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Enhancement after Small-Incision Lenticule Extraction

Incidence, Risk Factors, and Outcomes

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Purpose: To report the incidence, risk factors, and outcomes of enhancement after small-incision lenticule extraction (SMILE).

Design: Retrospective cohort study.

Participants: Five hundred twenty-four eyes of 307 patients who underwent SMILE at Singapore National Eye Center between February 2012 and March 2016.

Methods: The data collected included patient age at primary SMILE, gender, race, preoperative and postoperative manifest refraction spherical equivalent (MRSE), preoperative and postoperative uncorrected distance visual acuity and corrected distance visual acuity, the occurrence of suction loss during the procedure, and the need for enhancement. All enhancements were carried out by performing an alcohol-assisted photorefractive keratectomy (PRK) procedure with application of mitomycin C (MMC).

Main Outcome Measures: Incidence, prevalence, preoperative and intraoperative risk factors for enhancement, and outcomes after enhancement.

Results: The prevalence of enhancement was 2.7%, and 71.4% eyes had enhancement within 1 year of primary SMILE. The incidence of enhancement was 2.1% and 2.9% at 1 and 2 years, respectively. Age older than 35 years, preoperative MRSE more than −6.00 diopters (D), preoperative myopia more than 6.00 D, preoperative astigmatism more than 3.00 D, and intraoperative suction loss were significant risk factors for enhancement after SMILE after adjusting for all other covariates (odds ratios, 5.58, 4.80, 1.41, 3.06, and 2.14, respectively; $P = 0.004$, 0.021, 0.022, 0.002, and 0.020, respectively). In the patients who underwent bilateral SMILE, the first-operated eye had a marginal trend toward significance for enhancement ($P = 0.054$). There was no gender or racial difference. In the 14 eyes requiring enhancement, the uncorrected distance visual acuity before enhancement ranged from 20/80 to 20/25, and the mean attempted enhancement spherical equivalent was −0.50±0.86 D. The uncorrected distance visual acuity improved in most patients (92.9%) after enhancement.

Conclusions: The 2-year incidence of enhancement after SMILE was 2.9%. Risk factors associated with enhancement included older age at SMILE procedure, greater preoperative MRSE, greater preoperative myopia, greater preoperative astigmatism, and the occurrence of intraoperative suction loss. Clinical outcomes of using PRK with application of MMC for enhancement were good. *Ophthalmology 2017;■:1–9 © 2017 by the American Academy of Ophthalmology*

Small-incision lenticule extraction (SMILE), a variation of refractive lenticule extraction, became available clinically in Europe and Asia in 2012 as an alternative to LASIK for the correction of myopia and myopic astigmatism. More recently, it was also approved by the United States Food and Drug Administration in September 2016. Small-incision lenticule extraction has been shown to be a safe and effective procedure with good predictability, and the refractive outcomes are comparable with those of femtosecond laser-assisted LASIK.[1,2] To date, more than 500 000 SMILE procedures have been performed worldwide.[3]

Although modern refractive surgery has a high success rate, enhancement may be required after refractive surgery. Reasons for enhancement include initial overcorrection or undercorrection and refractive regression. Enhancement rates vary depending on several variables, such as patient expectations, the degree of refractive error being treated, the laser and nomogram used, and surgeon experience.[4] Reported enhancement rates after LASIK range from 5% to 28%.[5–7] Compared with LASIK, a smaller incision is created in SMILE and no excimer photoablation is used. It has been shown that SMILE has less postoperative epithelial remodeling and less stromal healing response.[8,9] Because these are 2 main factors contributing to refractive regression, SMILE may have advantages over LASIK with respect to enhancement rate. Reinstein et al[10] reported a 4% enhancement rate after treatment for low myopia. However, the enhancement rate after SMILE has not been reported extensively.

Understanding the prevalence and risk factors influencing the need for enhancement after refractive surgery is

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important because by informing patients and identifying these factors in the preoperative consultation, patient dissatisfaction can be minimized. Moreover, it would be helpful when evaluating treatment nomograms, especially for a new procedure like SMILE. Several studies have identified risk factors associated with higher enhancement rates after LASIK, including higher initial myopic or hyperopic correction, residual astigmatism, preoperative age older than 40 years, and previous rigid contact lens use.[11–13] Environmental factors such as laser room humidity and temperature and preoperative outdoor humidity and temperature also have been reported to affect enhancement rates after LASIK.[14] However, there have been no risk factors identified previously for SMILE.

