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Hussam Eldeen O. Elrashidy
Memorial Institute of Ophthalmic Research, hussamomare@gmail.com

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Effect of photorefractive keratectomy versus laser *in situ* keratomileusis on corneal hysteresis in moderate myopic eyes

Hussam Eldeen O. Elrashidy
Department of Ophthalmology, Memorial Institute of Ophthalmic Research, Giza, Egypt

Abstract

Introduction

Ablation procedures used for vision correction such as photorefractive keratectomy (PRK) or laser *in situ* keratomileusis (LASIK) flap creation produce massive changes within the corneal structure and biomechanical properties. These changes are due to thinning of the central cornea and disruption of continuity of the collagen lamellae. Several approaches to assessment of the biomechanical properties have been proposed. Refractive photoablation procedures that decrease corneal hysteresis (CH) and corneal resistance factor (CRF) have been shown by several studies; therefore, here in our study we are going to discuss the effect of PRK versus LASIK on the corneal biomechanics and stability over time.

Aim

To compare the postoperative biomechanical properties of the cornea after PRK and after LASIK in eyes with moderate myopia.

Patients and methods

The study is 'prospective, controlled, and randomized.' In all, 40 eyes with moderate myopia (−2.0 to − 5.0 D) underwent refractive correction of myopia; 20 of them (group A) were enrolled for PRK while the other 20 of them (group B) were enrolled for LASIK surgery. CH and CRF were measured with an ocular response analyzer preoperatively and 1and 3 months postoperatively. All eyes were subjected to corneal topography preoperatively and 1 and 3 months postoperatively ocular response analyzer was used preoperatively and 1 and 3 months postoperatively.

Results

All patients were followed up postoperatively at 1 and 3 months. The CH and CRF were measured in both groups preoperatively and postoperatively. In group A, the mean preoperative CH was 10.7 ± 0.4 (range: 10–11.1) and CRF was 10.2 ± 0.11 (range: 10.1–10.5), whereas in group B it was 10.57 ± 0.38 (range: 10–11.2) and the CRF was 10.21 ± 0.1 (range: 10–10.5), respectively, with no significant difference ($P = 0.43$ and 0.25, respectively).

After 1 month, CH and CRF were 8.4 ± 0.27 (range: 7.9–9.1) and 8.2 ± 0.23 (range: 7.8–8.6) in group A and 8.3 ± 0.25 (range: 8.0–9.0) and 8.17 ± 0.19 (range: 7.9–8.5) in group B, respectively, with no significant difference ($P = 0.28$ and 0.45, respectively). At 3 months, CH and CRF were 8.6 ± 0.28 (range: 8.1–9.2) and 8.3 ± 0.21 (range: 7.8–8.6) in group A and 8.55 ± 0.26 (range: 8.2–9.1) and 8.28 ± 0.18 (range: 7.9–8.6) in group B, respectively, with no significant difference ($P = 0.56$ and 0.32, respectively). The corneal biomechanical parameters decreased after both PRK and LASIK procedures. The corneal biomechanical parameters decreased after both PRK and LASIK procedures. The postoperative measurements of CH and CRF at 3 months were lower than the preoperative values in both groups with a significant amount ($P < 0.001$).

Conclusion

Both PRK and LASIK substantially weaken the biomechanical strength of the cornea, the greater the amount of myopic correction, the more the change in corneal biomechanics.

Keywords: corneal hysteresis, laser *in situ* keratomileusis, moderate myopic eyes, photorefractive keratectomy

Correspondence to: Hussam Eldeen O. Elrashidy, MD, 3 Al-Ahram Road Al Jiza, Giza 12511, Egypt.
E-mail: hussamomare@gmail.com

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Introduction

Ablation procedures used for vision correction such as photorefractive keratectomy (PRK) or laser *in situ* keratomileusis (LASIK) flap creation produces massive changes within the corneal structure and biomechanical properties. These changes are due to thinning of the central cornea and disruption of continuity of the collagen lamellae [1].

The cornea consists of about 200 collagen lamellae containing collagen fibers. Collage fibers are crucial to withstand and maintain the corneal shape. The biomechanical strength of the cornea are ensured by the lamellar interweaving and corneal cross-linking. Incision or any refractive photoablation procedures decreases the tensile strength within the corneal lamellae [2].

