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Original Article

The Relationship between Visual Acuity, Refraction and Pachymetry Values, and Topographic Keratoconus Screening Classification

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ABSTRACT

Objective: To evaluate the relationship between visual acuity, refractive and pachymetric parameters, and topographic keratoconus screening classification (KCSC) in patients without a known diagnosis of keratoconus (KC).

Methods: This retrospective study included 366 eyes of 183 patients for whom topography examination was performed due to clinical suspicion of KC. Visual acuity, refractive and pachymetry parameters, and KCSC result (normal, suspect KC, or KC compatible) according to Sirius topography (CSO, Firenze, Italy) were noted retrospectively. The eyes were divided into 4 groups based on the magnitude of astigmatism (< -1 D, -1 to -2 D, -2 to -4 D, and > -4 D) and the relationship between these groups and topographic KCSC was evaluated.

Results: BCVA was higher in the suspect KC group than in the normal group (p=0.008) and lower in the KC compatible group compared to the normal and suspect KC groups (p=0.015, p<0.001, respectively). CCT values were lower in the suspect KC and KC compatible groups than in the normal group (p<0.001) and in the KC compatible group compared to the suspect KC group (p<0.001). Cylindrical values and spherical equivalent were higher in the KC compatible group than the normal and suspect KC groups (p<0.001). In the KC compatible group, fewer eyes had astigmatism of < -1 D or between -1 and -2 D (p<0.05), while significantly more eyes had astigmatism higher than -4 D (p<0.05).

Conclusion: Patients whose vision did not improve with refraction, who had thin CCT, and/or high astigmatism should undergo topographic examination for KC. Eyes with cylindrical values less than -1 D may be classified as suspect KC or KC compatible, by topography while eyes with astigmatism higher than -4 D are more likely to be classified as KC compatible.

INTRODUCTION

Keratoconus (KC) is an ocular disease in which the cornea thins and deforms over time, and remains an important cause of visual impairment worldwide.[1] The reported incidence of KC has increased in recent years as a result of more detailed clinical examination using keratometry, refraction, and slit-lamp biomicroscopy.[2,3] Although its epidemiology is unclear, recent studies have indicated the prevalence of KC to be over 1 in 2000 individuals.[4]

KC can be diagnosed during the clinical eye examination by detecting scissor reflex on retinoscopy, irregular astigmatism, steep cornea, changes in topography and tomography maps, decrease in corneal thickness in pachymetry, and slit-lamp findings such as Vogt's striae, Fleischer ring, Rizzuti sign, Munson sign, and stromal scarring.[5] In the 1980s, Placido disc-based corneal topography instruments were introduced to the market, which helped diagnose corneal disease even before the detection of clinical signs on slit-lamp biomicroscopy. This further paved the way for technological advancement in devices used in the diagnosis of KC.[6]

Although some slit-lamp examination findings (corneal steepening, Vogt's striae, Fleischer ring, ruptures in Bowman's layer) are diagnostic in patients with overt KC, the gold standard method in diagnosis today is corneal topography examination.[7] However, the diagnosis of suspected KC is complicated and remains unclear. There are various KC-related indices and classifications for identifying patients in the early stages, but clinicians may find it difficult to consider all of them.[8] Topographic evaluation with Scheimpflug imaging is one of the most commonly used

methods for diagnosis and follow-up in eyes with KC and suspected KC.[9–12] The Sirius topographer shows high predictive accuracy in KC detection. Elevation indices and KC summary parameters have the highest diagnostic ability.[13]

We believe that many clinicians who are not directly involved with KC refer patients to the relevant physicians according to the results of topographic KC screening classification (KCSC). Our aim in this study was to evaluate the relationship between initial examination findings and Sirius® topographic KCSC in patients with suspected KC based on a clinician's evaluation of refractive parameters, best-corrected visual acuity (BCVA), and central corneal thickness (CCT).

