# Effects of Pterygium on Ocular Aberrations

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**Purpose:** To compare high-order aberration between the eyes with pterygium and normal fellow eyes.

**Setting:** Ophthalmic Research Center and Department of Ophthalmology Labbafinejad Medical Center Shahid Beheshti University of Medical Sciences Tehran, Iran.

**Method:** This comparative cross-sectional study comprised 31 patients with unilateral pterygium. NIDEK OPD-Scan wavefront aberrometry was performed in all patients in both eyes. Then, aberometric parameters were compared between the eyes.

**Results:** Sixty-two eyes of 31 patients (23 men and 8 women) with a mean age of 42.5 ± 5.9 years were included in the study. Root mean square (RMS) of total higher-order aberration increased statistically significantly in the involved eyes compared with normal fellow eyes (1.85 ± 2.22 and 0.36 ± 0.44 μm; $P = 0.001$). All RMS of Zernike orders and all RMS of different aberrations were higher in the involved eyes group and were statistically significant except for spherical aberration. The most significant differences belonged to RMS of total trefoil (1.37 vs. 0.25 μm) and RMS of total coma (0.37 vs. 0.14 μm) ($P = 0.0001$). With decreasing the uninvolved optical zone (increasing the size of pterygium), RMS of all aberrations increased and the differences were statistically significant except for spherical aberration.

**Conclusion:** Pterygium and its size have significant influence on high-order aberrations of the eye especially on measured total coma and total trefoil in compared with normal fellow eye.

**Key Words:** wavefront, OPD-Scan, aberrometry, pterygium

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Pterygium is a disease of the ocular surface with a fibrovascular growth of conjunctiva into the cornea. The induction of astigmatism because of invasion of the pterygium into the cornea has long been known. The change is often characterized as with-the-rule astigmatism resulting from localized flattening of the cornea, but this type of astigmatism is usually irregular.[1]

Several reports evaluated the effects of pterygium on refraction and corneal topography. These effects become quantified as sphere or astigmatism changes, but as readers know, irregular astigmatism could not express to sphere and cylinder.[1–7] Recently, ocular aberrometry enables us to evaluate irregular astigmatism more precisely. In addition, this method is able to discern refraction of the eye within 0.05 diopters (D), approximately 25–50 times greater than autorefraction or topographic analysis.[8]

Until now, several systems have been developed as clinical tools for aberrometry, 1 of which is OPD-Scan. The current prospective fellow eye study was conducted to investigate the influences of pterygium and its size on ocular aberrometry measured by OPD-Scan.

## PATIENTS AND METHODS

In a prospective study, we assessed the consecutive patients with unilateral primary pterygium who were presented to Labbafinejad Medical Center (Tehran, Iran) from September 2008 to January 2009. Informed consent was obtained from each patient after explaining the nature of the study.

Comprehensive ophthalmic examination was done for all patients, including uncorrected and best-corrected visual acuity, tonometry, slit-lamp biomicroscopy, and fundus examination.

Exclusion criteria were history of previous ocular surgery, abnormal findings not related to the pterygium at slit-lamp examination in the involved eye, and any abnormal change (including corneal scar, keratoconus, cataract, vitreous opacity, and any other ocular optic abnormalities) in the normal fellow eye. We also excluded patients older than 50 years to avoid the possible effect of the age on the ocular aberrations.

According to the size of uninvolved optical zone (UOZ), pterygia were classified into 3 groups, including 9 mm and more than 9 mm UOZ (≥9 mm UOZ group), between 7 and 9 mm UOZ (7- to 9-mm UOZ group), and between 7 and 5 mm UOZ (5- to 7-mm UOZ group). UOZ was measured with the eye in the primary position and the slit beam coaxial. Patients with large pterygium involving 5-mm central optical zone were excluded because of insufficient quality of measurements.

