BEYOND SPLITTING LIGHT

Why accommodating IOLs are the next step in presbyopia correction.

BY GARY WÖRTZ, MD

Over the past 20 years, presbyopia correction in cataract surgery has evolved dramatically. Diffractive trifocal and extended depth of focus (EDOF) IOLs are real engineering achievements, and, in the right patients, they can deliver meaningful spectacle independence and satisfaction. Many surgeons, including me, implant these lenses routinely and see the upside every week.

Even so, it has become increasingly clear that optics alone—no matter how refined—cannot fully re-create the visual experience of the youthful eye. Our specialty may be approaching diminishing returns with incremental iterations of light-splitting technology. This is not a criticism of trifocal or EDOF IOLs but an acknowledgment of the physical constraints that govern diffractive designs.

The next leap in presbyopia correction is unlikely to come from further redistributing light. It is more likely to involve restoring function—specifically, the ability to change focus dynamically. That recognition has renewed interest in accommodating IOLs and other technologies intended to preserve, restore, or reengage the biomechanical systems that make accommodation possible.

WHY LIGHT-SPLITTING PLATEAUS

Diffractive trifocal IOLs expanded the possibilities of refractive cataract surgery by allocating light to multiple focal points. EDOF designs refined the concept by extending the focal plane and, in many cases, improving contrast sensitivity relative to earlier multifocal optics.

When patient selection is thoughtful and expectations are managed carefully, both types of lenses can perform extremely well. The trade-off is inherent: dividing light reduces optical efficiency. Dysphotopsias, reduced contrast sensitivity under mesopic conditions, and night vision complaints are not design flaws but predictable consequences of splitting a finite amount of light.

Clinically, the question is not whether multifocal and EDOF IOLs work. They do. Rather, the question is whether the range of vision they offer can be further increased without adding trade-offs. For patients who place a premium on visual quality across a wide range of lighting conditions, it is reasonable to look beyond optical division alone.

WHAT WE ARE REALLY TRYING TO RESTORE

In a phakic eye, accommodation is achieved through a continuous biomechanical process rather than through splitting light. The crystalline lens changes shape in response to coordinated forces involving the ciliary body, zonules, lens capsule, and lens substance.

Understanding Natural Accommodation

The Helmholtz theory remains highly relevant. With ciliary muscle contraction, zonular tension decreases, and the elastic lens capsule helps the lens assume a more convex configuration for near. With relaxation, zonular tension increases, flattening the lens for distance. This is a system of counterbalancing forces, and the capsule functions as an active elastic element—not merely a passive container.

Presbyopia develops not because the ciliary muscle stops working but because the lens and capsule lose the ability to respond to these forces. Numerous studies have suggested that human ciliary muscle contractility persists well into later decades of life. The limitation is primarily mechanical, not neuromuscular.[1]

Why Standard Cataract Surgery Breaks the System

Standard cataract surgery disrupts the system on multiple levels. An anterior capsulotomy compromises capsular continuity, removal of the crystalline lens eliminates the deformable optical element, and postoperative fibrosis reduces biomechanical responsiveness. Structurally, most pseudophakic eyes are ill-suited for true accommodation, even if ciliary muscle function is preserved. To restore accommodation, either the crystalline lens must be replaced with a device that can respond to biomechanical forces, or the capsular environment must be preserved or reengineered to support that response.

PRESERVE THE CAPSULE, PRESERVE THE OPTION

If the goal is to restore accommodation through the eye's native pathway—force transduction from the ciliary body through the zonules to the lens capsule—then preserving capsular elasticity and structural integrity is essential.

Based on my experience developing the Gemini Capsule (Omega Ophthalmics), maintaining an open, volume-stable capsular environment appears to be foundational to capsular bag–based accommodative strategies. The human lens capsule is the thickest basement membrane in the body and serves as a reservoir for numerous cytokines. Once the capsule collapses, epithelial–mesenchymal transformation begins. Lens epithelial cells interact with inflammatory mediators such as transforming growth factor beta, resulting in fibrotic, contractile tissue that compromises capsular elasticity and biomechanical responsiveness.

