature is achieved; correlate size of pterygium with uncorrected visual acuity and astigmatism at baseline, and assess changes in these parameters postoperatively over time. **Methods:** This prospective study longitudinally assessed 30 eyes of 30 north Indian adults with primary pterygium encroaching upon ≥1 mm of the cornea pre- and postoperatively at 1 week and then monthly for 4 months, recording uncorrected (UCVA) and best-corrected logMAR visual acuity, astigmatism and keratometry. Results were analyzed using ANOVA, Mauchly's test of sphericity with Greenhouse–Geisser correction, and post-hoc test using Bonferroni correction. Pearson's correlation coefficient $r > 0.5$ was considered clinically significant, and $P < 0.05$ statistically significant. **Results:** Pterygium size was well correlated with pre-operative astigmatism ($r = 0.867$, $P < 0.001$) and pre-operative UCVA ($r = 0.856$, $P < 0.001$). There was mean improvement of 0.43 logMAR units of visual acuity ($P < 0.00001$), a mean increase of 0.79D of keratometric value for the flatter meridian ($P < 0.00001$) and a mean reduction of 2.00D of astigmatism ($P < 0.00001$). At 2-month follow-up, the keratometric value for the flatter meridian approached the final keratometric reading at 4 months such that the difference was not significant ($t = 1.185$, $P = 0.245$). There were no significant complications or recurrence during the follow-up period. **Conclusion:** Pterygium excision with modified autograft reduced corneal astigmatism and improved visual acuity comparable to classical technique. Alteration in corneal curvature stabilizes 2 months after surgery, when spectacle correction can be given to patients.

Key words: Astigmatism, autologous fibrin tissue adhesive, corneal topography, pterygium surgery, visual acuity

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Pterygium is a degenerative condition of the subconjunctival tissue, which proliferates as wing-shaped vascularized granulation tissue to invade the cornea, destroying superficial layers of stroma and Bowman's membrane.[1] Its occurrence in dry, dusty, and hot climate such as that of the Indian subcontinent is attributed to the effect of solar ultraviolet radiation. The nasal predominance of pterygium is explained by the fact that sunlight passes unobstructed from the lateral side of the eye and focuses more on the medial limbus.

Pterygia can lead to significant visual distortion and development of large amounts of corneal astigmatism with-the-rule (WTR), as measured by keratometry, corneal topography, and refraction.[2-29] Suggested mechanisms for induced astigmatism include pooling of tear-film between the elevated pterygium apex and the cornea, causing an apparent flattening of the normal corneal curvature in that meridian, as well as mechanical traction exerted on the cornea.[2] Surgical excision of pterygia leads to reduction in astigmatism with significant improvement in vision. However, there is a paucity of published literature regarding the time-course analysis of the change in corneal curvature following this surgery.[22] This study explored the relationship between size of pterygium with uncorrected visual acuity and astigmatism at baseline, and assessed the effect of surgical excision on these factors followed up over a period to determine the earliest postoperative time point at which the spectacles could be prescribed to the patient in view of stabilization of keratometric values.

Methods

This prospective longitudinal study was conducted from 2016 to 2018 at the Department of Ophthalmology of a tertiary care

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teaching hospital in North India. It included a cohort of 30 eyes of 30 adults with pterygium encroaching upon at least 1 mm of the cornea.

The sample size of 30 eyes was calculated assuming an effect size of 0.7, α of 0.05, power of 95% and an attrition of 25%. Exclusion criteria comprised of a history or evidence of pseudopterygium, recurrent pterygium, ocular surgery, ocular trauma, amblyopia, previous use of spectacles for distance, collagen vascular diseases, concurrent cicatricial ocular surface disease, corneal scarring, uveitis, lenticular and posterior segment diseases, and refusal to follow-up for the required number of visits at correct postoperative intervals.

Preoperative evaluation

The size of the corneal part of the pterygium was measured using the in-built graticule of the slit-lamp biomicroscope by projecting a well-focused horizontal slit beam from the limbus to the apex of the pterygium. The size of the pterygium was graded as follows:[4]

- Grade I—pterygium invading 1 to 2 mm of the cornea
- Grade II—pterygium invading >2 to 4 mm of the cornea
- Grade III—pterygium invading 4 to 6 mm of the cornea.

Uncorrected and best-corrected logMAR visual acuity and corneal astigmatism in diopters were recorded at baseline. LogMAR chart for 4-m distance (Haag Streit, Essex, UK) was used, and automated keratometry was performed using the ARK-530S (Nidek Co. Ltd., Aichi, Japan).

