Comparison of the predictability of refractive cylinder correction by laser in situ keratomileusis in eyes with low or high ocular residual astigmatism

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PURPOSE: To compare the manifest refractive cylinder (MRC) predictability of myopic astigmatism laser in situ keratomileusis (LASIK) between eyes with low and high ocular residual astigmatism (ORA).

SETTING: London Vision Clinic, London, United Kingdom.

DESIGN: Retrospective case study.

METHODS: The ORA was considered the vector difference between the MRC and the corneal astigmatism. The index of success (IoS), difference vector ÷ MRC, was analyzed for different groups as follows: stage 1, low ORA (ORA ÷ MRC <1), high ORA (ORA ÷ MRC ≥1); stage 2, low ORA group reduced to match the high ORA group for MRC; stage 3, grouped by ORA magnitude with low ORA (<0.50 diopters [D]), mid ORA (0.50 to 1.24 D), and high ORA (≥1.25 D); stage 4, high ORA group subdivided into low (<0.75 D) and high (≥0.75 D) corneal astigmatism.

RESULTS: For stage 1, the mean preoperative MRC and mean IoS were −1.32 D ± 0.65 (SD) (range −0.55 to −3.77 D) and 0.27, respectively, for low ORA and −0.79 ± 0.20 D (range −0.56 to −2.05 D) and 0.37, respectively, for high ORA. For stage 2, the mean IoS increased to 0.32 for low ORA. For stage 3, the mean IoS was 0.28, 0.29, and 0.31 for low ORA, mid ORA, and high ORA, respectively. For stage 4, the mean IoS was 0.20 for high ORA/low corneal astigmatism and 0.35 for high ORA/high corneal astigmatism.

CONCLUSIONS: The MRC predictability was slightly worse in eyes with high ORA when grouped by the ORA ÷ MRC. Matching for the MRC and grouping by ORA magnitude resulted in similar predictability; however, eyes with high ORA and high corneal astigmatism were less predictable.

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Ocular residual astigmatism (ORA) is the vectorial difference between corneal and refractive astigmatism calculated to the corneal plane.[1–3] It is the result of the combination of crystalline lens and posterior corneal surface astigmatisms with perceptual physiology and has been shown to be between 0.00 diopter (D) and 1.25 D in the majority of eyes in the normal population; however, it can range up to 2.00 D and beyond in otherwise normal eyes.[2–6] With-the-rule (WTR) astigmatism is more likely in eyes with low ORA, while oblique and against-the-rule (ATR) astigmatism is related to high ORA.[6] The magnitude of ORA has been found to be abnormally high in some pathologic conditions such as keratoconus[7–9] or

ectasia after laser in situ keratomileusis (LASIK)[10] as well as after keratorefractive surgery.[1] It has been hypothesized to have potential diagnostic value for the detection of some corneal disorders.[4]

High amounts of ORA have also been shown to be a potentially limiting factor in the predictability of refractive correction with an excimer laser. Some studies[2,11,12] report a relationship between the magnitude of ORA and the remaining astigmatism after keratorefractive procedures. In 1997, Alpins[2] and Alpins and Stamatelatos[13] introduced the concept that the ORA was a relevant factor to be considered when planning corneal refractive surgery to treat astigmatism, proposing that the treatment should be planned to also minimize corneal astigmatism. Kugler et al.[11] found that conventional LASIK was twice as efficacious in correcting refractive astigmatism in a low ORA group (ORA ÷ refractive astigmatism <1.0) as in a high ORA group (ORA ÷ refractive astigmatism ≥ 1.0). Similarly, in a retrospective study evaluating the outcomes of myopic LASIK Qian et al.[12] found that this procedure was less effective in correcting refractive astigmatism when the astigmatism was mainly located at the internal optics. These authors recommend considering both topography and refractive astigmatism values in surgical planning when a significant amount of ORA is detected preoperatively.

The aim of the current study was to evaluate the impact of the preoperative magnitude of ORA on the refractive astigmatism predictability of LASIK for the correction of myopic astigmatism while also considering the influence of the magnitude of refractive and corneal astigmatism to provide a more comprehensive analysis of the potential impact.

PATIENTS AND METHODS

This retrospective analysis comprised consecutive myopic patients who had LASIK between July 2003 and July 2013 at London Vision Clinic, London, United Kingdom. Informed consent and permission to use their data for analysis and publication were obtained from each patient.

Inclusion criteria were medically suitable for LASIK; no previous ocular, eyelid, or orbital surgery; no visually significant cataract; myopic manifest sphere treated between −0.25 and −10.00 D; manifest refractive cylinder (MRC) treated between −0.75 D and −4.00 D; corrected distance visual acuity (CDVA) not worse than 20/25; age younger than 55 years (to minimize the influence of early cataract); and a minimum follow-up of 3 months after LASIK.

A full ophthalmologic examination was performed by an in-house optometrist as previously described.[14]

Surgical Technique

All treatments were performed as bilateral simultaneous LASIK using the MEL 80 excimer laser and Visumax femtosecond laser (both Carl Zeiss Meditec AG) or a zero-compression Hansatome microkeratome (Bausch & Lomb) by 1 of 2 surgeons (D.Z.R., G.I.C.). The CRS-Master (Carl Zeiss Meditec AG) software platform was used to generate the ablation profiles (version 2.1.6 until January 11, 2009, and version 2.3.0 thereafter). The software version upgrade changed the graphic user interface but did not affect the ablation profiles. Proprietary aspheric ablation profiles were used that incorporated a small amount of spherical aberration; the profiles were intended to control the induction of spherical aberration to a level that would provide an increased depth of field without affecting contrast sensitivity or quality of vision. The optical treatment zone diameter was between 6.0 mm and 6.5 mm, with a larger optical zone used in eyes with larger pupil diameters. The intended flap thickness was between 80 μm and 120 μm when the femtosecond laser was used and 160 μm when the microkeratome was used.

Postoperative Evaluation

Patients were instructed to wear plastic shields while sleeping for 7 nights. Topical tobramycin 0.3%–dexamethasone 0.1% and ofloxacin 0.3% were applied 4 times daily for the first week, which is our standard protocol for broad-spectrum prophylaxis. Patients were reviewed at 1 day and 1, 3, 6, and 12 months using our standard protocol as described previously.[14] All postoperative examinations were conducted by 1 of 7 in-house optometrists. Manifest refraction was performed based on a standardized protocol,[15,16] and all optometrists had refraction training with this protocol.

Study Design

Figure 1 shows a tree diagram of the 4 stages of the study. They were as follows:

Stage 1. *Grouped by ORA ÷ MRC, not matched for MRC.* The first stage of the study was to replicate the methods used by Kugler et al.[11] and Qian et al.[12] in which the high ORA and low ORA groups were selected according to the following criteria: First, the fraction of ORA over the MRC treated (ORA ÷ MRC) was calculated for all eyes. All eyes in which the ORA ÷ MRC fraction was 1 or greater were included in the high ORA group. All eyes in which the ORA ÷ MRC fraction was less than 1 were included in the low ORA group. The mean index of success (IoS) was compared between the 2 groups.

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