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Posterior Corneal Astigmatism Changes in Cases with Keratoconus

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ABSTRACT

Background: keratoconus is bilateral (usually asymmetrical), progressive, non inflammatory, cone like anterior protrusion of the cornea involving the central and the inferior para central areas that results in corneal ectasia, astigmatism and diminution of vision. It usually seen after puberty, with incidence of 1 in 2000 of general population, the major benefit of corneal tomography is the measurement of the posterior corneal surface, because the posterior surface contributes minimally to the overall refractive power of the eye (due to the minimal difference between the index of refraction of the cornea and aqueous) it was considered less important both diagnostically and therapeutically. The posterior cornea, however, is an earlier indicator of ectatic change or ectasia susceptibility.

Aim of the Work: to determine the changes of posterior corneal astigmatism in cases with keratoconus.

Patients and Methods: one hundred eyes of 50 patients were included in this retrospective, case control study which adhered to the tenets of the Declaration of Helsinki and was approved by the Ethics Committees of the Ain Shams University Hospitals. All patients included in the study provided informed consent, these cases were divided into: 1- Keratoconus group: comprised 50 eyes of 25 patients with keratoconus diagnosed on the basis of clinical and topographic signs and 2- Control group comprised 50 eyes of 25 normal candidates for refractive surgery.

Results: the mean magnitudes posterior corneal astigmatism(PCA) were approximately 1 D, and The PCA values were significantly associated with the severity ofKeratoconus(KC), the posterior corneal surface was more affected in the early stages of KC.

Conclusion: we found that the mean magnitudes PCA were approximately 1 D, and The PCA values were significantly associated with the severity of KC, the posterior corneal surface was more affected in the early stages of KC.

Keywords: Keratoconus, corneal tomography, posterior astigmatism, pentacam.

INTRODUCTION

Corneal topographers based on Placido disc and recent elevation based tomography. Keratoconus is non inflammatory, ectatic corneal disorder characterized by progressive corneal thinning that results in corneal protrusion, irregular astigmatism, and decreased visual acuity[(1)]. The incidence of keratoconus is about 1 of 2,000 individuals with a higher incidence in refractive surgery candidates[(2)]. Keratoconus starts posteriorly with early change in posterior corneal curvature, then progress to anterior corneal surface. So that curvature changes on the anterior corneal surface might miss signs of early posterior corneal ectasia[(3)]. The corneal posterior surface has been suggested to be useful and important clinical tool for keratoconus detection and even for subclinical cases[(3)]**.** Diagnosis of keratoconus has greatly improved from simple clinical diagnosis with the advent of better diagnostic devices[(4)]. Since slit lamp examinations cannot detect keratoconus in early stages, and visual acuity may not be affected, corneal topography and tomography are the only reliable methods for detecting early keratoconus or keratoconussuspect[(5)]. Koch and his colleagues[(7)] in 2012, found that significant increase of posterior corneal astigmatism (PCA)(0.86 ± 0.45 D) in patients with KC than normal eyes (0.30 ± 0.15 D). In 2016, Naderan[(8)]and his associates reported a strong correlation between anterior corneal astigmatism (ACA) and posterior corneal astigmatism (PCA) with severity of KC, More importantly ACA was more affected than PCA with an increase in the severity of KC. On the other hand, PCA was more affected than ACA in the early stages of KC[(1)].

AIM OF THE WORK

To determine the changes of posterior corneal astigmatism in cases with keratoconus.

PATIENTS AND METHODS

One hundred eyes of 50 patients were included in this retrospective, case control study which adhered to the tenets of the Declaration of Helsinki and was approved by the Ethics Committees of the Ain Shams University Hospitals. All patients included in the study