Surgical technique

All patients were operated on by a single surgeon. The body of the pterygium was dissected to 4 mm from the limbus, down to the bare sclera. Corneal remnants were scraped off using a crescent knife. Thickened portions of conjunctiva and immediate adjacent and subjacent Tenon's capsule showing tortuous vasculature was excised. Hemostasis was allowed to occur spontaneously without the use of cautery. Limbal-conjunctival autograft was harvested from superior bulbar conjunctiva 2.0 mm larger than bare sclera in both dimensions, and including the superior limbal stem cells. The graft was placed maintaining the orientation of juxtalimbal border toward cornea, and its edges tucked under the edges of the conjunctiva at the recipient site. Scleral bed was viewed through the transparent conjunctiva to ensure that residual bleeding did not lift the graft. Graft was held in position for 10 min by application of gentle pressure with a lens spatula. The operated eye was bandaged for 24 h.[3]

Follow-up

All patients were instructed for follow-up visits for recording logMAR visual acuity and automated keratometry readings at 1 week, 1 month, 2 months, 3 months, and 4 months using the same methods as preoperatively to avoid bias. Any complications or recurrence of pterygium identified at any follow-up visit were also recorded.

Statistical analysis

Data were analyzed using SPSS 16.0 for Windows (Statistical Package for the Social Sciences, SPSS Inc, Chicago, IL, USA). The test values were expressed as mean ± SD (standard deviation wherever mentioned).

One-way repeated-measures analysis of variance (ANOVA) was done to determine the change in mean pre-operative test values which occurred postoperatively. Mauchly's test of sphericity with Greenhouse–Geisser correction was applied. Post-hoc test was done using Bonferroni correction to determine the level of significance between paired time-points, and $P < 0.05$ was considered statistically significant. Pearson's correlation analysis was done between pterygium size, preoperative visual acuity, and preoperative astigmatism. Correlation coefficient, $r > 0.5$ was considered clinically significant, and $P < 0.05$ was considered statistically significant.

Ethical approval

Research protocol was designed in accordance with the Declaration of Helsinki and Guidelines on Ethical Biomedical Research on Human Subjects of the Indian Council of Medical Research (ICMR). The Institutional Ethics Committee approved the research. Informed written consent was obtained from all patients prior to their enrolment.

Results

Thirty patients were evaluated and found eligible for the study, of which 19 (63.33%) were males and 11 (36.67%) were females. Mean age of patients was 42.4 ± 8 years (range 26–57 years). Most cases (12, 40%) were in the age group of 46–55 years. Most (18, 60%) were farm laborers. Twenty-nine (96.67%) patients had a nasal pterygium while one had a temporal pterygium. All patients underwent uneventful surgery and completed the 4-month follow-up schedule. Postoperatively, one patient (3.33%) was found to have graft retraction after 1 week, baring an area of 1 mm, which had spontaneously been covered by the surrounding conjunctiva at his 1-month visit. There was no recurrence of pterygium in our study over the follow-up period.

The mean size of pterygium was 3.88 ± 1.27 mm with a range of 2.0 to 6.0 mm. Most patients (56.67%) had Grade II pterygium [Fig. 1]. Correlation analysis between pterygium size and pre-operative astigmatism revealed a correlation coefficient $r = 0.867$ ($P < 0.001$), and that between pterygium size and pre-operative logMAR visual acuity revealed $r = 0.856$ ($P < 0.001$), both of which were statistically and clinically significant.

Table 1 shows the mean pre- and postoperative uncorrected logMAR visual acuity. Initial UCVA ranged between 0.20-1 and final UCVA ranged between 0-0.24. ANOVA and post-hoc analysis with Bonferroni adjustment revealed that pre-operative vision significantly improved from pre-intervention to all time-points post-surgery (F [4.59, 0.94] = 141.58, $P < 0.0001$, partial $\eta^2 = 0.959$). The best-corrected visual acuity (BCVA) at the initial visit was logMAR 0.0 for 26 cases, 0.2 for 3 cases, and 0.3 for 1 case. The BCVA improved postoperatively to 0.0 in one case, 0.1 in two cases, and 0.22 in one case.

Table 2 shows the mean pre- and postoperative astigmatism in diopters for all patients. The final mean astigmatism measured 0.19 ± 0.12D (range, 0–0.5D) at the end of 4 months, a mean reduction of 2.00 ± 0.99D. ANOVA and post-hoc analysis with Bonferroni adjustment revealed that the astigmatism significantly improved from pre-intervention to all time-points post-surgery (F [1.762, 51.11] = 130.379, $P < 0.0001$, partial $\eta^2 = 0.890$).

