

Diagnostic Accuracy of Anterior Segment Optical Coherence Tomography Pachymetry Mapping and Detection for Early Keratoconus using Corneal Topography as Gold Standard

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ABSTRACT

Background: Optical coherence tomography (OCT) derived pachymetry mapping has potential in diagnosis of early and advancing keratoconus. The OCT corneal pachymetry map-based logistic regression formula and the keratoconus risk scoring system has been proven to provide very accurate results in keratoconus identification. In keratoconus screening these techniques might be helpful.

Objectives: To ascertain the diagnostic accuracy of anterior segment optical coherence tomographic corneal pachymetry to diagnose the cases of early keratoconus by using corneal topography as a high standard with which other techniques of these kinds are compared.

Study Design: Cross-sectional (validation) study.

Duration: One year from July 01, 2019 to June 30, 2020.

Settings: Department of Ophthalmology, Allied Hospital/DHQ Hospital, Faisalabad Pakistan.

Methodology: A total of 195 patients having asymmetrical astigmatism (>1 diopter), 12-40 years of age of both genders were included. Patients with corneal ulcer and corneal opacity were excluded. After complete examination corneal topography and anterior segment optical coherence tomography was performed. Tomographic minimum central corneal thickness was recorded and assessed for cutoff value, if exceeding cutoff value patient was diagnosed with the early keratoconus.

Results: In OCT pachymetry positive patients, 103 (True Positive) had early keratoconus and 05 (False Positive) had no early keratoconus on corneal topography. Among 87, OCT pachymetry negative patients, 04 (False Negative) had early keratoconus on corneal topography whereas 83 (True Negative) had no early keratoconus on corneal topography ($p=0.0001$). Overall sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of anterior segment optical coherence tomographic corneal pachymetry to diagnose the cases of early keratoconus in the suspected individuals by using corneal topography as gold standard was 96.26%, 94.32%, 95.37%, 95.40% and 95.38% respectively.

Conclusion: This study concluded that diagnostic accuracy of anterior segment optical coherence tomographic corneal pachymetry to find out the cases of early keratoconus is very high.

Keywords: *Optical coherence tomographic corneal pachymetry, Keratoconus, Sensitivity.*

INTRODUCTION

The OCT corneal pachymetry map-based logistic regression formula and the keratoconus risk scoring system has proven to give very correct results.¹ Procedures of these kind may be beneficial in keratoconus screening. Keratoconus is a bilateral growing disease that is non-inflammatory and in this disease the cornea thins out ectatically.² It's a disorder of the cornea in which the central portion of cornea becomes thin and advances outwards in the shape of a cone which results in myopia, irregular astigmatism and blindness at the end.³ Both males and females are affected by Keratoconus, but it is not clear that if it affects male and female the same or differently.⁴ Keratoconus and other ectactic disorders have been known for more than 150 years.⁵ Over the last twenty years there has been a uprising research in the data and knowledge related to the identification and treatment of these diseases. In diagnostic terms, the dawn of corneal topography, which is recently called corneal tomography,

has made it easy for the ophthalmologists to detect corneal ectasia at an earlier stage, which was not possible before.⁵ Allergy is one of the important risk factors for keratoconus.⁶ Eye rubbing precipitates the onset and may also exacerbate the progression of keratoconus.⁶

Optical coherence tomography derived pachymetry mapping seems to have serious capability in initial and progressing keratoconus identification and diagnosis. The OCT corneal pachymetry map-based logistic regression formula and the keratoconus risk scoring system provided high accuracy in keratoconus identification.⁷ The one percentile cut off value can be used for the detection of early keratoconus. Corneal topography was taken as gold standard.⁸

The principle of the study of OCT pachymetry mapping was to detect the initial onset of keratoconus in the population suspected by using anterior segment OCT pachymetry mapping which can be helpful in the management and treatment of the affected individuals. The OCT corneal pachymetry is the technique used in this

study to identify the initial onset of keratoconus as it provides quantitative measure of corneal thickness which is significant for initial treatment modalities and their efficacy.

The goal of the study was to govern the diagnostic accuracy of anterior segment OCT corneal pachymetry to detect the cases of early keratoconus.

METHODOLOGY

Study Design: Cross-sectional (validation) study.

Settings: Department of Ophthalmology, Allied Hospital/DHQ Hospital, Faisalabad Pakistan.

Duration: One year from July 01, 2019 to June 30, 2020.

Sample Size: 195 patients.

Sample Technique: Non-probability, consecutive sampling.

Inclusion Criteria: All males and females patients with age of 12-40 years, patients complaining of eye rubbing (>6 months) and patients having asymmetrical astigmatism (>1 diopter) were included in the study.

Exclusion Criteria: Diagnosed case of keratoconus, patients with corneal ulcer, patients with corneal opacity and patients having refractive surgery before were excluded from the study.

