

LETTERS

Keratoconus and corneal ectasia after LASIK

Keratoconus is a naturally occurring ectatic corneal disorder in which the cornea progressively thins and steepens to produce myopia, irregular astigmatism, and, eventually, loss of best spectacle-corrected visual acuity (BSCVA). Reported risk factors for keratoconus include eye rubbing, a family history of keratoconus, genetic predisposition, Down's syndrome, ocular allergy, connective tissue disease, and contact lens wear. Pellucid marginal degeneration and keratoglobus are other noninflammatory corneal thinning disorders.¹

Progressive thinning and steepening of the cornea may also occur after laser in situ keratomileusis (LASIK). This condition, commonly referred to as post-LASIK ectasia, behaves in a manner similar to that of keratoconus.²

This document is the 2005 consensus opinion of a committee of 7 refractive surgeons brought together at the request of the American Academy of Ophthalmology, the International Society of Refractive Surgery, and the American Society of Cataract and Refractive Surgery (ASCRS) to summarize current knowledge of ectatic corneal disorders and ectasia after LASIK.

ECTATIC CORNEAL DISORDERS

Ectatic corneal disorders (including keratoconus and ectasia after LASIK) are the second most common indications for keratoplasty, accounting for about 15% of corneal transplants performed in the United States.³ Based on epidemiologic studies, the incidence of keratoconus is estimated to be approximately 1 in 2000 in the general population.⁴ The incidence of ectasia after LASIK is unknown as accurate data are unavailable ("Post LASIK Ectasia," ASCRS Member Survey, April 2003).

If corneal ectasia develops, there are many options available for treatment before an eye becomes a candidate for penetrating keratoplasty (PKP). These include soft contact lenses (spherical and toric), rigid gas-permeable lenses (spherical, bitoric, reverse geometry), scleral contact lenses, intracorneal ring segments (Intacs, Addition Technology Inc.),⁵ and lamellar keratoplasty. The percentage of eyes that have developed ectasia after laser vision correction and required a corneal transplant is unknown.

We think that if an eye progresses to PKP, the prognosis for vision in that eye is the same whether the ectatic condition developed de novo or as a result of laser vision correction. Corneal transplantation for keratoconus has the highest success rate of any indication, with graft survival rates of 97% and 92% at 5 and 10 years, respectively.⁶ Based on our combined clinical corneal transplant experience, we think the visual prognosis for patients who undergo PKP for ectasia is excellent; the majority of these patients should be able to achieve normal quantitative and qualitative visual function without restriction.

Traditionally, keratoconus has been diagnosed by slitlamp findings, including corneal thinning, Fleischer rings, stress lines, and scarring. Recently, more sophisticated methods of measuring corneal topography have allowed identification of eyes with unusual topographic patterns but no slitlamp findings or loss of BSCVA. Currently, it is not known whether eyes with these

patterns in the normal population will progress to develop ectatic corneal disorders or remain unchanged throughout life.⁷ It is our firm opinion that the diagnosis of corneal ectatic disorders is a clinical one that can be made only by careful examination of the eye as there is no definitive blood test, clinical marker, or single examination technique that can establish a specific diagnosis, although videokeratography can be useful to confirm the diagnosis in clinical disease.

Just as we recognize risk factors for keratoconus and other ectatic conditions (Table 1), possible risk factors for the development of ectasia following laser vision correction have been identified in the published literature. These include high myopia, reduced preoperative corneal thickness, reduced residual stromal bed after laser ablation, and asymmetrical corneal steepening (forme fruste keratoconus), but none of these characteristics definitively predict the development of ectasia.⁸ Ectasia can develop in eyes with no currently identifiable risk factors.

CONCLUSIONS

1. Although different stages of keratoconus can be diagnosed by slitlamp examination, more sensitive analyses of corneal topography and thickness reveal a continuum of findings from those that are clearly normal to those that are clearly pathologic. There is no specific test or measurement that is diagnostic of a corneal ectatic disorder. Because subtle corneal curvature changes can be overlooked on slitlamp evaluation and videokeratography has been shown to be useful to confirm a diagnosis preoperatively, videokeratography should be performed prior to corneal refractive surgery.
2. A computer-generated diagnosis of keratoconus suspect based on indices specific to certain instruments is not necessarily a contraindication to vision correction surgery. A decision to perform LASIK should take the entire clinical picture into account, as such topographically based, computer-generated warnings may occur in the presence of normal corneas.

Table 1. Current risk factors for corneal ectatic disorders.