Mean pre-operative keratometry reading of the flatter meridian was 43.82 ± 1.64D (range, 38.5–47.37D). Final mean

Table 1: Pre and Post-operative uncorrected visual acuity (UCVA, *n*=30)

UCVA (logMAR units)	Pre-op (%)	Post-op (%)				
		1 wk	1 mo	2 mo	3 mo	4 mo
0.0-0.20	6 (20)	13 (43.33)	27 (90)	27 (90)	29 (96.67)	29 (96.67)
0.21-0.40	13 (43.33)	13 (43.33)	3 (10)	3 (10)	1 (3.33)	1 (3.33)
0.41-0.60	8 (26.67)	3 (10)	0	0	0	0
0.61-0.80	3 (10)	1 (3.33)	0	0	0	0
Mean±SD	0.45±0.23	0.28±0.13	0.11±0.10	0.04±0.08	0.02±0.07	0.02±0.07

Table 2: Pre and postoperative astigmatism (*n*=30)

Astigmatism (in D)	Pre-op (%)	Post-op (%)				
		1 wk	1 mo	2 mo	3 mo	4 mo
0-1	1 (3.33)	14 (46.67)	29 (96.67)	30 (100)	30 (100)	30 (100)
1.1-2	17 (56.67)	15 (50)	1 (3.33)	0	0	0
2.1-3	7 (23.33)	1 (3.33)	0	0	0	0
≥3.1	5 (16.67)	0	0	0	0	0
Mean±SD	2.19±0.87	1.25±0.50	0.58±0.26	0.30±0.15	0.25±0.09	0.19±0.13

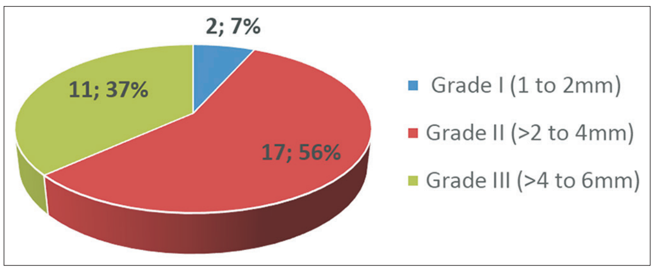

Figure 1: Distribution of size and grading of pterygium (N = 30)

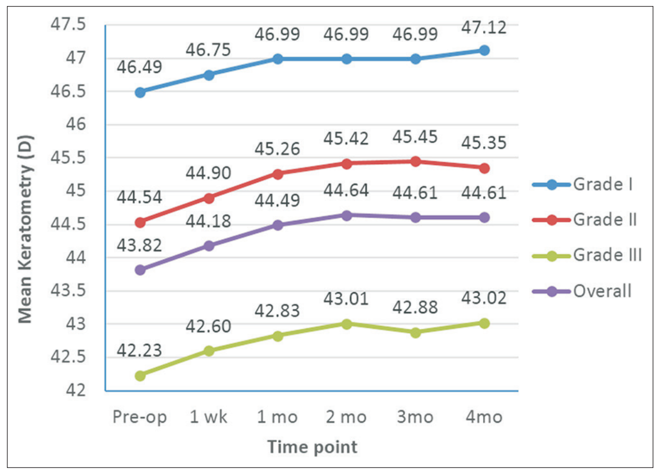

Figure 2: Changes in keratometry of flatter meridian over time (N = 30)

post-operative keratometry reading of the flatter meridian was 44.61 ± 1.58D (range, 39.9–48.12D) at the end of 4 months, a mean increase of 0.79D [Fig. 2]. Keratometry readings of the flatter meridian significantly improved from pre-intervention to all time-points post-surgery (F [2.670, 6.365] = 73.99, P < 0.0001, partial η^2 = 0.839). In addition, the postoperative keratometry correlated well with the preoperative keratometry (Pearson's correlation coefficient, R = 0.9911, P < 0.0001). Paired samples t-test between these values at different time-points showed that the paired differences remain statistically significant until 1-month follow up (t = −4.995, P < 0.001) but become insignificant at 2-month follow-up (t = 1.185, P = 0.245).

Discussion

The technique for autograft used in this study was a modification of the classical technique described by de Wit *et al*.[30] in their case series, the outcomes of which are well-documented.[3] Since there are no reports in available medline-indexed literature about the outcomes of this modified technique, the results are being compared to those of the classical technique.[31]

In our study, pterygium size correlated well with preoperative visual acuity (r = 0.856, P < 0.001), similar to that found by Bajantri *et al*.[5] Yagmur *et al*.[6] observed significant improvement in mean uncorrected visual acuity (in decimal form) from 0.41 ± 0.30 preoperatively to 0.63 ± 0.26 postoperatively (P < 0.001). In the study conducted by Shrivastava *et al*. mean preoperative visual acuity was 0.52 ± 0.32 which improved to 0.43 ± 0.29 post-operatively, an improvement of 0.09 logMAR units (P < 0.0001).[7] Shelke *et al*.[8] Yousuf[9] and Mohite *et al*.[10] also made similar observations. The present study had comparable outcomes with the pre-operative visual acuity of 0.45 ± 0.23, significantly improving to 0.02 ± 0.06 logMAR units at the end of 4 months (P < 0.0001, Table 1).