Measurements were performed with OPD-Scan (NIDEK, Co, Gamagori, Japan). Each eye was evaluated 3 times, and aberrations were measured in 5-mm optical zone across the

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undilated pupil. OPD-Scan units enable us to evaluate refraction, corneal topography, and wavefront aberrometry. Whole eye wavefront sensing was used for assessing pterygium-induced aberration. The Zernike coefficients were determined up to the fifth order, and root mean square (RMS) of total and higher-order aberrations, RMS of odd higher-order aberrations, RMS of even higher-order aberrations, the RMS of the third-, fourth-, and fifth-order aberrations, RMS of total coma, RMS of total trefoil, and RMS of spherical aberration were compared between 2 eyes. Enantiomorphism was neutralized by inverting the sign of mirror-symmetric coefficients of left eyes.[9]

Statistical testing was carried out by using the SPSS windows version 16 (SPSS, Inc, Chicago, IL). The variables are expressed as mean ± SD; to compare differences, paired *t* test were used. Differences were considered significant at *P* value less than or equal to 0.05. One-way analysis of variance was used for comparing against the size UOZ in the eyes with pterygium.

## RESULTS

In this study, 62 eyes of 31 patients (23 men and 8 women) with a mean age of 42.5 ± 5.9 years (range: 31–50 years) were examined. Mean best-corrected visual acuity was 20/30 (range: 20/40–20/20) in the involved eyes and 20/20 (range: 20/30–20/15) in the normal eyes. Mean steep/flat SimK was 45.42/41.96 D in the eyes with pterygium and 43.80/43.25 D in the normal fellow eyes. Both steep and flat SimK were statistically different between normal and affected eyes ($P < 0.05$), but mean K was not different (43.68 D in the eyes with pterygium and 43.52 D in the normal fellow eyes; $P > 0.05$).

Mean refractive sphere was 1.04 D (range: −2.50 to 6.75 D), and mean with-the-rule astigmatism was −2.32 D (range: −8.75 to 2.00 D) in the eyes with pterygium. These values were −0.27 D (range: −4.50 to 2.50 D) and −0.49 D (range: −3.00 to 2.00 D) in the normal eyes. The differences were statistically significant for both the groups ($P = 0.019$ for sphere and $P = 0.000$ for cylinder).

The total high-order RMS in 5-mm optical zone was 1.85 ± 2.22 and 0.36 ± 0.44 μm in the affected and normal eyes, respectively. The difference was statistically significant between 2 groups ($P = 0.001$). In the eyes with pterygium, the RMS of the third-, fourth-, and fifth-order aberrations were more than normal eyes (Table 1), and the differences were statistically significant ($P \geq 0.05$ for each order). The most significant differences belonged to total trefoil (1.37 vs. 0.25 μm) and total coma (0.37 vs. 0.14 μm). Total high astigmatism (0.20 vs. 0.05 μm; $P = 0.001$) and RMS of tetrafoil (0.49 vs. 0.11 μm; $P = 0.003$) were also different statistically between 2 groups. Although the mean spherical aberration was still greater in the eyes with pterygium (0.18 vs. 0.10 μm), this difference was not statistically significant ($P = 0.114$).

Using 1-way analysis of variance among 3 groups, including ≥9 mm UOZ, 7- to 9-mm UOZ, and 5- to 7-mm UOZ groups, showed that there were significant differences between groups in the RMS of all aberrations except spherical aberration. With decreasing the UOZ (increasing the size of pterygium), all RMS of modes and orders increased (Fig. 1), including RMS of higher-order aberrations (0.31 vs. 2.58 vs. 3.35 μm, respectively; $P = 0.004$), RMS of odd higher-order aberrations (0.28 vs. 1.53 vs. 2.77 μm, respectively; $P = 0.003$), RMS of even higher-order aberrations (0.15 vs. 0.65 vs. 1.04 μm, respectively; $P = 0.005$), RMS of the third-order aberrations (0.27 vs. 1.48 vs. 2.67 μm, respectively; $P = 0.003$), fourth-order aberrations (0.15 vs. 0.64 vs. 1.04 μm, respectively; $P = 0.005$), RMS of total coma (0.18 vs. 0.41 vs. 0.68 μm, respectively; $P = 0.0001$) RMS of total trefoil (0.20 vs. 1.69 vs. 2.95 μm, respectively; $P = 0.001$), and RMS of total tetrafoil (0.08 vs. 0.57 vs. 1.12 μm, respectively; $P = 0.000$). However, again the increasing of RMS of spherical aberration was not statistically significant ($P = 0.29$).

