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Research Article

Repeatability and Agreement of Anterion with Pentacam HR and Orbscan II in Corneal Parameters after Photorefractive Keratectomy

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Abstract

Introduction: This study aimed to evaluate the repeatability and agreement of Anterion with Pentacam HR and Orbscan II in corneal parameters after photorefractive keratectomy (PRK).

Methods: This prospective study involved 42 patients (42 eyes) aged between 20 and 40 years undergoing PRK surgery. Corneal measurements were measured two times using Anterion in order to assess the repeatability of this device. Then, the same parameters were measured using Pentacam and Orbscan in order to determine the agreement of Anterion and the other two devices in measuring corneal parameters after PRK. Intraclass correlation coefficient (ICC) checked Anterion's repeatability. Also, ICC and means of the 95% limits of agreement (LoA) were used to assess the agreement of Anterion results with those of the two other devices.

Results: Anterion demonstrated high to moderate repeatability in corneal parameters post-PRK, except for anterior flat keratometry (ICC = 0.73), 4th order root mean square (RMS), and horizontal trefoil (ICC < 0.75). While Anterion and Pentacam showed good agreement in corneal topography and tomography (ICC > 0.90, $P < 0.05$), they were only interchangeable in keratometric parameters. Additionally, no agreement was observed between Anterion and Pentacam in aberration parameters after PRK. Although Anterion and Orbscan exhibited agreement in anterior average keratometry and central corneal thickness (CCT) (ICC > 0.90, $P < 0.05$), it was not clinically interchangeable.

Conclusion: Anterion demonstrated notable repeatability in most corneal parameters after PRK. Although there was good agreement between Anterion and Pentacam HR in measuring corneal topography and tomography, their interchangeability was limited to other values. Furthermore, Anterion and Orbscan II were not clinically interchangeable.

Keywords: agreement, Anterion, Orbscan II, Pentacam HR, repeatability

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1. Introduction

Corneal topography is an essential diagnostic tool that enables ophthalmologists and eye surgeons to perform better at refractive surgeries [1] diagnosis and follow-up of keratoconus [2], corneal transplantations [3], contact lens fitting [4], orthokeratology lens fitting [5], and implantation of spherical and aspherical intraocular lenses [6]. These applications substantiate the importance of developing topographical tools and methods for assessing the anterior and posterior surfaces of the cornea.

Orbscan II and Pentacam HR are widely used for measuring cornea parameters [7, 8]. Each of them uses a different method for imaging the cornea: Orbscan II uses slit scanning, while Pentacam HR uses the Scheimpflug principle [8]. So far, Anterion is a new anterior segment imaging device that is designed for topography based on swept-source optical coherence tomography (SS-OCT). This multimodal imaging device captures high-resolution images using an optimizable platform. In accordance with the needs of the surgeon, Anterion features an image application that could be adjusted using other applications such as the cornea app, cataract app, and metrics app [9]. This advanced software makes it possible to do a thorough biometric evaluation of the anterior part of the eyes. While the metrics app helps evaluate the eye for glaucoma, the cornea app shows the spatial thickness of the cornea in addition to data pertaining to the axial and tangential curvature of anterior and posterior surfaces [9].

Many studies have explored the agreement between Pentacam HR and Orbscan II in terms of various parameters proposed for the anterior and posterior segments of the cornea [7, 10-13]. Meanwhile, most of these studies have focused on patients with myopia rather than patients with less common refractive errors or patients undergoing refractive surgeries [10-13]. Also, previous studies have reported different repeatability and agreement rates between Anterion and Pentacam HR, and other OCT-based devices such as CASIA II and IOL Master [9, 14-16]. However, no research has investigated the measurements of corneal parameters provided by Anterion after photorefractive keratectomy (PRK) surgery.

The evaluation of corneal topography and tomography following PRK surgery might be crucial for many purposes. Examples include the determination of a retreatment plan for individuals who have been under or over-corrected by refractive surgery [1] and the calculation of intraocular lens (IOL) power for patients who develop cataracts [17]. Furthermore, corneal diameter or white-to-white (WTW), pupil diameter (PD), and central corneal thickness (CCT) are important for cataract surgery [18]. CCT is also a key parameter in performing accurate tonometry [12, 19].

Recently, advances in anterior segment-OCT technology have led to further interest in its clinical applications. Thus, it is predicted that Anterion, the new OCT imaging device, will become the future ophthalmic imaging technique due to its high-resolution and high-contrast images [9]. Different devices, despite being designed for similar purposes, may produce unpredictable outcomes due to inherent technical differences. So, as commonly understood, for a new device to be utilized in clinical practice, it should be compared with other existing instruments to determine if they may be used interchangeably.

