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Demographic and Clinical Characteristics of Patients with Corneal Ectasia at Multiple Medical Centers in Saudi Arabia: A Hospital-based Study

Waleed Alghamdi[1], Sulaiman Aldakhil[1], Saif Hassan Alrasheed[1]*, Kareem Allinjawi[2], Mustafa Abdu[2], Raghda F. Mutwaly[1], Khaled Al Rashah[3], Hani M. Ghazal[4], Ghassan H. Radwan[5] and Naveen Kumar Challa[1]

[1]Department of Optometry, College of Applied Medical Sciences, Qassim University, Buraydah, Saudi Arabia
[2]Department of Optometry, College of Applied Medical Science, University of Jeddah, Jeddah, Saudi Arabia
[3]Medical Services, Ministry of Interior, Najran, Saudi Arabia
[4]Ophthalmology Department, King Fahad Medical City, Riyadh, Saudi Arabia
[5]Ophthalmology Department, King Abdulaziz Medical City, Jeddah, Saudi Arabia

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ABSTRACT

Objectives: We sought to explore the clinical characteristics of corneal ectasia and provide insights on related factors, including demography, ocular health, and the management trends in the Saudi population. ***Methods***: We conducted a retrospective hospital-based chart review of patients with corneal ectasia in multiple medical centers in Saudi Arabia between 1 January and 31 December 2018. Eye care professionals diagnosed these patients based on their medical history, physical examination, and the use of Pentacam. The severity of the condition was assessed using the k median index from the Pentacam map following the modified Krumeich grading system. ***Results:*** We reviewed the medical records of 430 eyes of 215 patients with corneal ectasia. The majority (98.6%) of patients had bilateral corneal ectasia, with 202 (94.0%) having keratoconus and 13 (6.0%) having post-laser in situ keratomileusis ectasia. Males and age groups between 14 and 45 years were more affected. The mean age of onset was 7.1 years, ranging from 2–32 years, which was higher among patients from the western region. Regarding severity, 230 (53.5%) eyes presented in the initial stages, while 36 (8.4%) were in the severe stage with no significant difference between the regions studied. No significant differences were observed in mean central corneal thickness and power between patients from the central and western regions. Corneal rigid gas permeable contact lens was most used in treatment of 176 (40.9%) eyes followed by glasses in155 (36. 0%), while corneal cross-linking was the common surgical intervention (10.9%), followed by penetrating keratoplasty (3.0%). ***Conclusions:*** Most keratoconus patients had a bilateral mild stage of the disease and were in their third decade. This high rate of bilaterality of diseases during diagnosis may be due to misdiagnosis in the initial stages, which highlights the importance of community and eye care professionals' awareness of comprehensive eye examinations and regular follow-up, including corneal topography assessments of both eyes.

Keratoconus (KC) is an eye disorder that affects the structure of the cornea, resulting in irregular astigmatism, vision impairment, and corneal scarring, leading to poor quality of life.[1] This disorder is a consequence of non-inflammatory processes characterized by ectasia of the central or inferior portion of the cornea.[2] KC has its usual onset in adolescence, and the likely course of progression extends to the third or fourth decade of life when it is usually arrested.[2,3] Although a large proportion of patients with KC can be managed with spectacles or contact lenses (CLs), about 20% of all cases requires corneal transplant.[4–6] Globally, the incidence of KC ranges between one and 50 individuals per 100 000.[7,8]

The etiology and pathogenesis of KC are not very well understood; however, genetic, and environmental factors such as eye rubbing, atopy, and ultraviolet exposure might play a role.[9] This corneal ectasia can also be a possible complication of refractive surgeries, occurring in 0.04–0.6% of those who undergo these procedures.[10,11]

A limited number of studies have investigated the prevalence and clinical characteristics of KC in

*Corresponding author: ✉s.rasheed@qu.edu.sa

Saudi Arabia, and their results have been variable. In 2005, it was estimated that KC could affect 20 cases per 100 000 in the Asir region.[8] Whereas in 2018, the prevalence of KC among patients seeking laser vision correction was reported to be 8.6% in Taif, Saudi Arabia.[12] However, a recent study reported that the prevalence of KC in Najran Province was 87.3 per 100 000 people, with an incidence rate of 28.47 per 100 000 cases.[13] A more recent study estimated that KC can affect up to 4.8% of Saudis aged between 6 and 21 years old.[14] While KC appears to be prevalent in Saudi Arabia, there is still a gap in knowledge about its clinical manifestation and management. Therefore, this study aimed to retrospectively investigate the clinical characteristics of corneal ectasia and provide insights on related factors, including demography, ocular health, and the management trends among the Saudi population.

