

Astigmatic changes following pterygium removal: Comparison of 5 different methods

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Aims: To investigate the effect of surgery type on the postoperative astigmatism in pterygium surgery. **Settings and Design:** Retrospective comparative clinical trial. **Materials and Methods:** Data of 240 eyes that underwent pterygium excision were investigated. Following removal of the pterygium, patients underwent 5 different types of surgeries: Conjunctival autograft with sutures (CAG-s) or fibrin glue (CAG-g), conjunctival rotational flap (CRF), or amniotic membrane transplantation with either suture (AMT-s) or with glue (AMT-g). The preoperative and postoperative keratometric measurements, evaluated using an automated keratorefractometer, were noted. **Statistical Analysis:** The overall changes in BCVA and astigmatic degree were evaluated using Wilcoxon signed rank test. The difference in astigmatic values between groups was calculated using one way analysis of variance (ANOVA). **Results:** The most commonly performed procedure was CAG-s ($N = 115$), followed by CAG-g ($N = 53$), CRF ($N = 47$), AMT-s ($N = 15$), and AMT-g ($N = 10$). Following surgery, astigmatic values decreased from 3.47 ± 2.50 D to 1.29 ± 1.07 D ($P < 0.001$, paired t test). The changes in astigmatism was significantly related to the preoperative size of the pterygium ($\rho = 3.464$, $P = 0.005$). The postoperative astigmatism correlated with preoperative astigmatism ($\rho = 0.351$, $P < 0.001$, Spearman correlation analysis). The changes in astigmatic values was not related to the method of surgery ($P = 0.055$, ANOVA). **Conclusion:** Pterygium results in high corneal astigmatism, which decreases to an acceptable level following excision. According to our study, the type of grafting as CAG, CRF or AMT or the use of suture or glue to fixate the graft does not have a significant effect on the change in astigmatism degree.

Key words: Amniotic membrane, astigmatism, autografting, fibrin tissue adhesive, pterygium, sutures

Pterygium is a wing-shaped fibrovascular growth of conjunctival connective tissue over cornea resulting in cosmetic problems, decrease in visual acuity secondary to astigmatism and blockage of the optical axis. It can cause flattening of the cornea to the leading apex.^[1]

In the treatment, several different surgeries are being performed to decrease the high recurrence of bare sclera technique, such as conjunctival autografting and amniotic membrane grafting.^[2-4] Recently, fibrin glue was recommended to secure the graft.^[5]

In present study, our aim was to investigate the effect of surgery type on the change in astigmatism following pterygium excision.

Materials and Methods

In this retrospective study, the data of 240 consecutive eyes that underwent pterygium excision by one surgeon (RAY) between 2003 and 2008, completed 3 months follow-up and showed no sign of recurrence were investigated. Patients with complaints of decrease in visual acuity, foreign body sensation and hyperemia due to pterygium were decided for surgery of the pterygium. History of ocular trauma, ocular surgery, and

presence of corneal abnormalities such as, scarring that might affect the astigmatic value were accepted as exclusion criteria.

Institutional review board approval was obtained. All patients were informed about the alternatives in surgery available at that time, and the decision was made according to the preference of the patient together with the surgeon. Thus, patients were not randomized. Patients have signed an informed consent for surgery preoperatively.

There were 127 male and 113 female patients with a mean age of 57.5 ± 12.1 years (range 27 to 86 years). All patients underwent comprehensive ophthalmic examination. The preoperative and postoperative 3rd month data of best corrected visual acuity (BCVA) and keratometric values were noted. The BCVA values were obtained on a Snellen scale and then converted into logarithm of the minimum angle of resolution (logMar) values.

Preoperative horizontal length was measured by focusing the slit on the pterygium and using ruler of the slit incorporated in the slit-lamp from limbus to the advancing edge of pterygium (Topcon SL-7F, Topcon Co., Japan).

Keratometric values were obtained using an automated keratorefractometer (Topcon K2-8100PA, Tokyo, Japan). Only keratometric values were included in the study since in approximately half of patients, we were unable to obtain a topographic measurement.

Pterygium excision was performed as follows: Lidocaine HCL 40 mg/2 ml + epinephrine 0.025 mg/ml (Jetokain, Adeka, Turkey) was injected under the conjunctiva into the body of the pterygium. Following removal of the body, the head was bluntly lifted off the cornea. The abnormal scar tissue on the cornea was

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removed. A moderate amount of Tenon’s capsule was removed from each patient. Either no or minimal cautery was used to the scleral bed. Following removal of the pterygium, patients underwent 5 different types of surgeries: Conjunctival autograft with sutures (CAG-s) or fibrin glue (CAG-g), conjunctival rotational flap (CRF), or amniotic membrane transplantation with either suture (AMT-s) or with glue (AMT-g).

