Femto-LASIK: Safely Creating Thinner Flaps

In our 18-month experience with the Ziemer LDV femtosecond laser, a higher predictability in flap thickness was noted.

BY JÉRÔME C. VRYGHEM, MD; THIBAUT DEVOGELAERE, MD; AND PAVEL STODULKA, MD

Compared with standard mechanical microkeratomes, use of a femtosecond laser during LASIK improves the safety and reproducibility of corneal flap creation. Since October 2006, we have been involved in a series of clinical trials for the Femto LDV Femtosecond Surgical Laser (Ziemer Group, Port, Switzerland).

A nonamplified solid-state laser, the LDV is insensitive to environmental influences such as temperature and shock. The laser's high repetition rate and pulse overlap, as well as its low pulse energy (less than 100 nanojoules) and short pulse duration (250 femtoseconds), create the corneal cut using microcavitation bubbles that discretely form within the cutting plane. A pocket for bubble accumulation is unnecessary; the bubbles disappear when the flap is lifted.

SMOOTH CORNEAL BED

Due to the LDV's higher numerical aperture and smaller focal point compared with other femtosecond lasers, energy is more precisely focused at the desired corneal depth, which is where optical breakdown takes place.

Flap thickness is determined by the InterShield spacer (Ziemer Group), a plastic foil interpositioned between the laser and the cornea that also functions as a sterile barrier. The computer controls vacuum levels, assuring constant suction conditions for all corneal cuts. In total, less than 40 seconds of vacuum time is needed. The handpiece, attached to an articulated arm that extends over the patient's chest and under the bridge of the excimer laser, is swiveled 180° to perform the procedure on the right and left eyes (Figure 1). After making the corneal cut—in less than 30 seconds—the flap is lifted and excimer ablation is performed without moving the patient, as the excimer laser's patient bed and operating microscope are used during flap creation.

Figure 1. With the LDV, the patient does not have to move between flap creation and excimer ablation.

Small spots are spaced closely together with a significant amount of overlap. To handle the fast pulse rate of the LDV, the beam is scanned across the cornea in a two-step process. The fast scan sweeps the laser beam left and right, creating a trace of spots a few tenths of a millimeter wide. The beam then moves perpendicularly, sweeping across the intended diameter of the flap. Due to overlapping spots, there are no tissue bridges; a smooth stromal bed surface is obtained (Figure 2).

Due to the high pulse repetition rate and the small spots achieved by tight focus, tissue disruption may be

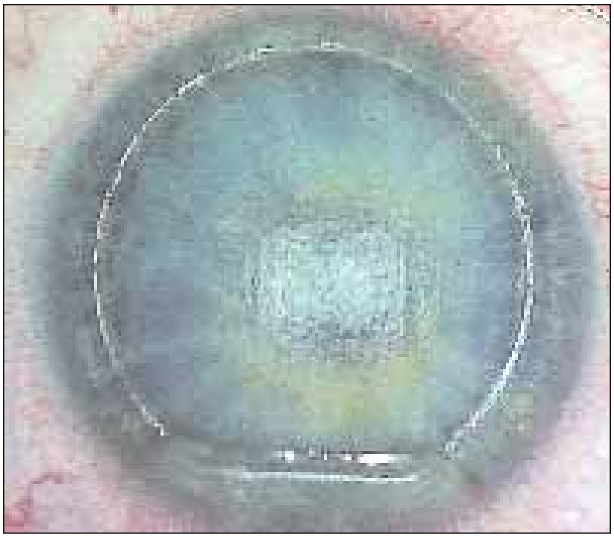

Figure 2. Smooth stromal surface when the 110-µm InterShield spacer is used to obtain a flap thickness of 110 µm.

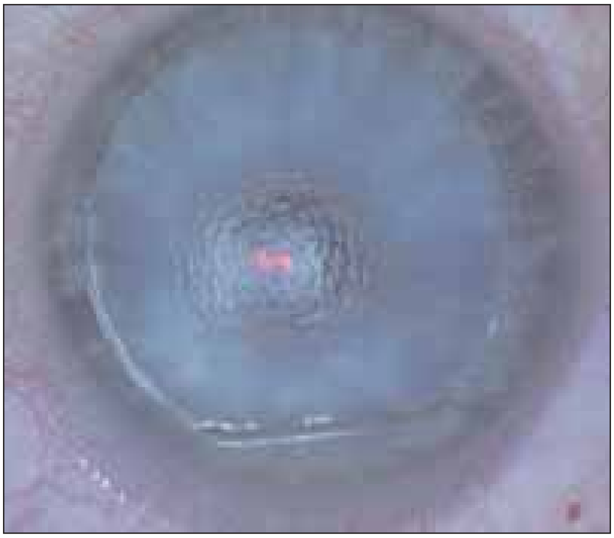

Figure 3. With thinner flaps, the central stromal bed has a slight cobblestone aspect. Here, an 80-µm flap was cut.

achieved at comparatively low pulse energies, avoiding thermal side effects that may occur when thermal energy is delivered to the tissue surrounding the cutting spot. This may explain why no transient photosensitivity is observed after femto-LASIK with the Ziemer LDV.