This is especially the case when the cornea is not intact anymore because measuring devices are usually programmed for healthy corneas. Given the increasing incidence of refractive surgeries, it seems essential to evaluate the repeatability and agreement of corneal imaging devices in these cases. To the best of our knowledge, this is the first study comparing the new device, Anterion, with Pentacam HR and Orbscan II in the anterior segment parameters of postoperative refractive surgery. In this context, the current study aimed to probe the repeatability of corneal topographic and tomographic measurements of Anterion and their agreement with those of Pentacam HR and Orbscan II in the case of myopic patients who had undergone PRK. The findings will reduce systematic errors, help practitioners to choose the best optical device for ophthalmic imaging and inform future device development for improved diagnostic accuracy.

2. Methods

This cross-sectional study was conducted in accordance with the principles of the Helsinki Declaration and was approved by the Ethics Committee of Mashhad University of Medical Sciences (Ethics Code: IR.MUMS.REC.1402.137). Participants were selected from the Refractive Surgery Center of Al-Zahra Ophthalmology Hospital in Zahedan, Iran in 2023. All participants expressed their willingness to enter the study, and they had undergone PRK surgery 4 months earlier. All the patients provided their written informed consent for using their data anonymously for research purposes.

The eligibility criteria included age 20 to 40 years, no complications after PRK surgery, and the best corrected visual acuity (BCVA) better than 6/6 m. The exclusion criteria were any ocular or systemic disease (e.g., such as pterygium or similar conjunctiva or corneal disease), poor fixation, and delayed corneal healing after surgery. All patients were myopic with a mean spherical equivalent of -3.40 ± 1.60 D. An ophthalmologist performed the standard ophthalmological examination of both anterior and posterior segments for all participants with a slit lamp (Topcon, Tokyo, Japan) and a binocular indirect ophthalmoscope (HEINE, OMEGA 500, Herrsching, Germany), respectively. Also, an optometrist performed an optometry examination, including cyclo-refraction using an auto kerato-refractometer (TopconKR-1, Hasunma-cho, Itabashi-UK, Tokyo, Japan), visual acuity using Snellen chart at a distance of 6 m recorded in Log MAR, and all imaging of three devices under consideration in this study.

2.1. Devices

Pentacam HR (Oculus; Optikgeräte GmbH, Wetzlar, Germany) has a Scheimpflug camera that rotates 360°, and provides an elevation map for both the anterior and posterior surfaces of the cornea. This device also assesses the shape of the cornea and measures corneal higher-order aberrations (HOAs). The data pertaining to wavefront aberration are ray-traced calculated [9].

Orbscan II (Bausch & Lomb, Orbtek Inc., Salt Lake City, United States) analyzes the anterior part of the eye noninvasively by using both Placido disc and slit-scanning systems. Specifically, slit scanning directly

evaluates the anterior and posterior segments of the corneal surface. For this purpose, two vertical scans are carried out by projecting 40 optical slits [20] from the right and 20 from the left onto the cornea. This projection is done at a fixed angle (45°) to the axis of the device. It is possible to integrate Orbscan IIz, with the Zywave II wavefront aberrometer [8].

Anterion (ACE, Technolas Perfect Vision GmbH, Munchen, Germany) is an SS-OCT device that uses a light source with a longer wavelength (1300 nm) to provide high-resolution biometry from the anterior segment of the cornea. An eye-tracking system, that is centered on the corneal vertex, is used to do the required measurements. The device quickly obtains 65 radial B-scan images and 256 A-scans per B-scan. Within a few seconds using the cornea app mode, Anterion measures the data about corneal topography and tomography, in addition to corneal wavefront analysis and pachymetry. Also, the ray tracing technique is used to measure the anterior and total corneal wavefront error [9].

The corneal parameters were measured twice in each eye in order to evaluate the repeatability of the measurements of Anterion [21, 22]. Because of the effect of the tear film on anterior corneal surface measurements, we considered a time interval of 1 min between each measurement with a device so that the tear film could stabilize. Also, a minimum of 5 min was considered between different devices. The patients were asked to blink normally between measurements and to keep both eyes open during the measurement. They were also asked to focus on an internal fixation target. All images obtained were free of lid artifacts. All measurements were recorded between 09:00 AM and 11:00 AM in low-light conditions. Also, the order of running the three devices was randomly determined for each participant.

