Original Article

Visual outcomes and quality of life before and after photorefractive keratectomy

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Purpose: To compare visual outcomes and vision-related quality of life (VRQoL) between subjects before and after photorefractive keratotomy (PRK) and controls. In addition, VRQoL was compared between subjects at different periods of PRK surgery. **Methods:** This was a cross-sectional study that included subjects with refractive errors aged 19–40 years and age-matched controls. Subjects were divided into three groups: pre-, post-PRK, and control. Subjects in the post-PRK group were divided into three subgroups (1-week, <6-month, and >6-month follow-up visits). Measurements including uncorrected distance visual acuity (UCVA), corrected distance visual acuity (CDVA), spherical equivalent (SE) of manifest refraction, and corneal topography were obtained for all participants. The Quality of Life Impact of Refractive Correction (QIRC) questionnaire was administered to compare VRQOL between groups and between post-refractive surgery subgroups. **Results:** A total of 145 participants were included in this study. The mean age ± standard deviation (SD) of all participants was 26.29 ± 5.1 years. There was a significant difference ($P < 0.001$) in total QIRC scores between groups. The total QIRC score was better in the post-PRK group than in the pre-PRK and control groups. The scores of items included in the convenience, well-being, and health concern domains were significantly higher in the post-PRK group than in the pre-PRK and control groups. Within the post-PRK group, significant differences ($P < 0.001$) were found in UCVA and SE between the post-PRK subgroups. Uncorrected VA and SE were better in the post-PRK groups who were followed up in the < 6 and > 6 months subgroups than in the 1-week follow-up subgroup ($P < 0.0001$). **Conclusion:** A significant improvement in visual outcomes and VRQoL occurred after PRK surgery. Subjects enjoyed their VRQoL after refractive surgery.

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Refractive errors are common visual problems that can be affected by genetic and environmental factors such as ethnicity, education, near-work, and outdoor activities.[1-3] Traditional optical corrections (spectacles and contact lenses [CLs]) have some disadvantages, which have played a role in the trends of many people to find alternative corrections of their refractive errors, such as refractive surgery.[4] Visual outcomes after refractive surgery can be determined by objective standards of clinical measurements, which do not always correlate well with subjects' postoperative impressions on visual functions. Thus, measuring subjects' perspectives on their VRQoL and the routine evaluation of refractive surgery outcomes are important outcomes of refractive surgery.[5]

Quality of life is a condition of well-being that has been introduced as one of the most significant criteria to assess health and physical, psychological, and social activities as well as subjects' satisfaction.[6] Increasing attention to VRQoL in ophthalmology has led to the development of many instruments to assess QoL in the form of questionnaires.[5,7] Refractive errors can decrease VRQoL, and many studies have reported that uncorrected refractive errors can negatively affect subjects' QoL as they can lead to an increased risk of falls, depression, and functional decline.[8] Rose *et al*.[9] found that subjects with high myopia (≥10.00 D) had significantly poorer VRQoL than subjects with low myopia. Chen *et al*.[10] reported that subjects with myopia of ≥0.50 D had worse VRQoL scores compared to normal subjects. McAlinden *et al*.[11] reported that the quality of vision of subjects with myopia and hyperopia was worse at 5 days and 2 weeks after LASEK surgery, but it was improved by 1 month after the surgery. Accordingly, the postoperative VRQoL of subjects may vary with different periods after surgery. It is important to point out that in December 2018, a female subject experienced a slow recovery after refractive surgery and committed suicide.[12] This accident led to the necessity of further studies focused on the impact of refractive surgery on subjects' QoL from the subjects' perspective.

