Effect of Pterygia on Refractive Indices, Corneal Topography, and Ocular Aberrations

Koray Gumus, MD, FEBO,† Kuddusi Erkilic, MD,* Duygu Topaktas, MD,* and Joseph Colin, MD‡*

Purpose: To investigate the effect of different sizes of pterygium on ocular aberrations along with corneal refractive changes, keratometry, and corneal topography.

Methods: Forty eyes of 34 patients who had different sizes of primary nasal pterygium and 40 eyes of 22 age- and sex-matched healthy subjects without a clinical diagnosis of pterygium or pinguecula were enrolled in this study. All patients underwent a measurement of uncorrected and best spectacle–corrected visual acuities, corneal topography, and ocular aberrations. The pterygia sizes were measured with a slit lamp by using a slit beam of light.

Results: All indices (topographic/refractive spherical and astigmatic values and topographic/refractive spherical equivalent) were higher in the pterygia group than in the control group. Both horizontal length (Rho: 0.64 and $P < 0.001$) and width of pterygia (Rho: 0.68 and $P < 0.01$) were found to be correlated with corneal astigmatism. When the root mean square values of ocular aberrations were compared among the groups (control, small, medium, and large size pterygia), differences were found to be statistically significant regarding all parameters including total ($P < 0.001$), tilt ($P < 0.001$), higher order aberrations ($P < 0.001$), total coma ($P < 0.001$), total trefoil ($P < 0.001$), total tetrafoil ($P < 0.001$), total spherical aberrations ($P = 0.004$), and higher order astigmatism ($P < 0.001$). Moreover, the root mean square values of ocular aberrations seem to strongly correlate with both horizontal length and width of pterygia.

Conclusions: Pterygia, particularly with larger sizes, seem to be correlated with increased ocular aberrations. Moreover, increase of ocular aberrations may become one of the indications for surgical treatment if this association is supported by further investigations.

Key Words: pterygium, refractive indices, corneal topography, ocular aberrations

(*Cornea* 2011;30:24–29)

A pterygium is an elevated, superficial, wedge-shaped growth of the fibrovascular conjunctival tissue that extends onto the corneal surface. In general, they do not require any surgical intervention except when there is visual impairment, recurrent inflammation, motility restriction, or cosmetic disfigurement.[1–5]

Even though numerous studies have investigated and documented the impact of different sizes of pterygium and of pterygium surgery on corneal refractive status including astigmatism, keratometry, and corneal topography,[1–8] there is limited data about the wavefront aberrations induced by pterygia and the impact of pterygium surgery on these aberrations.[9,10] However, because visual performance and optical quality seemed to be correlated with wavefront aberrations, ocular aberrations have been discussed in more detail particularly in articles that investigated the impact of keratorefractive surgeries and intraocular lenses on visual performance.[11,12] Moreover, new technological improvements occurred to minimize ocular aberrations for better optical quality in patients.

Consequently, this study aimed to provide all ophthalmologists and other eye practitioners better understanding of the impact of pterygia on ocular aberrations and to compare the results with those of healthy subjects without signs of pterygium or any limbal mass.

MATERIALS AND METHODS

The study protocol conformed to the principles outlined in the Declaration of Helsinki and was approved by the Institutional Ethics Committee (208-519) (Medical Ethics Committee, Erciyes University Medical Faculty, Kayseri, Turkey). Written informed consent was taken from all participants before the investigation. Forty eyes of 34 patients who had primary nasal pterygia of different sizes and 40 eyes of 22 age- and sex-matched healthy subjects without a clinical diagnosis of pterygium or pinguecula were enrolled in this clinical study.

Patients were excluded if they had a history of anterior segment surgery/trauma, topical drug usage, or a history of contact lens wear and if they had active ocular infection, severe blepharitis, meibomitis, dry eye, clinically significant nuclear sclerosis/cataract, or other ocular surface and corneal diseases

Received for publication May 6, 2009; revision received January 8, 2010; accepted March 3, 2010.

From the *Division of Cornea & Refractive Surgery, Department of Ophthalmology, Erciyes University Medical Faculty, Kayseri, Turkey; †Ocular Surface Center, Cullen Eye Institute, Baylor College of Medicine, Houston, Texas; and ‡Service d ophtalmologie, Bordeaux, France.

