

Lens Softening With a Femtosecond Laser

This procedure is one of the newest methods being investigated for presbyopia correction.

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A method of surgical correction of presbyopia that completely eliminates the need for spectacles and contact lenses is a significant goal for many cataract and refractive surgeons. Such a procedure would also benefit millions of people worldwide who experience accommodative loss as a result of aging. Although numerous techniques are available, each has limitations and involves some degree of compromise in distance or near visual acuity.

Presbyopia correction methods in use today can be grouped into two approaches: accommodative (ie, accommodating IOLs¹ and scleral expansion techniques²) and pseudoaccommodative (ie, multifocal IOLs,³ corneal inlays,⁴ excimer laser-based multifocal ablations,⁵ and intrastromal femtosecond laser procedures⁶). Another approach, softening the hardened crystalline lens, has been attempted with pharmaceutical agents; however, to the best of our knowledge, no data on these attempts have been published.

LASER LENS SOFTENING

Recently, the femtosecond laser has been proposed as a method to restore accommodation through lens softening. During treatment, the laser is used to make precise incision patterns within the crystalline lens in order to restore the flexibility that has been lost with age. These incisions create physical sliding planes and soften the lens without opening the capsule. The use of targeted lenticular photodisruption may permit translation of forces exerted by the zonular fibers, resulting in changes in lens shape during accommodation.

One main concern with applying laser photodisruption to the crystalline lens is that it may induce cataract progression. However, avoiding treatment in the subcapsular region—where disruption of cellular activity could result in opacification—and restricting laser pulse placement to the fibrous mass of the crystalline lens may prevent this collateral damage.

Preclinical studies with the Lensar Laser System (Lensar) were conducted in animal and human cadaver eyes to

determine the accommodative potential of laser lens softening.⁷⁻¹⁰ In these studies, the crystalline lens was placed on a rotating pedestal to simulate the pulling force of the zonules, a technique known as the spinning test.¹¹ The reduction of lens thickness with rotation (ie, polar strain) defined the deformability of the lens; in all cases, the effect was age-dependent.

The mean change in the human cadaver lens group, 5.80 ±2.80 D standard deviation (SD), suggests that the laser softening treatment works. Furthermore, these studies suggested that the procedure is safe and would not induce cataract formation.

FEASIBILITY STUDY

A feasibility study of the lens-softening procedure in 80 eyes of 80 patients less than 55 years of age with mild cataract (LOCS III grade 1 or 2) and distance BCVA of 20/40 or better was then conducted in 2010 at the Asian Eye Institute in Makati City, Philippines. The patients enrolled, who had previously elected to have cataract surgery, agreed to a minimum of 1-month follow-up of the lens-softening procedure before proceeding with lens removal and IOL implantation.

At 1 week after the laser procedure, 33.3% of patients showed improvement in objective accommodation (as measured with the WR-5100K Autorefractor; Grand Seiko)

TAKE-HOME MESSAGE

- During lens softening treatment, a femtosecond laser is used to make precise incision patterns within the crystalline lens in order to restore the flexibility that has been lost with age.
- Avoiding treatment in the subcapsular region by restricting laser pulse placement to the fibrous mass of the crystalline lens may prevent the collateral damage created by the photodisruption process.
- Results of a feasibility study performed in 2010 and a follow-up clinical trial in 2013 seem promising, and there was no sign of significant cataract progression at 5 years postoperative in one patient enrolled in the clinical trial.

and 53% showed improvement in subjective accommodation (using the push-down method).

Best distance-corrected near visual acuity (BDCNVA) improved in 37.3% of patients in the first week and in 40.8% by 1 month. In patients who experienced an increase in objective and subjective accommodation over baseline, the maximum improvements at 1 month were 1.50 and 2.30 D, respectively. Also in this group at 1 month, the mean improvement in distance BDCNVA was 31 letters logMAR.

In one patient enrolled in the feasibility study who chose not to proceed with IOL implantation following the lens-softening treatment, there was no sign of significant cataract progression at 5 years postoperative. The experience of this patient demonstrates the concept mentioned above, that the lens-softening treatment does not cause progression of cataract.

NEXT STEPS

The feasibility study just described was performed using a prototype system that had some limitations affecting the final results (eg, long pulse width, high pulse energy, limited lens diagnostic capabilities, and high capsular clearance). In November 2013, a new clinical trial with the commercially available Lensar laser was initiated at two clinical sites (Midland Eye in Solihull, United Kingdom, and Pacific Eye and Laser Institute in Makati City, Philippines). This laser has several advantages compared with the prototype, including short pulse width; reduced pulse energy, thereby limiting the collateral effects in the crystalline lens; and sophisticated capability for lens and anterior segment biometry that enables low capsular clearance.

Enrolled patients have elected to undergo early cataract or lens extraction surgery, with the cataract not exceeding LOCS II grade 1 or LOCS III nuclear grade 1.4. All patients are between the ages of 40 and 65 and have BCVAs of 20/40 or better in the eye to be treated and no signs of amblyopia.

Despite the broad inclusion criteria of this cohort, early results in 29 patients with 1-month follow-up are promising. The percentage of eyes with BDCNVAs of 20/40 or better improved from 7.7% at baseline to 38.5% at 1 month in the nonemmetropic group and from 0% to 100% in the emmetropic group. Additionally, the mean monocular preferred viewing distance at near changed from 50.3 to 46.3 cm (mean reduction, 3.92 cm) in the nonemmetropic group and from 45.8 to 37.2 cm (mean reduction, 8.66 cm) in the emmetropic group.

A typical case from the study is that of a 50-year-old man who underwent laser lens softening in his left eye. At 1 month postoperative, he experienced significant improvement from baseline in median values for near UCVA (from 12 to 27 letters logMAR) and for BDCNVA (from 53 to 58 letters logMAR).

CONCLUSION

Presbyopia correction is the holy grail in refractive surgery. Developments in lens-based technologies have improved dramatically over the past decade, allowing us to investigate this lens-softening treatment.

Early results with lens softening using the Lensar Laser System seem promising, although further research and longer follow-up are necessary. In the next few years, we will inevitably witness the introduction of many technologies that can help us to provide our patients with better visual outcomes and, possibly, to restore true accommodation in the presbyopic eye. ■

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