REFRACTIVE

Debate Over Corneal Thickness for LASIK

BY LORI BAKER SCHENA, CONTRIBUTING WRITER

Is "thin" synonymous with "weak"? With regard to corneal biomechanics, the answer is far from settled. And this has led William B. Trattler, MD, a Miami ophthalmologist in private practice, to ask the question, "Should preoperative thin corneas be considered an independent risk factor for post-LASIK ectasia?"

His answer: No. "Corneal thickness alone is not a measure of a cornea's inherent structural stability. Indeed, after corneal collagen crosslinking with riboflavin, corneas become stronger and stiffer, and more compact—that is, thinner.

"In fact, most thin corneas do not have topographic signs of keratoconus. And keratoconus can be seen even in eyes with thick corneas," Dr. Trattler said. "In essence, bigger is not always better."

Perennial Concern

Corneal ectasia represents a significant concern for refractive surgeons, who face the ongoing challenge of identifying patients at risk of developing ectasia following LASIK. The Ectasia Risk Factor Score System (published as part of a retrospective study by Randleman et al.[1]) provides a screening strategy to help minimize the incidence of post-LASIK ectasia. Yet Dr. Trattler questions the scoring system's ability to determine ectasia risk in eyes with normal preoperative topographies.

Recent developments in refractive surgery need to be taken into account, he noted. "The scoring system was developed based on cases where metal microkeratomes were used, and in most cases—88 percent—the residual stromal bed was not measured." In addition, 95 percent of eyes underwent surgery before 2004. Thus, the statistical findings from this study are representative of LASIK with metal microkeratomes where the true flap thickness is unknown, he said.

"The scoring system, in my opinion, is accurate when the corneal topography is abnormal, as with keratoconus, pellucid marginal degeneration (PMD) or forme fruste keratoconus (FFKC). However, it may not be predictive for surgeons who use modern flap-creation technologies, such as femtosecond flaps or modern microkeratome flaps, and/or measure the true flap thickness intraoperatively," Dr. Trattler said. "Clearly, eyes with keratoconus, PMD or FFKC should not have LASIK. The challenge is how to screen patients with relatively normal topographies."

And while there's no question that refractive surgeons should take the factors evaluated in the scoring system into consideration, he said, "The preoperative topography typically is the critical test that best identifies patients at significantly higher risk for ectasia."

The scoring backstory. As it happens, the Ectasia Risk Factor Score System does take preoperative topography into account—along with residual stromal bed thickness, age, preoperative corneal thickness and degree of myopia.

In the Randleman study, the system proved highly sensitive (91 percent) and specific (96 percent) for post-

Planar Flaps OK, Meniscus Flaps Destabilizing?

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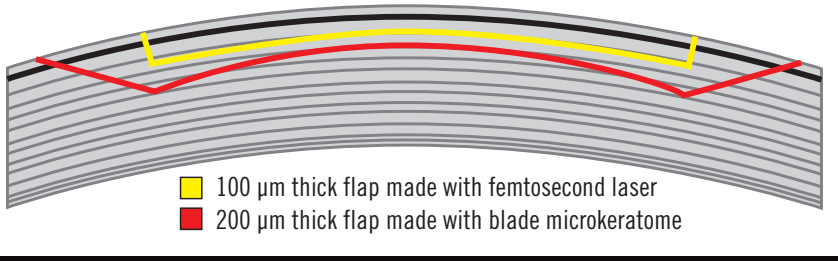

An inadvertently thick blade microkeratome flap of 200 µm leaves a residual stromal bed of 180 µm after a 70-µm ablation. The abnormally thin bed could predispose the cornea to ectasia, according to Dr. Culbertson. If the flap had been only 100 µm side-to-side when made by a predictable femtosecond laser, the residual bed would have been 280 µm.

ADAPTED FROM WILLIAM W. CULBERTSON, MD.

LASIK ectasia. The authors conclude that there appears to be no single characteristic that identifies all patients at risk for the condition. Instead, several factors should be reviewed in a weighted model.[1]

Dr. Trattler coauthored another study that validated the Ectasia Risk Factor Score System. The researchers applied the scoring system retrospectively to a group of patients who developed ectasia after LASIK and compared it with a control group. They found that the system demonstrated similar specificity and sensitivity of a population independent of those involved in the first study.[2] They also called the scoring system "a significant improvement over existing systems for identifying patients at risk for ectasia because it utilized multiple risk factors and evaluates them on a quantitative basis."

