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Original Research

Tomographic characteristics of keratoconus in a sample of Yemeni patients

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Abstract

Background: Keratoconus is a non-inflammatory disorder that leads to visual impairment. Early diagnosis and treatment save the vision of the patients.
Aim: This study aimed to identify tomographic characteristics of keratoconus in Yemeni patient sample.
Methods: This cross-sectional descriptive study included 158 eyes affected with keratoconus presented to Ibn Al-Haitham Eye Hospital during the period of 1st January 2019 to 1st March 2020. Besides the clinical signs, the diagnosis is confirmed by OCULUS Pentacam.
Results: The results revealed significant differences between males and females at the level of anterior chamber volume, depth and asphericity coefficient QV. Younger age groups were affected more severely than any other age group; and females were older at presentation on their first visit than males. Elevation maps especially back elevation map correlate better with the severity than sagittal maps.
Conclusion: children and females are at higher risk in terms of more severity in children. There is delay in presentation to health services for the females, besides the social shame of vision problems and glasses in our country. Early detection and early access to management services could save vision.

Keywords: Keratoconus, Topography, Pentacam, Astigmatism, Yemen

1. Introduction

Keratoconus is a non-inflammatory disorder characterized by progressive corneal thinning and ectatic protrusion resulting in myopia and irregular astigmatism and eventually visual impairment. It is commonly bilateral but may be asymmetrical [1].

Keratoconus prevalence varies between different regions in the world depending on several factors. Studies showed that certain Asian ethnicities, particularly Middle Easterners, may be affected more at a younger age and with a higher risk of progression as compared to white populations [2-5]. Eye rubbing, family history of keratoconus and allergies were the most relevant risk factors for keratoconus [6].

The onset of the disease usually occurs in the second decade of life, but studies showed that keratoconus could emerge earlier and KC is more severe in children. Therefore, they should be closely observed [7]. KC may continue to progress beyond thirties[8], but usually stabilizes by the fourth decade of life [9]. At an early stage of the disease, the patient is typically asymptomatic. As the disease progresses, visual acuity decreases and eventually the patient may become legally blind. The emergence of a new diagnostic tools, like Pentacam and treatment modalities as corneal cross linking and intracorneal rings in the last decades, hopefully decrease the serious complications of keratoconus and the need for penetrating keratoplasty [10]. Pentacam can detect KC in early stage and it is the gold standard method to diagnose and monitor progression of KC [11].

Early detection and treatment of patient with keratoconus leads to better prognosis and avoid visual

disabilities that will affect lives of the patients and their families and decrease the economic burden on the government. In our country, the lack of information about prevalence, the characteristics of keratoconus and the delay in the diagnosis make it necessary to do this research to be a starting point for governmental and community awareness of this silent blinding disease.

2. Methods

Study design

The study was conducted at Ibn Al-Haitham Eye Hospital, which is located in Sana'a city, the capital of Yemen. A cross sectional descriptive study was conducted on 79 patients attending the hospital during the period of 1st January 2019 to 1st March 2020. Best-corrected visual acuity and slit lamp examination for anterior and posterior segments of the eyes were done for all patients and the diagnosis of keratoconus is confirmed by oculus Pentacam. Patients who underwent previous surgical corneal interventions were excluded from the study. ABCD classification was used to grade the severity of keratoconus from 0 to 4. A represents k mean, B for posterior radius of curvature, C for corneal thickness at thinnest location and D for best corrected distant visual acuity.

Statistical Analysis

Data were analyzed by Statistical Package for the Social Sciences SPSS, version 24. For analysis purposes, the age groups were divided into four groups, namely; 7-15, 16-22, 23-29 and more than 30 years old. Associations between categorical variables were analysed using the t-test and ANOVA test. P value ≤ 0.05 was considered statistically significant.

3. Results

Patients' Characteristics

Out of 79 patients included in the study, 44 (55.7%) were females, and 35 (44.3%) males. The age of the patients ranged from 7 to 47 years (mean 23.14 years ±7.68). In this study, all patients were bilaterally affected and 158 eyes were included. Table 1 shows the basic keratometric parameters of the patients. There was no correlation between severity of keratoconus (all ABCD) and gender, but females were older at presentation than males (25 vs 21). Males had larger and deeper anterior chamber volume and depth respectively, and higher asphericity coefficient QV. But we found no differences in other parameters between males and females.