Statistical analysis was done in SPSS version 19 (SPSS Inc., Chicago, IL). First, Kolmogorov-Smirnov's normality test was performed to check the normality of the data. Descriptive statistics were expressed as mean, standard deviation, and 95% confidence interval. Intra-class correlation coefficient (ICC) was used to check the repeatability of the Anterion data. Also, ICC and means of the 95% LoA were used to assess the agreement of the Anterion results with those of the two other devices. ICCs, which are a widely used reliability index in repeatability and agreement analyses, are classified as follows: ICC < 0.75 = poor, ICC 0.75 to < 0.90 = moderate, and ICC 0.90 and more = high [23, 24]. The 95% LoAs are calculated as the mean $\pm$ 1.96 SD of the differences between the two measurement techniques [18]. According to previous studies, an upper and lower LoA of $\pm$ 0.5 D (range = 1 D) for Keratometry, $\pm$ 10 µm (range = 20 µm) for thickness [12], $\pm$ 0.5 mm (range = 1 mm) for WTW [18], and $\pm$ 0.1 µm (range = 0.2 µm) for aberration [25] was defined as clinically acceptable agreement between the instruments, indicating that the two devices can be used interchangeably. In addition, Bland–Altman graphs were used to visualize the agreement of some important variables. $P < 0.05$ was considered statistically significant.

3. Results

This study evaluated 42 eyes of 42 patients (22 females and 20 males) for both repeatability and agreement analyses and the demographic data are presented in Table **1**.

Table 1: Demographics of subjects and refraction measurements.

Characteristics	Pre- or postoperative	Mean ± SD	95% CI
Age (yr)		31.43 ± 5.89	
Gender (male: female)		20: 22	
SE (D)	Pre	-3.40 ± 1.60	-3.90 to -2.86
	Post	-0.25 ± 0.57	-0.43 to -0.06
UDVA (log MAR)	Pre	0.70 ± 0.28	0.61 to 0.78
	Post	-0.14 ± 0.13	-0.17 to -0.09
CDVA (log MAR)	Pre	0.00 ± 0.00	0.00 to 0.00
	Post	-0.15 ± 0.08	-0.18 to -0.13

SD: Standard deviation, CI: confidence interval, SE: Spherical equivalent, UDVA: Uncorrected distance visual acuity, CDVA: Corrected distance visual acuity

Tables **2** and **3** show the mean difference with 95% coefficient interval of the difference for the topographic, tomographic (central 3 mm of cornea) and aberration parameters of cornea in two measurements with Anterion in patients who had undergone PRK. These tables also included ICC for assessing the repeatability parameters of the device. Keratometry measurements revealed excellent repeatability for steep and average keratometry in the anterior and posterior corneal surfaces (ICC > 0.90). However, in flat keratometry, repeatability was only moderate for the posterior corneal surface (ICC = 0.88) and notably poorer for the anterior corneal surface (ICC = 0.73), indicating a suboptimal repeatability in flat keratometry. It is noteworthy that tomography findings highlighted the utmost repeatability observed on this particular device (ICC in CCT, TPT, and WTW was 0.99). In terms of aberration parameter in (Table **3**), Anterion demonstrated high repeatability in the majority of observations (ICC > 0.90). Nevertheless, in some cases, its repeatability appeared to be moderate (0.75 < ICC < 0.90) or even poor (ICC < 0.75). Aberration parameters exhibiting moderate repeatability on this device include horizontal tilt (ICC = 0.82), oblique astigmatism (ICC = 0.86), oblique trefoil (ICC = 0.85), and spherical aberration (ICC = 0.79). In addition, aberration parameters that demonstrated poor repeatability include horizontal trefoil (ICC = 0.69) and 4th-order RMS (ICC = 0.61).

Table 2: The mean difference in anterior and posterior corneal topography and tomography in two times of measurement with Anterion device in patients who underwent PRK.

	Mean difference ± SD	95% CI of the difference	ICC	P-value (F-Test)
Anterior topography				
K average (D)	0.23 ± 1.13	-0.15–0.61	0.93	<0.001*
K steep (D)	-0.23 ± 1.18	-0.63–0.16	0.93	<0.001*

Table 2: Continued.

	Mean difference ± SD	95% CI of the difference	ICC	P-value (F-Test)
Anterior topography				
K flat (D)	0.23 ± 2.60	-0.65–1.11	0.73	<0.001*
Posterior topography				
K average (D)	-0.02 ±.011	-0.06–0.01	0.91	<0.001*
K steep (D)	0.02 ± 0.11	-0.01–0.06	0.94	<0.001*
K flat (D)	-0.02 ±0.11	-0.06–0.01	0.88	<0.001*
Tomography				
CCT (µm)	-1.80 ± 7.31	-4.28–0.67	0.99	<0.001*
TPT (µm)	1.50 ± 6.77	-0.79–3.79	0.99	<0.001*
PD (mm)	0.05 ± 0.43	-0.09–0.19	0.91	<0.001*
WTW (mm)	0.02 ± 0.073	-0.00–0.04	0.99	<0.001*

SD: Standard deviation, ICC: Intra-class correlation coefficient, CI: confidence interval, K: Keratometry, CCT: Central corneal thickness, TPT: Thinnest point thickness, PD: Pupil diameter, WTW: white-to-white, *: Significant value

Table 3: The mean difference of corneal aberrations in two measurements with Anterion device in patients who underwent PRK.

