

What does the data say? Safety, efficacy, and clinical outcomes of laser-assisted cataract surgery

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Laser-assisted cataract surgery at 30,000 feet: Examining clinical aspects as seen in the literature

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by Eric Donnenfeld, MD



Practice pearl: Femtosecond laser-assisted cataract surgery has shown tremendous improvement since it became clinically available 5 years ago. The improvements in lens softening, capsulotomies, arcuate incisions, and primary cataract incisions offer all ophthalmologists the opportunity to become refractive cataract surgeons and increase the safety and precision of cataract surgery for our patients.

—Eric Donnenfeld, MD

The femtosecond laser increases precision and accuracy during cataract surgery

Laser-assisted cataract surgery (LACS) has 3 goals—to improve refractive outcomes, improve the safety of surgery, and increase patient comfort and satisfaction.

This is achieved by creating more precise and accurate capsulotomies, cataract incisions, and relaxing incisions and by disrupting and removing the lens more efficiently.

A closer look

A variety of studies have shown that laser capsulotomies are more round, more accurate, and more precise (Figure 1).¹ This may play a significant role in improving the effective lens position, although

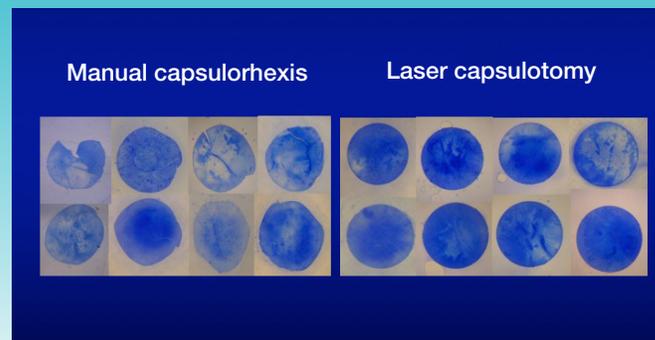


Figure 1. Manual versus femtosecond capsulotomies

investigators continue to study this.²

Research has clearly shown that lens fragmentation with the femtosecond laser offers an improved ability to soften the lens with dramatically less energy.³ Researchers showed that the smaller phacoemulsification pattern decreased the phacoemulsification

time and power compared with the larger pattern.⁴

Reduced energy translates into less endothelial cell damage, and a reduction in phaco time means less corneal trauma, reduced risk of posterior capsular tears, the ability to use irrigation

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Ophthalmologists who participate in this activity will be able to:

- Discuss the quantity and quality of the most recent (6–12 months) available literature and studies demonstrating: safety and efficacy of LACS compared to conventional cataract surgery

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Fragmentation and capsulorhexis creation: Perspectives from a teaching institution

by Sumit "Sam" Garg, MD



Practice pearl: Femtosecond laser cataract surgery provides many advantages in comparison with traditional phacoemulsification surgery. Perfectly centered capsulotomies and lens softening for dense nuclei are particularly helpful. Additionally, in complex cases, LACS can decrease some of the complexity, potentially improving outcomes.

—Sumit "Sam" Garg, MD

Femtosecond laser-assisted surgery offers advantages in routine and complex cases

Ongoing research continues to show that femtosecond laser-assisted cataract surgery (LACS) offers advantages compared with traditional cataract surgery.

Recent research

Recent research has demonstrated benefits of LACS. A study by Hatch et al. compared the effective phacoemulsification time (EPT) with femtosecond laser-assisted cataract surgery (LACS) versus standard phacoemulsification.¹

“In our teaching institution, I discourage residents from performing LACS until they are comfortable with manual surgery.”

—Sumit "Sam" Garg, MD

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and aspiration alone, and faster visual recovery.^{5,6}

The femtosecond laser offers improved wound architecture. Surgeons can create reverse side cuts, 3D incisions that allow us to create shorter incisions, making it easy to aspirate the subincisional cortex.⁷ These incisions are also more self-sealing.

