Update on Laser Cataract Surgery

BY MITCHELL C. SHULTZ, MD

This installment of "Peer Review" highlights the most recently published articles on laser cataract surgery. Since our last update in 2011, the use of femtosecond lasers in cataract surgery has rapidly gained acceptance by cataract surgeons around the world. With more than 200 femtosecond lasers installed and many additional devices on order, laser cataract surgery is a reality in the United States and abroad. At the forefront of cataract surgeons' minds, however, are the questions, who will pay for this, and how can we adapt our centers to create an efficient work environment for multiple surgeons using a single device?

Nearly 20 million cataract surgeries were performed around the world in 2012.[1] Despite a slow global economic environment and lagging excimer laser sales and volume, I anticipate that this year's buzzword at the American Society of Cataract and Refractive Surgeons annual meeting will be "femtophaco." Surgeons and cataract surgery administrators will attend booth talks and industry-sponsored events to learn more and determine if the time is right to jump in knee deep in the shark-infested waters of laser cataract surgery. Femtosecond laser, IOL, and phaco equipment manufacturers are quickly trying to capture global contracts with ambulatory surgery centers. Through comprehensive contracting (also known as CAPS agreements), manufacturers and ambulatory surgery centers alike hope to defray the costs and improve the reception of laser cataract surgery. Based on sales volume, the major players in the laser cataract surgery space are Alcon Laboratories, Inc.; OptiMedica Corporation; Lensar, Inc.; Bausch + Lomb, and Technolas Perfect Vision GmbH. Abbott Medical Optics Inc. and Ziemer Ophthalmic Systems AG both have femtosecond lasers that are capable of creating corneal incisions, but their optical coherence tomography (OCT)-guided technology is not currently available for clinical use in the United States.

Upon reviewing the currently available peer-reviewed literature from around the world on laser cataract surgery, I am presenting you with a sample that represents the current state of the technology and published results. I do caution that, much like when LASIK was introduced, advances in technology and safety for laser cataract surgery are growing at a rapid rate. As experience is gained, manufacturers and surgeons alike are adapting to advance this exciting new technology. In addition to reducing complications generally associated with manual capsulotomy and phacoemulsification, femtosecond laser cataract devices have demonstrated the ability to greatly decrease effective phaco time (EPT) and improve effective lens position and corneal wound architecture.

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.

—Allon Barsam, MD, MA, FRCOphth, section editor

TISSUE MORPHOLOGY, CATARACTOGENESIS, AND SAFETY

In the first safety study of femtosecond laser photodisruption, Krueger et al[2] evaluated the effects on tissue and potential cataractogenesis of laser modification of the crystalline lens. The investigators radiated six fresh porcine lenses and six living rabbit eyes (with the contralateral eye as a control) with a low-energy femtosecond laser to induce lens fiber disruption. In the rabbit eyes, an energy of 1 µJ and spacing of 10 µm was chosen for transcorneal delivery with minimal bubble coalescence. After 3 months, the rabbit eyes did not exhibit cataract formation. Additionally, there was no loss of lens function, and lens scatter was not induced. The results suggest that the use of a low-energy femtosecond laser might be safe when modifying the crystalline lens for presbyopia correction.

In a prospective study of 38 eyes of 38 patients, Takács et al[3] evaluated the effect of the femtosecond laser on central corneal thickness and 3-mm central corneal volume compared with conventional phacoemulsification. In the laser group, the surgeon used a femtosecond laser performed two corneal incisions, a 4.75-mm capsulotomy, and a crosspattern lens fragmentation. Central corneal thickness was significantly higher in the phaco group (607 µm ±91) than in the laser group (580 µm ±42) on postoperative day 1 but did not significantly differ 1 week or 1 month postoperatively. Corneal endothelial cell counts were slightly lower in the phaco group at all postoperative follow-up examinations. Endothelial cell counts (cells/mm^2) for the laser group were 2,861 ±216 preoperatively, 2,860 ±217 1 day postoperatively, 2,730 ±205 1 week postoperatively, and 2,738 ±245 1 month postoperatively. The endothelial cell counts in the laser group were 2,841 ±215 preoperatively, 2,719 ±350 1 day postoperatively, 2,669 ±377 1 week postoperatively, and 2,542 ±466 1 month postoperatively. The differences between the two groups were not statistically significant, possibly due to the large standard deviation in the phaco group.

