Original article

Effect of pterygium on corneal topography and astigmatism

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Abstract To study the effects of pterygium on corneal topography and astigmatism and to determine the critical pterygium size which induces significant astigmatism.

Methods Thirty-three patients with unilateral primary pterygium were evaluated for pterygium morphology (22 women and 11 men with mean age of 56.2±10.9 years). An automated keratometer and an Orbscan II were used to evaluate corneal astigmatism, and the latter was also used to assess corneal topography. Results from the pterygium and contralateral eyes were compared.

Results Mean corneal extension and width of the pterygia was 2.7±1.0 and 4.2±1.2 mm, respectively. With-the-rule astigmatism was the most common type (66.7%), followed by oblique (27.3%), and against-the-rule astigmatism (6.0%). The median (IQR) corneal astigmatism between the pterygium and contralateral eyes as measured by auto-keratometry and Orbscan II including auto-K, sim-K, K at the 3-mm and K at 5-mm zones were significantly different [1.00(0.50-1.94) and 0.75(0.38-1.07) (p =0.011), 1.2 (0.65-2.30) and 0.70 (0.35-1.05) (p<0.001),1.5 (0.95-2.5) and 0.80(0.50-1.35) (p<0.001), 1.7 (0.75-2.93) and 0.90 (0.40-1.25) (p<0.001),respectively. Pterygium induced astigmatism of ≥1 D when it extended ≥2.25 mm onto the cornea (sensitivity 76.2%, specificity 66.7%).

Conclusion Corneal extension is an important parameter in assessment of pterygium-induced astigmatism. Surgical intervention is recommended when the pterygium extends 2.25 mm or more onto the cornea. **Chiang Mai Medical Journal 2017;56(2):89-95.**

Keywords: Pterygium, keratometry, astigmatism, corneal topography

Introduction

Pterygium is an ocular pathology detected frequently in ophthalmologic practice. Prevalence is higher in countries near the equator since exposure to ultraviolet light from sunlight is an important etiologic factor of pterygium (1-3). In addition to being an aesthetic problem, pterygia may cause symptoms of irritation, lacrimation, foreign body sensation, and impaired vision. Pterygia affect vision by involving the visual axis in the case of large pterygia or by inducing corneal astigmatism. Post-operatively, corneal distortion may not be recover completely in eyes with advanced pterygium, and irregular topographic changes may persist if the lesion has reached the paracentral zone of the cornea (4).

This study investigated the effect of a pterygium on cornea topography by comparing

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keratometry (K) values of the affected eye with the normal contralateral eye and attempted to determine the minimum size of a pterygium that should be surgically removed to prevent permanent corneal distortion.

Methods

This cross-sectional observational study was performed on 33 patients with a unilateral primary pterygium at Chiang Mai University Hospital, Thailand, from November 2012 through August 2013. The study protocol was approved by the Research and Ethics Committee of the Faculty of Medicine, Chiang Mai University, prior to initiation. All patients gave their written informed consents before participation in study-related activities.

Inclusion criteria were patients with unilateral primary pterygium that had a corneal extension of 4.5 mm or less. Patients who had bilateral pterygium (nasal and temporal pterygium involving the same eye), recurrent pterygium, pseudo-pterygium, history of ocular surgery or ocular trauma, or severe dry eye were excluded.

In comparing astigmatism between both eyes, the normal eye was considered the control. Patients were evaluated for distance visual acuity (VA) and anterior eye segments using slit-lamp biomicroscopy. Pterygium size (mm), including horizontal extension onto the cornea (measured from the limbus to an apex of pterygium) and the width of the pterygium (the cord length at the limbus), were recorded. Morphology of the pterygium was graded according to Tan's classification into 3 grades: Grade 1(atrophic) where the episcleral vessels underlying the pterygium were clearly visible; Grade 3 (fleshy) where the pterygium was thick and the underlying episcleral vessels were totally obscured; and Grade 2 (between grades 1 and 3) where the episcleral vessels were partially obscured (5).

An automated refractor-keratometer (KR-8100, Topcon, Japan) was used to determine sphere and cylin der power as well as keratometry (K) power of each eye. An Orbscan II (version 3.00E, Bausch & Lomb, USA) was used to determine corneal astigmatism including simulated keratometry (sim K), central 3-mm, and 5-mm K measurement. Corneal astigmatism was calculated as the difference between the two refractive powers.