In figure 1, patients were categorized by age into four groups. We studied the correlation between age and k mean and found that 45% of patients younger than 15 years old were in Stage III and Stage IV in comparison with other age groups where only 13% were in more sever stage of keratoconus.

Table 2 showed the relation between k mean and other severity parameters (PRC, TCL, BCVA). The higher the k mean, the thinner the cornea at thinnest location and the worse the best-corrected visual acuity, but no significant correlation was found between posterior radius of curvature and k mean. K max, Flat k, Steep k, Astigmatism, QV, Average of thickness profile and AC depth all increase as the severity of keratoconus increases, but anterior chamber and corneal volumes seem to be not affected (do not correlate) with severity.

Table 1: Keratometric data and analysis of the study subjects by gender

	All		Male (n=70)	Female (n=88)		
	Mean ± SD	(Min-Max)	Mean ± SD	Mean ± SD	*t*	*P*
Age	23.14 (7.679)	7-47	21.00 (5.69)	24.84 (8.61)	3.214	0.002
Best corrected visual acuity/ D	0.36 (0.25)	0.02-1.00	0.34 (0.25)	0.37 (0.25)	0.638	0.525
K max	56.15 (7.44)	47.00-86.10	56.90 (6.61)	55.58 (7.98)	1.716	0.088
Flat curvature power, K1	47.32 (4.64)	37.50- 66.20	47.50 (4.31)	46.99 (4.84)	1.176	0.241
Steep curvature power, K2	51.70 (5.61)	43.80- 75.60	51.95 (4.27)	51.60 (6.36)	1.171	0.243
Mean curvature power, Km / A	49.39 (4.98)	40.70- 70.90	49.60 (4.18)	49.16 (5.41)	1.215	0.226
Astigmatism	4.38 (2.36)	0.00-14.50	4.45 (2.02)	4.60 (2.74)	0.474	0.636
Asphericity coefficient, QV	0.83 (0.44)	0.02-2.63	0.92 (0.49)	0.75 (0.37)	2.522	0.013
Thinnest corneal location(µm) /C	440.35(49.52)	227-532	438.40 (39.63)	441.59 (57.40)	0.968	0.335
Corneal volume	56.42 (4.68)	46.00-66.40	56.70 (4.58)	56.21 (4.77)	0.652	0.515
Anterior chamber volume (mm3)	197.56 (38.39)	93.0-287.0	210.69 (39.60)	187.13 (34.15)	4.013	<0.001
Anterior chamber depth (mm)	3.65 (0.42)	2.40-4.86	3.82 (0.40)	3.51 (0.39)	4.972	<0.001
Thickness at Pachy apex (µm)	451.08 (48.07)	249.0-547.0	445.61 (45.93)	455.42 (49.54)	1.276	0.204
Average of thickness profile	2.25 (1.42)	0.00-10.70	2.45 (1.47)	2.09 (1.36)	1.620	0.107
Posterior radius of curvature/ B	5.12 (0.46)	4.54-6.50	5.06 (0.44)	5.17 (0.46)	1.527	0.129
Horizontal displacement of thinnest location	0.56 (0.52)	3.91-1.36	0.47 (0.27)	0.64 (0.65)	1.985	0.049
Vertical displacement of thinnest location	0.34 (0.52)	2.94-1.85	0.35 (0.39)	0.33 (0.60)	0.340	0.734
Average of thickness profile	2.25 (1.42)	0.00-10.70	2.45 (1.47)	2.09 (1.36)	1.620	0.107

SD: standard deviation; t: *t* student test; *P*: P ≤ 0.05 was considered statistically significant.

