The effect of limbal autograft location at primary pterygium excision on anterior and posterior corneal astigmatism: a comparative prospective study

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The aim of the study is to evaluate the effect of limbal autograft location on corneal astigmatism in inferior and superior conjunctival autografted pterygium surgery.

Methods Patients were divided into 2 groups as diagnosed with primary pterygium and planned to receive surgical treatment. Pterygium surgery was performed on 25 patients with superior and 25 patients with inferior limbal autograft who have similar epidemiologic features. Cornea anterior and posterior surface keratometry (K) 1, K2, Kmax, peripheric radius (Rper) (the mean radius of curvature of the 7.0–9.0 mm ring area), refractive astigmatism and axis values, were examined. Corneal irregularity indices were the index of surface variance (ISV), index of vertical asymmetry (IVA, mm), index of height asymmetry (IHA, μm), index of height decen- tration (IHD, μm). The data were compared pre- and postoperative and the effect of graft location on results was evaluated.

Results K1 which is from the values of the cornea front face has risen after surgery both of superior and inferior groups (p = 0.011). However, no postoperative significant difference was detected in terms of the change. Otherwise, both groups have changed regarding astigmatism and Rper (p < 0.001), but no postoperative significant difference was found in terms of the change. There were not any differences between groups regarding the changes of postoperative back face values. Although there were significant decreases in ISV, IVA, and IHD values in both groups in terms of all corneal surface indices, there was no significant difference between the lower and upper groups in terms of postoperative results (p > 0.05).

Conclusion The effects of pterygium surgery with limbal autograft provide significant improvement on corneal astigmatism. However, we think that the location of the conjunctiva has no effect, but in cases where the bulbar conjunctiva needs to be preserved or cannot be used, the choice of the lower bulbar conjunctiva can achieve successful results.

Keywords Astigmatism · Limbal autograft · Cornea · Pterygium

Introduction

Pterygium is the elastoid degeneration of the conjunctiva in which ultraviolet B is responsible for its etiology that progresses from the bulbar area to the cornea in a triangular shape [1, 2]. This was supported...
by the high incidence of patients who work outside and is more common in areas close to the equator. In addition, heat, wind, and sand were thought to play a role in its etiology [2, 3].

In pterygium, surgery is planned due to closure of the visual axis of the fibrovascular structure, decreased vision with the changes in topographic, refractive and wavefront analysis, recurrent inflammation, and cosmetic deformity. At the same time, pterygium excision has been performed to obtain more accurate biometry values before cataract surgery [3–9]. Bare sclera excision, conjunctival transposition, mitomycin C or Beta radiation application added techniques were performed in pterygium treatment [1]. However, contemporarily the more secure than the other methods and accepted as the ‘golden standard’ method is ‘Conjunctival Autograft’ [2–10].

The superior bulbar conjunctiva has been generally preferable in terms of easier manipulation of the graft. However, it has been crucial to protect the superior bulbar conjunctiva for the success of glaucoma surgery that is already done or planned to be done [11]. In addition, it has not been possible to take a graft from the superior bulbar conjunctiva in case of cicatrization. In such cases, instead of the superior bulbar conjunctiva, the inferior bulbar conjunctiva can be preferred as a graft location [11]. It was demonstrated that there was no difference regarding the recurrence in pterygium excision with autograft which was performed by taking graft from inferior or superior conjunctiva [2, 11–13]. However, there is still no study about the effect of graft location choice between superior and inferior on post-surgery astigmatism.

