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Short communication

Effect of orthokeratology in patients with myopic regression after refractive surgery

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ABSTRACT

Purpose: To evaluate the clinical effect of orthokeratology (ortho-K) lenses and to introduce the fitting steps of ortho-K lens for myopic regression after keratorefractive surgery.
Methods: Twenty-one eyes from 12 patients with myopic regression after keratorefractive surgery were fitted with ortho-K lenses and followed up for 12.11 ± 3.68 months. The mean *K* value of the peripheral cornea was used to speculate preoperative central corneal *K* value, estimated *K*. After dispensing the lenses according to estimated *K*, biomicroscopic examination including fluorescein staining and over-refraction were performed to determine the final *K* and final lens power.
Results: LogMAR uncorrected visual acuity was 0.48 ± 0.39 before and 0.00 ± 0.00 after wearing ortho-K lenses ($p < 0.001$). Pre-fitted refractive error was −1.87 ± 1.05 diopters (D) in myopia, 0.54 ± 0.42 D in astigmatism, and spherical equivalent of −2.14 ± 1.01 D. At the final visit myopia level and spherical equivalent significantly decreased to −0.73 ± 0.84 D ($p < 0.001$) and −1.01 ± 0.87 D ($p < 0.001$), respectively. Estimated *K* was 8.07 ± 0.36 mm, and final *K* used for ortho-K prescription was 8.19 ± 0.30 mm. Final *K* significantly correlated with *K* value of pre-fitted peripheral cornea ($r = 0.737$, $p < 0.001$) and estimated *K* ($r = 0.721$, $p < 0.001$), respectively. There was no correlation between pre-fitted degree of myopia and the Final lens power ($r = 0.429$, $p = 0.053$).
Conclusions: Ortho-K lenses may be an effective solution for patients with myopic regression following keratorefractive surgery. Estimated *K* value can be used as reference value in ortho-K prescription.

1. Introduction

Despite advances in excimer laser technology, many refractive surgery patients still experience myopic regression [1,2]. Myopic regression diminishes the predictability, efficacy, and long-term stability of refractive surgery. Myopic regression can occur after photorefractive keratectomy (PRK) and after laser in situ keratomileusis (LASIK) or laser assisted sub-epithelial keratectomy (LASEK) [3–7]. Forward shift of the cornea and postoperative increase in corneal thickness are factors considered responsible for myopic regression following surgery [8–11]. Treatments for myopic regression include nonsurgical modalities, which include glasses, anti-glaucoma eye solutions, soft contact lenses, rigid gas permeable (RGP) contact lenses, and orthokeratology (ortho-K) lenses [3,12–14]. Retreatment with laser is also considered a treatment option [15,16]. However, each nonsurgical or surgical modality has drawbacks.

Ortho-K is a nonsurgical and reversible alternative for the correction of myopia by flattening the cornea using reverse geometry contact lenses [17,18]. Many studies support the value of ortho-K for correcting myopia. However, to the authors' knowledge, no studies that have assessed the effectiveness of ortho-K on myopic regression after keratorefractive surgery have been published. This study aimed to evaluate the clinical treatment effects of ortho-K lenses and to introduce the fitting steps of ortho-K lenses for myopic regression after keratorefractive surgery.

2. Methods

Twenty-one eyes of 12 patients (12 women, mean age 34.71 ± 4.44 years) with myopic regression after keratorefractive

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surgery (LASIK or LASEK) were included in the study. Nineteen eyes included in this study had LASIK and the other two eyes had LASEK. Among 21 eyes, 10 eyes were right eye and 11 eyes were left eye. Patients were fitted with ortho-K lenses (Ortho-K LK®-Lens PREMIER, Lucid Korea, Korea) at the YK eye clinic and Pusan National University Hospital and followed up for more than 6 months. Myopic regression was defined as a 0.5 diopter (D) or greater myopic shift between follow-up visits 1-month postoperatively [2,19,20]. Patients with presence of other ocular disease such as severe dry eye, nystagmus, strabismus, glaucoma, ambylopia, severe allergic disease, corneal decompensation, active infectious ulcer or persistent epithelial defect were excluded from the study. Patients with presumable corneal ectasia after refractive surgery during topographic examination were also excluded.

Ortho-K lenses were made from Hexafocon A (flourosilicone acrylate) with Dk value $100\,(\mathrm{cm\,mLO_2})/(\mathrm{s\,mL\,mmHg}) \times 10^{-11}$. The basic concept of the lens prescription was to fit the lens to the cornea prior to refractive surgery. The mean K value of the peripheral cornea analyzed by a sagittal map of corneal topography (Sirius®, Costruzione Strumenti Oftalmici, Florence, Italy) was used to speculate preoperative central corneal K value: estimated $K = \sqrt{R_{0^2} - px2.25 + 2.25}, R_0 = \sqrt{\mathrm{Ra}^2 + y^2 p - y^2}$, and $= 1 - e^2$. The Ra means keratometric reading of peripheral cornea. The e stands for eccentricity, and the y is half chord. A 4 mm periphery of the cornea was used to calculate estimated K (Fig. 1) for most patients; however, a peripheral 4.5 mm was used for one patient because of the large laser treated area. In the other two patients, peripheral K value was impossible to analyze owing to the extremely large laser treated zone; therefore, a value of 7.8 mm was used instead of estimated K. As it is impossible to calculate the exact preoperative eccentricity, 0.5 was selected as the standard. After estimated K was determined, the clinical history method was used to set the power of the trial ortho-K lenses [21,22]; postoperative corneal power is calculated by subtracting the change in manifest refraction at the corneal plane induced by the keratorefractive surgical procedure from the corneal power values obtained before surgery. Detailed biomicroscopic examination of the anterior segment including fluorescein staining assessment was performed (Fig. 2) after dispensing the trial ortho-K lenses. The "final K" value and "final lens power" were used for ortho-K lens prescription after achieving the best fluorescein patterns and over-refraction power between +0.25 and+0.75 D. "Final K" was defined as the K value used to determine the base curves of ortho-K lenses prescribed to the patients. In addition, "Final lens power" was the power of ortho-K lenses actually prescribed to the patients.