In conjunctival autografting, an oversized graft for 1 mm of length and width relative to the scleral bed was harvested from the superotemporal limbus, with care to obtain a Tenon-free graft. The graft was subsequently moved to the nasal area. In CAG-s group, interrupted Vicryl 8-0 sutures were used to attach the graft. In the CAG-g group, fibrin glue (Tisseel VH, Baxter AG) was used to attach to the conjunctival edges and episclera. The method of application of the glue was described previously.^[6]

For CRF, a Tenon-free flap originating from the inferior bulbar conjunctiva with a hinge at the inferonasal border of the bare sclera was prepared and rotated to cover the bare sclera with interrupted 8/0 Vicryl sutures.

The amniotic membrane was prepared as described previously.^[7] For AMT, the membrane was taken out of the preservation medium and cut to the proper size to cover the defect area. The membrane was spread over the denuded area so that the epithelial/basement membrane surface would be on top, and it was sutured to the surrounding conjunctiva and episclera by using interrupted 8-0 Vicryl sutures in AMT-s group. On the other hand, in the AMT-g group, fibrin glue was used to attach the amniotic membrane as reported earlier.^[8]

The eye was covered with an eye pad after administration of topical antibiotic ointment (tobramycin). Following surgery, topical antibiotic (ofloxacin 0.3%, 4 times a day) and steroid (dexamethasone 0.1%, 4 times a day) drops were given, and were tapered over 1 month period. Sutures were removed at 2 weeks.

The data was entered into SPSS software (Statistical Package for the Social Sciences, version 13.0, SPSS Inc, Chicago, Ill, USA). The overall changes in BCVA and astigmatic degree were evaluated using Wilcoxon signed rank test. The difference in astigmatic values between groups was calculated using one way analysis of variance (ANOVA). Difference with significance of < 0.05 was accepted as statistically significant.

Results

The most commonly performed procedure was CAG-s (N = 115). Next, the number of patients in each group was as followed: CAG-g (N = 53), CRF (N = 47), AMT-s (N = 15), and AMT-g (N = 10). The horizontal length of the pterygium changed between 2 and 7 mm (mean ± SD 3.78 ± 1.11 mm). Most of the pterygium sizes were 3 mm (N = 115), followed by 4 mm (N = 58), 5 mm (N = 30), 6 mm (N = 23), 2 mm (N = 11) and 7 mm (N = 3).

The mean preoperative logMar values were 0.37 ± 0.64 (range 0.00 - 3.00). Following surgery, the logMar values decreased to 0.12 ± 0.24 (range 0.00 to 2.00). This postoperative decrease was significant (P < 0.001, Wilcoxon signed rank test).

Preoperatively, the mean astigmatic value was 3.47 ± 2.50 D (range 0.00 D -12.50 D). After surgery, the mean astigmatic values decreased to 1.29 ± 1.07 D (range 0.00 D -5.50 D). The mean difference between pre- and postoperative astigmatic

values was 2.18 ± 2.34 D, and this decrease was statistically significant (P < 0.001, paired t test). 162 eyes (67.5%) had a preoperative astigmatism of ≥ 2.00 D, which decreased to 51 (21.3%) postoperatively.

The distribution of pterygium sizes according to the surgery groups is shown in Fig. 1. The mean ± SD pterygium size according to the surgery type was as followed: 3.83 ± 1,16 mm in CAG-s, 3.72 ± 1.21 mm in CAG-g, 3.74 ± 1.07 mm in CRF, 3.60 ± 0.63 mm in AMT-s, and 4.00 ± 0.81 mm in AMT-g, and there was no difference between groups for pterygium sizes (P > 0.05).

The changes in astigmatism values according to the pterygium size are shown in Fig. 2. The astigmatic changes were significantly different according to the preoperative size of the pterygium (F = 3.464, P = 0.005, One way ANOVA). The Post Hoc test revealed that this difference was mainly due to differences between the pterygiae with sizes of 2 mm and 5 mm as well as 6 mm (P = 0.009 and P = 0.017, Tukey HSD). There was a positive correlation between the preoperative size of the pterygium and the change in astigmatism degree (ρ = 0.224, P < 0.001, Spearman correlation analysis). Also, the change in astigmatism was significantly correlated with preoperative astigmatic values (ρ = 0.780, P < 0.001, Spearman correlation analysis).

