Refractive , Topographic and Tomographic analysis of Keratoconus in Egypt

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Abstract:

Objectives: The aim of this study was to evaluate the demographic profile, refractive ,topographic and tomograghic characters of keratoconus patients in Egypt**. Patients and Methods:** This study was designed as a retrospective cohort clinical study. The study met the ethical criteria of the Institutional Review Board (IRB) in Faculty of Medicine Benha University with approval No. of (MS 32-12-2019)**.** Our study included 102 eyes of 51 patient in the keratoconus group and 100 eyes of 50 patients in the control group. The study was designed as a retrospective cohort clinical study on keratoconus patients who attended at Al Ferdaws eye hospital in the period from January 2016 to December 2020. Study groups: Group 1: normal eyes as a control group. Group 2: keratoconus group (KC). **Data Synthesis:** The results analyzed using SPSS25, T-test, Mann-Whitney U test and Chi-square test. **Findings:** There was clinically significant difference between normal and KC cases regarding the cylinder, BCVA, keratometric power of anterior and posterior surface on both flat and steep meridian.also K max and km.,Q value at 6 mm., thinnest location, relative thickness map average,thickness profile map average (PPI),highest elevation front and back,corneal irregularity indices, corneal aberrometric values, BAD_ D and ARTmax. **Conclusion:** We found no significant association between the severity of KC with age and sex. many parameters in topography and tomography were efficient in differentiating normal cases from keratoconus cases even in early disease.

Key words: keratoconus, cornea, topography, pentacam

Introduction

Keratoconus (KC) is a bilateral asymmetrical and progressive corneal ectasia that leads to visual impairment via causing irregular astigmatism, myopia, higher order aberrations (HOAS), and corneal scar.[1] It typically presents in adolescence and progress until the third or fourth decade of life.[2]

The prevalence of KC in Asian populations is about 4 times higher than other ethnic populations, with the highest prevalence reported in the Mediterranean region and Middle East.[3-5]

The prevalence of KC varies in different countries, indicating the possible role of genetics in its etiology.[6]

It may be an isolated condition or occur with other ocular and systemic disorders such as atopy, vernal disease, Down syndrome, retinitis pigmentosa, Turner syndrome, connective tissue disorders such as Marfan syndrome, Ehlers-Danlos syndrome, osteogenesis imperfecta, and pseudoxanthoma elasticum. KC has a strong association with eye rubbing,repeated trauma from contact lenses, and allergic eye disease.[7]

KC should be suspected in any patient with significant irregular astigmatism, especially if unstable and increasing over time. In the early stages of the disease, there is altered metabolic activity that may lead to biomechanical instability and stretching of the corneal tissues.[8]

There is accompanying tissue loss with disease progression. In addition, there is a loss of correlation between the anterior and posterior corneal curvature.[9] Progressive corneal thinning and distortion causes a conical or cone-shaped protrusion, which may be visible at the slit lamp in advanced cases.[10] In early disease, the condition may go undiagnosed unless assessments of the posterior and anterior corneal surfaces are undertaken using corneal tomography.[11]

In the past, keratoconus was diagnosed using Placido-disc based topographers that analyze rings that are reflected off the corneal surface, which are only able to evaluate the anterior surface of the cornea. Unlike corneal topographers, tomographers generate a three-dimensional map of the anterior segment and provide information about the corneal thickness. Schiempflug imaging is one of the most commonly used techniques for corneal tomography. The development of the Scheimpflug camera system (Pentacam, Oculus Optikgerate

gmbh, Wetzlar, Germany) also enabled evaluation of the posterior corneal surface by generating cross-sectional images by a rotating camera. This device allowed the detection of early changes originating in the posterior cornea in clinically normal patients, which was a major breakthrough in the diagnosis and monitoring of the disease.[12-15]

The Global Consensus on Keratoconus and Ectatic Disease (2015), recommended the following criteria for diagnosis of keratoconus: abnormal posterior elevation, abnormal corneal thickness distribution and corneal thinning[10]

There are Several classification systems for keratoconus have been proposed in the literature; The Amsler-Krumeich keratoconus classification is the oldest and most commonly used classification system for keratoconus. It relies on anterior surface topography. This system grades keratoconus into 4 stages based on spectacle refraction, central keratometry, presence or absence of scarring, and central corneal thickness.[16]

Other studies such as the Collaborative Longitudinal Evaluation of Keratoconus (CLEK) Study used changes in vision, keratometry, biomicroscopic signs, corneal scarring, and vision-specific quality of life, as measures to define stage and severity of disease.[17]

A new classification ABCD keratoconus grading system was introduced in 2016 utilizing current tomographic data and it is dependent on corneal tomography. It includes the anterior (A) and posterior (B) average radii of curvature, thinnest pachymetric values (C) and best distance visual acuity (D) as well as the degree of scarring. The system classifies keratoconus into 5 stages from 0 to 4. [18]

Materials and methods

Search Strategy: The study was designed as a retrospective cohort clinical study on keratoconus patients who attended at Al Ferdaws eye hospital in the period from January 2016 to December 2020.