MATERIALS AND METHODS

The study included 366 eyes of 183 patients who presented to the ophthalmology outpatient clinic for low vision or spectacle examination between July 2020 and April 2021. All patients were evaluated by an ophthalmologist who requested topography examination with the suspicion of KC. The study was conducted in accordance with the principles of the Declaration of Helsinki and ethics committee approval was obtained. The ethics committee approval date was May 26, 2021, and the clinical trial protocol number was 2021/514/202/7.

For all patients, the data obtained during the examinations performed at the initial admission were included in the analyses. Non-cycloplegic spherical and cylindrical values were measured in all patients using an autorefractometer (Nidek ET al-700-A, Nidek Ltd., Tokyo, Japan). Intraocular pressure and CCT values were determined using a non-contact tonometer (Canon TX-20, Canon Corp., Japan). The patients' spherical and cylindrical values were obtained by autorefractometer, CCT measured with a non-contact tonometer, BCVA assessed with Snellen chart and converted to logMAR equivalent, and biomicroscopic examination findings at the initial examination were noted retrospectively. Corneal parameter values obtained with Sirius® topography device (Sirius, CSO, Frienze, Italy) were noted retrospectively. The eyes included in the study were divided into three groups according to the results of topographic KCSC: normal, suspect KC, and KC compatible. The relationship between this classification and the eyes' refractive values, CCT, and BCVA values were evaluated. The eyes were also divided into four groups according to the magnitude of astigmatism (< 1 D, 1 to 2 D, 2 to 4 D, and > 4 D) and the relationship between these groups and KCSC was evaluated.

Scheimpflug imaging

The Sirius® topographer (CSO, Firenze, Italy) combines two monochromatic 360° rotating Scheimpflug cameras with Placido disc topography and allows acquisition of 25 radial sections of the cornea and anterior chamber in seconds. The system performs keratometry measurements from a 3.0 mm diameter area of the central cornea.[14] Based on these measurements, the Sirius topographer classifies the eye as normal, suspect KC, or KC compatible using a special analysis.[15] Topography measurements of the patients included in our study were taken by the same experienced operator as recommended by the manufacturer. Three measurements were made for each eye to avoid possible operator error. The KCSC result of each eye was noted retrospectively.

Statistical analysis

SPSS version 20.0 (IBM Corp, Armonk, NY, USA) was used for statistical analyses. The Kolmogorov-Smirnov test was used to test the data for normal distribution and the results indicated that the data were non-normally distributed. Continuous variables were compared between the groups using the Kruskal-Wallis test (post-hoc Bonferroni correction Mann-Whitney U test). The results were presented as mean±standard deviation and a p-value less than 0.05 was considered statistically significant.

RESULTS

Of the patients included in the study, 94 (51.4%) were male and 89 (48.6%) were female. The mean age was 25.77±9.76 (range, 8–52) years. KCSC result was found to be normal for 218 eyes (59.6%), suspect KC for 64 eyes (17.4%), and KC compatible for 84 eyes (23%). Vogt's striae were detected on slit-lamp examination in 3 patients.

Examples of KCSC in the Sirius topography device output are shown in Figure 1. The BCVA, refractive parameters, and CCT values of all eyes and in the KCSC groups are shown in Table 1 and Table 2, respectively.

We evaluated the relationship between BCVA, CCT, and refractive parameters in the normal, suspect KC, and KC

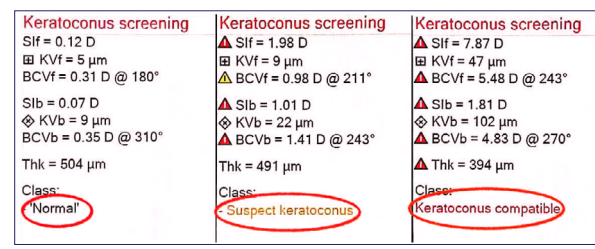

Figure 1. Examples of keratoconus screening classification in the output of the Sirius topography device.