	Mean difference ± SD	95% CI of the difference	ICC	P-value (F-Test)
Vertical tilt (µm)	-0.05 ± 0.27	-0.14–0.04	0.93	<0.001*
Horizontal tilt (µm)	0-.02 ± 0.28	-0.12–0.06	0.82	<0.001*
Oblique astigmatism (µm)	-0.01 ± 0.20	-0.08–0.05	0.86	<0.001*
Defocus (µm)	-0.011 ± 0.26	-0.10–0.08	0.93	<0.001*
Oblique trefoil (µm)	-0.01 ± 0.05	-0.03–0.002	0.85	<0.001*
Vertical coma (µm)	-0.002 ± 0.05	-0.02–0.01	0.98	<0.001*
Horizontal coma (µm)	0.002 ± 0.06	-0.01–0.02	0.94	<0.001*
Horizontal trefoil (µm)	-0.01 ± 0.05	-0.03–0.004	0.69	<0.001*
Spherical aberration (µm)	-0.002 ± 0.03	-0.01–0.01	0.79	<0.001*
4th order RMS (µm)	0.002 ± 0.03	-0.01–0.01	0.61	0.004*
RMS LOA (µm)	0.01 ± 0.20	-0.05–0.08	0.95	<0.001*
RMS HOA (µm)	-0.01 ± 0.06	-0.03–0.01	0.93	<0.001*

SD: Standard deviation, ICC: Intra-class correlation coefficient, CI: confidence interval, RMS: Root mean square, LOA: Low order aberration, HOA: High order aberration, *: Significant value

Tables **4** and **5** show the mean difference in corneal topography, tomography, and aberrations obtained by Anterion (first scan only) compared with Pentacam HR and Orbscan II. These tables also present the ICCs and the 95% LoA in participants.

Table 4: The mean difference in anterior and posterior corneal topography and tomography of Anterion and Pentacam HR and Orbscan II devices in patients who have undergone PRK.

	Anterion with Pentacam HR			Anterion with Orbscan II		
	Mean difference + SD (95% LOA)	ICC	P-value (F-Test)	Mean difference + SD (95% LOA)	ICC	P-value (F-Test)
Anterior topography						
K average (D)	0.06 ± 0.23 (-0.39–0.51)	0.99	<0.001*	-0.70 ± 1.66 (-3.97–2.55)	0.99	<0.001*

Table 4: Continued.

	Anterion with Pentacam HR			Anterion with Orbscan II		
	Mean difference + SD (95% LOA)	**ICC**	**P-value (F-Test)**	**Mean difference + SD (95% LOA)**	**ICC**	**P-value (F-Test)**
Anterior topography						
K steep (D)	0.10 ± 0.26 (-0.42–0.62)	0.99	<0.001*	-0.90 ± 1.21 (-3.27–1.47)	0.84	<0.001*
K flat (D)	0.02 ± 2.19 (-4.27–4.31)	0.80	<0.001*	-0.74 ± 2.56 (-5.77–4.28)	0.63	0.001
Posterior topography						
K average (K)	0.10 ± 0.04 (0.02–0.18)	0.93	<0.001*	Not		
K steep (K)	0.10 ± 0.04 (0.01–0.19)	0.95	<0.001*	Not		
K flat (K)	0.10 ± 0.04 (0.02–0.18)	0.91	<0.001*	Not		
Tomography						
CCT (µm)	-3.54 ± 15.20 (-33.35–26.25)	0.97	<0.001*	7.87 ± 37.66 (-64.66–80.40)	0.92	<0.001*
TPT (µm)	-3.26 ± 15.03 (-32.73–26.20)	0.97	<0.001*	-2.11 ± 28.73 (-58.42–54.18)	0.89	<0.001*
PD (mm)	3.22 ± 0.64 (1.95–4.49)	0.95	<0.001*	2.94 ± 0.74 (1.48–4.40)	0.68	<0.001*
WTW (mm)	0.00 ± 0.37 (-0.73–0.74)	0.66	<0.001*	0.41 ± 0.40 (-0.50–1.32)	0.45	<0.001*

SD: Standard deviation, ICC: Intra-class correlation coefficient, LoA: Limits of agreement, K: Keratometry, CCT: Central corneal thickness, TPT: Thinnest point thickness, PD: Pupil diameter, WTW: white-to-white, *: Significant value

Table 5: The mean difference of aberrations in Anterion and Pentacam HR in patients who have undergone PRK.

