Bilateral loss in the quality of vision associated with anterior corneal protrusion after hyperopic LASIK followed by intrastromal femtolaser-assisted incisions

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A patient was treated bilaterally for hyperopia (twice in the right eye and 3 times in the left eye) using laser in situ keratomileusis (LASIK) and achieved stable vision. Preoperatively, there was no known risk factor for ectasia. Three years after the last LASIK enhancement treatment, intrastromal femtolaser-assisted incisions (Intracor procedure using the Technolas femtosecond laser) were made bilaterally. After the procedure, a severe loss in the corrected distance visual acuity and in the quality of vision occurred, associated with a topography pattern suggestive of isolated anterior central protrusion. This case suggests that intrastromal femtosecond incisions in eyes that have had hyperopic LASIK should be done with caution, as there is no certainty about how the treated corneas will respond.

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The success of refractive surgery in correcting emmetropia has made the correction of presbyopia in an aging population a significant challenge. Ruiz et al.[1] developed a surgical treatment for presbyopia that applies circular intrastromal femtosecond laser pulses to produce a focal ectasia (Intracor procedure using the femtosecond laser system [Technolas Perfect Vision GmbH]). The anterior corneal surface is the first contributor to the refractive power of the eye and even small distortions can affect vision. We present a case in which the patient experienced a loss in the quality of vision following hyperopic laser in situ keratomileusis (LASIK) surgery and the subsequent application of bilateral intrastromal femtosecond incisions for presbyopia.

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CASE REPORT

A 55-year-old man presented for refractive surgery at another institution in February 2002. The preoperative corrected distance visual acuity (CDVA) was 20/25 and the manifest refraction was +2.75 diopters (D) sphere in both eyes. The preoperative corneal thickness was not available to us, but the preoperative topography appeared bilaterally normal, with no evidence of asymmetry, steepening, or irregularity (Figure 1). The mean central keratometry was 42.75 in both eyes. The remainder of the examination was described as normal.

Uneventful LASIK was performed in both eyes in February 2003. A nasally hinged flap of unknown thickness was created with a mechanical microkeratome from an unknown manufacturer. An EC-5000 excimer laser (Nidek, Inc.) was used to perform the ablations with a 6.5 mm optical zone.

Postoperatively, the patient was undercorrected, achieving 20/25 bilaterally with $+0.75$ -1.00×5 in the right eye and $+0.50$ -0.50×160 in the left eye. Placido topography showed bilateral regular moderate central steepening characteristic of the hyperopic laser ablation (Figure 2). The mean central keratometry was 46.0 D in the right eye and 45.5 D in the left eye. An uneventful LASIK flap lift enhancement and hyperopic photoablation was performed in both eyes in May 2003. After the LASIK enhancement, the uncorrected distance visual acuity (UDVA) was 20/30 in both eyes. In July 2006, the CDVA was 20/25 in both eyes with a manifest refraction of -0.50 in the right eye and $+1.75$ -1.75×160 in the left eye.

A second enhancement was performed in the left eye (data unavailable) in July 2006, 41 months after the primary

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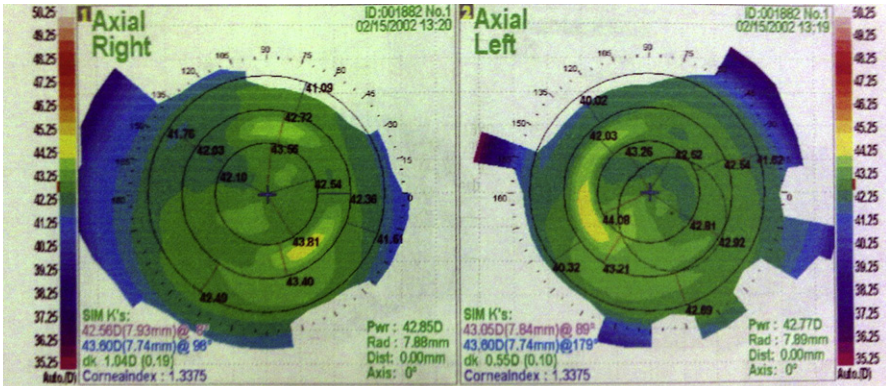