Many factors have suggested in the developmental mechanisms of pterygium, including oxidative stress, extracellular matrix modulators, apoptotic and oncogenic proteins, loss of heterozygous, DNA methylation, inflammatory mediators, lymphangiogenesis, migration from mesenchymal–epithelial cells, and cholesterol metabolism changes [14]. In other words, since it is a limbal conjunctival structure in which so many inflammatory factors play a role, it made us think that the healing process was affected. At the same time, it is accepted that in addition to chronic inflammation, hereditary DNA damage in the conjunctiva and susceptibility such as apoptosis play a role in pterygium [15]. Although there are many reports that postoperative astigmatism improved with pterygium surgery after a wide scan [9, 16–18], we did not find any publications between graft location and astigmatism in pterygium surgery. Considering that limbal conjunctival grafts taken from different places may have different effects in the correction of astigmatism, we formed our hypothesis and investigated this.

To the best of our knowledge, this is the first study which aimed to evaluate comparatively the effect of pterygium surgery with autograft by taking grafts from superior or inferior on astigmatism and cornea topographic data.

Materials and methods

This prospective, comparative, observational study consisting of interventional case series was conducted between August 2020 and June 2021 at a tertiary ophthalmology hospital. The study was approved by the Institutional Ethics Committee and was performed in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from all participants.

Study population

A total of 50 eyes of 50 consecutive patients who were diagnosed as primary pterygium and underwent pterygium excision with conjunctival autograft by a single experienced surgeon (BK) were included in the study. Primary pterygium cases with a limbus of at least 1.5 mm were included in the study. The graft location of patients was decided randomly as 25 patients superior limbal conjunctival graft, and 25 patients inferior limbal conjunctival graft.

Patients who have a history of glaucoma, ocular surface surgery or trauma, limbal stem cell failure which cause pterygium in another location of the cornea, conjunctival scar or symblepharon, and double-headed pterygium were not included in this study.

Assessment

At the preoperative visit, all the patients underwent a complete ophthalmic examination, which included best-corrected distance visual acuity (BCVA), intraocular pressure (IOP), slit-lamp biomicroscopic examination and dilated fundus examination. In a
bimicroscopic examination, the pterygium was graded with Tan’s grading system [19], as grade 1 (atrophic) with episcleral vessels under the body of the pterygium not obscured and clearly distinguishable; grade 3 (fleshy) with episcleral vessels totally obscured, or grade 2 (intermediate) for all other pterygium not falling into grades 1 or 3. Corneal topographic measurements of the patients in pre-operation and 6 months after the operation were performed by the same blind technician using Pentacam (Oculus, Inc., Germany). Indices which show corneal irregularity with cornea front and back face keratometry (K) 1, K2, Kmax, peripheric radius (Rper) (the mean radius of curvature of the 7.0–9.0 mm ring area), refractive astigmatism and axis values, were examined. These indices were an index of surface variance (ISV), index of vertical asymmetry (IVA, mm), index of height asymmetry (IHA, µm), an index of height decentration (IHD, µm). ISV is measured as the standard deviation of individual sagittal radii from mean curvature. IVA is the mean difference between superior and inferior corneal curvature. IHA is the mean difference between corneal elevation in the superior hemisphere and inferior hemisphere in the horizontal meridian. IHD measures vertical decentration of elevation data calculated using Fourier analysis [20]. These measurements were evaluated by the blinded researcher who did not know which patient in which group.

Surgical technique

The patient was draped and prepared for operation under sterile conditions. The involved eye was anesthetized with topical (0.5% proparacaine hydrochloride, Alcaine, Alcon, Belgium) and subconjunctival (lidocaine hydrochloride 40 mg/2 ml, epinephrine 0.025 mg/2 ml, Jetokain, Adeka, Turkey) anesthetic. The pterygium tissue was removed with blunt and sharp dissection by removing the corneal epithelium 2 mm from the central pterygium cap, and so bare sclera was revealed. Autografts to the same extent as the scleral opening were randomly prepared from the superior or inferior bulbar conjunctiva of the same side-eye. The graft was sutured with an 8.0 polyglyactin absorbable surgical suture (DemeTech, USA) to close the scleral opening. Conjunctival opening from the location that autograft was taken, was closed with 8.0 polyglyactin absorbable surgical suture (DemeTech, USA). The operation was terminated with the injection of gentamicin (1600 mg/2 ml, Genta ampul, IE Ulugay, İstanbul, Turkey) and dexamethasone (Dekort ampul, 8 mg/ml, Deva, İstanbul, Turkey). After dexamethasone/moxifloxacin fix combination (Moxicexa damla, Abdi İbrahim, Turkey) 4 times a day for two weeks was used, it suggested for patients to use Loteprednol drops (Dolte, Abdi İbrahim, Turkey) and Moxifloxacin (Vigamox, Alcon, Geneva, Switzerland) two times a day in the following two weeks.