Study groups

1- Group 1: normal eyes as a control group

2- Group 2: keratoconus group (KC)

We further subdivided the KC group according to Amsler-Krumeich classification to KC1,KC2,KC3,KC4 and forme fruste (FF) and subdivided the normal group to 3 subgroups according to the astigmatism to: with the rule(WTR), against the rule(ATR) and oblique.

Ethical approval: The study met the ethical criteria of the Institutional Review Board (IRB) in Faculty of Medicine Benha University. (MS 32-12-2019)

Study Selection:

The patients were included if they fulfilled the following criteria:

Inclusion Criteria: Male or female patients included. Patients' age: All patients must be above 20 years old. In group 2, patients with Keratoconus based on Amsler-Krumeich classification using Pentacam HR tomographer (OCULUS Optikgeräte GmbH, Germany). All eyes had clear unoperated corneas, and were not using contact lenses.

Patients with the following criteria were excluded from our study:

Exclusion Criteria: For group 1: Severe dry eye, corneal scar, severe allergic conjunctivitis, a history of eye surgery, glaucoma, cataract, a history of herpes simplex keratitis, pregnancy, breast-feeding, thyrotoxicosis, hypothyroidism, and use of certain medications, such as Accutane (Isotretinoin, Accutane™ Roche®, Canada). For group 2: previous corneal trauma, previous corneal surgery, less than 20 years old, patients wearing contact lens at time of presentation.

Sample Size

Our sample size was 101 patient; includes 102 eyes of 51 patient in the keratoconus group and 100 eyes of 50 patient in the control group.

Data Extraction:

A complete ophthalmologic examination, including manifest and subjective refraction, uncorrected distance visual acuity (UDVA) and corrected distance visual acuity (BCVA), slit lamp biomicroscopy, applanation tonometry, indirect ophthalmoscopy, and In addition, topographic, tomographic, topometric, and aberrometric maps were examined using **Pentacam HR tomographer (OCULUS Optikgeräte GmbH, Germany**) were performed on all eyes. The device is a noninvasive anterior segment tomographer that uses a 475-nm monochromatic slit of light to illuminate the cornea and a 1.45-megapixel camera for photography. The camera rotates about the line of fixation during the scanning period. There are several scanning options available including a 25-picture (1 second) scan, a 50-picture (two second) scan, and a cornea fine (50 pictures in 1 second) scan. Using data from these pictures, the system calculates a 3D model of the anterior segment from up to

138,000 true elevation points. Any eye movement is detected by a second camera and corrected for in the process.[19]

Data Synthesis:

- The results analyzed using SPSS25. Normally distributed continuous data expressed as mean ± standard deviation and not-normally distributed continuous data expressed as median (range).
- Categorical data expressed as percentage. T-test used to compare between two groups in case of normally distributed variables.
- Not-normally distributed variables analyzed using Mann-Whitney U test. Chi-square test used to compare between the qualitative.
- Other kinds of tests performed when necessary.

Results considered statistically significant at a p-value of less than 0.05.

Results

In the keratoconus group 17 patients were males and 34 patients were females with a mean age of 29.25 ± 8.13 years. In the control group 23 patients were males and 27 patients were females with a mean age of 30.24 ± 9.28 years. We found no significant difference between both groups regarding age or gender.(Table 1).

We found that the difference between control group and KC group was significant regarding BCVA and cylinder before and after cyclodilatation (p value <0.001) and not significant regarding sphere either before (p value= 0.988) or after cyclodilatation (p value =0.912) (Table 1).

The difference between KC group and control group was significant in the following parameters; True Net Power k1,k2, p-max (p value <0.001) and astigmatism (p value =0.001). Anterior k1(p value =0.001), k2, k mean, k Max front, topographic astigmatism (p value <0.001). Posterior k1, k2 (p value <0.001), post k mean (p value =0.001), SRAX, IS,SI and Q value (p value <0.001). (Table 1).

Regarding pachymetry ; The difference between KC and control group was significant regarding thinnest location TL, vertical displacement of TL(Y) (p value <0.001), difference between apex and TL (p value =0.001), pachymetry pattern (p value = 0.002). relative thickness map average (p value <0.001), thickness profile map average (p value <0.001) and shape (p value =0.001). The difference wasn't significant between KC and control group regarding pachy apex (p value =0.977), horizontal displacement of the TL(X) (p value = 0.64) and difference

between superior and inferior pachymetry at 5 mm zone (p value =0.522).(Table 2)

Regarding elevation maps; the difference between KC group and control group was significant in the following parameters; highest elevation front at central 5 mm (toric ellipsoid), highest elevation back at central 5 mm (toric ellipsoid), highest elevation front at TL(BFS), highest elevation back at TL (BFS) (p value <0.001) and shape of elevation back map (p value =0.001) (Table 4),(fig.1) .Regarding shape of elevation back in KC group we found that 43.1% tongue followed by 39.2% isthmus and least was nipple 17.6%. While in control group we found most cases have non specific shape or near to isthmus shape 64.8%, tongue 14.8% and least nipple 1.9% of cases.