The postoperative astigmatism correlated positively with preoperative astigmatism (ρ = 0.351, P < 0.001, Spearman correlation analysis). On the other hand, the postoperative astigmatic values were negatively correlated with the change in astigmatism (ρ = -0.262, P < 0.001, Spearman correlation analysis).

The changes in astigmatic values were not related to the method of surgery (P = 0.055, ANOVA) [Fig. 3]. The patient number in AMT groups was small. Thus, if we omit the groups where amniotic membrane was used from the statistical comparison, the astigmatic changes were also not statistically significant (P = 0.240, ANOVA). Also, the correlation between the surgery type and change in astigmatism was not statistically significant (ρ = -0.116, P = 0.072, Spearman correlation analysis).

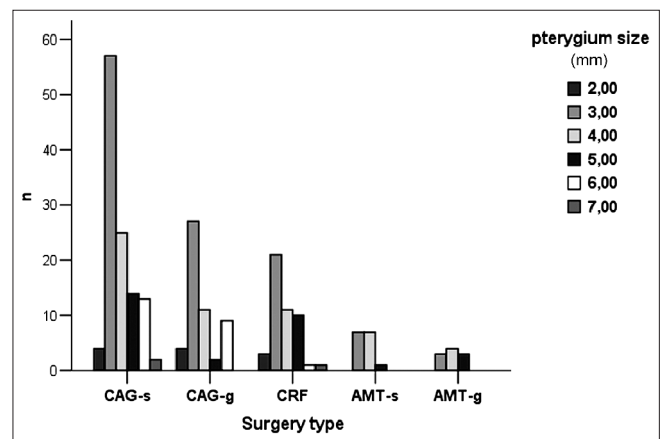


Figure 1: Simple bar chart shows the distribution of pterygium sizes according to the surgery type performed [N = Number of patients; CAG-s = Conjunctival autografting with sutures; CAG-g = Conjunctival autografting with fibrin glue; CRF = Conjunctival rotational flap; AMT-s = Amniotic membrane transplantation with sutures; AMT-g = Amniotic membrane transplantation with fibrin glue.]

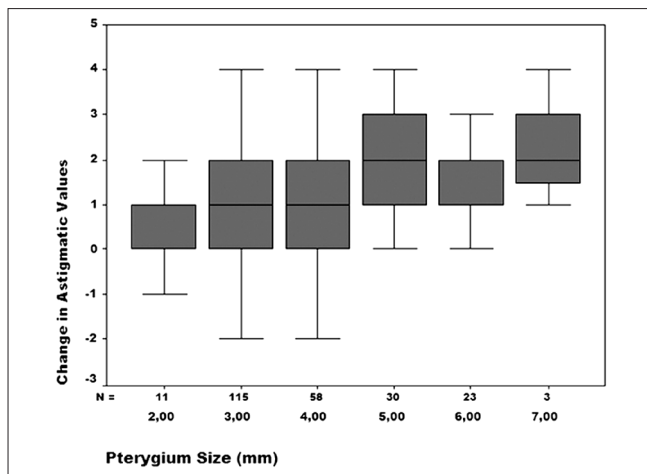


Figure 2: Whisker-plot showing the changes in astigmatic values (D: dioptre) according to the horizontal size of the pterygium measured from limbus to the head. [N = Number of patients]

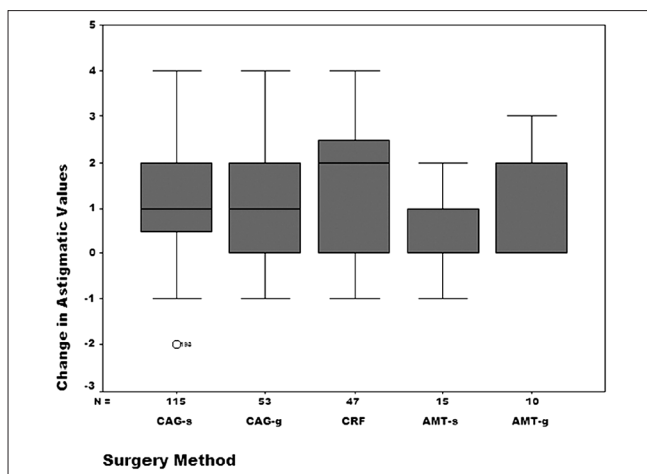


Figure 3: Whisker plot showing the changes in astigmatism (D) according to the type of surgery performed. [N = Number of patients; CAG-s = Conjunctival autografting with sutures; CAG-g = Conjunctival autografting with fibrin glue; CRF = Conjunctival rotational flap; AMT-s = Amniotic membrane transplantation with sutures; AMT-g = Amniotic membrane transplantation with fibrin glue.]