Prominent corneal nerves
Fleischer ring (iron line)
Scissoring of the retinoscopic reflex
Patterns of topography (including forme fruste keratoconus)
Family history of keratoconus
Keratoconus in 1 eye
Asymmetric thin corneas
Asymmetric astigmatism
Asymmetric steep corneas
Irregular astigmatism
Tilted (skewed) keratometry mires
Vogt's striae
Thinning of the cornea
Apical scarring of the cornea
Corneal irregularity that cannot be corrected by spectacles

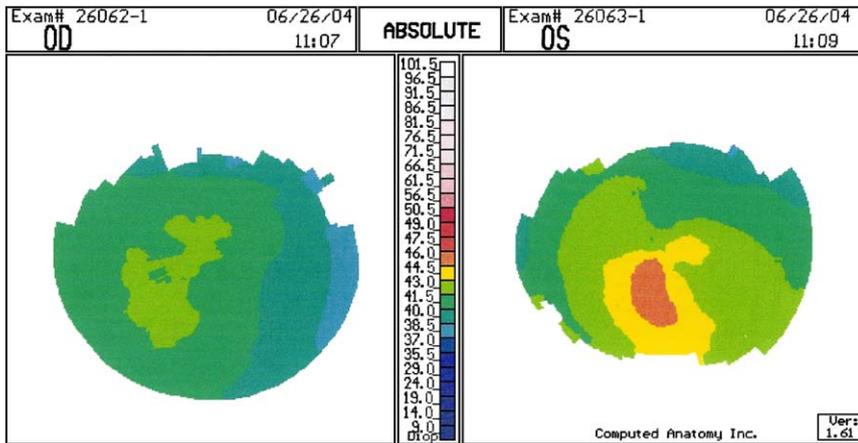


Figure 1. Videokeratography map of the left eye in the absolute scale demonstrates forme fruste keratoconus in a family member of a patient with keratoconus illustrating an asymmetric bowtie pattern with skewed steep radial axes above and below the horizontal meridian (very mild AB/SRAX pattern). The right eye of the same patient demonstrates normal appearing topography. Similar patterns can be seen in normal patients with contact lens warpage and in 0.5% of the normal noncontact lens-wearing population. (Reproduced with permission from Rabinowitz et al.⁹)

- Although some risk factors have been suggested for ectasia after LASIK, none of them are absolute predictors of its occurrence. Thus, the occurrence of ectasia after laser vision correction per se is not a deviation from the standard of care.
- Because keratoconus may develop in the absence of refractive surgery, the occurrence of ectasia after LASIK does not necessarily mean that LASIK was a causative or contributing factor in its development.
- Little information exists on the results of surface ablation in eyes with risk factors for ectasia after LASIK, so risk factors for ectasia after LASIK may not also predict ectasia after surface ablation.
- Ectasia is a known risk of laser vision correction, and if ectasia occurs in a patient following laser vision correction, it does not necessarily mean that the patient was a poor candidate for surgery, that the surgery was contraindicated, or that there was a violation of the standard of care.
- Forme fruste keratoconus is a topographic diagnosis, rather than a clinical one. It is not a variant of keratoconus. Rather, forme fruste implies subclinical disease with the potential for progression to clinically evident keratoconus. The existing literature on ectasia and longitudinal studies of the fellow eye of unilateral keratoconus patients indicates that asymmetric inferior corneal steepening or asymmetric bowtie topographic patterns with skewed steep radial axes above and below the horizontal meridian (Figures 1 to 4) are risk factors for progression to keratoconus and ectasia after LASIK. We now recommend against performing LASIK in such patients using current technology. Patients with these topographic patterns who are stable could be offered photorefractive keratectomy with informed consent, indicating that there may still be a risk for progression to keratoconus. Patients with an inferior "crab-claw" pattern accompanied by central flattening ("blue spot") are at risk for the development

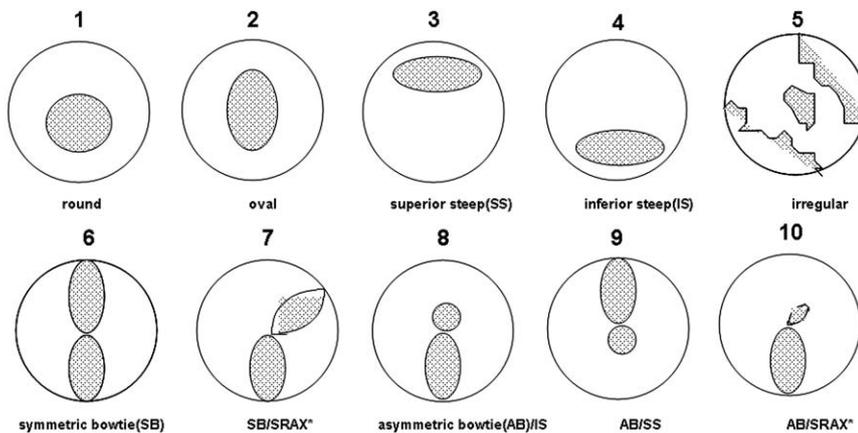
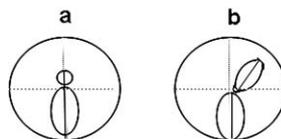