	Mean difference ± SD (95% LOA)	**ICC**	**P-value (F-Test)**
Vertical tilt (µm)	-0.39 ± 0.91 (-2.17–1.39)	0.72	<0.001*
Horizontal tilt (µm)	-0.031 ± 0.68 (-1.64–1.02)	0.67	<0.001*
Oblique astigmatism(µm)	0.01 ± 0.50 (-1.97–1.99)	0.63	<0.001*
Defocus (µm)	0.90 ± 0.93 (-1.04–2.84)	0.18	0.87
Oblique trefoil (µm)	-0.05 ± 0.11 (-0.26–0.16)	0.63	<0.001*
Vertical coma (µm)	-0.08 ± 0.36 (-0.78–0.62)	0.71	<0.001*
Horizontal coma (µm)	-0.02 ± 0.24 (-0.49–0.45)	0.71	<0.001*
Horizontal trefoil (µm)	-0.01 ± 0.08 (-0.16–0.14)	0.72	<0.001*
Spherical aberration (µm)	-0.32 ± 0.13 (-0.57 to -0.07)	0.49	0.02*
4th order RMS (µm)	-1.83 ± 0.51 (-2.85 to -0.82)	0.061	0.42
RMS LOA (µm)	-0.96 ± 0.44 (-1.83 to -0.09)	0.71	<0.001*
RMS HOA (µm)	-0.54 ± 0.25 (-1.03 to -0.04)	0.64	<0.001*

SD: Standard deviation, ICC: Intra-class correlation coefficient, LoA: Limits of agreement, RMS: Root mean square, LOA: Low order aberration, HOA: High order aberration, *: Significant value

Table **4** illustrates that in postoperative corneas, Anterion with Pentacam HR and Orbscan II does not have significant agreement in the majority of topography and tomography parameters. While the ICC value suggests good agreement between devices, the 95% LoA falls short of clinical acceptability. Considering the previously mentioned clinically acceptable 95% LoA interval, Anterion and Pentacam HR are interchangeable in the following parameters: anterior and posterior average keratometry (LoA -0.39 to 0.51, ICC = 0.99 and LoA 0.02–0.18, ICC = 0.93, respectively), anterior and posterior steep keratometry (LoA -0.42–0.62, ICC = 0.99 and LoA 0.01–0.19, ICC = 0.99, respectively), and posterior flat Keratometry (LoA 0.02–0.18, ICC = 0.91). Although some of Anterion's findings were in agreement with those of Orbscan II, such as a keratometry average and CCT (ICC > 0.90, $P < 0.05$), none of them were interchangeable, because their range of the 95% LoA was not small enough to avoid problems with clinical interpretation.

The agreement of Anterion and Pentacam HR in corneal aberrations is shown in Table **5**. As presented, no agreement was observed between the two devices for the scrutinized parameters, as indicated by the diminished ICCs (<0.75) and the considerably wider 95% LoA for corneal aberration (LoA > 0.2 µm range).

Figures **1** and **2** compare the Bland-Altman plot of corneal topography and tomography (the difference between the two values obtained for each subject versus the mean of the two values obtained for each subject) obtained by Anterion, Pentacam HR, and Orbscan II. As observed in the graphs, the range between the upper and lower levels of the 95% LoA for Anterion and Pentacam HR keratometry reveals a small magnitude, indicating a good correlation between the averages of keratometric parameters of Anterion and Pentacam HR and the differences of each variable in the two devices. This is in contrast to other graphs, which display a more extensive range of LoA, both in the Anterion and Pentacam HR graphs, as well as in the graphs of Anterion and Orbscan II. The widest LoA ranges were CCT and TPT when compared between Anterion and Orbscan II.

4. Discussion

PRK is an established, safe, and effective procedure for correcting refractive errors, especially myopia [20]. The precision of anterior segment measurements after PRK is crucial when planning refractive surgery retreatment, selecting the right IOL in cataract surgery, and doing accurate tonometry [1, 12, 17]. Anterion, a new OCT device introduced in 2019 [26], has been evaluated mostly in healthy individuals and for biometric purposes [18, 26, 27]. In this study, we assessed the repeatability of corneal topography and tomography as well as higher-order aberrations measured by the SS-OCT Anterion after PRK. We also assessed the agreement of the measurements of Anterion with the Scheimpflug camera Pentacam HR and the slit-scanning Orbscan II after PRK.

