Corneal Morphological Changes After Myopic Excimer Laser Refractive Surgery

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Purpose: To evaluate the changes in central corneal thickness (CCT) and corneal volume (CV) in eyes that have undergone myopic photorefractive keratectomy (PRK).

Methods: CCT and CV obtained with an Oculus Pentacam before 1, 3, and 6 months after PRK were analyzed in 84 eyes with a mean preoperative refraction of −4.93 ± 2.23 diopter. The changes were compared with the amount of refractive treatment. The differences were evaluated with the Student *t* test and the correlations with the Pearson index.

Results: One month after PRK, CCT and CV mean differences were 73.2 ± 31.5 μm ($P < 0.001$) and 2.2 ± 1.7 mm^3 ($P < 0.001$), respectively. Three months after PRK, CCT and CV mean differences were 66.6 ± 26.7 μm ($P < 0.001$) and 1.4 ± 1.3 mm^3 ($P < 0.001$), respectively. Six months after PRK, CCT and CV mean differences were 65.3 ± 25.7 μm ($P < 0.001$) and 1.4 ± 1.3 mm^3 ($P < 0.001$), respectively. The effective treatment at each follow-up point was correlated with CCT changes ($R = 0.62$, 0.71, and 0.73, respectively), but not with CV changes ($R = 0.04$, 0.04, and 0.01, respectively).

Conclusions: Our findings support the hypothesis that after myopic PRK, when a series of corneal lamellae are severed centrally, the remaining peripheral segments relax. The squeezing force on the matrix is reduced, and the distance between the lamellae expands.

Key Words: central corneal thickness, cornea volume, photorefractive keratectomy

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Photorefractive keratectomy (PRK) is a reliable method to correct refractive errors mainly in patients with myopia. With this method, a slice of corneal tissue is ablated, thus giving a flattening and a thinning of the central cornea.

The corneal changes induced by myopic corneal refractive surgery have been widely studied, but most of the articles deal with the changes in corneal power and/or in the central corneal thickness (CCT).[1–16] Unfortunately, the changes in CCT may be estimated, but do not reflect the effective amount of ablated tissue because they measure only the changes in a single point.

A few years ago, a new device, the Oculus Pentacam (Oculus, Wetzlar, Germany) was developed, which measures not only the CCT but also the corneal volume (CV).[17] The measurement of the latter parameter before and after PRK can provide us with the amount of ablated corneal tissue. For this reason, we decided to perform a prospective study to evaluate the volumetric corneal changes because of PRK treatment.

MATERIALS AND METHODS

Eighty-four myopic eyes of 55 patients (30 men and 25 women), which were consecutively treated with PRK in our department were included in this nonrandomized prospective clinical study. The age of the patients at the time of refractive surgery ranged from 19 to 55 years (mean = 33 ± 9.3 years). The spherical equivalent intended corrections ranged from –9.25 to −1 diopter (D) (mean = −4.93 ± 2.23 D).

Patients with systemic and ocular diseases that might interfere with the corneal healing process or with the refractive outcome, such as diabetes, connective tissue disorders, dry eyes, uveitis, corneal and lens opacities, and glaucoma, were excluded. Informed consent was obtained from all patients before surgery. The investigational review board of our institution reviewed the protocol and approved the study.

Patients were asked to discontinue wearing contact lenses for at least 1 month before the final refractive evaluation, which was performed the day the patients underwent PRK. All treatments were performed using topical anesthesia with oxybuprocaine eyedrops (Novesina; Novartis Farma, Origgio, Italy); a lid speculum was put in place and the epithelium debrided with a mechanical brush. The patients were treated with an Esiris (Schwind, Kleinostheim, Germany) excimer laser using a multizone approach with a number of zones ranging from 2 to 5 (mean = 3.64 ± 0.93) and an ablation diameter ranging from 5 to 7.5 mm (mean = 6.47 ± 0.58 mm). The mean planned ablation depth calculated with Munnerlyn approximation equation was 85.61 ± 25.68 μm (range = 40–137 μm).

Using the Gatinel formula[18]: volume of ablation (mm^3) = [diameter of treatment zone (mm)/9]^4 × diopters of correction (D), taking into account the multizone approach, the mean planned ablation volume was 1.094 ± 0.42 mm^3 (range = 0.18–1.83 mm^3). A bandage contact lens was applied to the

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TABLE 1. Corneal Parameters Before and After Surgery

Analyzed Parameters	Preoperative	1 Month Postoperative	3 Months Postoperative	6 Months Postoperative
CCT, μm	497–629 (558 ± 28.2)	366–577 (484.5 ± 41.2)	395–582 (491.8 ± 37.7)	422–591 (495 ± 37)
CV, mm^3	55.3–68.8 (61.8 ± 3.3)	52.3–66.7 (59.5 ± 3.1)	54.9–67.2 (60.2 ± 2.9)	54.7–69.1 (60.1 ± 3.3)

Row data, [minimum–maximum (mean ± SD)], of CV and CCT before and 1, 3, and 6 months after surgery.