In a 2nd evaluation, we omitted 56 eyes where the size of the pterygium was 5 mm or larger and performed the analysis in 184 eyes. The most commonly performed procedure was CAG-s (N = 86). Next, the number of patients in each group was as followed: CAG-g (N = 42), CRF (N = 35), AMT-s (N = 14), and AMT-g (N = 7).

The mean preoperative logMar values were 0.32 ± 0.59 (range 0.00 - 3.00). Following surgery, the logMar values decreased to 0.10 ± 0.23 (range 0.00 -2.00). This postoperative decrease was significant ($P < 0.001$, Wilcoxon signed rank test).

Preoperatively, the mean astigmatic value was 2.97 ± 2.28 D (range 0.00 D -12.50 D). After surgery, the astigmatic values decreased to 1.16 ± 0.91 D (range 0.00 D 4.50 D). The mean difference between pre- and postoperative astigmatic values was 1.81 ± 2.22 D, and this decrease was statistically significant ($P < 0.001$, paired t test).

In this group with pterygium sizes 4 mm or less, the astigmatic changes were significantly different according to the preoperative size of the pterygium ($F = 3.115$, $P = 0.047$, One way ANOVA). The Post Hoc test revealed that this difference was due to the difference between 2 mm and 4 mm pterygiae ($P = 0.039$, Tukey HSD). There was a positive correlation between the change in astigmatic values and change in logMar values ($R = 0.344$, $P < 0.001$, Spearman correlation analysis). The changes in astigmatic values did not correlated with the method of surgery ($R = -0.141$, $P = 0.056$, Spearman correlation analysis). Also, there was no correlation with the change in logMar values and the type of surgery ($\rho = 0.042$, $P = 0.570$, Spearman correlation analysis).

Discussion

Pterygium may cause flattening of the cornea to the leading apex.^[1] An induced astigmatism was explained by several mechanisms: Pooling of the tear film at the leading edge of the pterygium, and mechanical traction exerted by the pterygium on the cornea.^[9]

As reported earlier, pterygium results in high corneal astigmatism, which decreases following an excision.^[10] Accordingly, in present study, we found that the degree of astigmatism decreased significantly following excision, and this decrease was related to the size of the pterygium. The size was affecting the change in astigmatism as well as postoperative degree of astigmatism. We also found that the change in astigmatic degree was positively correlated with the change in visual acuity. On the other hand, the type of grafting as CAG, CRF or AMT or the use of suture or glue to fixate the graft does not have a significant effect on the change in astigmatism degree.

The refractive components were demonstrated to stabilize at 1 month following pterygium surgery.^[10] However, in present study, we included the postoperative 3rd months' results to make sure that refraction was stabilized. The conventional keratometry evaluates the corneal refractive power from 3 or 4 data points. Hence, many authors suggested using corneal topography in evaluating the change in astigmatism following pterygium surgery. Since this was a retrospective study and we were unable to perform corneal topography in all cases, we have chosen to include only the keratometric values.

An increase in visual acuity is expected following pterygium excision.^[11,12] It was reported that BCVA increased from 0.53 to 0.68.^[9] Accordingly, we observed a decrease in logMar values from 0.38 to 0.13. In a similar study, the logMAR values decreased significantly from 0.41 to 0.24 in 27 eyes ($P = 0.000$).^[13]

Lin and Stern found a significant correlation between the size of pterygium and corneal astigmatism.^[1] It was also suggested that pterygium extending more than 45% of corneal diameter results in increasing degrees of astigmatism.^[14] Mohammad-Salih and co-workers studied the pterygium extension, width, and total area and investigated their relationship with corneal astigmatism. Among the 3, an extension had the strongest and the most significant correlation with the astigmatism ($\rho = 0.462$, $P < 0.001$, Pearson correlation analysis).^[15] The authors reported that pterygium with larger than 2.2 mm extension might contribute to corneal astigmatism > 2 D. It was reported that significant astigmatism increases with an increasing size of the pterygium.^[16] Kampitak concluded that the amount of induced corneal astigmatism and timing for pterygium

excision are related to the pterygium size, and reported that 2.25 mm pterygium resulted in astigmatism of 2 D, and should be considered in the limits of surgery.^[17] Accordingly, Seitz *et al.* concluded that with the size of pterygium from 2.5 mm, the preoperative astigmatism increases, therefore, the authors believed that the surgery should be performed before it reaches beyond this point.^[18] In present study, we compared the size of the pterygium with the change in astigmatism and found a significant correlation ($P < 0.001$). Main difference in change of astigmatism was between the sizes of 2 mm and 5 and 6 mm. Thus, we agree with previous reports that it is better to remove the pterygium when it measures nearly 2 mm in horizontal length.