Determination of sample size was done using multiple regression methods which suggested a sample size of 30 (6). Regression analysis was also used to study association among extension, grading, width, corneal astigmatism, and VA. Either Student's t-test or the Wilcoxon Signed Rank test were used to compare variables between the study and the control eyes depending on the data distribution. The Receiver Operating Characteristic (ROC) curve was used to determine the size of pterygium that induced a significant amount of corneal astigmatism using Sim K ≥1.0 D as the criterion).

Results

There were 22 (66.7%) females, and 11 (33.3%) males. The patients' age ranged from 32-74 (mean±SD of 56.2±10.9) years old. The right eye was affected in 15 patients (45.5%) and the left eye in 18 (54.5%). Nasal pterygium was detected in 32 eyes (96.97%). Grade 1 pterygium was found in 1 eye (3.03%), grade 2 in 15 eyes (45.45%), and grade 3 in 17 eyes (51.52%). The mean pterygium extension was 2.7±1.0 mm (range 1.0-4.5 mm) and the mean pterygium width was 4.2±1.2 mm (range 1.9-6.4 mm). Mean uncorrected VA (UCVA) of the study eyes and the control eyes was 0.17±0.31 and 0.13±0.25, respectively.

The spherical and total cylindrical power and corneal astigmatism measured by autorefractor-keratometer as well as Orbscan sim K, K reading at 3-mm and 5-mm zone of the study and contralateral eyes is shown in Table 1. There was a statistically significant difference between the study and control eyes in median total corneal astigmatism (p=0.013), auto-K (0.011), sim K (<0.001), and K reading at 3- (<0.001) and 5-mm zone (<0.001). However, there was no difference in spherical power between the pterygium and contralateral normal eyes as measured by both the auto-refractor and the Obscan II (Table 1).

In the pterygium eyes, with-the-rule (WTR) astigmatism (axis from 0-30, 150-180) was the main type of astigmatism (22 eyes, 66.7%), followed by oblique (axis from 30-60 or 120-150) (9 eyes, 27.3%) and against-the-rule (ATR) astigmatism (axis from 60-120) (2 eyes, 6.0%). The proportion of astigmatism types was similar in the control eyes: WTR astigmatism (21 eyes, 63.6%) was the most common type of astigmatism followed by oblique (6 eyes, 18.2%), and ATR astigmatism (6 eyes, 18.2%).

Table 1. Comparison of mean visual acuity, spherical power and astigmatism parameters between study and control eyes

Variables (median and IQR)	Study eye	Control eye	*P-value*
UCVA (log MAR)	0.00 (0.00-0.25)	0.00 (0.00-0.25)	0.199^{w}
Autorefractor-keratometer values			
- Sphere (D)	+1.00 (0.00 - +2.45)	+0.75 (0.06 - +1.56)	0.074^{w}
- Total astigmatism (D)	1.00 (0.75-1.81)	0.75 (0.50-1.12)	0.013^{w}
- Corneal astigmatism (D)	1.00 (0.50-1.94)	0.75 (0.38-1.07)	0.011^{w}
Corneal topography values			
Corneal sphere power (mean±SD)			
- Sim K (D)	44.18±1.80	44.69±1.76	0.253^{t}
- K 3 mm (D)	44.34±1.94	44.66±1.73	0.499^{t}
- K 5 mm (D)	43.40±2.77	44.49±1.65	0.060^{t}
Corneal astigmatism			
- Sim K (D)	1.2 (0.65-2.30)	0.70 (0.35-1.05)	<0.001^{w}
- K 3 mm (D)	1.5 (0.95-2.5)	0.80 (0.50-1.35)	<0.001^{w}
- K 5 mm (D)	1.7 (0.75-2.93)	0.90 (0.40-1.25)	<0.001^{w}

K, keratometry; ^{D}, diopter; ^{W}, Wilcoxan signed ranks test; ^{t}, t-test

The correlation between both pterygium size (extension and width) as well as the degree of corneal astigmatism in study and control eyes using Sim K astigmatism was examined. There was a positive linear correlation between pterygium extension (r=0.480, *p*=0.005), and pterygium width (r=0.379, *p*=0.03). (Figure 1, 2) However, only the pterygium extension correlation was statistically significant. It was also slightly larger than the pterygium width (Table 2). Between the two difference ROC curves, pterygium extension had a larger area under the curve (AUC) for detecting corneal astigmatism of ≥1.0 D with a sensitivity of 76.2% and specificity of 66.7% for a pterygium extension onto the cornea ≥2.25 mm Table 3.