The difference between the KC group and control group was statistically significant regarding total RMS, RMS(HOA), corneal coma at 90 and 0 at 3rd order aberration, 90 and 0 at 5th order aberration, BAD D, and ARTI max (p value <0.001).(Table 2),(fig.2, 3).

Regarding inter eye asymmetry score ; most cases in KC group had score 5 (33.3%) followed by score 4 (23.5%) then score 2 (17.6%) , score 3 (13.7%) and least for score 1 (11.8%). While in control group most cases had score 0 (40%) followed by score 1 (34%), score 2 (16%) and finally score 3 (10%).(fig.4).

In comparing KC groups there was no significant difference between the KC groups regarding age or gender. (Table 3), BCVA decreased significantly with increased severity while refraction increased significantly with increased severity(Table 3),thinnest location and pachy apex decrease with increased severity of the disease (Table 4), regarding highest elevation front and back using either modes; BFS or toric ellipsoid we found that the values increased significantly with increasing severity of the disease(Table 4). There was statistically significant difference regardind SRAX. On pairwise comparison, the difference was significant between FF groups and KC3 groups. Q value was normal in 100% of FF cases, 80% of KC1 and 37.5% of KC2 , RMS (HOA) was abnormal in 100% of all groups. ART-max was abnormal in (78.9%) of FF cases, (73.3%) of KC1 and 100% abnormal in KC2, KC3 and KC4 so it could be normal in few cases of early KC disease. BAD-D was pathological in 100% of cases in KC2, KC3 and KC4., 80% in KC1 and 47.4% of FF cases, Suspecious in 47.4% of FF cases and 13.3% of KC1 cases.(Table 4).

In comparing normal groups There was statistically significant difference between the

studied groups regarding age On LSD comparison, the difference was significant between ATR and oblique astigmatism group.(Table 5). There was statistically non significant difference between the studied groups regarding BCVA, spherical, cylindrical refraction, thinnest local, relative thickness map and pachymap pattern. Q value, ART-max and BAD-D were normal in 100% of cases but RMS (HOA) was normal in (58.8%) of WTR cases, (72.1%) of ATR cases and (80%) of oblique astigmatism cases so RMS(HOA) shouldn't be used alone in assessing normal cases.(Table 5).

Table (1): Comparison between the studied groups regarding demographic data ,visual acuity , refraction and curvature parameters.

Parameter	**Groups**		**Test**	
	Keratoconus group N=51 (%)	**Control group N=50 (%)**	χ^2/t	P
Gender:				
Male	17 (33.3)	23 (46)	0.1	0.752
Female	34 (66.7)	27 (54)		
Age (year):				
Mean± SD	29.25 ± 8.13	30.24 ± 9.28	-0.568	0.571
	Median(range)	**Median(range)**	Z test	
BCVA				
Median(range)	0.55 (0.05 – 1)	1 (0.1 – 1)	-5.097	<0.001**
Sphere	-2.5 (-16, 4.5)	-3.34 (-13, 3.25)	-0.15	0.988
Cylinder	-3.25 (-11, 0)	-1.25 (-4.75, -0.25)	-6.938	<0.001**
Axis	125 (0, 180)	120 (5 – 180)	-2.418	0.016*
Cyclosphere	-1.625 (-16, 5)	-2.25 (-8.75, 1.25)	-0.11	0.912
Cyclocylinder	-3.375 (-8.75, 0)	-1.25 (-3.75, -0.5)	-4.444	<0.001**
Cyclocylinder axis	87.5 (0 – 180)	95 (5 – 180)	-1.089	0.276
	Mean ± SD	**Mean ± SD**		
Anterior K1	46.13 ± 4.47	42.2 ± 1.56	8.384	0.001**
Anterior K1 axis	90.1 (1.2, 179) ¥	93.5 (0.8, 179.4) ¥	-0.577	0.577
Anterior K2	49.28 ± 5.39	43.49 ± 1.39	10.398	<0.001**
Anterior K2 axis	90.1 (3.8, 176.4) ¥	88.9 (0.4, 169.1) ¥	-0.179	0.858
Anterior Km	51.44 ± 7.87	42.81 ± 1.51	9.721	<0.001**
KMax front	53.84 ± 8.6	43.96 ± 1.48	11.438	<0.001**
K Max- K2	3.45 (0.2 – 16) ¥	0.4 (0.1 – 2.4) ¥	-11.428	<0.001**
Topographic Astigmatism	-2.95 (-9.6, 2.2) ¥	-1.1 (-4.1, -0.1) ¥	-7.445	<0.001**
DD power of T. astig. VS manifest astig.	0.1 (-8.5, 6.25) ¥	0.05 (-1.1, 1.5) ¥	-0.207	0.836
DD axis of T. astig. VS manifest astig.	4.3 (-174.9, 171.6) ¥	2.85 (-177.8, 172.4) ¥	-0.89	0.374
I-S	4.31 (0.03, 20.66) ¥	0.41 (0, 1.4) ¥	-9.121	<0.001**
S-I	1.8 (0.3, 3.8)	0.4 (-0.33, 3.5)	-4.211	<0.001**
SRAX	12.12 ± 19.45¥	8.02 ± 7.3¥	-11.007	<0.001**
Q value	-0.72 (-2.81, 0.3)	-0.25 (-0.5, 0.03)	-11.007	<0.001**

Z Mann Whitney test t Independent sample t test, χ^2 Chi square test t Independent sample t test, *p<0.05 is statistically significant **p≤0.001 is statistically highly significant, ¥data is represented as median (Range)

Table (2): Comparison between the studied groups regarding pachymetry, elevation and some topographic parameters.

