

ANTERIOR SEGMENT

New Femtosecond Applications for Cataract, Cornea and Refractive Surgeries

BY MARIANNE DORAN, CONTRIBUTING WRITER

As the femtosecond laser continues to make inroads in the LASIK market, the bladeless surgery is poised to stake claims not only in other refractive procedures, but in cataract surgery and corneal transplantation as well. Despite cost and logistics, a host of manufacturers are betting on a bright future for this technology.

New Refractive Approach

Ronald R. Krueger, MD, medical director of refractive surgery at Cleveland Clinic's Cole Eye Institute, noted that the success of LASIK flap creation via IntraLase (Abbott Medical Optics) has spurred the development of several new femtosecond laser-based technologies. "Five companies are now making femtosecond lasers for flap-making, indicating a maturity in the field," he said.

The newcomers are Alcon, Carl Zeiss Meditec, Technolas Perfect Vision and Ziemer Ophthalmic Systems. Zeiss and Technolas, in particular, are preparing to roll out platforms with innovative applications.

One laser, many uses. Carl Zeiss Meditec, for example, has a femtosecond laser with a curved appplanation plate that allows precise placement of pulses without significantly compressing the cornea. The company has developed a procedure called femtosecond lenticule extraction, or FLEx. FLEx involves making two cuts that intersect in the periphery, creating a lenticule that can be removed from the

cornea without requiring an excimer laser for the refractive procedure. "The company is hopeful that FLEx will be a way of refining refractive procedures so that one laser technology can do it all," Dr. Krueger noted. "Investigators are beginning some early trials with a modification of FLEx called small-incision lenticular extraction, or SMILE. SMILE attempts to make corneal lenticule extraction less invasive by enabling the lenticule to be removed through the small incisions without having to lift up the flap."

Tissue not removed, just reoriented. Technolas Perfect Vision (a company created from an initial joint venture between Bausch & Lomb and 20/10 Perfect Vision) has fashioned an intrastromal procedure called Intracor. Intracor applies femtosecond laser energy inside the cornea without bringing it to the surface. The pulses are placed as concentric intrastromal circles centered about the visual axis and extending no closer than 100 μ m from the surface. The Intracor concept is novel because the procedure removes no tissue, instead applying a concentric pattern of cut fibers to shift the center of the cornea slightly anteriorly and create a hyperprolate shape. "The Intracor causes a biomechanical change in the cornea that shifts the center slightly forward, creating a pattern of hyperprolate asphericity that gives the person some near vision while still maintaining distance vision," Dr. Krueger said. "So this is a procedure for correcting presbyopia in emme-

Fast Laser Work



Using a femtosecond laser, Dr. Chang created a capsulorhexis along with two radial cuts through the underlying nucleus in a cataract of medium density.

tropic patients with normal distance vision."

The surgeon also can expand the circle diameters or add radial intrastromal incisions, depending on whether a small amount of hyperopia or myopia is involved. The radial intrastromal incisions are similar to those created in radial keratotomy and are effective in biomechanically correcting a small degree of myopia.

"Intracor is attractive because it provides a way of correcting low refractive errors and presbyopia with an entirely biomechanical method that never breaks the surface epithelium," Dr. Krueger said. "As a result, there is no migration of white blood cells coming in from the tear film and no aggressive healing response. No real pain is involved because you are not break-

ing the surface and exposing nerve fibers. In addition, the little bubbles that form from the femtosecond pulses in the cornea all dissolve within the first day or evening, and patients see well within hours.”

New Approach to Cataract

At least three additional U.S. companies are working on femtosecond laser-based cataract surgery: LensAR, LenSx Lasers and OptiMedica.

Lens disassembly. Dr. Krueger noted that the LensAR system uses multiple cube-shaped patterns of femtosecond pulses in the crystalline lens to break up the nucleus into small cubes. The cubes can then be aspirated from the eye without needing phacoemulsification energy—or at least very little of it. The other companies are conducting similar investigations.