Complex cases

There is a lot of information on the femtosecond laser improving the ability to treat traumatic cases and soften the lens, which makes it easier to remove it. It also is useful in patients with Fuchs' dystrophy because it causes less trauma to the corneal endothelium, enabling the surgeon to preserve the residual endothelial cells as much as possible.⁸ Research also has shown in patients with poor zonular support, such as those with pseudoexfoliation, the femtosecond laser is kinder to the zonules and less traumatic.⁹

The most significant advantage I have seen with the femtosecond laser is in treating a hypermature lens. The capsule is prone to tear and create an Argentinian flag sign. Because we can rapidly create the capsulotomy, it improves capsule viability without resulting in radial tears extending to the periphery.¹⁰

Conclusion

The outlook for LACS is bright. Almost all presbyopic IOLs in development will require perfect capsulotomy sizes.

In the future, cataract surgery will depend on fluidics rather than ultrasound energy. Therefore, less energy will be delivered into the eye.

In addition, the femtosecond laser will be very helpful in complex cases. New developments, such as the ability to identify the steep axis and place incisions automatically, will make it easier for refractive surgeons to reduce refractive errors. In addition, increased accuracy is encouraging

Two hundred forty eyes were separated into 4 groups based on the Lens Opacities Classification System III (LOCS III) with either standard cataract surgery or LACS. Patients were grouped according to nuclear

opalescence (NO) grade. Groups 1 and 2 treated NO3 with standard cataract surgery and LACS, respectively. Groups 3 and 4 treated NO5 (brunescant cataract) with standard cataract surgery and LACS, respectively. Significantly

many surgeons who were reticent to use the femtosecond laser to enter the LACS arena. The goal of LACS is to make all ophthalmologists better surgeons.

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Figure 1. Intraoperative photo demonstrating a laser capsulorhexis and pre-softened dense nucleus

less EPT was used in eyes in the LACS group compared with the standard phacoemulsification group. Additionally, the authors showed that brunescant (NOS) cataracts treated with LACS had similar amounts of EPT as NO3 cataracts treated with standard cataract surgery.

These findings are favorable because when we treat dense cataracts with a femtosecond laser, reduced phacoemulsification energy and EPT generally result in less corneal edema, so we expect less endothelial cell damage and a faster visual recovery, essentially “leveling the playing field.”

A meta-analysis by Chen et al. compared LACS and standard phaco surgery outcomes in 9 randomized controlled trials and 15 cohort studies (total of 4,903 eyes).² The analysis revealed endothelial cell loss was significantly less in the LACS group 1 week, approximately 1 month, and 3 months after surgery versus the standard group. Central corneal thickness was significantly lower in the LACS group 1 day, approximately 1 month, and 3 to 6 months after surgery. Corrected distance visual acuity 1 week after surgery was significantly better in the LACS group, and the uncorrected distance visual acuity during the final examination appeared significantly better in the

LACS group. LACS cases showed significantly less EPT, mean absolute error, and phacoemulsification power and better capsulorhexis circularity.

The meta-analysis reported data from a variety of publications, finding a statistical benefit to LACS in several endpoints. However, there was no benefit in CDVA (after the first week) and no significant difference in surgically induced astigmatism. Some surgeons prefer conventional phacoemulsification surgery (CPS) over LACS and think they can provide good patient outcomes without laser assistance. Financial concerns should be considered when contemplating the adoption of LACS.

LACS surgical benefits

LACS creates a capsulorhexis that is completely repeatable in easy and difficult cases, and it is 100% circular (Figure 1). Also, we can place it exactly where we would like it (centered on the limbus, lens equator, visual axis, or other), and that is generally free-floating, unless the capsule is fibrotic.

As a result, LACS reduces concerns of new surgeons. However, LACS is not a substitute for traditional phacoemulsification. In our teaching institution, I discourage residents from



Figure 2. Catalys Laser System lens fragmentation

performing LACS until they are comfortable with manual surgery. We expose residents to LACS, but their comfort zone needs to be manual cataract surgery.

LACS is particularly helpful when creating a capsulorhexis in difficult cases. If the lens is decentered because of zonulopathy, we can center the capsulorhexis on the bag and ensure the capsulorhexis is centered. Additionally, there is less stress on the zonules, lowering the chance of dehiscence.