**TABLE 1.** High-Order Aberrations in Eyes With Pterygium and the Normal Fellow Eyes

| Type of Aberration | Pterygium Mean ± SD | Normal Mean ± SD | *P* |
|---|---|---|---|
| Sph in 5 mm (D) | 1.04 ± 2.49 | −0.27 ± 1.60 | 0.019 |
| Cyl in 5 mm (D) | −2.33 ± 2.13 | −0.49 ± 0.51 | 0.000 |
| High (μm) | 1.85 ± 2.22 | 0.36 ± 0.45 | 0.001 |
| Coma (μm) | 0.37 ± 0.27 | 0.14 ± 0.14 | 0.000 |
| Trefoil (μm) | 1.36 ± 1.62 | 0.25 ± 0.21 | 0.000 |
| Tetrafoil (μm) | 0.49 ± 0.59 | 0.11 ± 0.33 | 0.003 |
| Spherical (μm) | 0.19 ± 0.26 | 0.10 ± 0.13 | 0.114 |
| HiAstig (μm) | 0.20 ± 0.22 | 0.05 ± 0.03 | 0.001 |
| Odd (μm) | 1.28 ± 1.48 | 0.33 ± 0.32 | 0.003 |
| Even (μm) | 0.53 ± 0.56 | 0.20 ± 0.39 | 0.019 |
| Third (μm) | 1.24 ± 1.45 | 0.29 ± 0.22 | 0.002 |
| Fourth (μm) | 0.52 ± 0.56 | 0.20 ± 0.39 | 0.020 |
| Fifth (μm) | 0.31 ± 0.36 | 0.11 ± 0.25 | 0.031 |

Differences are statistically significant except for spherical aberration.
Coma and trefoil are the major contributors.
Cyl, cylinder; D, diopter; Even, RMS of even orders; Fifth, RMS of fifth order; Fourth, RMS of fourth order; HiAstig, high astigmatism; High, high-order RMS; Odd, RMS of odd orders; Sph, sphere; Third, RMS of third order.

## DISCUSSION

The effect of pterygium on optical irregularity and distortion is well known. It also has been documented that pterygium excision improved corneal irregularity.[1–6] The corneal irregularity is 1 of the sources of ocular aberrations. Therefore, aberrations that are relatively new concerns in the quality of vision may be influenced by pterygium. Our knowledge of influence of pterygium on ocular aberrations is limited. The aim of this study was to explore changes in ocular higher-order aberrations in the eyes with pterygium and to compare it with the normal fellow eyes.

Effect of pterygium on corneal wavefront aberrations has been evaluated only in 1 recent study by Pesudovs et al.[10] They determined the higher-order aberrations at the corneal first surface before and after surgery for pterygium. All Zernike modes were elevated in their study, with trefoil being the major aberration. They showed that pterygium excision significantly reduced wavefront aberrations, but their

 

