

Comparison between Pentacam HR and Orbscan II after Hyperopic Photorefractive Keratectomy

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Abstract

Purpose: The aim of this study was to determine the agreement between Pentacam HR (Scheimpflug imaging, Oculus) and Orbscan II (scanning slit topography, Bausch and Lomb) in measuring corneal parameters after photorefractive keratectomy (PRK) for hyperopia.

Methods: In this prospective cross-sectional study, 38 hyperopic eyes undergoing PRK were examined before refractive surgery and 8 to 10 months postoperatively using Pentacam HR and Orbscan II. Ultrasound (US) pachymetry was also used to measure central corneal thickness (CCT). The radius of anterior (A-) and posterior (P-) best-fit sphere size (BFS), central elevation (CE), and anterior maximum tangential power in 3 mm (TG3) and 3-5 mm (TG5) zones, anterior chamber depth (ACD), and central corneal thickness (CCT) were collected and used in the analyses. To study the agreement between the measurements made by the two devices, the method described by Bland and Altman was used and the 95% limits of agreement were calculated.

Results: The 95% limits of agreement show reasonable agreement between the measurements by Pentacam HR and Orbscan II for A-BFS, P-BFS, A-TG3, and CCT, but not for A-CE, P-CE, A-TG5, or ACD. CCT values obtained by both Pentacam HR and Orbscan II correlated well with the values determined by US pachymetry.

Conclusion: Pentacam HR and Orbscan II after PRK for hyperopia show reasonable agreement for determining A-BFS, P-BFS, A-TG3, and CCT, but not for A-CE, P-CE, A-TG5, or ACD. CCT measurements with Pentacam HR have reasonable agreement with US pachymetry.

Keywords: Hyperopia; Orbscan; Pentacam; Photorefractive Keratectomy

J Ophthalmic Vis Res 2017; 12 (4): 374-9

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Received: 26-02-2017

Accepted: 06-06-2017

Access this article online

Quick Response Code:



Website:

www.jovr.org

DOI:

10.4103/jovr.jovr_47_17

INTRODUCTION

Photorefractive keratectomy (PRK) remodels the anterior corneal surface to correct refractive errors, allowing cornea to focus the light rays on the retina by adjusting its refractive power. Evaluation of the

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How to cite this article: Jabbarvand M, Askarizadeh F, Sedaghat MR, Ghadimi H, Khosravi B, Amiri MA, *et al.* Comparison between Pentacam HR and Orbscan II after hyperopic photorefractive keratectomy. *J Ophthalmic Vis Res* 2017;12:374-9.

corneal topographic and tomographic characteristics^[1] is important in patients who undergo corneal laser refractive surgery. Recently, Orbscan II and Pentacam HR are widely used for this purpose.^[1,2] Each uses a different method for imaging the cornea; slit-scanning is used by Orbscan II and the Scheimpflug principle is used by Pentacam HR.^[2] Numerous studies have been published investigating agreement between the two devices with respect to different anterior and posterior corneal parameters.^[2-5] However, a majority of these studies have been performed on myopic patients rather than the less commonly encountered hyperopic patients.^[2-7] Additionally, most of the previous studies have included patients who had undergone laser *in situ* keratomileusis (LASIK),^[8,9] whereas studies on patients who have undergone hyperopic photorefractive keratotomy (H-PRK) are scarce. In contrast to myopic correction, the central corneal steepening is achieved after hyperopic correction through a larger optical zone, larger peripheral transition zone, and ablation of mid-peripheral corneal tissue.^[6] Precise postoperative imaging of the anterior segment might be required for calculation of intraocular lens power for those who develop cataracts^[10] and for determining a retreatment strategy for those who have been under or over corrected. In addition, the accuracy of tonometry is affected by the central corneal thickness (CCT), which is another parameter measured using ultrasonic and optical devices.^[11,12]

The purpose of this investigation was to compare various corneal topographic and tomographic parameters measured by the Orbscan II and Pentacam HR to determine the correlation and agreement between these two devices in hyperopic patients who have had H-PRK.