Statistically analysis

Statistical analysis was performed using SPSS 25.0 software (IBM Corporation, Armonk, NY, USA). The compliance of the variables to the normal distribution was examined using visual (histogram) and analytical methods (Kolmogorov–Smirnov test). Statistics of the participants of this study were expressed with mean, standard deviation, and median values for continuous data. Statistical differences between groups were analyzed and interpreted by paired t-test in quantitative cases, Mann Whitney U Test and Wilcoxon tests. The comparisons of the gender and pterygium grade were made by chi-square test. It was considered statistically significant when the p value is lower than 0.05.

Results

Fifty eyes of 50 patients were included in the study. Pterygium excision was performed using a superior limbal conjunctival graft for 25 eyes, and an inferior limbal conjunctival graft for 25 eyes. The patients were followed up at least 6 months in the postoperative period. The mean age of the patients was 53.56 ± 10.29 (median 55 (range 30–70)) years in the group 1 and 52.52 ± 10.42 (median 54, range 37–69) years in the group 2 (p = 0.78). There were 13 males (%52) in the first group and 14 males (%56) in the second group and no significant differences were detected between the two groups. There were no differences in the healing process between the groups.

According to preoperative pterygium staging, 9 of the patients whose graft was taken from superior were grade 2, 16 of the patient were grade 3 pterygium; 7 of the patients whose graft was taken from inferior were grade 2, and the rest 18 ones were grade 3 pterygium. There was no significant difference between groups in
terms of pterygium staging ($p = 0.36$). When the preoperative data of superior limbal conjunctival group and inferior limbal conjunctival group were compared, there were no differences $K1$ ($p = 0.079$), $K2$ ($p = 0.49$) and $Rper$ (0.409) but $Kmax$ ($p = 0.024$) was different between the groups.

As demonstrated in Table 1, $K1$, $Rper$ and astigmatism values from the cornea front face Pentacam data showed a statistically significant improvement after surgery than before surgery in both graft groups.

A significant difference was not observed between the two groups when inferiorly and superiorly graft is taken from patients were compared regarding the cornea front face $K1$, $K2$, $Kmax$, $Rper$, astigmatism values and axis differences ($p > 0.05$, for every value) (Table 2).

In Table 3, when the corneal posterior Pentacam data were compared before and after surgery, a significant decrease in $Rper$ value was observed only in the upper conjunctival graft ($p = 0.046$).

There was no significant difference in the two groups after operation regarding cornea back faces $K1$, $K2$, $Kmax$, astigmatism changes ($p > 0.05$, for every value) (Table 4).

ISV, IVA, and IHD data of the corneal surface indices were significantly decreased in superior limbal conjunctival graft and inferior limbal conjunctival graft in postoperation compared to pre-operation (Table 5).

When a comparison was made between two groups regarding the changes after operation in ISV, IVA, IHA and IHD of corneal surface indices, no significant differences were detected (Table 6) (Fig. 1).

**Conclusion**

DNA damage, inflammation and fibrovascular proliferation initiated by UV effect have been shown to be the main factors in the formation of pterygium [13]. Torres et al. [21] showed that not only in the pterygium tissue, but also in the ipsilateral pterygium-free conjunctiva, there are different changes from healthy conjunctiva. This shows that the graft, which we consider to be healthy, is actually affected. The upper and lower bulbar conjunctiva were exposed to the sun at different degrees by the effect of the lid, suggesting that the graft we received would heal with different fibrosis levels during healing [21]. We think that grafts taken from different places may have different effects in the correction of astigmatism due to regional reorganization or subclinical fibrosis due to the conjunctiva adjacent to the cornea.