Still Some Reservations

Even though Dr. Trattler served as a coauthor of the validation study, he expresses reservations about the scoring system. For example, flap thickness was not known for most ectasia cases analyzed in the Randleman study, he said. "The authors may have assumed the flaps were 140 µm, but research has shown that with some metal microkeratomes, flaps of 200 to even 250 µm can be created."[3]

In the Randleman study, because only 12 percent of cases had intraoperative pachymetry, a "guesstimate" was used for the flap thickness and the residual stromal bed, Dr. Trattler said. "In cases with normal preoperative

Begging to Differ

A different perspective on corneal strength comes from R. Doyle Stulting, MD, PhD, professor of ophthalmology and director of cornea, external disease and refractive surgery at Emory University. Dr. Stulting is also coauthor of the Randleman study.[1] "Drs. Trattler and Culbertson are simply incorrect when they say that 'There really isn't any evidence that a thin cornea is an independent risk factor for post-LASIK ectasia if all other findings are normal.' This evidence was published in our *Ophthalmology* paper, and further data were presented at the recent Academy Subspecialty Day by Dr. Randleman[2] demonstrating the significantly increased risk of ectasia with thinner corneas—specifically in patients with normal preoperative topographies."

When assessing risk, one should consider factors other than topography because "more than half of the eyes in our study that developed ectasia would not have been identified by topography alone," Dr. Stulting said.

"There is more to this discussion than simply whether a cornea is too thin, and while Dr. Trattler states that flap thickness may have been thicker than anticipated, there is no evidence to support this assumption for the majority of patients who develop ectasia." In fact, Dr. Randleman also presented flap thickness data from a series of ectasia patients, and most of their flaps were not significantly thick (average 145 µm, ranging from 80 to 190 µm).[2]

Winnowing the literature. While Dr. Trattler quoted the literature to support his assertion, "He selects only certain examples from the literature that support his hypothesis, rather than the entire body of literature on the topic. This simply doesn't work," according to Dr. Stulting, who added that the Ectasia Risk Factor Score System uses multiple preoperative variables to assess the risk of ectasia.

"It is novel because it uses all of the risk factors that have been identified rather than focusing on a single one," Dr. Stulting said. "And it is novel because it is a statistically sound analysis of the available data that have been validated on a second independent population. To date, it has proven to be the best available method to identify patients at risk. It isn't perfect, but predictive tests rarely are."

How thick is too thin? Dr. Culbertson's assertion that a residual stromal bed thickness of 250 µm "is probably safe" has been disproven by statistical analysis of ectasia cases and controls, according to Dr. Stulting.

"Numerous patients have developed ectasia with stromal bed thickness greater than 250 µm, and about 4 percent of eyes with uncomplicated LASIK had calculated residual beds of less than 200 µm in our first paper.[3] Most patients who developed ectasia in our study with residual stromal bed thicknesses greater than 250 µm were still identified as being at high risk based on the combination of other factors used by the scoring system. In fact, residual stromal bed thickness is a continuously variable risk factor for ectasia. There is no reason whatsoever to choose 250 µm as the minimum for performing LASIK safely."

Dr. Stulting and his colleagues are working to refine and improve the scoring system, "but we need to do that on the basis of valid scientific evidence." Like any new test, he said, a revised system needs to be applied to patients who have the outcome it is supposed to predict (ectasia) and those who do not. It must correctly identify a high percentage of those who develop ectasia and misidentify only a small percentage of those who do not. Simply pointing out that the current scoring system misidentifies a few patients who have undergone successful LASIK is not enough to justify a change, he said.

Dr. Stulting and his colleagues "welcome any modifications that can improve the sensitivity, specificity and predictive power of the Risk Score System based on valid scientific evidence, rather than suppositions, case reports, selective citation of the literature and application of the Risk Score System only on patients who have good outcomes after LASIK."

1 *Ophthalmology* 2008;115:37–50.
2 Randleman, J. B. The latest on risk factors for ectasia. Presented at the Academy Refractive Surgery Subspecialty Day, Nov. 8, 2008, Atlanta, Ga.
3 *Ophthalmology* 2003;110:267–275.

corneal topography and thin corneas, where intraoperative pachymetry measurements were not taken, one cannot determine whether the ectasia was due to an inherent biomechanical weakness of the cornea—or whether flaps were created significantly deeper than planned." In the latter scenario, the thin cornea may have placed the eye at greater risk of developing ectasia, as the thick flap may have critically thinned the residual stromal bed. "The point being that the Randleman study only found that ectasia patients had thinner corneas on average than a control group, but it could not determine whether this was due to thicker-than-expected flaps or a biomechanically weaker cornea," he noted.

