The Eyesi Ophthalmic Surgical Simulator

Ophthalmologists have a new training mantra. See one. Simulate one. Do one. Teach one.

BY MICHAEL A. MAHR, MD

In recent years, the medical community has benefited from technological advances that simulate surgical environments. Ophthalmologists now have access to commercially available virtual reality systems, including the Eyesi Ophthalmic Surgical Simulator (VRMagic, Mannheim, Germany). Aided by this system, ophthalmology residents at the Mayo Clinic in Rochester, Minnesota, are learning how to perform cataract surgery.

ALTERNATIVE EDUCATIONAL TECHNIQUE

VRMagic originally developed the Eyesi system to simulate vitreoretinal surgery. Recently, however, the company added a training module for the anterior segment (Figure 1). In addition to simulating the use of forceps, precise navigational tasks, the capsulorhexis' formation, and phacoemulsification, the Eyesi's anterior segment module evaluates the user's performance and measures instructor-defined, standardized surgical tasks in a virtual environment.[1]

Approximately 1 year ago, my colleagues and I incorporated the Eyesi system into our standardized, competency-based surgical training curriculum for ophthalmology residents. The ophthalmic training system is based at the Mayo Clinic's Multidisciplinary Simulation Center (http://www.mayo.edu/simulationcenter), a 10,000-square foot clinical training facility dedicated to simulation-based clinical education and research.

Figure 1. The Eyesi Ophthalmic Surgical Simulator is shown with the interchangeable cataract head software on its adjustable platform. The device's hardware includes control pedals for phacoemulsification/vitrectomy (left) and the surgical microscope's adjustment (right). The virtual operating microscope features a stereoscopic view of the surgical field.

Gone are the days when residents first learned the basics of handling intraocular instruments and a surgical microscope in the OR or a variable wet lab environment. Instead, they now complete a structured curriculum that combines one-on-one instruction and independent study with the Eyesi simulator. Instructors create courses that residents repeat and practice until they achieve passing scores. The surgeons-in-training then advance to the Eyesi system's higher levels of difficulty until they master all of the simulator's training tasks. Residents are enthusiastic about the technology and its constant availability (24 hours a day, 7 days a week).

HOW IT WORKS

In studies, the Eyesi Ophthalmic Surgical Simulator demonstrated construct validity (the ability to reliably distinguish between novice and expert surgeons) for training tasks in the posterior and anterior segments.[2,3] Anecdotally, I have found that the device's stereoscopic view and foot-pedal controls are excellent proxies for the "real" environment of cataract surgery.

Using the anterior segment training module and the built-in forceps tool, residents learn how to manipulate instruments in the eye, pivot them at the wound, and avoid inadvertently injuring the cornea or crys-

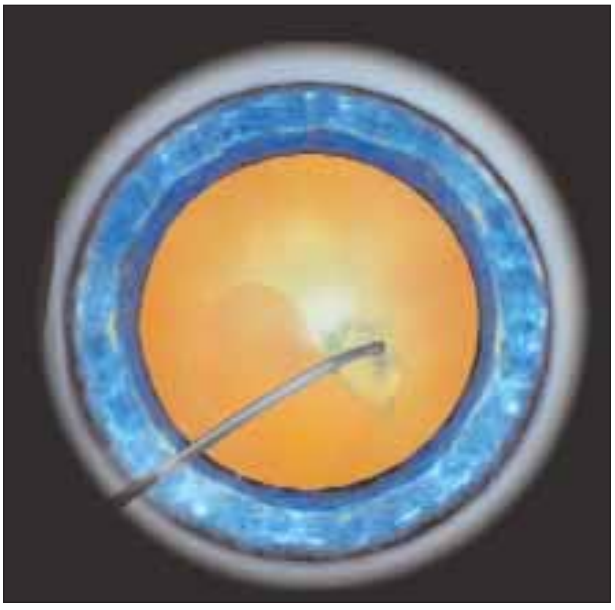

Figure 2. Students use the Eyesi Ophthalmic Surgical Simulator's capsulorhexis module to create a uniformly sized, continuous curvilinear capsulorhexis in an artificial eye. Their tools include viscoelastic, a bent needle tip (shown), and a capsulorhexis forceps.

talline lens. The simulator's scoring system rewards users for the efficiency of their intraocular manipulations and the precision with which they complete their tasks. The capsulorhexis training module (Figure 2) is actually more challenging than "the real thing," an acceptable and desirable quality for a surgical training system.

The posterior segment training modules simulate the manipulation of forceps, the precise movement of instruments in the posterior segment, antitremor training/control, and procedures such as vitrectomy, epiretinal membrane peeling, and internal limiting membrane peeling. Residents at the Mayo Clinic have reported that the Eyesi's retinal simulations "suspend reality" quite effectively. For example, my colleagues and I have watched inexperienced surgeons become so engrossed in virtually peeling an epiretinal membrane that they actually started sweating.