Several researchers have shown that pterygium causes asymmetric WTR astigmatism that is directly proportional to the size of the lesion.[5,7,8,11-19] Avisar *et al*.[11] found that when primary pterygium reaches more than 1.0 mm in size from the limbus it induces significant WTR astigmatism ≥1.0D) which increased with the increasing size of the pterygium. Hansen *et al*.[12] reported that pterygium larger than 3 mm induced 1.97D of astigmatism while that smaller than 3 mm induced 1.11D. Kampitak[13] reported that 2.00D or more astigmatism occurred when the length of pterygium exceeded 2.25 mm. Similar observations were also made in studies by various other authors.[6-9,14-18] Correlation analysis between pterygium size and pre-operative astigmatism in our study revealed clinically significant Pearson's correlation coefficient $r = 0.867$ ($P < 0.001$) which concurs with these findings.

Lin and Stern[19] found that lesions extending >45% of the corneal radius or within 3.2 mm of the visual axis produced increasing degrees of induced astigmatism as measured by corneal topography. The same authors in another study on 16 eyes found corneal astigmatism to reduce from 5.93 ± 2.46D to 1.92 ± 1.68D following pterygium excision.[20] In the study conducted by Bhandari *et al*.[21] mean astigmatism measured by simulated keratometry reduced significantly from a preoperative 2.308 ± 2.25D to 1.248 ± 0.99D postoperatively ($P < 0.026$). Bajantri *et al*.[5] found in a study on 70 cases, that the mean keratometric astigmatism underwent a reduction of 1.45 ± 0.77D ($P < 0.0001$). Yagmur *et al*.[6] showed the topographic astigmatism reduced from 4.65 ± 3.02 to 2.33 ± 2.26D with surgery in 30 eyes. Other researchers have reported similar findings.[22-26] Our study showed astigmatism to reduce from 2.19 ± 0.87D (range 0.75-4.0D) to 0.19 ± 0.12D (range 0-0.5D) over a period of 4 months, a mean reduction of 2.00 ± 0.99D with improvement shown at all time-points evaluated ($P < 0.0001$, Table 2).

In their study, Altan-Yaycioglu *et al*.[27] found that postoperative astigmatism correlated with preoperative astigmatism (Spearman's $\rho = 0.351$, $P < 0.001$) as measured by autokeratometry, which concurs with the present study (clinically significant Pearson's correlation coefficient, $R = 0.9911$, $P < 0.0001$).

Saleem *et al*.[26] showed that the mean keratometric reading for the flatter axis changes from 43.71 ± 1.12D to 44.45 ± 0.85D in 1 week of pterygium excision. Shastry *et al*.[23] in their follow-up of 12 weeks showed that the change was from 43.39 ± 1.57D to 45.37 ± 1.63D ($P < 0.001$, ANOVA). These reports concur with the present study, wherein the mean keratometric reading for the flatter axis changed from 43.82 ± 1.64 to 44.61 ± 1.58D over a period of 4 months, with improvement from baseline shown at all time-points evaluated ($P < 0.0001$).

Fig. 2 shows that 2-month postoperative keratometric value for the flatter axis became insignificantly different from the final keratometric reading observed at 4 months. Tomidokoro *et al*.[22] reported stabilization of Sim K using videokeratography 1 month after pterygium excision, and commented that an interval of at least 1 month or more should elapse before considering the refractive status as stabilized. This study shows that postoperative keratometry becomes relatively stable after 2 months of surgery and it is only after this period that appropriate spectacle correction should be provided.

Previous researchers have found that pterygium surgery with limbal-conjunctival autografting by the classical technique shows varying degrees of recurrence ranging from 0 to 15%.[28,29] There was no recurrence of pterygium in our study over the follow-up period in concurrence with this finding.

Limitations of our study include not measuring mean keratometry, Sim K, and refraction. There is also a lack of subgroup analysis between pterygium size and visual acuity, astigmatism, and keratometry in various grades of pterygium, as the group size did not allow this reliably. A larger cohort and longer follow-up could strengthen the results. In addition, the results of this study cannot be applied to patients with recurrent pterygia or double pterygia. The results may be generalizable if the eligibility criteria are strictly adhered to.

Conclusion

In conclusion, this study has affirmed that in north Indian subjects, pterygium-induced refractive change leads to visual impairment and induced astigmatism, and a significant correlation with the size of the pterygium exists. In the present study, using pterygium excision with a modified technique of sutureless, glueless limbal-conjunctival autograft significantly reduced corneal astigmatism and improved visual acuity comparable to the classical technique,[30] meaning that such improvement is dependent on the excision rather than the reconstruction technique. This study has been able to identify that the alteration in corneal curvature stabilizes 2 months after surgery, when spectacle correction can be given to patients.

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Conflicts of interest

There are no conflicts of interest.

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