Table 1. BCVA, refractive parameters, and CCT values of the eyes

n= 366	Min.	Max.	Mean	SD
BCVA (logmar)	0	1	0.09	0.22
Cylindrical value (D)	-10	0	-2.6	1.61
SE (D)	-7.75	4.75	-1.02	1.51
CCT (µm)	300	650	501.61	53.11

BCVA: Best corrected visual acuity; CCT: Central corneal thickness; D: Diopters; Max.: Maximum; Min.: Minimum; SD: Standard deviation; SE: Spherical equivalent.

compatible groups. BCVA was higher in the suspect KC group compared to the normal group (p=0.008) and lower in the KC compatible group compared to the normal and suspect KC groups (p=0.015, p<0.001, respectively). CCT values were lower in both the suspect KC and KC compatible groups compared to the normal group (p<0.001 for both) and in the KC compatible group compared to the suspect KC group (p<0.001). Cylindrical and spherical equivalent (SE) values were found to be significantly higher in the KC compatible group compared to the normal and suspect KC groups (p<0.001 and p<0.001), while no other significant differences were detected between the groups (p>0.05).

According to cylindrical values, none of the eyes had hyperopic astigmatism. The relationship between the magnitude of astigmatism and KCSC groups is shown in Table 3. The rates proportions of eyes with astigmatism less than -1 D and between -1 and -2 D were significantly lower in the KC compatible group (p<0.05). There was no significant difference between the groups in terms of the proportion of eyes with astigmatism between -2 and -4 D (p>0.05). The prevalence of astigmatism higher than -4 D was signifi-

Table 2. BCVA, CCT, and refractive parameters of the groups

Parameters	Normal (n=218)	Suspect KC (n=64)	KC Compatible (n=84)	p	Post-hoc analiz
BCVA (logmar)	0.08±0.22 (0–1)	0.02±0.08 (0–0.4)	0.17±026 (0–1)	<.001	N-Suspect KC: .008 N- KC Compatible: .015 Suspect KC- KC Compatible: <.001
CCT (µm)	530.59±38.67 (460–650)	478.28±31.95 (390–570)	444.16±41.86 (300–570)	<.001	N-Suspect KC: <.001 N- KC Compatible: <.001 Suspect KC- KC Compatible: <.001
Cylindrical value (D)	-2.27±1.22 (-6.5/0)	-2.12±1.44 (-7.0/-0.25)	42.73±29.40 (-10/-0.5)	<.001	N-Suspect KC: >.05 N- KC Compatible: <.001 Suspect KC- KC Compatible: <.001
SE (D)	31.18±23.10	29.57±26.58	33.53±23.64	<.001	N-Suspect KC: >.05 N- KC Compatible: <.001 Suspect KC- KC Compatible: <.001

BCVA: Best corrected visual acuity; CCT: Central corneal thickness; D: Diopters; KC: Keratoconus; KCSC: Keratoconus screening classification; SE: Spherical equivalent.

Table 3. Relationships between cylindrical refractive values and topografic KCSC

Cylindrical Values	Normal (n=218)	Suspect KC (n=64)	KC Compatible (n=84)	p	Post-hoc analiz
0- (-1) D	45 (64.7%)	17 (25%)	7 (10.3%)	<.05	N-Suspect KC: >.05 N- KC Compatible: <.05 Suspect KC- KC Compatible: <.05
-1- (-2) D	71 (68.6%)	23 (22.5%)	9 (8.8%)	<.05	N-Suspect KC: >.05 N- KC Compatible: <.05 Suspect KC- KC Compatible: <.05
-2- (-4) D	89 (65%)	16 (11.7%)	32 (23.4%)	|>.05	N-Suspect KC: >.05 N- KC Compatible: >.05 Suspect KC- KC Compatible: >.05
> -4 D	13 (23.1%)	7 (12.4%)	37 (64.5%)	<.05	N-Suspect KC: >.05 N- KC Compatible: <.05 Suspect KC- KC Compatible: <.05

D: Diopters; KC: Keratoconus; KCSC: Keratoconus screening classification.

cantly higher in the KC compatible group ($p<0.05$). There were no other significant relationships between the KCSC and astigmatism groups ($p>0.05$).

