Mechanical Microkeratome Versus Femtosecond Laser

Two surgeons provide a point/counterpoint debate.

BY BRIAN S. BOXER WACHLER, MD; AND MARK WEVILL, MD, MBChB, FCS(SA), FRCSE

Hang Up My Mechanical Microkeratome? Not Yet

Modern mechanical microkeratomes provide excellent outcomes and are still the standard of care.

BY BRIAN S. BOXER WACHLER, MD

In my refractive surgery practice, I perform mostly LASIK but also surface ablation and phakic IOL implantation. Although interest in femtosecond lasers has grown, my opinion after using both the latest mechanical and laser microkeratome technologies is that there is no clinically significant difference in outcomes between the two. I use the M2 microkeratome (Moria, Antony, France; Figure 1) for the vast majority of my LASIK cases and the IntraLase 60-kHz femtosecond laser (Abbott Medical Optics Inc., Santa Ana, California) for the remaining 5%.

FEMTOSECOND DISADVANTAGES

Slight disadvantages associated with the femtosecond laser are the cause of my preference to use the mechanical microkeratome in most of my patients. In my opinion, the following four disadvantages are associated with the femtosecond laser.

Patient discomfort. Patients feel a stronger pressure sensation with the femtosecond laser than with the mechanical microkeratome, and this causes discomfort during flap creation.

Quality of vision in the early postoperative period. Patients sometimes experience fuzzy vision during the first postoperative week after femtosecond laser flap creation. This flap edema, which is most likely due to the amount of energy used during flap creation, goes away in a matter of days, and subjective quality of vision improves.

Logistics. LASIK procedures last longer when the femtosecond laser is used for flap creation. If it also produced better visual outcomes, my patients and I would tolerate a few additional minutes in surgery; however, without such a clear advantage, it does not make sense to extend the procedure.

Cost to the patient. We charge patients more for a femtosecond flap. It is hard to recommend the additional charge when I do not believe there are additional clinical benefits.

INDICATIONS FOR FEMTOSECOND FLAPS

Currently, the biggest indication in my practice for femtosecond LASIK flap creation is basement membrane

Figure 1. The M2 Single-Use mechanical microkeratome.

One-Use Plus SBK Reportedly Achieves Same Results as Latest Femtosecond Lasers

By Laura Straub, Editor-in-Chief

Flap results obtained with latest-generation femtosecond lasers should strictly be compared with latest-generation automated microkeratomes. The trend in laser vision correction is a thin flap, and there is now evidence to suggest that the One Use-Plus SBK microkeratome (Moria, Antony, France) is a safe and effective modality for sub-Bowman keratomileusus (SBK).[1-6]

Microkeratome technology has evolved, and today's designs are automated to achieve reproducible results that are equivalent to those of femtosecond lasers. Norden et al[1] prospectively studied results of 100 eyes from 50 consecutive myopic patients, half of whom were treated with the One Use-Plus SBK microkeratome and the other half with the IntraLase 60-kHz femtosecond laser (Abbott Medical Optics Inc., Santa Ana, California). Both devices were used to create approximately 100-µm flaps, with similar predictability, accuracy, and results. The difference was, Norden noted, that the One Use-Plus SBK was associated with fewer complications, less discomfort, and faster visual recovery. Additionally, Vejarano et al[2] showed that both the flap and stromal bed were smooth and of excellent quality in 1,363 eyes that underwent SBK with the One Use-Plus.

According to Lewis et al,[3] the One Use-Plus SBK microkeratome creates a flap profile that is semi-planar. Results from more than 400 consecutive corneal flaps indicated that the average central corneal flap was 99 ±8 µm in the right eye and 97 ±10 µm in the left (range, 80–120 µm), with nasal and temporal flap thickness measuring between 104 and 115 µm. Casado et al[4] studied 1,350 eyes that underwent flap creation with the One Use-Plus SBK and concluded that the average central flap thickness was 100.48 ±12.77 µm (range, 74–130); the average vertical flap diameter was 9.26 ±0.34 mm. Anterior segment ocular coherence tomography showed all flaps were planar in shape, with no complications or defective flaps.

Figure 1. One Use-Plus SBK.

SBK is currently thought to achieve excellent results. According to the literature, the One Use-Plus SBK microkeratome produces planar and consistent flaps, with an average thickness of 100 µm and a tight standard deviation.[5] These outcomes are consistent with results with the latest generation of femtosecond lasers.

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dystrophy. Patients with this condition would be ill-served by a mechanical microkeratome because the translation forces during the microkeratome pass disrupt epithelial integrity. In such cases, PRK or femtosecond LASIK is a better choice.