Thus far, VRMagic has provided regular software updates for the Eyesi system and has shown a dedication to continually developing and improving its products. I would therefore expect that the company's relatively new phaco module—the current version of which I find to be the least rigorous or realistic of the tasks available—to ultimately achieve the high caliber of simulation offered by the system's other more advanced ophthalmic training modules.

TABLE 1. SELECT VARIABLES SCORED BY THE EYESI'S ANTERIOR SEGMENT MODULES

Type	Variable
Educational	Open forceps insertion and removal
	Nonhorizontal instrument insertion and removal
	Interacting out of focus and light cone
	Average radius of capsulorhexis
	Decentration and overall irregularity of capsulorhexis
	Deviation of capsulorhexis' radius from target value
	Instrument insertions
	Remaining aqueous humor
Efficiency	Time (after first interaction)
	Ultrasonic energy
	Decentration and overall irregularity of capsulorhexis
	Deviation of capsulorhexis' radius from target value
	Viscoelastic injection
Injury	Incision stress
	Injured cornea and lens area
	Lens displacement
	Damaged zonular fibers
	Iris contact
	Anterior chamber pressure too low
	Ultrasonic leakage
	Emulsification of adjacent cortex
	Cornea and capsule damaged by ultrasonic energy
	Anterior and posterior capsule torn
Target	Remaining objects
	Progress
	Capsulorhexis completed
	Lens cracked/removed

EXPANDING SKILL SETS

Although the Eyesi Ophthalmic Surgical Simulator (VRMagic, Mannheim, Germany) is marketed as a training tool for novice ophthalmic surgeons, experienced physicians can also benefit from its use. The physics-based capsulorhexis module allows surgeons who have mastered basic skills to rehearse new techniques for opening the capsule and, more importantly, to practice the management of intraoperative complications.[1]

In 2006, Brian Little, MD, published his strategy for saving the radializing capsulorhexis in even the most challenging situations.[2] In my opinion, this technique is one of the most significant contributions to cataract surgery during the past 5 years. Before the introduction of the Eyesi system, surgeons could only read about and mentally rehearse Dr. Little's technique before trying it on a live patient in a critical situation. With the Eyesi system, surgeons can intentionally radialize virtual capsulorhexes and rehearse Dr. Little's rescue technique until they achieve objectively verified competence.

At the Mayo Clinic in Rochester, Minnesota, more seasoned surgeons have also used the Eyesi system to practice performing cataract surgery with their nondominant hand or to refresh their surgical skills after a relatively long hiatus from the OR.

At the other end of the learning spectrum, the Eyesi system gives medical students the opportunity to "experience" intraocular surgery and helps them decide if they would like to pursue a career as an ophthalmic surgeon.

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2. Little B, Smith J, Packer M. Capsulorhexis tear-out rescue. *J Cataract Refract Surg.* 2006;32:1420-1422.

ARE WET LABS STILL RELEVANT?

Hands-on experience in traditional surgical wet labs is still the gold standard for training residents to perform corneal and scleral suturing techniques. Currently available surgical simulators do not attempt to replace the experience of working with real cadaveric eyes. Instead, the simulator provides a realistic, repeatable, and measurable intraocular surgical environment that is difficult to duplicate in the traditional wet lab setting.

In my experience, the Eyesi's on/off setup eliminates the significant time and effort typically involved in preparing and dismantling a wet lab. In addition, the surgical simulator measures and documents the user's efforts and performance.

Depending on which module is used during a training session, the system tracks and scores up to 74 different performance variables (Table 1). The Eyesi's screen displays the data for each trial, which can also be summarized and graphed at the end of each simulated surgical session or exported to a spreadsheet program for statistical analysis. I believe that, by allowing our residents to repeatedly perform standardized tasks and measuring their performance in a realistic environment, the Eyesi system helps us train surgeons to perform cataract surgery safely and competently without putting patients at risk.

CONCLUSION

Keeping up to date with the rapid advances and complexity of modern intraocular surgery is a challenging but ultimately satisfying and rewarding endeavor. Surgical simulators based in virtual reality allow residents to develop and hone their surgical skills so that they provide patients with the safest and highest-quality surgical outcomes possible. Currently, a barrier to the Eyesi's broad adoption appears to be the system's cost (between $100,000 and $200,000, depending on optional features and the date of purchase).

I encourage ophthalmologists who are passing through Rochester, Minnesota, to consider visiting the Mayo Clinic's Multidisciplinary Simulation Center to take the Eyesi system for a test drive. ■

To view a video of a simulated capsulorhexis rescue performed on the Eyesi Ophthalmic Surgical Simulator, visit the ESCRS's Video on Demand Web site at http://www.conference2web.com/escrs/Videos.aspx# or VRMagic's Web site at http://www.vrmagic.com/downloads/eyesi/videos/ESCRS%20Mahr.zip

If you are interested in testing the Eyesi Ophthalmic Surgical Simulator at the Mayo Clinic's Multidisciplinary Simulation Center, please contact Dr. Mahr.

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