Role of Anterior Segment Optical Coherence Tomography in The Diagnosis of Subclinical Keratoconus in Comparison with The Pentacam

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ABSTRACT

Background: The most common ectatic disorder is keratoconus which is characterized by bilateral and progressive corneal thinning. Role of the pentacam has been well established for screening form fruste keratoconus in ophthalmology practice. While for anterior segment OCT it can detect the characteristic abnormal corneal thinning in patients with keratoconus using its pachymetry maps.

Aim of the Work: was to detect how much anterior segment OCT can approach the pentacam's well established efficacy in diagnosis of early keratoconus among the highly myopic astigmatic patients.

Patients and Methods: This prospective, non-randomized population study followed the tenets of the Declaration of Helsinki, and the protocol was reviewed and approved by the Ophthalmology Department of Ain Shams University. An informed consent was signed by the patients before inclusion. We selected 40 eyes of twenty-three healthy young volunteers with high myopic astigmatism for the study from patients who attended the outpatient clinic of Maghraby Eye Hospital at the period of November and December 2017.

Results: This study included 40 eyes of healthy young adults (22 females, 18 males) with high myopic astigmatism **(-4.038 D± 1.194)**. The mean age **± SD was 24.1 ± 5.702** (range: 16-31 years). Statistically highly significant differences were observed in all measured cases between Pentacam and Anterior Segment OCT ($p < 0.01$). So the OCT corneal pachymetry mapping seems promising for evaluating corneas as in cases of early keratoconus.

Conclusion: The OCT corneal pachymetry mapping with its fast acquisition time seems promising for evaluating highly astigmatic corneas, as in early keratoconus.

Keywords: Anterior Segment Optical Coherence Tomography, Subclinical Keratoconus, Pentacam.

INTRODUCTION

Anterior segment OCT provides very comprehensive analysis of numerous anterior segment applications which involve, Angle evaluation (to diagnose narrow angle glaucoma), Anterior chamber biometry (to plan intraocular lens implantation) [1], Corneal flap depth measurement following LASIK, OCT can also visualize the LASIK flap early postoperatively to evaluate the efficacy of microkeratome or femtosecond laser being used, It can also assess the potential safety of lifting the LASIK flap via evaluating the residual stromal bed and flap [2].

The most common ectatic disorder is keratoconus which is characterized by bilateral and progressive corneal thinning. The cornea becomes conical in shape due to non-inflammatory thinning and protrusion**.** This corneal thinning is focally occurring in the infero-temporal corneal location, and this characteristic pattern of thinning is the clue to diagnose keratoconus [1].

Keratoconus in the moderete and sever stages is easily recognized clinically and topographically, while subclinical keratoconus is difficult to distinguish from normal corneas, because patients usually have normal visual acuity, stable topographic patterns and minimal or no clinical signs [3]. In such suspect cases, OCT plays a major role in producing highly reliable pachymetry maps that can detect keratoconus, ectasia and corneal thinning before LASIK.

Post-Lasik ectasia is a relatively rare vision-threatening complication. It is important to identify the absolute and relative risk factors of ectasia and their cut-off values following LASIK. The most important risk factors for keratectasia include abnormal preoperative corneal topography that is suspicious for keratoconus [2].

OCT pachymetry maps can accurately detect the characteristic abnormal corneal thinning in patients with keratoconus**,** using four parameters based on the central 5-mm diameter of the pachymetry map [4]. This four parameters are, { I–S: the average inferior octant thickness (I) minus the average superior octant thickness (S)}, {IT–SN: the average inferotemporal octant thickness (IT) minus the average superonasal (SN) octant thickness}, {Minimum: the thinnest corneal thickness}, {Minimum–maximum: the minimum pachymetry minus the maximum pachymetry}.

Using these four parameters asymmetry, global thinning and focal thinning can be detected, and we got diagnostic cut-off points for these parameters. Keratoconus is diagnosed if, asymmetry that is more than −45 μm for I–S or IT–SN, or Minimum thickness of less than 470 μm, or a minimum–maximum difference more than −100 μm. One abnormal parameter provides reason to suspect keratoconus.

Two or more abnormal parameters provide a definitive diagnosis**.** This method is sensitive and specific as the topographic KISA (keratometry, I-S, astigmatism, and skew percentage) [5].

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AIM OF THE WORK

We aim to detect the efficacy of anterior segment OCT in early detection of keratoconus and to compare it with the Pentacam.

PATIENTS AND METHODS

Patients

This prospective, non-randomized population study followed the tenets of the Declaration of Helsinki, and the protocol was reviewed and approved by the Ophthalmology Department of Ain Shams University. An informed consent was signed by the patient before inclusion. 40 eyes (18 males and 22 females) with high myopic astigmatism were selected for the study from patients who visited the outpatient clinic of Maghraby Eye Hospital at the period of November and December 2017.