Most of the researches in the literature which demonstrated astigmatism caused by pterygium decreased after surgically pterygium excision [17, 22–24]. It has shown that removal of pterygium surgically with limbal autograft treatment is more secure and effective among other methods regarding

| Anterior corneal surface | Preoperative Mean ± SD | Postoperative Mean ± SD | $p$,$^*$ |
|--------------------------|------------------------|-------------------------|--------|
| **Superior conjunctival graft** | | | |
| $K1$ | 41.9 ± 3.41 | 43.02 ± 1.69 | 0.011$^*$ |
| $K2$ | 42.84 ± 8.06 | 44.14 ± 1.3 | 0.917$^*$ |
| $Kmax^*$ | 44.92 ± 2.08 | 44.83 ± 2.03 | 0.771$^*$ |
| Astigmatism | 2.51 ± 3.56 | 1.04 ± 0.83 | |
| $Rper^*$ | 8.14 ± 0.36 | 7.97 ± 0.26 | <0.001$^*$ |
| **Inferior conjunctival graft** | | | |
| $K1^*$ | 40.28 ± 4.01 | 43.47 ± 1.68 | <0.001$^*$ |
| $K2^*$ | 44.66 ± 1.63 | 44.41 ± 1.98 | 0.078$^*$ |
| $Kmax$ | 46.34 ± 2.22 | 45.74 ± 2.94 | 0.035$^*$ |
| Astigmatism | 4.36 ± 3.92 | 0.87 ± 0.82 | <0.001$^*$ |
| $Rper$ | 8.28 ± 0.61 | 7.95 ± 0.26 | <0.001$^*$ |

$K1$: Flat keratometry, $K2$: steep keratometry; $Kmax$: Maximum keratometry; SD: Standard deviation; $Rper$: Peripheric Radius (8–10 mm), $^*$: Paired sample t test, $^*$: Wilcoxon test. Significant $p$ values are written in bold
Table 2  The comparison of corneal anterior surface K1, K2, Kmax, Rper and astigmatism changes after the operation in the ones which graft was taken from superior and inferior

|                     | Superior conjunctival graft Mean ± SD | Inferior conjunctival graft Mean ± SD | p<sup>0,₄</sup> |
|---------------------|---------------------------------------|---------------------------------------|-----------------|
| K1                  | 43.02 ± 1.69                          | 43.47 ± 1.68                          | 0.356<sup>₄</sup> |
| K2                  | 44.14 ± 1.3                           | 44.41 ± 1.98                          | 0.574<sup>₄</sup> |
| Kmax                | 44.83 ± 2.03                          | 45.74 ± 2.94                          | 0.331<sup>₄</sup> |
| Astigmatism         | 1.04 ± 0.83                            | 0.87 ± 0.82                            | 0.209<sup>₄</sup> |
| Rper                | 7.97 ± 0.26                           | 7.95 ± 0.26                            | 0.779<sup>₄</sup> |
| Ax differences anterior | 16.97 ± 16.99                        | 15.49 ± 18.68                          | 0.749<sup>₄</sup> |

K1: Flat keratometry, K2: steep keratometry; Kmax: Maximum keratometry; SD: Standard deviation; Rper: Peripheric Radius (8–10 mm), &: Independent samples t test, β: Mann Whitney U test. Significant p values are written in bold