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provided informed consent, **The study was approved by the Ethics Board of Ain Shams University** ,these cases were divided into: 1- Keratoconus group: comprised 50 eyes of 25 patients with keratoconus diagnosed on the basis of clinical and topographic signs. 2- Control group: comprised 50 eyes of 25 normal candidates for refractive surgery. Diagnosis of clinical keratoconus was previously defined and includes findings characteristics of keratoconus: corneal steepness higher than 47.20 diopters(D), superior-inferior asymmetry higher than 1.40 D, and thinnest pachymetric reading lower than 500 mm[(2)], corneal topography with asymmetric bowtie pattern or localized steepening, irregular cornea determined by distortion of the retinoscopic or ophthalmoscopic red reflex, and at least 1 of the following slit-lamp findings: stromal thinning, Fleischer ring greater than 2 mm arc, Vogt striae, and corneal scarring consistent with keratoconus. Control cases (were selected from a database of consecutive candidates for refractive surgery with normal corneas and myopia or myopic astigmatism (sphere <6.00diopters [D]; cylinder <3.00 D), eyes were considered normal if Eyes were considered normal when no clinical signs of keratoconus and no suggestive topographic or tomographic patterns of suspect keratoconus were found, such as asymmetric bowtie with a skewed radial axes, focal or inferior steepening, central keratometry greater than 47.0 diopters, or corneas thinner than500 mm and they did not develop any sign of corneal ectasia after laser in situ keratomileusis during a 2-year follow-up period. All eyes were examined by rotating Scheimpflug corneal tomography (Pentacam; Oculus Optikgera¨te GmbH, Wetzlar, Germany). Only cases with acceptable-quality images were included in the study. Each eye was required to have a corneal map with at least 9.0 mm of corneal coverage and no extrapolated data. The following anterior and posterior corneal surface parameters were evaluated with the Scheimpflug system: corneal diopteric power in the flattest meridian in the 3.0 mm central zone (flat keratometry [K]), corneal diopteric power in the steepest meridian in the 3.0 mm central zone (steep K), and mean corneal power in the 3.0 mm zone (mean K). Q values of anterior & posterior corneal surface were evaluated. Central corneal thickness (CCT) at the apex (geometric center of the examination); corneal thickness at the thinnest point (CTmin); and the distance between the CCT and CTmin (DistCCT_CTmin), both in the horizontal plane (DistCCT_CTminH) and the vertical plane (DistCCT_CTminV),were recorded. The average progression index (PPIavg) is calculated as the progression value at the different rings, referenced to the mean curve. Ambrosio relational thickness (ART) was calculated by the following formulas: ARTmax=CTmin/PPImax[(1)]**.** Different keratoconus indices like ISV, IHA, IVA & IHD were evaluated & documented**. Statistical analysis:** The statistical program SPSS (version 20, IBM company, USA) was used for data analysis. Chi-square test was used to compare qualitative variables between groups. Because the data were not normally distributed, the nonparametric Mann-Whitney U test was performed to compare each parameter between the 2 groups. Spearman correlation was used to rank variables versus each other positively or inversely. Quantitative data were presented as means, standard deviations and range, whereas qualitative data were presented as numbers and percentages. Receiver operating characteristic (ROC) curves were used to determine the overall predictive accuracy of the test parameters as described by the area under the curve (AUC) and to calculate the sensitivity and specificity of the parameters. A P-value less than 0.05 was considered statistically significant.

RESULTS

Table (1): The anterior corneal parameters of studied groups

Anterior corneal surface		Keratoconus	Control	P value
Flat K	Mean±SD	46.19±5.16	43.05±1.56	**<0.001**
	Range	(39.1- 68.2)	(36 - 46.5)	
Steep K	Mean±SD	50.68±6.37	44.26±1.40	**<0.001**
	Range	(41-74.4)	(39.4-48.1)	
Mean K	Mean±SD	48.44±2.8	43.66±1.2	0.3
	Range	(40.5 - 48.8)	40.1- 48.2)	
K max	Mean±SD	65.66±8.9	44.88±1.55	**0.009**
	Range	(43.4 - 79.5)	(41.2-49.2)	
Anterior corneal astigmatism	Mean±SD	4.79±2.44	1.21±.69	**<0.001**
	Range	(1.2 - 11.8)	(0.4 - 2.6)	
Q value	Mean±SD	-.73±.82	-.27±.20	**<0.001**
	Range	(-3.5 - 1.2)	(-0.5-0.4)	

The flat K, steep K, mean anterior corneal power and K max, were higher in keratoconus group (46.19±5.16, 50.68±6.37, 48.44 ±5.77and

65.66±8.9D respectively) than controls (43.05± 1.56, 44.26±1.4D, 43.66 ±1.48D and 44.88±1.55D respectively) as shown in table 1. The mean anterior corneal astigmatism was higher in keratoconus group (4.79±2.44D) than controls (1.21±0.69D). Q value of anterior corneal surface was higher in keratoconus (-0.73±0.82um) than controls (-0.27±0.2). These differences were highly statistically significant (P value <0.001) except the mean K of anterior corneal surface (P value = 0.3) as shown in table 1.