Several approaches to assessment of the biomechanical properties have been proposed. Ocular response analyzer (ORA) is a noncontact differential tonometer that evaluates the *in vivo* corneal viscoelasticity and intraocular pressure during a collimated air pulse pressurizing the corneal apex [3]. Based on the applied pressure, the corneal inward and outward applanation points are registered and translated into intraocular pressure values. The difference between the applied pressure during inward and outward applanation is defined as the corneal hysteresis (CH), and it describes the cornea's ability to dissipate energy due to viscous damping. CH reflects the combined change within the viscosity and elasticity. Corneal resistance factor (CRF) is determined by an empirical formula, based on the correlation between CH and central corneal thickness (CCT), reflecting corneal resistance [4]. Both values have been shown to be affected by CCT, intraocular pressure, and age; moreover they must be taken into consideration when interpreting ORA outcomes [5].

Refractive photoablation procedures that decrease CH and CRF have been shown by several studies; therefore, here in our study we are going to discuss the effect of PRK versus LASIK on the corneal biomechanics and stability over time.

Aim

The aim of this study was to compare the postoperative biomechanical properties of the cornea after PRK versus after LASIK in eyes with moderate myopia.

Patients and methods

Study design

The study is 'prospective, controlled, and randomized.'

Population of study and disease condition

The study included 40 eyes with moderate myopia (−2.0 to − 5.0 D) which underwent refractive correction of myopia; 20 of them (group A) were enrolled for PRK while the other 20 of them (group B) were enrolled for LASIK surgery. We measured CH and the CRF with an ORA (Reichert Inc., Dephew, New York, USA) preoperatively and 1 and 3 months postoperatively. We also plotted the correlation between these biomechanical changes and the amount of myopic correction.

This research followed the principles of the Declaration of Helsinki and all the contributing patients signed informed consents.

Method applied

All patients underwent ophthalmic examination that included:
(1) Visual acuity assessment.
(2) Slit-lamp examination for the anterior segment.
(3) Indirect ophthalmoscopy for the posterior segment.
(4) ORA.
(5) Corneal topographic imaging using the Oculus Pentacam.

Inclusion criteria include:
(1) Age range 20–45 years.
(2) Spherical equivalent (–2 D to –5 D).
(3) Preoperative CCT of more than 500 μm.

Exclusion criteria included:
(1) Previous ocular or refractive surgery.
(2) Previous ocular trauma.
(3) Glaucoma or any posterior segment abnormalities.
(4) Corneal opacities or irregularities.
(5) Medical history of hypertension or diabetes mellitus.

All eyes were subjected to:
(1) Corneal topography preoperatively and 1 and 3 months postoperatively.
(2) ORA preoperatively and 1 and 3 months postoperatively.

Statistical analysis

Data were presented in terms of parametric and nonparametric data. Parametric data were analyzed with analysis of variance and whenever appropriate with Student's t test. Nonparametric data were analyzed with $\chi 2$ and/or Mann–Whitney tests. Statistical significance was considered at 95% confidence interval. We considered *P* values of less than 0.05 to be statistically significant. We did statistical calculations using computer programs SPSS (Statistical Package for the Social Sciences; SPSS Inc., Chicago, Illinois, USA), version 18 for Microsoft Windows.

The benefit to the patient

The patient underwent the refractive surgery, either PRK or LASIK, for myopic correction as a proved successful line of surgical treatment for myopia. In addition, he was informed of any changes in his corneal biomechanics postoperatively that if profoundly present will keep close follow-up for this patient mandatory to prevent postoperative ectasia that is a possible postoperative complication after refractive surgeries.

Results

The study included 40 eyes of 22 patients, who had mild to moderate myopia (−2.0 to − 5.0 D). Eleven (27.5%) of the eyes were for males, while 29 (72.5%) were for females (Fig. 1) and 53.3% of the eyes studied were right eyes and 46.7% were left (Fig. 2).

They were divided into two groups: group A were treated surgically using PRK and group B were treated using LASIK.

Group A included 12 patients (20 eyes) with a mean age of 24.2 ± 4.2 years (range: 19–36 years), and group B included 10 patients (20 eyes) with a mean age of 23.9 ± 4.5 years (range: 20–35 years); there was no significant difference between the two groups (*P* = 0.84).