Parameter	Groups		Test	
	Keratoconus group Median (range)	Control group Median (range)	χ^2/t	P
Thinnest location	464.23 ± 48.28¥	551.9 ± 28.08¥	-15.737	<0.001**
Thinnest local X	-0.13 (-1.39, 1.58)	-0.04 (-1.21, 0.97)	-0.467	0.64
Thinnest local Y	-0.44 (-1.34, 0.68)	-0.28 (-0.89, 0.14)	-3.266	<0.001**
Pachy apex	473.9 ± 47.97¥	556.08 ± 27.73¥	-0.117	0.977
Difference ()Apex & TL	8 (0 – 39)	4 (0 – 11)	-6.479	0.001**
Pachymap pattern				
CONC	11 (10.8)	14 (14)		
Dome	43 (42.2)	19 (19)	12.771	0.002*
Horizontal	48 (47.1)	67 (67)		
IS DD pachy	29 (-30, 93)	27.5 (-10, 94)	-0.641	0.522
Highest elevation front central 5mm(toric ellipsoid)	7 (1, 48)	2 (0, 5)	-10.461	<0.001**
Highest elevation back central 5mm(toric ellipsoid)	15 (5, 88)	6 (3, 14)	-10.419	<0.001**
Highest elevation front TL(BFS)	17.5 (3, 73)	3 (-2, 8)	-11.876	<0.001**
Highest elevation back TL(BFS)	44.5 (3, 135)	5 (-1, 14)	-11.648	<0.001**
shape of elevation back map:				
Isthmus	40 (39.2)	35 (64.8)		
Nipple	18 (17.6)	1 (1.9)	20.691	0.001**
Tongue	44 (43.1)	8 (14.8)		
Relative thickness map average	-9.75 (-53, -1.1)	-3.1 (-5.8, 3.7)	-10.845	<0.001**
Thickness profIle map average	1.895 (0.69, 4.89)	0.91 (0.7, 1.18)	-11.125	<0.001**
Thickness profile map shape:				
N	41 (40.2)	100 (100)	85.677	0.001**
QS	44 (43.1)	0 (0)		
S shape	16 (15.7)	0 (0)		
			Z/t	**P**
Total RMS	6.42 (0.86, 32.28)	1.47 (0.42, 4.96)	-11.241	<0.001**
RMS(HOA)	1.61 (0.32, 7.33)	0.35 (0.21 – 1.08)	-11.395	<0.001**
Cornea coma at 90 3rd order	1.04 (0.02, 6.76)	0.11 (0 – 0.75)	-11.302	<0.001**
Corneal coma 0 3rd order	0.45 (0, 2.74)	0.089 (0.01, 0.36)	-9.916	<0.001**
Corneal coma 905th order	0.14 (0, 1.17)	0.02 (0, 0.12)	-8.706	<0.001**
Corneal coma 05th order	0.07 (0, 1.07)	0.018 (0, 0.1)	-7.34	<0.001**
BAD- D	6.98 (0.1, 25.65)	0.63 (-0.61, 1.55)	-11.934	<0.001**
ARTI- Max	186.5 (51, 691)	473.5 (340, 664)	-11.452	<0.001**

¥data is represented as mean ± SD **p≤0.001 is statistically highly significant.

Table (3): Comparison between groups of patients with keratoconus regarding demographic data,vision and refraction.

	Group					P
	FF group Mean±SD	**KC1 group Mean±SD**	**KC2 group Mean±SD**	**KC3 group Mean±SD**	**KC4 group Mean±SD**	
Age	30.64±7.42	27.71±6.43	32.07±8.72	24.33±7.06	28±11.98	0.299
Gender:						
Male	7 (63.63)	2 (14.3)	4 (26.7)	4 (66.7)	0 (0)	0.199
Female	4 (36.4)	12 (85.71)	11 (73.3)	2 (33.3)	5 (100)	
	Median(range)	**Median(range)**	**Median(range**	**Median(range)**	**Median(range)**	
BCVA	0.9 (0.3 – 1)	0.7 (0.3 – 1)	0.5 (0.1 – 0.8)	0.4(0.05 – 0.7)	0.4(0.3 – 0.5)	<0.001**
Sphere	-1.5 (-16, 4.5)	-1.63(-13, 4.5)	-2.75(-15, 2)	-5 (-11,0)	-9.75(-13,-5.25)	<0.001**
Cylinder	-2(-7.25, 0)	-2.38(-7.5, 0)	-3.75(-8.75,-0.25)	-4.5(-8.75, -2)	-5.5(-11, -0.75)	0.002*

*p<0.05 is statistically significant **p≤0.001 is statistically highly significant

