Original Article

Repeatability of Orbscan III for anterior segment parameters in normal eyes

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Purpose: Assessment of repeatability of Orbscan III in measuring steep keratometry (sKm), flat keratometry (fKm), thinnest corneal thickness (TCT), anterior chamber depth (ACD), white-to-white diameter (WTW) and 3 mm and 5 mm zonal irregularity in healthy eyes. **Methods:** In this prospective observatioanl study 100 eyes of 50 participants underwent three consecutive scans on Orbscan III by a single examiner with a gap of 5 minutes between scans. Statistical analysis was performed to assess the repeatability of sKm, fKm, TCT, WTW, ACD and parameters of 3- and 5 mm irregularity. Within subject standard deviation (Sw), coefficient of variation (CoV) and test retest variability (TRT) was calculated for the commonly used parameters, were the main outcome measures. The repeatability of sKm, fKm, TCT, WTW, ACD, 3 mm and 5 mm zonal irregularity on Orbscan III. **Results:** Total of 50 patients (25 male and 25 female) who fulfilled inclusion and exclusion criteria were assessed. sKm, fKm, TCT and WTW were found to have a TRT of 0.31, 0.29. 21.5 and 0.27, respectively, and the ICC values were found to be over 0.9, denoting high repeatability. Repeat measurements of parameters of irregularity and ACD were found to be statistically similar, again denoting similarity between repeat measurements. **Conclusion:** Orbscan III provides repeatable measurements of Sim-k, anterior chamber depth, thinnest corneal thickness, 3 mm and 5 mm zonal irregularity and white-to-white diameter in healthy eyes.

Key words: Corneal parameters, Orbscan III, repeatability

Cornea contributes to two-thirds of the eye's refractive power. It is significantly affected by relatively small changes in its structure, including minimal ocular surface changes. Ocular conditions like keratoconus and dry eye cause changes to the corneal architecture, resulting in poor visual outcomes. Measurement of several corneal parameters is required for diagnostic and therapeutic purposes, contact lens fitting and refractive surgery.[1]

Techniques commonly used have limitations. Standard keratometry measures four points in the para-central area to calculate the corneal curvature. Standard Placido-based topographers provide a global measure of the anterior corneal surface, but not of the posterior corneal surface or pachymetry. Ultrasound pachymetry determines corneal thickness; but depends on technician's experience and requires topical anesthesia.[2]

Orbscan II is a scanning slit based optical reflectance instrument. It takes several vertical slit images of different corneal sections for three-dimensional reconstruction of the corneal shape and provides details of anterior and posterior corneal curvatures and corneal thickness at any point in the cornea.[2,3]

Orbscan III is an evolution of the multidimensional Orbscan IIz topographer.[4] It provides contact-free analysis of anterior segment based on slit scanning and advanced Placido disc system.[5] It examines the size, shape and the extent of surface power abnormalities; anterior and posterior astigmatism, pachymetry, elevation and curvature measurements on anterior and posterior corneal surface, white-to-white diameter, anterior chamber depth, angle kappa and identifies appropriate candidates for refractive and cataract surgical procedures.[2]

Majority of the studies focus on reproducibility and repeatability of Orbscan II.[2,3] No studies have assessed the reproducibility or precision of the Orbscan III. The objective of our study was to assess the repeatability in normal eyes, of anterior chamber depth, white-to-white diameter, simulated keratometry, thinnest corneal thickness, 3 mm and 5 mm zonal irregularity on Orbscan III.

Methods

Study design

Prospective, observational study.

Duration of the study

15 Days.

Selection of the subjects

Participants were screened based on the inclusion and exclusion criteria given below. Visual acuity for near and

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distance vision was measured, slit-lamp evaluation and dilated fundoscopy were done to rule out any anterior and posterior segment pathology. The procedures and the study details were explained to the patient and informed consent was obtained. The study was approved by the Institutional research board (IRB) and the ethics committee and was conducted in accordance with the principles of the Declaration of Helsinki.