Table (2): Posterior corneal parameters in studied groups

Posterior corneal surface		*Keratoconus*	*Control*	*P value*
Flat K	Mean±SD	-6.86± 1.04	-6.11 ± .21	**<0.001**
	Range	(-12 - -5.7)	(-6.5 - -5.6)	
Steep K	Mean±SD	-7.77 ± 1.10	-6.14 ±1.85	**<0.001**
	Range	(-12.3 - -5.9)	(-6.8 - -6.2)	
Mean K	Mean±SD	-6.24 ± 0.32	-6.12 ±1.72	0.07
	Range	(-12.1 - -5.85)	(-6.65 - -0.1)	
Posterior Corneal Astigmatism	Mean±SD	0.91± 0.46	0.29±0.24	**<0.001**
	Range	(0 - 2.90)	(0-0.8)	
Q value	Mean±SD	-1.04 ± 0.68	-0.24±0.22	**<0.001**
	Range	(-3.36- -0.27)	(-0.65- -0.01)	

As regards posterior corneal surface the flat K, steep K and the mean posterior corneal astigmatism were higher in keratoconus (-6.86± 1.04, -7.77 ± 1.10 and 0.91± 0.46 D respectively)than controls (-6.11 ± 0.21, -6.14 ±1.85 and 0.29 ± 0.14 D respectively) as shown in table 4, figures 1-3, the mean Q value was more in keratoconus (-2.88+ 13.45) than controls (-0.24+ 0.22) as shown in figure 4. All these differences were highly statistically significant (P <0.001) except the mean K of posterior corneal surface which was slightly higher but not significant (p = 0.07) as shown in figure 5 and table 2.

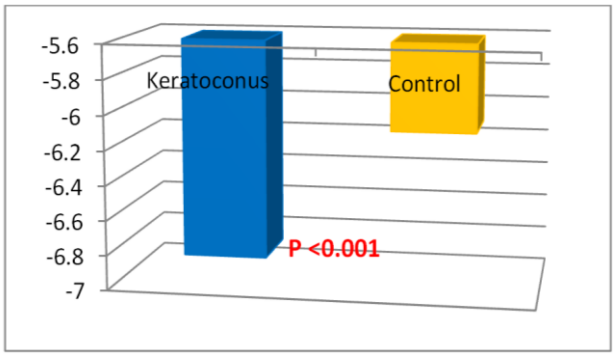

Figure (1): Flat K of posterior surface in studied groups.

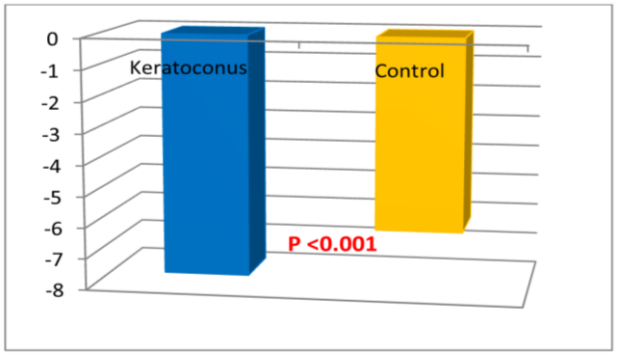

Figure (2): Steep k of posterior surface in studied groups.

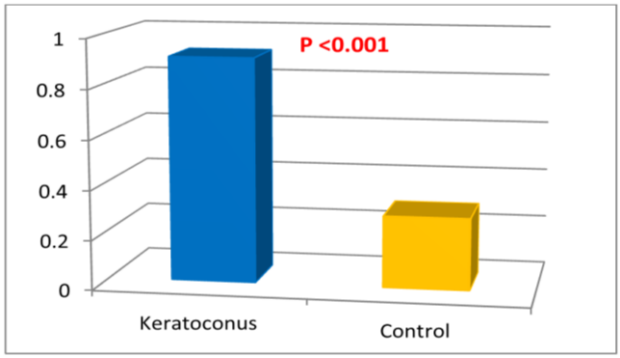

Figure (3): Posterior astigmatism in studied groups.