Table (4): Comparison between keratoconus groups regarding pachymetry, elevation and other topographic parameters

	FF group Mean±SD	**KC1 group** Mean±SD	**KC2 group** Mean±SD	**KC3 group** Mean±SD	**KC4 group** Mean±SD	**P**
Thinst local	492.5±32.4	497.7±41.8	447.2±34.2	430.2±32.1	394.9±28.4	<0.001**
Pachyapex	500±32.32	506.5±40.6	458.3±35.5	440.3±36.8	406.9±32.2	<0.001**
Pachy pattern						
Conc	2 (10.5)	1 (3.3)	4 (12.5)	2 (15.4)	2 (25)	
Dome	10 (52.6)	15 (50)	15 (46.9)	3 (23.1)	0 (0)	0.17
Horizontal	7 (36.8)	14 (46.7)	13 (40.6)	8 (61.5)	6 (75)	
Relative thickness map	-5.6(-9.9,-1.1)	-5.95(-12.8, -2.9)	-12.35(-53, -7.5)	-16.9(-22.3, -9.8)	-24.6(-26.7,-13.9)	<0.001**
Thickness profIle map average	1.24±0.24	1.59±0.67	2.18±0.53	2.68±0.41	3.8±0.76	<0.001**
thickness profile map shape						
Normal	19 (100)	18 (60)	5 (15.6)	0 (0)	0 (0)	
Quick slope	0 (0)	8 (26.7)	20 (62.5)	12 (92.3)	4 (50)	
Invered s	0 (0)	4 (13.3)	7 (21.9)	7 (7.7)	4 (50)	<0.001**
highest elevation front in central 5mm(toric ellipsoid)	3(1 – 6)	5 (2 – 12)	8.5 (3 – 32)	10 (7 – 29)	15 (7 – 48)	<0.001**
highest elevation back in central 5 mm (toric ellipsoid)	10 (5- 20)1	12 (5 – 37)	20 (11 - 63)	17 (11 – 64)	25 (11 – 88)	<0.001**
highest elevation front at TL(BFS)	7 (3 – 12)1	10.5 (3 – 29)	22 (6 – 54)	37 (26 – 54)	47.5 (35 – 75)	<0.001**
Highest elevation back at TL(BFS)	15 (6 – 31)	23.5 (6 – 64)	55.5 (24 – 122)	78 (65 – 99)	114.5 (76 – 135)	<0.001**
shape of elevation						
Isthmus	11 (57.9)	17 (56.7)	9 (28.1)	3 (23.6)	0 (0)	
Nipple	1 (5.3)	1 (3.3)	6 (18.8)	6 (46.2)	4 (50)	0.001**
Tongue	7 (36.8)	12 (40)	17 (53.1)	4 (30.8)	4 (50)	
	N=19 (%)	**N=30 (%)**	**N=32 (%)**	**N=13 (%)**	**N=8 (%)**	
Q at 6 mm						
Normal	19 (100)	24 (80)	12 (37.5)	1 (7.7)	0 (0)	
Abnormal	0 (0)	6 (20)	20 (62.5)	12 (92.3)	8 (100)	0.001**
RMS (HOA) >0.3	19 (100)	30 (100)	32 (100)	13 (100)	8 (100)	
ART-Max:						
<339	15 (78.9)	22 (73.3)	32 (100)	13 (100)	8 (100)	0.005*
>339	4 (21.1)	8 (26.7)	0 (0)	0 (0)	0 (0)	
BAD-D:						
Normal	1 (5.3)	2 (6.7)	0 (0)	0 (0)	0 (0)	<0.001**
Suspected	9 (47.4)	4 (13.3)	0 (0)	0 (0)	0 (0)	
Pathological	9 (47.4)	24 (80)	32 (100)	13 (100)	8 (100)	

Table (5): Comparison between normal groups regarding demographic data and some topographic indices

	WTR group Mean±SD	ATR group Mean±SD	Oblique astigmatism group Mean±SD	P
Age	32.86±9.62	27.52±7.31	39.25±8.72	0.005*
Gender:				
Male	5 (55.6)	13 (41.9)	9 (90)	0.115
Female	4 (44.4)	18 (58.1)	1 (10)	
	N=17 (%)	**N=68 (%)**	**N=15 (%)**	
Q at 6 mm				
Normal	17 (100)	68 (100)	15 (100)	
RMS (HOA)				
>0.3	10 (58.8)	49 (72.1)	12 (80)	0.421
<0.3	7 (41.2)	19 (27.9)	3 (20)	
ART-Max:				
>339	17 (100)	68 (100)	15 (100)	
BAD-D:				
Normal	17 (100)	68 (100)	15 (100)	

*p<0.05 is statistically significant **p≤0.001 is statistically highly significant