A guide, not a rule. At present, the Ectasia Risk Factor Score System should be viewed as a rough guideline until more prospective research is done to explore risk factors, Dr. Trattler argues. And this brings him back to his main hypothesis: A thin cornea has not been established as an independent risk factor for ectasia following LASIK in cases where intraoperative pachymetry has been used to rule out a thicker-than-expected flap. "On one hand, the Randleman study found that ectasia patients with a normal topo had an average preoperative corneal thickness that was thinner than a control group. However, without the true flap thickness measurements, the question of whether thin corneas with normal topography are biomechanically less stable than eyes with thicker corneas is still left unanswered."

To support his assertion, he cited four retrospective studies in which LASIK was performed in patients with thin corneas (450 to 500 µm) and the topography was normal. No ectasia was found in Caster's study of 109 eyes,[4] Binder's study of 117 eyes,[5] Doane's study of 114 eyes[6] or Kymionis' study of 56 eyes.[7] Dr. Trattler also noted a case of two patients with normal topographies and thinner-than-average corneas who underwent LASIK on the same day by the same surgeon; both patients developed ectasia due to deeper-than-expected flaps.[8]

Thin Corneas: Misunderstood?

William W. Culbertson, MD, professor of ophthalmology at Bascom Palmer Eye Institute, agreed with Dr. Trattler's assessment of corneal thickness and its role in post-LASIK ectasia. "In my opinion, thin corneas have received a bad rap. We have associated a thin cornea with keratoconus because thin corneas are often seen in keratoconus." Yet keratoconus is a stretching disease, and topography findings become apparent as the cornea stretches and thins. "Consequently, we have confused a naturally thinner-than-average cornea with the disease of keratoconus," he said.

Focus on the stroma. Instead of viewing the thin cornea as a risk factor by itself, Dr. Culbertson suggested that the risk factor is actually a thin stromal bed.

To illustrate: If an inadvertent 200-µm flap is made with a blade microkeratome on a 450-µm cornea, and a 70-µm ablation is performed on the 250-µm bed, the residual stromal bed will be only 180 µm. However, if instead a 100-µm flap is made with a femtosecond laser on the 450-µm cornea, the residual stromal bed after a 70-µm excimer ablation will measure a safer 280 µm (see Fig. 1).

"The key is to tailor the flap thickness to the amount of starting corneal thickness and the amount of ablation you are doing," Dr. Culbertson said. "If you add it up, and as long as the stromal bed is thicker than 250 µm and no other risk factors exist, you are probably safe."

According to Dr. Culbertson, thickness by itself does not determine the strength of the cornea. Rather it is the number of collagen fibrils and the amount of crosslinking in the cornea that determines its fundamental strength.

Dr. Trattler added that with corneal collagen crosslinking, there is some evidence that the cornea becomes thinner but also stiffer. "The point here is that a thinner cornea does not mean it is a weaker cornea," he said. For instance, the corneas of African-Americans are typically 20 to 30 µm thinner than Caucasian corneas, yet there is no reported increased risk of keratoconus among the African-American population.

Every cornea is different. With regard to preoperative topography, Dr. Trattler recommended doing a careful evaluation of the corneal shape with topography and the Orbscan or Pentacam to observe the distribution of corneal thickness and detect any abnormalities that would place a patient at risk for ectasia.

Dr. Trattler also advocated the use of intraoperative pachymetry to help ensure that the residual stromal bed is not too thin.

"The bottom line is that surgeons should not rule out a patient simply because his or her corneas appear thin," he said. "If the topography is normal and there are no other risk factors, the patient may be an excellent candidate for LASIK."

1 *Ophthalmology* 2008;115:37–50.
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3 Reinsten, D. Z. et al. *J Refract Surg* 2006; 22(9):851–860.
4 Caster, A. I. et al. *J Refract Surg* 2007;23(8): 782–788.
5 Binder, P. S. *J Cataract Refract Surg* 2007; 33(9):1530–1538.
6 Iyengar, S. and J. Doane. Long-term visual outcomes and stability after thin-flap LASIK on thin corneas. Presented at the ASCRS/ASOA Annual Meeting, April 29, 2007, San Diego.
7 Kymionis, G. D. et al. *Am J Ophthalmol* 2007;144(2):181–185.
8 Trattler, W. B. Is a thin cornea a risk factor for ectasia? Presented at the Academy Refractive Surgery Subspecialty Day, Nov. 7, 2008, Atlanta, Ga.

Dr. Culbertson reports financial interests in AMO, Carl Zeiss Meditech and Optimedica. Dr. Stulting reports interests in AMO, Allergan, Calhoun Vision, Inspire, Ista Pharmaceuticals, Lux Biosciences, Nidek, Opto Global, Peschke Meditrade and Vision Care. Dr. Trattler reports interests in Allergan, AMO, Glaukos, Inspire, Ista, Lenstec, Sirion and Vistakon.