PROSPECTIVE STUDY

Drs. Stodulka and Vryghem coordinated a clinical study of the LDV at Brussels Eye Doctors, Belgium, and the Gemini Eye Clinics, Zlin, Czech Republic. A total of 224 eyes (117 patients) underwent bilateral LASIK between October 2006 and May 2007. Ablations were performed with the Allegretto Eye-Q 400 excimer laser (WaveLight AG, Erlangen, Germany) with a 6.5-mm optical zone. In all cases, a 110-µm InterShield spacer was used; target flap thickness was 110 µm (Figure 2).

Only in Belgian patients, myopic eyes with less than 3.00 D of astigmatism and plano target were included in visual acuity and refractive outcome analysis, allowing comparison with published LASIK results.[1-16]

Mean preoperative BCVA in these 136 eyes was 1.33, and mean spherical equivalent was -4.48 D (range, -9.88 to -0.75 D). On postoperative day 1, mean UCVA and BCVA were 1.07 and 1.19, respectively. At week 6, mean UCVA and BCVA were 1.20 and 1.28, respectively. At 6 weeks, 83.5% of eyes achieved a UCVA of at least 0.8, and 77.22% achieved at least 1.0. Additionally, 88.75% and 98.8% achieved a manifest refraction spherical equivalent of ±0.50 D and ±1.00 D, respectively. Postoperative cylinder no greater than 0.25 D and 0.50 D was achieved in 90% and 95% of eyes at 6 weeks, respectively. The mean postoperative cylinder was less than 0.10 D, with no more than 1.00 D postoperative cylinder in any eye.

OPTIMIZE SETTINGS FOR FLAP CREATION

We optimized laser settings, including better suction control and higher energy levels, and measured the corneal thickness before and immediately after flap creation using the Corneo-Gage Plus pachymeter (Sonogage, Cleveland). The difference between measurements was considered the flap thickness. In the first 62 eyes, mean flap thickness was 117.28 ±14.86 µm (range, 90–152). In 79 additional eyes, mean flap thickness was 100.42 ±9.10 µm (range, 74–119). Thus, the range of achieved flap thickness varied less in the later series.

Flap thickness was homogeneous throughout the cutting plane, as demonstrated with Visante OCT images (Carl Zeiss Meditec AG, Jena, Germany). The edges of the flap exhibited a smooth transition to the peripheral cornea. The mean flap diameter was 9.47 ±0.28 mm horizontally and 9.08 ±0.29 mm vertically; mean hinge width was 4.88 ±1.13 mm.

There were no major complications. Mild epithelial

TAKE-HOME MESSAGE

- The LDV places spots at the desired corneal depth.
- No transient photosensitivity is observed after femto-LASIK with the LDV.
- Predictability of parameters with the LDV provides the surgeon with more control of cutting.

distortion was noted in six eyes, bandage contact lenses were used in seven eyes, and a slightly decentered cut occurred in five eyes; however, the large flap size (9.5 mm) obtained with the LDV allowed correct placement of the 6.5-mm optical zone in all cases.

No large epithelial defects occurred. Minor, strong, or central flap adhesions occurred in 12, 11, and five eyes, respectively. Two of the central adhesions required additional laser cuts. An irregular stromal bed was noted in six eyes. In two eyes, some air bubbles were seen in the corneal stroma, and microstriae occurred in two other eyes. An absent or small hinge occurred in seven eyes, resulting in a free flap in two instances.

Since purchasing the Ziemer LDV femtosecond laser in June 2007, Dr. Vryghem has performed 500 femto-LASIK procedures. In most cases, with a 110-µm InterShield spacer, mean flap thickness was 100.87 ±9.16µm (range, 69–135). At the beginning of 2008, Dr. Vryghem began a clinical study using the 90-µm InterShield spacer with target flap thickness of 90 µm (Figure 3). In this series of 70 eyes, mean flap thickness was 88.94 ±12.29 µm (range, 61–125). No major complications occurred during surgery.

CONCLUSION

Compared with flap creation with a mechanical microkeratome, the Ziemer LDV femtosecond laser produces thinner flaps with a higher predictability in flap thickness and a higher independence toward a full-thickness cornea before surgery. The predictability of parameters, including flap and hinge width, provides the surgeon with more control of cutting, and sight-threatening complications (eg, buttonholes, incomplete flaps) are avoided. In small-flap cases, a recut can be performed within minutes after the initial surgery. In the case of a free flap, the risk of a floating cap is avoided.

The Ziemer LDV femtosecond laser fits into the workflow of a busy refractive practice just as a mechanical microkeratome does because air bubbles disappear immediately when lifting the flap. There is no opaque bubble layer, as has been described when cutting flaps with other femtosecond technologies. Per eye, the average surgical time, including flap thickness and diameter measurements during the procedure, increased from 6 minutes when using a mechanical microkeratome to 7.5 minutes when using the LDV femtosecond laser.

In our early experience, femto-LASIK with the Ziemer LDV offers good outcomes, at least comparable with the results of mechanical microkeratomes in LASIK. Technical improvements within the laser system, such as better suction and higher laser energy levels, have solved minor complications that occurred in the first series. ■

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