The FEMTEC Laser in LASIK Flap Creation

A new laser device is testing the ophthalmic applications of femtosecond technology.

BY C. BANU COSAR, MD, AND A. BOZKURT SENER, MD

The FEMTEC femtosecond (ultrashort pulse) ophthalmic laser (20/10 PERFECT VISION Optische Geräte GmbH, Heidelberg, Germany) is a photodisruptive laser. Although performed since the early 1980s, ophthalmic photodisruption has previously been limited to intraocular procedures because of the relatively large amount of energy needed to initiate laser-induced optical breakdown with the available nanosecond-pulse-duration Nd:YAG lasers. Today, the lower limit of laser pulse duration has decreased by as much as six orders of magnitude to the femtosecond (10⁻¹⁵) range.

Photodisruption begins with laser-induced optical breakdown, when a strongly focused and short-duration laser pulse generates a high-intensity electrical field, thereby causing the formation of a mixture of free electrons and ions that constitutes the plasma state. The optically generated hot plasma expands with supersonic velocity and displaces surrounding material. As the plasma’s expansion slows, the initial supersonic displacement propagates through the surrounding tissue as a shock wave. The rapid expansion of the generated plasma quickly decreases its temperature, and the vaporized tissue forms a cavitation gas bubble in the focal volume of the laser beam (Figure 1). The cavitation bubble consists mainly of CO₂, N₂, and H₂O, which can diffuse out from the tissue through normal mechanisms. The ablation was found to be nonthermal due to the extremely short interaction time.

We clinically evaluated a prototype of the FEMTEC femtosecond ophthalmic laser to create LASIK flaps in a small series of eight eyes. None of these eyes underwent excimer laser ablation treatment thereafter. The mean follow-up period was 1.5 months (ranging from 1 week to 2 months). All of these eyes were scheduled for penetrating keratoplasty at a later date. After the keratoplasty procedure, we further evaluated the corneal buttons by electron microscopy.

SURGICAL PROCEDURE

We centered the curved patient interface on the cornea (Figure 2) and applied a low suction for stabilizing the eye, which was under local anesthesia. The patients were all comfortable with the suction. In contrast, conventional microkeratomes cause significant stress for patients during the suction stage by applying higher pressure to the eye.

When positioning the patient interface onto the eye, it is important that no bubbles remain in between the two surfaces. The patient must keep his eye as still as possible. If he moves his eye too much before the patient interface is in place, air may enter and create a space between it and the eye. Initially, we placed the interface temporally on the conjunctiva and then pushed it with a slow, sliding motion toward the center of the cornea. During our first clinical applications, we
observed that placing the interface directly onto the center of the cornea minimized the air bubbles that remained in between.

In our first set of procedures, we performed a double-pass disc cut pattern by moving from the center of the cornea to the periphery and then returning from the periphery to the center. With our second set of procedures, we performed a single-pass disc cut moving from the periphery to the center of the cornea. Comparing these two different approaches, we observed that the dissection quality appeared to be better with the single-pass cutting geometry. We then used different levels of laser energy, between 3 and 8 µJ, for creating the corneal flap.

**FIRST CLINICAL FINDINGS**

We found the flap created by the FEMTEC femtosecond laser to be of equal thickness over its entire surface. We further observed that the flap was thicker than comparable parameter settings in enucleated animal eyes. With the initial flaps we created during our clinical evaluation, we used a sharpened spatula to complete the ver-

---

### By Sinan Göker, MD

I have performed surgery on 14 human eyes with the FEMTEC femtosecond ophthalmic laser (20/10 PERFECT VISION Optische Geräte GmbH, Heidelberg, Germany), and I have found the system to be quite user-friendly. Each eye was amblyopic, and one had previous keratoplastic cuts.

**EXPERIENCE**

I performed the FEMTEC flap cutting procedure on 12 eyes, and the remaining eyes received intrastromal ablations. I set the laser’s energy parameters at levels between 2 and 7 µJ, and I set the intended flap depth at between 120 and 180 µm. The FEMTEC system created flaps that were very close to the attempted thickness and cuts that were parallel to the corneal surface. In some of my early patients, the anterior rim of the flap was somewhat difficult to locate, but this problem improved after I adjusted the procedure’s parameters. I used corneal forceps to lift the flap. In each of the 12 eyes selected for the flap procedure, I performed LASIK 5 minutes after creating the flap with the FEMTEC laser.