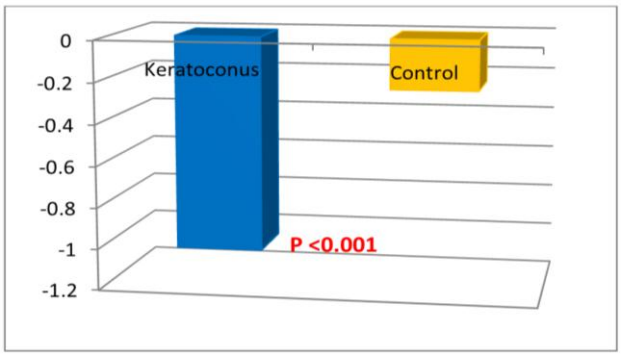

Figure (4): Back Q value in studied groups.

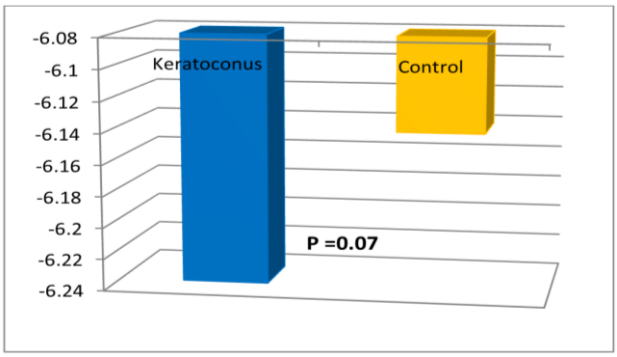

Figure (5): Mean K of posterior surface in studied groups.

Central corneal thickness was thinner in Keratoconus (436.52 +47.84Um) than controls (522.26+26.61Um), the pachymetry progression index was 2.58+1.27 in Keratoconus which is higher than controls (8.46 + 25.50). The mean anterior and posterior elevation thicknesses were higher in keratoconus (19.84+16.07 & 50.64+20.33 respectively) than controls (2.88+1.77 & 6.42+3.18 respectively). These differences were statistically significant as shown in table 3.

Table (3): CCT, pachymetric progressive index, Front elevation thickness and back elevation thickness in studied groups

Thickness profile		*Keratoconus*	*Control*	*P value*
CCT	Mean±SD	436.52±47.84	522.26±26.61	**<0.001**
	Range	(236-485)	(440-567)	
PPI	Mean±SD	2.61 ± 1.34	1.01±0.12	**<0.001**
	Range	(1.17 -6.9)	(0.65–1.3)	
Front Elevation Thickness	Mean±SD	21.39+15.56	2.88+1.77	**<0.001**
	Range	(-23 - 43)	(-3 – 7)	
Back Elevation Thickness	Mean±SD	51.51±21.47	6.42±3.18	**<0.001**
	Range	(3 – 96)	(-2 - 12)	

As regards keratoconus indices, ISV, IHA, IVA & IHD were higher in keratoconus than controls, while ART max was higher in controls than keratoconus. These differences were statistically significant as shown in table 4.

Table (4): Corneal indices in studied groups

Corneal indices		Keratoconus	Control	P value
ISV	Mean ±SD	88.27 ± 31.84	20.1 ± 6.85	**<0.001**
	Range	(40 - 173)	(8 - 38)	
IVA	Mean ±SD	4.21 + 15	0.15 ± 0.06	**<0.001**
	Range	(0.17 - 74)	(0.02 – 0.34)	
IHA	Mean ± SD	29.42 ± 26.73	5.11 ± 4.32	**<0.001**
	Range	(1.1 – 93.5)	(0 – 22)	
IHD	Mean ± SD	0.15 ± 0.16	0.011 ± 0.007	**<0.001**
	Range	(0.021 – 0.91)	(0.001 – 0.033)	
CK1	Mean ± SD	1.07 ± 0.068	1.01 + 0.01	**<0.001**
	Range	(0.78 – 1.18)	(0.98 – 1.02)	