DISCUSSION

Anterior segment imaging technology has progressed rapidly since KC was first described over 150 years ago. These advanced anterior segment imaging modalities have greatly improved the understanding and characterization of the anatomical and physiological changes that occur during the course of KC.[16]

The conical shape assumed by the cornea due to thinning and protrusion causes refractive errors including myopia and regular and irregular astigmatism that lead to mild to severe visual impairment.[17] Progressive astigmatism, especially irregular astigmatism, and uncorrectable refractive errors should raise suspicion of KC and warrant further examination.[18] The Sirius topographer is a device with high diagnostic capability that can be used for advanced examination of these patients.[13] In their study including patients before refractive surgery, Feng et al.[19] defined KC suspects as patients who were marked as suspected KC by the Sirius topographer or whose final D value was yellow or red according to Pentacam output, and who did not develop KC within 2 years of follow-up after laser corneal refractive surgery. Their normal control group comprised patients in whom all indices of both devices were normal and who did not develop KC within 2 years of follow-up after refractive surgery. In their study, the mean SE was found to be −5.86±1.74 D in the tomographically suspected KC group and −6.28±1.99 D in the normal control group. In our study, the mean SE values in eyes classified as topographically normal, suspect KC, and KC compatible were −1.85±1.84 D, −2.12±1.44 D, and −3.73±1.28, respectively. The reason for the lower SE values in our study compared to those reported by Feng et al.[19] may be that their patient group consisted of patients who were scheduled for refractive surgery and thus had more pronounced refractive errors. In contrast, the patients in our study presented to the outpatient clinic for low vision and spectacle examination, suggesting lower average refractive values. Feng et al.[19] reported the mean BCVA values of 1.12±0.11 logMAR in the suspected KC group and 1.12±0.10 logMAR in the control group, stating that there was no significant difference between the two groups. In our study, the mean BCVA was 0.08±0.22 logMAR in the normal group, 0.02±0.82 logMAR in the suspect KC group, and 0.17±0.26 logMAR in the KC compatible group. We determined that the mean BCVA was better in the suspect KC group compared to the normal group ($p<0.05$), and worse in the KC compatible group compared to the normal and suspect KC groups ($p<0.05$). The higher mean BCVA results in our study compared to those of Feng et al.[19] may be due to the lower SE values of our patients. The lower mean BCVA in the normal patient group compared to the suspect KC group may be attributable to patients in the normal group who had amblyopia due to higher mean cylinder.

According to Rakhshandadi et al.[20] examined refractive features in 50 bilateral KC patients with unilateral Vogt lines and found that the mean cylindrical values of striated and non-lined eyes were -5.10±2.27 D and -2.20±1.90 D and SE values of -6.20. they found. In non-cycloplegic autorefraction, ±2.91 D and -3.01±2.31 D, respectively. In our study, the mean SE of eyes classified as KC compatible according to topographic LSC was -3.73±1.28 D and the mean cylindrical values were -3 It was .92±1.92 D. Rakhshandadi et al.[20] examined refractive characteristics in 50 bilateral KC patients with unilateral Vogt's striae and found that eyes with and without striae had mean cylindrical values of −5.10±2.27 D and −2.20±1.90 D, and SE values of −6.20±2.91 D and −3.01±2.31 D, respectively, in non-cycloplegic autorefraction. In our study, eyes classified as KC compatible according to topographic KCSC had a mean SE of −3.73±1.28 D and mean cylindrical values of −3.92±1.92 D. The mean SE values of the eyes in the KC compatible group in our study were similar to those of the eyes without Vogt's striae in the study by Rakhshandadi et al.[20] However, the mean cylindrical values in our study were higher compared to the non-striated eyes studied by Rakhshandadi et al.[20] Only three of the patients included in our study had Vogt's striae. Therefore, when compared with Rakhshandadi et al.'s study,[20] our results are largely similar to eyes without Vogt's striae and our higher mean cylindrical value may be due to the eyes in our study that had Vogt's striae. The low prevalence of Vogt's striae in our study may be due to our exclusion of eyes with a previous KC diagnosis.

