

Corneal Aberrations and Topography Changes after Myopic Photorefractive Keratectomy Using Advanced Corneal Explorer and Pentacam

Mohammad Hosein Validad¹, Tahereh Rakhshandadi², Monireh Mahjoob³, Javad Heravian Shandiz⁴,
Abbas Ali Yekta⁵, Hadi Ostadi-Moghaddam^{4*}

¹Department of Ophthalmology, Al-Zahra Eye Hospital, Zahedan University of Medical Sciences, Zahedan, Iran.

²Rehabilitation Sciences Research Center, Department of Optometry, School of Rehabilitation Sciences, Zahedan University of Medical Sciences, Zahedan, Iran.

³Health Promotion Research Center, Department of Optometry, School of Rehabilitation Sciences, Zahedan University of Medical Sciences, Zahedan, Iran.

⁴Refractive Errors Research Center, Mashhad University of Medical Sciences, Mashhad, Iran.

⁵Department of Optometry, Mashhad University of Medical Sciences, Mashhad, Iran.

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ABSTRACT

Introduction: This study aimed to evaluate postoperative changes in corneal topography and corneal aberration parameters following photorefractive keratectomy (PRK) as detected by the Advanced Corneal Explorer (ACE) and Pentacam.

Methods: In this prospective study, 42 eyes of 42 myopic patients undergoing PRK were examined preoperatively and 4 months postoperatively. Corneal aberration and corneal topography were assessed using two imaging systems based on different measurement principles: the Scheimpflug-based Pentacam (Oculus Optikgeräte GmbH, Wetzlar, Germany) and the swept-source optical coherence tomography (SS-OCT)-based ACE (Technolas Perfect Vision GmbH, Munchen, Germany). Paired t-test was used to evaluate postoperative changes detected by each device.

Results: A statistically significant decrease was detected in the mean anterior keratometric values 4 months after PRK via Pentacam and ACE ($P < 0.05$). The mean posterior keratometry significantly increased after surgery using ACE ($P < 0.001$) but no changes were noticed with Pentacam ($P > 0.20$). Four months after PRK, ACE showed a significant change in defocus, horizontal astigmatism as well as in the root mean square (RMS) of higher-order aberrations (all $P < 0.05$). Pentacam showed significant postoperative changes in spherical aberration, vertical tilt, horizontal astigmatism, low order aberration (LOA), HOAs, and fourth-order RMS ($P < 0.001$).

Conclusion: Based on the results, both ACE and Pentacam independently detected significant anterior corneal flattening and an increase in certain corneal aberrations following myopic PRK.

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Introduction

Photorefractive keratectomy (PRK) is a widely used surface ablation laser eye surgery. It treats myopia through excising corneal epithelium and remodeling the corneal stroma within the optical zone. In this surgical operation, the central stromal tissue is ablated

more than the peripheral tissue, which inevitably causes flattening of the cornea and causes changes in the shape of the anterior corneal surface (1, 2). Previous studies have indicated that the stromal ablation in the optical zone reduces corneal biomechanical parameters, including corneal hysteresis and corneal resistance factor, after laser

***Corresponding author:** Hadi Ostadi-Moghaddam, Refractive Errors

Research Center, Mashhad University of Medical Sciences, Mashhad, Iran.

Email: optometry.h@gmail.com

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surgery (3). These postoperative changes in corneal biomechanical properties, corneal asphericity, and corneal wound healing may account for increased corneal aberrations (4-6). In addition, some researchers associate aberrations with poor night vision, glare, halo, as well as visual quality (7). Previous research confirmed the impact of aberrations on visual acuity and observed that some elevated aberrations could reduce visual quality (8, 9).