In eyes with a shallow anterior chamber, it is helpful to perform the capsulorhexis with the femtosecond laser because of space considerations. With white cataracts, we do not need a red reflex to create the capsulorhexis with the femtosecond laser. However, I recommend using trypan blue to be sure the capsulorhexis is complete (no residual tags) before removing it.

LACS also provides fragmentation benefits (Figure 2). When splitting moderate to dense nuclei, I think fragmentation with LACS improves EPT and results in less edema on postoperative day 1, for a faster visual recovery. It is also useful in eyes with Fuchs' dystrophy, where we need to minimize phacoemulsification energy to minimize endothelial cell trauma.

LACS is not appropriate for eyes with very small pupils or patients with tremors or other conditions who cannot be placed under the laser. It also may not be suited for eyes with a very fibrotic capsule or nystagmus.

Conclusion

The femtosecond laser provides numerous benefits in creating a capsulorhexis and performing fragmentation in cataract surgery. However, surgeons who are starting out should be well versed in phacoemulsification and each step involved before jumping into LACS. They need to be able to fall back on the basics if problems arise.

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Arcuate incisions: Using laser-assisted cataract surgery to improve refractive outcomes and reduce complications

by Robert Weinstock, MD



Robert Weinstock, MD

Research demonstrates the advantages of using the femtosecond laser in treating astigmatism

Researchers continue to study the safety and efficacy of laser-assisted cataract surgery (LACS) in creating arcuate incisions to correct astigmatism.

Ongoing research

In a retrospective chart review of patients who had cataracts with corneal astigmatism, Yoo et al. reported that astigmatic keratotomy performed with the femtosecond laser is precise, customizable, adjustable, and safe in reducing refractive errors in patients with residual astigmatism after cataract surgery.¹

- High amount of accuracy
- Many barriers no longer relevant:
 - Reproducibility
 - Precision
 - Overall learning curve
 - Safety and efficacy
- Body of literature growing to support outcomes to treat low amounts of astigmatism

Figure 1. Femtosecond laser arcuate incisions

Another study by Chan et al. demonstrated that femtosecond laser arcuate keratotomy combined with cataract surgery is an easy and safe means to manage a low to moderate amount of corneal astigmatism.²

Day et al. showed that corneal biomechanical parameters and astigmatism meridians predicted the efficacy of intrastromal astigmatic keratotomy created with the femtosecond laser.³

Experience from surgeons and a growing body of literature are validating that the femtosecond laser is a useful and safe technology to manage astigmatism, particularly in patients with regular low to moderate astigmatism (less than 1.25 D is ideal). Most patients who we see for cataract surgery have low to moderate amounts of astigmatism, so they fit the ideal profile for the femtosecond laser.

Optimizing astigmatic incisions

Results from the 2015 ASCRS Clinical Survey showed that surgeons still prefer manual methods compared with the femtosecond laser when performing limbal relaxing incisions (LRIs) or astigmatic keratotomy.

In my experience, however, I consider the femtosecond laser far superior in performing

“Surgeons should feel confident using the femtosecond laser to correct low to moderate amounts of astigmatism.”

—Robert Weinstock, MD

an arcuate incision compared with a diamond blade. When we objectively examine the data and technology, femtosecond laser arcuate incisions are more precise and controlled.

The femtosecond laser offers surgeons who perform peripheral corneal relaxing incisions a more precise and accurate technology (Figure 1).

Surgeons who have not used the femtosecond laser previously should choose a nomogram, continue using it, and track their data and results. Based on those outcomes, they should modify the nomogram. Surgeons can determine whether it is better for them to open the laser-created LRI during surgery and titrate it using intraoperative aberrometry, open it in all cases, or refract patients after surgery and open incisions later if needed.

Astigmatism treatment may not be wise if the patient has variable amounts of astigmatism or it is difficult to identify the true axis during preoperative testing. In such cases, we sometimes use average keratometric values to select a non-toric IOL. After the patient has healed, we can perform serial refractions and topography. If readings are stable, we may be able to use the femtosecond laser to perform LRIs.

If the patient has a spherical equivalent close to zero and less than 1.0 D of residual astigmatism and we can obtain consistent measurements, we can use the femtosecond laser to perform LRIs with the patient in the pseudophakic state.