METHODS

The study was a retrospective hospital-based chart review of patients with corneal ectasia conducted in multiple medical centers across Saudi Arabia between 1 January and 31 December 2018. Four hundred and thirty eyes of 215 patients with KC were selected using a non-probability sampling technique, with ages ranging from 14–68 years. The sample included 127 males and 88 females from the central and western regions of Saudi Arabia.

The inclusion criteria were patients with KC or corneal ectasia in one or both eyes. Patients with a previous history of intraocular surgery, or other significant ophthalmic disease rather than KC, and patient records with missing essential data were excluded from the study.

Ethical permission for the study was obtained from the regional ethics committee of the Saudi Ministry of Health (Qassim Office). The study was conducted according to the Declaration of Helsinki guidelines. The ethics committee waived the need for consent due to the retrospective nature of the study. Efforts were made by the principal investigator to ensure patient privacy and confidentiality.

De-identified data were extracted from patients' records at three medical centers in three Saudi cities: two from the central region (Riyadh and Qassim) and one from the western region (Jeddah). Extracted data included demographic data (age, gender, and residential area), onset of KC, dry eye assessment, stage of KC, and best corrected visual acuity (BCVA, decimal notation). The assessment of central corneal thickness (CCT) (in microns) and anterior curvature (in dioptre) was carried out by Pentacam. Additionally, the type of treatment, either optical correction (glasses or CLs) or surgical intervention, was determined. Many scales were used for the classification of KC. In this study, classification was based on the modified Krumeich grading system.[15]

Descriptive and inferential statistical analyses were performed using SPSS (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.). Data were reported as frequency and mean±SD. An independent sample *t*-test was used to compare the means of variables between different study groups. Pearson's correlation was used to find the relationship between dependent and independent variables among the study population. A p-value of < 0.05 was considered statistically significant with a 95% CI.

RESULTS

A total of 430 eyes from 215 patients with corneal ectasia in one or both eyes were enrolled in this study. The mean age of patients was 30.6±8.3 years (range = 14–68 years), while the mean age of onset was 7.1±6.5 years (range = 2–32 years). The distribution of men and women was 127 (59.1%) and 88 (40.9%), respectively, with no significant difference in age between both genders ($p = 0.451$). Of the total number of subjects, 212 (98.6%) had bilateral KC and three (1.4%) were diagnosed as unilateral KC. Two-thirds (n = 139; 64.7%) of the KC patients were from the western region, and 76 (35.3%) were from the central region. The mean age in the central and western regions was 29.2±6.0 years (range = 19–44 years) and 31.3±9.1 (range = 14–68 years) years, respectively. Regarding corneal ectasia, the majority (n =202; 94.0%) of patients were diagnosed with KC, while 13 (6.0%) were diagnosed with post-laser in situ keratomileusis (LASIK) corneal ectasia. Furthermore, 44 (20.5%) KC patients complained of dryness [Table 1].

Four-hundred ten (95.3%) of eyes had KC, seven (1.6%) had no corneal irregularities, and 13 (3.0%) had post-LASIK corneal ectasia [Table 2]. In the western region, 268 (96.4%) eyes had KC, four (1.4%) had no corneal irregularities, and six (2.2%) had post-LASIK corneal ectasia. In the central

Table 1: Demographic data of the patients (N = 215).

Demographics	n (%)
Gender	
Male	127 (59.1)
Female	88 (40.9)
Age, years	
14–30	102 (47.4)
31–45	101 (47.0)
46–60	11 (5.1)
61–70	1(0.5)
Residential area	
Central region	76 (35.3)
Western region	139 (64.7)
Laterality	
Bilateral	212 (98.6)
Unilateral	3 (1.4)
Corneal ectasia	
KC	202 (94.0)
Post-LASIK corneal ectasia	13 (6.0)
Dryness	
Yes	44 (20.5)
No	171 (79.5)

KC: keratoconus; LASIK: laser in situ keratomileusis.

region, 142 (93.4%) eyes had KC and seven (4.6%) eyes had post-LASIK corneal ectasia. Using the chi-squire test, the association between corneal ectasia and regions was not statistically significant (χ^2 = 3.294, df = 2; p = 0.193)

Further analysis using an independent sample t-test was conducted to compare the means of variables among study groups [Table 3]. Significant mean difference was detected in age and KC onset between patients in the central and western regions with p-values of 0.018 and < 0.001, respectively. Regarding clinical findings, unaided visual acuity and BCVA were found significantly difference between both study groups. However, no significant difference was found between the central and western region patients in mean corneal power, mean spherical equivalent of refraction, and mean corneal astigmatism. Additionally, no significant mean difference was also found between the study groups in terms of CCT and intraocular pressure [Table 3].