Discussion

Pterygium is a common disease which can interfere with vision by involving the visual axis or producing changes in refractive state and curvature of the cornea. Corneal distortion may be reversed following pterygium removal (7-9); however, in the case of a large size pterygium which involves the paracentral area, a corneal scar or an irregular astigmatism may result. In any event, pterygium surgery is not a complication-free procedure; the complication of greatest concern is recurrent pterygium that may cause an unappealing cosmetic appearance, irregular astigmatism, and ocular restriction which is more severe than that caused by the primary pterygium. It is important, therefore, to determine the critical size of the pterygium requiring excision to prevent any pterygium-induced visual threats and to be able to weigh the risk of possible surgery-related complications.

Corneal astigmatism in eyes with pterygium reflects the combined effects of naturally occurring astigmatism and that induced by the pterygium. A possible mechanism of pterygium-induced corneal distortion is the tractional force of contractile elements within the pterygium that mechanically distort and flatten the cornea (10). The change is usually characterized as WTR astigmatism resulting from localized flattening of the cornea central to the apex of the pterygium (9-11). In this study, the most common type of astigmatism in the pterygium eyes was also WTR astigmatism, followed by oblique and ATR astigmatism. This study found that pterygium eyes had higher corneal astigmatism than normal contralateral eyes as measured by both auto-keratometer and corneal topography (sim K and central 3-,

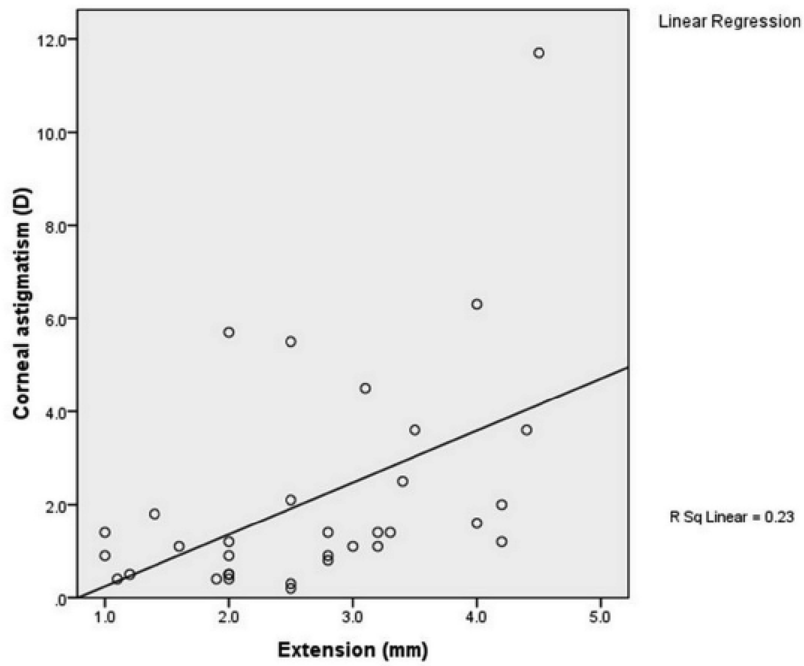

Figure 1. Interactive graphs representing the positive linear correlation between pterygium extension (mm) and corneal astigmatism (D)