CCT measurement is important in the diagnosis of KC.[21] In their study, Feng et al.[19] found the thinnest corneal thickness measured with Sirius to be 550.09±23.42 µm in the normal group and 520.28±25.49 µm in the suspected KC group. Yılmaz et al.[22] conducted a study including stage 3 and 4 KC patients and reported a mean corneal thickness of 482±28 µm measured with ultrasound pachymetry. Buyuk et al.[23] reported mean CCT measured with Pentacam as 573.8±35.7 µm in healthy individuals and 480.18±33.6 µm in eyes with KC. In our study, the mean CCT values were 530.59±38.67 µm in the normal group, 478.28±31.95 µm in the suspect KC group, and 444.16±41.86 µm in the KC compatible group. Compared to the results of Feng et al.,[19] the CCT values of the patients in the normal and suspect KC groups were lower in our study. This may be because, unlike their study, we include not only onl pre-refractive surgery patients but also patients in whom a clinician specifically suspect KC and requested topography examination based on pachymetry values. The mean pachymetry value of eyes marked as topographic KC was lower in our study compared to the study by Yılmaz et al.[22] This may be due to a higher number of eyes with advanced disease among those marked as KC compatible in KCSC in our study, or to a difference in the calibration of the instruments used to measure CCT. The lower CCT value in the normal group in our study compared to that reported by Buyuk et al.[23] may be due to our inclusion of patients suspected of having KC. The lower pachymetry values of the eyes in the KC compatible

group may be due to the high number of eyes with advanced disease. However, the use of different instruments for measurement may also have contributed.

With the progression of KC, myopia and astigmatism increase along with the structural changes in the cornea.[24] As KC is an asymmetric entity, visual acuity and refractive error are accepted as the main indicator of which eye is in better or worse condition.[25,26] In a study including 91 patients aged 18 years and over who presented for refractive corneal surgery and were diagnosed with KC in one or both eyes, Elbedewy et al.[27] reported that astigmatism was the most common refractive disorder associated with KC. They determined that among the eyes in their study, 1.2% of those corneas with astigmatism had KC. However, they stated that there was no significant relationship between KC stage and type of refractive error.[27] In our study, the KC compatible group had a significantly lower proportion of patients with cylindrical values less than -2 D ($p<0.05$) and a significantly higher proportion of patients with cylindrical values higher than -4 D ($p<0.05$). However, the fact that 25% of the eyes with a cylindrical value less than -1 D were marked as suspect KC and 10.3% as KC compatible by Sirius topography suggests that even if astigmatism is mild, patients with other clinically suspicious findings should undergo topography examination to support the diagnosis of KC, whereas more caution should be exercised in terms of the possibility of KC in patients with cylindrical values higher than -4 D. We also observed high rates of suspect KC and KC compatible in topographic KCSC among eyes with astigmatism between -1 and -4 D, suggesting that topography examination is also valuable in patients who have moderate astigmatism but are suspected of having KC based on clinical examination.

Our study has certain limitations. Because some of the patients were lost to follow-up over time while others continued topographic and clinical follow-up for potential KC, we were unable to determine exactly how many of the patients included in our study were ultimately diagnosed with KC. Another study with long-term follow-up can be conducted to elucidate this subject.