METHODS

In this cross-sectional prospective study, which was performed at a tertiary eye care center, 38 consecutive patients aged between 20 and 40 years were enrolled. We selected the sample size based on a pilot study. All selected patients received information about the study and consented to have additional examinations prior to and 8 to 10 months after corneal laser refractive surgery. This long postoperative follow-up was considered because H-PRK has a larger epithelial defect and a more prolonged healing time.^[6,13] The institutional review board and the ethics committee approved the study and ensured its protocol followed the tenets of the Declaration of Helsinki.

Inclusion criteria were preoperative hyperopia of +2.0 to +6.0 diopters, astigmatism of -0.75 diopters or less, and a corrected distance visual acuity (CDVA) of 0.1 logarithm of the minimum angle of resolution (LogMAR) or better (Snellen equivalent of 20/25 or better). The exclusion criteria were a history of intraocular surgery,

systemic and ophthalmic diseases, usage of systemic or ocular medications, pregnancy or lactation, contact lens usage during three weeks before the examination, and any abnormal slit lamp findings of the ocular surface.

Considering the mentioned criteria, we enrolled 38 eyes of 38 hyperopic patients for H-PRK and re-examined them after 8 to 10 months. If both eyes underwent H-PRK, we enrolled only one eye from each patient randomly for independent evaluation. We did not study femtosecond LASIK for this study because there are many refractive surgery centers without femtosecond technology around the world.

Corneal imaging using Pentacam HR (Oculus, Wetzlar, Germany), followed by Orbscan II (Bausch & Lomb, Rochester, NY, USA) was performed in the afternoon of the same day under the same room illumination. The acoustic equivalent correction factor of 0.92 proposed by the manufacturer was used to determine corneal thickness by Orbscan II.^[2] Subsequently, ultrasound (US) pachymetry (Pachymeter SP-2000; Tomey, Erlangen, Germany) was done to determine CCT. The pachymetry was performed at the end to avoid its probable influence on the other imaging modalities as US is a contact technique. The patients underwent H-PRK using the Bausch & Lomb 217z excimer laser system (Rochester, NY, USA) by a single experienced corneal refractive surgeon (MJ).

The variables recorded for each patient included age, sex, cycloplegic refractive error (Spherical Equivalent), uncorrected visual acuity (UCVA), and CDVA before and after H-PRK. Both Pentacam HR and Orbscan II were used prior to and 8 to 10 months after H-PRK. The following corneal measurements were recorded: the radius of anterior best fit sphere (A-BFS), the radius of posterior best fit sphere (P-BFS), anterior central elevation (A-CE), posterior central elevation (P-CE), anterior maximum tangential power in 3mm (A-TG3), anterior maximum tangential power in the 3-5mm zone (A-TG5), anterior chamber depth (ACD), and CCT. The same experienced optometrist (F.A) acquired all the corneal imaging and measurements before and after H-PRK in a consistent manner based on the manufacturer's users guide and previous studies.^[14] Measurements based on the quality and index provided by Pentacam and Orbscan were accepted and erroneous acquisitions were repeated 5 minutes later. The manufacturer representative routinely checked the calibration of the devices every 6 months and we did not change or adjust the manufacturer's default settings for BFS and the diameter of the cornea. Images were acquired 3 times, at 5-minute intervals, with each device for each patient; the mean of the three measurements was used for statistical analysis.

Validity and repeatability of Pentacam and Orbscan in healthy eyes were studied in numerous articles^[15-17], hence, we concentrate on outcomes of these devices after H-PRK. Statistical analysis was performed using

Statistical Package for Social Sciences (SPSS) version 23 software for Windows (IBM Inc., Chicago, Illinois, USA) and MedCalc software version 15.8.X86 (MedCalc Software bvba, Ostend, Belgium). Descriptive statistics including the mean readings of the parameters along with their standard deviations were calculated. Normality of the measured data was assessed with the Kolmogorov-Smirnov test and parametric tests were applied accordingly. A paired *t*-test was used to analyze the differences between the data of patients prior to and after H-PRK. A *P* value less than 0.05 was considered statistically significant. Pearson correlation coefficient was calculated to determine the correlation between the findings. To study the agreement between the measurements made by devices, the method described by Bland and Altman was used.^[18] The 95% limits of agreement (LoA) (mean difference ± 1.96 standard deviation [SD]) were calculated. 95% LoA define the range within which most differences between measurements by the two methods will lie.