Figure 1. Preoperative Placido topography of both eyes showing normal corneas without asymmetry or suspicious irregularity (OPD scan).

procedure. After the second LASIK enhancement, the UDVA was 20/25 in the left eye and remained stable in both eyes until 2009. At that time, the patient complained of near vision loss and in May 2009, intrastromal femtosecond incisions were applied at the same facility to enhance the near vision. Postoperatively, the patient complained of progressive blurred vision in both eyes associated with halos and severe glare. He was referred to our institution in March 2010.

The UDVA was 20/60 in the right eye and 20/70 in the left eye, with no improvement following manifest refraction. The elevation topographies (Figures 3 and 4) showed a bilateral central corneal protrusion. The anterior elevation map showed a maximum central anterior elevation of 49 μm in the right eye and 48 μm in the left eye. The maximum central posterior elevation was 23 μm in the right eye and 19 μm in the left eye. The mean central keratometry (1.0 mm radius) reached 51.5 D with a maximum of 55.0 D in the right eye and 51.0 D with a maximum of 53.0 D in the left eye. The OPD scan (Nidek, Inc.) Placido topography (Figure 5) showed the same pattern of isolated bilateral central anterior corneal protrusion with higher-order aberrations (HOAs) (6th-order) calculated for a 6.0 mm zone reaching 8.0 μm in the right eye and 6.5 μm in the left eye. Ultrasound pachymetry revealed a central thickness of 505 μm in the right eye and 495 μm in the left eye. Anterior segment optical coherence tomography (OCT) showed a flap thickness of 167 μm with a residual stromal bed thickness of 336 μm in the right eye and a flap thickness of 175 μm with a residual stromal

