Supplement to
CRST EUROPE
Cataract & Refractive Surgery Today

October 2015
Sponsored by ZIEMER

Contents

3 Femtosecond Laser Surgery—Quo Vadis?
BY THEO SEILER, MD, PHD

4 Technology of the FEMTO LDV Z8: An Overview
BY HOLGER LUBATSCHOWSKI, PHD

6 Live TopView Imaging for Cataract Surgery
BY KARL BODEN, MD

8 Seamless Workflow Integration With the FEMTO LDV Z8
BY BOJAN PAJIC, MD, PHD, FEBO

10 Intumescent Cataract Removal With the FEMTO LDV Z8
BY LUIS IZQUIERDO JR, MD, PHD

12 LASIK and Corneal Inlay Pocket Creation With the FEMTO LDV Z8
BY MINORU TOMITA, MD

14 Ultra-Thin DSEK: The Best of Both Worlds
BY THEO SEILER, MD, PHD

Femtosecond Laser Surgery—Quo Vadis?

For serious refractive surgery, you must use a femtosecond laser.

BY THEO SEILER, MD, PhD

Nearly 20 years ago, I had to review the first publication on femtosecond laser cuts by Holger Lubatschowski, PhD. Although an interesting concept, my initial impression was that there were less expensive ways to cut into the cornea. Even a few years later, once the first clinical applications were completed—the simplest of which was to create a corneal flap for LASIK—the femtosecond laser did not look like a real competitor to the mechanical microkeratome.

One should not underestimate the power of marketing in health care, however. Once stories of bladeless LASIK and its importance started to surface around 2005/2006, the femtosecond laser suddenly became the new-kid-in-town of refractive surgery.

BETTER REPRODUCIBILITY

In order to become successful, the femtosecond laser needed to offer a detailed medical indication, which was the reproducibility of flap thickness. The reproducibility with the femtosecond laser was in the range of ±5 µm, compared with ±15 to 25 µm with microkeratomes. Having that in mind, within 2 standard deviations (equivalent to ±30–50 µm), 5% of cases would be outside this range. It was obvious that some of the buttonholes (cause: too thin flaps) and post-LASIK keratectasia (cause: too thick flaps) originated from the variation of flap thicknesses that resulted from microkeratome use. Once this was documented approximately 7 to 8 years ago, it became clear that if you do serious refractive surgery you need to use a femtosecond laser.

Around the same time, most of us also learned that infrared femtosecond lasers either had a small or large aperture. Those with small apertures required high energy (1 µJ/pulse) in order to create tissue dissection; those with a high aperture required low energy (nJ/pulse). Side effects of low-energy lasers were small; however, those lasers needed a very high repetition rate. Still to this date, the only lasers following this approach are the Ziemer femtosecond laser series Z2 to Z8.

ADDITIONAL APPLICATIONS

Over time, various other corneal applications were proposed for femtosecond laser use, such as anterior lamellar keratoplasty with lamellar thicknesses up to 250 µm, pockets for stromal inlays, and penetrating keratoplasties with top-hat or mushroom profiles. Each of these applications searched for its place in corneal surgery, and some of them are here to stay. The latest application that is possible with the Z-series is the creation of ultra-thin DSEK lamellas (approximately 70 µm).

> "I believe that the femtosecond laser has found its position in cataract surgery."

Nobody was surprised when the next class of applications for the femtosecond laser—cataract surgery—approached the clinical phase. Again, there were less expensive ways to perform a capsulorrhexis or to fragment a small nucleus. This phase is not yet fully over, but many of us today use the femtosecond laser to make cataract surgery easier and more reproducible in terms of centration and dimension of the capsulorrhexis. This has given us new ways of implanting preplanned multifocal toric IOLs, even in case of posterior capsule defect. Also, the reproducibility of corneal incisions make complications like iris prolapse and other sides effects much less likely. In detail, some publications in the past few years have shown an improvement in safety of phacoemulsification when using the femtosecond laser but also more irritation of the iris. With these things said, I truly believe that the femtosecond laser has found its position in cataract surgery.

CONCLUSION

As a laser device that can be used for cataract surgery and corneal applications of any type without losing precision (as other devices do), the Femto LDV Z8 will find its place in many anterior segment surgery units. Since I have worked in this field for more than 30 years and as an early adopter and creator of new technologies, I think that the triumph of the femtosecond laser in ophthalmic surgery will continue as we find new fields of application, not limited to anterior segment surgery but also in glaucoma and posterior segment surgery. ■

Theo Seiler, MD, PhD, is a Professor at the University of Zurich and Chairman of the Institute of Refractive and Ophthalmic Surgery, Zurich, Switzerland. Professor Seiler states that he has no financial interest in the products or companies mentioned. He may be reached at info@iroc.ch.

Technology of the FEMTO LDV Z8: An Overview

With the shortest pulse duration and lowest pulse energy of all femtosecond laser systems, the FEMTO LDV Z8 provides extreme precision and excellent postoperative results.

BY HOLGER LUBATSCHOWSKI, PHD

The Femto LDV Z8 is the top model and the latest in the line of Ziemer's femtosecond laser systems. The first-generation Femto LDV was introduced 10 years ago. At the time of its launch, the Femto LDV was designed as a compact, mobile, extremely precise flap maker for LASIK surgery. Nobody envisioned the evolution to such a sophisticated workstation for a variety of surgical applications, including penetrating and lamellar keratoplasty, preparing pockets and channels for corneal inlays, and, finally, cataract surgery.

Despite its evolution to an all-in-one femtosecond device, the size of the Femto LDV Z8 is almost the same as the original Femto LDV. Although it looks like the same, almost every component has been redesigned and upgraded to enhance all surgical procedures that can be performed with the laser. Because the basics of this femtosecond technology has already been described,[1-5] this article focuses on the new features of the Femto LDV Z8.

LASER PULSE ENERGY AS A MEANS TO DECREASE UNWANTED SIDE EFFECTS

Cutting tissue by photodisruption, which requires a threshold in laser intensity of about 1 Tera-W/cm^2, can only be achieved with a tight focus of the laser beam down to some micron in diameter. Laser intensity is created by the photon energy needed per time measurement and per focal diameter. The key to increasing the precision of photodisruption while minimizing collateral damage is to decrease the laser pulse energy—the culprit of the laser's unwanted side effects. In other words, one must minimize the pulse duration and the focal spot size of the laser in order to avoid the negative effects of photodisruption.

The Femto LDV laser systems have a pulse duration of around 250 fs, which, by far, is the shortest pulse duration of any femtosecond system in clinical use today. By way of comparison, other systems have pulse durations between 350 and 800 fs.

The numerical aperture (NA) of a focusing optic determines the focal diameter of a Gaussian laser beam. In essence, the larger the NA, the smaller the focal spot and the energy threshold for disruption.[3] The optical systems of Ziemer's lasers reduce the focal length to a few millimeters but keep the lens diameter relatively large. This results in an NA that is about 2 to 3 times the NA of other femtosecond laser systems.