Data Collection Procedure: Overall 195 cases which fulfilled the criteria of inclusion/exclusion were registered from the outpatient Department of Ophthalmology, Allied Hospital and DHQ Hospital, Punjab Medical College, Faisalabad. First, the approval of research/ethical committee of the hospital was acquired and then the study was conducted. An informed consent of the patients was obtained to include their data in the study and their confidentiality was ensured. Socio-demographic profile like age, name, gender and history of current disease along with symptoms, complexity stage and duration were taken. Baseline inspection comprised visual acuity, refraction, retinoscopy, intraocular pressure measurement and detailed slit lamp examination including examination of anterior as well as posterior segment was done. After complete examination corneal topography and anterior segment OCT was performed. Tomographic minimum central corneal thickness was recorded and assessed for cutoff value, if exceeding cutoff value patient was diagnosed with the early keratoconus. All the information was saved on the pre designed proforma.

Data Analysis Procedure: SPSS version 17 was used to analyze and enter all the data. For all the quantitative variable factors, like age and minimum corneal thickness, mean and standard deviation were calculated. Frequency and percentage were calculated for all qualitative variables like gender and true positive and true negative. Sensitivity, Specificity, Positive predictive value, Negative predictive value and diagnostic accuracy was calculated by using corneal topography as gold standard.

OCT PACHYMETRY	CORNEAL TOPOGRAPHY	
	(+ ve)	(- ve)
	(+ve)	True positive (a)
(-ve)	False negative (c)	True Negative (d)

Table 2: Diagnostic accuracy of anterior segment optical coherence tomographic corneal pachymetry to detect the cases of early keratoconus in the suspected individuals among local population by using corneal topography as gold standard

	Positive result on corneal topography	Negative result on corneal topography	P- value
Positive result on OCT pachymetry	103 (TP)*	05 (FP)***	0.0001
Negative result on OCT pachymetry	04 (FN)**	83 (TN)****	

RESULTS

Effect modifiers which have the tendency to change the magnitude of effect like age and gender were controlled. It was done by stratification. Diagnostic accuracy after the stratification was measured. P value ≤ 0.05 was taken as significant. Likelihood ratio and

ROC (Receiver operating characteristic curve) was calculated.

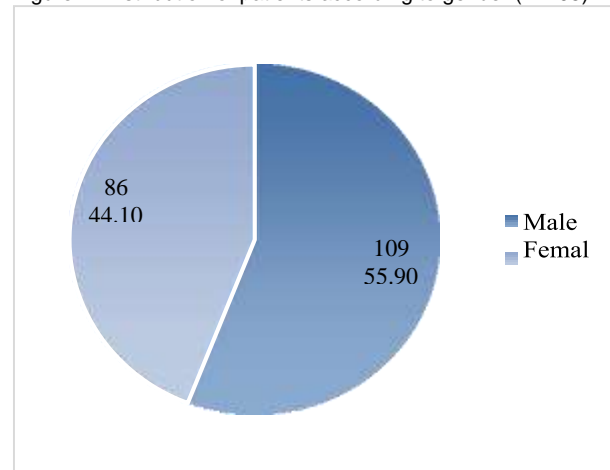
In this study the age range of the patient population was from 12-30 years with average age of 25.46 ± 6.42 years. Major population of the patients 115 (58.97%) were between 12 -25 years of age as shown in Table 1.

Table 1: Distribution of patients according to age

Age (years)	No. of Patients	Percentage
12-25	115	58.97%
26-30	80	41.03%
Total	195	100.0%

Out of these 195 patients, 109 (55.90%) were males and 86 (44.10%) were females with ratio of 1.3:1 (Figure 1). Mean minimum corneal thickness was 459.72 ± 12.78 µm.

Figure 1: Distribution of patients according to gender (n=195)



All the patients were subjected to anterior segment OCT and corneal topography and OCT pachymetry supported the diagnosis of early keratoconus in 108 (55.38%) patients and corneal topography confirmed early keratoconus in 107 (54.87%) patients. In OCT pachymetry positive patients, 103 (True Positive) had early keratoconus and 05 (False Positive) had no early keratoconus on corneal topography. Among 87, OCT pachymetry negative patients, 04 (False Negative) had early keratoconus on corneal topography whereas 83 (True Negative) had no early keratoconus on corneal topography (p=0.0001) as shown in Table 2. ROC curve is shown in Figure 2.