As refractive errors can be affected by environmental and cultural factors, the perspective of subjects living in different

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cultures can also differ regarding their VRQoL. No study has assessed visual outcomes and VRQoL in subjects living in hot and dry countries, such as Saudi Arabia, before and after refractive surgeries. Factors and results regarding VRQoL changes before and after refractive surgeries have been discussed in previous studies; however, most of these studies assessed VRQoL by using general VRQoL questionnaires. Few studies have used specific refractive correction questionnaires to assess VRQoL. In this study, we selected a valid and reliable tool to assess the effect of PRK on QoL in subjects living in a culture that differs from cultures where previous studies have been performed, which could be a factor affecting subjects' quality of life. Although PRK surgery is still promising in correcting refractive errors, decreasing visual outcomes and increasing dryness are issues that can occur after PRK, especially in hot and dry countries. Indeed, findings about the VRQoL of subjects before and after they have undergone refractive surgeries are contradictory in the literature. There is no study available in the literature that assesses the VRQoL of subjects living in very hot and dry environments before and after refractive surgeries. Thus, the aim of this study was to compare VRQoL in subjects living in different cultures before and after they underwent PRK surgeries.

Methods

This was a cross-sectional study that included subjects with refractive errors (myopia, hypermetria, or astigmatism) aged 19–40 years and age-matched controls. Refractive surgery is indicated for refractive error up to 10 D of myopia, 6 D of hyperopia, and up to 4 cylinders of astigmatism.[13] The inclusion criteria for subjects included in this study were myopia spherical equivalent ≤10.5 D, hyperopia spherical equivalent ≤4.50 D, and astigmatism ≤6.00 D.[14] Subjects were recruited from anterior segment clinics at the ophthalmology department of a tertiary hospital in Riyadh, Saudi Arabia. Subjects were chosen randomly for different groups based on the inclusion criteria. Subjects included in this study had good general health and normal ocular surfaces, with no ocular pathology, did not have any previous ocular surgery, and were confirmed to have pre-presbyopia.

Subjects were divided into three groups: pre-PRK, post-PRK, and controls. Subjects in the pre-PRK group had spherical equivalents less than −10 D and corneal thicknesses of 490 μm or higher with stable refraction for at least 1 year. Subjects in the post-PRK group had surgery for no longer than 5 years. Controls were subjects who wore spectacles and/or contact lenses (CLs) but who did not intend to correct their refractive error by refractive surgeries. Subjects in the pre-PRK group were different individuals than subjects in the post-PRK group. The PRK procedure was chosen in this study because it is most commonly a corneal refractive surgical procedure, and it is typically suitable for low degrees of myopia and hyperopia. In addition, PRK remains a popular procedure as it has no flap-related complications. Thus, it can be a suitable procedure in conditions such as a thin cornea, epithelial dystrophy, recurrent corneal erosions, and dryness.[15]

Subjects under the age of 19 years or above 40 years were excluded from this study. This is important as subjects aged 40 years and over could have presbyopia, which could be a confounding factor affecting the subject's perspective on their QOL. Subjects with spherical equivalent (SE) greater than −10 D or ocular diseases such as glaucoma, cataracts, retinal diseases, and keratoconus were excluded from this study. Subjects with systemic diseases such as diabetes or those under medication were also excluded from this study as these factors could alter visual function measurements.

All subjects underwent full ophthalmological examination. Ocular measurements included UDVA, CDVA (measured using a Snellen chart and recorded in LogMAR), SE (measured by autorefractometer), and corneal topography (measured by Oculus Pentacam HR). Because CLs may induce corneal warpage and corneal edema,[16] subjects were informed to avoid wearing CLs before the examination and the procedure.

Ethics approval was obtained from the institute's review board at medical group hospitals. Informed consent was obtained from participants after explanation of the nature and possible consequences of the study, and the research followed the tenets of the Declaration of Helsinki.

The Arabic version of the QIRC questionnaire was used in this study to assess VRQoL in subjects before and after PRK surgery and controls. The English version of the QIRC questionnaire was developed and validated using Rasch analysis to measure the impact of refractive correction.[7] The QIRC is a standard psychometric property and includes 20 items about visual function, symptoms, convenience, cost, health concerns, and well-being.[5] The Arabic version of the QIRC questionnaire was validated using Rasch analysis. Rasch analysis showed that the Arabic QIRC questionnaire had good precision and reliability as person separation (2.01) and reliability (0.80) and Cronbach's α (0.79) indicated good stability of the Arabic 20-item QIRC. The validity and reliability of the Arabic translation of the QIRC questionnaire is a topic of another study that is under the process of publication as an original article in another scientific journal (in press). Subjects participating in this study read the information sheet and signed the consent form. The questionnaire was administered to participants as a self-report questionnaire, and they were asked to respond to all items included in the questionnaire by using the response scale. The response scale for each item included five categories (1, 2, 3, 4, and 5) plus a "Not applicable" response. "Not applicable" responses or items left blank were considered missing data and were not considered when calculating the QIRC scores.