RESULTS

The mean (SD) age of the patients was 33.05 ± 5.23 years (range 20 to 40 years) and the subjects consisted of 18 men (47.3%) and 20 women (52.6%). Table 1 presents information regarding UCVA, CDVA, and cycloplegic refractive errors prior to and 8 to 10 months after H-PRK.

Pentacam HR and Orbscan II readings for the anterior and posterior corneal surface measurements are presented in Table 2.

A strong correlation was observed between the two imaging devices for A-BFS, P-BFS, A-CE, A-TG3, and CCT but the correlation was weak for P-CE, ACD, and A-TG5. The 95% limits of agreement (LoA) were determined for a better comparison of the degree of agreement between the two methods. Table 2 demonstrates a reasonable agreement between the measurements from the Pentacam HR and Orbscan II for A-BFS, P-BFS, A-TG3, and CCT, but not for A-CE, P-CE, A-TG5, or ACD.

Table 1. Refractive error and visual acuity of hyperopic patients prior to and 8 to 10 months after PRK

	Before PRK (mean±SD)	After PRK (mean±SD)	<i>P</i>
SE refractive error (D)	3.4±1.3	0.9±1.3	<0.001
UDVA (LogMAR)	0.48±0.19	0.88±0.16	<0.001
CDVA (LogMAR)	0.93±0.14	0.93±0.09	0.76
Difference CDVA-UDVA (LogMAR)	0.45±0.15	0.05±0.11	<0.001

PRK, photorefractive keratotomy; SE, spherical equivalent; D, diopter; LogMAR, logarithm of the minimum angle of resolution; UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity; SD, standard deviation

CCT measured by US pachymetry was 517.1 ± 22.8 µm. The correlation was high between both Pentacam HR (*r* = 0.912; *P* < 0.001) and Orbscan II (*r* = 0.829; *P* < 0.001) [Figure 1 and Table 3]. The 95% LoA between US pachymetry and Pentacam HR was 17.7 to -22.7 µm and between US pachymetry and Orbscan II was 16.3 to -40.9 µm [Figure 2 and Table 3].

DISCUSSION

In the present study, we studied hyperopic patients who underwent PRK. We compared two commonly used corneal tomographic imaging devices, the Pentacam HR and Orbscan II, and found that some parameters (A-BFS, P-BFS, A-TG3 and CCT) had a reasonable agreement and were strongly correlated. On the contrary, ACD, P-CE, and A-TG5 lacked agreement and did not correlate. A-CE measurements were highly correlated, but the 95% LoA failed to demonstrate a reasonable agreement between the two devices. Although, the correlation was high with both Pentacam HR and Orbscan II, the 95% LoA between US pachymetry and the Pentacam HR was better than US pachymetry and Orbscan II.

Other researchers had previously compared the two devices, but mostly in emmetropic or myopic patients. However, there are substantial differences in the refractive surgery performed for myopia and hyperopia; therefore, the results of studies on myopic patients cannot be generalized to hyperopic patients.

In a study by Hashemi and Mehravaran on myopic patients who underwent LASIK or PRK,^[4] statistically significant interdevice differences were found for ACD, anterior corneal axial power, and all posterior corneal parameters. test. The 95% LoA are also reported in that study, which indicate insufficient agreement in A-CE and P-CE, but reasonable agreement in ACD, A-BFS, P-BFS, A-TG3 and A-TG5.

Another study by Ha and associates on myopic patients who underwent PRK showed significant differences in measurements for P-CE and ACD between the Orbscan II and Pentacam. The 95% LoA revealed sufficient agreement with respect to ACD, but no agreement regarding P-CE.^[3] Lackner and colleagues showed that in healthy eyes, ACD readings from the Orbscan and Pentacam have acceptable agreement and can be used interchangeably.^[15] They also compared CCT measured by the Orbscan and Pentacam and US pachymetry^[16] and found that CCT values obtained by the Pentacam were much closer to the values obtained by US pachymetry, when compared with the Orbscan measurements.