The results of the study were presented as an oral presentation at the Winter Symposium of Turkish Society of Ophthalmology, January 23–25, 2009, Bursa, Turkey.

The authors have no financial or proprietary interest in any product, method, material, or concept used or discussed in this study.

Reprints: Koray Gumus, Division of Cornea & Refractive Surgery, Department of Ophthalmology, Erciyes University Faculty of Medicine, Kayseri, Turkey, 38039 (e-mail: drkorayg@hotmail.com).

Copyright © 2010 by Lippincott Williams & Wilkins

Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

that may have affected the study parameters mentioned below. All patients underwent a detailed ophthalmologic examination; all were performed by the same person (K. G.). Uncorrected and best spectacle–corrected visual acuities (UCVA and BSCVA, respectively) were measured with logarithm of the minimum angle of resolution chart (Smart System II 2020 Visual Acuity System, M&S technologies, Inc, IL). Subjective refraction including spherical error, cylindrical error, and spherical equivalent [spherical error plus (cylindrical error/2)] were performed. Biomicroscopy and dilated fundoscopy were also performed.

To assess the pterygium sizes associated with the cornea, 2 different lengths were noted. The first was the horizontal length (HL) between the nasal limbus and the apex (the point furthest away from the limbus) of the pterygium, and the second was the vertical length (VL) representing the line between 2 limbal points where the pterygium intersected with the limbus. The sizes (in millimeters) were measured with a slit lamp by using a slit beam of light.

After HLs and VLs were divided into 3 subgroups (HL: ≤2.0 mm, 2.0–3.5 mm, and >3.5 mm and VL: ≤5.0 mm, 5.1–7.0 mm, and >7.0 mm), the 3 below-mentioned separate groups were established according to different HL and VL subgroups:

- Group 1 (small size pterygium): HL ≤ 2.0 mm + VL ≤ 5.0 mm and HL ≤ 2.0 mm + VL = 5.1–7.0 mm and HL = 2.0–3.5 mm + VL ≤ 5.0 mm.
- Group 2 (medium size pterygium): HL = 2.0–3.5 mm + VL = 5.1–7.0 mm.
- Group 3 (large size pterygium): HL = 2.0–3.5 mm + VL > 7.0 mm and HL > 3.5 mm + VL = 5.1 + 7.0 mm and HL > 3.5 mm + VL > 7.0 mm.

All patients underwent corneal topography and ocular aberrations using NIDEK-Optical Path Difference Scanning System ARK-10000 refractive power/corneal analyzer (Version 1.12iAC, NIDEK Co, Ltd, Gamagori, Japan). Three images were recorded for each eye across a natural (undilated) pupil. The image with the best alignment and at least 6 digitized rings were selected for analysis. The simulated keratometry values in the 2 major axes were noted from each selected axial map.

Ocular aberrations were measured using sixth-order Zernike polynomials decomposition. The parameters analyzed included the root mean square (RMS) values of total aberrations (Total), tilt (S1), higher order aberrations (HOA), total coma (T. Coma) aberrations, total trefoil (T. trefoil), total tetrafoil (T. 4foil), total spherical aberrations (T. Sph), and higher order astigmatism (HiAstig).

SPSS 15.0 for Windows evaluation version (LEAD Technologies, Inc, Chicago, IL) was used for statistical analysis. The Pearson χ^2 test was applied to analyze sex differences among the groups. A Shapiro–Wilk test was carried out to determine whether data were normally distributed. Student *t* test for independent samples was used to determine whether there was a statistically significant difference between the 2 groups regarding normally distributed continuous variables. If a distribution could not be normalized by logarithmic transformation, the Mann–Whitney *U* test was used. Continuous parameters such as RMS values of ocular aberrations were analyzed among the groups (control and 3 pterygium subgroups) by 1-way analysis of variance and Welch analysis of variance tests. Tukey and Tamhane multiple comparison tests were also applied for the homogenous and nonhomogenous parameters, respectively. Spearman correlation test was carried out to analyze the association among the study parameters. A P value less than 0.05 was considered statistically significant.

RESULTS

No statistically significant difference was found between the pterygium and control groups in terms of age (respectively, 46.1 ± 11.0 and 44.2 ± 10.0, $P = 0.502$). The sex distribution was also comparable in both groups (in the pterygium group, men/women: 13 (38.2%)/21 (61.8%) and in the control group, men/women: 8 (38.1%)/13 (61.9%); $P = 1.00$).