Conclusion

Surgeons should feel confident using the femtosecond laser to correct low to moderate amounts of astigmatism. This technology is a necessary part of their armamentarium if their goal is to achieve uncorrected visual acuity of 20/20 in more of their patients.

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Examining routine and complex cataract cases: Determining factors of an LACS candidate

by William Trattler, MD



William Trattler, MD

Laser-assisted cataract surgery offers practical advantages in most patients

In my experience, laser-assisted cataract surgery (LACS) is a valuable tool in a variety of patients, whether they are receiving multifocal intraocular lenses (IOLs), toric IOLs, or monofocal IOLs.

Its advantages also extend to more complicated cases, such as pseudoexfoliation or very dense cataracts.¹

LACS: Patient selection pearls

One of the best features of LACS is its ability to create a centered, more precise capsulotomy² (Figure 1). My laser system provides a 3D image of the capsular bag, determines the center of the cataract to centrally place the capsulotomy, and creates a perfect circle. This helps when I am implanting a multifocal or toric IOL, as I want to ensure that the IOL is centered and the anterior capsule leaflets overlap the IOL.

LACS is also helpful in patients with loose zonules in pseudoexfoliation because the capsulotomy is performed

without exerting stress. The femtosecond laser helps reduce transferred energy into the eye during phacoemulsification, thus less zonular stress.^{3,4}

Some surgeons use manual techniques in certain situations, such as posterior capsular cataract (PSC) or a PSC that is very soft. They may take this approach if the case appears very easy and the patient has chosen a monofocal IOL, where a perfectly centered capsulotomy may not be as critical.

Patients with very small pupils may not be eligible for treatment with the femtosecond laser because the technology cannot image the anterior capsule through the iris. Therefore, in eyes with very small pupils and thus a smaller lens surface, the laser may not be able to perform the capsulotomy or soften the lens.⁵

Nuclear fragmentation

Nuclear fragmentation with LACS enables surgeons to choose a fragmentation pattern for the nucleus.⁶ As we sculpt into the nucleus, we can see where the laser treated, and it provides a road map guiding us on where to stop sculpting. We can determine when we are very close to the end of the nucleus (and approaching the posterior capsule) based on the pattern. After sculpting through the nucleus, we can easily crack the lens, which makes it much easier to manage dense lenses.

With exceptionally dense lenses, the imaging technology may not be able to image the posterior capsule and the laser may only be able to perform the anterior capsulotomy and soften the front part of the lens. However, a centered capsulotomy makes it easier to perform surgery, particularly with a dense lens.

“LACS is also helpful in patients with loose zonules in pseudoexfoliation because the capsulotomy is performed without exerting stress.”

—William Trattler, MD

LACS: My pearls for success

During LACS, we first make sure the pupils are dilated so we can ensure clear imaging after the cataract. Although the laser has a tracker, the procedure is easier if the patient remains still during the procedure.

When the laser procedure is completed, we place the patient under the operating microscope. After I create the paracentesis, I inject a little preservative-free anesthetic and place viscoelastic on top of the capsule so there is no shallowing of the anterior chamber. I keep the chamber deep the entire time. If an area of the capsulotomy is incomplete and the chamber shallows, there is a risk that the nucleus pushes forward, which can tear the capsule.

One innovation with femto cataract surgery is the main incision, which can be created to be self-sealing. The femtosecond laser system that I use creates a reverse-angle incision, which is more like a tongue-and-groove incision and results in a more self-sealing incision than that typically created with a metal blade.

After I open the incision, I ensure that the capsulotomy is free all of the way around, using a circular motion. Hydrodissection is a critical step. We first need to be sure the capsular bag is not overfilled with viscoelastic, so at times we may press on the lip of the incision and release excess viscoelastic. Once the eye is not too firm, we can gently perform the hydrodissection.