On the next day, all the flaps were stable and quite clear. I found no haze at the flaps’ surface, although mild haze developed at the rim of the flaps 1 week after the procedure in some patients. I now have up to 6 months’ worth of follow-up for these patients. None of the eyes has lost any lines of vision, and the corneas appear unchanged topographically.

I have seen that a variation of pulse energy and laser focus spacing can have some influence on the resulting quality of the stromal surface. If the combination of spot spacing and energy is too large, the resulting microbubbles can leave some residual tissue unablated between the bubbles. Therefore, the proper selection of the respective laser parameters is important for achieving high-quality stromal surface results.

**ANTICIPATING ROUTINE USE**

The FEMTEC flap procedure requires slightly more time to perform than a mechanical microkeratome procedure, because the staff must move the patient from the FEMTEC laser to the excimer laser. The FEMTEC procedure, however, appears to be safer due to its defined and precise flap and hinge geometry and computerized control. The FEMTEC procedure is also more attractive to patients who are wary of mechanical cutting. Although some of the laser’s parameters must undergo further refinement, I plan to use the FEMTEC routinely in my LASIK procedures by the middle of 2004. I expect it to produce a better cut than the conventional microkeratomes, and I am also excited about the technology’s other possible indications.

**Sinan Göker, MD, is in private practice at Istanbul Surgery Hospital in Istanbul, Turkey. He holds no financial interest in the product or company mentioned herein. Dr. Göker may be reached at +90 0212 296 94 50; s.goker@superonline.com.**
tical side cut due to remaining tissue bridges. However, after refining the spot separation and energy levels in the following cases, we found the flap edge to be completely cut by the laser, and the flap could be lifted easily without any further intervention (Figure 3). Before surgeons initialize excimer laser treatment after flap creation, we suggest they wait until the gas bubbles created by the femtosecond laser have evaporated. When the flap was not lifted, we observed that it took between 20 and 60 minutes for the gas bubbles to disappear completely. Our clinical findings suggest that future adjustments toward lower energy levels with a higher number of pulses may further improve the smoothness of the intrastromal cut.

The patients seemed as comfortable during the postoperative period as they did during the procedure. After the laser treatment, we placed a soft contact lens on some of the eyes and prescribed topical steroid and antibiotic drops for all the patients. In these initial procedures, we observed that subconjunctival hemorrhages due to suction were somewhat more common after the femtosecond treatment than after mechanical microkeratome use. Postoperatively, we easily visualized the flaps’ edges at the patients’ slit-lamp examinations. In these first patients, we observed grade 1 haze that persisted at 2 months postoperatively, especially at the flaps’ edges.

**CONCLUSION**

After having performed these initial clinical procedures, we consider the two most complex parts of the procedure to be placing the patient interface on the eye without introducing air bubbles, and the docking process of the laser to the patient interface. The other steps are performed automatically under the computer’s control.

Although the initial studies with the FEMTEC femtosecond laser used pig eyes and yielded excellent results, we found that, for the in vivo treatment of human eyes, certain adjustments in the energy level, pulse number and frequency, and scanning pattern were necessary. This process is still in progress, however, and our first clinical results seem very promising.

We feel that the FEMTEC laser is a new, exciting technology for creating LASIK flaps. We believe that, in addition to LASIK, this innovative device will play an important role in lamellar keratoplasty procedures in which making a deep lamellar mechanical cut is technically difficult.

C. Banu Cosar, MD, is in private practice at the Acibadem Eye Clinic in Istanbul, Turkey. He holds no financial interest in the product or company mentioned herein. Dr. Cosar may be reached at +90 21 22 84 90 90.

A. Bozkurt Sener, MD, is in private practice at the Acibadem Eye Clinic in Istanbul, Turkey. He holds no financial interest in the product or company mentioned herein. Dr. Sener may be reached at +90 21 22 84 90 90; bsener@ticaret.net.com.