DISCUSSION

A few studies have shown that posterior corneal astigmatism can have a significant influence on total corneal astigmatism; thus, traditional readings (based on the anterior corneal curvature only) may not be quite accurate and the presence of PCA cannot be ignored[8]. In our study we found the mean posterior corneal astigmatism was higher in keratoconus (0.91+ 0.46D) than controls (0.29+0.14D) ,the mean Q value was more in keratoconus (-2.88+ 13.45) than controls (-0.24+ 0.22). Orucoglu et al[9] in 2015 evaluated PCA in patients with KC using the Pentacam and reported mean magnitudes of 0.71 ± 0.44 D, which were lower than those in our study**.** Naderan and his colleague[8] in 2016 also evaluated posterior corneal astigmatism in 1273 patients with KC using Pentacam images and reported that PCA magnitudes of 0.90 ± 0.43 D, which are very similar to our results. Our findings are also in line with those of Kamiya***et al.*** [10], who evaluated PCA in 137 patients with KC using the Pentacam HR and reported mean respective magnitudes of 0.93 ± 0.64 D.

Table 5: comparison between our study and other studies which study posterior corneal astigmatism in cases with KC

Study	Country	Year	Cases examined/eyes	Mean age	Correlation with PCA
Kamiya et al.	Japan	2015	126/83	36.9	P<0.001
De Sanctis	Italy	2008	139/139	---	P<0.001
Naderan et al.	Iran	2016	-/1273	25	P<0.001
Mihältz et al.	Hungary	2009	111/65	---	P<0.001
Orocoglu et al.	Turkey	2015	338/656	30	P<0.001
Pinero et al.	Spain	2010	51/71	16-64	P<0.001
Our study	Egypt	2018	50/100	29	P<0.001

Our results showed a high prevalence of PCA in stages 1 and 2 according to Amsler-Krumeich Classification for Grading Keratoconus, Kamiya ***et al.*** [10] reported a high prevalence PCA in the different stages of KC, which gradually decreased with progression through the stages of KC, without any change in the most prevalent axis orientation. We found a significant correlation between the magnitude of ACA and that of PCA, which is in accordance with the reports by ***Naderan et al.***[8]**and**Kamiya ***et al.***[10]**.** We did not find any significant increase in PCA with the progressive stages of KC, which again is consistent with the findings of ***Kamiya et al. However, Naderan et al***[8]reported a gradually significant increase in the magnitude of PCA in eyes with stage 1, 2, and 3 KC. Although the findings of our study are similar to those

in the above two studies, we detected larger PCA values in eyes with stage 4 KC than in those with less severe KC (stages 1–3). Moreover, there was a trend for a decrease in the prevalence of posterior astigmatism as the severity of KC increased. Similar to our findings, ***Naderan et al.*** [8] reported a decrease in astigmatism at both corneal surfaces as the severity of the disease increased. Our study PCA is more affected in early stage KC. ***Tomidokoro et al.*** [11] [reported that both the anterior and the posterior corneal curvatures were affected in KC and that these changes could be observed even in early stage KC, but they did not report in detail on whether the PCA changed with increasing disease severity. In another study, Pinero et al reported that the mean posterior-anterior astigmatism ratio in eyes with subclinical KC was higher than that in other KC groups.

CONCLUSION

In conclusion, we found that the mean magnitudes PCA were approximately 1 D, and The PCA values were significantly associated with the severity of KC, the posterior corneal surface was more affected in the early stages of KC. Diminution of the correlation between PCA with disease severity, patterns of ACA and PCA with net change in the final power of resultant TCA and its axis.There is positive correlation between PCA and disease severity in keratoconus.In short, PCA deserves further investigation. In relation to the retrospective nature of our study and adding a control group of normal eyes will provide a better comparison of the prevalent pattern of astigmatism in terms of magnitude and orientation for PCA. Future studies with additional imaging devices rather than one (dual versus single Scheimpflug) and with 4 mm instead of 3 mm central zone may affirm and further validate our findings.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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