Simulators in Ophthalmology – A promising tool

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Abstract

Virtual Simulation potentially reduces training costs, increases accessibility, offers objective measurement of training outcomes, and improves patient safety during and after clinician training, all of which can help address the global burden of vision impairment and blindness. This is especially pertinent in unusual situations like the covid pandemic.

Keywords: Simulators, ophthalmology training, Holo eye.

Introduction

The development of surgical skills requires long hours of dedicated effort. You need to have a background theory knowledge, a mentor, and patients. Repetitions of the same procedure time and again open up new vistas and slowly you start developing an insight. There is always a definite learning curve. Today's era of speed learning requires that we make this learning curve short and less steep and also ensure safety of our patients. Simulation of the actual scenario by use of 'Simulators' is very useful in quick and structured learning.

Various disciplines that require some motor skill proficiency have developed innovative models to impart practical training to trainees. Airline pilots spend a great deal of time using simulators to acquire robust and mature skills necessary to safely fly whereas, athletes and musicians spend a lot of time in practice and rehearsal before game day or recital. They all learn the finer points to be used for the final job using simulation models. Simulation is an educational activity which is interactive and experiential and is designed to mimic a real-life activity as realistically as possible. Simulation in healthcare is used to develop necessary skills but avoiding exposing patients to undue risks.

Simulators and Ophthalmology

The downstream effects of COVID -19 have influenced the educational experience of both trainees and practicing clinicians around the world. With less number of available patients and social distancing norms use of simulators is much more relevant in COVID era. The first known medical simulation application was developed in 1963 by Entwislel. This application simulated patients with six unique diagnoses and provided medical students feedback on their diagnostic skills.1

An eye simulator was developed in 1997 at UC Davis Medical School, California but only slight improvements on this model have been carried out since then. These simulators are designed to demonstrate the effect of disability or malfunctioning of any of the ocular muscles and/or nerves controlling them; however, the representation of the eye and ocular region is very schematic and two dimensional.2 Current simulation systems are based on virtual reality and user feedback. Various simulators have been developed in the field of ophthalmology.

Holo Eye

Holo Eye Anatomy application, developed by the L V Prasad Eye Institute, works with the Microsoft HoloLens headset. Based on the concept of augmented reality, the application allows users to interact with a virtual 3D model or hologram of the eye using hand gestures to pan, zoom, rotate, or slice the 3D model into component layers or to the level of individual cells such as the cornea. Learning and visualizing anatomy is key to a deeper understanding of the function and structure, along with pathological process in the visual system. Mixed reality, combining virtual and augmented reality, provides a learning and teaching tool to project 3D eye models in space, allowing engaging and interactive learning from a new perspective.3(Figure1)
Help me see

Help Me See was founded with the mission of establishing a simulation-based surgical skills training program to teach Manual Small Incision Cataract Surgery (MSICS). HelpMeSee Eye Surgery Simulator is a highly realistic virtual reality trainer for Manual Small Incision Cataract Surgery (Figure 2 and 3). The system provides a scalable approach for training cataract eye surgery specialists and ophthalmologists.

HelpMeSee Eye Surgery Simulator establishes a new standard in virtual reality surgical simulation with quality 3D visuals, an ability to provide haptic feedback for the very low forces experienced in ophthalmic microsurgery, and a feature-rich training system.

The Simulator replicates the mechanics of surgical interaction: angles, forces, friction, flow and resistance with realistic cause and effect. High-fidelity, virtual reality simulation with tactile feedback elucidates the mechanics of ophthalmic surgery. Currently programmed with the tunnel incision step of the MSICS procedure, the Simulator’s Simulation-Based Learning System (SBLS) creates an unparalleled learning experience.

Phaco Vision and Eyesi

There are two other commercially available ophthalmic surgical simulators. One is the PhacoVision (Sweden) and the other the Eyesi (Germany). The first system focuses exclusively on the capsulorhexis and phacoemulsification aspects of cataract surgery. The second system was originally designed as a vitreo-retinal surgical training device, though an anterior segment module was subsequently developed. The Eyesi anterior and posterior segment platforms were obtained and implemented at various ophthalmology residency and retina fellowship programs as part of organized surgical training curricula. Recent hardware and software advances have expanded the simulators to include anterior segment training modules also. These include capsulorhexis and phacoemulsification training modules.

The Eyesi simulator consists of a mannequin head with a mechanical eye, various probes which mimic different intraocular instruments, a virtual operating microscope with functioning foot pedal, and a separate instrument foot pedal. The surgeon is shown stereoscopic images of the eye and instruments through the microscope while an observer is able to monitor from a separate viewing screen.

The Eyesi microscope gives a stereoscopic view identical to the real operation theatre microscope. The trainee is required to establish suitable visualization via the microscope’s foot pedal’s zoom, focus, and X/Y controls. BIOM/ SDI hardware is integrated into
the microscope setup. Modules are available from Eyesi for vitreoretinal training also (Figure 4). Training sessions include inducing posterior hyaloid detachment and performing peripheral vitrectomies, peeling the internal limiting membrane (ILM) or the removal of epiretinal membranes. To help trainees in refining manual dexterity skills associated with vitreoretinal surgery Eyesi provides a virtual surgical instrument tray. In the course of performing virtual surgery a trainee will use an illumination probe in their non-dominant hand. As in real retinal surgery Eyesi enables the surgeon's dominant hand to alternate between instruments such as vitrector, endolaser, forceps, scissors etc.

Three-dimensional (3D) technology helps to experience width, depth, and height to simulate real life. This includes VR, printing, and interactive mobile apps. A review study has assessed the recent literature pertaining to 3D simulated surgical training, which provides a rigorous analysis of the quality of assessment of these technologies. A recent review offers an example of 3D simulation in the printing of rigid gas permeable (RGP) lenses. These lenses are ideal for refractive error correction, treating keratoconus, and corneal transplant. RGP fitting is not easy on irregular corneas and repeated trying on of lenses is not only uncomfortable but also dangerous as it increases risk of corneal shedding or infection. A safer method of fitting RGP lenses uses corneal topography obtained through simulation of a fluorescence evaluation map based on the corneal anterior surface data and RGP lens design parameters. This simulation reduces the number of trial lenses required. Limitations of this technology, however, include the fact that positioning of the lens is influenced by the weight of the lens itself and by eyelid weight, which is even more influential with an irregular cornea.

Conclusion
Simulation in ophthalmology training is an emerging opportunity. Ophthalmologists can learn from those who have been developing robust methods to interpret evidence correctly and to assess validity in comprehensive manner. With the many advantages of simulation for training of clinicians and assessment of patients in a cost- and resource-effective manner, we are poised to embrace the teachings of this powerful emerging field to deliver equitable and timely eye care.

References


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