Preoperative spherical equivalent in group A was − 3.50 ± 1.27 D (range: −2.25 to −5.00 D) and the mean best-corrected visual acuity was 0.94 ± 0.06 (range: 0.8–1.0), whereas in group B it was −3.5 ± 1.5 D (range: −2.00 to −5.00 D) and 0.96 ± 0.05 (range: 0.8–1.0), respectively. There was no significant difference between the two groups (*P* = 0.27 and 0.43, respectively).

The mean preoperative CCT was 524.4 ± 12.5 μm (range: 511–561 μm) and 532.3 ± 11.4 μm (range: 519–559 μm) in groups A and B, respectively, with no significant difference (*P* = 0.66) (Table 1).

All patients were followed up postoperatively at 1 and 3 months. The CH and CRF were measured in both groups preoperatively and postoperatively. In group A, the mean preoperative CH was 10.7 ± 0.4 (range: 10–11.1) and CRF was 10.2 ± 0.11 (range: 10.1–10.5), whereas in group B it was 10.57 ± 0.38 (range: 10–11.2) and CRF was 10.21 ± 0.1 (range: 10–10.5), respectively, with no significant difference (*P* = 0.43 and 0.25, respectively).

Table 1: Preoperative values of spherical equivalent, best-corrected visual acuity, and central corneal thickness in both groups

Preoperative signs	Group A (*n*=20)	Group B (*n*=20)	*P*
SE	−3.50±1.27 D	−3.5±1.5 D	0.27
BCVA	0.94±0.06	0.96±0.05	0.43
CCT	524.4±12.5 μm	532.3±11.4 μm	0.66

BCVA, best-corrected visual acuity; CCT, central corneal thickness; SE, spherical equivalent.

Table 2: Preoperative, 1 month, and 3 months postoperative values of corneal hysteresis in both groups

CH	Group A	Group B	*P*
Preoperative			
Mean±SD	10.7±0.4	10.2±0.11	0.43
Range	10-11.1	10.0-11.2	
1 month postoperative			
Mean±SD	8.4±0.27	8.3±0.25	0.28
Range	7.9-9.1	8.0-9.0	
3 months postoperative			
Mean±SD	8.6±0.28	8.55±0.26	0.52
Range	8.1-9.2	8.2-9.1	

CH, corneal hysteresis.

Both CH and CRF were measured in both groups postoperatively at 1 and 3 months of follow-up.

After 1 month, CH and CRF were 8.4 ± 0.27 (range: 7.9–9.1) and 8.2 ± 0.23 (range: 7.8–8.6) in group A and 8.3 ± 0.25 (range: 8.0–9.0) and 8.17 ± 0.19 (range: 7.9–8.5) in group B, respectively, with no significant difference (*P* = 0.28 and 0.45, respectively). At 3 months, CH and CRF were 8.6 ± 0.28 (range: 8.1–9.2) and 8.3 ± 0.21 (range: 7.8–8.6) in group A and 8.55 ± 0.26 (range: 8.2–9.1) and 8.28 ± 0.18 (range: 7.9–8.6) in group B, respectively, with no significant difference (*P* = 0.56 and 0.32, respectively) (Tables 2 and 3).

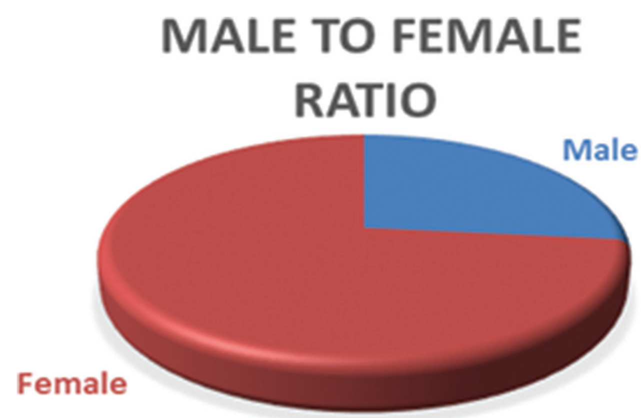

Figure 1 : Male to female ratio in our study.