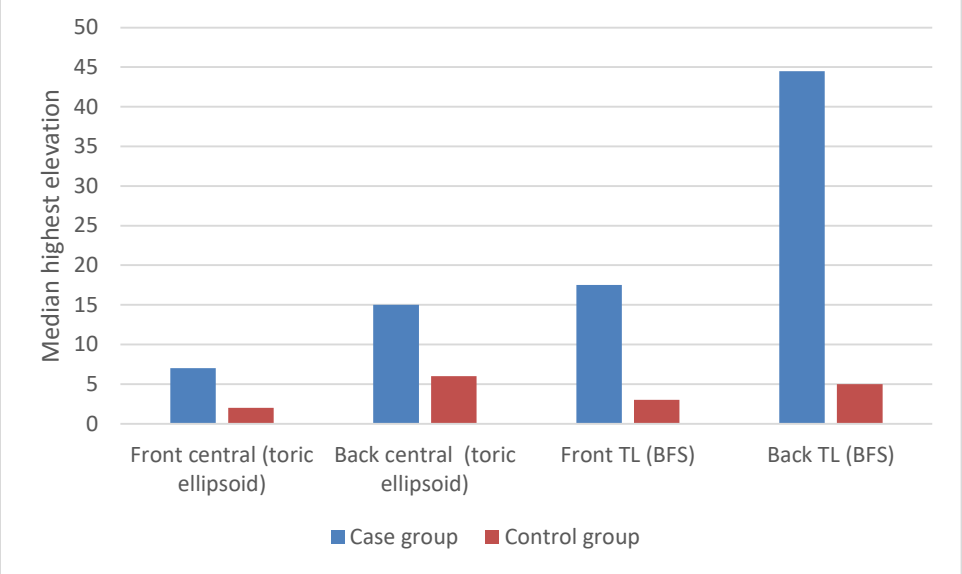

Figure (1**):** Multiple bar chart showing highest elevation values among the studied groups.

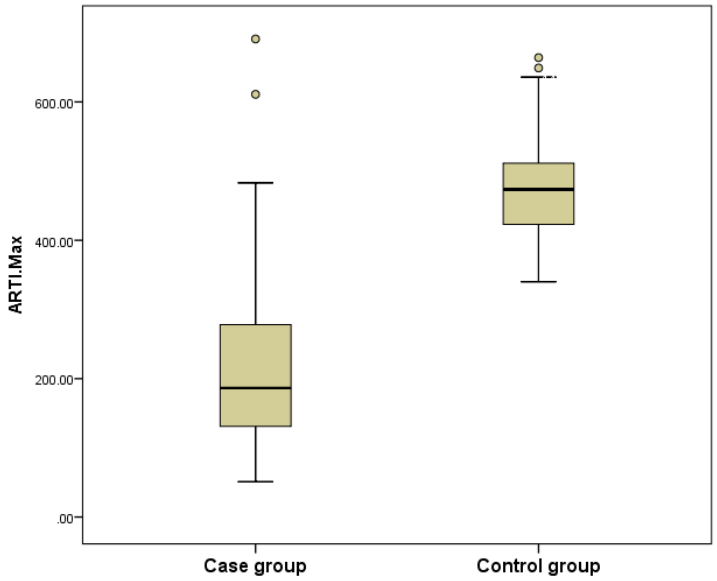

Figure (2**):** Boxplot chart showing ARTI Max values among the studied groups.