The extension of pterygium onto the cornea ranged from 1.8 to 6.5 mm, with a mean of 3.2 ± 1.1 mm. The width ranged from 3.5 to 8.2 mm, with a mean of 6.0 ± 1.3 mm. Both HL (Rho: 0.64 and $P < 0.001$) and VL of pterygia (Rho: 0.68 and $P < 0.01$) were found to be correlated with corneal astigmatism.

Although BSCVA was comparable among the groups, UCVA was significantly lower in the pterygium group. Moreover, both topographic and refractive spherical, cylindrical, and spherical equivalent values were significantly higher in the pterygium group compared with normal subjects. Regarding the types of astigmatism, although most of the control subjects had no astigmatism, 60% of patients with pterygium had "with-the-rule" astigmatism. Detailed data about UCVA, BSCVAs, and topographic/refractive spherical and cylindrical errors is presented in Table 1.

When RMS values were compared between the 2 groups, all RMS values in the pterygium group were significantly higher than those in the control group (Table 2). Moreover, these values were found to be strongly correlated with both HL and VL of pterygium. Details of the correlation between the RMS values of optical aberrations and HL and VL of pterygium on the surface of the cornea are documented in Table 3.

The mean photopic and mesopic pupil sizes were comparable in control and pterygia subgroups (respectively, $P = 0.104$ and $P = 0.146$). When RMS values of ocular aberrations were compared among the groups (control, small size pterygium, medium size pterygium, and large size pterygium), differences were found to be statistically significant regarding all parameters including total ($P < 0.001$), tilt ($P < 0.001$), HOA ($P < 0.001$), total coma ($P < 0.001$), total trefoil ($P < 0.001$), total tetrafoil ($P < 0.001$), total spherical aberrations ($P = 0.008$), and higher order astigmatism ($P < 0.001$). The distribution of the RMS values of the parameters according to the different sizes of pterygium groups and controls is documented in Figures 1 and 2. P values among the groups are also shown in these Figures.

DISCUSSION

Pterygium is a frequently seen ocular surface disease in ophthalmology practice. Recently, pterygium has gained more notice because of its impact on visual performance and because of increased types of surgical techniques for dealing

© 2010 Lippincott Williams & Wilkins

Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

TABLE 1. Visual Acuities, Topographic/Refractive Spherical and Astigmatic Values, and Type of Astigmatism in the Groups

Parameters	Pterygium Group (n = 40 Eyes)	Control Group (n = 40 Eyes)	*P*
UCVA (logMAR)	0 (0–0.8)	0 (0–0.3)	<0.001*
BSCVA (logMAR)	0 (0–0.2)	0 (0–0)	0.317*
Topographic spherical value	1.0 (−1.0 to +5.75)	0 (−1.0 to +0.75)	<0.001*
Topographic astigmatic value	−1.0 (−9.0 to 0)	0 (−0.75 to 0)	<0.001*
Topographic spherical equivalent	0.56 ± 1.14	−0.16 ± 0.47	<0.001†
simK2 – simK1	1.5 (0.25–6.75)	0.5 (0–1.5)	<0.001*
Refractive spherical value	0 (−1 to +6.0)	0 (−0.75 to 0)	<0.001*
Refractive astigmatic value	−0.5 (−6.0 to 0)	0 (0–0)	<0.001*
Refractive spherical equivalent	0 (−1.75 to +3)	0 (−0.75 to 0)	0.009*
Type of astigmatism, n (%)			
No astigmatism	8 (20)	30 (75.0)	<0.001‡
With-the-rule astigmatism	24 (60)	4 (10)	
Against-the-rule astigmatism	3 (7.5)	4 (10)	
Oblique astigmatism	5 (12.5)	2 (5.0)	

*Mann–Whitney *U* test [cells: median (minimum–maximum)].
†Independent samples *t* test (cells: mean ± SD).
‡Likelihood ratio [cells: number (%)].
logMAR, logarithm of the minimum angle of resolution; UCVA, uncorrected visual acuity; BSCVA, best spectacle-corrected visual acuity.

with it. Most recent studies have focused on both refractive and topographic changes induced by a pterygium and the visual and cosmetic outcomes after its excision.[13–15] However, to our knowledge, there is very limited data on the possible association between pterygia and ocular aberrations that may be responsible for deterioration in the quality of vision.[9,10] Moreover, there are no controlled studies that investigated this association. This study was planned to meet this deficit by investigating the impact of different sizes of pterygia on ocular aberrations along with other refractive and topographic changes.

