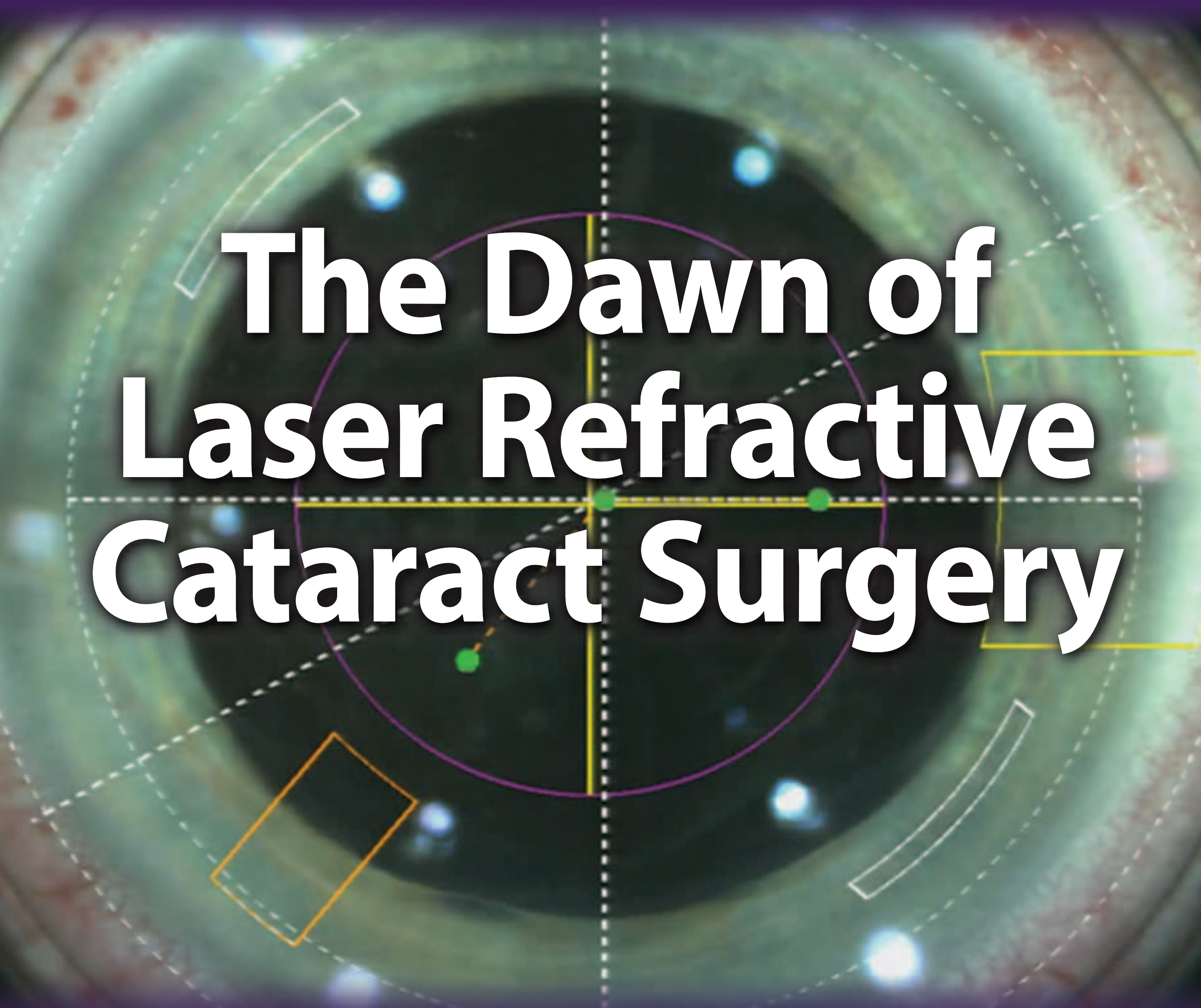
Supplement to

June 2011

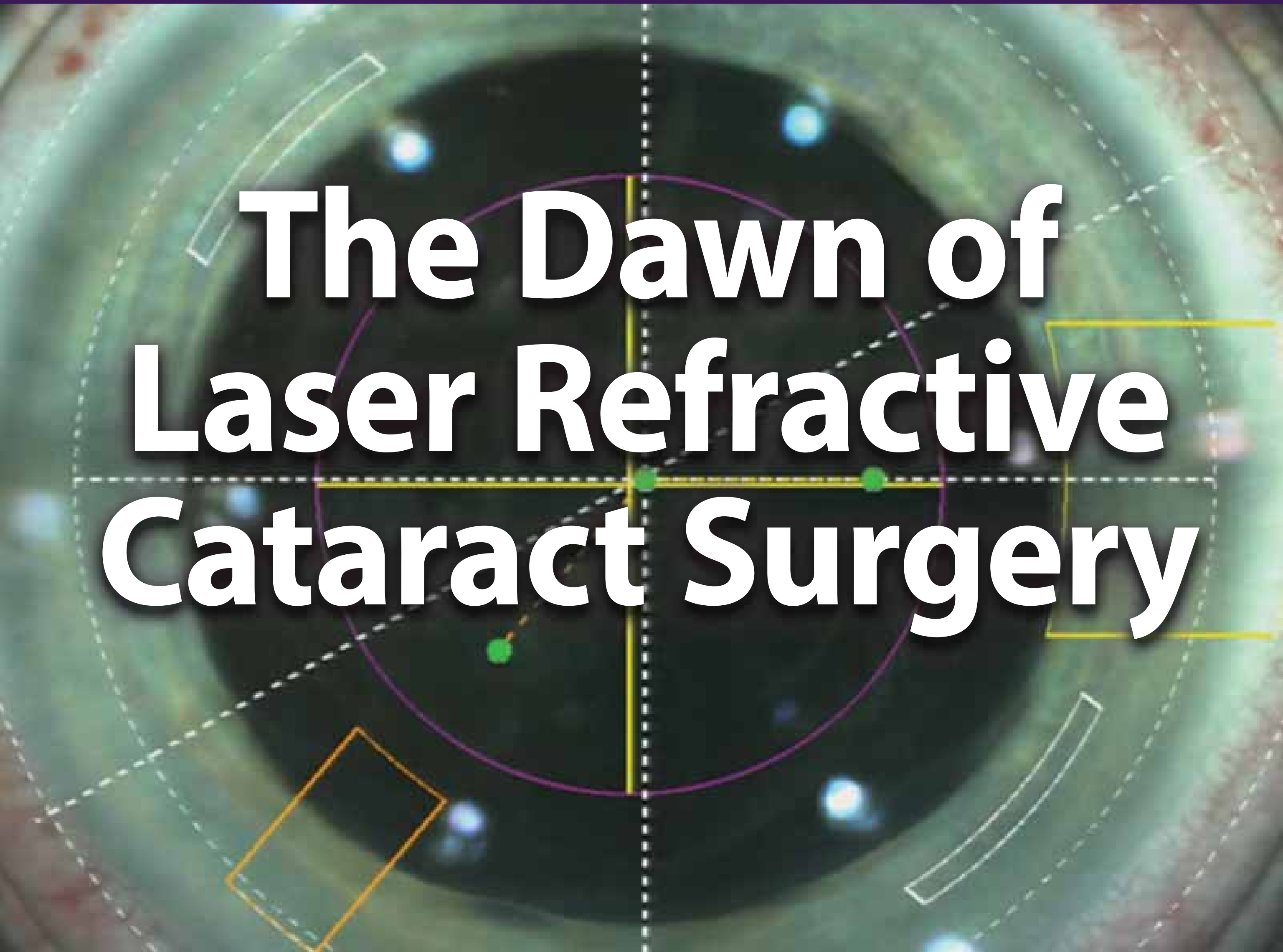
Cataract & Refractive Surgery TODAY



The Dawn of Laser Refractive Cataract Surgery

The LenSx laser in practice.

The Dawn of Laser Refractive Cataract Surgery



CONTENTS

Introduction

Welcome to the future of laser refractive cataract surgery. This monograph is based on material from the Ultimate Laser Show featuring the LenSx laser (Alcon Laboratories, Inc., Fort Worth, TX) that was held this April in San Diego, California. This technology represents a marriage of premium technology and a premium opportunity for surgeons and patients. Currently in the United States, there are approximately 78 million baby boomers who are turning age 65—roughly 10,000 people per day. These individuals are educated, financially secure, and embracing demand-driven patient care, meaning that they are willing to share the cost of premium surgical procedures. This is the same group of patients that largely drove the LASIK market, and now they are entering the age of developing cataracts. However, they have high expectations, they appreciate a service-oriented clinical experience, and they want a predictable procedure that will reduce their dependence on glasses and enhance their refractive outcome.

The LenSx laser.

Zoltan Nagy, MD, of Budapest, Hungary, first used the LenSx laser in 2008, and the first LenSx procedures were performed in the United States on February 29, 2010, by Stephen Slade, MD, of Houston. It received its first FDA approval in 2009 and currently has three 510(k) clearances for anterior capsulotomy, corneal incisions, and laser phacofragmentation. The LenSx laser also has CE marking as of January 2011.

I predict that the LenSx laser represents a new era of innovation in which ophthalmologists will have the means to achieve the outcomes that the baby boomer population wants. The LenSx laser is a dynamic platform that I believe will deliver true refractive cataract surgery with the precision and reproducibility of a femtosecond laser. It will establish laser refractive cataract surgery as a viable, premium-category surgery, and it will rapidly advance the evolution of true image-guided intraocular surgery for safer and more reproducible cataract surgery. Read on to learn how this technology will usher in refractive cataract surgery and how it will fit in the clinical practice.

—Richard L. Lindstrom, MD

Room to Grow

Integrating the LenSx laser with cataract/implantation surgery.

BY RICHARD J. MACKOOL, MD

Because femtosecond cataract technology is in its infancy, it is generating a great amount of interest and many questions from ophthalmic surgeons. How will this technology fit into the ophthalmic surgical flow? Will it add significant time to the cataract procedure or require new staff? Is there room for another laser in the clinic? This article provides an overview of the potential as well as the challenges of laser cataract technology.

