TODAY’S PRACTICE REFRACTIVE FUNDAMENTALS

Comparison of Microkeratomes and Femtosecond Lasers

Part 2: Theoretical advantages and disadvantages vary among the available technologies.

BY JÖRG H. KRUMEICH, MD

The first part of this two-part article (see January 2012 issue) discussed the physical differences in the cutting methods of linear and rotary microkeratomes and femtosecond lasers. This second part explores the theoretical advantages and disadvantages of these different modes of flap-cutting and the adverse events and complications associated with each.

FEMTOSECOND LASERS

The major theoretical physical advantage of femtosecond laser flap cutting is that surface-parallel tissue separation is achieved with no moving machine; these devices are not dependent on blade sharpness, are not dependent on speed of translation or oscillation of a blade, and are less dependent on quality of suction. There is no erosion and no irregular cutting, and one seems to be less dependent on mechanics overall. For example, if a suction break occurs, a second set-up of the device will allow the surgeon to perform the cut in the same level as the first, interrupted cut.

Gas bubbles. The major theoretical disadvantage of femtosecond lasers is gas bubbles that can occur when the surgeon is firing the laser. Femtosecond laser shots generate so-called cavitation bubbles, which may, for reasons such as temperature or humidity in the operating room, appear to coalesce without prior notice. The separation is caused by fine gas bubbles of 1 µm, which, if not tamed correctly to a diameter of about 50 µm, may become confluent and enter the deep posterior stromal layers or rupture Bowman membrane and appear as a megabubble close to the corneal center (Figure 1).

If this adverse event occurs, it may lead to a partial fill of the anterior chamber with bubbles, misleading the tracker and causing a decentered or irregular ablation. Centrally penetrating blebs may accumulate to cause a central opening identical to a microkeratome buttonhole. If bubbles enter the space between the corneal reference lens and epithelium, they may hinder tissue ablation in this area. This complication is observed mostly in pretreated corneas.

Transient light sensitivity syndrome. Transient light sensitivity syndrome is a unique femtosecond LASIK postoperative condition that can occur up to weeks after surgery. The complication appears with no known reasons and incapacitates the affected patient for weeks and, rarely, months. Transient light sensitivity syndrome may leave some patients in an isolated situation, as they may need to retreat to a dark room. Others are less affected but may have blurred vision and experience light as stinging rays. Little is known about the cause of this adverse event, although an inflammatory origin has been proposed. Treatment with dexamethasone four times daily can resolve this complication within several weeks without leaving remnants recognizable at the slit lamp. Deposits of debris or secondary products of gas bubbles on the iris are identified as possible causes of inflammation.

Diffuse lamellar keratitis. Diffuse lamellar keratitis

Figure 1. Bubble perforates Bowman membrane.

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(DLK) associated with femtosecond lasers is relatively uncommon. It is most often described in connection with slower lasers but occasionally occurs with the 150-kHz system (Figure 2) as well. In general, the periphery of the horizontal tissue separation is attained at the beginning of the sidecut, for which higher energies are needed from interface to surface. The sidecut energies are 25% to 100% higher than the stromal bed energies; for example, the IntraLase (Abbott Medical Optics Inc.) bed cut uses energy of 1.2 µJ, and a sidecut requires energy of 2.2 µJ. This type of DLK seems to be a more severe tissue alteration than that seen in microkeratome-cut flaps because, in some cases, flap borders may melt or show scarification. In a retrospective comparison of the first 18 months of experience with a femtosecond laser and a microkeratome, DLK appeared in a higher percentage of femtosecond laser cutting (10.5%) than with microkeratome cutting (6%; \( P = .0002 \)).

Rainbow glare. Another complication associated with femtosecond lasers is so-called rainbow glare, which has been reported to occur in 19% of patients. This side effect seems to be limited to the scanning type raster spot of the IntraLase. Initially, patients see as through a fine web with parallel clear spots surrounded by rainbow-like prismatic light dispersion.

