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Research Article

Outcomes of Photorefractive Keratectomy in Patients Who Underwent Keratoplasty

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Abstract

Purpose: To assess the efficacy of photorefractive keratectomy (PRK) in patients who underwent corneal transplantation, and to determine the influencing factors. *Methods*: The present study was a retrospective chart review research that was conducted at Dhahran Eye Specialist Hospital between 2014 and 2017. *Results*: Seventy-nine eyes were included in the study. The mean BCVA showed an improvement of two lines post-PRK as compared to that before PRK (0.73 ±0.1 and 0.54 ±0.2, respectively). There was a statistically significant decrease in the cylindrical value postoperatively as compared to that preoperatively (−2.15 ± 1.4 and−3.25 ±1.8, respectively; $p < 0.001$). However, there was no statistically significant difference in spherical equivalent and sphere. Three eyes (4%) developed postoperative complications. There was a medium positive correlation between residual stroma and achieved spherical equivalent (SE) ($r = 0.305$, $p = 0.006$), as well as between optical zone and postoperative uncorrected visual acuity ($r = 0.350$, $p = 0.001$), in addition to post SE ($r = 0.307$, $p = 0.006$). However, the depth of ablation showed a medium negative correlation with achieved SE ($r = -0.375$, $p = 0.001$). *Conclusion*: PRK may be an option for correcting refractive errors in patients who underwent keratoplasty. The optical zone and residual stromal thickness have a positive correlation with the effects of the outcomes, whereas the depth of ablation has a negative correlation with the outcomes.

Keywords

Photorefractive Keratectomy, Keratoplasty, Refractive Errors

1. Introduction

Corneal transplantation refers to the replacement of the diseased host corneal tissue with a healthy donor cornea. Although corneal transplantation is a successful procedure, it produces unpredicted refractive errors owing to several factors, such as wound healing pattern, surgical technique, suturing, and donor corneal tissue. [1, 2] One way to mitigate these errors is using spectacles and soft/hard contact lenses. [3] However, most patients prefer to avoid their use; thus, photorefractive keratectomy (PRK) is used to correct these refractive errors. The former procedure is approached either with a wavefront- or topography-guided treatment. In wavefront-guided treatments, the information is derived from the entire optical system. However, in topography-guided treatments, which is used mainly for patients with irregular cornea,

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the information is collected from corneal topography. [4]. The aim of this procedure is to reshape the cornea into an ideal curve by taking into account the current spherocylindrical correction. [4]

As no such study has been conducted in the Eastern province of Saudi Arabia previously, the present study aimed to assess the efficacy of PRK in patients who underwent keratoplasty and to determine the influencing factors.

Patients and Methods: The present retrospective study was conducted at Dhahran Eye Specialist Hospital between 2014 and 2017; data were collected from the patients' medical records, and no controls were included in this study. Approval was obtained from the aforementioned medical institution. Two modalities of treatment were used in the present study, namely, wavefront-guided and corneal topography-guided treatments. Most of the cases involved patients with advanced keratoconus [5], whereas a few cases involved patients with conditions ranging from corneal scars to dystrophies.

The inclusion criteria for the present included patients who underwent corneal transplantation and PRK; there was no exclusion criterion. Among the subjects who fulfilled all the eligibility criteria, the following data were collected: age, gender, treated eye, primary diagnosis, preoperative best uncorrected visual acuity (BUVA), best-corrected visual acuity (BCVA) with Snellen charts (converted to decimals values for analysis), manifest refraction, and topographic parameters. In addition, treatment characteristics, such as the optical and ablation zones, complications after PRK, complications after corneal transplantation, the interval between keratoplasty and PRK, the interval between removal of the last suture and PRK, and follow-up duration, were collected.

The outcome measures included best uncorrected visual acuity (BUVA) post-PRK, BCVA post-PRK, and any related factors. All patients were informed about the risks and benefits of the procedure and they signed an informed consent form.