Subsequently, the Femto LDV laser systems require the lowest pulse energy to achieve optical breakdown inside the corneal or crystalline lens tissue, resulting in the highest level of precision (Figure 1). At such low pulse energies, the cutting

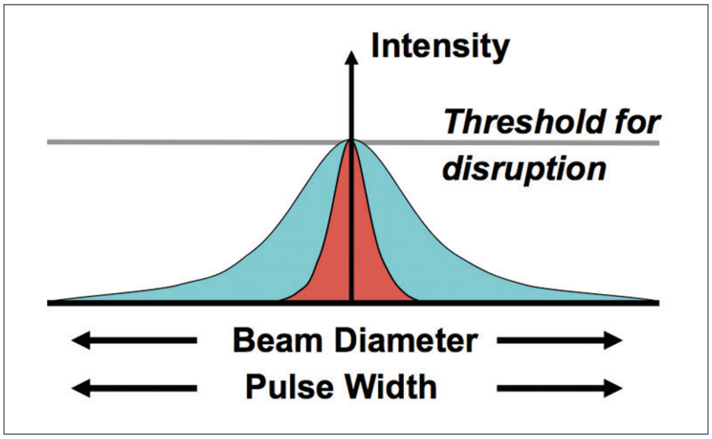


Figure 1. The Ziemer laser systems require lower pulse energy (red area) to achieve the appropriate threshold for photodisruption compared with other systems (blue area). This is because of its smaller pulse diameter and shorter pulse width.

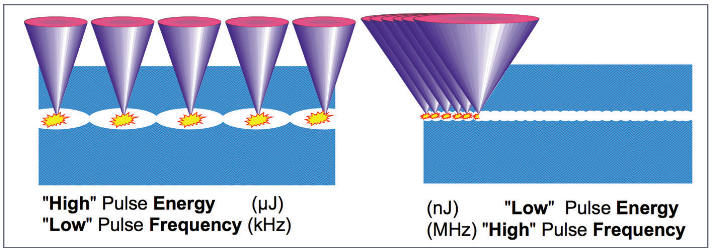


Figure 2. Higher pulse energy (left) allows the use of greater spacing between spots, as the cutting process is driven primarily by expanding cavitation and residual gas bubbles. Lower pulse energy (right) and smaller spot size and volume require substantially more spots with tighter spacing and greater overlap, as the cutting process is driven primarily by photochemically induced decomposition. To deliver this many spots in a reasonable time frame requires very high pulse frequencies (MHz).

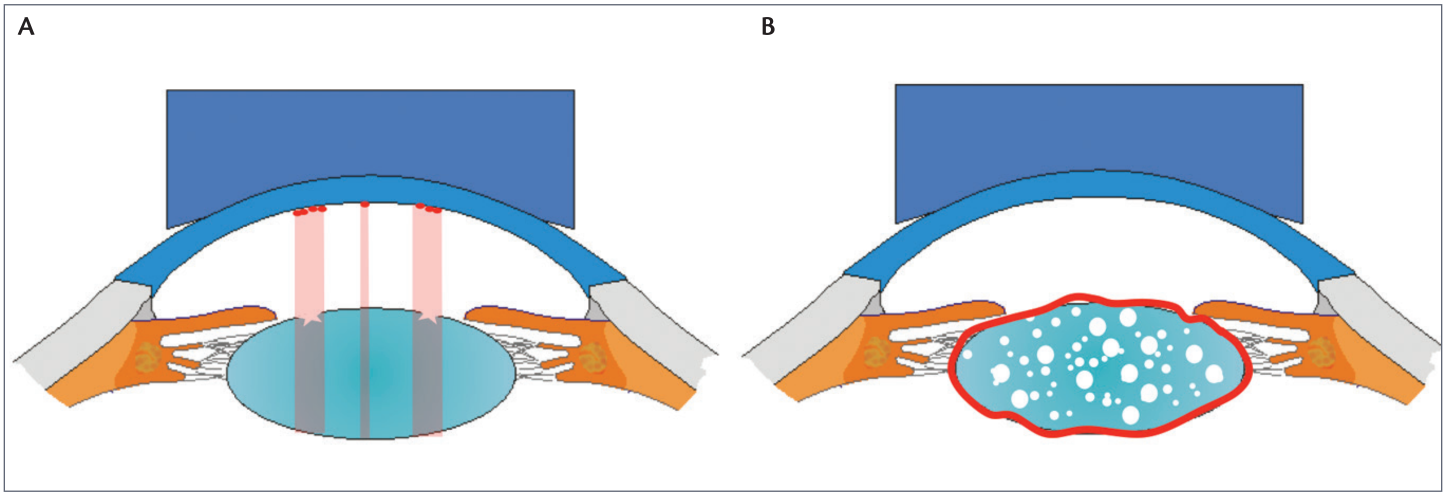


Figure 3. If the capsulotomy is done before fragmentation, the gas bubbles generated during capsulotomy rise to the cornea. In this schematic, they shadow the subsequent pulses and impede fragmentation (A). If fragmentation is performed before capsulotomy, at least the lasers with higher pulse energy produce a significant amount of gas volume, which displace the lens capsule or even crack it. Due to low pulse energy, the FEMTO LDV Z8 is able to do the fragmentation first without any harm to the capsule (B).

process is dominated by photochemically induced decomposition of the tissue and thermoelastic disruption,[6] as opposed to plasma-mediated ablation in all other femtosecond laser systems. In the latter, the explosive expansion of plasma causes mechanical rupture, transient cavitation, and residual gas bubbles (Figure 2).

FASTER RECOVERY, IMPROVED EFFICIENCY

The advantage of extremely high accuracy in processing corneal tissue is obvious, as it leads to faster recovery and, moreover, smaller irregularities in the surface of the cornea that have less chance of affecting visual outcomes.

But there are other reasons we aim for high-precision cutting in cataract surgery. First, it considerably improves the efficiency of the procedure. With the Femto LDV Z8, fragmentation is done prior to the capsulotomy. This can only be done with the Ziemer Z8 system (Figure 3).

Second, smooth cutting of the crystalline lens translates to smaller nuclear fragments. Alternatively, high-energy pulses create a lot of gas bubbles, which impede verification of a dense grid pattern.

Third, the ultrashort pulses required due to the smaller focus and lower pulse energy of the Femto LDV lasers can be generated with a simple laser oscillator only. Although Ziemer's lasers need more pulses to cut the same area as other femtosecond lasers can cut in less pulses, total operation time is kept short by using higher pulse repetition rates (MHz). Fortunately, because only a simple laser oscillator is required, the design of the Femto LDV is extremely compact and robust, and no other ophthalmic femtosecond laser is as mobile. This unit fits with every excimer laser, ensuring an optimum workflow for LASIK procedures. Moreover, it fits well under the microscope in the OR, where it also seamlessly integrates into the workflow for cataract surgery.

ADDITIONAL FEATURE

One additional feature of the Femto LDV Z8 is that the laser comes to the patient. This is not only important for a better workflow and higher productivity, but it is also important for situations where surgical interventions are necessary prior to laser intervention.

For example, if the patient's pupil is smaller than the intended diameter of the laser-guided capsulotomy, he or she must be shuttled back and forth between the OR and the laser suite, which both have different hygienic standards. As indicated by H. Burkhard Dick, MD, PhD,[7] the patient shuttle seems questionable from both hygienic and ethical points of view.