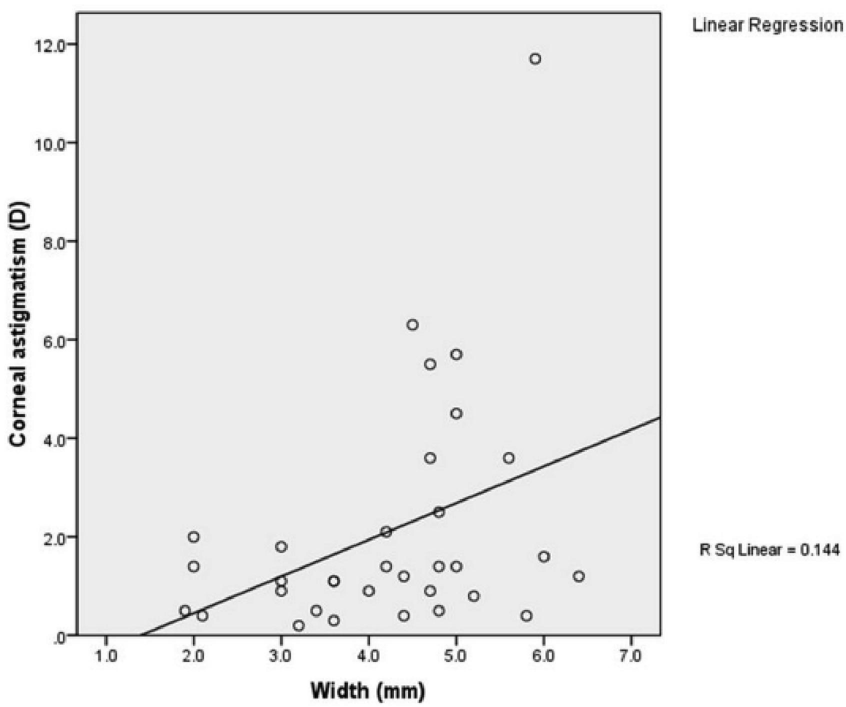

Figure 2. Interactive graphs representing the positive linear correlation between pterygium width (mm) and corneal astigmatism (D)

Table 2. Area under curve (AUC) of pterygium extension and width correlated to corneal astigmatism

Parameters	AUC	*P-value*	95% confidence interval
Pterygium extension	0.796	0.005	0.646 - 0.946
Pterygium width	0.635	0.635	0.436 - 0.837

Table 3. Pterygium size producing corneal astigmatism of 1 diopter or more

Pterygium size (mm) greater than or equal to	Sensitivity	Specificity	Sensitivity + specificity
0	100	0	100.00
1.05	95.2	8.3	103.50
1.15	95.2	16.7	111.90
1.3	95.2	25	120.20
1.5	90.5	25	115.50
1.75	85.7	25	110.70
1.95	85.7	33.3	119.00
2.25	76.2	66.7	142.90
2.65	61.9	83.3	145.20
2.9	57.1	100	157.10
3.05	52.4	100	152.40
3.15	47.6	100	147.60
3.25	38.1	100	138.10
3.35	33.3	100	133.30
3.7	28.6	100	128.60
4.1	19	100	119.00
4.3	9.5	100	109.50
4.45	4.8	100	104.80
5.5	0	100	100.00

5-mm K), whereas the spherical power of the pterygium eyes tended to be lower than normal contralateral eyes but the difference was not statistically significant.

Previous studies of the association between the size of the pterygium and corneal astigmatism have found that the corneal extension (7, 10, 12), width (10), and area (1) of the pterygium were significantly related to corneal astigmatism. This study, on the contrary, found that only pterygium extension was significantly associated with corneal astigmatism. This study did not determine total pterygium area because in practice it would be difficult to calculate the exact area of a pterygium on the cornea.

Even though evidence has shown that a pterygium may induce corneal spherical errors, astigmatism, and corneal irregularities, these effects could be reversed following pterygium surgery (7-9). Many studies have been done to determine the critical size of pterygium associated with a clinically significant amount of corneal astigmatism, but they have provided a variety of findings. Mohummad-Salih et al. found that pterygium might contribute to corneal astigmatism of ≥2 D when its extension is ≥2.2 mm, width ≥5 mm, or its total area ≥6.25 mm^2 (10). Oner et. al. suggested that a pterygium with a length or width exceeding 3 mm should be surgically removed as it would induce significant corneal astigmatism (13). Avisar et al. suggested early surgical intervention when the pterygium size was 1.0 mm from the limbus or extended to 16% of the corneal radius because it might contribute to corneal astigmatism of ≥1D (11). Avisar's study evaluated the extension of unilateral primary pterygium (from 0.2-6.7 mm) using computerized corneal analysis (TMS

II). However, that study did not compare the astigmatism eye with contralateral normal eye. Kampitak's study of the effects of pterygium on corneal topography using an Orbscan II found that the pterygium might contribute to corneal astigmatism of ≥2 D when it extended ≥2.25 mm onto the cornea with a sensitivity of 86.21% and a specificity of 80% (12). The findings from Kampitak's study were different from the results in this present study which found pterygium-induced astigmatism of ≥1 D when the pterygium extension was ≥2.25 mm with 76.2% sensitivity and 66.7% specificity. This difference in results may be due to the larger size of pterygium (up to 8.1 mm.) and the inclusion of bi-head pterygia (both nasal and temporal) in Kampitak's study that may have more impact on corneal curvature than smaller size pterygium. However, larger pterygia or lesions that approach the visual axis can cause errors in corneal topography measurement.