Statistical analysis

Statistical analysis was performed using Statistical Package for the Social Sciences version 22.0 software (SPSS Inc, Chicago, IL, US). First, the normality of the data was tested using the Shapiro–Wilk test. Demographic information and ocular measurements were compared between groups using the Chi-squared test. Analysis of variance (ANOVA) was used to compare CCT among the groups. The overall QIRC score and a question-by-question basis were compared between groups to assess VRQoL. Means and standard deviations were compared using the Kruskal–Wallis test. $P < 0.05$ was considered statistically significant.

Results

Participants

A total of 145 subjects were included in this study. The characteristics of the participants are shown in Table 1. Ocular

Table 1: Characteristics of participants

	Control *n*=51	Pre-PRK *n*=50	Post-PRK *n*=44	*P*
Age Mean±SD	23.92±4.54	26.44±4.36	28.89±5.43	<0.001
Gender				
Female *n* (%)	43 (84.3%)	40 (80.0%)	34 (77.3%)	0.679
Refractive error *n* (%)				
Mild myopia	30 (58.8%)	24 (48.0%)	21 (48.0%)	
Moderate Myopia	15 (29.4%)	20 (40.0%)	20 (45.4%)	
Sever myopia	5 (9.8%)	5 (10.0%)	3 (6.8%)	
Hyperopia	1 (2.0%)	1 (2.0%)	0 (0%)	
Optical correction *n* (%)				
Spectacles	44 (86.3%)	39 (78.0%)	0	0.187*
Contact lenses	0 (0%)	3 (6.0%)	0	
Spectacles and CL	7 (13.7%)	8 (16.0%)	0	
CCT (R) Mean±SD	554.78±44.346	556.02±37.874	557.98±37.504	0.928
VA SC (R) *n* (%)				
00.1	4 (7.8%)	0 (0%)	0 (0%)	<0.0001
0.2-0.3	7 (13.7%)	0 (0%)	0 (0%)	
0.4-0.6	10 (19.6%)	7 (14.0%)	3 (6.8%)	
≥0.7	30 (58.8%)	43 (86.0%)	41 (93.2%)	
VA CC (R) *n* (%)				
0-0.1	50 (98.0%)	48 (96.0%)	44 (100%)	0.396
0.2-0.3	1 (2.0%)	2 (4.0%)	0 (0%)	

*The value for the comparison between pre-PRK and control groups. CCT: Central corneal thickness, VA SC=Visual acuity without correction, VA CC=Visual acuity with correction, R: Right eye, SD=Standard deviation. Classification of myopia: Mild (−0.75-−2.99 D), moderate (−3.00-−5.99 D), sever (>6.00 D).[17]

measurements for only the right eye are presented in this study. The age of participants in the post-PRK group was older than the ages of the other two groups as follow-up visits for the post-PRK group were recorded in different periods after the surgery. All three groups (pre-, post-PRK, and controls) were comparable in terms of the degrees of refractive error. The mean ages ± standard deviation (SD) of refractive errors were 3.17 ± 1.9, 2.86 ± 2.1, and 2.58 ± 3.2 in the pre-PRK, post-PRK, and controls, respectively.

Table 2 shows the overall QIRC score for the three groups. There was a statistically significant difference ($P < 0.001$) in total QIRC scores between groups. The total QIRC scores in the post-PRK group were better than those of the controls and pre-PRK groups. In the comparison of individual scores between groups, the scores of items included in the convenience, well-being, and health concern domains were significantly higher in the post-PRK group than in the pre-PRK and control groups. In the comparison between the pre-PRK and control groups, the scores of the well-being domain in the pre-PRK group were higher than the scores of the controls. No significant difference was found between groups in terms of visual function, symptoms, or well-being, although the mean score was higher in the post-PRK group than in the other two groups [Table 2].

