

# Perfecting Clear Corneal Incisions

Femtosecond laser technology has the potential to increase the precision and integrity of cataract incisions.

**BY PERRY S. BINDER, MS, MD**

In recent years, single-plane clear corneal incisions (CCIs) have largely replaced sclero-corneal tunnel incisions for cataract surgery. First described by I. Howard Fine, MD, in 1992,<sup>1</sup> CCIs offer a number of advantages, including rapid healing and visual recovery, no bleeding and no need for sutures, and less surgically induced astigmatism. CCIs potentially induce more cylinder, because they are closer to the visual axis compared with scleral tunnel incisions of similar length.

Despite their advantages, CCIs have been associated with an increase in the rate of endophthalmitis.<sup>2</sup> The most important risk factor for endophthalmitis after cataract surgery is a wound leak, which increases the risk of infection 44-fold—far more than capsular rupture or a lack of antibiotics on the day of surgery.<sup>3</sup> To prevent leaks, the incision must be as carefully constructed as possible. Even for very skilled surgeons, however, it is difficult to precisely and repeatedly control the parameters for incisions created manually with a diamond or metal blade. Surgeons intend and expect attempted single-planed CCIs to be planar; they are often curved, however, and there is wide variation in their length, width, and amount of posterior wound gape.<sup>1,4</sup>

Wound apposition and sealing may be affected by the angle(s) of the incision.<sup>5</sup> Although evidence suggests that stepped incisions may be more resistant to the inflow of bacteria with fluctuations in IOP, it has

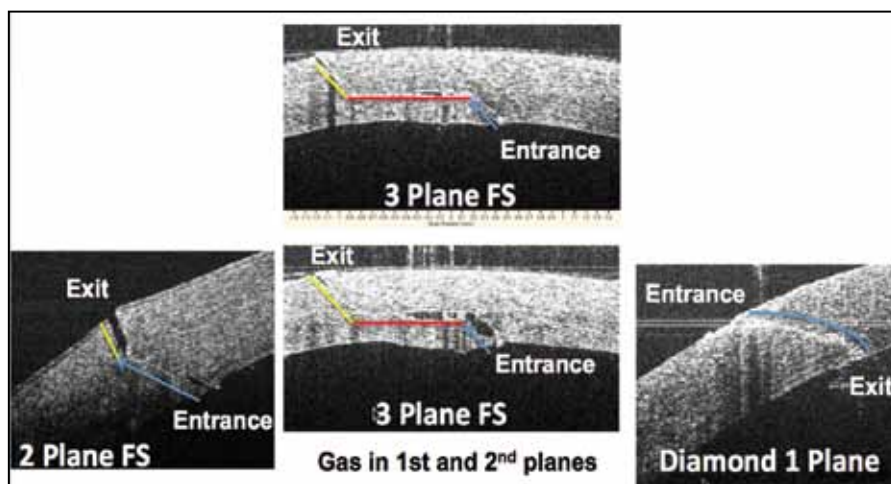


Figure 1. Optical coherence tomography (OCT) images of two- and three-planed CCIs created with the iFS laser in cadaveric eyes compared with a single-planed incision created with a diamond blade.

nevertheless been very difficult to manually create self-sealing two- or three-planed stepped incisions.<sup>6</sup>

## LASER-CREATED CCIs

Femtosecond laser technology is now being incorporated into many aspects of ocular surgery, particularly cataract surgery, including the construction of surgical incisions, correction of astigmatism, the capsulorhexis, and disassembly of the lens. The clinical benefits of lasers for these applications are still somewhat theoretical, but one can imagine that laser-created incisions might help surgeons more closely approach the ideal wound architecture.