SURGICAL PRECISION IS ALWAYS IN DEMAND

The manufacturers of femtosecond lasers are continuously developing ways to improve the efficiency of their surgical applications. For example, the LenSx laser (Alcon Laboratories, Inc., Fort Worth, TX) will soon have software that streamlines programming during the procedure. Furthermore, early adopters of these lasers for refractive cataract surgery are devising their preferred techniques for optimal performance. For instance, Stephen G. Slade, MD, of Houston, creates the capsulorhexis before he segments the nucleus, thereby eliminating the need to refocus the laser on the anterior capsule after nucleus segmentation changes the capsule's position. With such an array of applications—the creation of the capsulorhexis, nuclear segmentation, and all corneal incisions (arcuate, sideport, and primary), all executed in approximately 1 minute—I cannot fathom how a technology that offers such precision and safety would not find a prominent place in our surgical armamentarium.

> "I cannot fathom how a technology that offers such precision and safety would not find a prominent place in our surgical armamentarium."

BARRIERS TO ACCEPTANCE

Economic Rather Than Technological

Nonetheless, the laser refractive cataract procedure has issues that must be addressed before it gains widespread acceptance. Fortunately, these issues are not so much technological as they are economic.

To What Degree Can a Laser Improve Clinical Performance?

How can laser refractive cataract surgery be integrated into the ophthalmic clinic so that patients embrace the technology and surgical volumes increase? Although traditional cataract surgery is a highly advanced procedure and its rate of success is higher than ever, complications and less-than-optimal results still occur (Table 1). For example, there is evidence that if we do not properly size

Table 1. Incidence of Complications in Cataract Surgery

Problem	Incidence	Vision Threatening	Incidence
CME (transient)	2 to 10%	CME (persistent)	1 to 2%
Vitreous loss	1 to 5%	CME, RD, IOL malposition	0.30%
Corneal endothelial cell loss	4 to 10%	Corneal transplant	0.30%

The efficacy and safety of traditional cataract surgery is limited, and these limitations impact surgeons' confidence. Complications in cataract surgery are currently 10 times that of LASIK. The manual steps of traditional cataract surgery cannot be executed with reproducible precision and predictability.

and locate the capsulotomy, the position of the IOL is compromised and the patient's refractive outcome suffers.[1,2] Furthermore, corneal incisions are imprecise. Not all surgeons use a clear corneal incision, and some wounds require suturing. Poorly constructed wounds may even leak and possibly result in endophthalmitis. The best wound construction may well be a three-plane incision, but creating these cuts reliably and reproducibly by hand is impossible. Standardizing these steps would lead to greater surgical accuracy and safety for our patients.