Surgical Technique and Postoperative Management: PRK was performed using a Wavelight Ex500 excimer laser (Alcon Laboratories, Inc.). During the procedure, some cases were treated with wavefront-guided treatment and the other cases were treated with topography-guided treatment, based on consultant preference. The epithelium was removed using alcohol debridement. Application of 0.02% mitomycin C (MMC) was performed at the end of the procedure. The laser ablation and optical zone varied among the cases. Postoperatively, a bandage soft contact lens was used along with topical steroids, antibiotics, and lubrication for 1 week.

Statistical Analysis:

Data were collected and saved in Excel, results were analyzed with logMar, and analysis of visual acuity was converted to decimals for discussion and comparison. Statistical comparisons were made using SPSS software. A P value of 0.05 was considered statistically significant.

The Safety Index was defined as BCVA after treatment divided by BCVA before treatment (BCVA post/BCVA pre).

The Efficacy Index was defined as UCVA after treatment divided by BCVA before treatment (UCVA post/BCVA pre).

2. Results

In total, 79 eyes of 77 patients underwent PRK after keratoplasty. The mean patient age was 31.1 ± 6.1 (range, 16-49) years. Of the 77 patients, 35 (45.4%) were younger than 30 years of age, whereas the other 37 (48%) patients were older than 30 years of age. Twenty-seven (35.1%) patients were women, and 50 (64.9%) were men. Twenty-nine (36.7%) of the treated eyes were the right eye, and 50 (63.3%) were the left eye. In addition, 74 (93.7%) of the treated eyes had advanced keratoconus, and the other five eyes (6.3%) had other conditions, such as scars and corneal dystrophies. Table 1 shows the patient characteristics. Only four patients had associated ocular diseases, such as glaucoma and cataract. Thirty-one (39.2%) patients were treated with penetrating keratoplasty, whereas the other 40 (50.6%) patients were treated with lamellar keratoplasty. Eight eyes (10.1%) had complications post-keratoplasty, such as corneal neovascularization, penetrating trauma, and corneal transplanted rejection, and three eyes (4 %) had complications post-PRK, such as recurrent corneal erosion and exotropia. The mean duration between keratoplasty and PRK was 32.7 (range, 21-42.5) months. The mean duration between suture removal and PRK was 14.6 (range, 4.25-21.75) months. The mean duration between PRK and the last follow-up was 16.84 (range, 5-24) months. Table 2 shows the graft characteristics. Table 3 shows the ranges of the treatment variables.

Table 1. *Patient characteristics.*

	Wavefront-guided	Topography-guided	Total sample
Gender			
Male	20 (69.0 %)	32 (64.0%)	50 (64.9%)
Female	9 (31.0%)	18 (36.0%)	27 (35.1%)
Age in years			

	Wavefront-guided	Topography-guided	Total sample
Less than 30	12 (44.4 0/0)	23 (51.1 %)	35 (45.4 0%)
30 and above	15 (55.6 %)	22 (48.9 %)	37 (48%)
Treated eye			
OD	7 (24.1 %)	22 (44.0 %)	29 (36.7%)
OS	22 (75.2 %)	28 (56.0 %)	50 (63.3%)
Primary Diagnosis			
Keratoconus			74 (93.7%)
Other diagnoses			5 (6.3%)

Table 2. *Graft characteristics.*

Eyes (n)	**79**
Penetrating keratoplasty	31 (39.2%)
Lamellar keratoplasty	40 (50.6%)
Associated conditions (n)	
Glaucoma/ocular hypertension	2
cataract	2
Keratoplasty-related complications	8 (10.1%)
PRK-related complications	3 (4%)
Duration (months) between PRK and	Mean (Range)
Keratoplasty	32.7 (21 - 42.5)
Suture removal	14.6 (4.25 - 21.75)
Last follow-up	16.84 (5 - 24)
PRK, photorefractive keratectomy.	