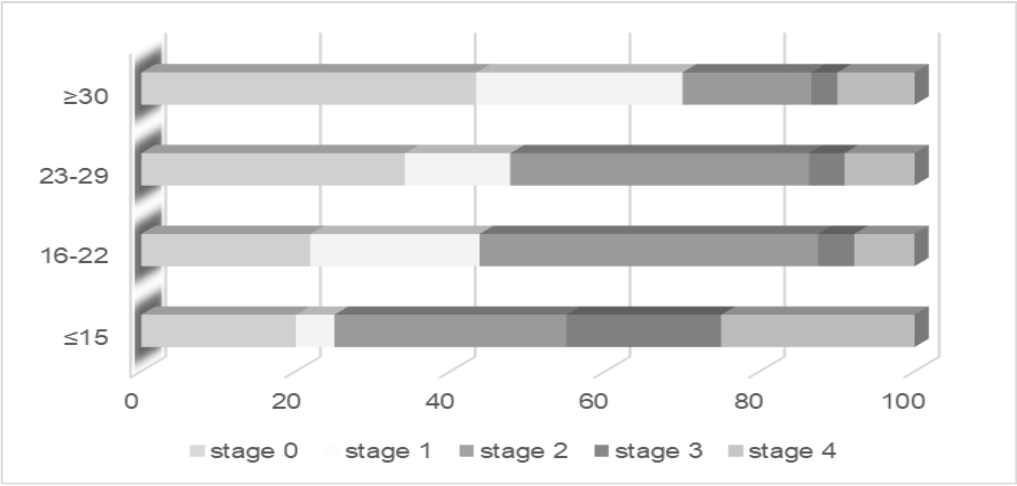

Figure 1: Correlation between K Mean and Age

Stage: 0 <46.5: stage 1: <48.0; stage: 2 <53.0; stage 3: <55.0; stage 4: >55.0

Table 2: Analysis based on correlation between k mean stages and other parameters including (PRC, TCL, BCVA)

Parameters	Stage 0 Mean ±S.D	Stage I Mean ±S.D	Stage II Mean ±S.D	Stage III Mean ±S. D	Stage IV Mean ±S.D	*P**
Age	24.93 (7.43)	24.48 (8.59)	21.86 (5.55)	19.40 (7.69)	22.41 (11.30)	0.111
Best corrected visual acuity	0.46 (0.25)	0.56 (0.25)	0.27 (0.15)	0.20 (0.14)	0.09 (0.10)	<0.001
K max	50.29 (2.20)	52.44 (2.34)	56.80 (3.52)	64.12 (3.45)	71.44 (7.62)	<0.001
Flat curvature power, K1	43.22 (1.57)	45.57 (0.83)	47.83 (1.60)	51.64 (1.38)	57.17 (4.89)	<0.001
Steep curvature power, K2	47.08 (1.54)	49.20 (1.09)	52.17 (1.86)	56.80 (1.77)	63.92 (6.19)	<0.001
Astigmatism	3.87 (1.91)	3.62 (1.77)	4.34 (2.07)	5.16 (2.88)	6.75 (3.41)	<0.001
Asphericity coefficient, QV	0.55 (0.32)	0.62 (0.21)	0.90 (0.30)	1.19 (0.18)	1.51 (0.52)	<0.001
Thinnest corneal location (μm)	454.74(39.20)	452.66(32.76)	444.34 (38.61)	434.90(50.18)	370.47(72.01)	<0.001
Corneal volume	55.06 (4.49)	56.00 (4.38)	56.96 (4.50)	58.78 (5.93)	57.68 (4.88)	0.069
Anterior chamber volume (mm3)	198.26(30.25)	197.24(48.02)	194.09 (42.42)	197.70(35.69)	207.59(28.21)	0.807
Anterior chamber depth (mm)	3.50 (0.34)	3.63 (0.43)	3.66 (0.44)	3.67 (0.28)	4.00 (0.43)	<0.001
Thickness at Pachy apex (μm)	468.28(38.06)	460.34(32.88)	453.96 (37.05)	446.30(51.21)	382.00(66.31)	<0.001
Average of thickness profile	1.85 (0.98)	1.76 (0.34)	2.23 (1.11)	2.49 (0.45)	4.08 (2.84)	<0.001
Posterior radius of curvature	5.26 (0.48)	5.04 (0.44)	5.13 (0.42)	4.93 (0.40)	4.99 (0.49)	0.084

**ANOVA* test: Stage: 0 <46.5: stage 1: <48.0; stage: 2 <53.0; stage 3: <55.0; stage 4: >55.0

The displacement of pachyapex in y and x coordinates seem to be not correlated with severity A, B, and D. However, both horizontal and vertical displacement of pachyapex increased as the thickness of cornea decreased C (p 0.007 and 0.008 respectively). In morphological analysis of sagittal map, nine different patterns were recognized in figure 2. The most occurring was asymmetric bowtie with inferior steepening 39.87% followed by asymmetric bowtie with skewed axis 27.22% and inferior steepening 13.92%. We found that there was no correlation between severity of keratoconus and sagittal map (no shape is related to severity).