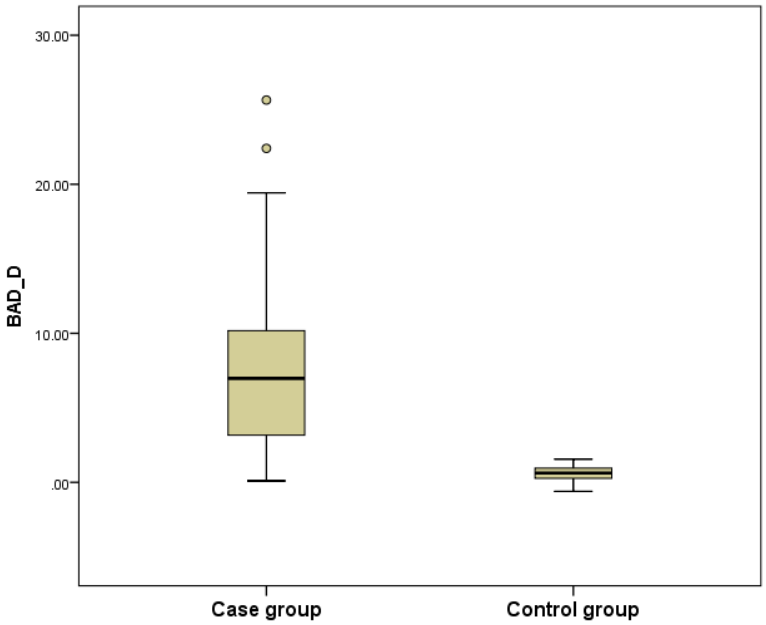

Figure (3**):** Multiple bar chart showing BAD-D values among the studied groups

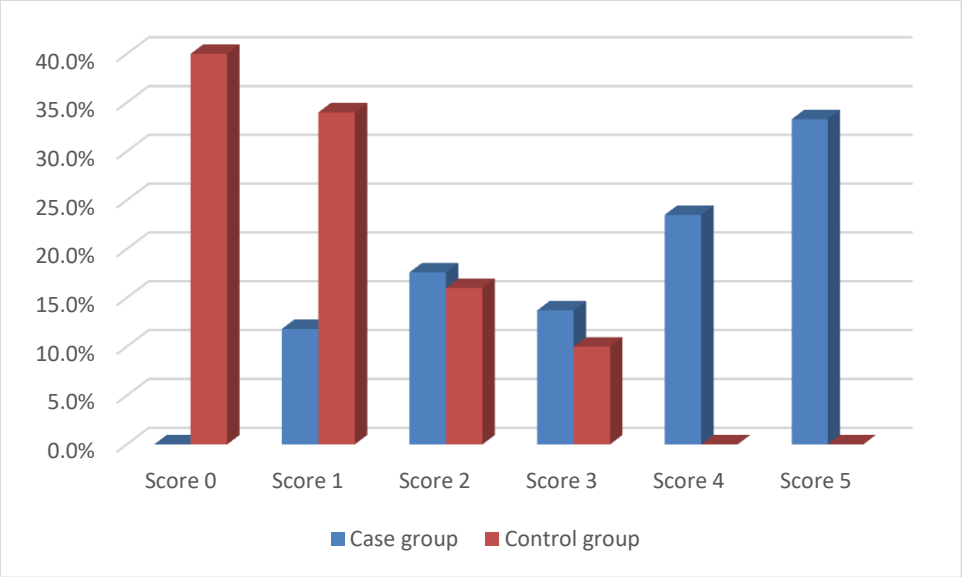

Figure (4): Multiple bar chart showing inter eye asymmetry among the studied groups.

Discussion

Keratoconus (KC) is a bilateral corneal, non-inflammatory condition characterized by gradual thinning and apical protrusion.[20] causing rapid decrease in the visual acuity early in the adulthood life. Several studies evaluated the demographic, clinical characteristics of patients with KC in different countries. [3, 21, 22] The Pentacam topography is a reliable method to screen and diagnose cases with KC allowing early and effective management.[23] in Egypt topographic screening and refractive surgeries are becoming more popular among patients with refractive errors and that was helpful in our study. **Pentacam HR tomographer (OCULUS Optikgeräte GmbH, Germany**) was the testing device in our study. The resolution of its images is five times that of the Pentacam® models as mentioned by OCULUS.[24] Ozkan et al. [25] and Rafati et al. [26] also used the same device. Elbedewy et al.).

Saini et al. [27] obtained topographical records from a placido based system (Nidek ARK 10000, Japan) for demonstrating features of KC., Naderan et al. [28] also obtained topographic measurments by OPD-Scan II (NidekCo. Ltd., Gamagori, Japan). The OPD-Scan uses Placido-based corneal topography to measure corneal aberrations. a malasian study[29] used Orbscan II corneal topography system (Bausch and Lomb

Surgical, Orbtek Inc., Salt Lake City, UT, USA). Reddy JC et al. [30] obtained topography by using the Galilei dual Scheimpflug analyzer.

Our sample size was 101 patient; 51 patients with KC and 50 patients as a control group. Elbedewy et al. [23] included 8124 subjects evaluated in his study, 91 subjects had KC in one or both eyes. Unilateral KC in only 5 cases.while 86 cases had bilateral KC. A total number of 177 eyes suffered from KC out of the 16,248 studied eyes. Rafati et al.[26] evaluated the records of 1080 eyes of 540 KC patients.

Ozkan et al.[25] evaluated data of 3128 patients, Saini et al. [27] studied 31 patients with 61 keratoconic eyes, Naderan et al. [28] evaluated 320 patients in his study, 110 had KC, 60 were FFKC, and 150 were normal. Castro-Luna et al.[31] included 205 patients; 82 normal,40 early subclinical KC and 83 KC. A total of 234 patients with KC were included in the study by Alqudah et al.[20]

This study was designed as a retrospective cohort clinical study on KC patients. Many studies used the same design as Elbedewy et al.[23], Rafati et al. [26], Castro-Luna et al. [31], Reddy et al. [30], Ozkan et al.[25] and Alqudah et al. [20] however, Saini et al. [27], Naderan et al.[28] were prospective studies.

KC usually starts to develop at the age of puberty. In this study, the mean age of patients with KC at time of diagnosis was 29.25 ± 8.13 years old, which is very close to another study done in Egypt by Elbedewy et al. [23] in which the mean age of onset was 29.40±9.79 years old, Cruz-Becerril et al. [32] with an onset at 28.14±10.30 years of age, in European countries as the mean age of the KC patients at time of diagnosis was 23–28 years [4, 33, 34] and Ljubic study in which the mean age of onset was 26.81±1.25 years[35]. Meanwhile, the asian countries shows a younger age of onset; in a study by Assiri et al. in Saudi Arabia the mean age at diagnosis was slightly lower than in our study, about 18.5±3.9 years [21] and Saini et al. with mean age at time of diagnosis 20.2 ±6.4 years.[27]

Concerning gender distribution, there was a predominance of the female gender with (66.7%) of the KC cases and (33.3%) for the male gender with no significant difference between them, This was in agreement with Elbedewy et al. [23] in which females consist (54.9%) and males (45.1%).females also more in Ljubic study (52.9%).[35] However there are other studies with male predominance[29, 36]. As in study by Rafati et al. [26] in which males were (70%).