Cataract surgeons and manufacturers alike are constantly seeking ways to reduce the amount of ultrasonic energy used in the eye during phacoemulsification. Dividing the nucleus is, in my opinion, the most difficult maneuver during cataract surgery. The risk of thermal burn is greatest during sculpting of the nucleus in preparation for segmentation. The more ultrasound we use, the greater the possibility of creating anterior or posterior capsular tears with resultant macular edema, IOL dislocation, vitreous loss, etc. Associated corneal edema and endothelial cell loss negate any postoperative "wow" factor for the patient, even if the edema clears within a week or two. Femtosecond fragmentation of the nucleus (also called *phacofragmentation*) essentially eliminates significant sculpting and dramatically reduces the amount of ultrasonic energy required to remove the lens.

Although in its infancy, femtosecond laser technology as delivered by the LenSx laser has undeniably improved the architecture and accuracy of corneal incisions, the capsulorhexis, and nuclear segmentation (Figure 1). I believe that this is the beginning of a new level of customization in cataract surgery where surgeons will be able to tailor these cuts and laser applications to the specifications of each eye. Such a level of surgical customization and safety should allow us to treat a greater range of patients. For example, imagine the possibilities for challenging cases, since laser nuclear fragmentation does not stress the zonules like phacoemulsification. Moreover, the imprecision of traditional cataract surgery significantly limits the performance of advanced-technology IOLs and thus has stalled the adoption of this technology, which currently stands at only 6% to 7% of every 100 procedures performed in the US.

Will Patients Embrace Laser Cataract Surgery and Be Willing to Pay for It?

When explaining the laser refractive cataract technology to patients, I have found few, if any, who have not immediately understood and embraced the idea of a more automated cataract procedure. Patients clearly desire the precision of a laser and nod their heads in agreement when I

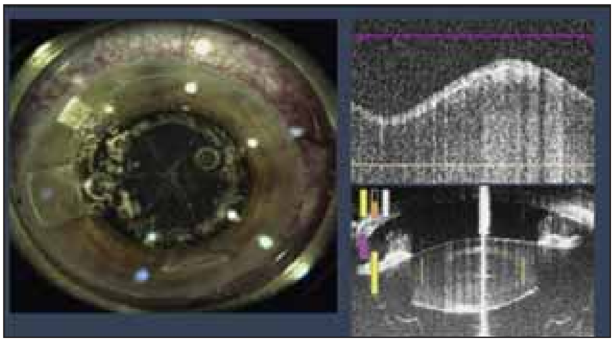


Figure 1. The LenSx femtosecond laser creates the capsulotomy. The visualization screen shows both the femtosecond application and the OCT image in real time.

describe the advantages of this procedure. I find it particularly useful to show these candidates a video of the LenSx laser in operation. Its speed and ease of use are impressive and help them understand how the procedure works. A video makes the concept of a truly premium, value-added experience immediately obvious. In truth, it is invaluable to have a patient walk into your office, look at your technology, and conclude, "This looks like the place where I want to have surgery!" This is the kind of experience patients desire.

THE FUTURE OF REFRACTIVE CATARACT SURGERY

I have no doubt that the femtosecond laser represents the future of cataract surgery. We have only scratched the surface of its potential, and I expect that the technology will soon have a multitude of research papers in print. Ophthalmologists are eager to embrace better equipment—there was standing room only at the LenSx course given at the ASCRS meeting in San Diego.

I foresee laser refractive cataract surgery driving the premium surgical channel. We should introduce it to our practices gradually and thoughtfully, however, by reserving it for the most appropriate patients. Like any new technology, it will of course have issues to resolve. However, even at this early stage of development, this technology offers remarkable prospects for advancing cataract surgery. ●

Richard J. Mackool, MD, is the director of the Mackool Eye Institute and Laser Center in Astoria, New York. He is a consultant for Alcon Laboratories, Inc., but acknowledged no financial interest in the product or company mentioned herein. Dr. Mackool may be reached at (718) 728-3400, ext 256; mackooleye@aol.com.

1. Norrby S. Sources of error in intraocular lens power calculation. *J Cataract Refract Surg.* 2008;34(3):368-376.
2. Cekiç O, Batman C. The relationship between capsulorhexis size and anterior chamber depth relation. *Ophthalmic Surg Lasers.* 1999;30(3):185-190.

In Pursuit of the Reproducible Capsulotomy

Making a reproducible capsulotomy with the LenSx laser.

BY ROBERT J. CIONNI, MD

At the beginning of my third year of residency at the University of Louisville, the staff attending physician instructed me to make the most perfect can-opener capsulotomy he had ever seen. Over the next 20 minutes, I finished the can-opener capsulotomy, having made it as perfectly as I could. After 20 minutes of precision work, the capsulotomy seemed perfect, but it still developed a radial tear and I lost vitreous in that case. Cataract surgical techniques have come a long way since then, but even now, having performed more than 30,000 surgeries, I cannot say that I make an ideal capsulorhexis in every eye. It is impossible for us to be perfect every time. Besides, what would an ideal capsulotomy look like?

THE IDEAL CAPSULOTOMY

Safety Issues

The ideal capsulotomy would, above all things, have to be reproducible. What we strive for is the same capsulotomy in each and every case, as if from a cookie cutter. Second, the shape and the size of the capsulotomy need to be made as planned based on the IOL chosen. Third, the capsulotomy should be centered on the visual axis to achieve an optimal refractive outcome for the patient, especially when planning to place an aspheric IOL. If I am going to implant a presbyopia-correcting or a toric lens, I have to be certain to nail the spherical power as well. Finally, the edge of the capsulorhexis must cover the IOL symmetrically for 360º. These are the minimum criteria for the reproducible capsulotomy.

If the capsulotomy is too big, the implant can vault forward, changing the effective power of the lens. A capsulotomy that is too small makes phacoemulsification more difficult and increases the likelihood of complications such as anterior capsular tears intraoperatively and capsular phimosis postoperatively, especially in eyes with pseudoexfoliation. A capsulorhexis that is irregular or off-center may cause the IOL to tilt or decenter and may induce some visual symptoms from its edge. Two studies, one conducted by the very experienced, talented surgeon and my mentor, Robert Osher, MD, showed that even for surgeons whose instances of anterior capsular tears are low, when the complication does occur, it is quite problematic.[1,2] In 40% of patients who experience an anterior capsular tear, the tear extends to the posterior capsule, and 20% of these eyes require a vitrectomy. Thus, there is a safety issue when the capsulotomy is not well formed.