Table 3. *The range of the treatment variables.*

	Range
CCT	400 — 650 pm
Residual stroma	300 — 500 um
Optical zone	5 — 7 mm
Ablation zone	8 — 9 mm
CCT, central corneal thickness	

In total, 32% of patients, without glasses, achieved their best-corrected visual acuity (BCVA) before photorefractive surgery with a total efficacy index of 0.70 (range: 0.40-1.20). In addition, BCVA showed a statistically significant improvement of two lines post-PRK as compared to before PRK (0.73 and 0.54, respectively, $P < 0.001$), as shown in Table 5. Both spherical equivalent and sphere did not change (−3.26 and−3.23, respectively; P = 0.552 and −2.08 and−2.82, respectively; P = 0.182); the cylindrical value decreased postoperatively (−2.15 vs. −3.25, P = 0.001), table 4. Moreover, the collected data were analyzed according to which modality of treatment was used to treat the refractive error. In the group that underwent wavefront-guided treatment, BCVA showed a statistically significant one-line improvement post-PRK as compared to before PRK (0.68 and 0.52, respectively; = 0.001), as shown in Table 5. The spherical equivalent (−3.96 vs. −1.79, P = 0.004), sphere (−3.12 vs. −0.8, P = 0.001), and cylindrical value (−3.13 vs. −1.99, P = 0.027) decreased postoperatively, as shown in Table 4.

In the group that underwent topography-guided treatment, BCVA showed a statistically significant one-line improvement post-PRK as compared to before PRK (0.65 and 0.54, respectively; = 0.005), as shown in Table 5. Postoperatively, the spherical equivalent increased (−4.35 vs. −2.54, P = 0.014), the sphere showed no change (−3.00 vs. −3.03, P = 0.28), and the cylindrical value decreased (−2.46 vs. −3.61, P = 0.001), as shown in Table 4.

Table 4. *Refractive errors.*

	Wavefrontguided	**Topographyguided**	**Total**
Preoperative (PRK) spherical equivalent (D)	-3.96 ±2.6	-2.54 ±1.9	-3.23 ±2.5
Postoperative (PRK) Spherical equivalent (D)	-1.79 ±1.8	-4.35 ±3.5	-3.26 ±2.9
P value	0.004*	0.014*	0.552
Preoperative (PRK) spherical power (D)	-3.12 ±2.9	-3.03 ±3.4	-2.82 ±3.1
Postoperative (PRK) spherical power (D)	-0.80 ±1.5	-3.00 ±3.4	-2.08 ±2.8
P value	0.001*	0.283	0.182
Preoperative (PRK) cylindrical power (D)	-3.13 ±1.6	-3.61 ±1.7	-3.25 ±1.8
Postoperative (PRK) cylindrical power (D)	-1.99 ±1.5	-2.46 ±1.5	-2.15±1.4
P value	0.027*	0.001*	<0.001*

All the visual acuities are in decimals PRK, photorefractive keratectomy.

Table 5. *Preoperative and postoperative comparison of BCVA in different modalities.*

	Wavefront-guided	**Topography-guided**	**Total**
Preoperative (PRK) BCVA	0.52 ±0.21	0.54 ±0.20	0.54 ±0.2
Postoperative (PRK) BCVA	0.68 ±0.25	0.65 ±0.21	0.73 ±0.1
P value	0.001*	0.005*	<0.001*

All the visual acuities are in decimals. PRK, photorefractive keratectomy; BCVA, best corrected visual acuity,

Figure 1 shows the efficacy of photorefractive keratectomy in patients who underwent keratoplasty. A comparison between preoperative BCVA and postoperative UCVA showed that the percentage of eyes with a visual acuity better than 20/30 and that of eyes with a visual acuity worse than 20/60 were similar. However, those with a visual acuity between 20/30 and 20/60 showed a noticeable difference between post UCVA and pre-BCVA.