LACS candidates

In my opinion, almost all patients can benefit from LACS technology. It creates a perfectly centered capsulotomy, and I can make an effective, self-sealing incision. Aforementioned studies and my experiences have shown that patients with dense cataracts may particularly benefit from LACS. It is important to point out that performing femto cataract surgery is a bit different than manual cataract surgery, so there is a bit of a learning curve with benefits and risks associated. However, with experience, I think that many surgeons will appreciate how laser cataract surgery can make the

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Embracing evolving refractive enhancements: Safety, efficacy, and future opportunities

by Kerry Solomon, MD



Kerry Solomon, MD

To achieve the outcomes that patients expect, surgeons need to develop customized plans and precise enhancement strategies

Despite their efforts, refractive cataract surgeons achieve outcomes within 0.5 D of their intended refractive target only approximately 71% of the time.¹

To deliver the visual outcomes patients expect, ophthalmologists who are expanding their services to include refractive cataract surgery need to master enhancement techniques or refer enhancements to a colleague. Precise enhancements are a vital part of this process.

Evaluating residual refractive error

If a patient is dissatisfied with his or her outcome, our first task is to determine the cause of the residual error. If a toric intraocular lens (IOL) rotated, we need to reposition it. If rotating it does not correct the problem, I may insert a capsular tension ring, which usually holds the toric IOL in place, or I optic-capture it to hold it in position.

To correct residual spherical or cylindrical error, I usually perform LASIK, creating a 100–110 μm flap with a femtosecond laser

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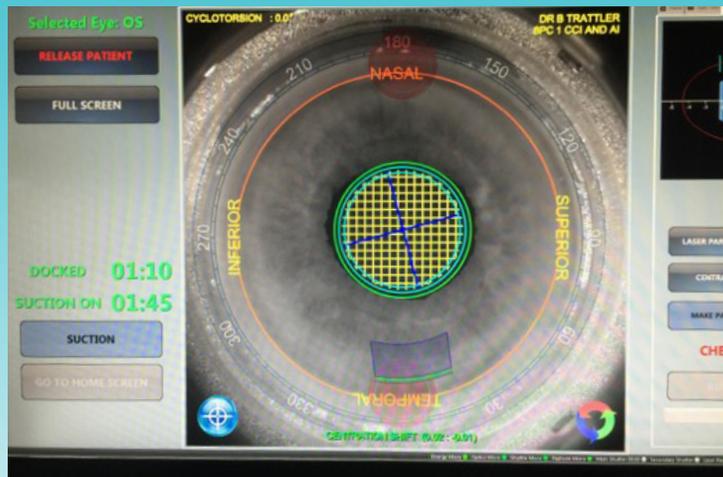


Figure 1. This image shows the planned laser pattern on an eye with a small pupil. It was captured after imaging of the eye was completed on a femtosecond laser. The central part of the pattern (yellow) is the planned fragmentation pattern of the nucleus. The green curved line toward the limbus is the location for the main incision. The capsulotomy is designated by the inner green circle, which is just outside the yellow region.

cataract surgery easier, especially in cases where the pupil is on the small side or when the lens is quite dense.

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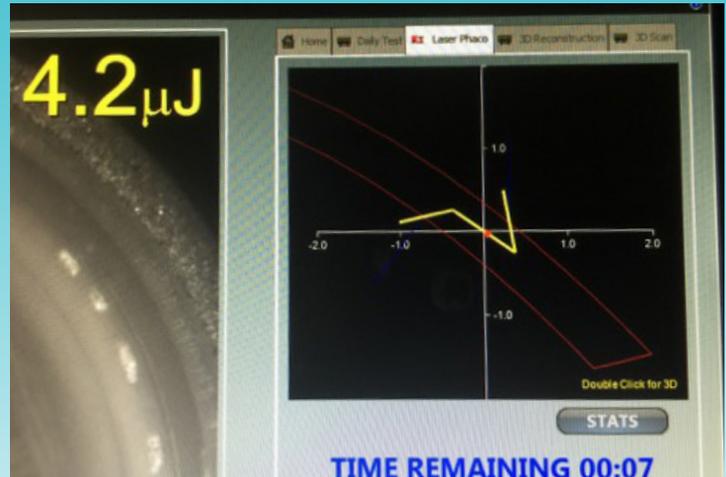


Figure 2. The femtosecond main incision can be custom-designed. In this case, the main incision has been designed with a reverse-angle exit from the cornea. This provides improved sealing at the end of the procedure.

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and treating the residual error with an excimer laser.