CONCLUSION

The Femto LDV Z8 stands out because of its compactness and mobility as well as its unprecidented precision in cutting corneal tissue.

One can assume that the Femto LDV Z8 will be a trendsetter for high precision/low energy tissue processing in femtosecond laser-assisted cataract surgery, just as it was in 2005 when typical pulse energy for corneal surgery was 1 to 4 µJ. The introduction of nJ-cutting with the LDV was startling and, within a couple of years, all manufacturers had tuned their lasers below 1 µJ pulse energy. Today, typical pulse energy for cataract surgery is 4 to 15 µJ. Let's see how long it takes for the competitors to reach that landmark. ■

Holger Lubatschowski, PhD, is CEO at Rowiak GmbH, Hanover, Germany. Professor Lubaschowski states that he is a consultant to Ziemer Group. He may be reached at H.Lubatschowski@Rowiak.de.

1. Pepose J, Lubatschowski H. Comparing femtosecond lasers. *Cataract & Refractive Surgery Today*. 2008;10:45-51.
2. Lubatschowski H. Overview of commercially available femtosecond lasers in refractive surgery. *J Refract Surg*. 2008;S102-S107.
3. Lubatschowski H. Laser technology of the Femto LDV Z models. *Cataract & Refractive Surgery Today Europe*. 2012;9:S4-S5.
4. Lubatschowski H. The physics and engineering of femtosecond lasers. *Cataract & Refractive Surgery Today*. 2012;2:57-58.
5. Lubatschowski H. Update femtosekundenlaser-technologien in der augenheilkunde. *Klin Monatsbl Augenheilkd*. 2013;230(12):S1207-S1212.
6. Vogel A, Noack J, Hüttman G, et al. Mechanisms of femtosecond laser nanosurgery of cells and tissues. *Appl Phys B*. 2005;81:1015-1047.
7. Dick HB, Gerste RD. Plea for femtosecond laser pre-treatment and cataract surgery in the same room. *J Cataract Refract Surg*. 2014;40(3):S499-S500.

Live TopView Imaging for Cataract Surgery

Use of this built-in camera allows one to check live images of the patient's eye during different steps of the cutting process.

BY KARL BODEN, MD

I have been using various models of the Femto LDV laser (Ziemer) for refractive surgery procedures including LASIK and keratoplasty. Although my experience with this technology for laser-assisted cataract surgery (LACS) is not as extensive, in the short time I have been performing the procedure, results have been excellent.

My involvement with all of the Femto LDV devices has been positive, as is also the case with the Femto LDV Z8, which I began using in July 2014. This specific laser is the perfect combination of low energy and versatility, enabling surgeons to perform a wide spectrum of refractive surgery procedures—from LASIK to refractive cataract surgery to a growing number of corneal therapeutic procedures.

USES AND ADVANTAGES IN CATARACT SURGERY

Prior to my experience with the Femto LDV Z8, I had not performed LACS consistently. One of the nice things about this specific laser system is that it has allowed me to expand my horizons into this field, and I now have performed LACS in about 100 patients. Thus far, I have used the laser for anterior capsulotomy, nuclear fragmentation, and clear corneal incisions.

I did experience a learning curve, as a rupture of the anterior capsulotomy occurred in my first two patients; however, I learned that simply changing the cutting profile solved this problem.

The biggest advantages of the Femto LDV Z8 for cataract surgery are, in my opinion, the two-step docking, which includes a suction ring that easily centers on the pupil, and the device's handpiece. Compared with the other femtosecond lasers designed for cataract surgery, it is easy to dock the liquid patient interface. The second biggest advantage is the mobility of the Femto LDV Z8. The system can be used in different operating rooms or it can be shared with other experts in another ophthalmic surgical center. The third biggest advantage is the live TopView camera, as now I can see an image of the patient's eye during different steps of the cutting process (Figure 1).

LIVE TOPVIEW CAMERA

Of the three biggest advantages of the Femto LDV Z8 system, the one that I am most excited about is the live TopView camera, which is built into the handpiece of the laser system. The TopView camera provides a live image of the patient's eye during different steps of the cutting process in LACS. In essence, the Femto LDV Z8 performs lens fragmentation, pauses (allowing me to see the live TopView image and check on the pupil size), and then continues to the creation of the capsulotomy and/or incisions, where there is also a live top view image between the two steps.

What I also like about the TopView camera is that I have full tactile and visual control of the procedure (cataract and corneal) and can observe the treatment field through the operating microscope as well as through the TopView camera.

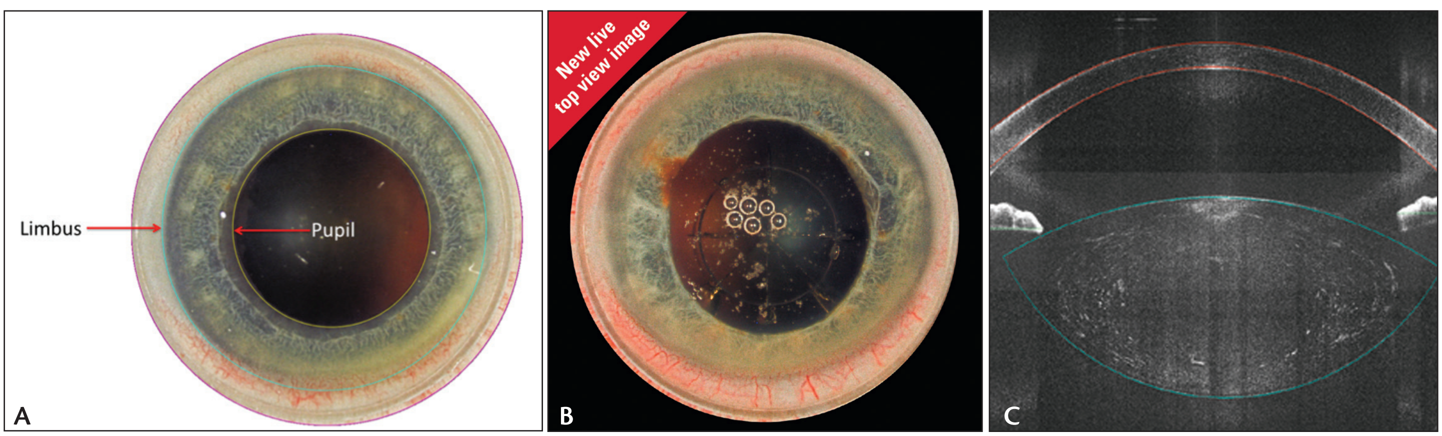


Figure 1. The live TopView camera detects the limbus and the pupil (A); the Live TopView image between different steps of the procedure (B); automatic edge detection (C).