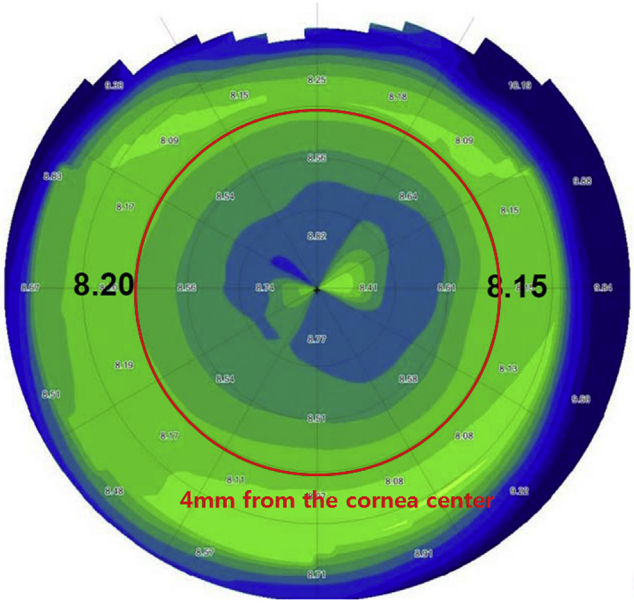

Fig. 1. Peripheral corneal curvature 4 mm from the cornea center, which is used for calculating estimated K.

After the ortho-K lenses arrived in the clinic, patients were scheduled to visit 1 week after fitting and then monthly thereafter. All patients were instructed to wear the lenses during sleep for 8–10 h. The uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), subjective refraction, corneal status analyzed by corneal topography, contact lens fitting status, and complications arising from wearing ortho-K lens were evaluated at each visit. Distant visual acuity was measured at 6 m. Subjective refraction was performed to determine the best-vision sphere in each eye. Subjective refraction was obtained using both retinoscopy (Retinoscopy, Welch Allyn, USA) and autokeratometer (Accuref-K 9000, Shin-Nippon, Japan) for all patients during the entire period of the study. If the two methods showed discrepancy, the retinoscopy result was used [23]. Statistical analysis was performed using SPSS 12.0 software (SPSS Inc., Chicago, IL), with the significance level set at $p < 0.05$. Paired student's t-test was used to determine statistically significant changes in UCVA, BCVA, and corneal values between pre- and post-fitting ortho-K lenses. Pearson correlation analysis was used to analyze the relationship between final K and estimated K.

The study was carried out in accordance with the rules described in the Helsinki Declaration. We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research. Informed written consent was obtained from all patients included in the study

3. Results

Twenty-one eyes of 12 patients were fitted with ortho-K lenses and followed up for 12.11 ± 3.68 months. Mean LogMAR (logarithm of the minimum angle of resolution) UCVA was 0.48 ± 0.39 before wearing ortho-K lenses, and 0.00 ± 0.00 after wearing ortho-K lenses ($p < 0.001$, Table 1). Pre-fitted refractive error was -1.87 ± 1.05 diopters (D) in myopia, 0.54 ± 0.42 D in astigmatism, and spherical equivalent of -2.14 ± 1.01 D. At final visit, myopia level and spherical equivalent significantly decreased to -0.73 ± 0.84 D ($p < 0.001$) and -1.01 ± 0.87 D ($p < 0.001$), respectively. Refractive astigmatism at final visit was -0.57 ± 0.38 D, which was not significantly different from that at the initial visit ($p = 0.679$). These changes were achieved sine 1 week after ortho-K lens wearing and maintained throughout the follow-up period.

The mean K value of the peripheral 4 mm cornea was 8.29 ± 0.36 mm (7.89–9.18), and pre-fitted mean simulated keratometry (SimK) from steep and flat cornea meridian were 39.38 ± 1.65 D and 38.58 ± 1.80 D, respectively. Estimated K was 8.07 ± 0.36 mm (7.67–8.99), and final K used for ortho-K prescription was 8.19 ± 0.30 mm (7.85–7.9), where the final K was somewhat flatter than the estimated K. After wearing the lens, steep and flat SimK showed significant flattening to 38.75 ± 0.16 D ($p < 0.001$) and 37.75 ± 2.00 D ($p < 0.001$), respectively, and corneal astigmatism increased significantly from 0.17 ± 0.09 D to 0.24 ± 0.14 D ($p = 0.019$). Final K significantly correlated with the pre-fitted peripheral cornea K value ($r = 0.737$, $p < 0.001$) and estimated K value ($r = 0.721$, $p < 0.001$), respectively. There was no correlation between pre-fitted myopia level and the Final lens power ($r = 0.429$, $p = 0.053$). No patients suffered from corneal complications or lens discomfort that resulted in discontinuation of wearing the lens. In addition, none of the patients in this study needed lens exchange during the follow-up.