Within the post-PRK group, subjects were classified into three groups (1 week, <6 months, and >6 months), which was based on the period of follow-up visits after surgery. Visual outcomes (VA and SE) and scores of the QIRC questionnaire were compared between subgroups at different follow-up visits. Significant differences ($P < 0.0001$) were noted in UCVA and SE between all subgroups [Table 3] as they were better in subjects followed up at the < 6 months and >6 months than at the 1-week follow-up. No significant difference was detected in the mean total QIRC score between the three subgroups [Table 3]. However, the symptom and convenience domains were found to be significantly different between the post-PRK subgroups as the scores were higher in the >6 months subgroup than in the 1-week and <6 months subgroups [Table 4]. Moreover, we did not find a correlation between the total QIRC score and UCVA in the post-PRK group ($P > 0.05$).

Discussion

Refractive surgery can be successfully used to correct refractive errors and reduce the dependency on optical correction. It provides good visual acuity and comfort to subjects with a low rate of side effects.[18] This cross-sectional study compared subjects' visual outcomes and VRQoL before and after PRK at different periods.

The principal findings of this study showed that the VRQoL of subjects after PRK surgery was better than the VRQoL of subjects before surgery. Similarly, previous studies found improvement of QoL in subjects after laser refractive surgery.[19] Pesudovs *et al*.[20] found that the VRQoL scores in subjects who underwent refractive surgery were higher than those wearing optical correction. Chen *et al*.[10] revealed that myopia corrected with optical correction had a negative impact on some domains of VRQoL, and myopes who had refractive surgery had the same VRQoL as emmetropes.

In the current study, the post-PRK group had higher scores in all domains of the QIRC, except for one item representing health concerns: "How concerned are you about eye protection from ultraviolet (UV) radiation?" [Table 2]. This indicates that subjects in the post-PRK group were more concerned about UV radiation because of continuous instructions given by ophthalmologists, especially in the early period after PRK surgery. Stojanovic and Nitter[21] proved that high UV light levels may increase the risk of late-onset corneal haze after PRK.

Table 2: The overall and individual QIRC scores of the three groups

	Control	Pre-PRK	Post-PRK	*P*
Overall QIRC score	45.79±7.15	43.68±5.69	53.84±7.14	<0.0001
1. How much difficulty do you have driving in glare conditions?	43.00±14.14	38.69±11.00	45.06±6.90	0.256
2. During the past month, how often have you experienced your eyes feeling tired or strained?	45.03±9.99	45.25±11.80	49.30±8.59	0.054
3. How much trouble is not being able to use off-the-shelf (nonprescription) sunglasses?	43.42±13.31	43.84±14.84	52.56±9.79	0.002
4. How much trouble has to think about your spectacles or contact lenses or your eyes after refractive surgery before doing things, e.g., traveling, sport, going swimming?	45.28±12.73	38.04±11.85	52.43±12.25	<0.0001
5. How much trouble is not being able to see when you wake up, e.g., to go to the bathroom, look after a baby, see alarm clock?	49.92±12.39	41.98±13.24	50.44±11.54	0.002
6. How much trouble is not being able to see when you are on the beach or swimming in the sea or pool, because you do these activities without spectacles or contact lenses?	46.72±12.56	41.08±11.62	56.19±10.92	<0.0001
7. How much trouble are your spectacles or contact lenses when you wear them when using the gym/doing keep-fit classes/circuit training, etc.?	42.53±12.14	34.71±13.16	49.61±9.85	<0.0001
8. How concerned are you about the initial and ongoing cost to buy your current spectacles/contact lenses/refractive surgery?	51.32±12.87	49.16±12.49	55.94±10.39	0.034
9. How concerned are you about the cost of unscheduled maintenance of your spectacles/contact lenses/refractive surgery, e.g., breakage, loss, new eye problems?	45.49±13.05	41.16±12.79	50.21±11.54	0.004
10. How concerned are you about having to increasingly rely on your spectacles or contact lenses since you started to wear them?	45.18±12.81	38.97±8.92	55.80±12.87	<0.0001
11. How concerned are you about your vision not being as good as it could be?	42.27±11.78	37.02±6.76	47.93±11.65	<0.0001
12. How concerned are you about medical complications from your choice of optical correction (spectacles, contact lenses, and/or refractive surgery)?	39.86±12.64	36.32±11.04	46.85±11.19	<0.0001
13. How concerned are you about eye protection from ultraviolet (UV) radiation?	47.22±13.09	47.74±12.28	45.52±11.33	0.722
14. During the past month, how much of the time have you felt that you have looked your best?	49.15±19.71	41.30±13.88	59.97±18.52	<0.0001
15. During the past month, how much of the time have you felt that you think others see you the way you would like them to (e.g., intelligent, successful, cool, etc.)?	46.12±16.66	52.18±16.90	56.91±14.68	0.013
16. During the past month, how much of the time have you felt complimented/flattered?	49.89±15.06	52.70±16.39	64.64±14.54	<0.0001
17. During the past month, how much of the time have you felt confident?	50.25±18.33	54.34±16.52	62.88±15.52	0.002
18. During the past month, how much of the time have you felt happy?	45.67±16.82	47.77±16.41	59.62±15.73	<0.0001
19. During the past month, how much of the time have you felt able to do the things you want to do?	37.33±18.67	39.15±16.42	52.08±15.16	<0.0001
20. During the past month, how much of the time have you felt eager to try new things?	48.64±19.77	48.31±15.98	56.21±15.93	0.07