According to Krumeich scale, stages 1 and 2 of KC are most commonly found among the patients. In addition, a cross-tabulation test was used to find the distribution of KC stages among the study population. The chi-square test showed no significant differences in KC stages between study groups (p > 0.05) [Table 4].

A cross-tabulation test was used to determine the distribution of several types of optical correction used among study groups. Corneal rigid gas permeable (RGP) CL was the most common treatment method (n = 176, 40.9%), followed by glasses (n = 155, 36.0%). In the central region, glasses were commonly used (n = 101, 66.4%), whereas in the western region, corneal RGP CL (n = 143, 51.4%) was the most common optical treatment for KC patients. Almost 40 (9.3%) eyes remain without corrections [Table 5].

A cross-tabulation test was used to assess the distribution of several types of surgical interventions used among study groups. Corneal cross-linking (CXL) was the most common surgical intervention (n = 47; 10.9%), followed by penetrating keratoplasty (PKP) (n = 13; 3.0%). In the western region, CXL was the most used surgical intervention (n =31; 11.2%) followed by PKP (n = 13, 4.7%) [Table 6].

DISCUSSION

Describing the distribution proportion characteristics of the disease and its management is crucial for predicting current and future clinical needs in different geographical locations. Given the high prevalence of KC among the Saudi population, our study was conducted to assess the clinical characteristics of corneal ectasia and offer insights

Table 2: Distribution of corneal ectasia among the study population.

Corneal ectasia	Western region n (%)	Central region n (%)	Total n (%)	Chi-square tests
KC	268 (96.4)	142 (93.4)	410 (95.3)	χ^2 = 3.294, df = 2; p = 0.193
No corneal irregularities	4 (1.4)	3 (2.0)	7 (1.6)	
Post-LASIK corneal ectasia	6 (2.2)	7 (4.6)	13 (3.0)	
Total	278 (64.7)	152 (35.3)	430 (100)	

KC: keratoconus; LASIK: laser in situ keratomileusis.

Table 3: Comparison of variables among the study population.

Variables	Total (n = 416)	Central region (n = 138)	Western region (n = 278)	*p*-value
Age, years	30.6 ± 8.3	29.2 ± 6.0	31.3 ± 9.1	0.018
KC onset, years	7.1 ± 6.5	3.4 ± 3.7	8.8 ± 6.8	< 0.001
CCT, micron	465.2 ± 53.2	462.5 ± 43.1	466.4 ± 57.6	0.499
IOP, mmHg	14.7 ± 2.5	14.9 ± 2.7	14.5 ± 2.2	0.444
CP, diopter	47.4 ± 5.1	47.5 ± 5.6	47.4 ± 4.9	0.788
Unaided vision, decimal	0.2 ± 0.2	0.2 ± 0.1	0.3 ± 0.2	< 0.001
BCVA, decimal	0.6 ± 0.2	0.5 ± 0.2	0.6 ± 0.2	< 0.001
SE, diopter	5.1 ± 4.3	4.9 ± 4.5	5.3 ± 4.0	0.625
Ocular astigmatism, diopter	3.2 ± 2.0	3.0 ± 2.0	3.5 ± 1.9	0.133
BCVA, decimal	0.6 ± 0.2	0.5 ± 0.2	0.6 ± 0.2	< 0.001

KC: keratoconus; CCT: central corneal thickness; IOP: intraocular pressure; CP: corneal power; BCVA: best corrected visual acuity; SE: sphere equivalent.

Table 4: Distribution of the keratoconus (KC) stage among the study population.