Figure 2: ROC curve

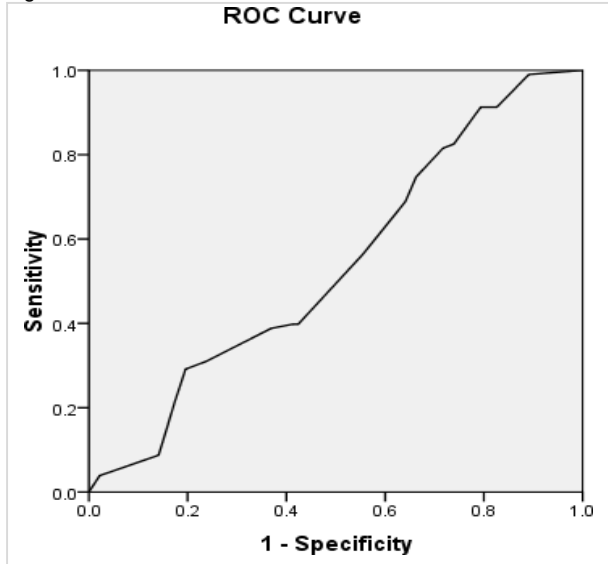


Table 3: Stratification of diagnostic accuracy with respect to age 12 -25 years (n=115)

	Positive result on corneal topography	Negative result on corneal topography	P-value
Positive result on OCT pachymetry	62 (TP)	02 (FP)	0.001
Negative result on OCT pachymetry	03 (FN)	48 (TN)	

Table 4: Stratification of diagnostic accuracy with respect to age 26 -40 years (n=80)

	Positive result on corneal topography	Negative result on corneal topography	P-value
Positive result on OCT pachymetry	41 (TP)	03 (FP)	0.001
Negative result on OCT pachymetry	01 (FN)	35 (TN)	

Stratification of diagnostic accuracy with respect to age is shown in Table III to IV. Gender stratification is shown in Table 5 & 6.

Table 5: Stratification of diagnostic accuracy with respect to male gender (n=109)

	Positive result on corneal topography	Negative result on corneal topography	P-value
Positive result on OCT pachymetry	63 (TP)	00 (FP)	0.001
Negative result on OCT pachymetry	01 (FN)	45 (TN)	

Table 6: Stratification of diagnostic accuracy with respect to female gender (n=86)

	Positive result on corneal topography	Negative result on corneal topography	P-value
Positive result on OCT pachymetry	40 (TP)	05 (FP)	0.0001
Negative result on OCT pachymetry	03 (FN)	38 (TN)	

Overall sensitivity of anterior segment OCT corneal pachymetry to detect the cases of early keratoconus in the suspected individuals by using corneal topography as gold standard was 96.26% and specificity was 94.32%. Positive predictive value was 95.37%, negative predictive value was 95.40% and diagnostic accuracy was 95.38%. (Table 7).

DISCUSSION

Keratoconus is a progressive, bilateral and asymmetric, chronic disorder of the eye. It is caused by thinning of the cornea. Its frequency is of one person per 2000 in the population.⁹ In its advanced stages it usually leads to the need for corneal transplant.¹⁰

It is not complicated to diagnose advanced keratoconus because of the typical biomicroscopic and topographic readings and data findings. It may be difficult

in detection of keratoconus in subclinical or forme fruste cases.¹¹ In numerous complications of the cornea and anterior eye segment, OCT of the anterior segment was clinically validated and this tomographic technique was lately augmented for imaging of the entire anterior segment, including parts of the lens and the chamber angle.^{12,13} I have conducted this study to find out the diagnostic accuracy of anterior segment OCT corneal pachymetry to find out the cases of early keratoconus by using corneal topography as gold standard. In OCT pachymetry positive patients, 103 (True Positive) had early keratoconus and 05 (False Positive) had no early keratoconus on corneal topography. Among 87, OCT pachymetry negative patients, 04 (False Negative) had early keratoconus on corneal topography whereas 83 (True Negative) had no early keratoconus on corneal topography (p=0.0001). Overall sensitivity of anterior segment OCT

corneal pachymetry to detect the cases of early keratoconus in the suspected individuals by using corneal topography as gold standard was 96.26% and specificity was 94.32%. Positive predictive value was 95.37%, negative predictive value was 95.40% and diagnostic accuracy was 95.38%. In a study conducted by Li Y *et al*, it was observed that anterior segment OCT pachymetry mapping can be used to diagnose keratoconus using five different pachymetric parameters.¹⁴ They observed that cornea having keratoconus were thinner and minimum corneal thickness has sensitivity of 97.3 percent and specificity of 97.2 percent in detection of keratoconus.¹⁴ The refractive index (RI) of the interface is the value on which corneal thickness obtained from the OCT technique is based on. The RI of corneal stromal layers is assumed to be constant for normal corneas. However, for the eyes with keratoconic condition, posterior displacement of Bowman's membrane or stromal scarring happens which leads to abnormal reflectivity in OCT images.¹⁵ Wang *et al*¹⁶ found considerable connection between the CCT values obtained from RTVue-OCT and Visante-OCT in keratoconic eyes.

CONCLUSION

This study concluded that diagnostic accuracy of anterior segment OCT corneal pachymetry to find out the cases of early keratoconus is very high, and it has dramatically enhanced our capability of precise diagnosis of primary and initial stage keratoconus but also upgraded patient care by timely and proper treatment.

Limitations Suggestions / Recommendations: We recommend that OCT corneal pachymetry should be used routinely as a key methodology for evaluation of early keratoconus which will result in proper and timely management for reducing the morbidity of these particular patients.

Conflict of Interest / Disclosure: None.

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