Table 3: Visual functions and mean total score of QIRC for postoperative group

	1 week (*n*=13)	≤6 Months (*n*=16)	>6 Months (*n*=15)	*P*
VA SC Mean+SD	0.169±0.1377	0.031±0.0602	0.013±0.035	<0.0001
SE Mean+SD	-0.6538±0.451	-0.0781±0.405	- 0.0833±0.323	<0.0001
Mean total score of QIRC	51.962±9.02	53.633±6.626	55.703±5.746	0.390

VA SC: Uncorrected visual acuity, SE: Spherical equivalent, VA SC and SE for right eye only

It was recommended to advise subjects to wear UV-protection spectacles during the first year after PRK surgery.

UCVA and SE were worse in the 1-week post-PRK subgroup and then improved over time after the surgery. Corneal ablative procedures (PRKs) require a longer recovery period than intrastromal procedures (LASIKs).[22] Visual outcomes may be largely directed by the epithelial layer, which usually heals within 4–7 days after surgery and may take as long as 2 weeks, which could explain the reduction in UCVA in the 1-week post-PRK subgroup in the present study. Many previous studies investigated visual recovery after PRK surgery.[23] Walker and Wilson[24] found that UCVA 1 week postoperatively was significantly better in LASIK than in PRK. Similarly, Mc Alinden *et al*.[12] showed that visual symptoms were worse at 5 days and 2 weeks after surgery and improved 1 month postoperatively. The studies comparing PRK and LASEK in terms of postoperative visual recovery showed that the two surgeries were comparable, with some studies reporting some benefits of LASEK over PRK.[25]

The present study showed that the total QIRC was lower in the pre-PRK group than in the controls. The perspective of

Table 4: Comparison of individual items QIRC scores between the three post-PRK subgroups