Refractive Issues

Additional studies speak to the effect of the lens' position in the eye on the refractive outcome.[3,4] Warren Hill, MD, of Mesa, Arizona, has taught us that if we cannot consistently achieve a symmetric capsulorhexis that overlaps the anterior edge of the optic, we cannot expect to be within 0.50 D of the target refraction, regardless of what IOL formula we use or our method of biometry. At minimum, we must make a symmetrical capsulorhexis that is consistently sized and that overlaps the optic.

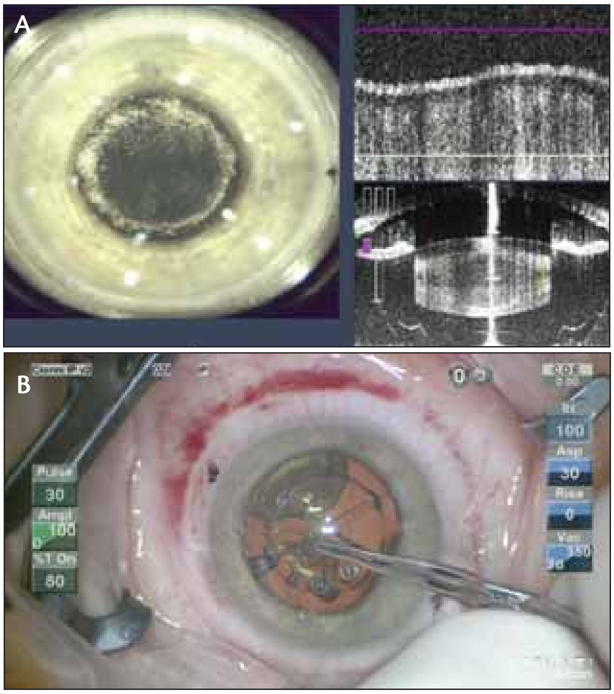


Figure 1. The LenSx laser creates a symmetrical capsulotomy (A) that the surgeon can open easily in the OR (B).

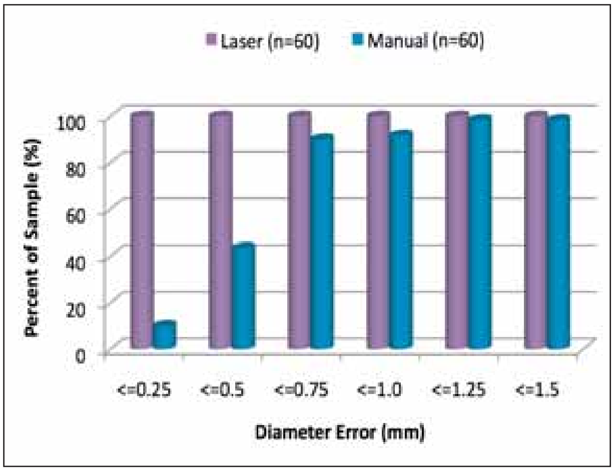


Figure 2. This figure shows the accuracy in diameter (absolute difference between attempted and achieved) of capsulotomies created with the LenSx laser versus manually. Only 10% of the manual tears achieved within ±0.25 mm of their intended diameter.

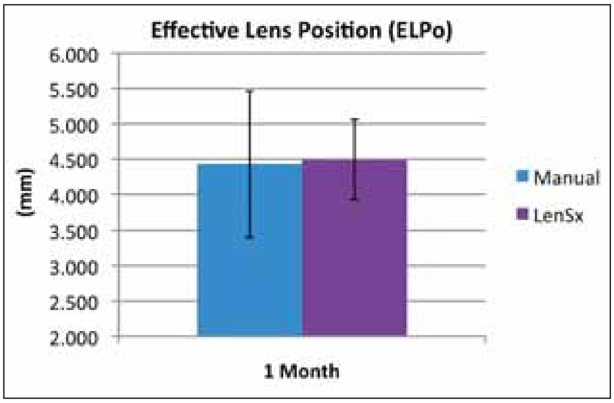


Figure 3. Dr. Nagy found reduced variability in the effective lens position in the LenSx laser group compared with the manually made capsulotomies.

The LenSx laser (Alcon Laboratories, Inc., Fort Worth, TX) gives us surgeons a tremendous advantage in creating the capsulotomy. It enables us to make a consistently round, symmetrical, centered capsulorhexis in every eye by removing the variability inherent in manual techniques (Figure 1A and B). As Dr. Mackool described, the LenSx laser's three-dimensional optical coherence tomography-guided imaging system provides us visualization of the capsulotomy to further verify its precise architecture and placement (*see the sidebar,* The LenSx Laser's Imaging System). With such a uniformly round capsulorhexis, the implant should always be covered for a full 360° and centered on the visual axis. Therefore, I believe this technology will improve our cataract patients' refractive results.

CLINICAL DATA

Many ophthalmic practitioners have already seen video of the LenSx laser in action. Although it looks impressive, any new technology is only as valuable as the quality of its research. Are there data that demonstrate a correlation between a nicely centered and sized capsulotomy and patients' refractive result? In fact, there are. Zoltan Nagy, MD, from Budapest, Hungary, has published results of creating capsulotomies with the LenSx laser system that are within 0.25 mm of the desired size 100% of the time (n = 60). Comparatively, this skilled surgeon achieves within 0.25 mm of the desired size of manual capsulorhexes only 10% of the time (n = 60; Figure 2).[5,6]

THE LENSX LASER'S IMAGING SYSTEM

By Gautam Chaudhary, PhD

Optical Coherence Tomography (OCT) is a noninvasive imaging modality for obtaining subsurface images of biological tissue in micrometer resolution. The LenSx laser system integrates a proprietary anterior-segment OCT, video microscope, and femtosecond laser to enable image-guided cataract surgery. The system provides real-time cross-sectional images of the anterior segment that extend from the corneal epithelium to beyond the posterior lens capsule.

The surgeon first uses live images from the video microscope and OCT to align the patient's eye with the system during docking. Then, the surgeon positions the laser treatment patterns onto the high-resolution video and OCT images to localize the three-dimensional laser cuts. Once the surgeon verifies the placement of the cuts, he or she initiates and monitors the laser procedure.

Gautam Chaudhary, PhD, is a visualization scientist for the LenSx laser. Dr. Chaudhary may be reached at (949) 360-5884; gautam.chaudhary@alconlabs.com.