Pterygia do not only lead to visual impairment by invading the visual axis or distorting the central topography, but they also induce a focal corneal flattening and severe astigmatism.[1,3,16] However, the exact mechanism of these changes has not yet been clarified. Oldenburg et al[1] and Budak et al[15] hypothesized that the observed corneal flattening and topographic changes may be produced by a pooling of tears at the pterygia apex and mechanical traction of the pterygium. However, Yasar et al[17] suggested that although these changes can be attributed to the pooling of tears, fibrovascular traction had no effect on the changes induced by pterygium. In the current study, all indices (topographic/refractive spherical and astigmatic values and topographic/refractive spherical equivalent) were higher in the pterygia group than in the control subjects. Moreover, although UCVA values were statistically lower in the pterygia group, BSCVA values were comparable in the 2 groups. This means that pterygia may cause correctable refractive errors and lower UCVA values.

Most of the pterygia revealed with-the-rule type of astigmatism that seemed to be in proportion to their sizes.[14] Similarly, in our study, most of our cases were found to have with-the-rule astigmatism (60%) followed by oblique (12.5%) and against-the-rule astigmatism (7.5%). Moreover, both the HL and vertical width of pterygia correlated significantly with induced corneal astigmatism.

Even though numerous studies[4,8,13,18,19] have documented that surgical excision of pterygium improved the corneal and also topographic changes mentioned above, Tomidokoro et al[5] stated that corneal distortion could not be repaired completely especially in cases with larger pterygium. Pterygia do not seem to affect only the visual parameters; they may also have some structural impacts on cornea. For instance, an interesting article documented that long-standing nasal pterygia could rarely induce deep corneal changes at the level of the endothelium and Descemet membrane.[20] Based on these data, we can speculate that earlier excision may be more logical to reverse the changes of visual parameters and to not cause permanent detriment to the cornea.

These days, the quality of human visual performance starts to gain more attention than its quantitative properties. In addition, ocular wavefront aberrations constitute the most important part of the optical quality of the eye. Consequently,

TABLE 2. The Root Mean Square (RMS) Values of Ocular Aberrations in the Pterygium and Control Groups

Parameters	Pterygium Group (n = 40 Eyes)	Control Group (n = 40 Eyes)	*P*
Total*	0.47 ± 0.36	−0.10 ± 0.13	<0.001
Tilt*	0.07 ± 0.39	−0.42 ± 0.21	<0.001
Higher-order aberration*	0.15 ± 0.45	−0.45 ± 0.12	<0.001
Total coma†	0.51 (0.12–4.04)	0.19 (0.04–0.39)	<0.001
Total trefoil*	−0.03 ± 0.53	−0.67 ± 0.20	<0.001
Total tetrafoil*	−0.32 ± 0.57	−1.12 ± 0.25	<0.001
Total spherical†	0.15 (0.01–1.47)	0.09 (0.002–0.285)	0.002
Higher order astigmatism*	−0.68 ± 0.47	−1.22 ± 0.22	<0.001

*After logarithmic transformation, independent samples *t* test was used. Cells are presented as logarithmic mean ± SD.
†Mann–Whitney *U* test was used. Cells are presented as median (minimum–maximum).

© 2010 Lippincott Williams & Wilkins

Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

TABLE 3. Correlation Between Root Mean Square (RMS) Values of Ocular Aberrations and Horizontal and Vertical Lengths of Pterygium

Correlation With HL of Pterygium	Rho	*P*	Correlation With VL of Pterygium	Rho	*P*
Total	0.724	<0.001	Total	0.739	<0.001
Tilt	0.545	<0.001	Tilt	0.643	<0.001
Higher-order aberration	0.747	<0.001	Higher-order aberration	0.740	<0.001
Total coma	0.632	<0.001	Total coma	0.696	<0.001
Total trefoil	0.742	<0.001	Total trefoil	0.697	<0.001
Total tetrafoil	0.702	<0.001	Total quadrafoil	0.674	<0.001
Total spherical	0.449	0.004	Total spherical	0.447	0.004
Higher order astigmatism	0.679	<0.001	Higher order astigmatism	0.656	<0.001