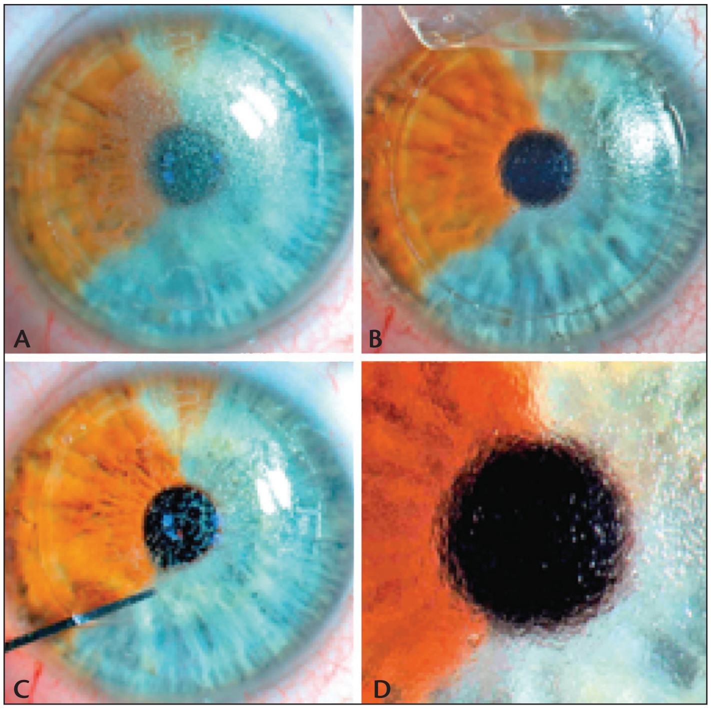


Figure 2. A pattern of fine gas bubbles is created by the FEMTO LDV's stream of pulses scanning across the cornea (A,B). Once the flap is lifted, the gas bubbles disappear immediately, leaving a clear and smooth stromal bed (C) that can be subjected to laser ablation without any waiting time. An enlarged view of the ablated stromal bed is shown in Figure 2D.

A UNIQUE LASER SYSTEM

The Femto LDV laser platform continues to be unique from other femtosecond lasers on the market.

Reason No. 1: In contrast to the high-pulse energies (µJ) used with other systems, the Femto LDV operates at a much lower pulse energy (nJ). This results in cleaner tissue dissection with miniscule bubbles that disintegrate instantly when the flap is lifted (Figure 2), avoiding the thermal and radiation-related side effects that occur in the corneal tissue with lasers that use higher pulse energies and large cavitation bubbles, such as an opaque bubble layer, transient light sensitivity, or diffuse lamellar keratitis.

Reason No. 2: The threshold for tissue disruption with the Femto LDV laser is reached at short interaction times, thereby preventing any thermal effects from affecting corneal tissue. The laser's small, tightly overlapping spots ensure that there is no risk for tissue bridges, and its short focal length optics ensure a precise cutting depth.

Reason No. 3: Due to the laser's unique handheld laser delivery system—attached to an articulated arm—patients can be treated on the excimer laser bed, without having to be transported between flap creation and ablation. Also, patients experience rapid healing and visual recovery, which is extremely important for not only my patients but for my practice as well. It is common for patients to achieve 20/20 or better UCVA on the first postoperative day, with minimal incidence of higher-order aberrations.

In my experience, the combination of the laser's smooth, even cutting surface and even incision depth—in both cataract and corneal procedures—makes it a top-performing platform for refractive surgery. It is ideally suited for thin-flap LASIK, corneal inlay and intracorneal ring segment implantations, lamellar and penetrating keratoplasty, and also cataract pre-treatments.

CONCLUSION

As a community, we ophthalmologists have only scraped the surface of possibilities of LACS, but second-generation femtosecond cataract devices, such as the Femto LDV Z8, are helping us to uncover more benefits of the procedure. The TopView camera is, in my opinion, one of the latest features to help us enhance not only surgical outcomes but also gives more comfort during the procedures.

Innovations in LACS are important, but this is only one part of the equation with the Femto LDV Z8. This mobile femtosecond laser unit can be used to perform corneal and cataract surgery procedures. The biggest advantage here is that the system offers OCT imaging in all functions. As a result, the Femto LDV Z8 provides my patients with precise and reliable results, and I can rest easy knowing that I am in complete surgical control during the entire procedure. ■

Karl Boden, MD, is Deputy Director at Kanppschaftsaugenklinik Knappschaftsklinikum Sulzbach, Germany. Dr. Boden states that he has no financial interest in the products or companies mentioned. He may be reached at drkarlboden@googlemail.com.

Seamless Workflow Integration With the FEMTO LDV Z8

The laser's liquid patient interface for cataract applications enhances patient comfort and surgeon workflow.

BY BOJAN PAJIC, MD, PhD, FEBO

A little more than 1 year ago, Ziemer received the CE Mark for its Femto LDV Z8 low-energy femtosecond laser system, for the purposes of clear corneal and arcuate incisions, capsulotomy, lens fragmentation, and all previously covered corneal therapeutic applications. Although femtosecond laser technology has been widely used in a variety of refractive surgery functions for more than a decade, its relevance in cataract surgery is much more recent, with increased interest among the ophthalmic community due to its various benefits over a manual cataract surgery technique.

The addition of cataract surgery applications in the Femto LDV Z8—possible thanks to the system's Tissue Adaptive Pulse Management (TAP) technology, a unique laser source allowing the surgeon to adapt the pulse energy to the specific surgical procedure depending on the resection type, tissue, and cataract grade—is undoubtedly welcome, as more surgeons are transitioning to laser-assisted cataract surgery (LACS) techniques to compliment their use of premium IOLs and to compensate for increased patient expectations. Numerous studies have confirmed the possible advantages of LACS over standard cataract surgery in terms of performing anterior capsulotomy, lens fragmentation, and clear corneal incisions,[1-8] and my clinical experience, which I share below, follows suit.

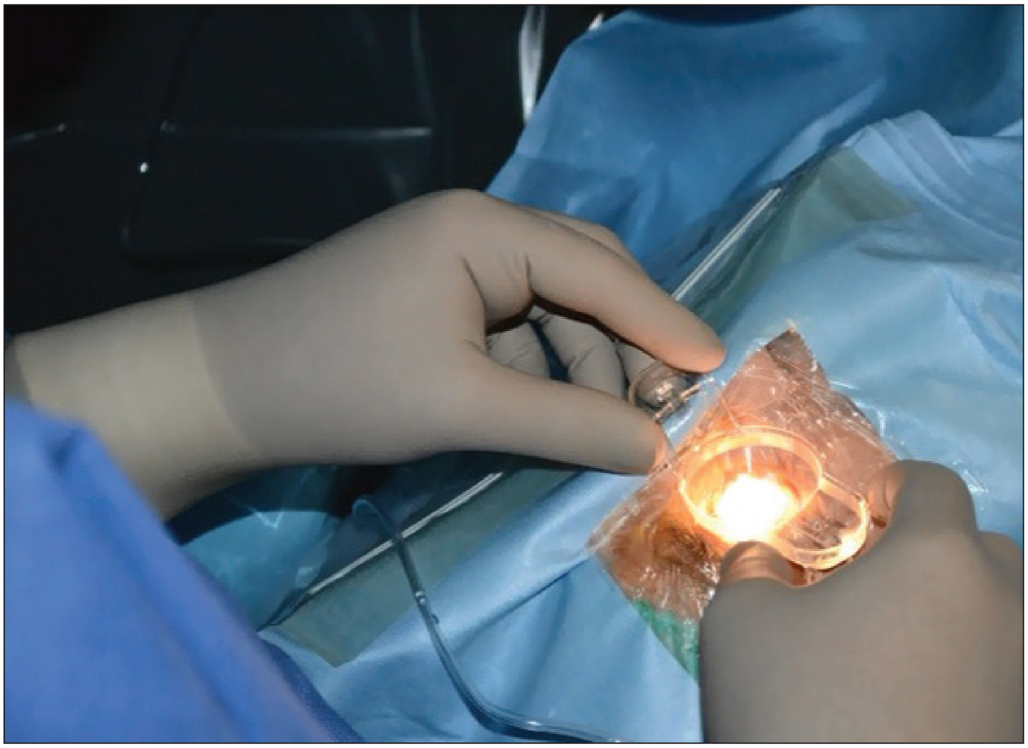


Figure 1. The FEMTO LDV Z8's liquid patient interface.