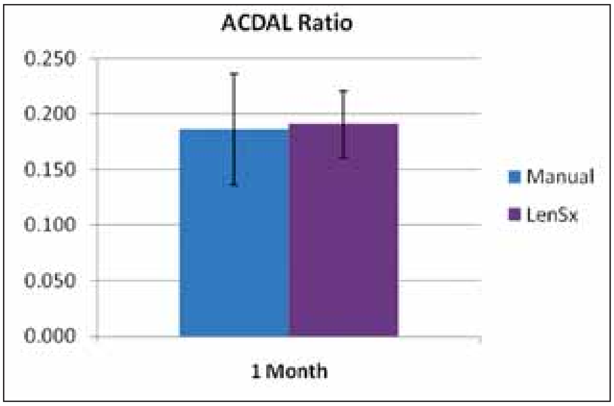


Figure 4. There was a statistically significant difference in variance between the capsulotomies made with the LenSx laser versus manually.

These results demonstrate that the LenSx laser markedly improves the precision of the capsulotomy.

Dr. Nagy conducted another study in two groups of 20 eyes each to learn the effect of the method of capsulotomy creation on effective lens position. He sought to determine whether the effective lens position was truly more consistent with a laser-created capsulotomy, when it was precisely sized every time, or whether there was no difference in the variability of the effective lens position between the laser and the manual technique. In this study, Dr. Nagy also examined the ratio of postoperative anterior chamber depth to axial length, which is important for calculations with the newer-generation IOL formulas. In both instances, the variability in effective lens position was significantly less with the femtosecond laser, because the IOL was always covered by the capsulorhexis' edge (Figures 3 and 4). As we know, less variability in the effective lens position should lead to a more predictable refractive result.

SUMMARY

In my early experience, I have seen the LenSx refractive cataract laser system deliver reproducibly sized, shaped, and centered capsulotomies. Now, with clinical evidence that supports the role of effective lens position in refractive outcomes, I am even more certain of this technology's potential to advance the cataract procedure. In combining this capability with the ability to make precise, laser-cut corneal incisions, I anticipate that refractive results for our patients are going to be much better than they have been in the past. ●

Robert J. Cionni, MD, is the medical director of The Eye Institute of Utah in Salt Lake City, and he is an adjunct clinical professor at the Moran Eye Center of the University of Utah in Salt Lake City. He is a consultant to Alcon Laboratories, Inc. Dr. Cionni may be reached at (801) 266-2283.

1. Marques FF, Marques DM, Osher RH, Osher JM. Fate of anterior capsule tears during cataract surgery. *J Cataract Refract Surg.* 2006;32:1638-1642.
2. Unal M, Yücel I, Sarici A, et al. Phacoemulsification with topical anesthesia: resident experience. *J Cataract Refract Surg*. 2006;32:1361-1365.
3. Hill WE. Hitting Emmetropia. In: Chang DF, ed. *Mastering Refractive IOLs: The Art and Science*. Thorofare, NJ: Slack Inc.;2008.
4. Hill WE. Does the capsulorhexis affect refractive outcomes? In: Chang DF, ed. *Cataract Surgery Today*. Wayne, PA: Bryn Mawr Communications LLC;2009:78.
5. Nagy, Z. 1-Year clinical experience with a new femtosecond laser for refractive cataract surgery. Presented at: The AAO 2009; San Francisco, CA.
6. Nagy, Z. Intraocular femtosecond laser applications in cataract surgery: precise laser incisions may enable surgeons to deliver more reproducible outcomes. *Cataract & Refractive Surgery Today*. September 2009:29-30.

Phacofragmentation in Laser Refractive Cataract Surgery

Reducing the amount of ultrasound in the eye for a safer procedure and better outcomes.

BY STEPHEN S. LANE, MD

Traditional longitudinal ultrasonic phacoemulsification probably uses more ultrasonic power than is necessary for cataract extraction. Minimizing the amount of power used in the procedure would obviously be safer for the eye and therefore produce better results. Using too much ultrasonic power in the eye can delay patients' visual recovery by destroying endothelial cells, creating corneal edema, and possibly rupturing the capsule.

One of the most exciting applications of femtosecond lasers is the phacofragmentation of cataracts. The idea behind phacofragmentation is to soften the lens to such a point where the amount of ultrasonic power needed to extract it is minimal or even zero. Then, we could simply remove the lenticular material with aspiration alone via a designated nuclear aspiration device. Thus, conceivably, phacofragmentation would lead to a much safer cataract procedure with fewer complications. With the LenSx laser (Alcon Laboratories, Inc., Fort Worth, TX), I think we now have that capability.

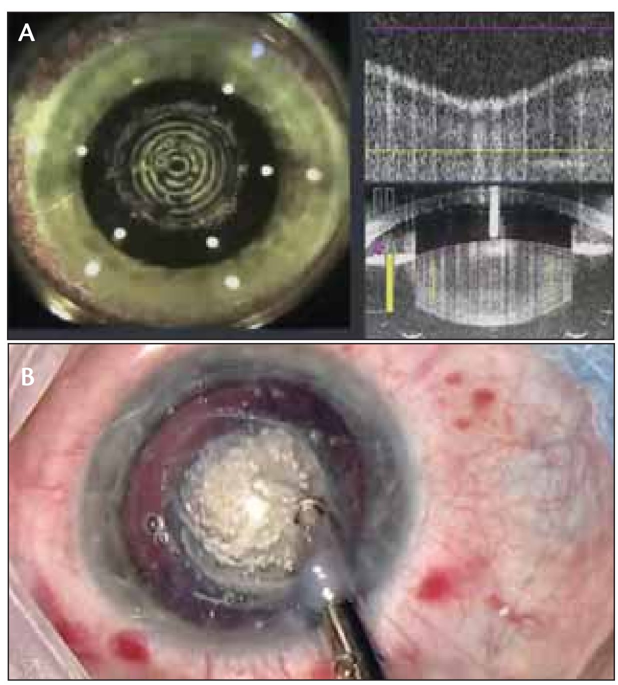
REAL-TIME, THREE-DIMENSIONAL IMAGING FOR SURGICAL PRECISION

The feature that enables all other capabilities of the LenSx laser is its imaging system. The optical coherence tomography (OCT)-guided laser has an intuitive touch screen that allows me to easily customize each step of the procedure. It also provides real-time video imaging for three-dimensional visualization during each component of the surgery. With this image-guided surgical planning, I can precisely program and verify exactly what I want to achieve, from the size, shape, and location of each incision to phacofragmention of the nucleus. I feel that this laser gives me exceptional control during surgery. Additionally, it has many built-in safeguards to ensure that I will deliver the laser energy exactly the way I want to before I push the pedal.