Measurements

All measurements were taken between 10 AM and 3 PM (at least 2 hours after awaking), when corneal thickness is considered stable. Patients selected have astigmatism more than -2.00 D, aged between 15-30 years. Patients who had a history of previous ocular surgery, ocular abnormalities, other than refractive error, pregnancy, lactation or who were unable to cooperate in the examination were excluded. Contact lens wearers were asked to cease lens wearing for 1 week prior to data collection. An informed consent was signed by all participants.

A full ophthalmologic examination will be performed for the patient. Examination includes:

- Uncorrected and best corrected visual acuity.
- Cycloplegic refraction.
- Slit lamp examination including:
  - Careful Corneal examination searching for keratoconus or corneal scarring.
- Complete dilated fundus examination.
- Anterior segment OCT to detect corneal thickness. Then, Pentacam schiempflug imaging will be done to assess corneal thickness, curvature, and elevation by the same investigator.

The corneal thickness measurements were measured using the Oculus pentacam HR (Oculus, Lynnwood, WA, USA) and the FD-OCT (Optovue, Inc., Fremont, CA).

Imaging devices

OCT

The OCT-based corneal topographer, a 1310 nm swept-source device, captures 8192 points during 0.34 second for 16 radial scans of the corneal topography. The success rate of precisely digitizing the corneal surfaces, patterns of the color-coded maps, central corneal thickness (CCT), and central axial power were compared between OCT and Pentacam.

The FD-OCT RTVue-100/CA (Figure 44) is a special version of the RTVue system that includes two cornea lens adapters, that is CAM-L (low-magnification cornea lens adapter) and CAM-S (high-magnification cornea lens adapter), for imaging the cornea and anterior chamber. Both lenses can be used to measure corneal flap or stromal thickness but only CAM-L can provide a corneal thickness map. We thus selected CAM-L for this study.

In pachymetry map mode, the machine has a scanning range of 6 mm x 6 mm and scanning depth of 2 mm. In this defined area, a total of 8 x 1024 scans were performed in 0.32 seconds (operator's manual).

For examination, the patients were positioned with a headrest and external illuminations [two short goose neck cables with 735 nm light-emitting diode (LED)] were used for pupil illumination. To allow more precise alignment, the examiner observed a real-time image of the patient's eye on the video monitor. The cross-hair indicating the center of area of interest was centered on the pupil center. As soon as the image was perfectly aligned, patients were asked to keep their eyes open during image capture.

At the end of measurement, FD-OCT displayed a value of Central Corneal Thickness that was an average of the central 2 mm of the cornea.

Statistical analysis

Statistical presentation and analysis of the present study was conducted, using the mean, standard deviation, Chi-square and Analysis of variance [ANOVA] tests by SPSS V17.

RESULTS

Table (1): Statistical analysis of OCT diagnosis according to sex

Sex	Diagnosis according to OCT examination								Chi-Square	
	Free		Suspect		Keratoconus		Total			
	N	%	N	%	N	%	N	%	X^2	P-value
Male	8	33.33	6	75.00	4	50.00	18	45.00	4.310	0.116
Female	16	66.67	2	25.00	4	50.00	22	55.00		
Total	24	100.00	8	100.00	8	100.00	40	100.00		

Table (2): Statistical analysis of OCT diagnosis according to complaint

Complaint	Diagnosis according to OCT examination								Chi-Square	
	Free		Suspect		Keratoconus		Total			
	N	%	N	%	N	%	N	%	X^2	P-value
Ask for lasik	20	83.33	6	75.00	4	50.00	30	75.00	14.222	0.007*
Change spectacle	4	16.67	0	0.00	4	50.00	8	20.00		
Follow up	0	0.00	2	25.00	0	0.00	2	5.00		
Total	24	100.00	8	100.00	8	100.00	40	100.00		

Table (3): Statistical analysis of OCT diagnosis according to Slit lamp Finding

Slit lamp findings	Diagnosis according to OCT examination								Chi-Square	
	Free		Suspect		Keratoconus		Total			
	N	%	N	%	N	%	N	%	X^2	P-value
Negative	24	100.00	6	75.00	4	50.00	34	85.00	12.549	0.002*
Positive	0	0.00	2	25.00	4	50.00	6	15.00		
Total	24	100.00	8	100.00	8	100.00	40	100.00		

Table (4): Statistical analysis of AS-OCT vs Pentacam diagnosis

Pentacam Diagnosis	Diagnosis according to OCT Diagnosis								Chi-Square	
	Free		Suspect		Keratoconus		Total			
	N	%	N	%	N	%	N	%	X^2	P-value
Free	24	100.00	7	87.50	2	25.00	33	82.50	32.121	<0.001*
Suspect	0	0.00	1	12.50	0	0.00	1	2.50		
Keratoconus	0	0.00	0	0.00	6	75.00	6	15.00		
Total	24	100.00	8	100.00	8	100.00	40	100.00		

The pentacam could diagnose 6 highly astigmatic eyes as keratoconus. The AS- OCT could detect the same 6 keratoconic eyes. The AS- OCT could detect 8 eyes as keratoconus suspect, of which only 1 eye is keratoconus suspect with the pentacam. Among 33 pentacam free eyes, AS- OCT could detect 24 eyes as free. So, there was a statistically high significant difference of the A-S OCT diagnosis and the pentacam diagnosis (P value < 0.01).