There are different commercial wavefront sensors such as Tscherning aberrometry, Shack-Hartmann wavefront sensors, and laser ray-tracing (10). Pentacam and Advanced corneal explorer (ACE) are valuable tools in assessing corneal aberrations and topography, however, they differ in their methodology and the type of information they provide. Pentacam is a Scheimpflug imaging device with a rotating camera that captures multiple high-resolution images from different angles, providing detailed information on corneal topography, thickness, and elevation. The posterior corneal surface is reconstructed indirectly from these Scheimpflug images, and corneal aberrations are derived using an outgoing Shack-Hartmann sensor (11, 12). In contrast, ACE is a more recent device that combines swept-source optical coherence tomography (SS-OCT) and Placido disk technology to provide comprehensive anterior segment imaging. Unlike Pentacam, ACE directly acquires high-resolution cross-sectional images of both the anterior and posterior corneal surfaces using SS-OCT. Furthermore, ACE rapidly measures corneal aberrations using a laser ray-tracing technique, an ingoing sensor that more closely represents the physiological optical pathway of the eye because it evaluates the optical system along the incoming light pathway, which more closely resembles the physiological propagation of light through the eye (12, 13). Recently, advances in Anterior Segment-OCT technology have led to further interest in its clinical applications, especially in corneal topography and corneal aberration. Thus, it is predicted that ACE, the new OCT imaging device, will become the future ophthalmic imaging technique. Considering that Pentacam and ACE employ different acquisition principles for aberrometry and topography and assuming that corneal aberration increase after PRK, this study was designed to evaluate postoperative changes in corneal topography and higher-order aberrations after myopic PRK using ACE and Pentacam.

Materials and methods

The total sample size was calculated using G power 3.1.9.2 software for paired t-test with an effect size of 0.5, alpha of 0.05, and power of 0.90, 44 people.

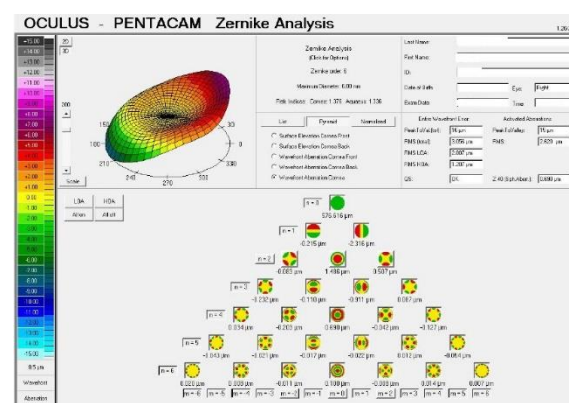
This prospective comparative study was conducted in the refractive surgery center of Al-Zahra Ophthalmology Hospital in Zahedan, Iran, in 2023. Approval to conduct this study was obtained from the Ethics Committee of Mashhad University of Medical Sciences (Ethics Code: IR.MUMS.REC.1402.137), and the study followed the tenets of the Declaration of

Helsinki. All recruited patients had been scheduled for PRK and a four-month follow-up, met the inclusion criteria, and provided their informed consent. The eligibility criteria were as follows: age of 20 to 40 years, low/moderate myopia (<-6.00 D), stable refraction for a minimum of 1 year, a best corrected visual acuity of more than 6/6 m, no use of soft contact lens for 2 weeks, no use of hard contact lens for 6 weeks prior to baseline assessments, and had no postoperative complications following PRK. On the other hand, the exclusion criteria were a history of systemic diseases (particularly autoimmune or collagen vascular diseases, diabetes, corneal ectasia, and any ocular abnormalities except for refractive error), history of eye surgery, poor fixation, and delays in corneal healing post operation.

The surface of the cornea underwent refractive surgery, and the morphology of the anterior corneal surface was substantially altered afterward without changing the lens. Hence, this present study investigated corneal aberration in order to assess the aberrations following refractive surgery. In addition to corneal topography, this study analyzed pre- and postoperative corneal aberrations, including vertical and horizontal tilt, oblique and horizontal astigmatism, defocus, vertical and horizontal coma, oblique and horizontal trefoil, spherical aberration, fourth-order root mean square (RMS), RMS HOAs, and RMS low-order aberration (LOA).