Safety of the procedure is shown in Figure 2. Preoperative and postoperative BCVA were analyzed, and the gain or loss of visual acuity lines is shown in Figure 2. In total, 57.0% of the eyes gained one or more lines; these results reflect potential extra benefits of the procedure and might be explained by the correction made on the corneal level, which is optically better than that on the glasses level. However, only 8.8% of eyes lost 2 or more lines of BCVA, which reflects the excellent safety of the procedure, shown in Figure 2.

The residual refractive errors post-PRK showed a mean of −3.26 ± 2.9 for spherical equivalent, a mean of −2.08 ± 2.8 for spherical power, and a mean of −2.15 ± 1.4 for cylindrical power. Table 4 shows a comparison of refractive errors preoperatively and postoperatively.

3. Discussion

The present study was undertaken to assess the outcomes of PRK in patients who underwent keratoplasty using wavefront- or topography-guided treatment methods. Both procedures provided satisfactory outcomes with regard to BCVA post-PRK. Presently, PRK, one of the many forms of refractive surgeries, is becoming the mainstay of therapy to correct refractive errors post-keratoplasty [1, 6-9]. A study by Paul et al. [10] showed a significant decrease in SE and improvement in UCVA. In their practice, they retained the suture until they became fragile or broke, to decrease the refractive errors, while in our practice, we usually removed the suture 1-year post-keratoplasty; this difference might have affected the results of UCVA and BCVA.