Table 3  Pre- and postoperative changes of corneal posterior face K1, K2, Kmax, Rper and astigmatism values in both graft locations

| Posterior corneal surface | Preoperative Mean ± SD | Postoperative Mean ± SD | p<sup>*,#</sup> |
|---------------------------|------------------------|-------------------------|-----------------|
| Superior conjunctival graft |                        |                         |                 |
| K1                        | − 6.27 ± 0.269         | − 6.22 ± 0.305          | 0.141<sup>*</sup> |
| K2                        | − 6.54 ± 0.3           | − 6.59 ± 0.462          | 0.434<sup>*</sup> |
| Kmax                      | − 6.39 ± 0.255         | − 6.4 ± 0.301           | 0.597<sup>*</sup> |
| Astigmatism               | 0.37 ± 0.46            | 0.27 ± 0.234            | 0.135<sup>₄</sup> |
| Rper                      | 6.72 ± 0.32            | 6.6 ± 0.292             | 0.046<sup>₄</sup> |
| Inferior conjunctival graft |                        |                         |                 |
| K1                        | − 5.42 ± 3.751         | − 6.15 ± 0.31           | 0.605<sup>₄</sup> |
| K2                        | − 6.23 ± 1.702         | − 6.58 ± 0.454          | 0.924<sup>₄</sup> |
| Kmax                      | − 5.46 ± 3.15          | − 6.35 ± 0.328          | 0.680<sup>₄</sup> |
| Astigmatism               | 0.82 ± 2.105           | 0.42 ± 0.408            | 0.266<sup>₄</sup> |
| Rper                      | 7.87 ± 5.655           | 6.7 ± 0.311             | 0.095<sup>₄</sup> |

K1: Flat keratometry, K2: steep keratometry, Kmax: Maximum keratometry, SD: Standard deviation, Rper: Peripheric Radius (8–10 mm), *: Paired sample t test, #: Wilcoxon test. Significant p values are written in bold

Table 4  The comparison of corneal posterior surface K1, K2, Kmax, Rper and astigmatism changes after the operation in the ones which graft was taken superior and inferior

| Posterior corneal surface | Superior conjunctival graft Mean ± SD | Inferior conjunctival graft Mean ± SD | p<sup>0,₄</sup> |
|---------------------------|---------------------------------------|---------------------------------------|-----------------|
| K1                        | − 6.22 ± 0.31                          | − 6.15 ± 0.31                          | 0.37<sup>₄</sup> |
| K2                        | − 6.59 ± 0.46                          | − 6.58 ± 0.454                         | 0.93<sup>₄</sup> |
| Kmax                      | − 6.4 ± 0.30                           | − 6.35 ± 0.33                          | 0.56<sup>₄</sup> |
| Astigmatism               | 0.37 ± 0.46                            | 0.42 ± 0.41                            | 0.66<sup>₄</sup> |
| Rper                      | 6.6 ± 0.29                             | 6.7 ± 0.31                             | 0.25<sup>₄</sup> |
| Axial differences         | 30.84 ± 33.87                          | 37.346 ± 36.65                         | 0.35<sup>₄</sup> |

K1: Flat keratometry, K2: steep keratometry; Kmax: Maximum keratometry; SD: Standard deviation; Rper: Peripheric Radius (8–10 mm), &: Independent samples t test, β: Mann Whitney U test
recurrence and cosmetic [24, 25]. On an ocular surface with pterygium formed by the effect of ultraviolet; It is based on the hypothesis that non-pterigium tissues are also affected at different degrees, especially in the upper and lower conjunctiva. We thought that this would affect wound healing. We wanted to examine that fibrosis, even subclinical, is inevitable during healing on this inflammatory surface and whether this will affect astigmatism. In their study, Grupcheva et al. examined ultraviolet damage on the anterior ocular surface by confocal microscopy, and interestingly, a marked change was observed in the upper lid conjunctiva, with typically the horizontal meridian being affected [26]. This shows that contrary to popular belief, tissues that we think are protected under the lid are affected at different levels. In fact, given the anatomy of the eye and the function of the eyelids, the lower limbus is considered to be the most vulnerable part of the limbus. In particular, in summer, people look at the sky and relax with slightly closed eyes, and the reflected light easily reaches the lower limbus, even under sunglasses. Alternatively, the limbal form of vernal keratoconjunctivitis or superior paralimbal damage in superior limbal neovascularization may be explanatory [27]. As a result, even if conjunctival healing does not affect astigmatism, rearrangement in the cornea adjacent to the conjunctiva may be occurring. Thus, this may be at different degrees at the superior and inferior; we aimed to