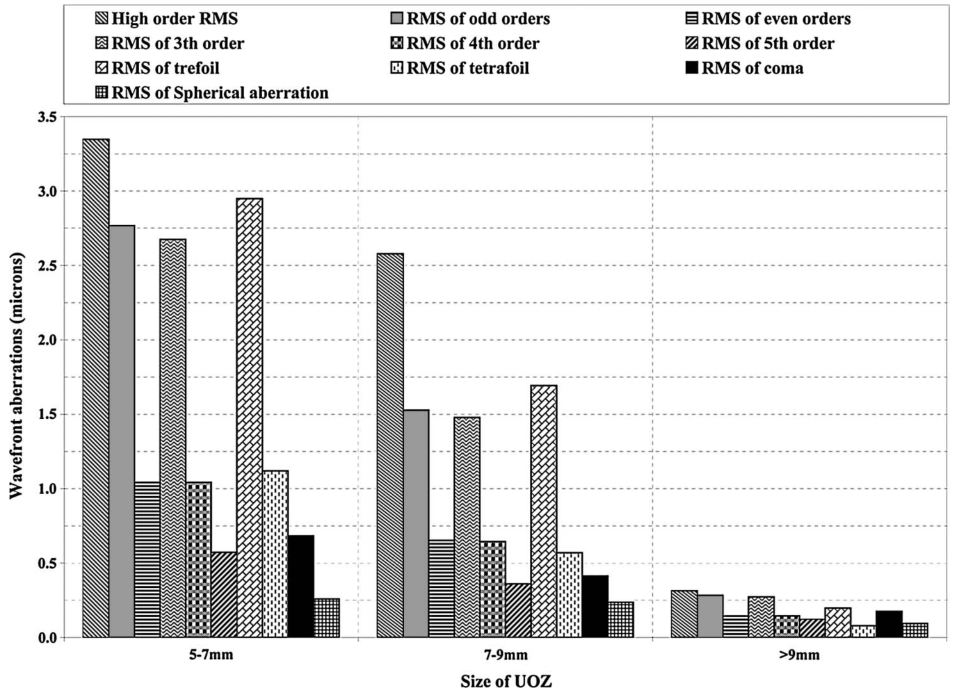


**FIGURE 1.** Comparing high-order aberrations according to the size of UOZ. With increasing the size of pterygium (reduction of UOZ), high-order aberrations increase. Spherical aberration difference is not also statistically significant among 3 groups ($P > 0.05$).

study had several limitations. Wide-ranged age of the cases (25–86 years) might cause age-induced aberrations. In addition, this study has compared wavefront aberration changes before and after surgery. As readers know, corneal changes secondary to pterygium may persist after surgery, and some patients even have an increase in astigmatism after surgery. Therefore, unexpected effect of surgery on corneal aberration may work as conflicting variable and did not allow us to relate all of postoperative changes to pterygium itself.

We used the normal eyes of the same patients for comparing the high-order aberrations as control group in our study. This fellow eye study can exclude the different aberrations, which are not related to the pterygium, and determine more exactly the high-order aberrations induced by pterygium. In addition, the range of age was limited in our study (range: 31–50 years). Therefore, the measured aberrations were less influenced by the effect of aging on ocular wavefront. These make the results of our study more reliable, but we should consider that limiting the study to a specific age group might also limit the ability of generalization of our results to other ages as well.

We found significant increases in RMS of total and higher-order aberrations, RMS of odd higher-order aberration, RMS of even higher-order aberrations, RMS of total third-, fourth-, and fifth-order aberrations, RMS of total coma, and RMS of total trefoil in the eyes with pterygium compared with normal fellow eyes. These were consistent with work by Pesudovs et al.[10] Along with total trefoil, which was reported by Pesudovs et al as the major fraction of higher-order aberration, total coma was the other major contributor in our study and significantly higher in eyes with pterygium than in normal eyes. Pterygium is usually located in nasal quadrant (all of our cases) and makes asymmetric optical distortion; therefore, we could expect coma-like aberrations, which are not symmetric across the eye, in the eyes with pterygium. For the same reason, as could be expected, spherical aberration was the only high-order wavefront aberration that was not statistically different between normal and involved eyes in our study.

We classified pterygium into 3 groups according to the size of UOZ. Although the size of UOZ is relevant to the size of pterygium, it is also dependent to the size of cornea. For example, 2 eyes with equal pterygium size of 3 mm, with different corneal size of 11 and 13 mm, have different UOZ of 5 and 7 mm, respectively, and logically have not the same induced aberrations. This may be an explanation for contradictory findings in the evaluation of relation of pterygium size in some previous studies.

Results of current study demonstrated that pterygium had significant influence on higher-order aberrations of the eye, and this influence was dependent on the size of UOZ. It means that the larger the size of the pterygium, the more high order the ocular aberrations. The most significant increase in higher-order aberration belonged to total coma and total tetrafoil according to the size of UOZ ($P = 0.000$).

## CONCLUSIONS

Pterygium has significant influence on high-order aberrations. These changes are dependent to the size of pterygium. Total coma and total trefoil are the most affected aberrations by pterygium, and total trefoil and total tetrafoil are the most affected by its size. These finding may be helpful in deciding the time of surgery in the eyes with pterygium and may justify why the patients with pterygium have significant visual symptoms despite visual axis sparing and appreciated spectacle correction.

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