Hosseini et al demonstrated that corneal thickness measured by the Pentacam HR correlated well with those obtained by US in healthy subjects.^[14]

Crawford and associates showed that the keratometry and CCT measurements obtained by the Orbscan II and

Table 2. Pentacam HR and Orbscan II measurements for corneal tomographic evaluation after PRK for hyperopic patients

Parameter	Pentacam HR (Mean±SD)	Orbscan II (Mean±SD)	Difference		Correlation		95% LoA	
			Δ	P	r	P	Lower	Upper
A-BFS (mm)	42.4±1.5	41.8±1.5	0.58	<0.001	0.961	<0.001	-0.23	1.39
P-BFS (mm)	50.8±1.8	51.6±2.7	-0.82	0.011	0.700	<0.001	-4.5	2.9
A-CE (μm)	18.1±7.9	27.7±10.1	-9.66	<0.001	0.647	<0.001	-24.9	5.6
P-CE (μm)	11.3±6.8	17.3±10.7	-6.03	0.003	0.169	0.311	-28.9	16.9
A-TG3 (D)	45.4±2.2	51.4±2.0	-5.97	<0.001	0.616	<0.001	-9.5	-2.4
A-TG5 (D)	40.9±3.4	47.6±2.6	-6.72	<0.001	-0.259	0.116	-16.1	2.6
ACD (mm)	2.6±0.3	2.8±0.8	-0.17	<0.001	0.031	0.852	-1.9	1.6
CCT (μm)	519.6±24.6	529.4±25.3	-9.82	<0.001	0.935	<0.001	-27.4	7.8

A-BFS, anterior best fit sphere; P-BFS, posterior best fit sphere; A-CE, anterior central elevation; P-CE, posterior central elevation; A-TG3, anterior maximum tangential power in 3 mm; A-TG5, anterior maximum tangential power in 3-5 mm zone; ACD, anterior chamber depth; CCT, central corneal thickness; D, diopter; r, Pearson correlation coefficient

Table 3. Comparison of central corneal thickness measurements between the 3 devices (Pentacam, Orbscan, and ultrasound pachymetry)

CCT Measurement by devices	Mean±SD	Min	Max	95% CI	P*	95% LOA (lower to upper)	r†
Pentacam HR-Orbscan II	-9.82±8.99	-36.00	+5.00	-12.77--6.86	<0.001	-27.40--7.80	0.935
Pentacam HR-US	2.47±10.09	-23.00	+20.00	-0.84--5.80	0.139	-22.30--17.30	0.912
Orbscan II-US	12.29±14.26	-19.00	+51.00	+7.60--16.98	<0.001	-40.20--15.70	0.829

CCT, central corneal thickness; CI, confidence interval; LoA, limits of agreement; US, ultrasound. *Paired t-test. †Pearson correlation

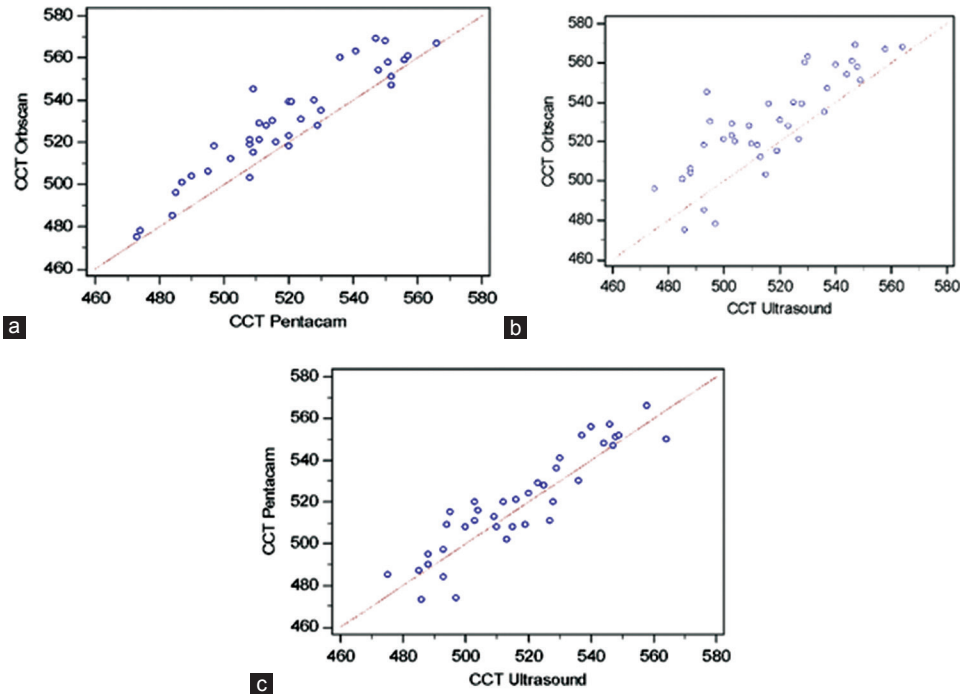


Figure 1. Scatterplots of the Pearson correlation for central corneal thickness (CCT) as measured by Orbscan II versus Pentacam HR (a), Orbscan II versus Ultrasound (b), and Pentacam HR versus Ultrasound in all eyes after PRK for hyperopia (c).