	1 week	<6 months	>6 months	*P*
1. How much difficulty do you have driving in glare conditions?	39.91±8.92	47.63±6.30	45.06±0.00	0.287
2. During the past month, how often have you experienced your eyes feeling tired or strained?	43.22±7.96	52.56±8.40	50.69±7.07	0.013
3. How much trouble is not being able to use off-the-shelf (nonprescription) sunglasses?	48.99±12.32	55.68±3.99	52.29±11.22	0.188
4. How much trouble is having to think about your spectacles or CLs or your eyes after refractive surgery before doing things, e.g., traveling, sport, going swimming?	47.20±13.91	49.78±11.65	59.16±8.26	0.017
5. How much trouble is not being able to see when you wake up, e.g., to go to the bathroom, look after a baby, see alarm clock?	42.68±11.74	53.37±10.05	54.90±9.44	0.009
6. How much trouble is not being able to see when you are on the beach or swimming in the sea or pool, because you do these activities without spectacles or CLs?	50.68±10.66	54.65±11.38	61.34±8.92	0.039
7. How much trouble are your spectacles or CLs when you wear them when using the gym/doing keep-fit classes/circuit training, etc.?	47.45±10.92	47.45±11.74	53.45±5.15	0.343
8. How concerned are you about the initial and ongoing cost to buy your current spectacles/CLs/refractive surgery?	55.59±12.25	56.89±11.28	55.10±7.82	0.714
9. How concerned are you about the cost of unscheduled maintenance of your spectacles/CLs/refractive surgery, e.g., breakage, loss, new eye problems?	54.68±11.86	48.07±11.85	48.49±10.79	0.153
10. How concerned are you about having to increasingly rely on your spectacles or CLs since you started to wear them?	57.74±11.68	57.74±12.32	52.59±14.48	0.595
11. How concerned are you about your vision not being as good as it could be?	47.31±13.89	46.79±10.12	49.69±11.68	0.766
12. How concerned are you about medical complications from your choice of optical correction (spectacles, CLs, and/or refractive surgery)?	48.79±13.21	44.04±9.77	48.16±10.87	0.377
13. How concerned are you about eye protection from ultraviolet (UV) radiation?	44.04±11.99	45.65±11.51	46.76±11.22	0.750
14. During the past month, how much of the time have you felt that you have looked your best?	56.41±19.48	57.96±20.95	64.96±14.79	0.461
15. During the past month, how much of the time have you felt that you think others see you the way you would like them to (e.g., intelligent, successful, cool, etc.)?	58.38±17.99	55.47±13.98	57.42±13.47	0.871
16. During the past month, how much of the time have you felt complimented/flattered?	61.13±13.24	65.58±17.03	66.62±16.19	0.788
17. During the past month, how much of the time have you felt confident?	57.90±20.10	64.28±13.58	65.72±12.73	0.583
18. During the past month, how much of the time have you felt happy?	58.91±20.28	58.16±14.14	61.63±13.94	0.779
19. During the past month, how much of the time have you felt able to do the things you want to do?	48.06±17.67	51.39±15.29	55.93±12.80	0.456
20. During the past month, how much of the time have you felt eager to try new things?	57.62±17.67	53.62±18.39	57.32±12.75	0.837

pre-PRK subjects could be based on their opinion while wearing optical correction as control subjects are satisfied with their optical corrections. Similarly, McDonnell *et al*.[19] found that the QoL score in the prerefractive surgery group was substantially lower than the QoL score among optical correction wearers who were not considering refractive surgery. However, in the present study, the scores on three items (numbers 5, 6, and 7) in the well-being domain were higher in the prerefractive surgery group than in the controls.

The female to male ratios were higher in the pre- and post-PRK groups [Table 1] as females in Saudi Arabia are seeking refractive surgeries for social interest. Similarly, previous studies included a higher proportion of female participants than males when evaluating QoL after refractive surgery.[26] It was surprising that no correlation was found in the present study between UCVA and total QIRC scores in the post-PRK subgroups. Previous studies demonstrated that the reduction in UCVA in the postoperative group was due to residual refractive error, which is a common reason for dissatisfaction.[27]

This study had a few limitations. The sample size was small, especially for post-PRK subgroups. We could not conduct a separate analysis to compare VRQoL in mild, moderate, and severe myopia in either the pre- or post-PRK group as the numbers of subjects with severe myopia both pre- and post-PRK were very small compared to the number of subjects with mild/moderate myopia. In addition, measurements for contrast sensitivity testing and quantitative assessments of tear production (i.e., TBUT and Schirmer test) were not collected. There were participating females than males. Future longitudinal research may be required with a larger sample size to compare visual outcomes and VRQoL between subjects with different severities of myopia pre- and post-PRK surgery and with different types of refractive surgeries.

Conclusion

In conclusion, visual outcomes and VRQoL are improved after PRK. Subjects enjoyed their VRQoL after surgery, especially in the convenience and well-being domains. This improvement in VRQoL should be considered when recommending refractive surgery.

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Conflicts of interest

There are no conflicts of interest.

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