ARTICLE

Comparing corneal higher-order aberrations in corneal wavefront-guided transepithelial photorefractive keratectomy versus small-incision lenticule extraction

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Purpose: To evaluate the changes in corneal higher-order aberrations (HOAs) after corneal wavefront-guided transepithelial photorefractive keratectomy (PRK) and small-incision lenticule extraction (SMILE).

Setting: Yonsei University College of Medicine and Eyereum Eye Clinic, South Korea.

Design: Retrospective case series.

Methods: Medical records of patients having either corneal wavefront-guided transepithelial PRK or small-incision lenticule extraction were examined. The root-mean-square total HOAs, 3rd-order coma aberration, and 4th-order spherical aberration were measured preoperatively and 6 months postoperatively. Independent *t* tests and analysis of covariance were used to compare changes in corneal HOAs between the 2 groups.

Results: The study comprised 77 eyes having corneal wavefront-guided transepithelial PRK and 81 eyes having small-incision lenticule extraction. The total HOAs and spherical aberration increased after transepithelial PRK (all $P < .001$), whereas coma aberration was stable after transepithelial PRK. The total HOAs, spherical aberration, and coma aberration increased after small-incision lenticule extraction ($P < .001$ for total HOAs, spherical aberration; $P = .004$ for coma). At 6 months postoperatively, total HOAs and spherical aberration were significantly larger in the transepithelial PRK group than in the small-incision lenticule extraction group. Coma aberration was larger in the small-incision lenticule extraction group than in the transepithelial PRK group. Spherical aberration induction was significantly smaller in the small-incision lenticule extraction group than in the transepithelial PRK group ($P < .001$), and coma aberration induction was larger in the small-incision lenticule extraction group than in the transepithelial PRK group ($P = .011$).

Conclusions: Small-incision lenticule extraction demonstrated that the induction of total HOAs was comparable to corneal wavefront-guided transepithelial PRK, accompanied by smaller spherical aberration induction and larger coma aberration induction. During small-incision lenticule extraction, surgeons should aim to obtain optimum centration for smaller induction of corneal HOAs.

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Photorefractive keratectomy (PRK) is a commonly performed corneal laser refractive surgery for myopic astigmatism.[1] Although standard spherical ablation profiles can eliminate lower-order refractive errors, they can induce incidental higher-order aberrations (HOAs) that can adversely affect the postoperative quality of vision.[2–4] Changes in corneal shape after laser refractive surgery toward an oblate shape, with steepening from the

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center to the periphery (positive asphericity), are known to be responsible for inducing positive spherical aberration and other HOAs.[5,6]

With technical advances in refractive surgery, there has been a growing interest not only in investigating the correction of refractive errors, but also in improving the quality of vision. Corneal wavefront-guided ablation profiles use customized ablation(s) designed to eliminate preexisting HOAs from the preoperative measurement of the corneal aberrations using a wavefront aberrometer and to avoid inducing additional aberrations associated with refractive error-correcting ablation. Corneal wavefront-guided ablation profiles were found to induce fewer aberrations and glare symptoms, consequently resulting in better night-vision performance when compared with conventional treatment.[4,7]

Small-incision lenticule extraction (SMILE, Carl Zeiss Meditec AG), using only a femtosecond laser is a new technique for the correction of myopia and myopic astigmatism.[8] This procedure extracts the refractive lenticule through a small corneal incision ranging from 2.0 mm to 5.0 mm, with the absence of a flap and the preservation of the anterior-most stromal lamellae and Bowman layer.[8,9] Thus, small-incision lenticule extraction provides many benefits over laser in situ keratomileusis (LASIK) because it carries no risk for traumatic flap displacement and reduces postoperative dry-eye symptoms, caused by reduced damage to corneal nerves, while providing excellent clinical outcomes.[10,11] Small-incision lenticule extraction can also induce an increase in total HOAs, spherical aberration, and coma aberration, but to a lesser extent than femtosecond-assisted LASIK and femtosecond lenticule extraction.[12–14]

In a recent study that compared the refractive outcomes of small-incision lenticule extraction with PRK using aberration-free ablation in eyes with low myopia, there were no statistically significant differences in 12-month postoperative spherical, trefoil, or coma aberrations between small-incision lenticule extraction and PRK.[15] However, total HOAs after small-incision lenticule extraction were significantly higher than PRK with aberration-free aspheric ablation profiles.[15] To our knowledge, there have been no studies comparing corneal wavefront-guided transepithelial PRK and small-incision lenticule extraction with regard to the induction of corneal HOAs. Accordingly, the aim of the present study was to investigate and compare clinical outcomes, including visual acuity, refractive errors, and corneal HOAs, after corneal wavefront-guided transepithelial PRK and small-incision lenticule extraction.