In conclusion, for patients whose vision did not improve with refraction, had thin CCT, and/or high astigmatism, the topographic examination is important to avoid overlooking KC. Although patients with astigmatism higher than -4 D are more likely to be classified as KC compatible in KCSC, patients with mild (< -1 D) or moderate (-1 – (-4) D) astigmatism may also be classified as suspect KC or KC if the topography is requested based on clinical suspicion. Further studies including more patients and longer follow-up will allow us to evaluate more clearly for which patient group topographic examination should be requested to support the diagnosis of KC.

Ethics Committee Approval

This study approved by the Kartal Dr. Lutfi Kirdar City Hospital Clinical Research Ethics Committee (Date: 26.03.2021, Decision No: 2021/514/202/7).

Informed Consent

Retrospective study.

Peer-review

Internally peer-reviewed.

Authorship Contributions

Concept: R.D.G., B.T.; Design: R.D.G., B.T.; Supervision: R.D.G., B.T.; Fundings: R.D.G., B.T.; Materials: R.D.G., B.T.; Data: R.D.G., B.T.; Analysis: R.D.G., B.T.; Literature search: R.D.G.; Writing: R.D.G.; Critical revision: R.D.G., B.T.

Conflict of Interest

None declared.

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Topografik Keratokonus Tarama Sınıflaması ile Görme Keskinliği, Refraksiyon ve Pakimetri Değerleri Arasındaki İlişki

Amaç: Amacımız bilinen keratokonus (KK) tanısı olmayan olgularda, görme keskinliği, refraktif ve pakimetrik parametreler ile topografik keratokonus tarama sınıflamasının (KKTS) ilişkisini değerlendirmektir.

Gereç ve Yöntem: Bu geriye dönük çalışmada klinisyenlerin, KK'tan şüphelenerek, topografi tetkiki istediği 183 hastanın 366 gözüne ait görme keskinliği, refraktif ve pakimetrik parametreler ile Sirius topografi (CSO, Frenze, İtalya) ile elde edilen KKTS sonuçları normal, şüpheli KK ve KK olarak geriye dönük not edilmiştir. Gözlere ait astigmatik değerler; < -1 D, -1 / -2 D, -2 / -4 D, and > -4 D olmak üzere dört gruba ayrılmış ve KKTS ile bu gruplar arasındaki ilişki değerlendirilmiştir.

Bulgular: EİDGK şüpheli KK grubunda normal gruba göre yüksek (p=0.008), KK grubunda normal ve şüpheli KK grubuna göre düşük (sırasıyla p=0.015, p<0.001) bulunmuştur. SKK değerleri şüpheli KK ve KK gruplarında normal gruba göre düşük (p<0.001), KK grubunda ise şüpheli KK grubuna göre düşük (p<0.001) bulunmuştur. Şüpheli KK ve KK gruplarında sferik refraktif değerler normal grubuna göre yüksek (sırasıyla p=0.03, p<0.001), KK grubunda şüpheli KK grubuna göre yüksek (p<0.001) bulunmuştur. Astigmatik refraktif değerler ve sferik eşdeğer (SE), KK grubunda normal ve şüpheli KK grubuna göre yüksek (p<0.001) bulunmuştur. KK sınıfında astigmatik değeri 0/-1 D arası ve -1/-2D arası olan göz bulunma oranı düşük (p<0.05), > -4 D olan göz bulunma oranı yüksek saptanmıştır (p<0.05).

Sonuç: Vizyonu refraksiyonla artmayan ve/veya SKK ince olan ve/veya yüksek astigmatizması olan hastalarda KK açısından topografik değerlendirme istenmelidir. Astigmatik refraktif değeri -1 D'nin altında olan gözlerde de KKTS'nda şüpheli KK ve KK bulunma ihtimali mevcuttur, -4 D'den büyük olanlarda ise KK olarak işaretlenme ihtimali artmaktadır.

Anahtar Sözcükler: Astigmatizm; görme keskinliği; keratokonus; pakimetri; topografi.