KEY FEATURES

There are several key features to the Femto LDV Z8, but the two that stand out particularly are the following:

Liquid patient interface. With regard to cataract surgery, one key feature of the Femto LDV Z8 is its liquid patient interface (Figures 1 and 2). The design of the interface enhances laser transmission and results in uninterrputed treatment, due to the prevention of posterior corneal folds, and ensures low intraocular pressure rise for higher patient comfort.

High-definition OCT. Incorporation of high-definition OCT into the Femto LDV Z8 allows the surgeon to identify the precise location of the ocular surfaces in real time during surgery. The system facilitates visualization of the anterior corneal surface and posterior lens capsule regardless of cataract opacity.

INCISION CREATION

The Femto LDV Z8 performs clear corneal incisions in only a few seconds, and the shape of the cut can be customized. Thus, the surgeon decides the incision angle, diameter, length, and shape. As already mentioned, the Femto LDV Z8 is a high-frequency femtosecond laser with overlapping laser spots. Therefore, the cutting surface is smooth, with no tissue bridges.

PROSPECTIVE STUDY

We recently conducted a small prospective observational case

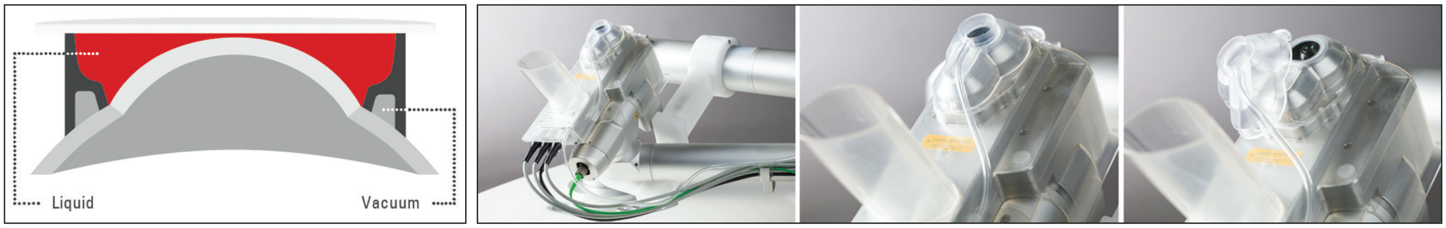


Figure 2. The liquid patient interface of the FEMTO LDV Z8 uses nonapplanation and a novel design to assist with higher patient comfort. The design of the interface ensures that patients do not experience subconjunctival hemorrhage and that there is only a minimal increase in intraocular pressure.

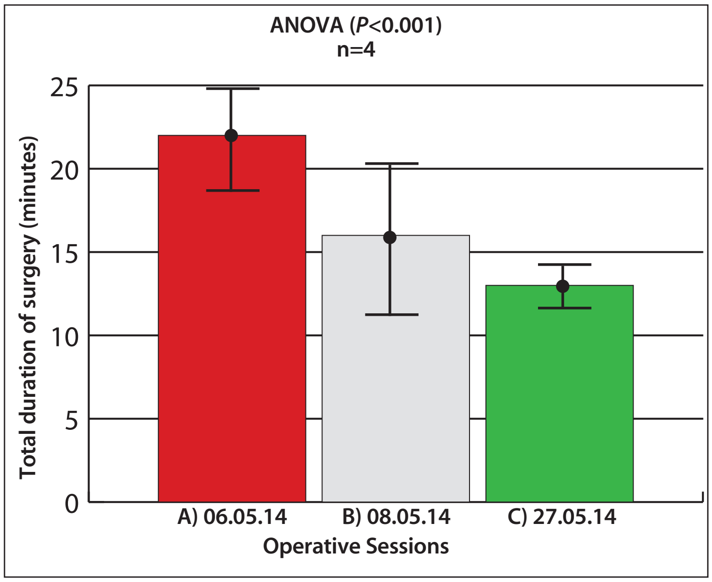


Figure 3. Total duration of LACS with the FEMTO LDV Z8 laser system in three different time sessions during the learning curve with this laser. (ANOVA = one-way analysis of variance)

series to determine the safety and performance of the Femto LDV Z8 in cataract surgery as well as the workflow. The results included in our analysis are representative of 14 eyes with nuclear sclerosis that underwent unilateral LACS with the Femto LDV Z8 system.

WORKFLOW

I have found that the Femto LDV Z8 integrates seamlessly into my patient workflow, and after a short time using the system I am now able to perform four to five procedures per hour (Figure 3).[9] This is because the system is small, mobile, and easy to operate. Instead of using a knife or a hook to perform cataract surgery, I simply take the handpiece of the laser and achieve the cataract pretreatment. After the laser treatment, I set down the handpiece and continue surgery as a routine procedure. Neither the patient nor myself need to move. This is one asset of the laser that allows me to keep the same workflow as I have with conventionally treated cataract surgeries. The laser treatment only takes 1 to 2 minutes longer, which allows me to perform the same number of procedures per day as I had previously using a standard cataract surgery technique.

Results. There were no major complications, and no patient developed subconjunctival hemorrhage after surgery. The total duration of LACS was 16.3 ±4.5 minutes, and during the learning curve it was 21.9 ±1.8 minutes for the first surgery session, 16 ±2.7 minutes for the second session, and 12.5 ±1.1 minutes for the third. Now, with our level of experience, we are able to perform surgery on four to five patients in 1 hour. Additionally, effective phaco time was 2.5 ±3.1 seconds, ease of fragmentation (on a scale of 4) was 3.9, and completeness of capsulotomy (on a scale of 10) was 9.9.

CONCLUSION

The combination of the Femto LDV Z8's liquid patient interface and high-definition OCT helped us to ensure precise removal of the capsule button and resulted in free-floating capsulotomies.

