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**Burcu Kasım**

**Yusuf Koçluk**

Department of Ophthalmology, Adana City Training and Research Hospital, Adana, Turkey

### Corresponding Author:

**Burcu Kasım\***

Department of Ophthalmology, Adana City Training and Research Hospital, Adana, Turkey.

## Variability in Topographic Measurements in Keratoconus

### ABSTRACT:

**Purpose:** To analyze the variability of the parameters for diagnosis in two consecutive scans using Pentacam in patients with keratoconus.

**Methods:** Seventy two eyes of 38 patients with keratoconus were recruited. Patients were divided into three groups based on mean TA (Group 1:  $<3D$ , group 2:  $\geq 3D$  and  $<6D$  and group 3:  $\geq 6D$ ). Two consecutive scans with two minutes intervals were performed by the same operator with Pentacam. Topographic astigmatism (TA) and mean keratometry (Km) readings from anterior and posterior surface, maximum keratometry (Kmax), central corneal thickness (CCT) and Belin/Ambrósio enhanced ectasia display (B/A) from both scans were recorded. The differences of these parameters in two scans were analyzed.

**Results:** There was no statistically significant difference between consecutive scans in any of the parameters. However, the difference in CCT and TA of posterior surface were statistically significant amongst the subgroups. Group three has the greatest difference in CCT (8.4 in group 3 vs. 2.9 in group 1 and 1.1 in group 2,  $p=0.037$ ) and TA of posterior surface (0.2 in group 3 vs. 0.02 in group 1 and 0.04 in group 2,  $p=0.045$ ).

**Conclusions:** Pentacam is a reliable tool to detect keratoconus and assess the progression of the disease. On the other hand, in group 3 with high astigmatism, the difference in the parameters to detect the progression between consecutive scans was greater than group 1 and 2.

**Keywords:** Keratoconus; Pentacam; Variability

### INTRODUCTION

Keratoconus is a bilateral corneal disorder which is characterized by progressive focal thinning and protrusion of the cornea. Most common clinical change is irregular astigmatism, resulting in visual impairment [1,2]. Early management of keratoconus involves spectacles and contact lenses fitting. In advanced cases, where conservative methods are inadequate for visual correction or in patients with contact lens intolerance, surgical intervention is required [1,2]. In 2003, Wollensak et al. [3] described corneal collagen crosslinking (CXL) which is still the only procedure shown to be effective in stabilizing the progression of the disease. Therefore, accurate grading and diagnosis of progression is essential to choose the course of treatment.

Diagnosis of the condition is mostly based on clinical suspicion, then careful slit-lamp examination and imaging of cornea. Numerous techniques are used to evaluate the corneal thickness and curvature which are the main criteria for diagnosis. Pentacam is one of the most commonly used device for diagnosis, staging and the evaluating the progression of keratoconus. It uses a Scheimpflug camera and monochromatic light source that rotate together, providing topographic imaging and pachymetry [4]. Several studies have shown good results in repeatability of the test in healthy subjects [5-8]. However, studies have shown contradictive results in keratoconus patients [9-12].

In this study we aim to analyze the variability of the parameters for diagnosis in two consecutive scans using Pentacam in patients with keratoconus.

## MATERIAL AND METHODS

Seventy two eyes of 38 patients with keratoconus evaluated at Adana City Research and Training Hospital, Department of Ophthalmology, Adana, Turkey between March 2015 and March 2016 were recruited into this study. Informed consent was obtained from all participants. The study was approved by the local ethics review board and adhered to the tenets of the Declaration of Helsinki. All subjects and controls underwent a comprehensive ocular examination, including visual acuity, slit-lamp examination and Pentacam tomography (Oculus Inc., Wetzlar, Germany).

Patients were divided into three groups based on mean TA (Group 1: less than 3 diopters, group 2: greater or equal to 3 diopters and less than 6 diopters and group 3: greater or equal to 6 diopters). Two consecutive scans with two minutes intervals were performed by the same operator with Pentacam, using the standard automated mode. Only the scans with a quality factor >95% were included. Topographic astigmatism (TA) and mean keratometry (Km) readings from anterior and posterior surface, maximum keratometry (Kmax), central corneal thickness (CCT) and Belin/Ambrósio enhanced ectasia display (B/A) from both scans were recorded. The differences of these parameters in two scans were analyzed.

Data analysis was performed using Statistical Package for Social Sciences for Windows software (SPSS version 16.0, SPSS Inc. Chicago, USA). Normality distribution of variables was tested by Kolmogorov–Smirnov test. Mean ± standard deviations (SD) were used in the presentation of the data.

Comparison of the parameters before and after and between groups was performed using paired-sample T test and general linear model (repeated measure) where appropriate. Categorical variables were presented as frequency (%) and compared between the groups using chi-square test and Fisher's exact test. Differences were considered statistically significant when p value was <.05.

