

Update on Femtosecond Laser Technology

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This installment of "Peer Review" highlights the most recently published articles on femtosecond laser technology. While there is not much to report yet on outcomes, currently, at least four companies are developing lasers to make laser cataract surgery a reality in the United States. They are Abbott Medical Optics Inc. (Santa Ana, CA), Alcon Laboratories, Inc. (Fort Worth, TX), LensAR Inc. (Winter Park, FL), and Optimedica Corporation (Santa Clara, CA). Last month, having acquired LenSx Lasers, Alcon Laboratories, Inc., began installing lasers at multiple centers around the country.

For those who did not attend the American Society of Cataract and Refractive Surgery symposium in San Diego earlier this year, laser cataract surgery was the hot new topic of discussion. Much like during the early days of phacoemulsification, many surgeons argued against femtosecond laser technology as a means of optimizing results. As a surgeon who routinely performs 6-minute cataract surgery, I, too, find it hard to believe that I can do better. The time it takes to perform surgery is not the main issue, however; ultimately, it is the refractive result. Recently, William Trattler, MD, discussed with me a multisurgeon outcomes analysis performed by Guy Kezarian, MD, and SurgiVision Consultants, Inc. (Scottsdale, AZ). It involved highly competent surgeons. Interestingly, fewer than 30% of their patients with a target of plano and no comorbidities achieved 20/20 uncorrected vision postoperatively. As LASIK surgeons, we would consider ourselves failures with those kinds of results. Now that we are on the frontier of refractive lens-based surgery, we must challenge ourselves to improve upon these statistics.

In the first 5 months of 2011, my refractive lens-based surgical business grew from 22% to nearly 35% of my cataract volume. In the March 2011 issue of Cataract & Refractive Surgery Today, Shareef Mahdavi commented that surgeons and industry should focus on market conversion rather than expansion. In the near term, Mr. Mahdavi said, "it is about improving the conversion of cataract surgery to premium cataract surgery, where much greater value for the services performed is communicated, accepted, paid for, and realized by both the patient and the surgeon. In the longer term, widespread adoption of lens-based refractive surgery should become a commonly accepted option for patients who see its value and are willing to pay for it." No different from the experience with LASIK, the early adopters and those providers who most effectively educate patients will succeed.

In early 2000, when LASIK Vision Canada (Toronto, Ontario, Canada) chose to enter the US marketplace in Southern California, I was presented with a fascinating book that has shaped my perspective with regard to ophthalmology, business, and life in general. If you have not already done so, I encourage you to read Who Moved My Cheese? An Amazing Way to Deal With Change in Your Work and in Your Life by Spencer Johnson, MD.

I hope you enjoy this installment of "Peer Review," and I encourage you to seek out and review the articles in their entirety at your convenience.

—Mitchell C. Shultz, MD, section editor

LASER CATARACT SURGERY

Naranjo-Tackman reviewed recent applications in femtosecond laser technology for capsulotomy and nuclear fragmentation in cataract surgery. He noted that the advantage of the femtosecond laser is that it can create incisions or spaces of different shapes at a desired depth. He further stated that a new and important application for femtosecond lasers is fragmenting the lens, and they can provide precise circular capsulotomies with an adjustable diameter. The technology also allows aspiration of the nuclear material without the application of phaco

energy in eyes with a soft or medium-hard nucleus.¹

Researchers at Stanford University and the University of Miami outlined the advantages of laser cataract surgery. They noted that it offers surgeons the ability to make precise cuts in a targeted area without damaging the surrounding tissue. They concluded that the technology has dramatically changed refractive surgery and is "poised to do the same for cataract surgery."²

In a clinical evaluation, a femtosecond laser was used to perform anterior capsulotomies and phacofragmentation on five porcine eyes. Researchers then performed the same

procedures on nine patients undergoing cataract surgery. In porcine eyes, mean diameters were 5.88 ± 0.73 mm using a standard manual technique and 5.02 ± 0.04 mm using the femtosecond laser. Scanning electron microscopy revealed that the femtosecond laser and the manual technique produced equally smooth cut edges of the capsulotomy. The researchers stated that, compared with the porcine eyes, phaco power was reduced by 43% in human eyes undergoing laser phacofragmentation, and there was a 51% reduction in procedural times. They reported similarly high levels of accuracy and effectiveness in both porcine and human eyes, with no operative complications.³

Researchers conducted a preliminary investigation to determine whether corneal tunnel incisions could be constructed with femtosecond laser technology in a manner that would preclude deformation and leakage at any IOP. A 15-kHz femtosecond laser was used to create corneal incisions of 90% thickness in cadaveric eyes. A 3-mm wide, single plane-angled incision was generated using the side-cut feature of the laser system. Incisions with tunnels that were 1 mm, 1.5 mm, and 2 mm long were constructed. A standard ophthalmodynamometer (ODM) was used to simulate deformation of the eye following surgery. Manometric elevation and reduction of IOP were used to test the incision's integrity at various levels of pressure, as the ODM device was applied near the equator of the globe. Seidel testing with dry fluorescein was used to test incisions for leakage. With tunnels of different lengths, the 3- X 1-mm incision leaked at all levels of external pressure and at all levels of IOP. The 3- X 1.5-mm incision leaked with less external pressure by the ODM and at lower levels of IOP. As IOP was raised manometrically, the incision became less likely to leak. The 3- X 2-mm incision did not leak at any IOP, despite deformation by the ODM at full levels of indentation pressure.⁴

