ABSTRACT

PURPOSE: We describe ten patients who developed progressive keratectasia following laser in situ keratomileusis (LASIK) and identify possible factors that may lead to ectasia.

METHODS: In this retrospective study, we reviewed the files of 3,634 patients (6,941 eyes) who had LASIK between March 2000 and April 2003. Ten patients (14 eyes, 0.2%) developed progressive keratectasia. We also evaluated consequent therapeutic measures and final visual status of these patients.

RESULTS: Patients were examined at a mean 24.9 ± 8.1 months after LASIK. Ectasia developed within a mean 14 ± 0.3 months after surgery. At baseline, mean keratometric power was 44.7 ± 2.30 D, mean corneal thickness was 516 ± 18.9 µm, and mean attempted correction was -10.85 ± 3.20 D. We found a statistically significant correlation between residual stromal thickness, attempted correction, and occurrence of progressive keratectasia. We also found that preexisting abnormal corneal topography was a risk factor for progressive keratectasia. Ultimately, most patients had reasonable visual acuity after penetrating keratoplasty.

CONCLUSION: Progressive keratectasia is a vision threatening complication of LASIK that may occur in previously healthy or diseased eyes. The most important risk factors are residual stromal thickness and preexisting abnormal corneal topography. Penetrating keratoplasty may be a reasonable therapeutic measure for severe cases of progressive keratectasia. [J Refract Surg 2004; 20(suppl):S718-S722]

Laser in situ Keratomileusis

Progressive Keratectasia After Laser in situ Keratomileusis

Ahmad Salamat Rad, MD; Mahmoud Jabbarvand, MD; Nader Saifi, MD

From the Cornea and Refractive Section, Novin Didegan Eye Center, Tehran, Iran.

The authors have no proprietary interest in the materials presented herein.


Correspondence: Ahmad Salamat Rad, MD, P.O. Box 13185-773, Tehran, Iran. E-mail: a_s_rad@iranmedical.com

Given the fast visual recovery and low rate of complications, laser in situ keratomileusis (LASIK) has gained worldwide acceptance as the procedure of choice for correction of refractive errors.1,2 However, it can have serious complications—corneal ectasia is one of the vision threatening complications after LASIK. Various studies have been published regarding its diagnosis, treatment, and prevention; and several diagnostic criteria and preventive measures have been described.1-12 In most reports, eyes developed progressive thinning of the cornea associated with increasing myopia and astigmatism, and progressive steepening of the central or inferior cornea.1-5,7,11

This disorder has several names, including but not limited to LASIK-induced corneal ectasia, post-LASIK keratectasia, iatrogenic keratectasia, iatrogenic keratoconus, and progressive post-LASIK keratectasia (PPLK).1,3,5,7,8,11 We prefer progressive keratectasia after LASIK, as the phrase defines the etiology, natural history, and pathology of the disorder.

In this retrospective study we examined 14 eyes of 10 patients who developed progressive keratectasia after LASIK for correction of myopia, in order to identify factors that may have contributed to complications. We also evaluated the results of penetrating keratoplasty in these eyes.

PATIENTS AND METHODS

In this retrospective study, we reviewed the medical charts of 3634 patients (6,941 eyes) who had LASIK between March 2000 and September 2003. Ten patients (14 eyes, 0.2%) developed progressive keratectasia. All patients underwent a thorough eye examination before LASIK, which included uncorrected visual acuity (UCVA), best spectacle-corrected visual acuity (BSCVA), autorefraction (AR600, Nidek, Gamagori, Japan), topography (Topo-Map, CSO, and Orbscan, Orbtek, Salt Lake City, UT), pachymetry, (UP-1000, Nidek and Orbscan) and tonometry.
After creation of a superior hinge flap with a Moria CB mircokeratome (Moria SA, Antony, France), a Nidek EC-5000 excimer laser was used to ablate the cornea. The following information was recorded from our review of patient charts: age, gender, affected eye, BSCVA, refraction, topography, pachymetry, and tonometry.

Progressive keratectasia was diagnosed by decreasing visual acuity, unstable refraction, progressive topographic steepening, (≥1.00 diopter [D] for each 6-month period of follow-up), and corneal thinning (≥20 µm for each 6-month period of follow-up).

**RESULTS**

Mean patient age was 36.5 ± 11.2 years (range 22 to 53 yr). According to our center’s data bank, the mean patient age for LASIK was 25.3 ± 8.2 years.
Six patients (60%) were females and four (40%) were males. Mean follow-up was 24.9 ± 8.1 months (range 14 to 38 mo).

Preoperatively, mean BSCVA was 0.8 (range 0.5 to 1.0), mean spherical equivalent refraction was -10.85 ± 3.20 D (range -5.75 to -15.00 D), mean keratoatomic power was 44.7 ± 2.30 D (range 42.40 to 48.30 D), and mean corneal thickness (pachymetry) was 516 ± 18.9 µm (range 492 to 547 µm). Corneal topographic patterns included asymmetric bow-tie in six eyes (42.8%); symmetric bow-tie in five eyes (35.7%), and round or oval in three eyes (21.4%). The mean intraocular pressure (IOP) was 13.07 ± 0.9 mmHg (range 12 to 15 mmHg) (Table 1).

At the last examination after LASIK, mean BSCVA was 0.3 (range 0.1 to 0.6) and the mean spherical equivalent refraction was -8.00 ± 2.00 D (range -4.25 to -11.00 D)—both reveal the worsening visual status of patients (Table 2). The mean postoperative corneal thickness (pachymetry) was 382.8 ± 15.1 µm (range 360 to 409 µm) and the mean calculated residual stromal thickness was 222.8 ± 15.1 µm (range 200 to 249 µm). We calculated residual corneal thickness by subtracting estimated flap thickness from preoperative corneal thickness, although this was not always precise (Table 2). Mean IOP was 12.7 ± 0.8 mmHg (range 11 to 14 mmHg).