Although conventional keratometry is a simple tool for assessing corneal astigmatism, the technique evaluates the corneal refraction from four data points on a single mire ring which may limit the evaluation of corneal curvature in eyes with irregular astigmatism due to corneal pathology such as pterygium. Corneal topography provides sim K values calculated based on numerous dioptric data points and can measure the keratometric power over the whole cornea. For those reasons, corneal topography should be more reliable than conventional keratometry. However, corneal topography has some measurement limitations in the case of certain conditions, e.g., dry eye, a surface with tear pooling, a lesion approaching the optical zone, and in patients who cannot open their eyes wide enough for the test. One study using computerized videokeratography (VKG) to evaluate the effects of pterygium on corneal astigmatism confirmed that a pterygium extending beyond 40% of corneal diameter could affect the image from VKG and the sim K values (7). Others have suggested performing corneal topography in eyes without excess tearing to minimize measurement errors (11).

In conclusion, pterygium extension into the cornea is a simple procedure which provides an important parametric measurement for determining the degree of corneal astigmatism induced by pterygium. Surgical intervention was recommended in pterygium exceeding 2.25 mm onto the cornea to prevent significant amount of pterygium-induced corneal astigmatism.

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ผลของต้อเนื้อต่อลักษณะพื้นผิวและภาวะสายตาเอียงของกระจกตา

สุดารัตน์ ล้อนันทกุล และ นภาพร ตนานุวัฒน์
ภาควิชาจักษุวิทยา คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

วัตถุประสงค์ เพื่อศึกษาผลของต้อเนื้อต่อลักษณะพื้นผิวกระจกตาและภาวะสายตาเอียง และเพื่อประเมินขนาดของต้อเนื้อที่เหนี่ยวนำให้เกิดภาวะสายเอียงในปริมาณที่มีนัยสำคัญ

วิธีการ ศึกษาในผู้ป่วยต้อเนื้อที่เป็นในตาข้างเดียวจำนวน 33 ราย (เป็นหญิง 22 ราย และชาย 11 ราย อายุเฉลี่ยที่ 56.2±10.9 ปี) ผู้ป่วยได้รับการประเมินลักษณะของต้อเนื้อ เครื่องมือที่ใช้ประเมินภาวะสายตาเอียงได้แก่ เครื่องวัดความโค้งของกระจกตาแบบอัตโนมัติ และเครื่อง Obscan II โดยอย่างหลังใช้ประเมินลักษณะพื้นผิวของกระจกตาด้วย

ผลการทดลอง ขนาดของต้อเนื้อที่งอกเข้าไปบนกระจกตามีค่าเฉลี่ยที่ 2.7±1.0 มม.และมีความกว้างเฉลี่ยที่ 4.2±1.2 มม. ชนิดของสายตาเอียงที่พบมากที่สุดคือ ชนิด with-the-rule (ร้อยละ 66.7) รองลงมาคือ ชนิด oblique (ร้อยละ 27.3) และชนิด against-the-rule (ร้อยละ 6.0) ตามลำดับค่ากลางของสายตาเอียงที่เกิดจากกระจกตาระหว่างตาที่เป็นต้อเนื้อและตาข้างที่ปกติจากการวัดด้วยเครื่องวัดความโค้งกระจกตาแบบอัตโนมัติ และเครื่อง Orbscan II ได้แก่ ค่า auto K, sim K และค่าความโค้งของกระจกตาที่บริเวณ 3 มม.และ 5 มม. มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ [1.00 (0.50-1.94) and 0.75 (0.38-1.07) (p=0.011), 1.2 (0.65-2.30) and 0.70 (0.35-1.05) (p<0.001), 1.5(0.95-2.5) and 0.80 (0.50-1.35) (p<0.001), 1.7 (0.75-2.93) and 0.90 (0.40-1.25) (p<0.001), ตามลำดับ] ต้อเนื้อเหนี่ยวนำให้เกิดสายตาเอียงได้มากกว่า 1 ไดออปเตอร์ หากต้อเนื้องอกเข้ามาในบริเวณกระจกตาตั้งแต่ 2.25 มม.ขึ้นไป (ความไว ร้อยละ 76.2 และความจำเพาะ ร้อยละ 66.7)

สรุป ขนาดของต้อเนื้อที่งอกเข้ามาบนกระจกตาเป็นตัวแปรที่สำคัญในการประเมินภาวะสายตาเอียงที่เหนี่ยวนำโดยต้อเนื้อ ขนาดของต้อเนื้อที่ควรแนะนำให้ทำการผ่าตัดคือต้อเนื้อที่เข้ามาในกระจกตาตั้งแต่ 2.25 มม. ขึ้นไป **เชียงใหม่เวชสาร 2560;56(2):89-95.**

คำสำคัญ: ต้อเนื้อ ค่าความโค้งของกระจกตา สายตาเอียง พื้นผิวกระจกตา