KC stage	Total n (%)	Central region n (%)	Western region n (%)	*p*-value
Stage 1	230 (53.5)	108 (71.1)	122 (43.9)	0.330
Stage 2	100 (23.3)	25 (16.4)	75 (27.0)	0.681
Stage 3	46 (10.7)	9 (5.9)	37 (13.3)	0.787
Stage 4	36 (8.4)	7 (4.6)	29 (10.4)	0.524
No KC	8 (1.9)	3 (2.0)	5 (1.8)	
No reading	10 (2.3)	0 (0.0)	10 (3.6)	
Total	430 (100)	152 (35.3)	278 (64.7)	

Stage 1: early KC = 7.8–6.7 mm, ≤ 48D, CCT > 400 µm; stage 2: moderate KC = 7.5–6.5 mm, ≤ 53D, CCT > 400 µm; stage 3: advance KC = 6.9–5.3 mm, 53–55D, CCT = 200–400 µm; stage 4: severe KC = 6.6–4.8 mm, > 55D, CCT < 200 µm.

on related factors, including demography, ocular health, and the trends of KC management among the Saudi population.

Our study found that the most common corneal ectasia was KC and about 6.0% had post-LASIK corneal ectasia. The mean age of the patients with KC was 30.6±8.3 years, these findings were higher than recent studies of KC in Middle Eastern people, which have reported mean ages ranging from 23–29.3 years.[16–18] Conversely, previous studies reported significantly lower mean ages at the time of diagnosis (18.5–22.5 years) and anticipated an early age of onset of KC among Middle Eastern people.[8–19] However, in the current study, the mean age of KC onset was 7.1 (2-32 years), which shows significant difference between the regions ($p < 0.001$). These are consistent with an early study showing that KC commonly manifests during the late teenage years, with a gradual development for approximately 15 years from diagnosis.[20] Due to several factors such as climate, environment, race, demography, and geography, the epidemiology of diseases can vary significantly between regions. For example, environmental or geographic factors, including a warm, sunny, and dusty climate, might affect the risk of KC and cause eye allergies and dryness. A previous study reported that the interaction between eye rubbing, and allergies can lead to the rapid development of KC.[21] Earlier studies reported that

Table 5: Distribution of optical correction among the study population.

Variables	Total n (%)	Central region n (%)	Western region n (%)
No correction	40 (9.3)	14 (9.2)	26 (9.4)
Glasses	155 (6.0)	101 (66.4)	54 (19.4)
Corneal RGP	176 (40.9)	33 (21.7)	143 (51.4)
Hybrid lenses	26 (6.0)	4 (2.6)	22 (7.9)
Soft spherical CL	16 (3.7)	0 (0.0)	16 (5.8)
Scleral/mini scleral	11 (2.6)	0 (0.0)	11 (4.0)
Soft toric CL	6 (1.4)	0 (0.0)	6 (2.2)
Total	430 (100)	152 (35.3)	278 (64.7)

RGP: rigid gas permeable; CL: contact lens.

Table 6: Distribution of surgical interventions among the study population.

Variables	Total n (%)	Central region n (%)	Western region n (%)
No surgery	336 (78.1)	126 (29.3)	210 (50.4)
CXL	47 (10.9)	16 (10.5)	31 (11.2)
CXL/intacs	2 (0.5)	0 (0.0)	2 (0.7)
PKP	13 (3.0)	0 (0.0)	13 (4.7)
ICRS	1 (0.2)	0 (0.0)	1 (0.4)
Correcting laser	4 (0.96)	0 (0.0)	4 (1.4)
Intacs	11 (2.6)	10 (6.6)	1 (0.4)
ICL	7 (1.6)	0 (0.0)	7 (2.5)
Corneal graft	2 (0.5)	0 (0.0)	2 (0.7)
PKP/refractive surgery	1 (0.2)	0 (0.0)	1 (0.4)
Laser/CXL	1 (0.2)	0 (0.0)	1 (0.4)
Laser/CXL/PKP	1 (0.2)	0 (0.0)	1 (0.4)
PKP/LKP	1 (0.2)	0 (0.0)	1 (0.4)
ICRS/ICL/PKP	1 (0.2)	0 (0.0)	1 (0.4)
CXL/ICL	2 (0.5)	0 (0.0)	2 (0.7)
Total	430 (100)	152 (35.3)	278 (64.7)

CXL: corneal cross-linking; PKP: penetrating keratoplasty; ICRS: intra corneal ring segment; ICL: implantable collamer lens; LKP: lamellar keratoplasty.