Table 5 The comparison of cornea face indices pre- and post-operatively in the ones which graft was taken from superior and inferior

|                    | Preoperative Mean ± SD | Postoperative Mean ± SD | p* |
|--------------------|------------------------|-------------------------|----|
| Superior conjunctival graft |                    |                        |    |
| ISV                | 58.84 ± 44.12          | 23.52 ± 12.11           | < 0.001 * |
| IVA                | 0.426 ± 0.35           | 0.178 ± 0.09            | < 0.001 * |
| IHA                | 8.544 ± 8.62           | 7.564 ± 7.32            | 0.15 * |
| IHD                | 0.04 ± 0.02            | 0.026 ± 0.02            | 0.02 * |
| Inferior conjunctival graft |              |                        |    |
| ISV                | 76.64 ± 82.36          | 20.16 ± 5.757           | < 0.001 * |
| IVA                | 0.57 ± 0.69            | 0.203 ± 0.16            | 0.001 * |
| IHA                | 10.98 ± 8.38           | 6.08 ± 4.62             | 0.01 * |
| IHD                | 0.05 ± 0.03            | 0.04 ± 0.03             | 0.07 * |

ISV: index of surface variance, IVA: index of vertical asymmetry, IHA: index of height asymmetry, IHD: index of height decentration, SD: Standard deviation, #: Wilcoxon test. Significant p values are written in bold

Table 6 Pre- and postoperatively comparison of the ones which graft was taken from superior and inferior

|                   | Preoperative Mean ± SD | Postoperative Mean ± SD | pβ |
|-------------------|------------------------|-------------------------|----|
| Superior conjunctival graft |                        |                        |    |
| ISV               | 58.84 ± 44.12          | 23.52 ± 12.11           | 0.53β |
| IVA               | 0.43 ± 0.35            | 0.57 ± 0.69             | 0.63β |
| IHA               | 8.54 ± 8.62            | 10.98 ± 8.38            | 0.19β |
| IHD               | 0.04 ± 0.02            | 0.05 ± 0.03             | 0.21β |
| Inferior conjunctival graft |                    |                        |    |
| ISV               | 76.64 ± 82.36          | 20.16 ± 5.757           | 0.89β |
| IVA               | 0.57 ± 0.69            | 0.20 ± 0.157            | 0.09β |
| IHA               | 10.98 ± 8.38           | 6.08 ± 4.62             | 0.98β |
| IHD               | 0.05 ± 0.03            | 0.04 ± 0.03             | 0.15β |

ISV: index of surface variance, IVA: index of vertical asymmetry, IHA: index of height asymmetry, IHD: index of height decentration, SD: Standard deviation, β: Mann Whitney U test
investigate the difference of astigmatism in those who were grafted from above or below.

However, the preference of graft location is still controversial today. Hence, we aimed to research the effect of taking graft from a different location on cornea topographic data and astigmatism data which are the data that reveal the effect of the operation on visual quality. As the first study of the literature which we investigated the effect of pterygium surgery with superior and inferior bulbar autograft on corneal astigmatism changes, when we evaluated cornea anterior face, flattest (K1) meridians were statistically steeper after the operation in the cases of taking autograft from both superior and inferior; meanwhile no significant difference was detected in the steepest (K2) meridian. While there was no difference in Maximum K values for the superior conjunctival graft group, a decrease was detected for the inferior conjunctival graft. At the same time, Rper values showed a statistically significant decline in both groups. As the cap of the pterygium approaches the corneal apex, a meniscus formed by the tear film layer between the raised pterygium tissue and the cornea causes significant flattening. This situation improved after the pterygium surgery and resulted in improvement of astigmatism [4]. Our research as well supported that a significant decline performs in astigmatism value and Rper value of the anterior face and observation in K1 values.