In most other instances, I have not seen any tremendous marketing advantage to owning a femtosecond laser. If a patient called demanding all-laser LASIK, we would certainly accommodate him—but inquiries related to a specific device are extremely rare, according to my front-office staff. In my experience, patients generally defer to the surgeon's expertise when it comes to choosing surgical devices and instrumentation.

OUTCOMES AND COMPLICATIONS

Regardless of microkeratome modality, I perform all laser ablations with the Ladar 4000 (Alcon Laboratories, Inc., Fort Worth, Texas). I track and analyze my LASIK outcomes and have seen no difference in terms of predictability, visual acuity, long-term quality of vision, or enhancement rates between mechanical and laser microkeratomes. There is no clinically significant difference in stromal bed smoothness, flap quality, or postoperative patient discomfort.

The rate of flap complications is similar with both flap-creation methods, but certain complications are unique to each. With the mechanical microkeratome, for example, epithelial defects are the most common complica-

tion; transient light sensitivity can be a problem with femtosecond flaps. Neither complication is common.

No surgeon likes to discover that he has cut a thicker-than-intended flap, thus putting the patient at risk for ectasia. Although femtosecond laser flap creation has been touted as a way to prevent ectasia—the LASIK complication we all worry about most—modern microkeratomes have greatly improved the accuracy and predictability of flap thickness. All of the Moria keratomes rely on nomograms based on corneal curvature for each ring type and stop, and I think this has been the key to successful and consistent results. My standard deviation for a 110-µm microkeratome flap is ±15 µm with the M2, which is comparable to the standard deviations obtained with the femtosecond laser.

Using the femtosecond laser for flap creation does not eliminate the risk of ectasia. The reality is that a femtosecond flap is still a flap, and in an eye prone to ectasia, any lamellar flap can be enough to destabilize the cornea and tip it into ectasia. Suspicious preoperative topography is by far the most significant predictor of ectasia risk. Randleman and coauthors recently reviewed 158 published and 13 unpublished cases of ectasia.[1] They found that abnormal topography was the most significant factor distinguishing ectasia cases from controls, followed by residual stromal bed thickness, patient age, and preoperative corneal thickness. William B. Trattler, MD, of Miami, and I presented two cases of femtosecond LASIK patients who developed ectasia.[2] In both patients, preoperative topographies were suspicious for, but not diagnostic of, forme fruste keratoconus. The bottom line is, if we want to be vigilant about preventing ectasia, thorough and conservative review of preoperative topography and assessment of other risk factors is the best approach.

Studies have shown a difference in postoperative higher-order aberration (HOA) profiles that appear to favor femtosecond flaps.[3] Because the femtosecond laser produces a planar flap, it may reduce HOAs slightly compared with the more meniscus-shaped microkeratome flap; however, the differences are clinically insignificant, in my opinion. HOAs are more strongly associated with the laser ablation itself.

CONCLUSION

Modern microkeratomes such as the Moria M2 offer superb levels of safety and predictability. On all the measures that are important to me, these mechanical microkeratomes continue to be equal to or slightly better than femtosecond lasers for making a LASIK flap in most patients.

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The Differences Between Plasma and Steel in Flap-Cutting Technologies

Results of more than 20,000 cases support superior outcomes with the femtosecond laser.

BY MARK WEVILL, MD, MBChB, FCS(SA), FRCSE

In the 9 years that femtosecond laser technology has been available in the ophthalmic market, the indications for use have grown considerably. In addition to LASIK flap-making, the femtosecond laser is now used for anterior lamellar keratoplasty; penetrating keratoplasty; posterior donor lamellar buttons; creation of tunnels for intrastromal corneal ring segment insertion and pockets for corneal inlays; arcuate astigmatic keratotomy incisions; and the most recently added indication, cataract surgery. However, the debate over what modality creates the best LASIK flap—femtosecond laser or mechanical microkeratome—is ongoing.

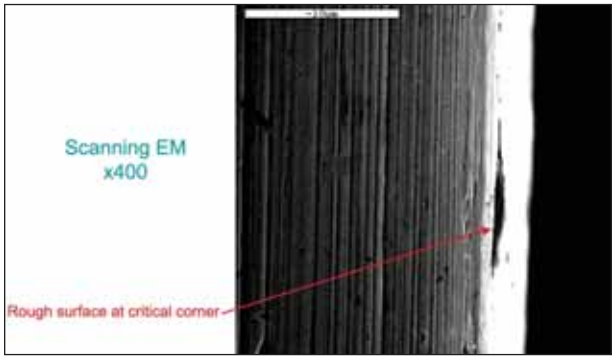

Figure 1. Friction is increased if the critical corner of the microkeratome head has cracks or irregularities.