In a prospective study, the videokeratographic changes of 55 eyes were evaluated and found that pterygium surgery significantly reduced refractive astigmatism from 3.12 to 2.51 ($P = 0.05$).^[11] Also, several reports showed a decrease in corneal astigmatism.^[10,12,13,19-23] We also found that corneal astigmatism decreased from 3.47 D to 1.29 D. The mean difference in corneal astigmatism change was 2.18 ± 2.34 D, and this decrease was statistically significant ($P < 0.001$). Surgical removal of pterygium can improve the changes; however, in eyes with advanced pterygium, corneal distortion does not normalize completely and irregular changes may persist if the lesion has reached the paracentral cornea.^[24] Some other factors, like changes in corneal stroma and Bowman's layer, are suggested to be responsible for these persistent refractive changes in eyes after pterygium surgery.^[25]

We found a significant correlation between the pre- and postoperative astigmatic values ($\rho = 0.351$, $P < 0.001$). Contrary to our results, some studies show no correlation between these 2 parameters.^[11,20,23] This contradiction might be related to the larger number of patients included, and the larger horizontal pterygium sizes in present study. Similar to our results, Wu *et al.* found a significant correlation between the differences in refractive cylindrical power before and after surgery.^[13]

Since the primary excision with bare sclera technique has a high recurrence rate, nowadays, many surgeons prefer conjunctival autograft or amniotic membrane transplantation.^[26] Also, recently fibrin glue application is suggested as an alternative to suture placement, and its use is increasing.^[5] The results and recurrence rates of different surgical techniques is studied in several reports.^[4,10] However, to our knowledge, there is limited study comparing the effect of different surgical approaches on astigmatism. Frau and co-workers noticed that following surgery, corneal astigmatism exceeded more than 3 D in 7 patients and did not change dramatically in the rest of their 109 eyes with corneo-conjunctival autografting.^[27] Yilmaz *et al.* compared the astigmatic changes following different types of surgeries including conjunctival autografting, limbal-conjunctival autograft, bare sclera and bare sclera with mitomycin.^[28] The authors found a statistical difference between groups for mean topographical astigmatism and surgically-induced astigmatism ($P = 0.033$ and 0.030 , respectively). In that study, the mean difference was between the bare sclera and graft techniques where postoperative astigmatism was smaller in the former. In present study, we found no difference in postoperative astigmatic changes between different surgical techniques. The main difference between the 2 studies (ours and Yilmaz

et al.'s) is the measurement of astigmatism in present study via keratometry. The other difference was in surgical techniques. We did not use bare sclera technique. Also, limbal grafts were not included in this study. All 5 methods included in this study involved some type of graft or flap either secured with sutures or with fibrin glue.

In conclusion, pterygium results in high corneal astigmatism, which increases with the increase in horizontal length, and decreases to an acceptable level following excision. We found a significant correlation between the preoperative and postoperative astigmatic values as well as the changes in astigmatism with surgery. According to our study, the type of grafting as CAG, CRF or AMT or the use of suture or glue to fixate the graft does not have a significant effect on the change in astigmatism degree. Further prospective studies with topographic measurements and larger patient numbers are warranted to evaluate this topic in detail.