The first research which investigated the change of posterior and anterior face astigmatism with Pentacam after pterygium surgery belonged to Kheirkhah et al. [28, 29]. In the research, three different surgical techniques have been used which are bare sclera with mitomycin C, amnion graft, and free conjunctival graft [1]. As a result of the study, only astigmatism and axis values were examined in 96 patients and it was reported that anterior astigmatism decreased significantly, and posterior astigmatism decreased but it was not a statistically significant difference [29]. In our study, unlike the study of Kheirkhah et al. [29], we evaluated not only astigmatism values but also K1, K2, Kmax, Rper, axis and astigmatism changes for anterior and posterior surfaces. While K1 values show a significant difference for the anterior face, there was no any significant change for K2 values. In addition, Rper slope has also decreased which we think is related to the disappearance of the mechanical effect of the pterygium. Rper has shown a change only in the superior conjunctival graft group for posterior face values, but there was no statistically significant difference for other values even if changes have shown. In the study of Kheirkhah et al. [29] even if a decrease from 0.35 D to 0.32 D was observed, no statistically significant difference was found. In our study, similar to the study of Kheirkhah, even though a decrease in posterior astigmatism for 2 groups was observed, it wasn’t statistically significant.

Fig. 1 The change of Pentacam index and topography in preoperative and postoperative 6th month
Levinger et al. [9] have evaluated posterior corneal surface and surgery-induced astigmatism (SIA) and they have found a significant difference at posterior ocular surface. In our study, different from the study of Levinger et al. [9], although we have obtained the change in the posterior face less than a significant change in the anterior face after pterygium surgery. Also, we found that the graft location does not affect anterior and posterior face corneal astigmatism. Our study’s one of the limiting factors was the low number of patients, but if there can be more patients in studies, they can enlighten this subject more.

ISV, IVA, IHD, IHA: These are the indexes that show the irregularities of the posterior surface of the cornea in Pentacam HR. Improvement in ISV indicates reduced variation in corneal curvature that may result in a more regular corneal surface. Improvements in IVA and IHA are indicative of a reduction in the difference in curvature and height between the upper and lower curvature and the height of the cornea, respectively. Improvement in IHD indicates improved vertical decentralization. In the research of Misra et al. [3], they only took superior graft and they solely evaluated ISV and IVA which is from the corneal front face regularity indices and astigmatism data evaluated with Pentacam. As a result, they have detected a decline in all data. In our study too, we have found a decline in ISV, IVA and astigmatism values after surgery of graft taken from both superior and inferior. In addition, in our research as different from Misra et al. [3], we have examined IHD and IHA. Moreover, we have detected that IHA was not changing in the superior graft group, but the IHD indices have a decline. In the inferior graft group, IHA and IHD values have declined. We attributed this to the improvement of corneal asymmetry after successful pterygium surgery, regardless of graft location.

One of the limitations of our study was the small number of patients, and the correlation between the size of the pterygium tissue and the effect of postsurgical changes could not be determined. There is a need for prospective studies involving more patients who examine the corneal topography and astigmatism changes after pterygium surgery of germs taken from different localizations. In addition, only patients with nasally located pterygium were included in our study. When the pterygium is nasal or temporal, examining whether there are differences in astigmatic healing may also affect the results.

In conclusion, we know that a successful pterygium surgery with a limbal conjunctival autograft is sufficient for the treatment of astigmatism. In this study, we aimed to investigate whether graft location is an additional factor in astigmatism. The preference of surgeons and the clinical condition of the patient should be taken into account when deciding on graft placement.

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Declarations

Conflict of interest The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Informed consent Informed consent was obtained from all individual participants included in the study.

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