TABLE 2. Change in Corneal Parameters and Refraction After Surgery

Analyzed Parameters	1 Month Postoperative	*P*	3 Months Postoperative	*P*	6 Months Postoperative	*P*
Effective treatment, D	−9.5 to 0 (−4.7 ± 2.3)	<0.001	−9.5 to −1 (−4.8 ± 2)	<0.001	−9.5 to −1.125 (−4.8 ± 2)	<0.001
Difference in CCT, μm	16–157 (73.2 ± 31.5)	<0.001	17–127 (66.6 ± 26.7)	<0.001	23–127 (65.3 ± 25.7)	<0.001
Difference in CV, mm^3	−1.8 to +7.5 (2.2 ± 1.7)	<0.001	−1.7 to +4.1 (1.4 ± 1.3)	<0.001	−1.8 to +4.4 (1.4 ± 1.3)	<0.001

Row data, [minimum–maximum (mean ± SD)], of the effective treatment and the differences in CV and CCT at 1, 3, and 6 months after surgery.

treated eye under sterile conditions immediately after surgery, and it remained in place until the epithelium was completely healed.

During the postoperative period, operated eyes received the following medications: diclofenac sodium 0.1% eyedrops twice daily for the first 2 days, netilmicin preservative-free eyedrops until the reepithelialization was complete, and preservative-free artificial tears for 1 month. After reepithelialization, clobetasone eyedrops were prescribed for all patients for 1 month in a tapered dose: 1 drop 4 times daily for the first week, 1 drop 3 times daily for the second week, 1 drop 2 times daily for the third week, and 1 drop once daily for the last week.

The preoperative and follow-up ophthalmic examinations at 1, 3, and 6 months included, among others, an examination with an Oculus Pentacam to determine the changes in CCT and CV within a 10-mm circle around the central cornea. The statistical evaluation was performed with the Student *t* test, and correlations between evaluated parameters were evaluated with the Pearson index.

RESULTS

CV and CCT values before surgery and after 1, 3, and 6 months are shown in Table 1. None of the patients' eyes showed a significant haze during the follow-up period. The effective treatment and the differences in CV and CCT at 1, 3, and 6 months are shown in Table 2. The correlation between the effective treatment and the changes in CV and CCT at 1, 3, and 6 months are shown in Figures 1–6.

Our results showed a decrease in both CCT and CV after treatment, with a good correlation between CCT changes and treatment (1 month after PRK, $R = 0.62$; 3 months after PRK, $R = 0.71$; and 6 months after PRK, $R = 0.73$), whereas no correlation could be found both between CV changes and treatment (1 month after PRK, $R = 0.04$; 3 months after PRK, $R = 0.04$; and 6 months after PRK, $R = 0.01$) and both between volume ablation according to Gatinel formula and the differences in CV at 1, 3, and 6 months of follow-up (Figs. .7–9). There was a statistically significant difference ($P < 0.01$) 1 month after PRK between volume ablation according to Gatinel formula and the difference in CV evaluated with Oculus Pentacam, whereas no significant difference was found both at 3 ($P = 0.31$) and at 6 months of follow-up ($P = 0.27$) with a poor correlation all over the follow-up.

DISCUSSION

In the early 90's, when PRK was introduced as a treatment option for myopic refractive surgery, some

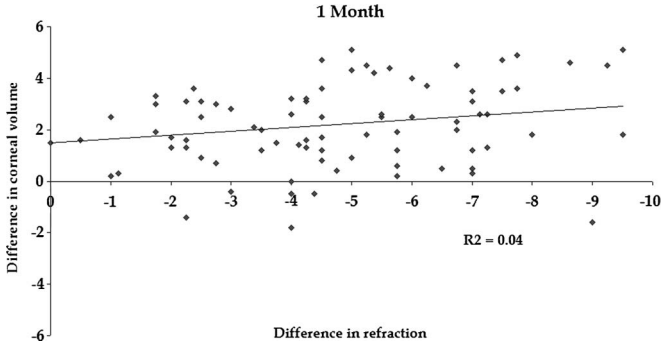

FIGURE 1. Correlation between the effective treatment and the changes in CV 1 month after PRK.

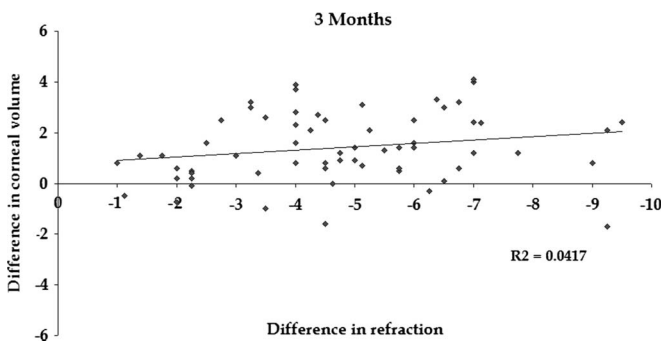

FIGURE 2. Correlation between the effective treatment and the changes in CV 3 months after PRK.