Therefore, our small case series indicates that use of the Femto LDV Z8 system for LACS is helpful in facilitating complete, precise, and reproducible capsulotomy and highly effective lens fragmentation. All surgeons involved in the study, myself included, found the safety level of the procedure to be excellent and our time commitment to decrease with more experience with the laser system. Although further studies with a greater number of patients is warranted for valid investigation of efficiency and safety, our preliminary results indicate the great promise with this system. ■

Bojan Pajic, MD, PhD, FEBO, is a Consultant in the Division of Ophthalmology, Department of Clinical Neurosciences, University Hospitals of Geneva, Switzerland; the Medical Director of the Swiss Eye Research Foundation, Eye Clinic Orasis, Reinach, Switzerland; a member of the medical faculty, Military Medical Academy, University of Defense, Belgrade, Serbia; and a surgeon and member of the Board of Specialized Hospital Vidar-Orasis Swiss at the Eye Hospital Vidar-Orasis Swiss, University of Novi Sad, Faculty of Physics, Novi Sad, Serbia. Dr. Pajic states that he has no financial interest in the products or companies mentioned. He may be reached at e-mail: bpajic@datacomm.ch.

1. Nagy ZZ, Kranitz K, Takacs AI, et al. Comparison of intraocular lens decentration parameters after femtosecond and manual capsulotomies. *J Refract Surg*. 2011;27:564-569.
2. Kranitz K, Takacs A, Mihaltz K, et al. Femtosecond laser capsulotomy and manual continuous curvilinear capsulorrhexis parameters and their effects on intraocular lens centration. *J Refract Surg*. 2011;27:558-563.
3. Congrad-Hengerer I, Hengerer FH, Schultz T, et al. Effect of femtosecond laser fragmentation on effective phacoemulsification time in cataract surgery. *J Refract Surg*. 2012;28:879-883.
4. Friedman NJ, Palanker DV, Dchuele G, et al. Femtosecond laser capsulotomy. *J Cataract Refract Surg*. 2011;37:1189-1198.
5. Abell RG, Kerr NM, Vot BJ. Toward zero effective phacoemulsification tiem using femtosecond laser pretreatment. *Ophthalmology*. 2013;120:942-948.
6. Grewal DS, Basti S. Comparison of morphologic features of clear corneal incisions created with a femtosecond laser or keratome. *J Cataract Refract Surg*. 2014;40:521-530.
7. Alió JL, Abdou AA, Soria F, et al. Femtosecond laser cataract incisions morphology and corneal higher-order aberration analysis. *J Refract Surg*. 2013;29:590-595.
8. Mastropasqua L, Toto L, Mastropasqua A, et al. Femtosecond laser versus manual clear corneal incisions in cataract surgery. *J Refract Surg*. 2014;30:27-33.
9. Pajic B, Vastardis I, Gatzioufas Z, et al. First experience with the new high-frequency femtosecond laser system (LDV Z8) for cataract surgery. *Clinical Ophthalmology*. 2014;8:2485-2489.

Intumescent Cataract Removal With the FEMTO LDV Z8

This platform simplifies capsulorrhexis creation in eyes with hypermature cataracts.

BY LUIS IZQUIERDO JR, MD, PHD

An intumescent cataract can be a nightmare for any surgeon, even the most experienced. These cataracts, which have progressed to a hypermature state, can present with a bulging anterior capsule and a shallowing anterior chamber. Poor surgical management of an intumescent cataract can lead to complications with the capsulorrhexis and instantaneous anterior capsular rupture extending into the zonules, better known as *Argentinean flag syndrome*.

In addition to other precautions, such as overfilling the anterior chamber with OVD and relieving elevated intraocular pressure in the capsular bag, I have found the use of the Femto LDV Z8 (Ziemer) to be extremely helpful in complex cataract cases. This laser is capable of achieving the following steps in cataract surgery: anterior capsulotomy, lens fragmentation, and clear corneal incisions. Below I describe my initial experience with this laser platform in an intumescent cataract and recount my outcomes in this and eight subsequent cases of the same type. In all instances, the cataract was completely white and hard.

Figure 1. Complete capsulotomy as achieved with the FEMTO LDV Z8 femtosecond laser (A,B).

THE ROLE OF OCT

The role of OCT in any cataract surgery case is helpful to visualize the ocular surfaces during surgery, but it is especially so in intumescent cataracts. The proprietary OCT system of the Femto LDV Z8, integrated directly into the system's handpiece, simplifies surgical planning and provides me with a high-resolution image of the cornea and lens. This OCT technology uses the same optics as the laser beam and provides automatic edge detection, surface mapping, and precise alignment for accurate resection.

What I like most about using this feature is that I can customize my treatment plan based on the OCT imaging.

A BETTER CAPSULORRHEXIS, EASIER FRAGMENTATION

The biggest advantage of the Femto LDV Z8 in intumescent cataracts is the fact that I can still create a perfect capsulotomy,

Figure 2. The FEMTO LDV Z8 promotes good fragmentation of the nucleus.

even in the presence of elevated intraocular pressure in the capsular bag. In all nine cases I have performed in intumescent cataracts with the laser, I have achieved a complete capsulotomy (Figure 1). I try to remember to travel gently around the capsulotomy, as the capsule is always harder in an intumescent cataract as compared with a standard cataract.

One of the reasons that the Femto LDV Z8 is so efficient at creating perfect capsulotomies is because it uses lower pulse energy, in the nJ range, which is generally associated with fewer side effects.[1,2] Higher pulse energies, on the other hand, can cause weakness at the edges of the capsulotomy, potentially compromising the capsular bag.[3] Combined with very high pulse frequencies (MHz), the low pulse energies of the Femto LDV Z8 provides excellent resection and high precision.

Another crucial part of surgery in intumescent cataracts is nucleus fragmentation, which must be carried out meticulously. Just as the Femto LDV Z8 promoted perfect capsulotomies in all nine intumescent cataracts, the laser also promoted good fragmentation of the nucleus (Figure 2). In all cases, I used a pie-shaped fragmentation pattern, as I have found it crucial to use a linear fragmentation approach in these cases as well as in morgagnian cataract cases. Furthermore, I am still able to create a deep-enough grooves in the nucleus, thanks to the use of OCT imaging.

On average, the effective phacoemulsification time after the Femto LDV Z8 was used to fragment the lens was 4.2 seconds. Also, there was no incidence of postoperative subconjunctival hemorrhage, as the vacuum system is gentle with this machine.

In all of the intumescent cataract cases I have performed, inflammation was minimal after LACS with the Femto LDV Z8. Also, the IOL was well centered in the capsular bag, and the patients were all happy.

CONCLUSION

Many studies have shown that the postoperative results after LACS and standard cataract surgery are comparable; however, we must also keep in mind that use of a femtosecond laser for certain steps of the procedure is especially beneficial in complicated cases, such as in eyes with intumescent cataracts. The laser can help ensure that a perfect capsulotomy is formed and that nucleus fragmentation is well defined prior to phacoemulsification. Having a stable and perfect capsulotomy is of upmost importance in complicated cases in order to adequately support IOL implantation. For these reasons, I have become more confident performing difficult procedures with the femtosecond laser.

I have come to determine that, in a busy surgical center such as ours, with surgeons who sees many kinds of complicated cataract cases, LACS is extremely beneficial. It saves me time in the operating room (after the learning curve), it saves me stress from performing a difficult procedure, and it promotes outstanding postoperative outcomes. ■

Luis Izquierdo Jr, MD, PhD, practices at the Oftalmosalud Instituto de Ojos in Lima, Perú. Dr. Izquierdo states that he has no financial interest in the products or companies mentioned. He may be reached at izquierdojrluis@hotmail.com.