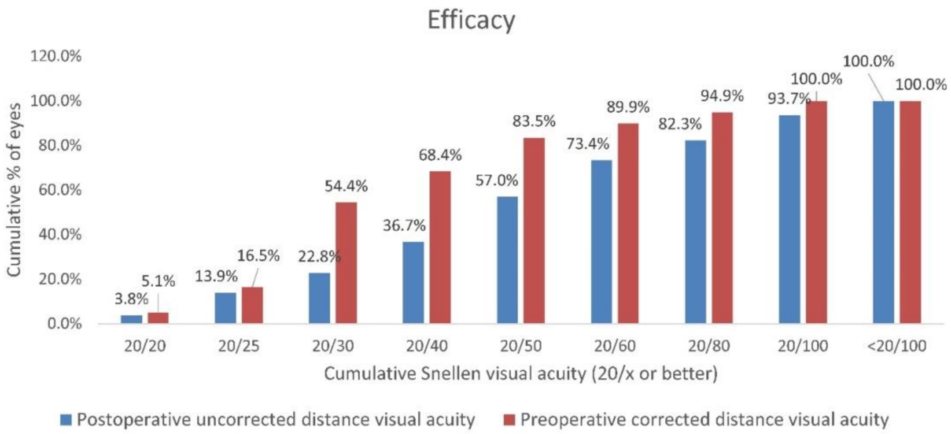

***Figure 1**. Efficacy of PRK in patients who underwent keratoplasty.*

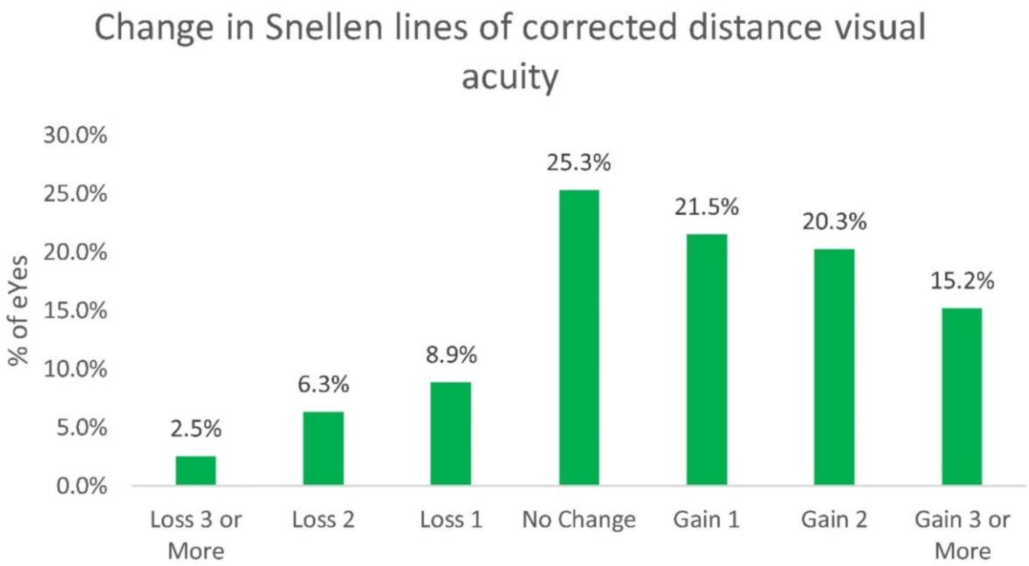

***Figure 2**. Safety of photoreactive keratectomy in patients who underwent keratoplasty.*

Another study conducted by Inês et al. [11] analyzed the efficacy of topography-guided photorefractive keratectomy (TG-PRK) to treat the refractive errors post-keratoplasty in 31 eyes (23 of them were diagnosed with keratoconus). A gain of >1 UCDVA line was noted in 96.8% (n = 30) of the eyes, and a significant improvement of the refractive parameters was noted. Their results are similar to the results of the present study, except for that of the spherical power; in the present study, there was no significant difference.

Matthew et al. [12] evaluated the efficacy of PRK with adjunct MMC treatment in patients who underwent keratoplasty in 20 eyes. In their study, 10 eyes (50%) gained 2 or more lines of BCVA, 13 patients (65%) had an UDVA of 20/40 or better, and 18 eyes (90%) had a BCVA of 20/40 or better.

Adriana et al. study [13] showed that 19 out of 36 eyes (52.8%) achieved an uncorrected visual acuity of 20/40 or better. In the present study, 35 out of 79 eyes (44 %) had an UDVA of 20/40 or better, and 67 out of 79 eyes (85 %) had a

BCVA of 20/40 or better.

In addition, Timmy et al. showed in their study [14] that there was a 2-line or greater improvement of uncorrected visual acuity in 8 of the 14 patients who underwent PRK treatment.

Although > 96% of non-transplanted eyes achieved an UCVA of 20/40 or better after PRK [15], this result was only achieved in 44% of the eyes in the present study.

As shown in Figure 3, the procedure was effective in reducing preoperative refractive astigmatism of 3 D or more. Mukhtar et al [16] has a similar results regrading reducing preoperative refractive astigmatism, their mean astigmatism improved from −4.4 ± 0.26 D preoperatively to −2.4 ± 0.26 D at the final follow-up.