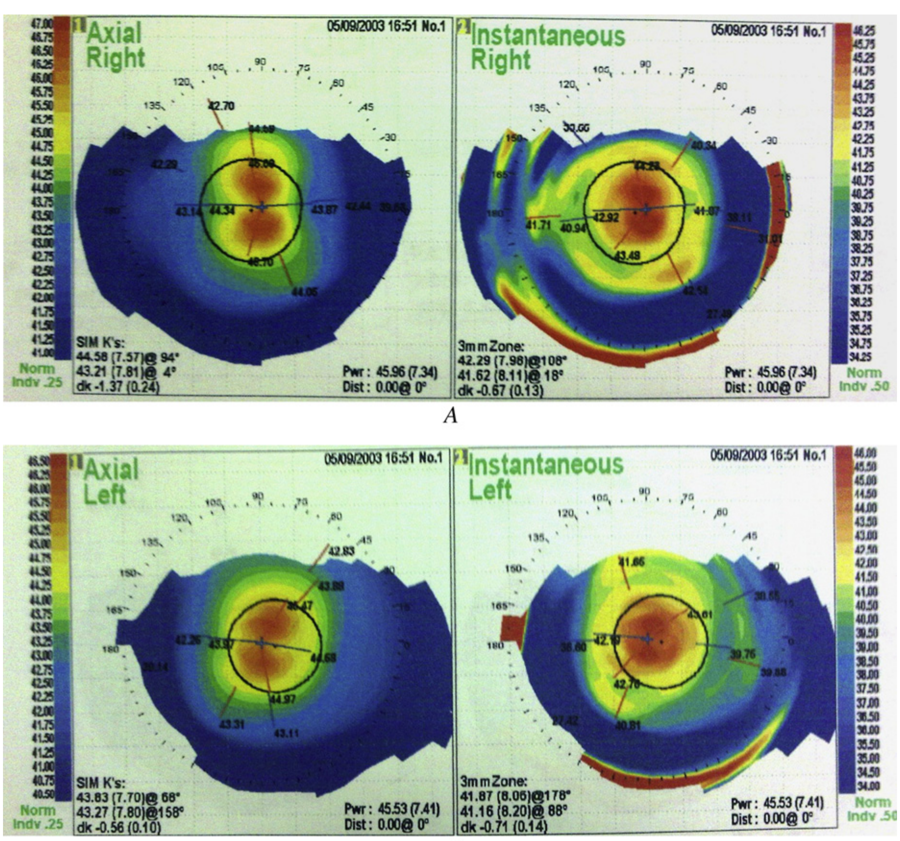


Figure 2. Post-LASIK Placido topography of both eyes showing a central moderate steepening (OPD scan).

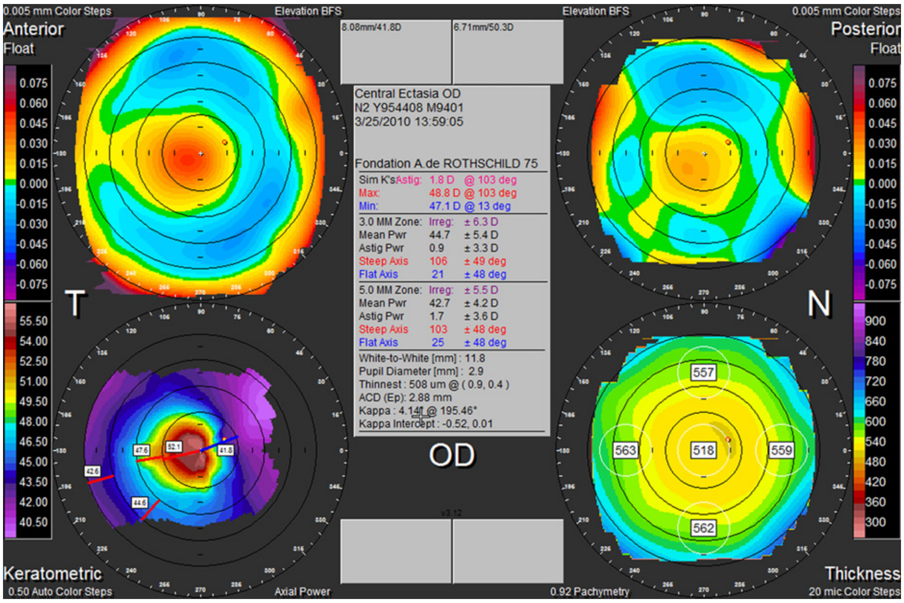


Figure 3. Combined Placido and elevation topography of the right eye after the intrastromal femtosecond incision procedure showing a severe steepening with isolated anterior protrusion. The maximum central anterior elevation is 49 μm. The maximum central posterior elevation is 23 μm, and the mean central keratometry (1.0 mm radius) reached 51.5D with a maximum of 55.0 D.

bed of 316 μm in the left eye (Figures 6 and 7). No thinning was detected in the residual stromal bed. Rigid gas-permeable contact lens fitting improved the visual acuity to 20/25 in both eyes.

DISCUSSION

Corneal ectasia after myopic LASIK has been well described in the literature; however, to our knowledge, few cases of ectasia after hyperopic LASIK have been reported.[2] In hyperopic LASIK, maximum ablation depth is reached at the periphery of the optical zone, thus preserving the central thickness and leading to less biomechanical weakening.[3] This may explain the lower incidence of ectasia after hyperopic LASIK.

The major established risk factor for ectasia is a preoperative topography sharing similarities with ectatic disorders. Recently, a large review performed by Randleman et al.[4] found that along with an abnormal preoperative topography, higher degrees of myopia, preoperative corneal thickness of 510 μm or less, an assumed or calculated residual bed thickness of 280 μm or less, and patients younger than 25 years are statistically associated with the development of post-LASIK ectasia. The removal of a critical amount of corneal tissue from the stromal bed that could structurally