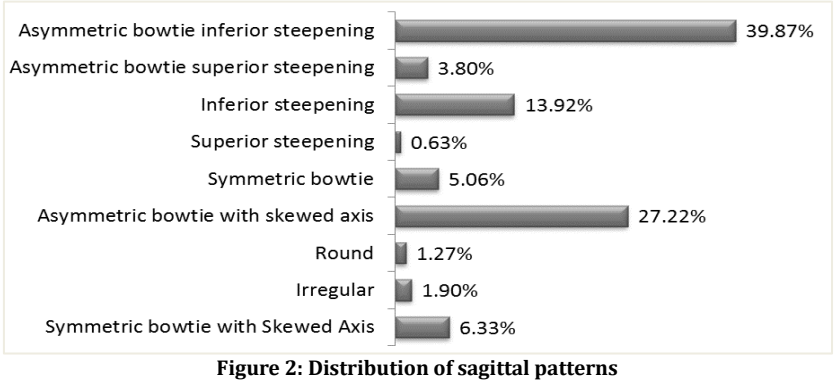

Figure 2: Distribution of sagittal patterns

In elevation maps, the most common pattern was U shape followed by ridge and island. This is true for both front and back elevation maps as illustrated in Figure 3. Comparison between parameters of the three shapes revealed that eyes with island pattern significantly more affected than u shape and ridge with poorer BCVA, higher km, thinner

cornea at TCL and smaller PRC table 3. The Island significantly had more vertical displacement of pachyapex than any other shape and larger AC volume.

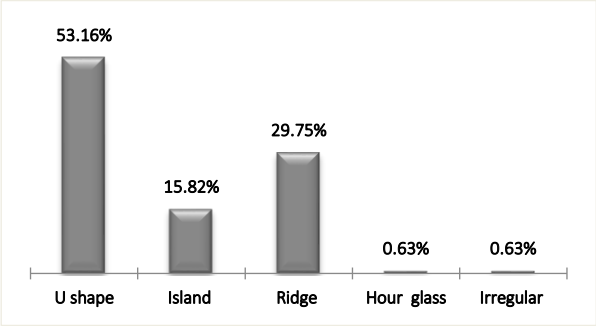

Figure 3: Front elevation Map

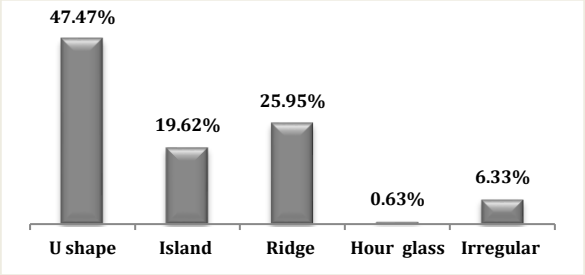

Figure 4: Back Elevation Map

Ridge shape had higher astigmatism while island had the least. We found that island in back elevation map correlates with more severe keratoconus parameters than front elevation map and had higher k max, flat k, and steep k as indicated in Table 4.

Table 3: Comparison between parameters of the three shapes of front elevation map

Without irregular/hour glass	Front elevation map			
	U shape	Island	Ridge	
	Mean (S.D)	Mean (S.D)	Mean (S.D)	*P*
Best corrected visual acuity	0.35 (0.24)	0.33 (0.21)	0.37 (0.27)	0.806
K max	55.59 (6.84)	57.05 (9.04)	56.81 (7.71)	0.552
Flat curvature power, K1	47.29 (3.83)	48.30 (5.86)	46.82 (5.31)	0.444
Steep curvature power, K2	51.42 (5.04)	51.60 (5.81)	52.35 (6.55)	0.659
Mean curvature power, Km	49.24 (4.31)	49.88 (5.72)	49.41 (5.81)	0.857
Astigmatism	4.11 (2.11)	3.31 (2.35)	5.53 (2.38)	0.000
Asphericity coefficient, QV	0.86 (0.41)	0.82 (0.66)	0.80 (0.34)	0.771
Thinnest corneal location (mm)	448.21 (38.93)	424.12 (43.30)	432.89 (64.93)	0.052
Thickness at Pachyapex (mm)	456.93 (39.01)	440.44 (40.01)	443.81 (63.078)	0.172
posterior radius of curvature	5.10 (0.44)	5.04 (0.43)	5.19 (0.50)	0.330
Horizontal displacement of thinnest location	-0.54 (0.39)	-0.56 (0.65)	-0.53 (0.43)	0.951
Vertical displacement of thinnest location	-0.27 (0.33)	-0.61 (0.82)	-0.37 (0.45)	0.009
Average of thickness profile	2.15 (0.91)	2.37 (1.57)	2.41 (2.00)	0.559
Corneal volume	56.80 (4.33)	55.23 (4.32)	56.19 (5.39)	0.323
Anterior chamber volume (mm3)	196.06 (33.75)	218.76 (39.35)	190.70 (42.25)	0.009
Anterior chamber depth (mm)	3.61 (0.40)	3.77 (0.42)	3.66 (0.45)	0.215