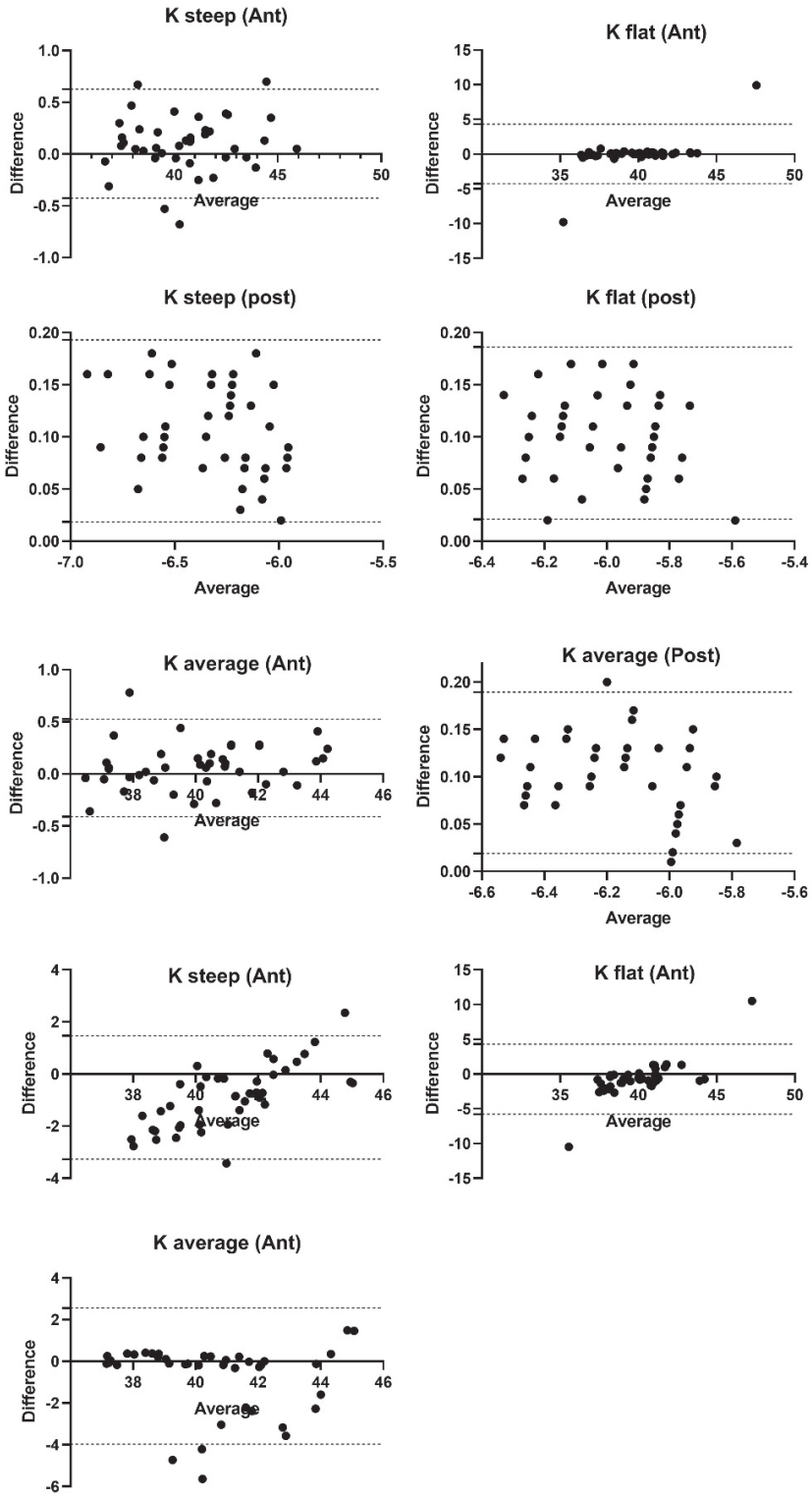

Figure 1: Bland-Altman plot for anterior and posterior topography of Anterion with Pentacam HR and Orbscan II. The X-axis represents the average results of the two devices for each individual and the Y-axis shows the difference between the results of the two devices for each individual. The top four plots correspond to Anterion with Pentacam HR, and the bottom three plots represent Anterion with Orbscan II (K: Keratometry, Ant: Anterior, Post: posterior).

