COVER STORY

Side-Cut Architecture

A discussion of advantages and disadvantages.

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n the effort to maximize LASIK surgical outcomes, the side cut has come under scrutiny. Advances in femtosecond laser technology allow the creation of ever more ablative patterns, and surgeons are left to determine the supremacy of one over another. This article discusses the recent evolution of the side-cut angle.

RESEARCH

Historically, mechanical microkeratomes create a fixed side-cut angle of between 25° and 30°.1 The mechanical microkeratome automatically slants the side cut from the site of the blade's entrance through the epithelium and then inward toward the visual axis so that the diameter of the flap at its base is smaller than at the epithelial surface. The side-cut angle is fixed by the manufacturer. The length of the wound depends on several factors, including the IOP, the blade's sharpness and oscillation speed, the translation speed of the microkeratome across the cornea, and—to a lesser degree—the corneal curvature. This oblique side cut often gapes for several hours after the flap's creation, and it also tends to gape in synchrony with the patient's heartbeat, which changes the IOP. Histopathological studies of excised lamellar refractive specimens from mechanical microkeratomes² demonstrate the presence of epithelium within one-third to one-half of these wounds that never heal. Their oblique nature seems to create a path that the epithelium follows without difficulty, which leaves a wound that is easily opened.³

Previous iterations of the IntraLase FS laser's software (Abbott Medical Optics Inc., Santa Ana, CA) allowed users to select a side-cut angle between 30° and 90°. In their in vitro biomechanical studies using laser shear speckle interferometry, Knox-Cartwright and Marshall



Figure 1. The distribution of the graded difficulty of lifting the flap in 30 pairs of eyes by one surgeon (AC) who was unaware of the side-cut angle that had been created 10 weeks earlier. (Data on file with Abbott Medical Optics Inc.)

demonstrated that increasing the side-cut angle from the standard 30° to an inverted bevel of 150° improved the incision's resistance to deformation (data on file with Abbott Medical Optics Inc.). Subsequent in vivo studies by Knorz and coworkers using the new IntraLase iFS laser software (Abbott Medical Optics Inc.)⁴ in a rabbit model found that using an inverted side-cut angle of up to 150° significantly increased the wound's strength. In a clinical study by Chayet, patients received a 70° oblique side cut in one eye and a 150° inverse side cut in their other eye (data on file with Abbott Medical Optics Inc.). The flaps were not lifted at the time of surgery. Ten weeks later, however, the surgeon, who was unaware of the use of a side cut, lifted the flaps. Chayet graded the difficulty with which the flap was elevated and found that the inverted side cut was more difficult to open (Figure 1). It is unclear, however, whether aug-

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Figure 2. Optical coherence tomography of an inverted 150° side cut in a human eye immediately after surgery.

mented wound healing will decrease the risk of post-LASIK ectasia.

ADVANTAGES

Theoretically, because changes in IOP will tend to close an inverted side cut, it should gape less than an oblique side cut. Moreover, because the diameter of the wound at the site of epithelial entrance is smaller than the diameter at its base, fewer anterior lamellar and corneal nerves will be severed than with an oblique cut (Figure 2). Even fewer corneal lamellae would be affected if the inverted side cut were combined with an elliptical flap of up to 12% using the new software only available on the IntraLase iFS laser. (A flap that is 9 mm in diameter with a 12% overlap would translate as a flap of approximately 8 X 9 mm in diameter.)

DISADVANTAGES

Are there disadvantages to an inverted side cut of up to 150°? The diameter of the epithelial wound is smaller than that of the stromal wound at the base of the flap. As a result, the greater the angle of the inverted side cut is, the smaller is the available diameter at the epithelial aperture through which to perform excimer laser ablation. For example, using an inverted side-cut target of 150° and a flap that is 9 mm in diameter would mean an anterior diameter of 8.4 mm, which could be too small for some hyperopic treatments. The surgeon would therefore have to attempt to increase the planned diameter of the flap or decrease the inverted side-cut angle. Because of the limitations on maximum flap diameter created by the anatomy of the individual eye and orbit of the patient, it might not be possible to achieve flaps with diameters greater than 9.2 mm. Under these circumstances, the surgeon could reduce the side-cut angle to 120°, thereby increasing

the flap's anterior diameter to 8.65 mm.

It takes longer to create an inverted versus an oblique side cut. With an attempted diameter of 9 mm and a 7 X 8 spot/line separation, creating an inverted side cut of 150° will take 17 versus 11 seconds for a 120° side cut. The requirement of an oval flap will lengthen this time. Of course, the surgeon can further increase the spot and line separation to hasten the flap's creation but at the cost of a rougher stromal bed and a flap that is more difficult to lift. In general, increasing the line separation has a greater benefit in terms of higher speed compared with increasing the spot separation. With the current IntraLase FS laser, the maximum spot separation is $7 \mu m$, and the maximum line separation is 9 µm. The spot and line separation are, as always, the surgeon's choice. For the initially installed lasers, the settings and optimization ranged from 5 X 5 µm to 7 X 8 µm.

CONCLUSION

The theoretical and practical advantages of the inverted side cut outweigh the disadvantage of the time required for its creation. With the IntraLase iFS laser, the surgeon now has the options of maximizing the side cut with an oval flap to minimize structural damage to the cornea and decreasing the planned diameter of the flap. To augment the speed of the procedure, the ophthalmologist can increase the spot/line separation and decrease the inverted side cut from 150° to 120° or less while still maintaining the benefit of the incision's configuration. Unfortunately, other currently available femtosecond lasers do not have the software and hardware to permit these new side-cut angles. Because another manufacturer's femtosecond laser uses technology that is akin to that of microkeratomes, the side-cut angles are very similar to those created by a mechanical microkeratome.

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