Advances will take surgical visualization to a new level

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Richard L. Lindstrom, MD

A critical element in any successful surgical procedure is the ability to visualize the tissue being manipulated surgically. I have often said to my fellows that while steady hands are definitely an asset, ophthalmic surgery is a “visual sport,” and seeing clearly what is being operated upon is critical to a successful outcome. During my residency training, many surgeons were still using loupes for intracapsular cataract extraction while others were pioneering the use of the operating microscope. The operating microscope changed the way we see in ophthalmic surgery, and for 40 years we have benefited from ever better optics and illumination.

The access a few years back of a Zeiss Lumera was, for me, the latest amazing advance in operating microscopes, allowing me to see detail I never before observed during surgery. In addition, we now have 2-D and 3-D video projection technology that can magnify any object of interest and even provide surgical templates for guidance. Many of our surgeon colleagues in other fields have transitioned to these as preferable over direct observation, and a few ophthalmic surgeons are evaluating the benefit of this approach in ocular surgery.

There are many other structures and pathology that I would like to see during surgery that I still cannot observe with even the best operating microscope. Better visualization of the posterior surface of the iris for tumors and cysts, the so-called ciliary sulcus for phakic and pseudophakic IOL placement, the ciliary muscle and processes for glaucoma treatment, and in the future accommodating IOL sizing and the ora serrata and anterior retina for numerous pathologies would all be very helpful. We do have endoscopes, but their field of view is limited, and there is much room for improvement. Ultrasonography is another potentially useful intraoperative diagnostic that might someday be incorporated into an operating microscope or diagnostic unit. Especially interesting are the great advances in OCT as a preoperative and intraoperative diagnostic. The resolution of OCT continues to advance, and we are approaching the time when we will be able to visualize single cells as deep as 100 µm below the surface. This would be a fantastic advance for the anterior segment and posterior segment surgeon.

Increased accuracy and success in anterior and posterior lamellar corneal transplantation can be anticipated as the surgeon will be able to better visualize Descemet’s membrane in deep anterior lamellar keratoplasty and determine if there are even small pockets of residual fluid in Descemet’s stripping endothelial keratoplasty and Descemet’s membrane endothelial keratoplasty. Cataract surgery will advance as well, as demonstrated in the current application of femtosecond laser-assisted cataract surgery. Improved accuracy in vitreoretinal interface surgery and epiretinal membrane peeling, as well as retinotomy and subretinal surgery, can also be anticipated. As always, the early prototype devices will be more awkward to use and more expensive, but the amazing power of the innovation cycle catalyzed by focused application of financial and human capital can be expected to continually improve our ability to visualize every ocular structure and perhaps every ocular cell in real time during surgery.

With the addition of a dose of robotics, I can see the way we do surgery today evolving again in a disruptive fashion over the next few decades. The generation of ophthalmologists practicing before me never used operating microscopes as we know them today. I suspect the generation after me will routinely use visualization technologies and techniques that will represent an equally amazing advance similar to the loupe being replaced by the operating microscope. The microsurgery of the future will be at the cellular or even perhaps micro-organelle and gene level. How exciting is that!