Original Article

# Study of Post Operative Regression after Photorefractive Keratectomy for Treatment of Hyperopia and Hyperopic Astigmatism

**Nargess Moslehi Moghadam [1], MS; Hossein Mohammad Rabei [*2,3,4], MD; Bahram Khosravi [5], PhD; Kourosh Sheibani [4], MD, MS**

1. International branch, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
2. Imam Hossein Medical Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
3. Eye Research Center, Negah Eye Clinic, Tehran, Iran.
4. Basir Eye Health Research Center, Tehran, Iran.
5. Tavanbakhshi School, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

***Corresponding Author:** Hossein Mohammad Rabei

**E-mail:** mhrabie@yahoo.com

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## Abstract

**Purpose:** To study post operative regression rates after photorefractive keratectomy among patients with hyperopia and hyperopic astigmatism with follow-up of at least six months.

**Patients and Methods:** In this historical cohort study, 171 eyes from 91 patients with moderate hyperopia and hyperopic astigmatism were treated using Bausch and Lomb Technolas 217 Z Excimer Laser. Pre-operation evaluation included; best spectacle corrected visual acuity, manifest and cycloplegic refraction, diameter of optical zone, central corneal thickness and simulated keratometry. Postoperative evaluation, performed at least six months after the procedure, included measurement of corneal curvature, manifest and cycloplegic refraction, best corrected visual acuity, uncorrected visual acuity, refraction manifest, haze, and any pathologic finding.

**Results:** The mean regression was 0.35 ± 1.04. Post surgical manifest refraction equivalent in ± 0.5 diopter range of surgeon's desired refraction was observed in 57.1 % of eyes. Manifest refraction equivalent in ± 1.00 diopter range was observed in 85.7 % of eyes, and manifest refraction equivalent in ± 2.00 diopter range in 96.6 % of eyes. Uncorrected visual acuity of 20/20 or better was reported in 37.1 % and 20/40 or better in 92 % of patients. Loss of the best spectacle corrected visual acuity of one line was observed in 13.4 % and 2 lines or more in 5.7 % of patients.

**Conclusion:** In patients with moderate hyperopia and hyperopic astigmatism undergoing PRK the rate of regression was in ± 1 diopter range of surgeon's intended correction in 85.7 % of patients at least six months postoperatively, which is in line with other studies findings.

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## Introduction

The prevalence of hyperopia has been reported in various studies [1-4]. For example, in an epidemiological survey in the United States, the incidence of hyperopia was reported to be 21 % [1]. The lowest reported hyperopia rate in Asia has been 8.9 % in china [2,3]. In a survey conducted by Hashemi et al., the prevalence of hyperopia in Tehran was 26 % [4]. At present, the most common surgical technique for correcting hyperopia is corneal refractive surgery including LASIK and Photorefractive Keratectomy (PRK) [5]. Several studies have been conducted regarding the use of LASIK in correcting hyperopia [6-10], and some researchers have reported that, since in this method the correction is performed at a deeper level of stroma, there is less chance of regression compared to PRK [11]. Another advantage of this method compared to PRK is the faster retrieval of stable vision and the rapid reduction of the patients' symptoms such as pain, tearing and photophobia after the procedure [5-14]. On the other hand, some complications such as corneal ectasia and epithelial in-growth, which can be the result of LASIK, are less likely to be present in PRK [5,12,15]. Up to now, a limited number of studies have been performed in patients with hyperopia, regarding the degree of regression [13,14,16]. For example, Juhás et al. reported that among patients with less than 3.5 diopters of hyperopia between 62 % and 70 % stayed within 1 diopter of desired correction over a 1 year period, and for patients with hyperopia greater than 3.5 diopters this rate was between 32 % and 44 % [17]. In another study by Nagy et al., this rate was 84.8 % for patients with hyperopia less than 3.5 diopters and 46.8 % for those patients with hyperopia greater than 3.5 diopters [18]. It should be noted that haze after refractive surgery to correct hyperopia is circular and appears in midperiphery of the cornea [12,19,20]. Due to the lack previous studies regarding the degree of regression among patients with hyperopia undergoing PRK in Iran, the present study was designed to evaluate the rate of regression after PRK, among Iranian patients with hyperopia or hyperopic astigmatism.

## Patients and Methods

This historical cohort study included all hyperopic and hyperopic astigmatism patients with hyperopia of above 0.5 diopter, who underwent PRK between March 2009 and April 2012, and were followed up for at least six months. This study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences and written consent was received from all patients entering the study. All patients were treated with Bausch and Lomb Technolas 217Z laser and the optical zone (OZ) was constant for all patients (OZ = 6.00 mm treatment area = 9.00 mm). In this study, all patients were treated using PRK with application of mitomycin C 0.02 % and wave-front guided technique. Since the aim of surgery in the present study was to achieve plano state in subjective exams the regression rate was calculated based on the manifest refraction spherical equivalent. One hundred and fifteen patients had the inclusion criteria, of which 18 were not available for follow-up, and 6 patients were excluded for the following reasons: performing cataract surgery after PRK, using ocular drugs due to glaucoma, mild single-sided central serous retinopathy, pregnancy and breast-feeding.