1. Lubatschowski H. Comparing femtosecond lasers. *Cataract & Refractive Surgery Today*. October 2008.
2. Lubatschowski H. Applications of the femtosecond laser. *Cataract & Refractive Surgery Today Europe*. February 2012.
3. Talamo et al. Optical patient interface in femtosecond laser-assisted cataract surgery: Contact Corneal applanation versus liquid immersion. *J Cataract Refract Surg*. 2013;39(4):501-510.

LASIK and Corneal Inlay Pocket Creation With the FEMTO LDV Z8

The high-definition OCT system of the FEMTO LDV Z8 enhances safety and efficiency of LASIK as well as the inlay implantation procedure.

BY MINORU TOMITA, MD

I have been working with the Femto LDV laser system for many years—first with the Crystal Line, Z2, then with the Z4 and Z6, and now with the Z8.

At a large refractive surgery center like Shinagawa, where we saw about 15,000 patients every month, having a reliable femtosecond laser technology—like the Ziemer Femto LDV—was extremely important. We used the Ziemer technology in the vast majority of our LASIK cases, as we truly had found it to be the best flap-maker on the market. We had also found in my time practicing at Shinagawa that patients were willing to pay a premium for better results with the more advanced technology of the Femto LDV. I have drawn these same conclusions at my new practice, Tomita Minoru Eye Clinic Ginza.

Some of the benefits we have seen with use of the low pulse energy, high repetition rate Femto LDV lasers for flap creation include better distance visual acuity postoperatively and lower incidence of higher-order aberrations as well as lower diffuse lamellar keratitis as compared with other femtosecond laser systems.[1] In general, the Femto LDV is gentle on patients' eyes, and stromal bed quality is excellent after Z-LASIK.

CORNEAL INLAY POCKET CREATION

The functionality of the Femto LDV Z8 does not stop with flap creation, however. As most surgeons who implant corneal inlays know, and I have reported previously,[1] creation of a pocket with a femtosecond laser is of crucial importance to the success of the procedure. Because inlay implantation is typically performed in patients who have previously undergone LASIK, the pocket must be placed a safe distance from the LASIK flap interface in order to ensure improved near vision and patient satisfaction.

In my clinic, I use the Femto LDV Z8 to create a corneal pocket at a depth of 200 or 250 µm, 80 µm or more below the previous LASIK flap interface. With the Femto LDV Z8, it is now possible to also use OCT imaging to create a pocket intrastromally and to see the former LASIK flap in order to place the pocket right underneath the flap.

Another advancement in femtosecond laser technology is enhancing the results of corneal inlay implantation, and that is high-definition OCT technology. In a subsequent study, I demonstrated that OCT-guided femtosecond laser technology further increased the safety and accuracy of inlay implantation.[2]

> "I have worked with various laser systems and, in my experience, I believe that the Femto LDV offers the most advanced software, creates the smoothest corneal beds, and provides my patients with the best postoperative outcomes."

In this study, I enrolled 150 eyes scheduled to undergo Kamra corneal inlay (AcuFocus) implantation using an OCT-guided approach. All patients had previously undergone LASIK. At 3 months postoperatively, near UCVA was J2—an improvement from J8 preoperatively. Additionally, distance and near BCVAs did not change from preoperative levels (20/12 and J1, respectively). Our results clearly demonstrate that the OCT-guided technology increased the safety and accuracy of corneal inlay implantation and helped the patient to achieve excellent visual and refractive outcomes.

WHY OCT?

Today, more than 90% of patients who elect corneal implantation require a LASIK procedure first. This alone highlights the importance of high-definition OCT, as the technology ensures beyond a shadow of a doubt that the surgeon creates the corneal inlay pocket at a safe distance from the LASIK flap, which is at least 80 µm. He or she can see on the OCT exactly where that pocket is being set.

Ziemer is one of the leaders in OCT technology. In my experience, it creates a smoother stromal bed than the IntraLase technology (Abbott Medical Optics), mainly because it employs small-bubble technology low energy. The combination of the laser's low energy, smooth stromal bed, and high-definition OCT technology is excellent for corneal implantation.

PERSONAL EXPERIENCE

To date, I have performed more than 5,000 corneal inlay implantation procedures with the Femto LDV laser systems. I have done the majority with the Femto LDV Z6, but my most recent 100 cases have been performed with the Femto LDV Z8. Results have been strikingly similar, but the true advantage is the fact that I now can rely on OCT to detect the position of the LASIK flap and to be more accurate with pocket placement.

Before we had access to this technology, some patients experienced regression if the corneal pocket was placed too close to the LASIK flap. Additionally, there was a higher incidence of corneal aberrations postoperatively.

ENHANCED USE IN ICRS IMPLANTATION

The Femto LDV Z8 also offers a next-generation intracorneal ring segment (ICRS) implantation module. Paired with live OCT guidance, ICRS implantation has become even safer and more effective, as surgeons can use it to precisely identify 75% to 80% corneal depth—the ideal place for ICRS tunnel placement, so we can virtually enable the potential of creating tunnels safely. This will be crucial to ICRS implantation surgery.

Corneal thickness in keratoconus patients is highly variable, with differences of 100 to 200 µm in different parts of same cornea. If we do not check actual corneal images during surgery, the risk of perforation to the anterior chamber is significantly increased.

CONCLUSION

Over the years, I have garnered much experience with the Femto LDV laser systems. In addition to being my preferred laser for flap creation, I have also come to believe that the creation of pockets with this femtosecond laser is the best method for corneal inlay implantation.

I have worked with various laser systems and, in my experience, I believe that the Femto LDV offers the most advanced software, creates the smoothest corneal beds, and provides my patients with the best postoperative outcomes. ■

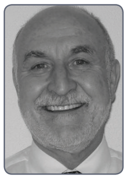
Minoru Tomita, MD, PhD, was former Executive and Medical Director of Shinagawa Eye clinic and now is the Medical Director of Tomita Minoru Eye Clinic Ginza, Chuoku Tokyo, Japan. Dr. Tomita states that he is a consultant to Ziemer. He may be reached at tomita@eyecanmedical.com.

1. Tomita M et al, Comparison of DLK incidence after laser in situ keratomileusis associated with two femtosecond lasers: Femto LDV and Intralase FS60. *Clinical Ophthalmology*. 2013:7;1365-1371.
2. Tomita M, Huseynova T. Evaluating the short-term results of KAMRA inlay implantation using real-time optical coherence tomography-guided femtosecond laser technology. *J Refract Surg*. 2014;30(5):326-329.

Ultra-Thin DSEK: The Best of Both Worlds

All models of the FEMTO LDV laser platform are capable of performing this procedure.

BY THEO SEILER, MD, PhD



Although the concept of lamellar keratoplasty is not new, a handful of novel techniques have surfaced in the past decade, mainly ones that target replacement of only the diseased layers of the cornea. These newer treatments can be divided into to two categories: anterior lamellar keratoplasty, targeting selective replacement of diseased corneal stroma, and endothelial keratoplasty, targeting selective replacement of damaged endothelium. In the latter category, Descemet stripping endothelial keratoplasty (DSEK), Descemet membrane endothelial keratoplasty (DMEK), and ultra-thin DSEK have gained increased interest.