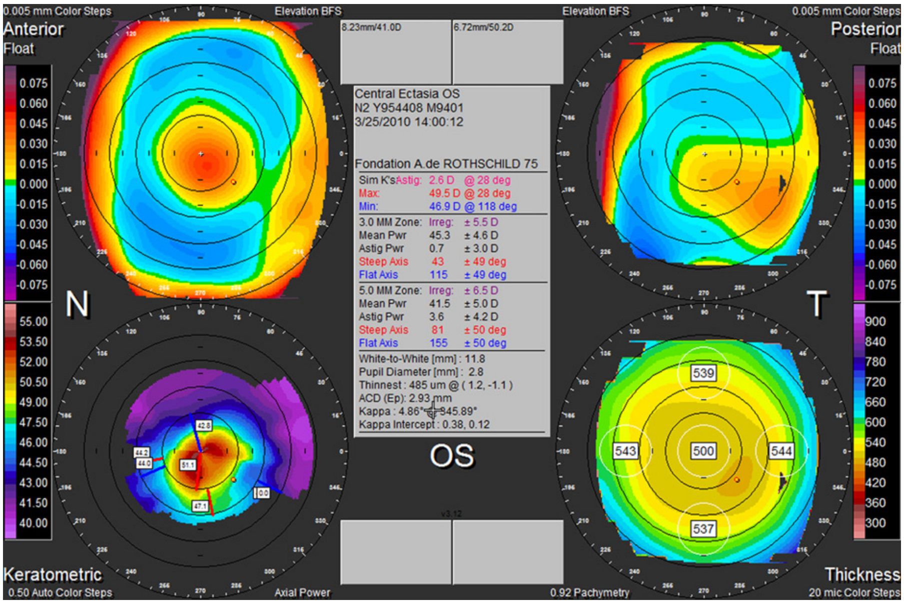


Figure 4. Combined Placido and elevation topography of the left eye after the intrastromal femtosecond incision procedure showing similar topography pattern. The maximum central anterior elevation is 48 μm. The maximal central posterior elevation is 19 μm, and the mean central keratometry (1 mm radius) reached 51.0 D with a maximum of 53.0 D.