In a prospective study, Ecsedy et al[4] evaluated the effect of the LenSx Laser (Alcon Laboratories, Inc.) (laser group; n = 20) on macular thickness and volume compared with standard phacoemulsification (control group, n = 20) using OCT. The investigators assessed macular thickness and volume preoperatively, 1 week, and 1 month after surgery. The primary outcomes were retinal thickness in three areas and total macular volume 1 week and 1 month postoperatively. The secondary outcomes were changes in retinal thickness 1 week and 1 month postoperatively with respect to preoperative retinal thickness values and EPT. Using multivariable modeling, the authors demonstrated significantly lower macular thickness in the inner retinal ring in the laser group compared with the control group after adjusting for age and preoperative thickness across the time course (P = .002). In the control group, the inner macular ring was significantly thicker 1 week postoperatively (21.68 µm; 95% confidence limit, 11.93-31.44 µm; P < .001) and became marginally significant 1 month postoperatively.

The authors hypothesize that delayed detection of macular thickening is probably due to the long-term subclinical inflammation triggered by the manipulation of intraocular tissue and mediated by prostaglandins in both groups. EPT did not appear to correlate with any changes in macular thickness. Although long-term results were not evaluated, the early stability of macular thickness in the laser group was thought to be related to less blood-retinal barrier disruption compared with the control group and may be particularly advantageous in patients who are at risk for developing postoperative cystoid macular edema, such as those with uveitis or diabetic retinopathy.

IOP DURING FEMTOSECOND LASER PRETREATMENT

A concern among cataract surgeons with regard to laser cataract surgery is the risk of elevated IOP and the potential for IOP-related complications in the relatively elderly cataract population. In addition to an increase in IOP resulting from the application of the vacuum ring and laser-patient docking station, femtosecond laser pretreatment leads to the production of plasma in the anterior chamber. This plasma formation results in expansile cavitation bubbles that may further elevate IOP. In a recent nonrandomized prospective study of 25 eyes, Kerr et al[5] evaluated the effects of femtosecond laser pretreatment with the Catalys Precision Laser System with Liquid Optics Interface (OptiMedica Corporation) on IOP at varying stages of the procedure. The mean baseline IOP was 17.5 mm Hg ±2.4. During the application of the vacuum, the mean rise in IOP was 11.4 mm Hg ±3.3. Peak IOP after laser capsulotomy and lens fragmentation was 36 mm Hg ±4.4, with a mean increase of 18.5 mm Hg ±4.7. IOP remained elevated for 2 minutes after the procedure (26.6 mm Hg ±4 [P < .001]).

Schultz et al[6] also evaluated the IOP rise in 100 consecutive eyes (mean age, 70 years ±12 [range, 28-91]) using the same femtosecond laser. The mean baseline IOP was 15.6 mm Hg ±2.5. Upon application of the vacuum ring, the mean IOP rose to 25.9 mm Hg ±5 (mean elevation, 10.3 mm Hg [P < .001]) and remained constant after the laser procedure (27.6 mm Hg ±5.5). The mean total suction time was 3:45 minutes ±1.21. After removal of the suction ring, the mean IOP returned to 19.1 mm Hg ±4.4. According to the investigators, 1 hour after surgery, IOP was not significantly higher than the preoperative values. There were no adverse events, no cases of suction loss, and no patient reported amaurosis during or after the procedure.

LENS TILT AND IOL DECENTRATION

In a prospective, randomized study, Kranitz et al[7] compared IOL decentration and tilt following a circular capsulotomy created with a femtosecond laser (laser CCC; n = 20 eyes) versus a manually performed continuous curvilinear capsulorrhexis (manual CCC; n = 25 eyes). The investigators measured IOL decentration and lens tilt 1 year after surgery using a Scheimpflug camera (Pentacam, Oculus Optikgerāte GmbH). No significant differences were noted with regard to uncorrected distance acuity at any postoperative time point. Best corrected distance acuity, however, was reported to be significantly better in the laser CCC group 1 month and 1 year after surgery. Vertical and horizontal lens tilt in addition to total decentration was higher in the manual CCC group compared with the laser CCC group. Linear regression analysis showed a significant correlation between IOL vertical tilt and best corrected distance acuity (R2 = 0.17; β = -0.41; 95% confidence limit, -0.69 to -0.13; P = .005).

In an earlier prospective study by the same authors, IOL decentration was six times more likely to occur when the capsulorhexis was performed manually.[8] According to Kranitz and colleagues, an overlap of the capsulotomy over the IOL was the only factor that significantly affected horizontal decentration.