KC typically starts in one eye but can later progress to the other eye and sometimes it takes years after the initial diagnosis.[12–23] This was consistent with our findings; most of the cases were bilateral (98.6%). The high rates of bilaterality in our study upon diagnosis may be due to misdiagnosis in the initial stages of the KC. This highlights the importance of comprehensive eye examinations and regular follow-up, including Pentacam assessments of both eyes, to prevent missing the disease in the unaffected eye.

Males and 14–45 age groups were more affected by KC and the majority (53.5%) of patients presented at an early stage, whereas only 8.4% had a severe stage. In this study, the number of male patients exceeded the number of female patients, which aligns with the global trend of a slightly higher number of males are affected by KC in comparison to females.[13,16,22] The majority of the patients in the present study, as well as in Palestine,[18] Macedonian,[23] and Malaysia,[24] were in the mild KC stage at the time of diagnosis. For instance, in our study, 53.3% had mild, 23.3% had moderate, and only 8.4% had severe KCs. Furthermore, in Palestine, 62% were in the mild, 28.1% were in the moderate, and 9.9% were in the severe stages.[18] In Macedonia, 52.08% of cases were mild, 36.45% were moderate, and 11.57% were late stage.[23] Most patients had a mild to moderate form of the KC at diagnosis, with some variations. There are several reasons for these findings, as cited in previous studies.[18,23,24] Firstly, eye care professionals are more aware of KC and actively investigate to identify patients in the preliminary stages. Secondly, KC may be unintentionally detected during comprehensive eye exams or when changing spectacles, especially since KC patients often have myopia and astigmatism and require frequent prescription updates. Lastly, the growing popularity of refractive surgeries for myopia increases the chances of detecting KC, as preoperative assessments using technologies.

The mean CCT and anterior corneal power of KC patients were 465.2±53.2 µm and 47.4±5.1 D, respectively. Our clinical findings, such as corneal thickness, and corneal power, were consistent with previous reports on the Saudi population.[8,12,13] In the present study, complaints of dryness were found in 20.5%. Corneal RGP CL was the most used treatment (40.9%) followed by glasses (36.0%). Whereas CXL was the most frequently performed surgical intervention (10.9%) followed by PKP (3.0%). The mean BCVA was 0.6±0.2, while the mean unaided visual acuity was 0.2±0.2. This difference was statistically significant ($p < 0.001$). Even so, a sizable portion of patients arrived without any optical correction, while the majority of patients with KC wore spectacles as their primary optical correction even though their BCVA mean was only 6/10. This result was comparable to those in Palestine and Malaysia,[18, 24] where most patients have a BCVA of 0.5. Additionally, previous studies conducted among Saudi Arabians with KC showed comparable results.[8] Most optometrists were prescribing corneal RGP, and only 2.6% of KC patients were wearing scleral lenses. This could be due to the limited availability of scleral lenses as well as the lack of qualified optometrists to deal with this exceptional design of CL. Thus, the training of eye care professionals on fitting and assessment of different types of scleral CL needs to be expanded, especially since one out of every five patients reported having a dry eye in the present study. Furthermore, CXL is only found in 10.9% of the eyes, even though it is covered by free public hospital care and private insurance. This treatment method is essential because most of the KC patients are still in mild form, and it is beneficial at this stage. In our study, corneal ectasia

after refractive surgery affected up to 6% of those visiting eye clinics, which indicated patients who underwent refractive surgery may be affected.

Our study is limited by its retrospective nature. Some patient records were incomplete and there was a loss of information. A second limitation concerns generalizability since the information was only from three centers in two regions. Nevertheless, despite the limitations mentioned, our study provides useful information about the clinical characteristics of corneal ectasia and offers insights on related factors, including demography, general, ocular health, and the treatment trends of KC among the Saudi population.

CONCLUSION

Most patients with KC had a bilateral mild stage of the disease and were in their third decade. Males more commonly presented with disease than females, with a higher proportion in the western region. Post-LASIK corneal ectasia and dryness complaints were found among patients. Corneal RGP CL was the most used optical treatment followed by glasses, and CXL was the most common surgical intervention followed by PKP. Thus, the high rates of bilaterality of diseases during diagnosis may be due to misdiagnosis in the initial stages. This highlights the importance of community and eye care professionals' awareness of comprehensive eye examinations and regular follow-up, including corneal topography assessments of both eyes.

Disclosure

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