Based on results from more than 20,000 cases of flap creation, I believe that the femtosecond laser is the better choice. My rationale is described in this article; in

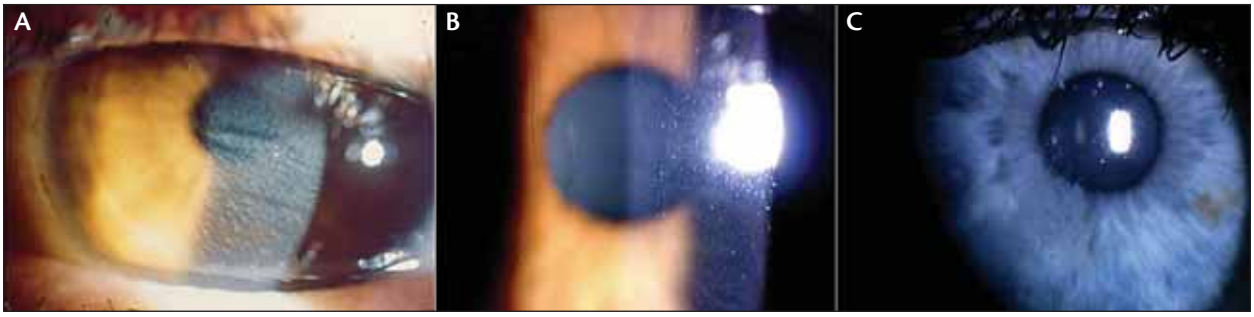

Figure 2. Abrasions can be associated with (A) diffuse lamellar keratitis, (B) striae, and (C) epithelial ingrowth, among other complications.

short, the femtosecond laser is more effective, safer, and has several more applications compared with the mechanical microkeratome.

I retrospectively studied results from 21,377 eyes treated with the Moria One Use-Plus (Moria, Antony, France; n=6,920) or the IntraLase FS60 femtosecond laser (Abbott Medical Optics Inc., Santa Ana, California; n=14,457) over 6 months.[1] All patients had at least 6 months of follow-up and were treated at one of 30 clinics in Ireland or the United Kingdom. Mean age and preoperative spherical equivalent were similar in both groups, which largely comprised myopic patients.

VISUAL RESULTS

Our large-scale study of more than 20,000 eyes not only confirmed that visual recovery is quicker with a femtosecond flap and that visual results in both groups are similar after 6 months, it also demonstrated that the final result of treatment was better with IntraLase. Table 1 shows the visual results for both groups.

The number of lines lost and gained was similar in both groups, with 80.6% in the femtosecond group and 82.4% in the microkeratome group remaining the same from pre- to postoperative. However, more patients in the femtosecond group gained 1 or 2 lines of visual acuity (13.6% vs 7.3% and 0.7% vs 0.4%, respectively).

OTHER ADVANTAGES OF THE FEMTOSECOND LASER

Efficacy. A number of studies have shown that the femtosecond laser produced more rapid visual recovery and reduced astigmatism and higher-order aberrations compared with mechanical microkeratomes.

Safety. Compared with the mechanical microker-

TABLE 1. VISUAL RESULTS IN MICROKERATOME VERSUS FEMTOSECOND LASER GROUPS

	Moria (n=6,920)	IntraLase (n=14,457)	*P*
Mean UCDVA* (LogMAR)	0.07 (±0.17)	-0.02 (±0.12)	<.01
Mean SE† (D)	-0.22 (±0.47)	-0.07 (±0.38)	N/A
Mean DE†† (D)	0.47 (±0.48)	0.32 (±0.40)	N/A
≥ 6/6	76.4%	82.3%	<.05
± 0.50 D	71.6%	81.6%	<.05

* UCDVA = uncorrected distance visual acuity
† SE = spherical equivalent
†† DE = diopter error

atome, flap complications are less frequent and less severe when the femtosecond laser is used. Between April 2007 and March 2008, a total of 25,885 LASIK procedures were performed at UltraLase locations, with a total of 91 complications. Of the 2,874 procedures performed with the microkeratome, 17 were associated with a complication (0.6%); in the 23,011 procedures with the femtosecond laser, there were 74 complications (0.3%).

> Progress with both instruments is important, because the ultimate beneficiaries are the most important people in this debate—patients.