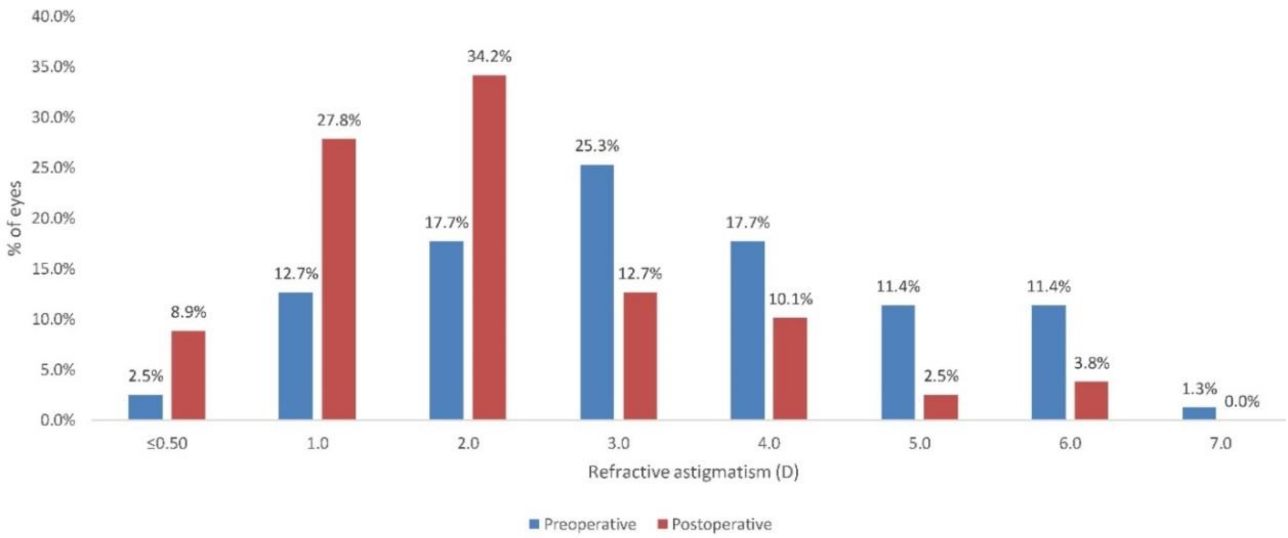

Figure 3. *Comparison between preoperative refractive astigmatism and postoperative refractive astigmatism.*

Table 6. *Comparing the results of previous similar studies with the present study.*

Comparing the results of previous similar studies with the present study									
	Sample size	**Gaining lines of**	**VA 20/40 or better**	**Pre-BCVA**	**Post-BCVA**	**P value in spherical power D**	**P value in cylindrical power D**	**P value in SE**	**The efficacy index**
Present study	79	BCVA in 20%	44% of UCVA	0.54	0.73	insignificant (-0.182)	significant (< 0.001)	insignificant (-0.552)	0.7
Inés et al (topography guided)	31	UCVA in 96%	no data	0.56	0.71	no data	significant (< 0.001)	significant (< 0.002)	no data
Matthew et al	20	no data	Eighteen eyes (90%) BCVA	0.4	0.6	significant (-0.001)	significant (0.01)	significant (0.001)	no data
Paul et al	32 (PRK)	BCVA in 91%	no data	no data	no data	no data	no data	significant (< 0.01)	2.21
Adriana et all	36	BCVA of 8 eyes (22.2%)	Nineteen eyes (52.8%) UCVA	0.62	0.69	no data	significant (< 0.001)	significant (< 0.001)	0.76
Timmy et al	11 (PRK)	UCVA in 8 eyes (57%).	no data	0.36	0.44	insignificant (-0.06)	significant (< 0.02)	insignificant -0.25	no data

PRK, photorefractive keratectomy; CDVA, corrected distance visual acuity; UCVA, uncorrected visual acuity; SE, spherical equivalent; VA; visual acuity.

Table 6 summarizes the results of previous similar studies and our current study.

Adriana et al. [13] showed a significant negative correlation between time of keratoplasty and safety index (r = 20.37; P = 0.026). However, in the present study, time of keratoplasty and safety index had a statistically insignificant negative correlation (r = −0.172, p = 0.178).

The analysis of the correlation between the measured outcome and related variables showed that there was no significant effect of age, gender, modality of treatment (wavefront-guided and topography-guided), corneal transplantation type (penetrating keratoplasty and deep anterior lamellar keratoplasty) central corneal thickness, ablation zone, and the duration between keratoplasty and suture removal and that between suture removal and PRK on postoperative BCVA, postoperative UCVA, postoperative SE, and achieved SE.