Devices

Pentacam HR (Oculus Optikgeräte GmbH, Wetzlar, Germany) features a Scheimpflug camera with a 360-degree rotation. Both the anterior and posterior surfaces of the cornea could be examined thanks to its elevation map. It also gauges the shape of the cornea and deploys a built-in software to automatically convert the data points into corneal wavefront data. Figure 1 shows an example of the Zernike polynomial map by Pentacam (11).



Germany) deploys the SS-OCT technology. It features a light source with a longer wavelength (1,300 nm) and swiftly captures 65 radial B-scan images and 256 A-scans per B-scan. Besides, it uses the ray tracing technique to evaluate the error pertaining to the anterior and total corneal wavefront (13). Figure 2 shows an example of wavefront parameter by ACE.

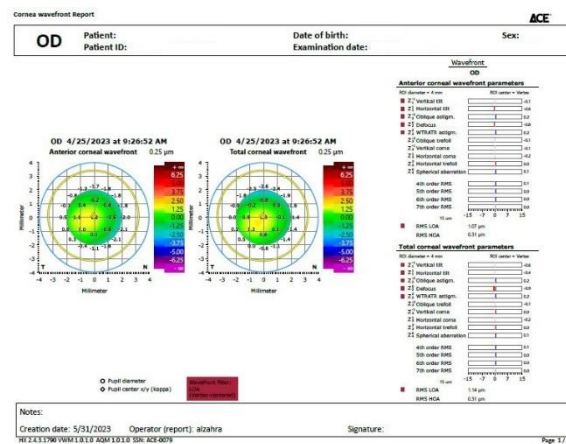


Figure 2. The wavefront parameter obtained by ACE.

Preoperative and four-month postoperative assessments included cycloplegic refraction, Snellen best-corrected visual acuity, slit lamp examination, and dilated fundus examination. Topographical and aberrometric parameters of participants were measured with ACE and Pentacam under dim light condition, and an image was acquired for analysis only when the data quality statement indicated "OK". To minimize the diurnal variations in the measurements, all examinations were performed at the same time of the day, from 9:00 to 11:00 AM. All preoperative and postoperative measurements were conducted by an expert optometrist using Pentacam and ACE. All patients underwent conventional PRK by the same surgeon (M.V.) using the Allegretto Wave Eye-Q (Version 2.020 default treatment, Alcon Laboratories, Inc., Fort Worth, US).

Statistical Analysis

Statistical analysis was done in SPSS version 19 (SPSS Inc., Chicago, US). The data are presented as mean $\pm$ standard deviation at a 95% confidence interval. The paired t-test was used to compare the differences between preoperative and postoperative values

provided they followed a normal distribution. If the measurements did not show a normal distribution, the Wilcoxon test was used instead. A P-value of less than .05 was considered statistically significant.

Results

This study evaluated 42 eyes of 42 patients (22 females and 20 males) who completed preoperative and postoperative examinations and were followed up for 4 months. No major complications related to PRK were observed, and the mean age of participants was 31.43 ± 5.89 years.

The results showed a statistically significant reduction in the mean spherical equivalent (SE) from -3.40 ± 1.60 diopter preoperatively to -0.25 ± 0.57 diopter at 4 months postoperatively ($P < 0.000$). The mean of logMAR uncorrected distance visual acuity (UDVA) improved significantly from 0.70 ± 0.28 logMAR preoperatively to -0.14 ± 0.13 logMAR at 4 months postoperatively ($P < 0.000$). Corrected distance visual acuity before and four months after PRK was 0.00 ± 0.01 logMAR and -0.15 ± 0.08 logMAR, respectively, which is not significantly different ($P = 0.32$).