Capsular preservation technologies, such as the Gemini Refractive Capsule, are designed to maintain capsular volume, prevent collapse, and preserve long-term access to the capsular space. The value here is not limited to reducing posterior capsular opacification, although that benefit may be substantial. The larger goal is to maintain a structure capable of transmitting physiologic forces and supporting future optical or accommodative solutions.

In that sense, capsule-preserving platforms may complement accommodating IOLs by improving their long-term performance and enabling modular upgrades as the technology evolves. Alternatively, the platforms may allow surgeons and patients to defer definitive presbyopia correction while preserving future optionality.

TWO PATHWAYS TO DYNAMIC FOCUS

Current accommodating IOL development generally falls into two categories: capsular bag–based systems and sulcus-based systems. Both approaches aim to harness ciliary muscle activity, but they rely on different anatomic pathways to translate that activity into a change in optical power.

Bag-Based: Stabilize, Then Change Power

Capsular bag–based accommodating IOLs aim to preserve capsular geometry and convert equatorial compression into a change in optical power. Platforms such as Juvene (LensGen), OmniVu (Atia Vision), and JelliSee (JelliSee) exemplify this approach.

Several systems use fluid-based or shape-changing optics within a stabilized capsular framework. Early clinical data suggest these systems can provide patients with smooth defocus curves, meaningful intermediate and near visual acuity, excellent refractive accuracy, and contrast sensitivity comparable to that achieved with monofocal IOLs.[2-5] Many designs also appear to have low rates of posterior capsular opacification,[3,6] likely because the capsular bag remains filled and supported instead of collapsing around a single optic.

From a surgical standpoint, these lenses may integrate well into standard cataract workflows, but they typically require precise capsulorhexis sizing and intact zonular support. The technology's long-term performance depends on sustained capsular elasticity and effective control of fibrosis.

Sulcus-Based: Bypass the Bag

Sulcus-based accommodating IOLs take a different approach: they bypass the capsular bag and engage the ciliary body more directly. The Lumina (AkkoLens) and Opira (ForSight Vision6) lenses are leading examples.

These systems convert circumferential ciliary compression into optic translation or controlled shape change. Randomized and early clinical studies have suggested that these IOLs improved patients' uncorrected intermediate and near visual acuity compared to monofocal controls while maintaining contrast sensitivity similar to that of a monofocal lens.[7,8] Because sulcus-based accommodating IOLs do not depend on capsular integrity, they may be less affected by capsular collapse and fibrosis and may be useful in eyes with compromised capsules.

Meticulous custom sizing of the Lumina and precise capsulorhexis sizing for the Opira are critical to minimize uveal irritation, but early safety data have been encouraging.[9-11]

EVALUATING ACCOMMODATING IOLS IN CLINICAL PRACTICE

As accommodating IOLs move closer to broader adoption, evaluation of these IOLs should go beyond patients' Snellen visual acuity. Key metrics include the following:

- Defocus curves to define functional range of vision;
- Objective and subjective accommodation measurements;
- Contrast sensitivity, particularly under mesopic conditions;
- Patient-reported outcomes, including visual comfort and dysphotopsias;
- Long-term stability, both optical and biomechanical; and
- Biometry performance, including the ability to predict IOL power with a platform that can change power.

These technologies will also be judged against what many of us can now achieve with modern trifocal IOLs—excellent early postoperative distance, intermediate, and near vision for our patients—supported by years of refinement in biometry and a familiar implantation/explantation workflow. The bar is high, and it should be.

LOOKING AHEAD

Several milestones—the completion of large regulatory trials, publication of longer-term outcomes, and successful integration with capsule-preserving platforms—will determine whether accommodating IOLs fulfill their promise. Meanwhile, emerging work in laser-based capsular modulation and other biomechanical interventions may expand the solution set and help address fibrosis-related limitations that have historically undermined accommodative strategies.

CONCLUSION

Presbyopia correction is entering a new phase—one that builds upon, rather than replaces, the achievements of multifocal and EDOF optics. Light-splitting IOLs have expanded patients' options and improved quality of life for many of them. At the same time, a deeper understanding of ocular biomechanics suggests that restoring dynamic focus may offer a more physiologic path forward.

Accommodating IOLs, technologies that preserve the lens capsule, and biomechanical innovations are converging rather than competing ideas. Together, they point toward a future in which cataract surgery restores not only clarity but also function. ■

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