PHACOFRAGMENTATION

There are number of ways in which the LenSx laser can phacofragment or soften the nucleus prior to emulsification. Most cataract surgeons agree that soft nuclei are challenging to fragment, because they are difficult to manipulate. Zoltan Nagy, MD, of Budapest, Hungary, has shown video footage of the LenSx laser delivering the femtosecond laser energy in a spiral pattern that softens the lens (Figure 1A) so that he can remove it entirely with I/A (Figure 1B)—no ultrasonic power whatsoever.

Stephen Slade, MD, has also shown a video of softening and dividing denser nuclei using the LenSx laser. He softened the nucleus using phacofragmentation and then divided it into six pie-shaped fragments (Figure 2) that he later removed separately in the OR. Again, the LenSx laser's OCT-guided image prevents us from fragmenting too deeply or starting the procedure too close to the posterior capsule. Next, Dr. Slade performed hydrodissection followed by phacoemulsification. Once hydrodissection frees the nucleus from its cortical attachments, the surgeon can simply grasp



(Courtesy of Zoltan Nagy, MD.)

Figure 1. The LenSx laser delivers a spiral pattern of energy to phacofragment the nucleus (A) so that the surgeon can remove it in the OR without ultrasonic power (B).

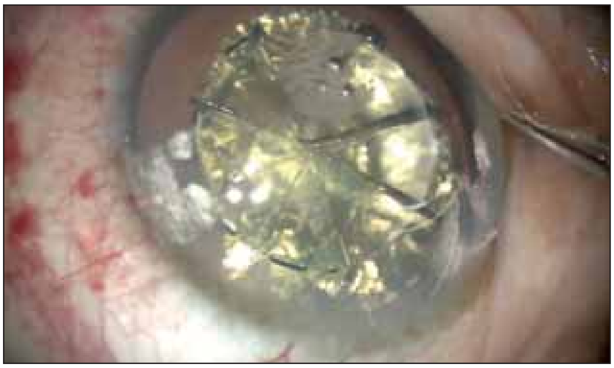


Figure 2. The LenSx laser divided the nucleus into six segments.

nuclear segments with the phaco tip, pull them to the center, and then safely emulsify the fragments in a very controlled fashion. In this case, Dr. Slade positioned and then emulsified each pie-shaped segment with one hand, and he only used the second-hand instrument to manipulate the nucleus. With this technology, Dr. Slade's phaco tip only edged past the central portion of the eye to bring the next pie piece to the aspiration port. In this manner, phacofragmentation allows us to remove cataracts quickly, easily, efficiently and—most importantly—safely.

SURGICAL IMPACT

What difference will laser refractive cataract surgery make to the clinical practice? A few preliminary studies have shown that the efficiency of phacofragmentation for lens removal reduces phaco time and power. The LenSx laser's clinical performance demonstrates a high degree of accuracy and reproducibility for faster pulse placement. Studies have shown a 51% reduction in the amount of phaco power and a 43% reduction in the amount of phaco time with this laser (Figure 3A and B). Clearly, these data translate into less energy used in the eye, thereby diminishing stress on the endothelium, reducing the chance of edema, and providing faster visual rehabilitation of vision for our patients.

INCREASED SAFETY AND EFFICACY

I believe that laser refractive cataract surgery as performed with the LenSx laser is going to increase the safety and efficacy of cataract removal. Prechopping the cataractous nucleus will reduce the amount of ultrasonic energy needed for this surgery, which in turn will lessen the inflammatory response and preserve corneal endothelial cells. The laser's OCT-guided imaging and surgical planning technology provide additional precision and safety features for an enhanced surgical experience. Finally, the LenSx laser permits a level of surgical automation and reproducibility that is unmatched by traditional techniques. ●

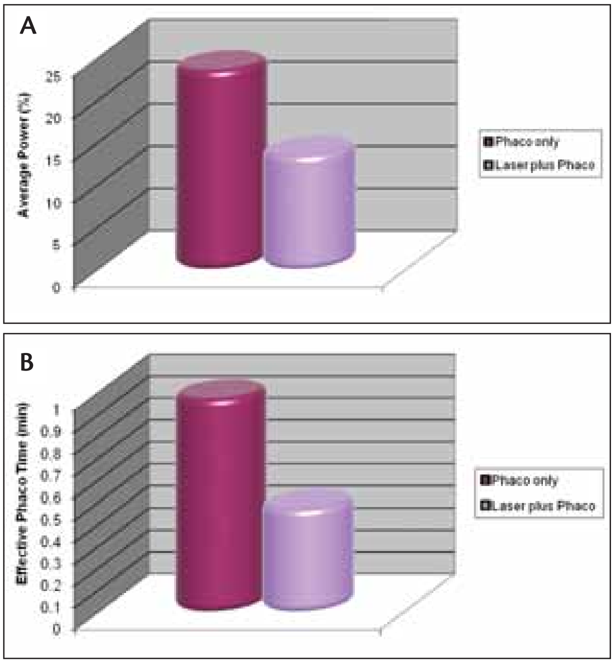


Figure 3. The nuclei of porcine eyes pretreated with phacofragmentation via the LenSx laser required 43% less average phaco power (A) and 51% less average phaco time (B) for removal than the eyes treated with phacoemulsification alone. (Adapted from Nagy Z, Takacs A, Filkorn T, Sarayba M. Initial clinical evaluation of an intraocular femtosecond laser in cataract surgery. *J Refract Surg*. 2009 Dec;25(12):1053-1060.)

Stephen S. Lane, MD, is medical director of Associated Eye Care in St. Paul, Minnesota, and an adjunct clinical professor for the University of Minnesota in Minneapolis. He is a consultant to and receives lecture fees from Alcon Laboratories, Inc. Dr. Lane may be reached at (651) 275-3000; sslane@associatedeyecare.com.

The Architecture of Corneal Incisions

Designing safer incisions with the LenSx femtosecond laser.

BY ERIC D. DONNENFELD, MD

When I look back at my career in ophthalmology, I remember three landmark advances: phacoemulsification, intraocular lenses, and LASIK. I am not yet ready to say that laser refractive cataract surgery will be an event of the same caliber as those technologies, but I feel it has a good chance. The possibilities for this new technology are limitless. It is an exciting time to be an ophthalmologist.