DISCUSSION

The importance of our study lies in the fact that distinguishing keratoconus suspects can be of great clinical importance for refractive surgery candidates.

Pentacam is probably one of the most important and effective devices that can contribute to early detection of keratoconus, and distinguish keratoconus suspects.

Now pentacam is the gold standard preoperative screening tool for refractive corneal surgery candidates to detect keratoconus and keratoconus suspect cases. The pentacam can present information on corneal thickness and keratoconus risk through Sheimpflug imaging.

We aimed in our study to evaluate how much the anterior segment OCT can approach the Pentacam (with its established efficacy) in diagnosing subclinical keratoconus among highly myopic astigmatic patients.

We applied the keratoconus analysis to the central 5-mm area of the OCT pachymetry maps; because it was found that the repeatability to be better in the 0- to 5-mm diameter zones than in larger diameter zones. This was confirmed for keratoconus parameter calculations (I-S and IT-SN) in this study. Another rationale for applying the analysis to the central 5-mm region is that the cone peak of a keratoconic eye is most likely located inside this region [4].

First, the examination of corneal thickness in the minimum thickness area, difference of thickness between the inferior and superior quadrants (I-S value), the difference between inferior and temporal segment (IT value), as well a superior and nasal segment (SN), (IT- SN Value), can be a good indicator to predict keratoconus.

Second, it seems that the OCT Visante machine can prove to be an appropriate device to assess keratoconus and keratoconus suspect patients.

Using OCT in fourier domain prepares the grounds for improving image resolution, as well as pachymetry image quality. Improved resolution of

OCT machines can naturally provide us with more accurate and precise information of corneal thickness [6]. Statistically highly significant differences are observed in all measured cases between Pentacam and Anterior Segment OCT ($p < 0.01$).

So we can conclude that the OCT corneal pachymetry mapping seems promising for evaluating corneas as in cases of early keratoconus.

These findings are in line with other studies:

Li et al's study has used the OCT pachymetric parameters and a quantitative topographic keratoconus index (keratometry, I-S, astigmatism, and skew percentage [KISA %]) for keratoconus diagnosis. Their results indicated that OCT pachymetry can be a diagnostic indicator for keratoconus and at least as sensitive and specific as the topographic KISA.

However, Ponce et al's study (Which compared Central corneal thickness measurements between Pentacam, AS-OCT, Ultrasound Biomichroscopy) has shown that OCT pachymetry maps results seem to have more accuracy especially for post-Lasik corneas. In addition, OCT results have proved to have appropriate reliability [7].

Li et al study evaluates the repeatability of Fourier-domain optical coherence tomography (OCT) pachymetric mapping and compare central corneal thickness (CCT) measurements by OCT, ultrasound pachymetry, and scanning-slit tomography, it confirmed that OCT pachymetry map analysis can provide decisive diagnostic information in cases where topography is ambiguous [8]

Qin et al study depends on a more diagnostic power using the OCT corneal pachymetry map–based logistic regression formula and the keratoconus risk scoring system (formula = 0.543 × minimum + 0.541 × (S–I) − 0.886 × (SN–IT) + 0.886 × (minimum–median) + 0.0198 × Ymin). This formula proved to be highly accurate in keratoconus detection. Also it was proved to be useful in keratoconus screening [9].

Another study was reported by Hashemi and Jabbarvand for comparing the optical coherence tomography (OCT) pachymetry patterns in keratoconus suspect and normal people, states that AS-OCT system can be utilized to diagnose keratoconus, keratoconus suspect and assess patients prior to refractive surgery along with Pentacam. However, OCT may be recommended for confirming Pentacam finding or as indicator for considering more inspections for KCN detections [10].

One limitation of the current OCT technology is that interpolation is used in the central 0.5- to 1.0-mm diameter. Thus, small areas of corneal thickness variation might be missed [11].

Other limitation is that it provides pachymetric and epithelial thickness maps of only the central 6-mm diameter of the cornea. The 6-mm map size may be sufficient for planning myopic LASIK, photorefractive keratectomy and keratoconus screening (because the cone apex was located inside the central 5-mm diameter of the cornea in most of keratoconic eyes). However, the 6-mm map size is a limitation for diseases involving the peripheral cornea, such as pellucid marginal degeneration [4].

CONCLUSION

The OCT corneal pachymetry mapping with its fast acquisition time seems promising for evaluating highly astigmatic corneas, as in cases of early keratoconus.

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