LASER KERATOPLASTY

Farid and Steinert reviewed the recent advances in corneal transplantation using femtosecond lasers. They stated that femtosecond laser technology has been used to perform penetrating keratoplasty and disease-targeted lamellar corneal surgery in order to improve surgical outcomes and wound healing. It is now possible to create customized patterns of trephination that have proven to produce more rapid visual recovery and decrease amounts of astigmatism when compared with penetrating keratoplasty using conventional blade trephination. They concluded, "Femtosecond laser-assisted corneal surgery is improving traditional outcomes in transplantation. Continued studies using this ultrafast laser may continue to yield new and exciting possibilities in the treatment of corneal disease."

Laser corneal surgery is improving the outcomes in corneal transplantation.⁵

In a retrospective, noncomparative, interventional case series, 13 consecutive patients underwent sutureless laser anterior lamellar keratoplasty for the treatment of anterior corneal pathology. Between 12 and 69 months postoperatively, patients were measured for BSCVA, manifest refraction, need for adjunctive surgery, and complications. More than 54% of patients achieved a BSCVA of greater than 20/30 at the 12-month visit, when all 13 were available for follow-up. Patients achieved a mean gain of five lines of BSCVA at the 6-, 12-, 18-, and 24-month visits; four lines at the 36-month visit; five lines at the 48-month visit; and six lines at the 60- and 72-month visits. At a mean of 5 weeks postoperatively, 83.3% of patients achieved a BSCVA within two lines of what was recorded at the 24-month visit. At the 12-month visit, mean spherical equivalent and refractive astigmatism were -0.40 D and 2.20 D, respectively. Adjunctive surgeries included phototherapeutic keratectomy, PRK, cataract extraction, and the debridement of epithelial ingrowth. Complications included residual corneal pathology, mild haze in the interface, anisometropia, a recurrence of pathology, haze after adjunctive PRK, dry eye disease, epithelial ingrowth, and suspicious ectasia.⁶

In a case study, cataract surgery was performed using a femtosecond laser on a 62-year-old man with superficial corneal irregularity in his left eye. The superficial corneal opacity originated from a fibrous proliferation and was mainly located within the superficial anterior cornea. His postoperative visual acuity was 20/80. The IntraLase FS laser (Abbott Medical Optics Inc.) was used to perform lamellar keratectomy and smooth the corneal surface. Two months postoperatively, a slit-lamp biomicroscopic examination showed a transparent and smooth corneal surface and stable keratometric value. Six months postoperatively, the patient underwent cataract surgery and IOL implantation, and his postoperative BCVA was 20/32.⁷

Researchers described the surgical technique for laser lamellar keratoplasty on a 63-year-old patient with a cataract and a history of corneal opacity. Because the patient had a deep stromal corneal opacity, the surgeon created a 400- μ m corneal button for lamellar keratoplasty. After the corneal graft was removed, cataract surgery was performed. The researchers noted that lifting of the flap and removal of the corneal button before cataract surgery were successful without any intraoperative complications. By postoperative day 1, the donor graft was well positioned on the recipient cornea, and no inflammation was noted. The bandage contact lens was removed after 7 days. At that time, corneal opacity was still present in the recipient cornea, but the patient's visual acuity had improved from count fingers to 20/200. Twelve months postoperatively, his

vision and cornea were stable with a manifest refraction of +3.00 D of sphere.⁸

LASER PROCEDURES ON THE HORIZON

In a literature review and commentary, Soong and Malta provided an update and review of femtosecond lasers in clinical ophthalmology based on the literature and data from their own clinical and laboratory studies. They noted that, although the major use of femtosecond lasers is to cut LASIK flaps, the technology has proven to be useful for anterior and posterior lamellar keratoplasty, the cutting of donor buttons in endothelial keratoplasty, customized trephination in penetrating keratoplasty, the creation of the tunnel for intracorneal ring segments, astigmatic keratotomy, and corneal biopsy. Currently, research is being conducted to examine laser refractive keratomileusis sans flap, the cutting of corneal pockets for the insertion of biopolymer keratoprosthesis, noninvasive transscleral glaucoma surgery, retinal imaging and photodisruption, presbyopia surgery, and anterior lens capsulorhexis. The authors concluded that current advances continue to improve the surgical safety, efficiency, speed, and versatility of femtosecond lasers in ophthalmology.⁹

In a literature review, case report, and commentary, researchers from the Massachusetts Eye and Ear Infirmary stated that the advantages of etching flaps with the femtosecond laser for LASIK have been well established. Alternatively, femtosecond lasers can be used in refractive ophthalmology for lenticule extraction to correct myopia and intrastromal biochemical manipulation to correct presbyopia. They stated that femtosecond lasers can also be used to prepare host and donor tissue for both full-thickness and lamellar keratoplasty. They concluded that the laser could be used to treat blind eyes with corneal leukoma.¹⁰ ■

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