When we analyzed the refractive parameters in this study, statistically significant

differences were found between the KC and control groups regarding the cylinder, p value <0.001. but not for the sphere (p =0.988).

Reddy et al. [30] also observed statistically significant differences for the cylinder (p < 0.001) not for the sphere (p= 0.08)., a study by Castro-Luna et al. [31] found statistically significant differences for the sphere, the cylinder and the spherical equivalent (p< 0.05) as also found in a study by Xu et al. [37]

Saad and Gatinel [38] obtained that the mean of the sphere was significantly higher in their normal group than in their early subclinical KC group (p< 0.001).

However, Naderan et al. [28] didn't find statistically significant differences for sphere (p= 0.136) or cylinder (p= 0.108)

Regarding BCVA This study also found a significant negative correlation between severity of KC and BCVA. p value (<0.001) many studies found the same result as the Saudi Arabian[21], the malasian[29] and the Egyptian [23] studies.

We found no significant association between the severity of KC with age and sex. Similar finding was found in many studies[26, 29, 39]. Other studies found the same regarding sex[36, 40] but not the age; some studies found that KC is more in younger age groups[36, 41].

A study in jordan [20] found no correlation between severity and age but regarding sex; the study found that females were more likely to have severe KC than males attributing this to the effect of hormonal levels in the biomechanics of cornea and so the progression of KC.[42, 43]

Regarding severity; our study found that KC1 consist of (27.4%) of cases and KC2 were (29.4%) while KC3 (11.7%) and KC4 (9.8%) so most of our cases were mild to moderate which is consistent with many studies as that done in malasia [29] found that 37.6% were stage I, 30.1% stage II, 4.4% stage III and 27.8% stage IV at the time of diagnosis. in Saudi Arabia it was found that 39.2% were in the early stage, 42.5% in the moderate stage and 18.3% in the advanced one[21]. A study by shanti et al.[44] found that 62% had mild form, 28.1% had moderate KC and 9.9% had severe KC. Elbedewy et al. [23] found that 54.2% of the affected eyes had a mild degree of KC, 27.1% had a moderate degree, while 18.7% suffered from the severe form. also a study in Jordan [20] found that most of the eyes were mild 63.3%, followed by moderate 24.7%, and then severe 11.9%. however a study in Iran [26] found that The frequency of moderate (56.4%) and severe (28.4%) KC was more than mild cases (15.2%) and said this

because patients with more severe disease seek medical advice more.

We found that the anterior and posterior curvature indices were significantly higher in KC group than control group which is the same finding by Piñero et al.[9] and Tomidokoro et al.[45] regarding pachymetry we found that the central thickness significantly lower in KC group than control group and also significantly decrease with increase grading of KC therefore, corneal thinning in eyes with KC can be accurately monitored using the Scheimpflug imaging system. these findings are consistent with Piñero et al. [9] and Emre et al.[46]

Regarding corneal asphericity, Q value of eyes with KC had a more significant prolate shape (negative asphericity) than normal eyes, Several studies evaluated the correlation of anterior curvature and asphericity and reported controversial results; our findings agreed with that by Piñero et al.[9], one rejected such correlation[47] and another has reported a poor correlation.[48] However we found Q value in early KC cases normal in 100%of FFKC and in 80% of KC1.

Regarding thickness profile map average (PPI average), keratometry and elevation values for anterior and posterior surface, they were significantly higher in KC group than in control group. a study by Müftüoğlu et al.[49] found nearly the same results regarding PPI, keratometry, and posterior elevation values while comparing eyes with clinical, subclinical KC and normal eyes.

Ambrosio et al. [50] emphasized the importance of the relative corneal thickness indices instead of relying on point measurements. They introduced new indices named Maximum Ambrosio Relational Thickness "ARTmax". We found that it is highly significant in differentiating between control group and KC group.

Our findings showed that BAD_D was very important in the diagnosis of KC which is in agreement with other studies[51, 52, 53].

We found BAD_D and ARTmax values are normal in 100% of control group and abnormal in 100% of KC2,3,4 but in early KC BAD_D values were more abnormal than ARTmax. Which is evident by other studies [51, 52].

Regarding Aberrometric indices we found that RMS total, RMS HOA, 3rd Ver. coma total, 3rd Hor. coma total, 5th Ver. coma total, 5th Hor. coma total were highly significant between control and KC group. Ozkan et al.[25] found the same except for 3rd Hor. coma total and 5th Hor. coma total; their difference was insignificant.

There is an increased inter-eye asymmetry in keratoconic patients compared to subjects with normal corneas and this is also evident by studies.[54]

Conclusion:

We found no significant difference between groups regarding age or gender. Many parameters in topography and tomography were efficient in differentiating normal cases from keratoconus cases even in early disease. Q value was normal in most early KC cases so it is not advisable to use this parameter alone in differentiating normal and KC cases. Inter-eye asymmetry score in keratoconic patients increased compared to subjects with normal corneas.

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