In total, 175 eyes from 91 patients were evaluated. The last measurement of the patients' regression was at least six months after the surgery. All demographic data and information regarding best corrected visual acuity (BCVA), keratometry results, central corneal thickness (CCT), and customized individual profiles were

gathered from patients' records. After recalling the patients, complete visual examination including measurement of BCVA, Uncorrected Visual Acuity (UCVA), refractive error with and without cycloplegic eyedrops (retinoscopy), manifest refraction, corneal curvature and haze were performed. Also eyes were examined for the presence of any eye pathology. Patients were divided to subgroups based on age, sphere correction, cylinder correction, mean keratometry (Mean K), CCT, and corneal astigmatism (Table 1).

**Statistical analysis**

The main aim of this study was to find the prevalence of post surgical manifest refractive spherical equivalent (MRSE) in ± 0.5 diopter range of surgeon's desired refraction. The sample size was calculated based on the results of a study by Waring et al. [6] indicating a 63 % prevalence for post surgical MRSE in the range of ± 0.5 from normal, to achieve a confidence level of 95 % and a maximum error of 10 %. To describe the data, mean, standard deviation, frequency and percentage were used. To compare the results between the different groups, we used logistic regression and generalized estimation equations. All analyzes were performed using SPSS software version 17 (SPSS Co. Chicago, IL), and P values less than 0.05 were considered statistically significant.

**Results**

One hundred seventy five eyes from 91 patients with hyperopia or hyperopic astigmatism were evaluated in the present study. The mean age of patients was 36.4 ± 12.4 and 33.1 % of patients were male, while 66.9 % were females. Other demographic characteristics of the patients, including refractive error, keratometry results, the presence or absence of haze, the amount of corneal astigmatism, and CCT are summarized in table 2. The mean spherical equivalent (SE) among patients was 2.25 ± 1.86 (1.50 to 6.75), and the mean hyperopia was 3.00 ± 1.57 (0.5 to 7.0) diopter. The mean astigmatism was -1.51 ± 1.45 (0.00 to - 6.00), and the mean follow-up time was 20 ± 8 (6 to 39) months.

In the present study, UCVA of 20/20 and 20/40 or better were achieved in 37.1 % and 92 % of patients after PRK, respectively. Also a reduction in BCVA of one line was observed in 13.4 % of patients and a reduction of two lines or more in 5.7 % of cases.

**Table 1: Division of patients into subgroups based on age, sphere, cylinder, Mean K, CCT, and corneal astigmatism.**

| Age (Year) | Sphere (Diopter) | Cylinder (Diopter) | Mean K (Diopter) | CCT (Micron) | Corneal Astigmatism (Diopter) |
|---|---|---|---|---|---|
| ≤ 30 | ≤ + 3.00 | < - 1.00 | < 43.00 | ≤ 550 | ≤ 2.00 |
| 31 - 40 | + 3 | - 1.00 - 2.50 | ≥ 43.00 | > 550 | > 2.00 |
| ≥ 41 | | > - 2.75 | | | |

CCT: Central Corneal Thickness
Mean K: Mean Keratometry

The mean post-surgical regression after PRK in patients with hyperopia and hyperopic astigmatism was 0.14 ± 0.35 diopter, while regression in 57.1 % of eyes was in ± 0.5 diopter range and in 85.7 % of eyes was in ± 1.00 diopter range of surgeon's desired refraction.

There was a significant correlation between regression rate of ± 0.5 diopter from surgeon's desired refraction and age, so that regression was significantly higher in the age group of less than 30 years (P = 0.014)(Table 3). Our results indicated a relation between regression of ± 1 and gender (P = 0.007), so that women had less regression (Table 3). Also, there was a signifi-

cant correlation between regression of ± 1 and keratometry results (P = 0.023), with regression being significantly higher in patients with keratometry results below 43 D (Table 3). Finally our results indicated a significant relation between regression and the severity of hyperopia with hyperopia of higher than 3.00 diopters being associated with a higher degree of regression (P = 0.046) (Table 3).