Tables 1 and 2 illustrate the mean $\pm$ standard deviation of the topographic and tomographic values (central three millimeters of cornea) before and after PRK using Pentacam and ACE, respectively. These tables also show the mean differences before and after PRK with a 95% confidence interval. As shown, in the case of both Pentacam and ACE, anterior corneal parameters (steep, flat, and average keratometry) decreased significantly after PRK compared to baseline ($P < 0.001$). But the results were different concerning posterior topography. Although Scheimpflug Pentacam did not show any statistically significant change in posterior keratometry after PRK ($P > 0.20$), SS-OCT ACE revealed a significant increase in posterior keratometric (steep, flat, and average keratometry) results after the operation compared to baseline ($P < 0.001$). Additionally, compared to baseline, it was noticed a significant decrease in central corneal thickness and thinnest point thickness after PRK using both Pentacam and ACE ($P < 0.001$).

Table 1. The mean $\pm$ standard deviation and the mean difference of anterior and posterior corneal topography and tomography (central three millimeters) and the mean difference before and after PRK with Pentacam

	Mean $\pm$ SD Before PRK (95% CI)	Mean $\pm$ SD After PRK (95% CI)	Mean Difference $\pm$ SD (95% CI)	P value
Anterior topography				
K average (D)	43.29 ± 1.01 (43.01 to 43.60)	40.20 ± 2.09 (39.61 to 40.83)	3.10 ± 1.53 (2.60 to 3.59)	$<0.001^*$
K steep (D)	43.97 ± 1.19	40.66 ± 2.24	-3.31 ± 1.63	$<0.001^*$

	(43.63 to 44.35)	(40.04 to 41.32)	(2.79 to 3.82)	
K flat (D)	42.66 ± 1.02 (42.35 to 42.96)	39.74 ± 1.98 (39.19 to 40.35)	2.92 ± 1.53 (2.43 to 3.41)	<0.001*
Posterior topography				
K average (D)	-6.23 ± 0.23 (-6.30 to -6.16)	-6.22 ± 0.22 (-6.28 to -6.15)	-0.01 ± 0.05 (-0.03 to 0.01)	0.253
K steep (D)	-6.40 ± 0.29 (-6.49 to -6.31)	-6.38 ± 0.28 (-6.47 to -6.30)	-0.01 ± 0.06 (-0.03 to 0.01)	0.200
K flat (D)	-6.07 ± 0.20 (-6.13 to -6.01)	-6.06 ± 0.19 (-6.12 to -6.00)	-0.01 ± 0.06 (-0.03 to 0.01)	0.323
Tomography				
CCT (μm)	538.88 ± 34.75 (528.23 to 548.77)	479.92 ± 47.40 (462.31 to 491.67)	61.95 ± 33.13 (51.35 to 72.55)	<0.001*
TPT (μm)	537.35 ± 35.10 (526.86 to 547.36)	474.30 ± 46.55 (459.98 to 488.62)	63.05 ± 34.36 (52.06 to 74.04)	<0.001*
PD (mm)	3.03 ± 0.65 (2.86 to 3.22)	2.91 ± 0.64 (2.74 to 3.11)	0.12 ± 0.46 (-0.02 to 0.27)	0.099
WTW (mm)	11.92 ± 0.31 (11.83 to 12.03)	11.94 ± 0.05 (11.84 to 12.04)	-0.01 ± 0.06 (-0.03 to 0.01)	0.291

PRK: Photorefractive keratectomy, SD: Standard deviation, CI: confidence interval, K: Keratometry, CCT: Central corneal thickness, TPT: Thinnest point thickness, PD: Pupil diameter, WTW: white to white, *: significant value

Table 2. The mean ± standard deviation and the mean difference of anterior and posterior corneal topography and tomography (central three millimeters) before and after PRK with ACE.