Pentacam in healthy eyes were disparate and could not be considered equivalent.^[19] Furthermore, Yazıcı et al compared measurements of the anterior segment by the Pentacam and Orbscan but this study was performed in keratoconus patients.^[20] Notably, all of the above-mentioned

studies were performed in healthy, keratoconus, or myopic eyes prior to or after refractive surgery.

In conclusion, we compared the corneal parameters measured by the Pentacam HR and Orbscan II in hyperopic patients who underwent PRK. We found that

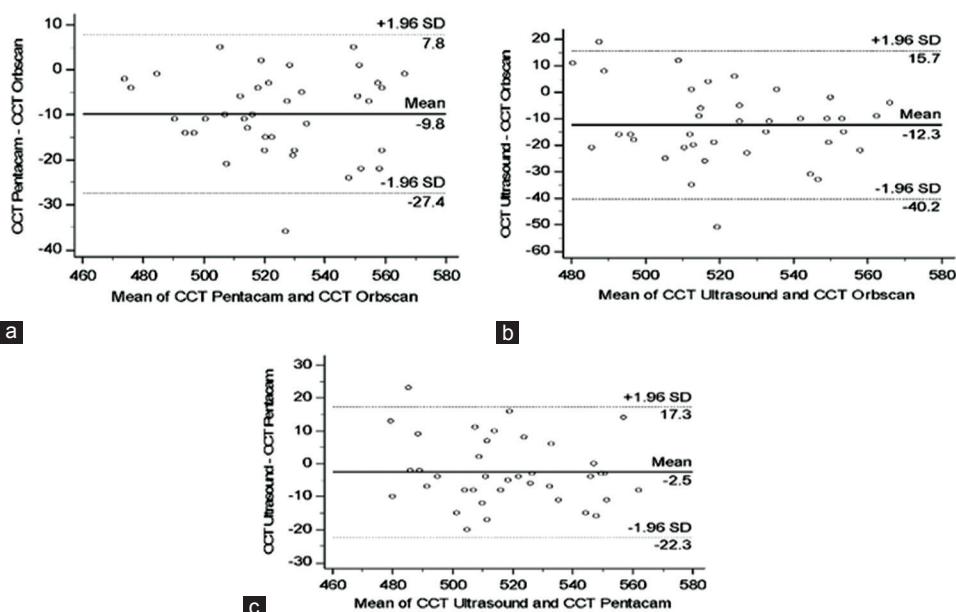


Figure 2. Bland-Altman plots of the central corneal thickness (CCT) as measured by Pentacam HR against Orbscan II (a), Ultrasound against Orbscan II (b), and Ultrasound against Pentacam HR in all eyes after PRK for hyperopia (c). The middle line in each figure is the mean difference of values and the lines on the sides represents the upper and lower 95% Limits of Agreement (mean difference \pm 1.96 SD).

the agreement between the two devices was reasonable in some parameters (CCT, A-BFS, P-BFS, and A-TG3), but not in other measurements (ACD, A-CE, P-CE, and A-TG5). Furthermore, in this study, we determined the validity of CCT measurements by the Pentacam HR and Orbscan II compared with measurements by US pachymetry (as the gold standard for CCT measurement) in post H-PRK patients and showed that the measurements with Pentacam HR were comparable to that obtained using US pachymetry.

Our findings can be applied for an accurate calculation of intraocular lens power, decision making for retreatment of under- or overcorrection, precise intraocular pressure measurements, and ectasia detection after H-PRK.

Larger studies comparing the Pentacam and Orbscan in hyperopic patients, both prior to and after different refractive surgery procedures, are recommended.

Financial Support and Sponsorship

Nil.

Conflicts of Interest

There are no conflicts of interest.

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