Friedman et al[9] evaluated the accuracy of the capsulotomy's size, shape, and centration when created with an OCT-guided femtosecond laser in porcine and human cadaver eyes. Subsequently, the procedure was performed in 39 patients as part of a prospective randomized study of laser cataract surgery. Capsulotomy strength was assessed separately in porcine eyes. The deviation from the intended diameter of the resected capsular disc was 29 µm ±26 (standard deviation) for the laser capsulotomy group and 337 µm ±258 for the manual capsulotomy group. The mean deviation from circularity was 6% and 20%, respectively. The center of the laser capsulotomies was within 77 µm ±47 of the intended position. The strength of the laser capsulotomy decreased with increasing pulse energy (152 mN ±21 for 3 µJ, 121 mN ±16 for 6 µJ, and 113 mN ±23 for 10 µJ). The strength of the manual capsulotomy was 65 mN ±21.

Because actual axial position of the IOL is significantly influenced by the configuration of the capsulotomy, complete overlap of the IOL optic secures the IOL in the capsular bag and raises the likelihood that the IOL will reside in its predicted position. Incomplete overlap leads to increased influence of postoperative capsular contraction, affecting ELP, which can result in lens tilt, induced myopic or hyperopic shift, astigmatism, and capsular phimosis.

ARCHITECTURAL STABILITY AND REPRODUCIBILITY OF INCISIONS

In a pilot study using an Intralase femtosecond laser (Abbott Medical

Optics Inc.), Masket et al[10] subjected cadaver eyes to partial-thickness clear corneal tunnel incisions, creating variable tunnel lengths. The investigators used a standard ophthalmodynamometer to simulate deformation of the eye, similar to that of a patient rubbing his or her eye after surgery. They used manometric elevation and a reduction in IOP to test the incisions' integrity and various levels of pressure as the ophthalmodynamometer device was applied near the equator of the globe. Although the authors concluded that cadaver eyes might not adequately mimic a clinical situation, the incision created with the femtosecond laser (3 mm × 2 mm) did not leak at any of the tested IOP levels (5, 10, and 20 mm Hg).

SURGICAL OUTCOMES

In a prospective study, Roberts et al[11] reported their results of 1,500 consecutive eyes that underwent laser cataract surgery and refractive lens exchange in a single group private practice. The study was conducted from April 2011 to March 2012 and separated into two groups. Group 1 included the first 200 cases, and group 2 included the subsequent 1,300 cases performed by the same surgeons. Baseline demographics were similar in both groups. Anterior capsular tears occurred in 4% and 0.31%, posterior capsular tears in 3.5% and 0.31%, and posterior lens dislocation occurred in 2% and 0% of eyes in group 1 and group 2, respectively. The number of docking attempts per case (1.5 vs 1.05), incidence of post laser pupillary constriction (9.5% vs 1.23%), and anterior tags (10.5% vs 1.6%) were significantly lower in group 2. The authors concluded that surgical outcomes and safety improved with surgeons' experience, the development of modified techniques, and improved technology.

In a prospective randomized clinical trial, Conrad-Hengerer et al[12] evaluated the feasibility of using the femtosecond laser to perform the capsulotomy and lens fragmentation in 160 patients undergoing cataract surgery. Patients were treated with 350-µm (n = 80) and 500-µm fragmentation grids (n = 80). Patients were evaluated preoperatively with the Lens Classification System III. The mean preoperative grade was 3.7 +0.8 in the 350-µm group and 3.5 +0.8 in the 500-µm group. The mean laser treatment time was 66.4 seconds +14.4 in the 350-µm group and 52.8 seconds + 11.9 in the 500-µm group. The authors concluded that the EPT was significantly lower for the 350-µm group compared with the 500-µm group (0.03 seconds ±0.05 and 0.21 seconds ±0.26, respectively). In addition, according to the authors, the creation of the capsulotomy takes 4 seconds in every case with a free-floating anterior capsule detected in eyes without adhesions or tags. None of the eyes developed anterior capsular tears, posterior capsular rupture, zonular dehiscense, vitreous prolapse or loss, phaco burn, or phaco bite. No adverse events occurred during the 4-week postoperative follow-up period.

THE CAPSULOTOMY'S DIAMTER AND VISUAL PERFORMANCE

In a prospective pilot study, Szigeti et al[13] compared the long-term visual outcomes and IOL position with the Crystalens AT-50AO (Bausch + Lomb) after the creation of a 5.5- or 6-mm capsulotomy with a femtosecond laser. The investigators evaluated near and distance visual acuity, manifest refraction spherical equivalent, IOL tilt, and IOL decentration 1 year postoperatively. Although the sample size was small (n = 17), the 5.5-mm capsulotomy created with the femtosecond laser was associated with less IOL tilt than the 6-mm capsulotomy. Secondary to the small sample size, however, the authors did not find any statistically relevant difference in IOL centration, near and distance visual acuity, or manifest refraction spherical equivalent in either group. ■

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