	Mean ±SD Before PRK (95% CI)	Mean ±SD After PRK (95% CI)	Mean Difference ±SD (95% CI)	P value
Anterior topography				
K average (D)	43.47 ± 1.05 (43.17 to 43.88)	40.26 ± 2.13 (39.67 to 40.90)	3.20 ± 1.59 (2.69 to 3.71)	<0.001*
K steep (D)	44.21 ± 1.19 (43.88 to 44.58)	40.77 ± 2.27 (40.12 to 41.43)	3.44 ± 1.67 (2.90 to 3.97)	<0.001*
K flat (D)	42.85 ± 1.07 (42.54 to 43.17)	39.77 ± 3.23 (38.79 to 40.87)	3.08 ± 2.81 (2.18 to 3.98)	<0.001*
Posterior topography				
K average (D)	-6.08 ± 0.20 (-6.15 to -6.02)	-6.11 ± 0.21 (-6.18 to -6.05)	0.02 ± 0.02 (0.02 to 0.03)	<0.001*
K steep (D)	-6.25 ± 0.26 (-6.33 to -6.18)	-6.28 ± 0.26 (-6.36 to -6.20)	0.03 ± 0.02 (0.02 to 0.03)	<0.001*
K flat (D)	-5.93 ± 0.18 (-5.99 to -5.88)	-5.95 ± 0.18 (-6.01 to -5.90)	0.02 ± 0.02 (0.01 to 0.03)	<0.001*
Tomography				
CCT (μm)	537.13 ± 36.26 (526.20 to 547.59)	473.43 ± 43.91 (459.75 to 487.22)	63.70 ± 31.11 (53.75 to 73.65)	<0.001*
TPT (μm)	534.30 ± 35.89 (523.63 to 544.37)	471.13 ± 43.45 (457.73 to 484.62)	63.18 ± 31.37 (53.14 to 73.21)	<0.001*
PD (mm)	5.98 ± 1.08 (5.64 to 6.30)	6.16 ± 0.76 (5.93 to 6.38)	-0.18 ± 0.94 (-0.48 to 0.12)	0.238
WTW (mm)	11.94 ± 0.37 (11.83 to 12.06)	11.94 ± 0.39 (11.82 to 12.06)	-0.00 ± 0.09 (-0.03 to 0.03)	0.943

ACE: Advanced corneal explorer, PRK: Photorefractive keratectomy, SD: Standard deviation, CI: confidence interval, K: Keratometry, CCT: Central corneal thickness, TPT: Thinnest point thickness, PD: Pupil diameter, WTW: white to white, *: significant value

The mean ± standard deviation of corneal aberration measured by Pentacam and ACE preoperatively and postoperatively are illustrated in Tables 3 and 4. The mean corneal aberration parameters after PRK via Pentacam (including vertical tilt, vertical astigmatism, RMS HOAs, RMS LOAs, fourth-order RMS, and spherical aberration) differed significantly from the mean value

at baseline (P<0.001) (Table 3). However, ACE measurements regarding corneal aberration showed a statistically significant increase in vertical astigmatism and RMS HOAs and a significant decrease in defocus 4 months post operation (P<0.001) (Table 4).

Table 3. The mean ± standard deviation and the mean difference of corneal aberrations (in the central 6 mm of the cornea) before and after PRK with Pentacam

	Mean ±SD Before PRK (95% CI)	Mean ±SD After PRK (95% CI)	Mean Difference ±SD (95% CI)	P value
Vertical tilt (μm)	-0.144 ± 0.916 (-0.453 to 0.090)	-0.506 ± 1.237 (-0.932 to -0.159)	0.361 ± 0.632 (0.159 to 0.569)	0.001*
Horizontal tilt (μm)	-0.045 ± 0.452 (-0.194 to 0.094)	-0.123 ± 0.867 (-0.401 to 0.137)	0.078 ± 0.666 (-0.134 to 0.291)	0.458
Oblique astigmatism (μm)	0.081 ± 0.724 (-0.139 to 0.312)	0.193 ± 0.637 (-0.177 to 0.226)	0.062 ± 0.515 (-0.102 to 0.227)	0.449
Defocus (μm)	0.631 ± 0.400 (0.509 to 0.755)	0.427 ± 0.801 (0.185 to 0.675)	0.204 ± 0.735 (-0.031 to 0.439)	0.087