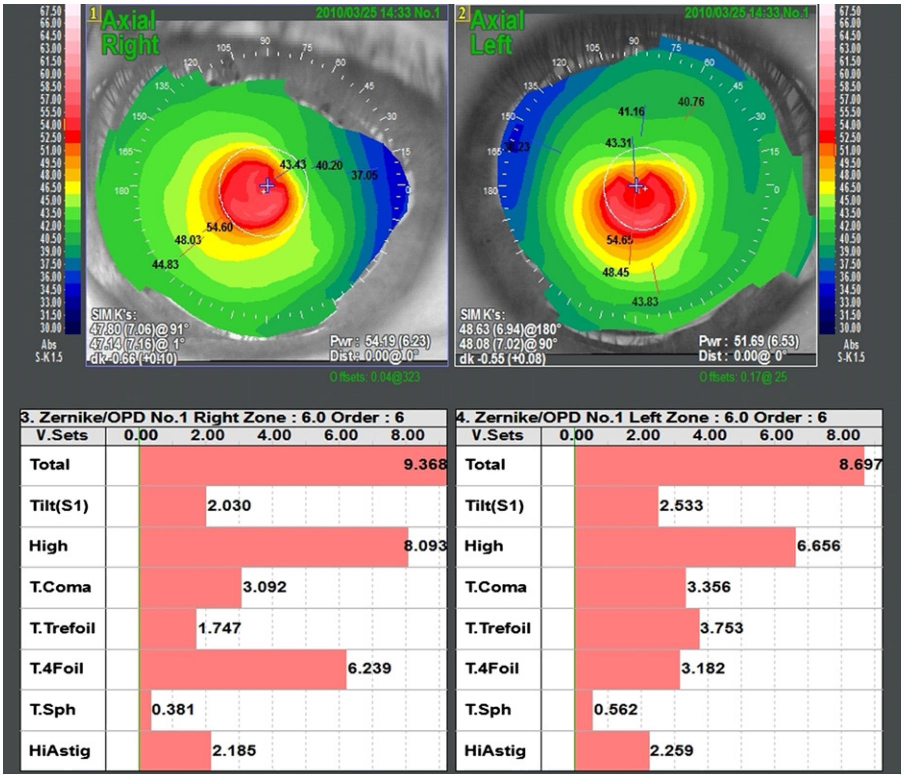


Figure 5. Placido topography of both eyes after the intrastromal femtosecond incision procedure showing the same pattern of bilateral central corneal protrusion with HOA (6th-order) calculated for a 6.0 mm zone reaching 8.0 μm in the right eye and 6.5 μm in the left eye.

weaken the eye is an additional risk factor.[5] In the patient we described, none of those risks were present and assuming that the preoperative central corneal thickness was greater than 500 μm, the calculated Randleman ectasia risk score would be 0 for both eyes. This assumption is based on the fact that central corneal thickness was almost 500 μm bilaterally after the repeated LASIK treatments.

The intrastromal femtosecond incision procedure delivers a series of 5 femto-disruptive cylindrical rings beginning within the posterior stroma, at a variable distance from Descemet membrane, and extending anteriorly through the midstroma to an anterior location at a predetermined distance beneath Bowman layer.[1] Preliminary studies show that the 5 incisions are not similar in terms of thickness and orientation.[A] The aim of these incisions is to induce a local reorganization of the biomechanical forces and a change in corneal shape. The net effect is a central steepening of the anterior corneal surface.[1] Preliminary results show good uncorrected near visual acuity postoperatively and no major loss in UDVA.[1,6] Relative stability of total aberrations and HOAs is described, with a shift in primary spherical aberration toward negative values and secondary spherical aberration toward positive values.[1] Biomechanical studies (obtained with the Ocular Response Analyzer, Reichert, Inc.) reveal only a slight reduction of corneal resistance factor with no modifications of the corneal hysteresis, both indicators of the viscoelastic properties of the cornea.[1] No perioperative or postoperative complications are described. In the Ruiz et al. study,[1] all patients complained of halos starting the day after the surgery but the symptoms

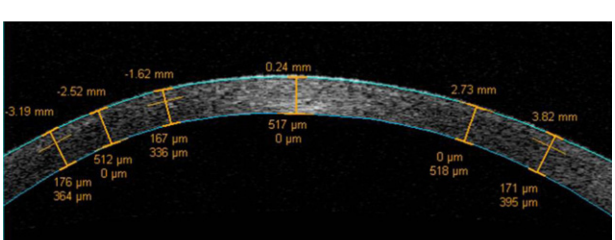


Figure 6. Anterior segment OCT of the right eye showing a flap thickness of 167 μm and a minimum residual stromal bed of 336 μm.

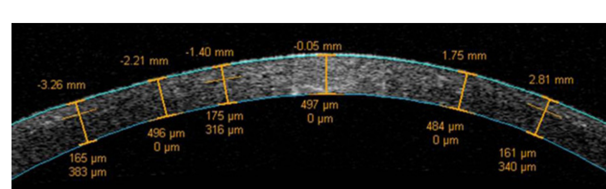


Figure 7. Anterior segment OCT of the left eye showing a flap thickness of 175 μm and a minimum residual stromal bed of 316 μm.

improved with time and at 12 months, only 3% of patients reported halos.