A recent review of the literature by Alio et al. reported that LASIK provides the most accurate means of enhancement after cataract surgery, and lens procedures had less predictable outcomes.² Fernández-Buenaga et al. compared IOL exchange, implantation of a piggyback lens, and LASIK to address residual error after cataract surgery, reporting that LASIK had the greatest predictability and efficacy (Figure 1).³

Before performing laser vision correction, however, we identify dry eye and optimize the ocular surface.

If patients have basement membrane dystrophy or had previous LASIK, I usually perform surface ablation. I think it is safer in those cases, and it may treat dystrophy. In patients with previous LASIK, it avoids epithelial ingrowth. Because we usually perform 1.0 D or 2.0 D enhancements, patients do very well with surface ablation.

If multifocal IOL recipients are dissatisfied or an axis was flipped with a toric IOL, I perform an IOL exchange.

Effective lens position

Surgeons need to be comfortable with all of these modalities because visual outcomes from cataract surgery are not as accurate as those from LASIK. One of the main barriers to achieving outcomes within 0.5 D or better in 95% of cases is that we have not been able to accurately identify the effective lens position (ELP). If we can predict the ELP, plan surgery, and achieve that consistently, I think we will deliver next generation outcomes.

Research by Packer et al. showed that the ELP was more consistent when the capsulotomy was centered on the approximate optical axis of the lens, with a diameter of 5.25 mm.⁴

Among surgeons who are skilled in capsulotomy and capsulorhexis techniques, the difference between laser-assisted cataract surgery and manual outcomes in achieving ELP probably will be negligible. However, the laser may offer advantages for those less comfortable creating capsulotomies.

We will need additional technology to predict the ELP of an IOL. Real-time optical coherence tomography, ray tracing, and modern IOL formulas may offer advantages.

“If we can predict the ELP, plan surgery, and achieve that consistently, I think we will deliver next generation outcomes.”

—Kerry Solomon, MD

Conclusion

To optimize outcomes from refractive cataract surgery, surgeons need to systematically plan their surgeries, customize procedures, and minimize residual astigmatism. They also need to optimize their surgeon factors for each IOL they use.

In addition, by developing high-quality enhancement techniques, in most cases they will be able to deliver the excellent refractive outcomes patients seek.

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| IOL exchange | | Piggyback lens | | LASIK | |
|-----------------------|----------------|-----------------------|----------------|-----------------------|----------------|
| Median efficacy index | Predictability | Median efficacy index | Predictability | Median efficacy index | Predictability |
| 0.58 | 62.50% | 0.75 | 85% | 0.91 | 100% |

Figure 1. Efficacy and predictability of procedures used to correct residual refractive error after cataract surgery³

What does the data say? Safety, efficacy, and clinical outcomes of laser-assisted cataract surgery

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CME questions (circle the correct answer)

1. According to Dr. Trattler, in patients with _____ surgeons may prefer to use manual cataract surgery rather than LACS.
 - a. Dense cataracts
 - b. Pseudoexfoliation
 - c. Multifocal IOLs
 - d. Very soft posterior capsular cataracts

2. In a meta-analysis by Chen et al., discussed by Dr. Garg, patients who had LACS had _____ after surgery compared with those treated with standard surgery.
 - a. Significantly less endothelial cell loss
 - b. Greater corneal thickness
 - c. Greater effective phacoemulsification time
 - d. Greater mean absolute error

3. According to Dr. Donnenfeld, the femtosecond laser enables surgeons to create reverse side cuts, which _____.
 - a. Allow surgeons to create longer incisions
 - b. Are more self-sealing
 - c. Require more ultrasound energy
 - d. Reduce endothelial cell loss

4. According to Dr. Weinstock, a growing body of literature is validating that the femtosecond laser is ideal to manage astigmatism in patients _____.
 - a. With less than 1.25 D of astigmatism
 - b. With small pupils
 - c. With more than 2.25 D of astigmatism
 - d. With more than 3.25 D of astigmatism

5. According to Dr. Solomon, if patients are dissatisfied with their outcomes after cataract surgery, the first task is to:
 - a. Implant a piggyback lens
 - b. Reposition the IOL
 - c. Determine the cause of the residual error
 - d. Perform LASIK

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