References

1. Lin A, Stern GA. Correlation between pterygium size and induced corneal astigmatism. *Cornea* 1998;17:28-30.
2. Sanchez-Thorin JC, Rocha G, Yelin JB. Meta-analysis on the recurrence rates after bare sclera resection with and without mitomycin C use and conjunctival autograft placement in surgery for primary pterygium. *Br J Ophthalmol* 1998;82:661-5.
3. Shimazaki J, Shinozaki N, Tsubota K. Transplantation of amniotic membrane and limbal autograft for patients with recurrent pterygium associated with symblepharon. *Br J Ophthalmol* 1998;82:235-40.
4. Prabhawat P, Barton K, Tseng SCG. Comparison of conjunctival autografts, amniotic membrane graft and primary closure for pterygium excision. *Ophthalmology* 1997;104:974-85.
5. Koranyi G, Seregard S, Kopp ED. Cut and paste: A no suture, small incision approach to pterygium surgery. *Br J Ophthalmol* 2004;88:911-4.
6. Karalezli A, Kucukerdonmez C, Akova YA, Altan-Yaycioglu R, Borazan M. Fibrin glue versus sutures for conjunctival autografting in pterygium surgery: A prospective comparative study. *Br J Ophthalmol* 2008;92:1206-10.
7. Kucukerdonmez C, Akova YA, Altinors DD. Comparison of conjunctival autograft with amniotic membrane transplantation for pterygium surgery. Surgical and cosmetic outcome. *Cornea* 2007;26:407-13.
8. Kucukerdonmez C, Karalezli A, Akova YA, Borazan M. Amniotic membrane transplantation using fibrin glue in pterygium surgery: a comparative randomised clinical trial. *Eye* 2010;24:558-66.
9. Maheshwari S. Effect of pterygium excision on pterygium induced astigmatism. *Indian J Ophthalmol* 2003;51:187-8.
10. Tomidokoro A, Miyata K, Sakaguchi Y, Samajima T, Tokunaga T, Oshika T. Effects of pterygium on corneal spherical power and astigmatism. *Ophthalmology* 2000;107:1568-71.
11. Bahar I, Loya N, Weinberger D, Avisar R. Effect of pterygium surgery on corneal topography: A prospective study. *Cornea* 2004;23:113-7.
12. Stern GA, Lin A. Effects of pterygium excision on induced corneal topographic abnormalities. *Cornea* 1998;17:23-7.
13. Wu PL, Kuo CN, Hsu HL, Lai CH. Effect of pterygium surgery on refractive spherocylinder power and corneal topography. *Ophthalmic Surg Lasers Imaging* 2009;40:32-7.
14. Alisan L, George AS. Correlation between pterygium size and induced corneal astigmatism. *Cornea* 1998;17:28-30.
15. Mohamad-Salih PA, Sharif AF. Analysis of pterygium size and induced corneal astigmatism. *Cornea* 2008;27:434-8.

16. Avisar A, Loya N, Yassur Y, Weinberger D. Pterygium induced corneal astigmatism. *Isr Med Assoc J* 2000;2:14-5.
17. Kampitak K. The effect of pterygium on corneal astigmatism. *J Med Assoc Thai* 2003;86:16-23.
18. Seitz B, Gütay A, Kuchle M, Kus MM, Langenbacher A. Pterygiumgröße, Hornhauttopographie und Visus – eine prospektive klinische Querschnittstudie. *Klin Monatsbl Augenheilkd* 2001;218:609-15.
19. Soriano JM, Janknecht P, Witschel H. Effect of pterygium operation on preoperative astigmatism. Prospective Study. *Ophthalmologie* 1993;90:688-90.
20. Cinal A, Yasar T, Demirok A, Topaz H. The effect of pterygium surgery on corneal topography. *Ophthalmic Surg Lasers* 2001;32:35-40.
21. Yagmur M, Ozcan AA, Sari S, Ersoz RT. Visual acuity and corneal topographic changes related with pterygium surgery. *J Refract Surg* 2005;21:166-70.
22. Maheshwari S. Pterygium-induced corneal refractive changes. *Indian J Ophthalmol* 2007;55:383-6.
23. Errais K, Bouden J, Mili-Boussen I, Anane R, Beltaif O, Meddeb Ouertani A. Effect of pterygium surgery on corneal topography. *Eur J Ophthalmol* 2008;18:177-81.
24. Tomidokoro A, Oshika T, Amano S, Eguchi K, Eguchi S. Quantitative analysis of regular and irregular astigmatism induced by pterygium. *Cornea* 1999;18:412-5.
25. Cameron ME. Histology of pterygium: an electron microscopic study. *Br J Ophthalmol* 1983;67:604-8.
26. Tan DT, Chee SP, Dear KB, Lim AS. Effect of pterygium morphology on pterygium recurrence in a controlled trial comparing conjunctival autografting with bare sclera excision. *Arch Ophthalmol* 1997;115:1235-40.
27. Frau E, Labetoulle M, Lautier-Frau M, Hutchinson S, Offret H. Corneo-conjunctival autograft transplantation for pterygium surgery. *Acta Ophthalmol Scand* 2004;82:59-63.
28. Yilmaz S, Yuksel T, Maden A. Corneal topographic changes after four types of pterygium. *J Refract Surg* 2008;24:160-5.

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