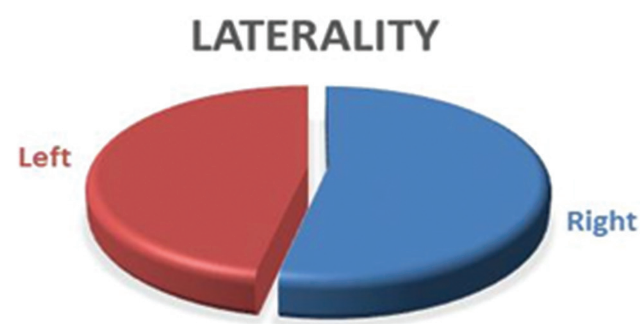

Figure 2 : Left to right ratio in our study.

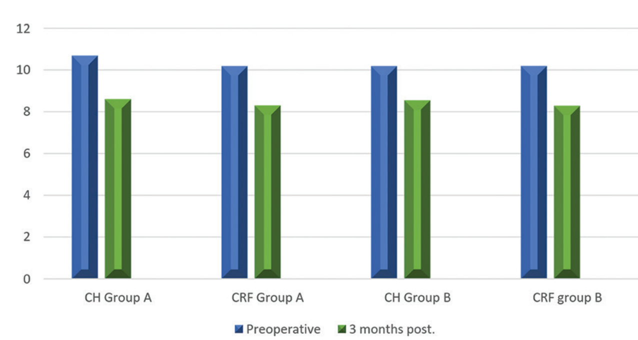

Figure 3 : Chart showing CH and CRF values pre and post at 3 months in both groups.

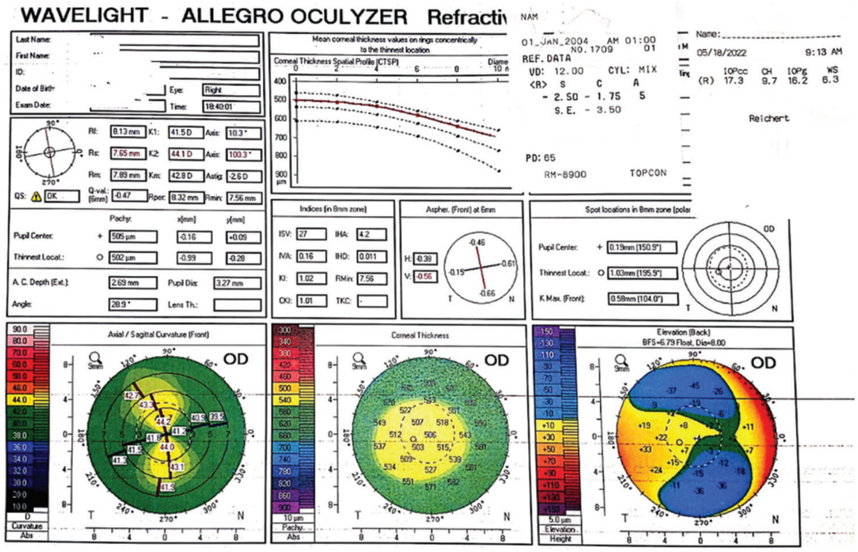

Figure 4 : Preoperative patient for LASIK

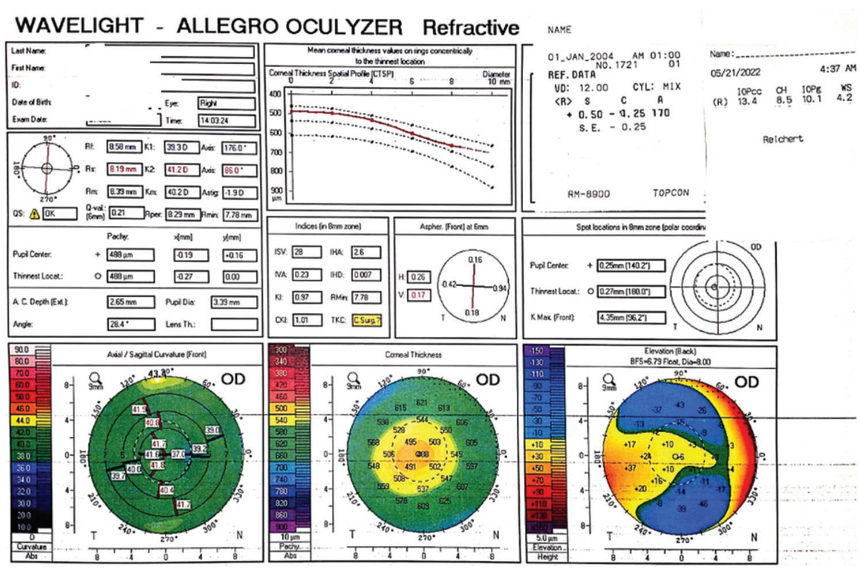

Figure 5 : Postoperative 3 months after LASIK

Table 3: Preoperative, 1 month, and 3 months postoperative values of corneal resistance factor in both groups