A given femtosecond laser's ability to safely and successfully make corneal incisions will depend on the numerical aperture of the optics system that focuses the pulse energy and on the spot-line separation for the laser pulses. In addition, one must ensure that the laser

| TABLE. PROCEDURES AND PARAMETERS  |                                                                                                                                                      |                                                                                                                                                                                              |                                                                                                                                                                                        |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                   | Single-Plane                                                                                                                                         | Two-Plane                                                                                                                                                                                    | Three-Plane                                                                                                                                                                            |
| Diamond blade free-hand incisions | n = 3                                                                                                                                                | n = 4                                                                                                                                                                                        |                                                                                                                                                                                        |
|                                   | Iris parallel to entry                                                                                                                               | Enter limbus @ 90° to 50%<br>Tilt blade to enter anterior chamber                                                                                                                            |                                                                                                                                                                                        |
| iFS Laser incisions               | n = 4                                                                                                                                                | n = 6                                                                                                                                                                                        | n = 2                                                                                                                                                                                  |
|                                   | 30° side cut<br>or<br>Tilt globe to obtain < 30°<br>Incision begins in anterior chamber<br>Width: 2.2 mm<br>Energy: 1.8 µJ<br>Spot-line: 2 µm × 2 µm | Opposite side of same cornea<br>Incision begins in the anterior chamber, 90° to 50% depth followed by 30° entry through surface<br>Width: 2.2 mm<br>Energy: 1.8 µJ<br>Spot-line: 2 µm × 2 µm | Incision begins in the anterior chamber 30° to 50% depth followed by lamellar 2 mm, followed by 30° entry through surface<br>Width: 2.2 mm<br>Energy: 1.8 µJ<br>Spot-line: 2 µm × 2 µm |

pulse energy (which varies considerably among different laser platforms) does not damage the front or back surface of the cornea.

Among the femtosecond lasers approved for use in the United States—the iFS (Abbott Medical Optics Inc.), LenSx Laser (Alcon Laboratories, Inc.), Catalys (OptiMedica Corporation), and Lensar Laser System (Lensar, Inc.)—all are indicated for the creation of CCLs.

There are limited reports in the literature of femtosecond laser-created single- or multiplaned cataract incisions.<sup>7,8</sup> Although most of the attention has focused on the lenticular applications of femtosecond lasers in cataract surgery, I continue to believe that their ability to create precise, watertight corneal inci-

sions would be clinically beneficial.

With colleagues at the Gavin Herbert Eye Institute at the University of California, Irvine, and others at Abbott Medical Optics Inc., I have been investigating<sup>9</sup> the morphology of these incisions in cadaveric eyes by comparing laser-created CCLs to single-planed manual incisions (Table).

In the study, the manual incisions were performed by one of three experienced surgeons using a diamond blade. The laser incisions were performed by one surgeon using the iFS 150-KHz femtosecond laser and the IntraLase-enabled keratoplasty software with an infrared-blocking metal keyhole mask. Soon-to-be-released software simplifies the programming. Parameters for the incisions, includ-

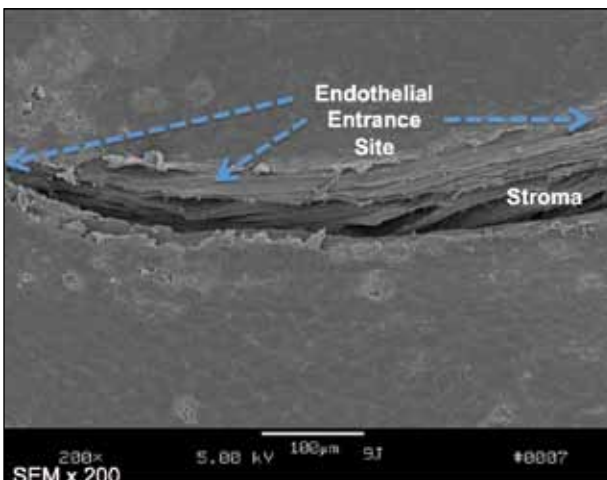


Figure 2. Scanning electron microscopy image of a two-planned CCI created with a femtosecond laser. Note the sharp demarcation with minimal collateral damage to endothelial cells.