Correlations were carried out using Spearman correlation test.
HL, horizontal length; VL, vertical length.

the most significant part of the current study is that it provides us data about the association of different sizes of pterygia with ocular aberrations. In our study, aberrations were investigated by the optical path difference scan that has been reported to measure wavefront aberrations accurately.[21] Moreover, the repeatability and reproducibility of this method of measuring high-order aberrations have been found to be similar to other measurement methods.[22]

In our study, aberration parameters including total, tilt, HOA, total coma, total trefoil, total tetrafoil, total spherical, and higher order astigmatism were all found to be higher in the pterygia group than in the normal subjects. Moreover, the RMS values of optical aberrations seem to strongly correlate with both HL and VL of pterygia. In other words, larger sizes of pterygia accompany increased lower and higher order ocular aberrations. Despite the comparable BSCVA values in both groups (pterygia and control), the fact that wavefront aberrations were higher in the pterygia group revealed the deterioration of the optical quality in patients with pterygium. In a subgroup analysis, RMS values of ocular wavefront aberrations reached the highest levels in the fourth group (large size pterygium group). As discussed previously, there is limited data on this issue. In one study that aimed to determine the HOA at the corneal first surface before and after surgery for pterygium, pterygia were found to be associated with wavefront aberrations, especially trefoil.[9] Moreover, it has also been documented that these aberrations were largely eliminated by surgery.[9] The same study also emphasized that earlier excision of pterygia might reduce the likelihood of significant residual aberrations.[9]

In conclusion, pterygia lead to the deterioration of the quality of visual performance not only by causing refractive and topographic changes but also by increasing ocular wavefront aberrations. Based on this information, the authors believe that after the findings of this study have been replicated and improved by other large clinical studies, ocular wavefront aberrations may be considered as one of the indications for surgical excision.

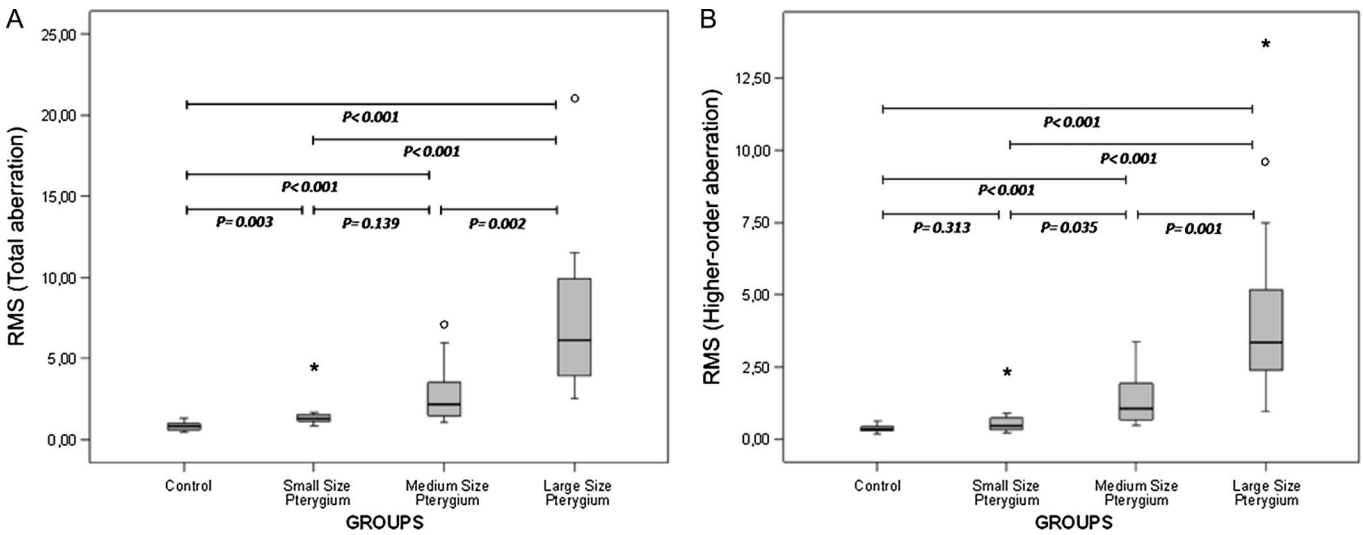


FIGURE 1. The box plots representing root mean square (RMS) values of total (A) and higher-order aberration (B) in 4 groups. They include the most extreme values (*), outliers (o), maximum and minimum values, the median value of the data set and *P* values among the groups.