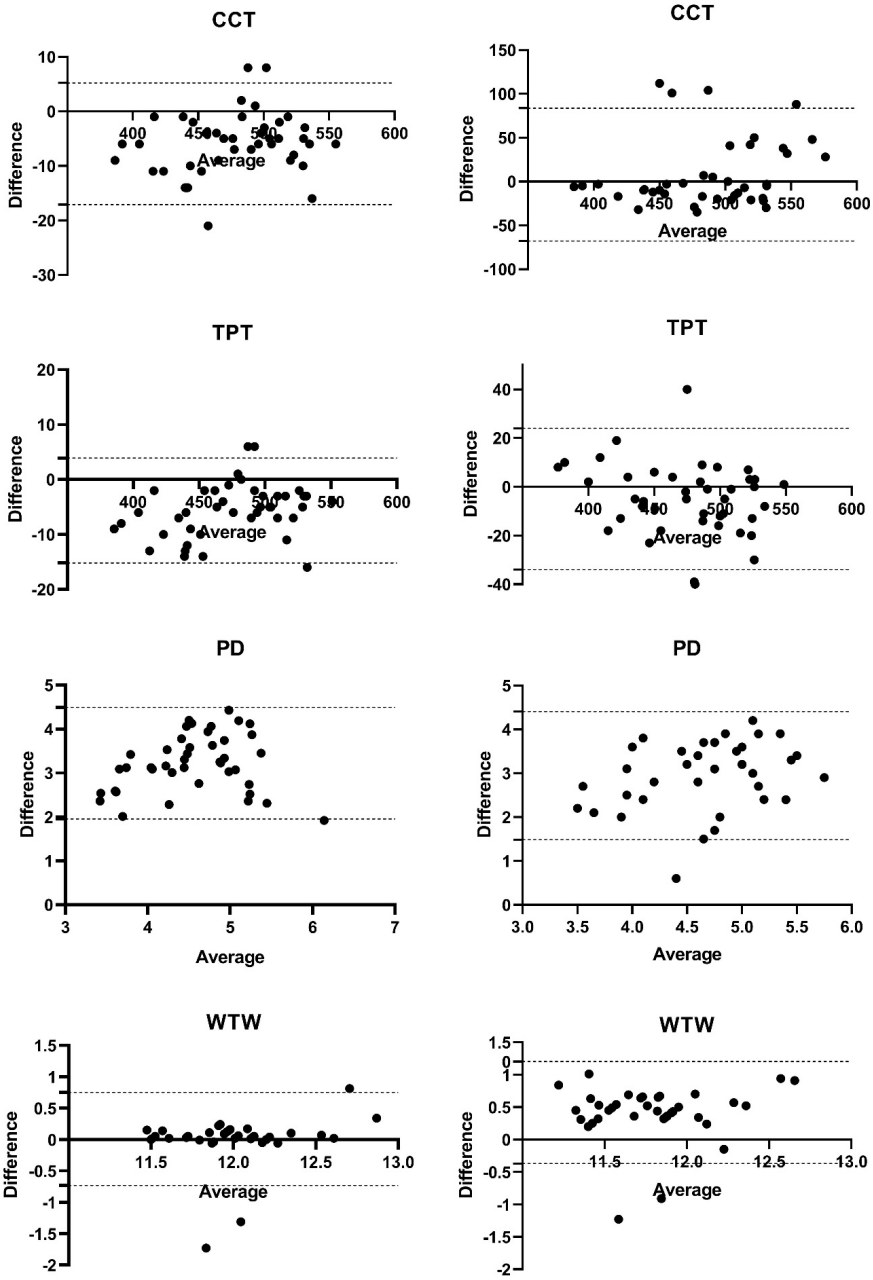

Figure 2: Bland-Altman plot for corneal tomography of Anterion with Pentacam HR and Orbscan II. The X-axis represents the average results of the two devices for each individual, and the Y-axis shows the difference between the results of the two devices for each individual. The right plots correspond Anterion with Orbscan II, and the left plots represent Anterion with Pentacam HR (CCT: Central corneal thickness, TPT: Thinnest point thickness, PD: Pupil diameter, WTW: White-to-white).

According to the results of the present study, the measurements obtained with Anterion are highly repeatable in terms of topography and tomography of the cornea after PRK except for flat keratometry. Similarly, Schiano-Lomoriello et al., [24] studied healthy individuals and reported the high repeatability of Anterion in terms of corneal findings (anterior and posterior keratometry, TPC, and CCT). Gjerdrum et al., [28] confirmed the good repeatability of results of Anterion in the control group and patients

with a high osmolarity in their tear film. The authors suggested that tear film quality is less important in OCT-based keratometers than in conventional, reflection-based keratometers [28]. They reported that Anterion repeatability was not influenced by osmolarity in simulated keratometry, posterior corneal power, and total corneal power [28]. Another study that evaluated the repeatability of Anterion in individuals with cataracts also reported high repeatability of this device in flat keratometry, steep keratometry, and CCT [29]. Additionally, Abicca et al., reported high repeatability of automatic measurements of Anterion in Keratoconic patients [30]. Considering that the present study was performed on patients who had undergone PRK surgery, the good coordination of our results with previous studies on healthy people, cataract patients, and Keratoconic patients confirms the repeatability of the measurements of Anterion.

Another aspect of this study was to evaluate the agreement between three imaging devices after PRK. Evaluating the agreement between the measurements of Anterion and those of Pentacam HR and Orbscan II revealed that despite showing high ICC values (ICC > 0.90), Anterion and Orbscan II cannot be interchangeable. Additionally, Anterion and Pentacam HR are clinically interchangeable only in keratometric parameters (except anterior flat keratometry) and not in any of the applied aberration parameters. In contrast to the present study, Gim et al., [27] concluded that most keratometric measurements obtained by Pentacam HR and Anterion show poor agreement in healthy people and, therefore, it is difficult to use the two devices interchangeably. Their results showed statistically significant differences in most corneal values (i.e., anterior and posterior corneal curvature and the total power cornea (TPC) of the steep meridian of the cornea), but not in relation to the anterior flat keratometry and the TCP of the flat meridian of the cornea [27].