**Table 2: Demographic findings of patients entering the study.**

| Variable | Group | Results* |
|---|---|---|
| Age | | 36 ± 12.4 (18 to 62) |
| Sex | F | 117 (66.9 %) |
| | M | 58 (33.1 %) |
| Eye | OD | 87 (49.7 %) |
| | OS | 88 (50.3 %) |
| Spher | | 3 ± 1.57 (0.5 to 7) |
| Cylinder | | 1.51 ± 1.45 (0 to 6) |
| SE | | 2.25 ± 1.86 (- 1.5 to 6.75) |
| BCVA (log MAR) | | 0.03 ± 0.1 ( - 0.08 to 0.7) |
| | 20/20 | 140 (81.4 %) |
| | Worse than 20/20 | 32 (18.6 %) |
| CCT | | 550 ± 35 (460 to 644) |
| Ablation Depth | | 64 ± 26 (21 to 134) |
| Mean K | | 43.16 ± 1.58 (39.35 to 47.1) |
| Follow-up (months) | | 20 ± 8 (6 to 39) |

## Discussion

In the present study, the mean post-surgical regression after PRK in patients with hyperopia and hyperopic astigmatism was 1.04 ± 0.35 diopter, while regression in 57.1 % of eyes was in ± 0.5 diopter range and in 85.7 % of eyes was in ± 1.00 diopter range of surgeon's desired refraction. Nagy et al. examined 800 eyes in two groups of patients with hyperopia of less than 3.50 diopters and more than 3.75 diopter undergoing PRK [18]. In their study regression in the range of ± 0.50 and ± 1.00 diopters from surgeon's desired refraction was observed in 74.4 % and 84.8 % of patients in the first group, respectively. In their second group the regression in the range of ± 0.50 and ± 1.00 diopters from surgeon's desired refraction was observed in 22.3 % and 46.8 % of patients, respectively. It seems that Nagy's results in their first group of patients were better than our results. When we excluded our patients with hyperopia of more than 3.5 diopter from our results to have a better comparison with the first group of patients in Nagy et al. study, our findings showed a 58.9 % prevalence of regression in the range of ± 0.50 diopters and 89.3 % within the range of ± 1.00 diopter, which is more similar with Nagy et al. findings.

In a study by O'Brart et al. [21], on 40 eyes with hyperopia undergoing PRK with a mean follow-up of about 7.5 years, mean regression of 1.86 ± 0.83 diopters was observed. Although their study and the present study are similar in regard to the range of treated hyperopia, the difference in regression with our findings might be related to their longer follow-up period.

On the other hand, the results of Razmju et al.[19] regarding the mean regression after PRK to correct hyperopia (1.55 ± 0.55) are close to our findings. It should be noted that these researchers also used Bausch and Lomb Technolas 217Z excimer laser device similar to our study, which may explain the more similar results. However, Razmju et al. reported a regression in range of ± 1.00 in only 46.6 % of their patients versus 85.7 % in our study, which seems to be the result of their inclusion criteria (hyperopia of over 3 diopters). It should be noted that most studies indicate that PRK has a better success in correcting hyperopia of less than 3 diopter [17-20] and recommend other treatment methods for hyperopia of higher than 6 diopter [22].

In the present study a reduction in BCVA of 1 line was observed in 13.4 % of patients and a reduction of 2 lines or more in 5.7 % of cases.

**Table 3: The rate of regression based on variables such as age, sex, hyperopia, astigmatism, keratometry results, central corneal thickness and corneal astigmatism.**

