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# Efficacy of corneal tomography parameters and biomechanical characteristic in keratoconus detection

Seyed Mahdi Ahmadi Hosseini[a,b,*,1], Fereshteh Abolbashari[a,b,1], Hamed Niyazmand[a,b], Mohammad Reza Sedaghat[a,b]

[a] Refractive Errors Research Center, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran
[b] Department of Ophthalmology, Mashhad Medical University, Mashhad, Iran

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ABSTRACT

*Aim:* To determine the efficacy of corneal thickness parameters and corneal biomechanical properties (CBPs) in discriminating between normal and keratoconus eyes.
*Method:* After performing a comprehensive ophthalmic examination, 50 mild to moderate keratoconus and 50 age and sex matched myopic astigmatism eyes were prospectively included in the study. The corneal topographic maps and CBP were obtained by Pentacam and Ocular response analyser, respectively. Central corneal thickness (CCT), thinnest corneal thickness (TCT), corneal thickness (CT) and percentage thickness increase (PTI) at 1, 3 and 5 mm from the thinnest point and corneal volume (CV) at 3, 5, 7 and 10 centred on thinnest point, corneal hysteresis (CH) and corneal resistance factor (CRF) were recorded. Independent *t*-test and receiver operating characteristic (ROC) were done with SPSS software (version 15.0, SPSS, Inc.).
*Results:* CCT, TCT, CT at 1, 3 and 5, CV at 3, 5, 7 and 10 mm, CH and CRF were significantly lower in keratoconus eyes compared to controls ($p < 0.001$). In addition, PTI at 1, 3 and 5 mm from the thinnest point showed significantly higher values in keratoconus group. ROC analysis demonstrated good predictive accuracy for cut-off point values. However, the centrally located indices had higher predictive accuracy compared to the peripherally located indices.
*Conclusion:* Although good sensitivity and specificity were found for the mentioned parameters, the centrally located indices had higher predictive accuracy compared to peripherally located indices. It is suggested to use a combination of corneal pachymetry together with CBP for more accurate detection of keratoconus.
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## 1. Introduction

Keratoconus is a bilateral [1,2] and asymmetric [3] corneal degeneration characterized by central and para-central stromal thinning and subsequent conical ectasia. This progressive disorder is the most common corneal dystrophy with the incidence of 5–23 per 10,000 in the general population [3,4]. Keratoconus affects the vision by generating irregular astigmatism and corneal scarring. It has been proposed that the thinning of the cornea during the disease progression is related to the keratocytes apoptosis around the cone [5].

Sometimes patients with keratoconus or other forms of ectasia, such as pellucid marginal degeneration, have poor outcomes after laser in situ keratomileusis (LASIK) and photorefractive keratectomy (PRK) [6]. Previous studies reported that 1–6% of myopic patients who have vision-correction surgery have keratoconus or are suspected of having keratoconus or other forms of corneal ectasia. The high prevalence of corneal ectasia among these candidates indicates the vital role of pre-surgical screening [7,8].

Cornea is a viscoelastic tissue and corneal hysteresis (CH) together with corneal resistance factor (CRF) are indications of corneal viscoelastic characteristics [9,10]. Hysteresis is defined as the response of a viscoelastic tissue such as cornea to the imposed stress, that is measured in millimetres of mercury (mmHg). Being knowledgeable about corneal biomechanical properties (CBPs) could be beneficial in detection of some corneal pathologies such as keratoconus, Fuch's dystrophy, keratoglobous, determination of intraocular pressure (IOP) and also prior to refractive surgeries [11,12]. Ocular response analyser (ORA) is a fairly recent advance in ophthalmic technology that could help clinicians

* Corresponding author at: Refractive Errors Research Center, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran. Tel.: +98 9376771702.
*E-mail address:* Mahdi.ahmadihosseini@yahoo.com (S.M. Ahmadi Hosseini).
[1] These two authors contributed equally to the work presented here and should therefore be regarded as equivalent authors.

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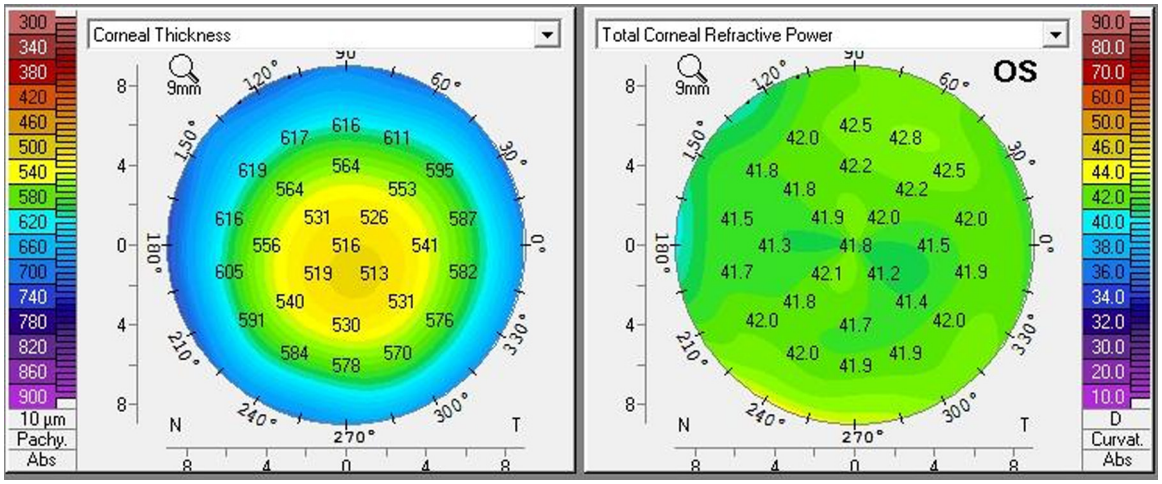