© 2010 Lippincott Williams & Wilkins

Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

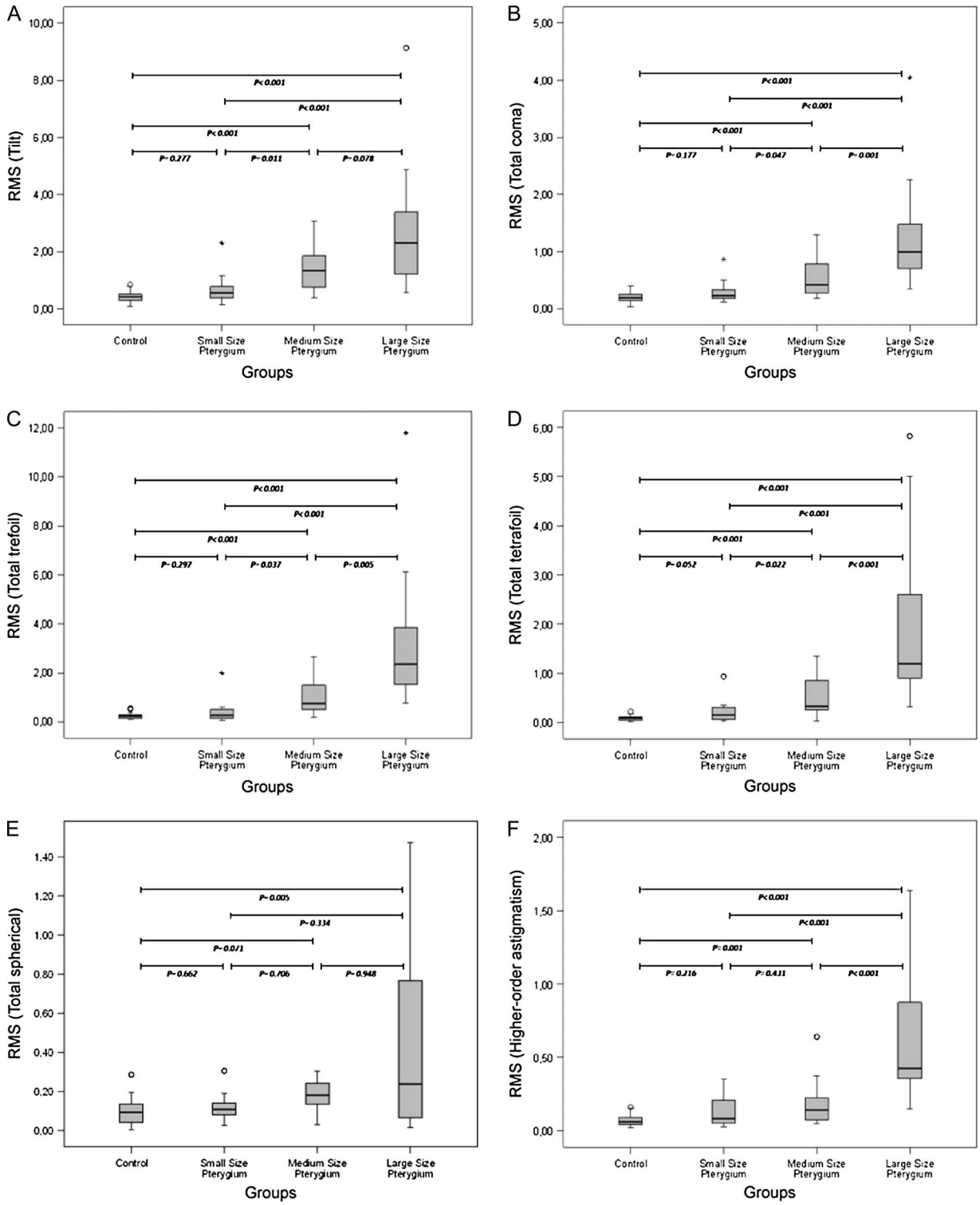


FIGURE 2. The box plots representing root mean square (RMS) values of lower- and higher-order aberrations including tilt (A), coma (B), trefoil (C), tetrafoil (D), spherical (E) and higher-order astigmatism (F) in 4 groups. They include the most extreme values (*), outliers (o), maximum and minimum values, the median value of the data set and *P* values among the groups.