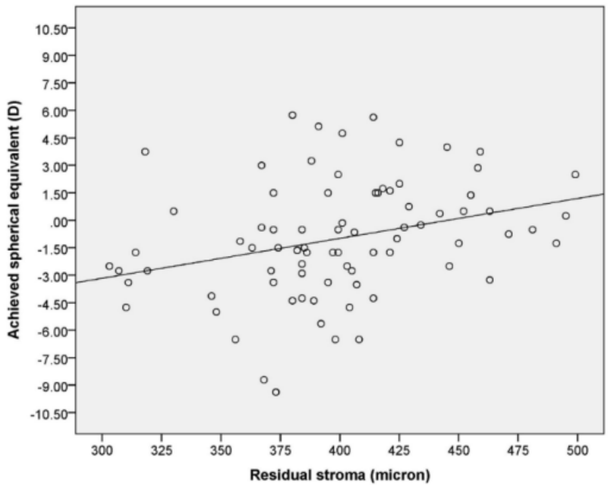

Figure 4. *Association between residual stromal bed thickness and achieved spherical equivalent; A spherical equivalent of plano or more is achieved with a large stromal bed.*

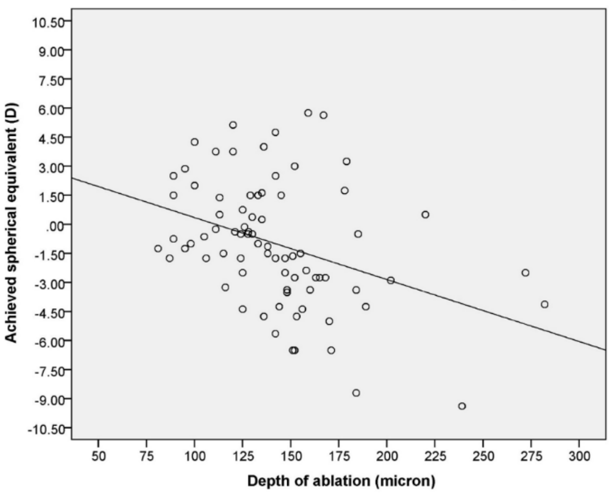

Figure 5. *Association between depth of ablation and achieved spherical equivalent; A spherical equivalent of plano or more is achieved when the depth of ablation is less.*

There was a medium positive correlation between residual stroma and achieved SE (r = 0.305, p = 0.006), as shown in figure 4, and between optical zone and postoperative UCVA (r = 0.350, p = 0.001), in addition to post SE (r = 0.307, p = 0.006). However, there was a medium negative correlation between the modality of treatment (wavefront-guided vs. topography-guided) and postoperative UCDVA (r = -0.355, p = 0.001). The UCDVA post-wavefront-guided treatment (0.50 ± 0.21) was better than that post-topography-guided treatment (0.34 ± 0.26). In addition, the depth of ablation had a medium negative correlation with achieved SE (r = -0.375, p = 0.001), as shown in Figure 5.

A review of the complications post-PRK in the present study showed one patient who developed exotropia. Few studies discuss orthoptic changes post-PRK, and most of them are more about ocular decompensation. Rajavi et al. [17] showed in their study that 6 patients (4%) developed new near exotropia.

Other studies [17-19] showed that preexisting strabismus might improve, especially in esotropia, or remain unchanged after PRK.

The primary objective of our intervention was to achieve BCVA without the use of spectacles; thus, future studies should include better surgical interventions to overcome the residual refractive errors post penetrating keratoplasty. In addition, a future study should conduct a more detailed comparison between the wavefront-guided and topography-guided method.

One of the limitations of our study was its retrospective design. In addition, UCVA, which would have been a valuable measure, was not collected in the present study.

In conclusion, the present study showed that photorefractive surgery is an option to reduce refractive errors in patients who underwent keratoplasty.

4. Conclusion

PRK may be an option for correcting refractive errors in patients who underwent keratoplasty. The optical zone and residual stromal thickness have a positive correlation with the effects of the outcomes, whereas the depth of ablation has a negative correlation with the outcomes.

Abbreviations

PRK	Photorefractive Keratectomy
SE	Spherical Equivalent
BUVA	Best Uncorrected Visual Acuity
BCVA	Best Corrected Visual Acuity
MMC	Mitomycin C
TG-PRK	Topography-Guided Photorefractive Keratectomy
UCDVA	Uncorrected Distance Visual Acuity

Conflicts of Interest

The authors declare no conflicts of interest.

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