**Fig. 1.** Corneal thickness (left) and total corneal refractive power (right) of a subject with normal eye.

in vivo assessment of the corneal tissue elasticity. This instrument works by applying the jet air puff to the centre of the cornea. With an electro-optical system, the corresponding deformation of the cornea is detected. Then the difference between 2 pressures is recorded and considered as the CH. The CH is the result of the energy being absorbed or dissipated in the corneal tissue. Furthermore, the CRF is calculated using a linear combination of inward and outward applanation pressures. It is believed that the CBP is the measure of the corneal stromal characteristics [13].

The aim of this study was to evaluate the efficacy of corneal tomography parameters and CBP in discrimination between normal and keratoconic eyes.

## 2. Materials and methods

This was a prospective comparative case series study. Subjects were selected from the patients referred to Toos ophthalmology clinic, Mashhad, Iran. All of the study procedures were conducted in accordance with the Declaration of Helsinki in 1975 and approved by the Human ethics committee of Mashhad University of Medical Sciences.

### 2.1. Subjects

Keratoconus subjects were diagnosed based on biomicroscopy, keratometry, retinoscopy and topography examinations in accordance with the criteria established by the Collaborative Longitudinal Evaluation of Keratoconus (CLEK) Study [14]. In this group, subjects with any ocular pathology, corneal scar, history of surgery, dry eye and contact lens wear within the last 2 months (soft or hard) were excluded from the study. In the next step, keratoconus subjects with mild to moderate keratoconus were selected according to their mean keratometry reading (K-reading) driven from the Pentacam topographic maps (47 D < K-reading < 52 D) [15,3].

Control subjects were chosen from the candidates of refractive surgeries (PRK) with myopic astigmatism. The control group had refractive errors of myopia ≤ 4D and astigmatism ≤ 1.5D. The exclusion criteria for this group were any signs of keratoconus in slit lamp biomicroscopy, retinoscopy and topography examinations (inferior-superior localized steepening or asymmetric bow-tie pattern), history of ocular surgeries, trauma, dry eye, contact lens wear within the last 2 months or any other ocular pathology.

### 2.2. Measurements

For the Pentacam measurement, the instrument was set to take 25 images per scan using the automatic release mode. Subjects were asked to sit on a chair and placed their foreheads on the headrest of the device. Then they were told to focus on the black ring at the centre of the blue LED light. An expert operator used the joy stick to align and focus the image. Once the image was stable, the instrument automatically recorded the image. Only one measurement was performed for each eye; however, if the quality specification was not white "OK", the examination was repeated. The high reproducibility and repeatability of this machine has been documented previously in the measurement of anterior segment parameters [16]. The following parameters were extracted from the topographic and pachymetric maps for further analysis: central corneal thickness (CCT), thinnest corneal thickness (TCT), peripheral corneal thickness (PCT) at 1, 3 and 5 mm from the thinnest point, percentage thickness increase (PTI) at 1, 3 and 5 mm from the thinnest point and corneal volume (CV) at 3, 5, 7 and 10 $mm^3$ centred on the thinnest point. Figs. 1 and 2 illustrate the corneal thickness and total corneal power maps of a control subject and a subject with keratoconus, respectively.

CH and CRF were measured with ORA (Reichert Ophthalmic Instruments, Depew, New York, USA). For the ORA measurement, subjects sat on a chair and placed their foreheads on the headrest of the ORA device that was made to match their height by adjusting the height of the table. To avoid startling the subjects, they were first briefed about the procedures. Then subjects were told to focus on a blinking red light on the device and the measurement was automatically done. Three consecutive ORA measurements were done for each eye and results were averaged. The quality of ORA measurement was defined as the waveform score (WS) that was graded between 0 and 10. In this experiment the measurements with the WS 5 or higher were accepted, otherwise the examination was repeated.

### 2.3. Statistical analysis

Since the progression of the keratoconus is not symmetric between the 2 eyes of each subject, both eyes of the keratoconus subjects were included in this study if they met the inclusion criteria. On the other hand, only one eye of the control subjects were randomly selected for the analysis.

Statistical analysis was performed with SPSS software (version 18.0, SPSS, Inc.). According to the Shapiro–Wilk test, data for all the

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