Inclusion criteria

Inclusion criteria for the study were as follows:

- Age: 10–35 years
- Participants who co-operated to undergo all the examination scans
- Participants with emmetropia, myopia up to –2D and hypermetropia up to +2D
- Best-corrected visual acuity of 6/6 in both eyes
- No other anterior or posterior segment ocular abnormalities affecting vision or fixation

Exclusion criteria

The following patients were excluded from the study:

- Refractive error of more than -2D myopia or more than +2D hypermetropia
- Active ocular surface diseases such as significant dry eye, papillary conjunctivitis
- Any posterior segment ocular abnormality
- History of systemic or neurological disorder, intraocular surgery or trauma affecting the pupil regularity
- Use of any ocular topical medications
- History of wearing extended wear lenses
- Abnormal corneal topography
- Clinically significant lenticular opacity

Procedure

Orbscan III scan (Bausch and Lomb) was performed three consecutive times at 5 minutes-intervals (after completely realigning the Orbscan) on each eye in all the study subjects at one visit only. The total time for acquiring all the measurements did not exceed 15 minutes for each subject. This was done to minimize the effect of diurnal variation of pachymetry. The scan was taken under similar lighting conditions for all the participants. Same operator performed all the Orbscan measurements in all the subjects. The parameters noted from all the scans included anterior chamber depth (ACD), white-to-white diameter (WTW), minimum and maximum Sim-K, 3 mm and 5 mm zone irregularity and thinnest corneal thickness (TCT).

Statistical analysis

Statistical analysis was performed using the Medcalc Version 19.4.1. All continuous variables were assessed for normality of distribution using the Kolmogorov-Smirnov test. For 3 mm and 5 mm irregularity and ACD, the repeatability was assessed using the Friedman test for three measurements and whether statistical significance existed between the three measurements was analyzed.

For keratometry values, thinnest corneal thickness and White to White repeated measurements, the intra-observer repeatability of measurements for the parameters studied was described using within-subject standard deviation (Sw) and coefficient of variation (CoV%) and Intraclass correlation coefficient (ICC). Test–retest variability or repeatability (TRT) was calculated as 2.77 times Sw for all the parameters studied.[2]

Results

Total of 50 patients (25 male and 25 female) who fulfilled the inclusion and exclusion criteria were assessed during the study period as per the study protocol. Within-subject standard deviation, CoV and ICC calculated for Sim K maximum and minimum, TCT and WTW are mentioned in Table 1. All the parameters in Table 1 had a very good repeatability with CoV around 1% and ICC over 0.9. These parameters are the most commonly used from Orbscan III and any other anterior segment analyser for planning cataract, refractive surgery and assessing progression of keratoconus.

For 3- and 5 mm irregularity and ACD, difference between the three mean rank measurements has been shown in Table 2. All these parameters had no significant difference between the three repeat measurements.

Discussion

Assessment of corneal shape, refractive power, and thickness of the cornea are vital for designing vision correction surgeries and diagnosing corneal diseases.[6] Corneal shape assessment is a vital aspect in the preoperative evaluation of refractive surgery candidates and in the follow up of keratoconus eyes for progression.[7] Corneal thickness is an important factor to evaluate corneal endothelial pump function and additionally to monitor the progression of keratoconus.[7] The commercially available systems, which evaluate the corneal morphologic features include Placido disc-based computerized video keratography (CVK) and scanning slit based CVK. CVK is important in keratoconus diagnosis. It also possesses many important uses in refractive surgery including pre-operative screening, surgical planning, postoperative assessment, patient follow up and contact lens (CL) fitting, where it is used in orthokeratology, corneal refractive therapy, and CL fit on irregular corneas.[3]

Orbscan III is a scanning slit-based topo/tomography system, which has the capacity to provide detailed information regarding curvature and elevation of both anterior and posterior corneal surfaces, the global thickness of the cornea and anterior chamber depth. It is a valuable screening tool to detect abnormal corneal shapes, such as keratoconus and contact lens-induced corneal warpage.[2] Orbscan II was also a slit scanning based topo/tomographer, which evaluated the topo/tomography based on 9600 points studied. Orbscan III calculates different variables studied based on 23000 points per scan. In addition, Orbscan III is integrated with a Zyoptix aberrometer and can be utilised for wavefront-guided treatments, including a PresbyLASIK platform called Supracor.