Within months, the web vanishes, but the rainbow may persist depending on pupil size.

MICROKERATOMES

Nearly all microkeratome complications are related to the movement of the engine, suction capability, or a poor surgical decision to attempt to complete the cut in the fastest time possible. To better understand the complications that may arise from microkeratome use, one must be aware of the differences between microkeratomes, as outlined in Table 1.

**Rotary microkeratomes.** Most of the complications associated with rotary microkeratomes involve their mode of cutting. For rotary microkeratomes, the list of complications cited in the literature includes the following: epithelial defects, buttonholes, cap lacerations, free caps, irregular flaps, unanticipated thick or thin flaps, decentered flaps, and translation interruption.

The mechanics of these machines are associated with problems, as detailed in Part 1 of this article. Surgeons using rotary microkeratomes must be aware that complications they cannot foresee or prevent may happen.

**Linear microkeratomes.** With linear microkeratomes, the list of complications is shorter: epithelial defects, free caps, flap not the desired size, and epithelial ingrowth.

Epithelial defects rarely occur with linear microkeratomes, as pressure is applied from above if clicking mechanisms are used. Epithelial ingrowth is a feared complication that occurs more often with rotary microkeratomes but also with linear microkeratomes. The flat angle of entrance allows the epithelium to grow in more easily than does the steep angle entrance in the femtosecond laser. Special care must be taken to clean the rim of the posterior stromal bed. A safe and effective measure is to apply vancomycin solution 0.5% on a cellulose sponge at the cut border and hinge. No flap irregularities or decentrations are seen with linear microkeratome use.

The size of the flaps can be predetermined by using a Barraquer simulator to applanate the protruding corneal dome before the cut. This measurement should be taken at least for keratometry readings that deviate from the medium range: for example, less than 41.00 D or greater than 44.00 D. Otherwise, a postcut surprise will result: flaps that are too large in steep corneas and too small in flat corneas. To avoid free caps the same is true; one must know how large the flap will be for the particular cornea before the microkeratome is started.

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- In LASIK flap creation with a linear microkeratome or a femtosecond laser, no clinically convincing advantage of either technology is apparent.
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**CONCLUSION**

Arguments in favor of femtosecond laser flap creation include the possibility of flap customization and a supposedly lesser degree of spherical aberration compared with microkeratomes, as well as the certainty of obtaining a surface-parallel cut with little standard deviation. Further, the femtosecond laser is often preferred based on alleged reduction of higher-order aberrations, which were thought to be caused by the meniscus-shaped flap configurations from mechanical microkeratomes. With the surface-parallel cutting of the linear microkeratome, however, this argument loses its basis.

The advantages of microkeratome flap cutting include a more physiologic cutting method, shorter duration of elevated IOP, less drying of the eye, no myopic regression in high myopes, and less DLK.

In LASIK flap creation with a linear microkeratome or a femtosecond laser, no clinically convincing advantage...
of either technology is apparent. Both procedures have typical complications that are uncommon but may occur even when the procedures are performed with great caution. Rotary microkeratomes have physical disadvantages that are prone to increase the complication rate.

The issue of whether the laser technique outweighs the traditional mechanical one raises the question of what standard we use when we decide to switch technologies. When femtosecond lasers were first introduced to refractive surgery, hundreds of surgeons convinced themselves to use a 15-KHz laser when the cuts produced did not visibly offer advantages over mechanical devices but rather the opposite. It seemed that not the clinical superiority of the new technique but rather the personal and public prestige of using a no-touch procedure overcame objective comparison, as presented in this paper. The femtosecond laser allows the surgeon to appear to be in touch with the newest instrumentation. In this respect, surgeons favoring mechanical microkeratomes will not be able to generate a similar level of prestige as is generated by femtosecond lasers, even though they can point to advantages of the older technology regarding predictability, BCVA, long-term quality of vision or enhancements, lower costs, and similar outcomes.

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