Figure 2. Diagrammatic representation of various videokeratography patterns in the normal population in the absolute scale to illustrate interpretation of the asymmetric bowtie with skewed steep radial axes above and below the horizontal meridian (AB/SRAX) pattern. (Reproduced with permission from Rabinowitz et al.⁹)

Explanation of how to interpret SRAX* (skewed radial axes):

this pattern suggests that there is skewing of the steepest radial axes above and below the horizontal meridian. To interpret this as such, an imaginary line is drawn to bisect the upper and lower lobes of asymmetric bowtie (see solid line). If there is no deviation from the vertical meridian, there is no skewing and the pattern is labeled AB (figure a). However if the lines bisecting the two lobes appear skewed by more than 30 degrees from the vertical meridian, it is called skewed (as in figure b), and this pattern is labeled AB/SRAX.



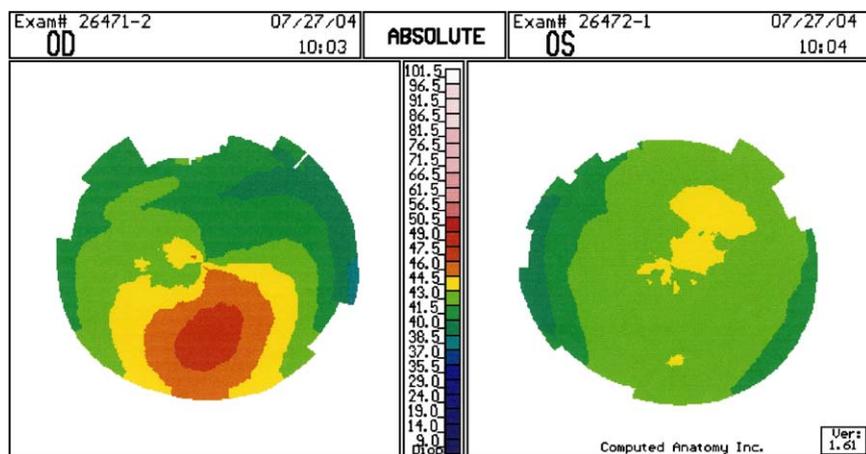


Figure 3. Videokeratography map of a patient with "early" keratoconus in the right eye with an asymmetric bowtie with skewed steep radial axis above and below the horizontal meridian (AB/SRAX) pattern. The topography in the left eye appears normal. (Reproduced with permission from Rabinowitz et al.⁹)

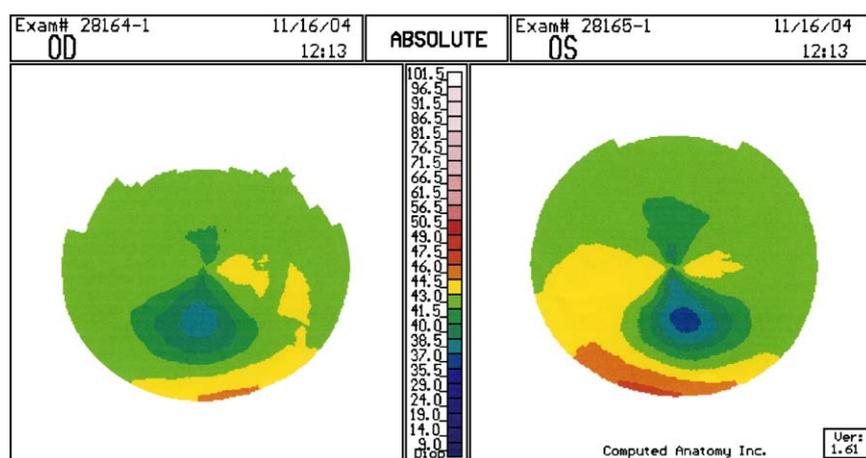


Figure 4. Videokeratography maps of a patient with pellucid marginal degeneration suspect topography and against-the-rule astigmatism in the left eye. Note the central blue spot depicting central flattening and an incomplete inferior crab-claw appearance commonly seen in patients with clinical pellucid marginal degeneration.

of pellucid marginal degeneration even if there are no clinical signs of it (Figure 4). This pattern should be designated pellucid suspect, and LASIK should be avoided in eyes exhibiting this topographic pattern.