## RESULTS

The study recruited 72 eyes of 38 keratoconus patients. The mean age of all patients was 23.3±7.1 (range: 13-39 years). Thirty-one were male (43.1%) and 41 (56.9%) were female. The patients were divided into three groups; group 1 included patients with mean TA of less than 3 diopters (n=22, 9 males, 13 females, mean age 26.4±8.4), group 2 with mean TA of greater or equal to 3 diopters and less than 6 diopters (n=40, 16 males, 24 females, mean age 21.8±5.8) and group 3 with mean TA of greater or equal to 6 diopters (n=10, 6 males, 5 females, mean age 22.1±7.6).

The mean values of the parameters analyzed of all patients in both scans were shown in **Table 1**. There was no statistically significant difference between consecutive scans in any of the parameters. However, the difference in CCT and TA of posterior surface were statistically significant amongst the subgroups. Group three has the greatest difference in CCT (8.4 in group 3 vs. 2.9 in group 1 and 1.1 in group 2, p=0.037) and TA of posterior surface (0.2 in group 3 vs. 0.02 in group 1 and 0.04 in group 2, p=0.045). Moreover, the difference in Kmax was also greater in group 3 but not statistically significant (0.76 in group 3 vs. 0.09 in group 1 and 0.18 in group2, p=0.252).

**Table 1:** The mean values of the parameters of all patients in both scans.

	First scan of all patients	Second scan of all patients	P value
Kmax	57.1±6.9	57.3±7.2	0.075
CCT	432±59	434±56.1	0.268
Km of anterior surface	49.4±4.9	49.4±4.9	0.526
Km of posterior surface	-7.5±0.9	-7.5±0.9	0.610
TA of anterior surface	4.1±2.1	4.2±2.1	0.306
TA of posterior surface	0.86±0.4	0.82±0.4	0.141
B/A	10±4.9	9.9±4.7	0.213

Kmax: Maximum keratometry reading, CCT: Central corneal thickness, Km: Keratometry reading, TA: Topographic astigmatism, B/A: Belin/

Ambrósio enhanced ectasia display.

## DISCUSSION

Keratoconus is the most common ectasia of cornea, typically progresses until the fourth decade with a prevalence of 54.5 per 100000 [1,2,13]. Although there is no consistent or clear definition of ectasia progression according to Global Consensus on Keratoconus and Ectatic Diseases, it has been agreed that ectasia progression requires changes in at least 2 of the following; steepening of the anterior surface, steepening of the posterior surface, and/or thinning or changes in the pachymetric rate of change. However, no exact values have been established [14].

The Pentacam is a rotating Scheimpflug camera that generates images in three dimensions. The image is completed in maximum 2 seconds and a second camera is used to detect and correct for any eye movements in the process [4]. It is the most commonly used tool for diagnosis and to detect the progression of keratoconus.

Several studies found good repeatability of the parameters used for the diagnosis in patients with keratoconus [10-12]. We also found no statistically significant difference in any parameter between consecutive scans. However, Vienna et al. [9] found a significant difference in CCT and Km between consecutive scans in keratoconus patients when compared to control group. They also showed an increasing variability in mean keratometry and central corneal thickness values with increasing TA. We also evaluated these parameters among subgroups with different TA and found that these differences are greater in patients with higher TA ( $\geq 6D$ ) in CCT and Km of posterior surface. Vienna et al. [9] showed mean maximum difference in CCT  $35.3 \pm 49.6$  in patients with TA over 6D and suggested that it is a result of fixation problems in this group. In our study, we found only  $8.4 \mu m$  in this group of patients. However, when evaluating the progression, a mean decrease of 5% in CCT in 6 months is used in most clinical practices and a change of even  $8 \mu m$  can be misleading in advanced cases, where the corneal thickness is thinner. In addition to fixation problems, we suggest that the altered biomechanics in keratoconus, such as decreased elasticity and increased viscosity, may be another cause for this difference. Although no statistically significant difference has been shown between

consecutive scans, we found the difference in Km of posterior surface is also greater in the higher TA group. In a study by Labiris et al. [12], they analyzed the variability of posterior corneal measurements in keratoconus patients and found good repeatability in posterior elevation measurements, except in lower hemisphere. In another study, which evaluates the repeatability of Pentacam scans in normal subjects, the relative repeatability has been found to be poorer in Km of posterior surface than anterior surface [8]. It is suggested that this finding may be a result of the lower contrast edge to determine the posterior cornea due to the smaller difference in index of refraction between cornea and aqueous.

One of the limitations of our study is we analyzed two consecutive scans instead of three as other studies to evaluate the repeatability. We might have more reliable results if we had more scans to compare. Another limitation is the smaller sample size of group 3 because of the difficulty to obtain scans with a high quality factor.

## CONCLUSION

We found that Pentacam is a reliable tool to detect keratoconus and assess the progression of the disease. On the other hand, in group 3 with high astigmatism, the difference in the parameters to detect the progression between consecutive scans was greater than group 1 and 2. Thus, when progression is evaluated, attention must be paid for the patients with advanced disease to decide for treatment.

## Conflict of interest

Burcu Kasım and Yusuf Koçluk declare that they have no conflict of interest.

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## Compliance with Ethics Guidelines

The study has received the approval of an institutional review board, Adana City Training and Research Hospital ethics committee and conformed with the Helsinki Declaration of 1964, as revised in 2013, concerning human and animal rights.

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