WTRATR astigmatism (μm)	-0.793 $\pm$ 0.969 (-1.103 to -0.484)	-0.556 $\pm$ 0.657 (-0.771 to -0.359)	-0.237 $\pm$ 0.675 (-0.453 to -0.021)	0.032
Oblique trefoil (μm)	-0.100 $\pm$ 0.160 (-0.153 to -0.056)	-0.139 $\pm$ 0.166 (-0.191 to -0.095)	0.038 $\pm$ 0.191 (-0.022 to 0.099)	0.211
Vertical coma (μm)	-0.054 $\pm$ 0.258 (-0.139 to 0.0139)	-0.104 $\pm$ 0.532 (-0.259 to 0.070)	0.049 $\pm$ 0.407 (-0.080 to 0.179)	0.446
Horizontal coma (μm)	-0.010 $\pm$ 0.143 (-0.056 to 0.035)	-0.042 $\pm$ 0.341 (-0.149 to 0.060)	0.032 $\pm$ 0.255 (-0.049 to 0.113)	0.430
Horizontal trefoil (μm)	-0.018 $\pm$ 0.113 (-0.054 to 0.014)	-0.049 $\pm$ 0.160 (-0.102 to -0.004)	0.030 $\pm$ 0.178 (-0.026 to 0.087)	0.280
Spherical aberration (μm)	0.215 $\pm$ 0.067 (0.194 to 0.236)	0.381 $\pm$ 0.181 (0.317 to 0.436)	-0.165 $\pm$ 0.167 (-0.219 to -0.112)	<0.001*
4th order RMS (μm)	1.551 $\pm$ 1.127 (1.237 to 1.944)	1.912 $\pm$ 1.127 (1.615 to 2.276)	-0.361 $\pm$ 0.822 (-0.624 to -0.983)	0.008*
RMS LOA (μm)	1.602 $\pm$ 1.070 (1.290 to 1.968)	1.816 $\pm$ 1.101 (1.526 to 2.195)	-0.214 $\pm$ 0.812 (-0.474 to 0.045)	0.103
RMS HOA (μm)	0.382 $\pm$ 0.211 (0.332 to 0.458)	0.774 $\pm$ 0.370 (0.661 to 0.895)	-0.392 $\pm$ 0.303 (-0.489 to -0.294)	<0.001*

PRK: Photorefractive keratectomy, SD: Standard deviation, CI: confidence interval, RMS: Root mean square, LOA: Low order aberration, HOA: High order aberration, *: significant value.

Table 4. The mean $\pm$ standard deviation and the mean difference of corneal aberrations (in the central 4 mm of the cornea) before and after PRK with ACE.