PD, which is an important parameter for corneal and cataract surgeons [26], was in low agreement between the Anterion and the two other devices. In the present study, although the mean difference between Anterion with Pentacam HR and Orbscan II (3.22±0.64 and 2.94 ± 0.74, respectively) was not statistically significant, the ranges of difference between these devices were quite wide to be interchangeable. Furthermore, while both measurements were taken at the same location under low light conditions, Pentacam HR measurements were taken using a dark cloth, as recommended by the manufacturer, and this may account for the difference in pupil size between the two devices. In line with the present study, Bartolome et al., [26] did not find a good agreement in pupil size between the measurements provided by Anterion and Pentacam HR that confirms the findings of the current study.

Considering the importance of WTW in cataract surgery (such as phakic intraocular lens implantation) for using new generation formulas and selecting the lens size in phakic intraocular lenses [18], the present results found low agreement among Anterion and other studied devices in terms of WTW. A recently published literature conducted by Salouti et al., aimed to assess the agreement between Anterion and Pentacam AXL, IOLMaster 700, and Orbscan IIz in measuring WTW in 129 refractive surgery candidates

and found a weak agreement between Anterion and three optical devices and reported they were not interchangeable, which is consistent with our study [31]. Tañá-Rivero et al., [18] measured WTW distance in 53 eyes of 53 patients using Anterion, IOLMaster 700, Pentacam HR, and Cassini color LED. A statistically significant difference was observed in WTW measurement among the four devices used. However, from a clinical point of view, they believe that the WTW measurement obtained via Anterion and IOLMaster 700, and Anterion and Pentacam HR may be considered interchangeable [18].

Another objective of this research was to assess the aberrations measured by Anterion and compare them with Pentacam HR. To our knowledge, no study has investigated the repeatability of Anterion for aberration parameters after corneal surgery so far. The results demonstrated a high repeatability for some parameters of corneal aberration as follows: vertical tilt, vertical coma, horizontal coma, RMS LOA, RMS HOA, and focus (all ICCs > 0.90). Considering that Orbscan II measures total aberrations of the human eye [32], we compared Anterion only with Pentacam HR in corneal aberrations. The results showed no agreement between Anterion and Pentacam HR in terms of HOAs. In contrast, Gim et al., [27] reported a good agreement between Anterion and Pentacam HR in terms of corneal HOA measurements, except for horizontal trefoil, vertical coma, spherical aberration, and RMS of the fifth and sixth order [27]. These differences could be due to significant changes in corneal aberration after PRK [33], which could influence the outcomes, especially considering that Gim et al., [27] conducted their study on healthy individuals. Additionally, they probably considered a wider range of the 95% LoA for clinical interchangeability than what is presented in the current study.

The present research had some limitations. First, the sample size was relatively small. Second, this study was on people who had done refractive surgery 4 months ago. Therefore, it is recommended that future studies evaluate repeatability and agreement of these devices with a larger sample size and at a later stage after PRK and other refractive surgeries.

5. Conclusion

According to the findings of this study, it can be concluded that topographic (except flat K), tomographic, and some HOAs readings of Anterion are repeatable after PRK surgery. In addition, Anterion demonstrates good agreement with Pentacam HR in keratometric parameters but not with Orbscan II in terms of anterior segment parameters in patients undergoing PRK. This means that clinical practitioners should be cautious when using these devices interchangeably for postoperative PRK patients.

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Statement of Ethics

The authors declare that this study was conducted in accordance with the principles of Helsinki Declaration.

Ethical Approval

This study was approved by the Ethics Committee of Mashhad University of Medical Sciences (Ethics Code: IR.MUMS.REC.1402.137).

Informed Consent Statement

Authors state that written informed consent was obtained from all participants to participate in the study.

Conflict of Interest

The authors declare that there is no conflict of interest.

Artificial Intelligence (AI) Disclosure Statement

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Author Contribution

Hadi Ostadi-Moghaddam and Javad Heravian Shandiz: Supervision and planning methodology to reach the conclusion.

Mohammad Hosein Validad: Constructing an idea or hypothesis for research, designing the study, and data collecting and processing.

Monireh Mahjoob: Data analyzing and interpreting the results and drafting the manuscript.

Abbas Ali Yekta: Supervision and reviewing literatures.

Sadegh Basharaf: Data collecting, managing patient follow-up, and reporting.

Tahereh Rakhshandadi: Writing the manuscript, designing the study, reviewing literatures, and data collecting.

All authors reviewed the results and approved the final version of the manuscript.

Data Availability

The authors are unwilling to make the research data publicly available. Following acceptance for manuscript publication, if necessary and upon the editor's request and availability, it will be made accessible to the Journal.

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