© 2010 Lippincott Williams & Wilkins

Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

ACKNOWLEDGMENT

The authors are very grateful to Oznur Kose for her technical support throughout the study.

REFERENCES

1. Oldenburg JB, Garbus J, McDonnell JM, et al. Conjunctival pterygia. Mechanism of corneal topographic changes. *Cornea*. 1990;9:200–204.
2. Walland MJ, Stevens JD, Steele ADM. The effect of recurrent pterygium on corneal topography. *Cornea*. 1994;13:463–464.
3. Lin A, Stern G. Correlation between pterygium size and induced corneal astigmatism. *Cornea*. 1998;17:18–30.
4. Stern GA, Lin A. Effect of pterygium excision on induced corneal topographic abnormalities. *Cornea*. 1998;17:23–27.
5. Tomidokoro A, Oshika T, Amano S, et al. Quantitative analysis of regular and irregular astigmatism induced by pterygium. *Cornea*. 1999;18: 412–415.
6. Tomidokoro A, Miyata K, Sakaguchi Y, et al. Effects of pterygium on corneal spherical power and astigmatism. *Ophthalmology*. 2000;107: 1568–1571.
7. Alison L, George AS. Correlation between pterygium size and induced corneal astigmatism. *Cornea*. 1998;17:28–30.
8. Bahar I, Loya N, Weinberger MD, et al. Effect of pterygium surgery on corneal topography: a prospective study. *Cornea*. 2004;23:113–117.
9. Pesudovs K, Figueiredo FC. Corneal first surface wavefront aberrations before and after pterygium surgery. *J Refract Surg*. 2006;22:921–925.
10. Applegate RA, Hilmantel G, Howland HC, et al. Corneal first surface optical aberrations and visual performance. *J Refract Surg*. 2000;16: 507–514.
11. Cadarso L, Iglesias A, Ollero A, et al. Postoperative optical aberrations in eyes implanted with AcrySof spherical and aspheric intraocular lenses. *J Refract Surg*. 2008;24:811–816.
12. Fernández-Sánchez V, Ponce ME, Lara F, et al. Effect of 3rd-order aberrations on human vision. *J Cataract Refract Surg*. 2008;34: 1339–1344.
13. Cinal A, Yasar T, Demirok A, et al. The effect of pterygium surgery on corneal topography. *Ophthalmic Surg Lasers*. 2001;32:35–40.
14. Mohammad-Salih PA, Sharif AF. Analysis of pterygium size and induced corneal astigmatism. *Cornea*. 2008;27:434–438.
15. Budak K, Khater TT, Friedman NJ, et al. Corneal topographic changes induced by excision of perilimbal lesions. *Ophthalmic Surg Lasers*. 1999; 30:458–464.
16. Pavilack MA, Halpern BE. Corneal topographic changes induced by pterygia. *J Refract Surg*. 1995;11:92–95.
17. Yasar T, Ozdemir M, Cinal A, et al. Effects of fibrovascular traction and pooling of tears on corneal topographic changes induced by pterygium. *Eye*. 2003;17:492–496.
18. Yagmur M, Ozcan AA, Sari S, et al. Visual acuity and corneal topographic changes related with pterygium surgery. *J Refract Surg*. 2005;21: 166–170.
19. Yilmaz S, Yuksel T, Maden A. Corneal topographic changes after four types of pterygium surgery. *J Refract Surg*. 2008;24:160–165.
20. Mootha VV, Pingree M, Jaramillo J. Pterygia with deep corneal changes. *Cornea*. 2004;23:635–638.
21. Hieda O, Kinoshita S. Measuring of ocular wavefront aberration in large pupils using OP-scan. *Semin Ophthalmol*. 2003;18:35–40.
22. Rozema JJ, Van Dyck DEM, Tassignon MJ. Clinical comparison of 6 aberrometers. Part 2: statistical comparison in a test group. *J Cataract Refract Surg*. 2006;32:33–44.

© 2010 Lippincott Williams & Wilkins

Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.