In the case we described, the effects of hyperopic LASIK remained stable 6 years after the right eye enhancement and 3 years after the left eye second enhancement. Thus, the occurrence of an isolated topographic anterior central protrusion pattern was probably triggered by the intrastromal femtosecond incision procedure, especially since the aim of this treatment is to increase corneal hyperprolacity, with steepening of the central portion. However, the reported results[1,6] involve topographically normal and nonoperated corneas. In our case, intrastromal femtosecond incisions in a hyperprolate cornea produced an excessive central anterior protrusion associated with a severe loss in CDVA and a high level of HOAs. The typical post-LASIK ectasia is topographically defined as an inferior progressive steepening associated with corneal thinning.[4,7,8] Our case presented a limited ectasia pattern not associated with corneal thinning. Thus, the pathophysiology of the ectatic result in this report may not be the same as in previously described post-LASIK ectasia resulting from excessive thinning of the stromal wall and affecting both the anterior and posterior corneal surfaces. It might be explained by a progressive over-response to the intrastromal femtosecond incision procedure in already steepened corneas or by additional biomechanical stress to the bed and flap stromal components caused by the relaxing incisions. One hypothesis that could explain our findings is that femtosecond intrastromal incisions caused an excessive relaxing effect on the stromal tissue of both the posterior stromal bed and the LASIK flap. On the OCT maps, it is difficult to visualize the incisions that probably affected the stromal portion of the 170 μm thickness flaps. Ruiz et al.[B] performed the intrastromal femtosecond incision procedure in 30 post-LASIK eyes and found that most are overcorrected. They believe that going deep below the flap to perform the intrastromal procedure may result in a greater effect. Thus, the Intracor algorithm, ring patterns, and depth would have to be adjusted in post-LASIK cases.

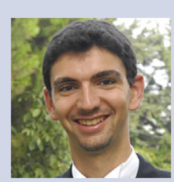
As the intrastromal femtosecond incision procedure is developing, its use might increase rapidly, especially in patients who have had a refractive procedure and seek independence for near correction. Even if the procedure alone has a slight impact on the corneal biomechanics, the results of its association with LASIK has not been described. Thus, intrastromal femtosecond incisions should be used cautiously in eyes previously treated by LASIK because the predictability of this technique is not currently known.

REFERENCES

1. Ruiz LA, Cepeda LM, Fuentes VC. Intrastromal correction of presbyopia using a femtosecond laser system. J Refract Surg 2009; 25:847–854
2. Randleman JB, Banning CS, Stulting RD. Corneal ectasia after hyperopic LASIK. J Refract Surg 2007; 23:98–102
3. Shah S, Laiquzzaman M, Yeung I, Pan X, Roberts C. The use of the Ocular Response Analyser to determine corneal hysteresis in eyes before and after excimer laser refractive surgery. Cont Lens Anterior Eye 2009; 32:123–128
4. Randleman JB, Woodward M, Lynn MJ, Stulting RD. Risk assessment for ectasia after corneal refractive surgery. Ophthalmology 2008; 115:37–50. Available at: http://download.journals.elsevierhealth.com/pdfs/journals/0161-6420/PIIS0161642007003715.pdf. Accessed June 20, 2010
5. Binder PS, Trattler WB. Evaluation of a risk factor scoring system for corneal ectasia after LASIK. J Refract Surg 2010; 26:241–250
6. Holzer MP, Mannsfeld A, Ehmer A, Auffarth GU. Early outcomes of INTRACOR femtosecond laser treatment for presbyopia. J Refract Surg 2009; 25:855–861
7. Dawson DG, Randleman JB, Grossniklaus HE, O'Brien TP, Dubovy SR, Schmack I, Stulting RD, Edelhauser HF. Corneal ectasia after excimer laser keratorefractive surgery: histopathology, ultrastructure, and pathophysiology. Ophthalmology 2008; 115:2181–2191.e1
8. Seiler T, Koufala K, Richter G. Iatrogenic keratectasia after laser in situ keratomileusis. J Refract Surg 1998; 14:312–317

OTHER CITED MATERIAL

A. Guedj T, Danan A, Pietrini D, Lebuisson DA, "Imagerie IntraCor," presented at the 116th Congrès de la Société Française d'Ophtalmologie, Paris, France, May 2010
B. Ruiz LA, "Presbyopia Treatment With IntraCor," round table discussion at the 1st Technolas Perfect Vision Alliance, Bali, Indonesia, May 2009. Available at: http://www.technolaspv.com/dasat/images/4/100544-1st-tpv-alliance-bali-may-2009.pdf. Accessed June 20, 2010



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