8. Although no formal guidelines have existed to date and good scientific data for future guidelines are presently lacking, based on the review of the literature and the current body of knowledge available in 2005, to reduce some of the risks for ectasia after LASIK, we recommend that surgeons review topography prior to surgery. Intraoperative pachymetry to determine flap thickness should be considered in cases in which the calculated residual stromal bed might be near the safe lower limits for the procedure and/or the reproducibility of the microkeratome might result in a residual stromal bed less than those limits.

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Editor's Note: This letter also appears in the November 2005 issue of the Journal of Refractive Surgery.

Stereopsis in bilaterally pseudophakic patients

Hayashi and Hayashi¹ show that 90% of bilaterally pseudophakic patients possess useful stereoacuity. However, the authors have not considered the natural progression of the post-cataract extraction refractive error, which will be closely associated with the stereoacuity.

In their longitudinal observation of 1817 post-cataract extraction cases,² Murphy and coauthors point out that the refractive error does not stabilize for 3 weeks after the cataract extraction, which is generally believed to be the minimum period required for stabilization of the postoperative refractive error. Refraction before this period is bound to be inaccurate and subjected to measurement bias. In Hayashi and Hayashi's study, all refraction measurements were completed 2 weeks after the cataract extraction. The authors do not clearly indicate whether the patients' postoperative refractive errors were fully corrected during the stereoacuity test.

Titmus is a near stereoacuity, and stereopsis may be underestimated if the refractive error at near is not corrected. It is important to note that even though full corrections were prescribed in all cases at 2 weeks, the measurement of stereoacuity is susceptible to the influences of the changing postoperative refraction until the minimum stabilization period of 3 weeks. Therefore, the proportion of postoperative patients achieving useful stereoacuity might have been higher than 90% if the documentation of best corrected visual acuities was premature.

This inference is in keeping with others' observation about good visual quality outcome in patients with implantation of monofocal IOLs.^{3,4} Stereoacuity has been demonstrated to be related to monocular and binocular visual acuity.⁵ However, the difference in visual acuity was not a significant predictor in this study. It would be interesting if authors could measure the near visual acuity and evaluate its relationship to near stereoacuity.

We are eager to learn more from authors about the rationale behind the time chosen for the post-cataract extraction refraction.

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Reply: Liu and coauthors raise several questions regarding our article on the stereoacuity of patients who have had bilateral implantation of monofocal acrylic intraocular lenses (IOLs).¹ We reported that a difference in spherical equivalent between the 2 eyes is the main cause of poor stereoacuity. In our study, all examinations, including refractions, were done approximately 2 weeks after surgery. Liu and coauthors assert that the postoperative refraction may be unstable for up to 3 weeks on the report by Murphy et al.² However, in the article to which they refer, the temporal change in postoperative refraction was not studied. Furthermore, it is not clear why these authors chose 3 weeks for the time at which to measure refraction. From their article, it is not possible to pinpoint when the refractive status stabilizes after cataract surgery.

We recently examined temporal changes in spherical equivalent in eyes that received a 1-piece acrylic and in those that received a 3-piece acrylic IOL.³ The spherical equivalent was virtually unaltered after surgery in eyes with the 1-piece acrylic IOL, while a slight myopic shift occurred in eyes with the 3-piece IOL. However, even in eyes with a 3-piece IOL, most of the spherical equivalent change occurred within 2 weeks of surgery. Accordingly, since stabilization of postoperative refraction occurs rapidly following modern cataract surgery, our results regarding stereoacuity are not biased by the timing of the examination.

When examining stereoacuity, the spherical equivalent of near visual acuity at approximately 0.35 m was first determined using a near vision tester (Lumichart, Hoya). After full correction, near stereoacuity was measured using the Titmus test.

It is reasonable to assume that substantially worse visual acuity in either eye can lead to impaired stereoacuity. However, the gist of our study was to investigate stereoacuity in typical pseudophakic patients; ie, those without serious ocular pathology. We therefore excluded patients who had pathology of the macula or optic nerve; almost all the enrolled patients had good distance and near visual acuity in each eye. Based on the findings in these typical cataract patients, we have shown that most bilaterally pseudophakic patients who do not have other serious pathology in either eye have useful stereoacuity following implantation of monofocal acrylic IOLs.—*Ken Hayashi, MD, Hideyuki Hayashi, MD*

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