This article describes using the LenSx laser (Alcon Laboratories, Inc., Fort Worth, TX) to make corneal incisions, the architecture of which I feel is the most important aspect of refractive cataract surgery. Although the capsulotomy and removal of the cataract are important, I believe that the rate-limiting factor for most surgeons is the ability to reliably control and treat astigmatism. Concern about astigmatism prevents many surgeons from entering the premium channel of refractive cataract surgery, because they feel that this refractive error compromises the quality of vision they are able to provide patients. The LenSx laser may be able to significantly reduce this concern.

CATARACT INCISIONS

The ophthalmic literature shows that poorly constructed corneal incisions are responsible for many cases of endophthalmitis.[1] According to a paper from the Moran Eye Center in 2007, at least half of endophthalmitis cases result from late wound leaks,[2] and a wound leak increases the chance of endophthalmitis 44-fold. A true self-sealing, three-planed incision should significantly reduce the risk of endophthalmitis.

Laser refractive cataract surgery offers the flexibility and reproducibility of creating customizable, automated incisions. The LenSx laser features three-dimensional visualization and surgical planning via real-time optical coherence tomography (OCT). The surgical planning function allows the surgeon to create self-sealing incisions in any shape, size, and location he or she wishes. Figure 1 shows a beautiful two-plane corneal incision

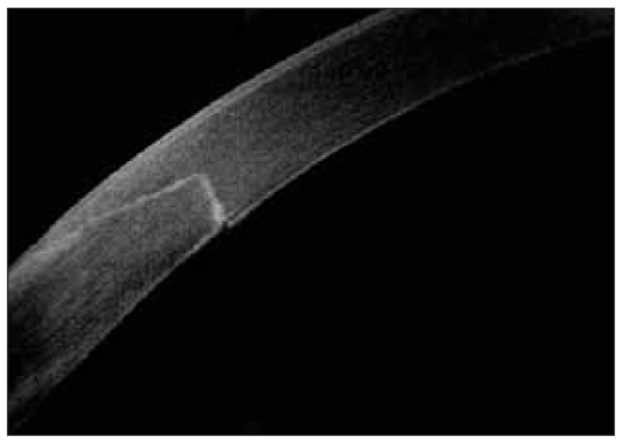


Figure 1. A postoperative OCT image of a two-plane corneal incision created with the LenSx Laser.

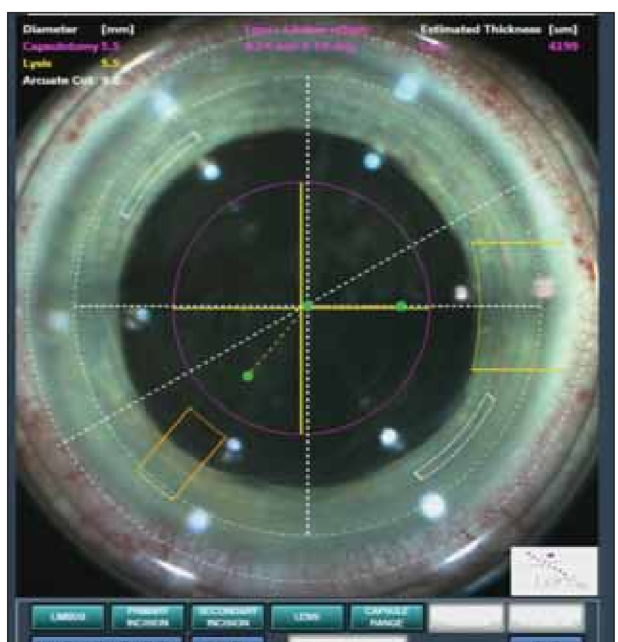


Figure 2. The LenSx laser's software interface enables the surgeon to program the location, shape, and dimensions of arcuate incisions.

STEP-BY-STEP INCISIONS WITH THE LENSX LASER

Making corneal incisions with the LenSx laser is surprisingly easy. The laser's touchscreen interface allows us to drag and drop the size and placement of the main, sideport, and arcuate incisions. We can even program the laser to make a two- or three-plane cut. I use the Slade/Donnenfeld nomogram set at 9 mm, and once I have determined the size and placement of these wounds, I verify their location once more with the laser's OCT-guided image of the cornea before I tell the laser to make the cuts. Then, I am ready to proceed to making the capsulorhexis, using the same image-guided planning software.

made with the LenSx laser. The laser is also FDA-approved to make arcuate incisions (incisions placed in the cornea's periphery parallel to the limbus and perpendicular to the steep meridian in order to flatten the meridian). Traditional astigmatic incisions are made by hand with a diamond knife and therefore have imprecise architecture. Although nomograms have shown that limbal relaxing incisions are able to reduce cylinder by up to 70% if performed correctly, the majority of cataract surgeons avoid using these incisions because of their unpredictable nature. Here again, the LenSx laser's image-guided, three-dimensional visualization enables the surgeon to preprogram the width, depth, and location of arcuate incisions (Figure 2). The possibilities are enticing: on a patient's first postoperative day, if necessary, the surgeon can titrate the LenSx-made incision with a forceps rather than a blade to achieve the desired effect. We should be able to reduce patients' residual astigmatism significantly and get them much closer to emmetropia. In the future, we may be able to create intrastromal ablations through incisions that do not reach the corneal surface. This technology will give patients less pain, greater comfort, and again, more reliable incisions.

CONCLUSION

Laser refractive cataract surgery is here today. Predictable incisional architecture for clear corneal tunnel incisions is the key to cleaner, safer wounds. Furthermore, the LenSx laser gives us a new opportunity to define and develop refractive arcuate incisional geometry with which to treat surgically induced astigmatism. Precise, reproducible corneal incisions may enable surgeons to design and deliver an entirely new level of refractive cataract surgery. ●

Eric D. Donnenfeld, MD, is a professor of ophthalmology at NYU and a trustee of Dartmouth Medical School in Hanover, New Hampshire. Dr. Donnenfeld is in private practice with Ophthalmic Consultants of Long Island in Rockville Centre, New York. He is a consultant to Abbott Medical Optics Inc.; Advanced Vision Research; Alcon Laboratories, Inc.; Allergan, Inc.; and Inspire Pharmaceuticals, Inc. Dr. Donnenfeld may be reached at (516) 766-2519; eddoph@aol.com.