CRF	Group A	Group B	*P*
Preoperative			
Mean±SD	10.2±0.11	10.21±0.1	0.25
Range	10.1-10.5	10-10.5	
1 month postoperative			
Mean±SD	8.2±0.23	8.17±0.19	0.45
Range	7.8-8.6	7.9-8.5	
3 months postoperative			
Mean±SD	8.3±0.21	8.28±0.18	0.32
Range	7.8-8.6	7.9-8.6	

CRF, corneal resistance factor.

The corneal biomechanical parameters decreased after both PRK and LASIK procedures. The postoperative measurements of CH and CRF at 3 months were lower than the preoperative values in both groups with a significant amount ($P < 0.001$) (Table 4, Figs. 3-7).

Discussion

The biomechanical properties of the eye play an important role in good optical and visual functions of the eye. These properties are essential in visual performance and quality of vision after corneal refractive surgery [6].

Corneal refractive surgeries such as LASIK, PRK, femtosecond LASIK, laser-assisted subepithelial keratectomy, and SMILE

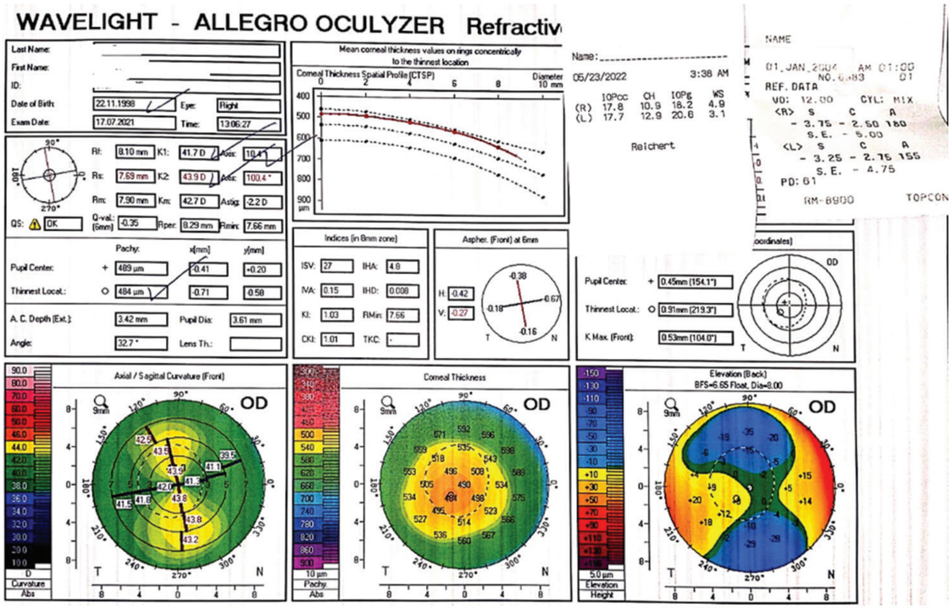

Figure 6 : Preoperative patient for PRK

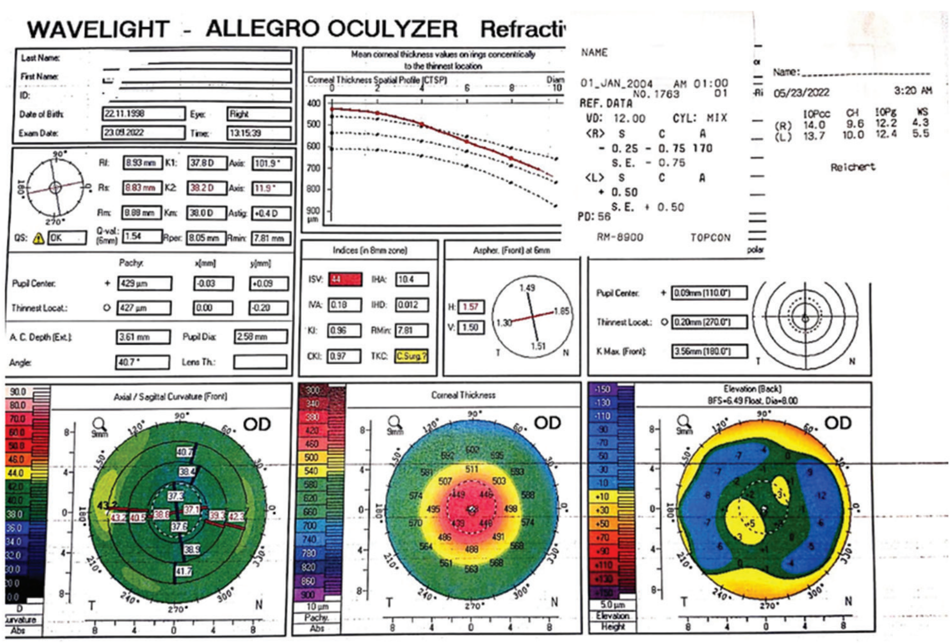

Figure 7 : Postoperative patient after PRK

Table 4: Statistically significant difference between preoperative and postoperative values of corneal hysteresis and corneal resistance factor

	Group A		Group B	
	CH	**CRF**	**CH**	**CRF**
Preoperative	10.7±0.4	10.2±0.11	10.2±0.11	10.21±0.1
3 months postoperative	8.6±0.28	8.3±0.21	8.55±0.26	8.28±0.18
P	<0.001	<0.001	<0.001	<0.001

CH, corneal hysteresis; CRF, corneal resistance factor.

lead to changes in corneal biomechanical parameters due to stromal removal or ablation, which in turn causes a decrease in CH and CRF [7–9].

CH and CRF are corneal biomechanical properties, which reflect the corneal viscoelastic properties [10]. In the present study, we evaluated CH and CRF after PRK and LASIK.

The study participants included 40 eyes with mild to moderate myopia eligible for refractive surgery. Eleven (27.5%) of the eyes were of males while 29 (72.5%) were of females and 53.3% of the eyes studied were right eyes and 46.7% were left. They were divided into two groups: group A: 20 myopic eyes undergoing PRK surgery, with age ranged from 19 to 36 years and group B: 20 myopic eyes undergoing LASIK surgery with age ranged from 20 to 35 years. There was no statistically significant difference in age and sex between the two studied groups ($P > 0.05$).