Between repeated measurements on the same eye, the maximum difference between the individual measurements is represented by TRT or test–retest variability. Studies using Orbscan II and other devices such as Pentacam, Galilei and Sirius have described the repeatability for anterior segment parameters in normal eyes and in those with ectasia.[2,7] A study comparing Orbscan, Pentacam and Sirius in normal eyes has described the TRT of keratometry measurements between 0.7 and 0.8 for Orbscan II, between 0.23 and 0.28 for Pentacam and between 0.42 and 0.74 for Sirius.[2] In our study, the TRT for steep and flat SimK in Orbscan III has been found to be 0.31 and 0.29. This denotes a very precise and repeatable measurement of Keratometry by Orbscan III in normal eyes.

Table 1: Steep and flat keratometry, thinnest corneal thickness and white to white repeatability in Orbscan III

	ICC	Sw (median and 95% CI)	Test retest repeatability (TRT)	Coefficient of variation (median and 95%CI)
sKm	0.97	0.1155 (0.058-0.17)	0.3199	0.2557 (0.14-0.39)
fKm	0.96	0.1077 (0.058-0.17)	0.2983	0.2517 (0.14-0.41)
TCT	0.93	7.7675 (5.68-9.25)	21.516	1.4393 (1.09-1.67)
WTW	0.90	0.1000 (0.058-0.12)	0.277	0.8929 (0.54-1.04)

Table 2: Study of repeatability between 3 readings for 3- and 5-mm zone irregularity and ACD on Orbscan III using test of repeated measures.

Parameters	Reading time	Mean rank	Significance
3 mm zone irregularity	I	1.94	0.711
	II	1.97	
	III	2.09	
5 mm zone irregularity	I	1.93	0.735
	II	1.99	
	III	2.08	
Anterior chamber depth (ACD)	I	2.21	0.161
	II	1.85	
	III	1.94	

For TCT as well, compared to Pentacam, Sirius and Orbscan II, the TRT values are comparable. In a previous study, the TRT of Pentacam and Sirius for TCT were found to be better than Orbscan II.[2] In this study using Orbscan III, the TRT for TCT has been found to be similar to Orbscan II as reported in the previous study. With a very good repeatability for SimK and TCT, Orbscan III can be a very useful tool to monitor subtle changes in the cornea. This can be useful in the detection of ectasia, refractive surgery assessment, follow up of patients with endothelial dysfunction such as Fuchs dystrophy.

To our knowledge, no previous study on Orbscan III has evaluated the repeatability of Sim-K, anterior chamber depth, thinnest corneal thickness, 3 mm and 5 mm zonal irregularity and white to white diameter parameters. The present study revealed repeatable measurements of Sim-k, anterior chamber depth, irregularity index, thinnest corneal thickness and white-to-white diameter with Orbscan III.

This study provides reference coefficients for repeatability using Orbscan III for the commonly used anterior segment parameters. However, several more parameters can be assessed and compared with other existing devices,[2]

especially in eyes with irregular corneas, with corneal haze or scars as reported using other devices in the past to further contribute to the literature on precision and accuracy of Orbscan III.

Conclusion

Orbscan III provided repeatable measurements of Sim-k, anterior chamber depth, thinnest corneal thickness, 3 mm and 5 mm zonal irregularity and white-to-white diameter. Thus, it is a repeatable modality for evaluation of cornea in healthy eyes.

Conflicts of interest

There are no conflicts of interest.

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