Of these three techniques targeting selective replacement of damaged endothelium, DMEK arguably offers the best opportunity for patients' eyes to return to normal anatomic configuration;[1] however, due to the procedure's delicate nature, it is difficult and time-consuming, with a higher percentage of rebubbling and a longer duration for preoperative preparation. Although DMEK is performed by a handful of surgeons who are well versed in the technique, many of us corneal surgeons prefer ultra-thin DSEK, a technique that is far simpler and nearly as effective as DMEK.

Below is an overview of my personal encounter with DMEK, DSEK, and ultra-thin DSEK, and a detailed explanation of why ultra-thin DSEK with the Femto LDV Z8 (Ziemer) is my procedure of choice today.

A COMPARISON OF TECHNIQUES

I briefly experimented with DSEK in 2007; however, I abandoned the procedure because it caused a significant loss of endothelial cells within the first 2 years postoperatively. Additionally, the visual results were disappointing, with patients not achieving more than 20/40 or 20/30 visual acuity, and the procedure must be repeated within 8 to 10 years after the initial surgery.

My first attempt with DMEK, in 2011, was not much better. Although the visual results were spectacular, I found difficulty in handling the lamella, which, in order for the procedure to work, was about 40 µm thick. I lost a few, and they are very expensive to obtain. Furthermore, DMEK was time-consuming work: For a keratoplasty to take 2 hours, it just didn't pay off. Also, the procedure required two more rebubblings, which were performed at 1 day and 1 week postoperatively.

My third trial with an endothelial keratoplasty technique was ultra-thin DSEK. I was drawn to the procedure, because it combined the advantages of DSEK (ie, a thicker lamella) with the advantages of DMEK (ie, faster and more significant visual rehabilitation). I started performing ultra-thin DSEK 3 years ago, and it is still the technique I prefer today.

ADVANTAGES OF THE FEMTO LDV PLATFORM

Ultra-thin DSEK requires implantation of a maximum 100-µm thick lamella. One can use a specially prepared mechanical microkeratome with a two-pass cut or a low-energy femtosecond laser to create the lamellar cut. The challenge with a mechanical microkeratome is that the lamella is not very homogenous; although some manufacturers claim that it is possible to create a 60- to 80-µm lamella, I have not yet seen one that can so far.

With a low-energy femtosecond laser platform like the Femto LDV, a lamellar cut as low as 100 or 70 µm including the endothelium is easily achievable. These same cuts are not possible with a high-energy laser platform, however, as they create too big cavitation bubbles and shockwaves for the endothelium to handle. I use

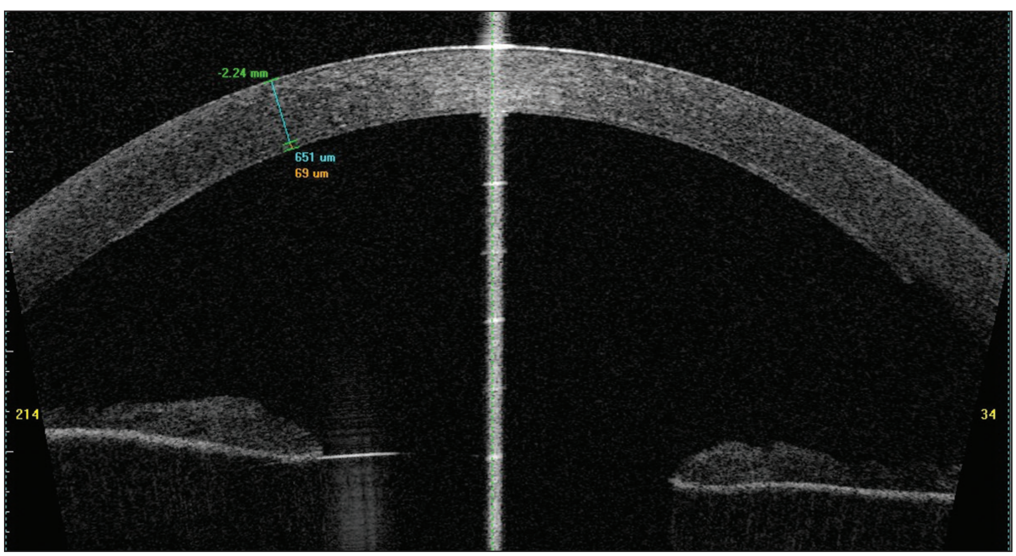


Figure 1. Ultra-thin DSEK 1 month after surgery: The thickness of the lamella is less than 100 µm.

the Femto LDV Z8 to create the lamellar cuts for ultra-thin DSEK; however, any laser on the Femto LDV platform is capable of making them. For cataract surgeons who have any of these platforms, it is good to know that these lamellar cuts for ultra-thin DSEK can be made easily.

What I like about using the Femto LDV Z8 laser for ultra-thin DSEK is that the lamella is not only homogenous, but it never rolls in or out and can be transplanted in a folded manner and then unfolded inside the eye. The laser creates a really nice cut on the stromal side, and this makes it possible for the patient to achieve a visual acuity of 20/30 to 20/20 (Figure 1).

In essence, the handling of the lamella inside the eye is much easier with ultra-thin DSEK compared with DMEK. With the combination of the Femto LDV and the Tan EndoGlide system (Angiotech) for lamellar insertion, usually the procedure takes less than 30 minutes from start to finish.

CHALLENGES THAT REMAIN

With ultra-thin DSEK, a fair amount (30% or 40%) of re-bubbling is still needed at 1-week follow-up. This is because the lamella is not totally coherent to the cornea. However, compared with penetrating keratoplasty and DMEK, ultra-thin DSEK seems to be the best compromise of any endothelial keratoplasty procedure.

Although I believe that the visual results after DMEK may be equivalent or better than after ultra-thin DSEK, the latter is the easier, faster way to achieve targeted replacement of damaged endothelium. Additionally, from patients' points of view, it is better for them to be in the clinic once (with ultra-thin DSEK) than three times (with DMEK). Because recovery is approximately the same in both procedures after 3 months, I prefer using ultra-thin DSEK because it is the more convenient procedure for all of us—the surgeon and the patient.

CONCLUSION

Prior to my experience with ultra-thin DSEK, endothelial keratoplasty was always a difficult operation that required a large time commitment. Now that I perform ultra-thin DSEK with the Femto LDV Z8, the procedures are simpler, faster, and yet they produce excellent visual outcomes. If I compare it with DALK or PKP, ultra-thin DSEK is now actually the most pleasant procedure to perform.

So, in conclusion, the Femto LDV Z8 and the ultra-thin DSEK technique have made my life in corneal world much easier. ■

Theo Seiler, MD, PhD, is a Professor at the University of Zurich and Chairman of the Institute of Refractive and Ophthalmic Surgery, Zurich, Switzerland. Professor Seiler states that he has no financial interest in the products or companies mentioned. He may be reached at info@iroc.ch.

1. Melles GR, Ong TS, Ververs B, et al. Descemet membrane endothelial keratoplasty (DMEK). *Cornea*. 2006;25(8):987-990.

CRST EUROPE
Cataract & Refractive Surgery Today