PATIENTS AND METHODS

This was a retrospective observational case series involving consecutive transepithelial PRK and small-incision lenticule extraction patients treated between May 2015 and December 2016. The study was performed with the approval of the Institutional Review Board of Yonsei University College of Medicine (Seoul, South Korea). The study was conducted in accordance with the tenets of the Declaration of Helsinki and followed good clinical practices. All patients provided informed written consent for their medical information to be included for analysis and publication.

Patients were included in the analyses if they exhibited stable refraction at least 1 year before surgery, preoperative corrected distance visual acuity (CDVA) of at least 20/25 in both eyes preoperatively and at the 6-month follow-up visit, and normal preoperative corneal topography. Patients were excluded from the analyses if they had any optical opacities or pathology on slitlamp evaluation, had previous corneal surgeries, experienced ocular trauma or intraocular surgery, severe dry eye, corneal disease, ocular infection, or collagen vascular/autoimmune diseases. One eye from each patient was included in the analysis using randomization tables, regardless of ocular dominance, refraction, or aberrations. A randomization sequence was created using Excel software (2007, Microsoft Corp.) using random block sizes of 2 and 4.

Transepithelial Photorefractive Keratectomy

Topical proparacaine hydrochloride 0.5% (Alcaine) drops were instilled in the upper and lower fornices. The eyes were then scrubbed and draped and a lid speculum was inserted between the lids of the eye to be treated. The other eye was occluded. The epithelium and stroma were ablated using a single continuous profile with the Amaris 1050RS excimer laser platform (Schwind eye-tech-solutions GmbH & Co. KG). The goal diopter (D) of the ablation profile was set at +0.50 D. Ablation profile planning was performed using integrated Optimized Refractive Keratectomy-Custom Ablation Manager software (version 5.1, Schwind eye-tech-solutions GmbH and Co KG). Using this software, ablation planning was performed based on clinical parameters including manifest refraction, pachymetry, and corneal wavefront data (up to the 7th order) obtained using a Placido corneal topographer (Keratron Scout, Optikon 2000 SpA). The surgeon could change the optical zone (OZ) diameter and select the aberrations to be treated. The ablation profiles used were custom full corneal wavefront-guided ablation profiles, calculated using the ablation profile planning software module. For corneal wavefront-guided treatments, all HOAs were treated using the corneal wavefront-guided ablation profile. A static cyclotorsion compensation algorithm profile was used for corneal wavefront-guided treatments and dynamic cyclotorsion control was implemented automatically for all treatments. Centration focused on the corneal vertex that was imputed from the Placido corneal topographer. Postoperatively, mitomycin-C 0.02% was applied for 30 seconds and the eye was then irrigated. Topical levofloxacin 0.5% (Cravit) was applied to the surgical site and a bandage contact lens (Acuvue Oasys, Johnson & Johnson Vision Care) was applied to the cornea for 4 to 5 days until epithelial healing was complete. After surgery, topical levofloxacin 0.5% and fluorometholone 0.1% (Flumetholon) were applied 4 times per day for 1 month. The dosage was gradually reduced over a 3-month period.

Small-Incision Lenticule Extraction

All small-incision lenticule extraction treatments were performed using a 500-kHz femtosecond laser (Visumax, software version 2.4.0, Carl Zeiss Meditec AG) by the same surgeon (D.S.Y.K.). The intended depth of the superior cap was set between 120 μm and 140 μm, and the length of the side cut was set to 2.0 mm. The OZ diameter used was between 6.2 mm and 7.0 mm. Target refraction was emmetropia in all cases. Before surgery, 3 centration points were marked using the slitlamp while the patient, in a sitting position, fixated on the center of the slitlamp beam, which was narrowed as much as possible.[16] The first 2 markings were made 7.0 mm apart at the horizontal meridian; these markings were made by appropriately bisecting the first Purkinje reflex or the coaxially sighted corneal light reflex. The third marking was made in the inferior cornea by vertically rotating the light.