1. Nagaki Y, Hayasaka S, Kadoi C, et al. Bacterial endophthalmitis after small-incision cataract surgery. Effect of incision placement and intraocular lens type. *J Cataract Refract Surg*. 2003;29(1):20-26.

2. Moshirfar M, Feiz V, Vitale AT, et al. Endophthalmitis after uncomplicated cataract surgery with the use of fourth-generation fluoroquinolones: a retrospective observational case series. *Ophthalmology*. 2007;114(4):686-691.

The LenSx Laser in Action

A refractive surgeon polishes his cataract skills.

BY STEPHEN G. SLADE, MD

I have had the LenSx laser (Alcon Laboratories, Inc., Fort Worth, TX) since February 2010, and I have no doubt that I will be performing laser refractive cataract surgery for the rest of my career. Since my partner and I purchased the laser, we have been able to convert the majority of our patients to its treatments. This article describes the first year of my clinical experience with the LenSx laser.

PATIENT ACCEPTANCE

My cataract candidates comprehend the benefits of laser-based surgery and are willing to pay an additional fee for them. In my first year of having the technology, laser refractive cataract surgery has become the primary procedure I perform, and it could not have come at a better time (*see* The Cataract Market in the United States). Approximately 3,261,000 cataract procedures are performed in the United States annually, and this figure will continue to rise as more baby boomers reach age 65 every year. In fact, U.S. Census data show that 10,000 people turn 65 each day in the United States, and that the number of Americans aged 65 and older will double in 7 years. If the number of ophthalmic residents doubled tomorrow, there would still not be enough ophthalmologists to serve this coming growth.

This certainly is an exciting time to be an ophthalmologist. Baby boomers have discretionary income, want to preserve their health, and are looking for the best value for their healthcare dollars. Some may have unrealistic expectations, but it is part of our job to manage these expectations and meet them when we can, and I believe that the laser cataract surgery technology will better allow us to do so. It is also incumbent upon surgeons to market our services by reminding these consumers of the importance of their eyesight and the value of premium cataract surgery. Does anything else affect peoples' quality of life so directly as functional vision?

So, we surgeons must prepare ourselves to meet this growing demand. We will do this by using the LenSx laser to deliver the two things patients want most: safety and efficacy. Patients naturally equate lasers with greater surgical precision and safety. To patients, efficacy means not having to wear glasses at all, no matter how unrealistic that goal may be. Because this is what our patients want, it behooves us to become refractive-cataract surgeons. I am undergoing this transformation myself. Previously, I was performing cataract surgeries one morning per month. When I learned of the development of laser cataract surgery and decided I wanted to become involved in it, I knew I had to hone my cataract skills. For the past year, I have had the great fortune of hosting some of the country's best cataract surgeons—the likes of Robert Cionni, MD; Richard Mackool, MD; and Eric Donnenfeld, MD—so that I could watch and learn from them.

I know that many practitioners are skeptical about laser refractive cataract surgery, because it is just emerging and has yet to define its place in clinical practice. I am confident in this technology, because I have seen first-hand that patients are willing to pay for what they perceive to be an all-laser procedure.

"I am confident in this technology, because I have seen first-hand that patients are willing to pay for what they perceive to be an all-laser procedure."

HOW THE LENSX LASER WORKS

The LenSx refractive cataract procedure begins with fixating a one-piece docking ring on the patient's eye, similar to creating a femtosecond LASIK flap. The laser's

TABLE 1. THE CATARACT MARKET IN THE UNITED STATES
• 18,900,000 cataract procedures globally in 2010
• 3,261,000 cataract procedures performed in the US in 2010
• 900 million cataract packs sold in the US
• 85 million presbyopes in the US, 72% with astigmatism of 0.50 D or greater

optical coherence tomography (OCT) imaging system shows the real-time view of the eye from the microscope. With the touchscreen user interface, I can choose the size, shape, and location of my incisions. In fact, the digital nature of this technology will allow surgeons to track their results and compare them with those of their colleagues (for example, the use of a 2.2-mm versus a 2.3-mm incision).

The LenSx laser's applanation beam is curved, and patients can see through it to the fixation target. Once I have programmed all the surgical specifications, I depress the pedal and allow the laser to make the primary incision, secondary cut, capsulotomy, and arcuate incisions to counter astigmatism, and then to phacofragment the nucleus. I watch the progress in real time via the OCT imaging software (Figure 1). My patients have reported that the LenSx procedure is comfortable. Once it is finished, I simply disengage the docking ring from the patient's eye, and my technician and I wheel his or her gurney into the OR for the cataract extraction and IOL implantation. Even the surgical planning aspect of this technology is customizable, however. For example, Zoltan Nagy, MD, of Semmelweiss University in Budapest, Hungary, allows several hours between applying the femtosecond laser procedure and completing the surgery.

SURGICAL PEARLS FOR THE OR

Based on my clinical experience with the LenSx laser thus far, I have developed a few surgical strategies for completing the case in the OR. First, I have found that there is no need to re-cut the main or the stab incisions; I simply verify they are open by using a blunt instrument. I use a cystotome or forceps to confirm that the capsulotomy is free. Next, I hydrodissect under the edge of the capsule to detach the nucleus. For nuclear extraction, I use OZil IP Torsional Ultrasound on the INFINITI Vision System (Alcon Laboratories, Inc.). I am impressed with this system's capacity for adjusting amplitude and flow rates in response to the densities of nuclei. Once I have removed the nucleus, the epinucleus is typically disengaged from the cortex via the LenSx laser's gas hydrodissection, and it is easy to emulsify. Likewise, the cortex has a well-defined edge and aspirates easily, often in one piece.

Figure 1. The LenSx laser's imaging system shows a 360º view of the capsule and the placement of the cataract incisions.

CONCLUSIONS

Patients and physicians alike always seek out better technology. I am excited about the potential of laser refractive cataract surgery and how it will continue to improve with the input and experience of more and more surgeons. With a larger user base, we will be able to confer with one another and compare our results for continual refinement.

By automating certain surgical steps, we gain the advantages of precision and reproducibility. Rather than measuring, positioning, and creating the incisions and capsulorhexis, we are now merely identifying and monitoring these steps. In my opinion, laser refractive cataract surgery is an amazing technology, and it is just getting started. ●

Stephen G. Slade, MD, practices at Slade and Baker Vision in Houston. He is the medical director for LenSx Lasers Inc. and chief medical editor of Cataract & Refractive Surgery Today. *Dr. Slade may be reached at (713) 626-5544; sgs@visiontexas.com.*

LSX11500JS-B