David F. Chang, MD, a clinical professor at the University of California, San Francisco, and in private practice in Los Altos, Calif., has already used the LensAR laser to do cataract surgery outside the United States. He said that being able to automate many of the most important steps in cataract surgery would have several advantages. “The circular capsulotomy would be perfectly round with a consistent and precisely programmed diameter, and the nucleus would be fragmented within the bag. Prechopping the nucleus would be especially advantageous for brunescient lenses by reducing the ultrasound time and the zonular stress of sculpting. In addition, corneal relaxing incisions of a precise depth, length and orientation could be automated and used to treat astigmatism.”

Dr. Chang added that although capsulorhexis is arguably the most important step in cataract surgery, it is one of the few steps that has not yet been improved through new technology. “Because it’s a purely manual maneuver and because of parallax, it is difficult to make a perfectly centered capsulorhexis. It is also hard to gauge the precise diameter because we rely on visual clues, such as the corneal diameter, which varies among individuals. Even experienced surgeons wrestle

with making the capsulorhexis when there is poor visibility, zonular weakness, a shallow chamber or too much eye movement.”

Easier implantation for premium lenses? Femtosecond laser-based cataract procedures are expected to enhance the results of premium intraocular lens implantation. “Achieving a consistently symmetric and properly sized capsulotomy is important for refractive IOLs, and especially with accommodating IOLs,” Dr. Chang said. “For example, with the dual-optic Synchrony accommodating IOL, if the capsulorhexis is too large or is elliptical, the moving front optic may partially protrude from the capsular bag. This would require lens repositioning or explantation to resolve the resulting visual distortion. For toric and multifocal IOLs, a capsulotomy that completely and symmetrically overlaps the optic edge ensures perfect centration and minimizes variance in the effective lens position from case to case.” (Synchrony is made by Visiogen, which is under acquisition by Abbott Medical Optics.)

Recently, the LenSx technology has received FDA clearance for femtosecond laser capsulotomy. OptiMedica’s platform is under design to execute capsulorhexis, lens segmentation, lens softening and other manual surgery steps, according to company CEO Mark Forchette.

New Corneal Transplantation Concepts

The femtosecond laser has been used experimentally in corneal transplantation and, despite limited peer-reviewed reports and no long-term follow-up, the evidence thus far suggests that the laser procedure may offer several advantages over the standard approach.

Pick a shape, any shape. “The femtosecond laser can create any type of wound you want,” said Christopher J. Rapuano, MD, acting director of the cornea service and codirector of the refractive surgery department at Wills Eye Institute and professor of ophthalmology at Thomas Jefferson University in Philadelphia. “You can make it like a Christmas tree, a mushroom or a top

hat. Ideally, the femtosecond laser creates a better, stronger wound that undergoes faster healing and potentially causes less astigmatism and less change in astigmatism over time. It also has a theoretical advantage in partial-thickness corneal transplants because you can very accurately create the depth and shape of the tissue you are trying to remove and replace.”

Availability. The logistics are challenging, as most transplant surgeons do not have a femtosecond laser in the operating room and instead must “share” the laser with a LASIK center. “If your laser center is five miles from the hospital, you have to do part of the cut at the laser center and then put the patient in a taxi or van to be transported to the hospital, where you will finish the procedure. It’s not that bad if the laser is on a different floor of your hospital. At Wills we recently bought an IntraLase femtosecond laser and have it in our operating room because we were not particularly comfortable with the idea of doing half of the surgery a floor or a building away.”

Femtosecond for better harvesting. “Another issue is the need to have the donor tissue created with a femtosecond laser so that it fits in perfectly, whether it’s for a full-thickness or partial-thickness transplant,” Dr. Rapuano said. “A lot of people are having an eye bank with a femtosecond laser create the donor tissue and then upcharge for it, as is done for DSEK. This ensures that you have good donor tissue and that you don’t have to take extra time in the operating room to create it. On the other hand, you have to import the tissue from an eye bank that has a femtosecond laser—and most don’t.” He added: “If you can get faster healing, less astigmatism and a stronger wound that is more stable over time, there will be real benefits to femtoseconds in cornea medicine.”

Dr. Chang is a consultant for Alcon, AMO and LensAR and is on the medical advisory board of LensAR. He is also a medical monitor for the Synchrony IOL. Dr. Krueger is a consultant for Alcon and cofounder of LensAR. Dr. Rapuano has no related financial interests.