Table 4: Comparison between parameters of the three shapes of back elevation map

Without irregular/hour glass	Back elevation map			
	U shape	Island	Ridge	
	Mean (S.D)	Mean (S.D)	Mean S.D	*P*
Best corrected visual acuity	0.36 (0.25)	0.24 (0.17)	0.39 (0.23)	0.014
K max	55.59 (6.02)	60.03 (10.66)	55.17 (5.99)	0.008
Flat curvature power, K1	47.18 (3.10)	49.65 (7.07)	45.96 (4.07)	0.003
Steep curvature power, K2	51.42 (4.33)	54.29 (8.06)	50.79 (4.86)	0.018
Mean curvature power, Km	49.17 (3.54)	51.86 (7.46)	48.23 (4.30)	.006
Astigmatism	4.24 (2.35)	4.63 (2.48)	4.82 (2.28)	0.420
Asphericity coefficient, QV	0.82 (0.36)	0.95 (0.69)	0.80 (0.32)	0.300
Thinnest corneal location (mm)	444.07 (38.92)	425.52 (54.99)	442.49 (55.81)	0.176
Thickness at Pachy apex (mm)	455.47 (39.54)	435.52 (50.50)	451.51 (54.25)	0.132
posterior radius of curvature	5.06 (0.41)	5.05 (0.48)	5.28 (0.49)	0.027
Horizontal displacement of thinnest location	-0.57 (0.47)	-0.49 (0.57)	-0.57 (0.33)	0.668
Vertical displacement of thinnest location	-0.31 (0.44)	-0.47 (0.73)	-0.41 (0.42)	0.281
Average of thickness profile	2.12 (0.63)	2.74 (2.06)	1.90 (0.97)	0.009
Corneal volume	56.67 (4.09)	56.60 (4.73)	55.18 (5.41)	0.228
Anterior chamber volume (mm3)	194.43 (32.78)	214.87 (36.36)	192.49 (43.45)	0.019
Anterior chamber depth (mm)	3.60 (0.38)	3.80 (0.43)	3.64 (0.47)	0.089

4. Discussion

In this study, 45% of patients younger than 15 years old had sever keratoconus and were in Stage III and Stage IV, in comparison with other age groups (16 to 47) where only 13% were in more sever stage of keratoconus. This is consistent with Léoni-Mesplié et al findings [12] . On the contrary, studies from Turkey and Oman did not find any correlation between age and severity of keratoconus. Mean age in our study was similar to those in studies done in Saudi Arabia and Oman [5, 13] . Studies showed that keratoconus affects Asian people at earlier age than white

people [14]. Females were older in their first visit; and this is perhaps attributed to the delay in reaching health services and the shame of wearing glasses in our culture, so decreased vision in female is ignored. Other research revealed that females were significantly younger [15]. Severity of keratoconus did not affect the anterior chamber and corneal volumes in our sample of patients and a similar finding is revealed in Jordanian population [16]. Morphological analysis of sagittal maps revealed nine patterns, the most occurring being bowtie patterns (82.28%) vs 17.72 for global patterns. A reverse result of higher proportion of global shapes was found in a study done on Turkish population [17]. No correlation was found between severity and sagittal map patterns [18]. In contrast, we found that elevation maps especially back elevation map patterns correlated well with the severity; while island pattern was associated with more advanced stage of keratoconus with poorer BCVA, higher km, thinner cornea at TCL and smaller PRC. Elevation map parameters and patterns could be added as aiding method for evaluating progression and grading the severity of keratoconus [19].

5. Conclusion

Severe keratoconus affects pediatric population; and there should be early detection and incorporation of health screening for children in early school years. Besides, health education regarding preventable risk factors could save the vision of vulnerable children. The importance of tomography as integral tool in diagnosing, grading and monitoring the progression of keratoconus, makes it a necessity to provide each city in Yemen with a Pentacam, as only a few major cities and hospitals are having it. Females should know and seek their rights to get a best vision; community and cultural awareness will help to achieve this goal.

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Competing interests
The authors declare that they have no competing interests.

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