	Mean $\pm$SD Before PRK (95% CI)	Mean $\pm$SD After PRK (95% CI)	Mean Difference $\pm$SD (95% CI)	P value
Vertical tilt (μm)	-0.253 $\pm$ 0.396 (-0.387 to -0.156)	-0.292 $\pm$ 0.441 (-0.446 to -0.174)	0.038 $\pm$ 0.149 (-0.01 to 0.087)	0.117
Horizontal tilt (μm)	-0.030 $\pm$ 0.293 (-0.120 to 0.061)	-0.051 $\pm$ 0.413 (-0.179 to 0.082)	0.02 $\pm$ 0.182 (-0.038 to 0.079)	0.487
Oblique astigmatism (μm)	-0.005 $\pm$ 0.280 (-0.089 to 0.084)	0.005 $\pm$ 0.288 (-0.076 to 0.097)	-0.010 $\pm$ 0.284 (-0.102 to 0.081)	0.823
Defocus (μm)	0.523 $\pm$ 0.130 (0.479 to 0.559)	-0.192 $\pm$ 0.542 (-0.359 to -0.010)	0.715 $\pm$ 0.501 (0.552 to 0.877)	<0.001*
WTRATR astigmatism (μm)	-0.394 $\pm$ 0.388 (-0.512 to -0.269)	-0.217 $\pm$ 0.291 (-0.312 to -0.128)	-0.176 $\pm$ 0.41 (-0.309 to -0.044)	0.010*
Oblique trefoil (μm)	-0.025 $\pm$ 0.063 (-0.043 to -0.005)	-0.030 $\pm$ 0.069 (-0.051 to -0.010)	0.005 $\pm$ 0.068 (-0.017 to 0.027)	0.643
Vertical coma (μm)	-0.020 $\pm$ 0.095 (-0.053 to 0.005)	-0.030 $\pm$ 0.152 (-0.082 to 0.017)	0.010 $\pm$ 0.111 (-0.026 to 0.046)	0.570
Horizontal coma (μm)	-0.007 $\pm$ 0.048 (-0.023 to 0.005)	-0.010 $\pm$ 0.107 (-0.043 to 0.023)	0.002 $\pm$ 0.101 (-0.030 to 0.035)	0.875
Horizontal trefoil (μm)	0.000 $\pm$ 0.068 (-0.020 to 0.020)	-0.0128 $\pm$ 0.057 (-0.028 to 0.005)	0.012 $\pm$ 0.069 (-0.009 to 0.035)	0.257
Spherical aberration (μm)	0.074 $\pm$ 0.44 (0.061 to 0.087)	0.076 $\pm$ 0.053 (0.061 to 0.092)	-0.002 $\pm$ 0.070 (-0.025 to 0.020)	0.822
4th order RMS (μm)	0.092 $\pm$ 0.027 (0.082 to 0.100)	0.097 $\pm$ 0.042 (0.084 to 0.110)	-0.005 $\pm$ 0.045 (-0.020 to 0.010)	0.487
RMS LOA (μm)	0.908 $\pm$ 0.372 (0.807 to 1.029)	0.887 $\pm$ 0.428 (0.777 to 1.035)	0.020 $\pm$ 0.262 (-0.064 to 0.105)	0.633
RMS HOA (μm)	0.123 $\pm$ 0.083 (0.103 to 0.153)	0.205 $\pm$ 0.108 (0.173 to 0.24)	-0.082 $\pm$ 0.080 (-0.108 to -0.055)	<0.001*

ACE: Advanced corneal explorer, PRK: Photorefractive keratectomy, SD: Standard deviation, CI: confidence interval, RMS: Root mean square, LOA: Low order aberration, HOA: High order aberration, *: significant value.

Discussion

Assessment of the anterior segment is essential in postoperative ophthalmic evaluation, and yet there is no gold standard to perfectly represent the corneal topography and corneal aberrations. Therefore, this prospective study investigated changes in corneal topography and corneal aberrations before and after PRK with two devices ACE and Pentacam.

After PRK surgical operation, most patients gained satisfactory visual and refractive outcomes at 4 months postoperatively. Besides, 94.7% of the eyes achieved ≥ 0.00 logMAR uncorrected distance visual acuity, and all patients achieved a spherical equivalent of -0.25 diopter with a standard deviation of ± 0.57 diopter.

Perhaps not surprisingly, after stromal ablation in the optical zone during myopic PRK, the anterior surface keratometric parameters indicated a significant reduction according to both ACE and Pentacam. Given that changes in corneal shape can lead to changes in biomechanics (5, 14-16) and thus affect the posterior keratometry (5), and since keratectasia initially appears on the posterior—not anterior—corneal surface (17), it is important to recognize changes, if any, in the posterior corneal surface after refractive surgery. In the present study, a key finding was that SS-OCT-based ACE indicated the steepening of the

posterior corneal curvature postoperatively. Some studies have reported both a steepening and an increasing elevation in posterior corneal surface after surgery using slit-scanning Orbscan, and they have attributed them to the regression of myopia a few days post operation (15, 18). However, some studies have not reported any significant changes in the posterior corneal curvature after laser refractive surgery (14, 19, 20). Ciolino & Belin (21) did not observe a significant change in the posterior corneal surface after PRK using Pentacam (Scheimpflug imaging) (21), which is in line with the results obtained by Pentacam in the present study. The discrepancy between the two devices regarding posterior corneal keratometry may therefore be explained by their different imaging technologies. ACE directly acquires high-resolution cross-sectional images of the posterior corneal surface using SS-OCT, whereas Pentacam estimates posterior corneal tomography from multiple Scheimpflug image (11-13). In addition, the two devices differ in image acquisition speed, data-processing algorithms, robustness against noise, all of which may influence posterior corneal measurements (22). Consequently, subtle postoperative posterior corneal changes may not necessarily be detected identically by the two imaging systems. Given that changes in the posterior surface of the cornea are considered the first sign of corneal thinning (17), it is necessary to conduct more studies on the posterior surface changes when measured with ACE.