| Variable | Group | Total | Manifest SE | | | |
|---|---|---|---|---|---|---|
| | | | ± 0.50 | ± 1.00 | ± 2.00 | Mean ± SD |
| Number of Eyes | | 175 (100.0) | 100 (57.1) | 150 (85.7) | 169 (96.6) | 0.35 ± 1.04 |
| Age | ≤ 30 | 80 (45.7) | *39 (48.8) | 68 (85.0) | 77 (96.3) | 0.15 ± 0.93 |
| | 31.0 - 40.0 | 27 (15.4) | 21 (77.8) | 25 (92.6) | 26 (96.3) | 0.77 ± 2.3 |
| | ≥ 41 | 68 (38.9) | 40 (58.8) | 57 (83.8) | 66 (97.1) | 0.55 ± 0.77 |
| Sex | X | 117 (66.9) | 68 (58.1) | *108 (92.3) | 112 (95.7) | 0.34 ± 0.83 |
| | Y | 58 (33.1) | 32 (55.2) | 42 (72.4) | 57 (98.3) | 0.37 ± 1.38 |
| Sphere | ≤ + 3.00 | 112 (100.0) | 66 (58.9) | 100 (89.3) | 109 (97.3) | 0.2 ± 0.84 |
| Cylinder | < - 1.00 | 59 (52.7) | 37 (62.7) | 53 (89.8) | 57 (96.6) | 0.31 ± 0.87 |
| Cylinder | - 1.00 to - 2.50 | 18 (16.1) | 12 (66.7) | 17 (94.4) | 17 (94.4) | 0.33 ± 0.97 |
| Cylinder | > - 2.75 | 35 (31.3) | 17 (48.6) | 30 (85.7) | 35 (100.0) | 0.01 ± 0.77 |
| Sphere | ≥ + 3.25 | 63 (100.0) | 34 (54.0) | 50 (79.4) | 60 (95.2) | 0.59 ± 1.28 |
| Cylinder | < - 1.00 | 26 (41.3) | 14 (53.8) | 19 (73.1) | 25 (96.2) | 0.35 ± 1.11 |
| Cylinder | - 1.00 to - 2.50 | 25 (39.7) | 16 (64.0) | 20 (80.0) | 23 (92.0) | 1.08 ± 1.8 |
| Cylinder | > - 2.75 | 12 (19.0) | 4 (33.3) | 11 (91.7) | 12 (100.0) | 0.41 ± 0.66 |
| Mean K | < 43.00 | 79 (45.1) | 42 (53.2) | *61 (77.2) | 73 (92.4) | 0.54 ± 1.29 |
| | ≥ 43.00 | 96 (54.9) | 58 (60.4) | 89 (92.7) | 96 (100.0) | 0.16 ± 0.7 |
| Haze | No | 140 (80.0) | 85 (60.7) | 122 (87.1) | 135 (96.4) | 0.32 ± 1.1 |
| | Yes | 35 (20.0) | 15 (42.9) | 28 (80.0) | 34 (97.1) | 0.44 ± 0.88 |
| CCT | ≤ 550 | 86 (49.1) | 46 (53.5) | 76 (88.4) | 83 (96.5) | 0.39 ± 1.11 |
| | > 550 | 89 (50.9) | 54 (60.7) | 74 (83.1) | 86 (96.6) | 0.3 ± 0.97 |
| Corneal Astigmatism | ≤ 2.00 | 119 (68.0) | 70 (58.8) | 99 (83.2) | 113 (95.0) | 0.49 ± 1.16 |
| | > 2.00 | 56 (32.0) | 30 (53.6) | 51 (91.1) | 56 (100.0) | 0.08 ± 0.73 |

*P ≤ 0.05
Mean K: Mean Keratometry
CCT: Central Corneal Thickness

O'Brart et al. [21] reported a reduction in the BCVA of 1 line in 38.5 % and 2 lines or more in 5 % of their cases. Razmju et al. [19] reported a reduction in BCVA of 1 line or more in 16.6 % of their cases. Nagy et al. [18] reported a 2 line or more drop in 2.1 % of their patients undergoing PRK to correct hyperopia of less than 3.5 diopter.

We observed that the rate of regression was lower among our patients over 30 years of age, but this difference was only observed in those patients with regression in the range of ± 0.50 diopter from surgeon's desired refraction, which is not clinically significant. Most studies have described age as an effective factor in success of PRK in treating hyperopia [23-27], but the effect of age on regression has not been investigated. Perhaps age can be considered as an underlying variable in corneal healing process and regression, with older patients showing less healing response and hence less regression.

In the present study, there was a significant relationship between regression and hyperopia of more than 3.00 + diopter (P = 0.046). In this regard, the creation of a deeper ablation and the resultant longer healing process might be responsible for this finding, which is in line with previous reports [18-29].

There was no significant relationship between regression and the degree of astigmatism in our study, but in most other studies, high-level of astigmatism alone or in conjunction with higher hyperopia has been considered as a risk factor for regression [19,28,30], which seems to be the result of ablation with different depths in corneal surface [19].

In this study, we found significant relationship between regression and flat keratometry, (higher regression was observed among patients with keratometry of less than 43.00 diopter), which is not in agreement with findings by Wiliams et al. [10] and Young et al. [24]. This difference may be related to different surgical techniques, since they used LASIK, while we used PRK to correct hyperopia.

We found lower regression among female patients compared to male patients which is in line with findings reported by Khanlari et al. [31]. Similarly, Ditzen et al. considered gender to be a probable factor in emergence of haze and regression [27], but many other studies have not reported a relation between the sex and regression [9,25,26,32,33]. Due to lack of consent regarding the effect of sex on regression further studies with a higher sample size are suggested to specifically evaluate the role of gender in regression.

We did not find a relation between corneal thickness and regression, which was predictable since in correction of hyperopia most of ablation is performed in the corneal periphery [10,24]. This finding was in line with the results of previous studies [34].

A shortcoming of the present study was relatively wide variation in post operative follow-up times among our patients. We inevitably accepted this limitation due to the time constraints and the rarity of cases undergoing hyperopic PRK.

## Conclusion

In patients with moderate hyperopia and hyperopic astigmatism undergoing PRK the rate of regression was in ± 1 diopter range of surgeon's intended correction in 85.7 % of patients at least six months postoperatively, which is in line with other studies findings.

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## Footnotes and Financial Disclosures

### Conflict of Interest:

The authors declare no conflict of interest with the subject matter of the present manuscript.