In this series, the mechanical microkeratome more frequently lost suction (0.21% vs 0.14%; *P*<.01) or caused a corneal abrasion (0.17% vs 0%) than the femtosecond laser. Abrasions occur with microkeratomes because of the friction created when the microkeratome moves across the epithelium. Friction is increased if the critical corner of the microkeratome head has cracks or other irregularities (Figure 1). There is no translational friction force with IntraLase, and therefore fewer abrasions occur. Abrasions may seem trivial, but they are associated with delayed visual recovery, increased risk of infections and diffuse lamellar keratitis (Figure 2A), reduced final BCVA, increased risk of retreatment, recurrent erosion, striae (Figure 2B), epithelial ingrowth (Figure 2C), and reduced patient satisfaction.

There are more incomplete flaps with the microkeratome versus IntraLase (0.14% vs 0.11%; *P*<.01). Vertical gas breakthrough and buttonholes between the two modalities is similar (0% vs 0.07%); however, the consequences of each are different. There is a high risk of epithelial ingrowth, corneal irregularities, and diffuse lamellar keratitis near the visual axis with microkeratome buttonholes. Treatment is often delayed by months or years, leaving the patient anisometropic. In some cases, there is long-term reduced visual acuity and haze.

Conversely, with the femtosecond laser, vertical gas breakthrough and incomplete flaps are recognized immediately. The flap is not disturbed, epithelial ingrowth and haze are uncommon, and surface treatment can usually be performed within weeks. In the interim, the patient can cope with symptoms by using contact lenses or glasses.

In another UltraLase study, Dermott[2] studied 120 LASIK cases with intraoperative flap complications—80 with microkeratomes and 40 with IntraLase—causing delayed or cancelled treatment. Within 1 year, 10% of microkeratome cases with complications and 65% of IntraLase cases with complications were treated. The mean time between flap complication and treatment was 76 days in the microkeratome group and 22 days in the IntraLase group.

Stromal bed quality has improved with later generations of microkeratomes and IntraLase lasers. The latest generation of each technology produces smooth stromal beds. IntraLase stromal bed smoothness has improved with higher frequency lasers,[3] and it can be changed by altering the spot and line separation of the laser pulses. Increased oscillation speeds have improved microkeratome stromal bed smoothness.

Predictability. Confocal microscopy images confirm similar responses to microkeratome and femtosecond laser flaps 7 days after LASIK, with keratocyte transformation beneath the interface in both groups.[4] Results remain similar between groups at 6 months. However, almost all studies have shown that the flap thickness with the IntraLase femtosecond laser is more predictable than with the mechanical microkeratome.[5-7] Planar flaps with a constant flap thickness are preferred because the deeper peripheral cut and meniscus-shaped flaps created by some older microkeratome models divide more corneal nerves. This may cause increased dryness, avulsed flaps, and spherical aberration. An avulsed IntraLase flap, when healed, will result in a refraction similar to the original.

Many surgeons prefer an intended flap thickness of 100 µm; however, the flap-cutting method influences the final outcome. Talamo and colleagues[5] found that flaps created by LSK-1 and M2 microkeratomes (both by Moria) were within ±19 and ±24 µm of intended flap thickness, respectively, and the IntraLase was within ±12 µm. In another study comparing the IntraLase with the LSK-1 and the Hansatome (Bausch & Lomb, Rochester, New York), femtosecond laser flaps were within ±14 µm of intended thickness, whereas the CB (Moria) and the Hansatome flaps were within ±26 µm and ±29 µm of intended thickness, respectively.[6] Alió et al[7] showed closer results; however, the IntraLase still had the best predictability: ±6.2 vs ±7.8 vs ±8.3 for the IntraLase, M2, and Carriazo-Pendular microkeratome (Schwind eye-tech-solutions, Kleinostheim, Germany), respectively.

IntraLase produces a planar flap, as do the newest generation of microkeratomes, such as the Moria One Use-Plus, Hansatome XP, and Carriazo-Pendular microkeratome.

TRANSIENT LIGHT SENSITIVITY AND OTHER LIMITATIONS

The femtosecond laser does have limitations. First, transient light sensitivity has been reported in 1% to 2% of IntraLase cases;[8] however, the incidence decreases by a factor of five if 20% less energy is used. The cause is thought to be a late inflammatory response. In 30% of patients who develop diffuse lamellar keratitis, transient light sensitivity will also occur. Steriods are an adequate treatment for both transient light sensitivity and diffuse lamellar keratitis. Second, corneal scarring can limit the use of femtosecond lasers because of poor penetration of the laser.

CONCLUSION

The latest generation of femtosecond lasers produces excellent outcomes that are safe and reproducible. However, just as femtosecond technology continues to improve, microkeratomes will continue to evolve. This debate is not over yet. Progress with both instruments is important, because the ultimate beneficiaries are the most important people in this debate—our patients. ■

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