Progressive keratectasia developed within a mean of 14 ± 0.3 months (range 11 to 17.5 mo). It occurred in eight right eyes (57.2%) and six left eyes (42.8%); four patients (40%) developed bilateral disease. We found no statistically significant difference between unilateral and bilateral cases in terms of age (P=.2), gender (P=.3), magnitude of refractive error (P=.1), mean keratometric power (P=.3), or mean corneal thickness (P=.2).

Corneal steepening occurred centrally in eight eyes (57.2%) and inferiorly in six eyes (42.8%) (Table 2). In all but one of the inferior steepening eyes, there were previous corneal risk factors including decreased corneal thickness, high keratometric power, and abnormal topographic patterns. The mean preoperative central corneal thickness of the central steepening group was 526.2 ± 13.9 µm and in the inferior steepening group, 503.1 ± 17.3 µm. Of eight central steepening cases, only one (12.5%) had abnormal topography, but five of six (83.3%) inferior steepening cases had abnormal topography. There was a statistically significant difference between the central and inferior steepening groups in pre-existing topographic abnormalities (P=.02) and corneal thickness (P=.01).

Seven patients eventually underwent penetrating keratoplasty and all of them had reasonable BSCVA and refractive errors after surgery. At last follow-up, mean BSCVA was 0.7 (range 0.5 to 0.9) and mean spherical equivalent refraction was -2.15 ± 2.35 D (range +1.50 to -6.00 D) (Table 3).

The results of histopathological examinations of the corneal buttons after keratoplasty were surprisingly insignificant and included normal epithelium, normal Bowman’s layer, irregular lamellae with decreased density, and normal Descemet’s membrane.

**DISCUSSION**

The occurrence of keratectasia following LASIK is a great concern in modern refractive surgery and has been reported since 1998. Several studies have been published about its etiology, natural history, treatment, and prevention. We think that the term progressive post-LASIK keratectasia (PPLK), first introduced by Comaish and Lawless, may be the best name, as it describes etiology, natural history, and pathology of the disorder.12

Although the incidence of progressive keratectasia after LASIK is unknown, in one large study the incidence was 0.66%. The disorder may occur within a few months and up to 4 years after LASIK.1,5,11,14

Some factors thought to be responsible for development of progressive keratectasia after LASIK are:

1) **Residual stromal thickness.** Although it is difficult to determine what constitutes a safe residual stromal thickness, 250 µm and more is widely accepted as a reasonable limit to prevent
progressive keratectasia after LASIK.1,4,13-16 Regarding preoperative corneal thickness, this limit was not achieved in any of our cases. Although Flanagan and Binder reported several patients with a residual stromal thickness less than 250 µm who did not develop progressive keratectasia after LASIK during follow-up of more than 3 years17, and Argento and colleagues reported a few cases of progressive keratectasia after LASIK, even with residual stromal thickness of more than 250 µm10, we think that maintaining this limit can prevent most, and perhaps all, instances of progressive keratectasia after LASIK. The anterior 100 to 120 µm of cornea is more compact and more resistant to mechanical deformation than the rest of cornea.18 To create a flap in this area we cut the lamellae, and since the flap forms a relatively weak attachment to the rest of stroma after LASIK, it may not contribute to the biomechanics of cornea as it did before.3,4 Hence, we think keeping as much residual stroma as possible is critical.

2) Pre-existing corneal pathology. We found corneal risk factors including low pachymetry measurements, abnormal corneal topography, and high keratometric power in 6 of 14 eyes (43%). These risk factors were found in only one of eight central steepening cases and in all but one in the inferior steepening group. This is similar to the findings reported by Faraj and colleagues, who suggested that progressive keratectasia after LASIK in normal eyes presents as central steepening, and as inferior steepening in eyes that had preoperative pathology such as keratoconus or forme fruste keratoconus.19 Regarding these data, we suggest dividing cases of progressive keratectasia after LASIK into two subgroups: with central steepening and no previous corneal risk factors, and with inferior steepening and previous corneal risk factors. Additional study is required to confirm this hypothesis.

3) Attempted correction. In 13 of 14 eyes (94.7%), attempted correction was >-6.00 D. In the ophthalmic literature, we found that the attempted correction in the majority of eyes with progressive keratectasia after LASIK was >-6.00 D17,14,15, but reports also exist with lower corrections, making the etiopathology of the disorder complex.1,14,20,21

4) Age. The mean age of our patients was 36.5 ± 11.2 years (range 22 to 53 yr). According to our center’s data bank, mean age of LASIK patients is 25.3 ± 8.2 years. Although cases of progressive keratectasia after LASIK are few, the age range of the patients is clearly higher. Whether age itself can change the corneal response to the laser, its tolerance to ablation energy, or wound healing after LASIK is a matter of controversy, and we found different hypotheses in the literature.2,22-25

There may be multiple risk factors for developing progressive keratectasia after LASIK, such as low residual stromal thickness, previous corneal risk factors, attempted correction, age, and other factors not yet identified. We should carefully monitor the residual stromal thickness and corneal topography of LASIK candidates and avoid performing LASIK in doubtful cases, as there are alternative procedures for correction of refractive errors: photorefractive keratectomy, laser subepithelial keratomileusis, phakic intraocular lens, and clear lens extraction. We suggest that a multi-center study be conducted to elucidate factors that might contribute to development of progressive keratectasia after LASIK and define a standard protocol for reporting cases.

REFERENCES
Progressive Keratectasia After LASIK/Rad et al