Several possible approaches for enhancement after SMILE have been considered, and the choice of the approach is determined depending on the degree of enhancement required, the depth of anterior cap of primary SMILE, the residual stromal bed thickness from primary SMILE, and the patient's desire to maintain flaplessness.[2] Topography-guided photorefractive keratectomy (PRK) has been used effectively to treat residual irregular astigmatism after SMILE.[15] Reinstein et al[10] used a thin-flap LASIK procedure anterior to the primary SMILE interface. Secondary SMILE anterior or posterior to the primary SMILE also can be considered, but at least −1.00 diopter (D) spherical equivalent (SE) of correction needs to be performed because of the thickness of the created lenticule. A modified SMILE procedure called *sub-cap-lenticule extraction*, in which the authors[16] used the interface of the primary SMILE procedure as the superior plane of the new lenticule, also has been described for the enhancement.[16] A new software nomogram called Circle (Carl Zeiss Meditec, Jena, Germany) has recently been developed with the aim to transform the original SMILE cap into a flap. An initial case series has shown good safety and efficacy.[17]

Herein we describe the incidence, prevalence, and risk factors that are associated with enhancement after SMILE. We also present the outcomes of the patients who have undergone enhancement after SMILE in our center. To our knowledge, this is the first study reporting the predisposing factors of enhancement after SMILE.

Methods

Patients

This retrospective study included 524 eyes of 307 consecutive patients undergoing SMILE performed at the Singapore National Eye Center from February 17, 2012, through March 30, 2016. Among the 307 patients, a cohort of 90 patients also were enrolled for our ongoing randomized controlled trial comparing the refractive outcomes of SMILE versus LASIK,[18] and therefore SMILE was performed on only 1 eye selected randomly. Patient data collected included patient age at primary SMILE, gender, race, preoperative and postoperative manifest refraction spherical equivalent (MRSE), preoperative and postoperative uncorrected and corrected distance visual acuity, the occurrence of suction loss during the procedure, and the need for enhancement. There were no absolute criteria in terms of postoperative visual acuity or refraction used to determine whether to perform enhancement. Instead, the criteria for enhancement in our cohort was residual, correctable refractive error causing patient dissatisfaction with the postoperative uncorrected distance visual acuity, as well as the presence of postoperative refractive stability, defined as a change in SE refraction within ±0.25 D between periods 3 months apart. The attempted correction was set at 0.25 to 0.50 D overcorrection for the nomogram adjustment to achieve plano. Patients whose target refractions were not plano were excluded. Refractive regression was defined as a myopic shift more than 0.50 D in the first year after SMILE. Approval for the study was granted by the institutional review board of SingHealth, Singapore, Republic of Singapore (reference no. 2011/109/A), and the study was conducted in accordance with the tenets of the Declaration of Helsinki.

Small-Incision Lenticule Extraction Procedure

Under topical anesthesia, SMILE was performed using a previously described technique.[2,18] The eye was centered and docked with an S-sized curved interface cone before suction fixation was applied. After suction was applied, the main refractive and nonrefractive femtosecond incisions were performed in the following optimized sequence: the posterior surface of the lenticule (spiral inward pattern); the anterior surface of the lenticule (spiral outward pattern), which extended beyond the posterior lenticule diameter by 0.5 mm to form the anterior cap; and a 2.8-mm vertical circumferential incision placed at 120°.[19] The following femtosecond laser parameters were used: 120-μm cap thickness, 7.5-mm cap diameter, 6.5-mm optical zone, and 145-nJ power with side-cut angles at 90°. The spot distance and tracking spacing were, respectively, 4.5 and 4.5 μm for the lenticule, 2.0 and 2.0 μm for the lenticule side cut, 4.5 and 4.5 μm for the cap, and 2.0 and 2.0 μm for the cap side cut. After suction release, a SMILE dissector (ASICO, Westmont, IL) was inserted through the side cut over the roof of the refractive lenticule, dissecting the anterior plane and then the posterior border. The lenticule then was grasped and removed through the small incision using a microforceps. The intrastromal space was flushed with a balanced salt solution using a standard irrigating cannula. For patients who underwent bilateral SMILE, the right eye was operated on first. All procedures were performed by senior refractive surgeons (M.R., J.S.M.). The postoperative regimen consisted of topical preservative-free dexamethasone and moxifloxacin every 3 hours for 1 week and then 4 times daily for 2 weeks. Subsequently, lubricating drops were used as needed for up to 3 months.

Enhancement Procedure

All enhancements were carried out by performing an alcohol-assisted PRK procedure. The corneal epithelium was removed with an application of 20% dilution of absolute alcohol for 45 seconds. The stromal ablation was performed using a Wavelight EX500 excimer laser (Alcon, Fort Worth, TX) with an optical zone of 6.5 mm and ablation depth ranging from 16 to 34 μm, followed by application of 0.02% mitomycin C (MMC) for 60 seconds, which is same as that in an enhancement procedure after primary surface ablation or LASIK in our center. The postenhancement regimen consisted of topical preservative-free dexamethasone and moxifloxacin every 3 hours for 1 week and then 4 times daily, tapered over 3 weeks.

Statistical Analysis

All data were expressed as mean ± standard deviation. Differences between enhancement and nonenhancement groups were assessed with a 2-sided Student *t* test for continuous variables and with a chi-square test (for the comparisons for gender, eye laterality, and the