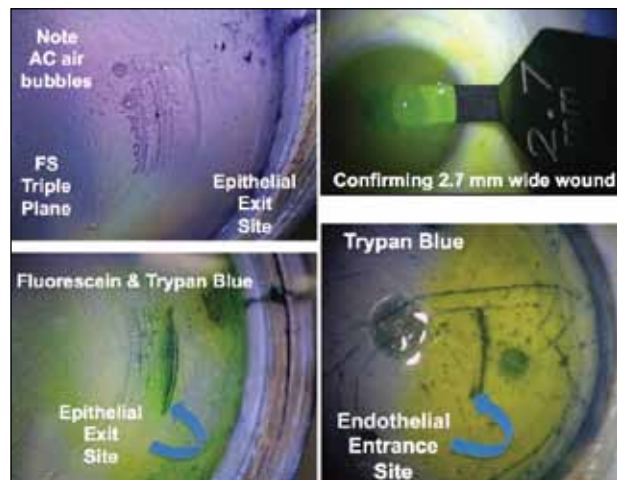


Figure 3. The three-planned femtosecond laser-created incisions were predictable and self-sealing, and they had minimal posterior wound gape.

ing the raster energy settings, spot-line separations, incisional shape, number of incision planes, and type of incision, are described in the table.

### LABORATORY RESULTS

OCT performed immediately after each procedure shows that femtosecond laser stromal wounds are more clearly demarcated than blade-created wounds (Figure 1). The laser incisions' width, angulation, and depth were as predicted by the system's software, whereas the manually created incisions were more variable in length and width. In every case, the manual single-planned incisions were more curved than expected, despite being created by very experienced surgeons.

The multiplaned incisions were very interesting. We found that laser incisions made perpendicular (90°) to the surface tended to gape anteriorly and that a more sharply angled entry had little or no gaping (Figure 2). In comparing two-planned incisions, the length and site of anterior chamber entry of the manual incisions were much less predictable compared with the two-planned laser incision.

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“OCT performed immediately after each procedure shows that femtosecond laser stromal wounds are more clearly demarcated than blade-created wounds.”

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The three-planned laser-created incisions (Figure 3) were self-sealing based on fluorescein staining and had minimal posterior wound gape compared with published OCT and light micrographs of similar manually created incisions. We saw no leakage over either the primary incision or paracentesis wound exit sites with the laser incisions (Figure 4).

Surface features demonstrate similar changes in the epithelium and Bowman layer with both laser and manual incisions. There was minimal collateral endothelial damage with either method.

### CONCLUSION

The results described herein suggest that femtosecond lasers have the potential to increase the precision and integrity of cataract incisions, thereby enhancing safety

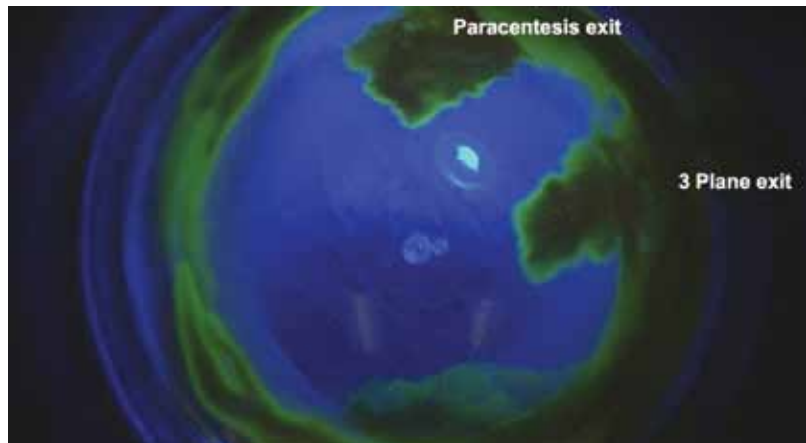


Figure 4. In this three-planned CCI in a cadaveric eye, fluorescein staining shows no leakage over either the primary incision site or the paracentesis.

and improving refractive results. Certainly, more data are needed regarding the incisions' morphology and their impact on surgically induced astigmatism for this and other laser platforms. Laser energy and parameters, as well as the ideal wound construction, are likely to evolve as ophthalmologists gain more experience with femtosecond lasers for cataract surgery. As technique and technology change, I would encourage surgeons to maintain skeptical but open minds when evaluating actual results compared to current surgical procedure. ■

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