Preoperatively, there was no significant difference between the two groups concerning spherical equivalent and CCT as well as the values of CH and CRF that showed no statistically significant difference between both groups preoperatively.

This study showed that there was statistically significant difference between PRK and LASIK in CH and CRF degree of change with more decrease after LASIK. So both LASIK and PRK showed significant decrease in CH and CRF with more value difference in the LASIK group.

These results were in agreement with the Kamiya *et al*.[11] study, which demonstrated that LASIK significantly decreased CH and CRF more than PRK, suggesting that LASIK could affect corneal biomechanics more than PRK. The main t reason could be that LASIK procedure includes flap creation and tissue removal, but PRK includes only tissue removal. In addition, LASIK ablates more of the deeper layers of the corneal stroma than PRK.

On the other side, Hwang *et al*.[1] recently studied the biomechanical properties of 230 eyes after LASIK and 115 eyes after PRK without MMC and found similar decreases after both procedures. The lack of a significant difference between the two procedures mostly indicates similar long-term effects on corneal biomechanical properties by LASIK and PRK. This study did not report early postoperative changes, so the changes in CH and CRF in the immediate postoperative time period are unknown for their patients. One advantage of the Hwang *et al*. [1] study is that they included a large cohort of patients and measured CH and CRF at 3, 6, and 12 months after LASIK and PRK, with and without MMC. However, the main disadvantages of their study is that they did not randomize the patients and that the treatment groups had variant baseline refractive error, CCT, CRF, and CH.

Conclusion

In conclusion, this study demonstrated that both PRK and LASIK substantially weaken the biomechanical strength of the cornea, the greater the amount of myopic correction, the more the change in corneal biomechanics, where changes were larger after LASIK than after PRK. These findings indicate that PRK may be biomechanically a less invasive approach than LASIK, which requires not only deeper tissue ablation but also the creation of a thick flap.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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