Concerning the aberration outcomes in this study, Pentacam and ACE produced similar results for horizontal tilt, oblique astigmatism, oblique and horizontal trefoil, and vertical and horizontal coma, which showed no significant changes postoperatively. According to the results, spherical aberration (i.e., the distance between different focal points that induces the variation in the focus position of entering light rays into the eye) (23) increased significantly at 4 months after PRK using Pentacam. Conversely, ACE showed a small postoperative increase in these parameters, which was not statistically significant. The postoperative coma variations measured by Pentacam were greater than those obtained by ACE, but there were no significant changes for both devices after surgery.

Aberration changes observed using Pentacam after laser surgery have been confirmed by previous studies. Biscevic et al (24) reported no significant changes in the coma and trefoil 3 months after PRK using an aberrometer (L80wave+TM, Luneau SAS, Prunay-le-Gillon, France), yet a significant change was observed only in the spherical aberration (24). Furthermore, Wu et al (4) found that PRK caused the anterior corneal surface to become flatter and the morphology of the corneal surface to become irregular (4). They used Pentacam, the Shack-Hartmann sensor, to assess the corneal higher-order aberrations before and after PRK, and reported a significant increase in vertical and horizontal coma and spherical aberration after surgery (4). Another study by Xi L (25) showed that the values

of spherical aberration and coma measured with Pentacam increased significantly after PRK, but trefoil values were not significantly changed (25). Meanwhile, in the present study, coma did not show any variation after PRK using Pentacam and ACE. Defocus (a second-order Zernike term) decreased significantly as measured by ACE, Pentacam measurements did not show a change in this parameter in the present study and previous studies (4, 24, 25).

In general, a greater number of aberration parameters were altered after PRK using Pentacam compared to ACE in the present study. The observed differences between ACE and Pentacam are likely related to the fundamental differences in their imaging principles as mentioned previously, as well as differences in the corneal area analyzed, with ACE generally evaluating a smaller corneal diameter than Pentacam (15, 17).

There are some limitations in this study. The sample size was relatively small, and the follow-up period was limited to 4 months postoperatively. While this timeframe allowed for evaluation of early postoperative changes, it may be relatively short for assessing stability of posterior keratometric changes. Additionally, only one surgical approach was evaluated. Furthermore, the present study was designed specifically to investigate within-device postoperative changes detected by each imaging device individually, rather than evaluating between-device agreement or interchangeability between ACE and Pentacam. Consequently, formal between-device agreement analyses, such as Bland-Altman plots and intraclass correlation coefficients, were not performed. Future studies with larger sample sizes, longer follow-up periods and multiple laser refractive surgery procedures are recommended.

Conclusion

In conclusion, the results demonstrated that both ACE and Pentacam detected significant anterior corneal flattening and increases in specific corneal aberrations following myopic PRK.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Conception and design of the study: Mohamad Hosein Validad, Hadi Ostadi-Moghaddam, and Javad Heravian Shandiz.

Statistical analysis and illustrations: Monireh Mahjoob and Tahereh Rakhshandadi. *Data collecting, managing patient follow-up, and reporting:* Monireh Mahjoob, Tahereh Rakhshandadi, and Mohammad Hosein Validad.

Drafting of the manuscript: Tahereh Rakhshandadi, Monireh Mahjoob, and Abbas Ali Yekta.

Critical revision of the manuscript: Abbas Ali Yekta, Mohamad Hosein Validad, Hadi Ostadi-Moghaddam, and Javad Heravian Shandiz. All authors have read and approved the final manuscript.

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