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Ari August, BS
Thomas Jefferson University

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A New Dimension to Offer

By Ari August, BS | Faculty Reviewer: Allen C. Ho, MD

Technological advancements are crafted, fielded, and sold from the vantage point of benefit: How can this make my life better? The origins of three-dimensional (3D) technology are no different. 3D technology targets the mind's ability to make sense of two different angles of an image, and therefore perceive depth. Earlier models, common in movie theaters and cereal box toys, utilized red and blue lenses to outwit one's perception of a flat image and project it into 3D images, promising deeper immersive experiences and even "x-ray vision." More recently, the capacity of 3D technology has expanded, as seen with the recent virtual reality craze in the entertainment field. The ability to use software to create physical objects within 360-degree experiences allows users to not only observe a high-fidelity experience but also actively manipulate projected surroundings. Beyond the entertainment industry, virtual reality has also been utilized to improve educational outcomes[1] through real-time 3D visualization of 3D structures, showing great potential for positive impact on student, physician, and patient lives.

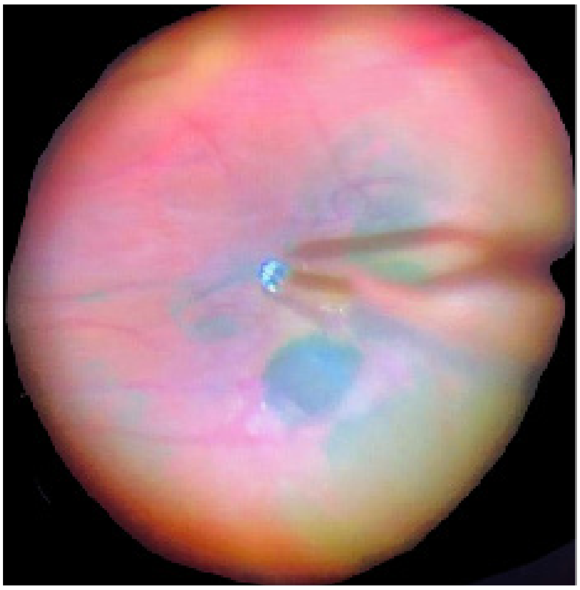

Figure 1. *2D digitized visualization of an indocyanine green dye-assisted macular peel from a standard operating microscope.*

Within the field of ophthalmology, the incorporation of 3D visualization technology aims to improve on limitations with current methods used to visualize structures within the eye during surgery. High-quality visualization of intraocular structures is required for examination, diagnosis, and surgery. According to Wills Eye Hospital vitreoretinal (VR) surgeon Dr. Allen C. Ho, visualization is also "an unmet need" in retinal surgery. The traditional method of visualizing the eye during surgery is a Standard Operating Microscope (SOM),[2] which provides bifocal 2D visuals using classical optics. This microscope has a split ocular, allowing for visualization of the surgical field by two individuals simultaneously, and can digitally project the surgical field onto a screen for recording or observation purposes. However, the digital monitors of the projected images are located away from the surgical field,[3] putting students far from instruction, narration, and the ability to ask questions. Furthermore, this method of traditional microscopic visualization comes with "limitations in field of view, color, contrast and sharpness."[4] Compared to images seen directly through SOM oculars, the brightness, resolution, and colorization of projected digital images (Figure 1) suffer.[3] Overall, these limitations diminish the potential for learning and visualization.[5] In current 3D visualization systems for ophthalmic surgery, two cameras attached to an operating microscope will send their signals to a central processor that will transmit an image onto a monitor, which can be viewed by surgeons wearing polarized glasses so that they may appreciate the 2D image in 3D (Figure 2). This technology lends to an immersive experience in the operating room for all those present (Figure 3).

3D visualization technology enhances visibility with the real time use of computed filters. Just as a digital photograph may be artificially augmented to emphasize contrast or warmer tones for the sake of consumer experience, the application of a filter allows for increases in image saturation, especially of green tones, which promotes better visualization of stained regions (Figure 4).[6] Furthermore, the ability to adjust gain and brightness on the end of the digitization rather than a light source have led to an improved ability to sufficiently highlight the retina with an extra-globular light source used as a scleral depressor.[3] Finally, while SOMs sacrifice some light to the dual oculars for surgeon/observer viewing, lowering the digital image's quality, 3D technology removes the use of oculars, thereby decreasing the risk of light loss,[3] which enhances the digital image (Figure 4). Thus, the benefits for visualization with 3D digital augmentation can provide unique benefits for both VR surgeons and patients.

3D technology in VR surgeries not only improves visualization but also decreases risk for phototoxicity. Due to its location and requisite viewing through anterior ocular structures, visualization of the posterior segment requires specific posterior segment illumination, which may increase risk for phototoxicity. The retina is typically protected from phototoxicity

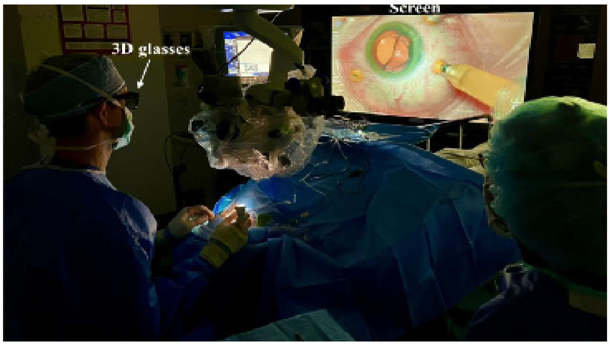

Figure 2. *Dr. John Hinkle (retina fellow at Mid Atlantic Retina) removes silicon oil via vitrectomy using the NGenuity Alcon 3D visualization system. The fellow is wearing polarized glasses to appreciate the 2D image transmitted through a central processor onto a screen in 3D.*

by pigments and antioxidants present in the cornea, lens, uvea, and retina that act to absorb wavelengths of electromagnetic energy to prevent excitation and damage.[7] Upon exceeding a phototoxicity threshold, the retinal epithelium, choroid, and outer segments of the eye are at risk of damage because of non-extensive repair mechanisms, which may result in permanent insult to retinal function.[7] Such phototoxic retinopathy may result from thermal, mechanical, or photochemical damage,[8] including that which is caused by SOM light.[9] It has been found that even with maximal precautions taken with light sources during SOM VR surgeries, endoillumination can be unsafe with respect to retinal phototoxicity.[10] This is especially of concern during vitrectomy when light from a source does not pass through the lens, and the threshold of safety is surpassed with even just one minute[10] of exposure to most commercial light sources. However, because of the electronic processing functions of 3D visualization, minimum endoillumination during 3D VR surgeries was found to be significantly lower compared to SOM surgeries,[2] lowering the risk of phototoxicity.

VR surgeons also report greater satisfaction with the use of 3D visualization in surgery. Dr. Ho emphasizes the advancement of this technology on functional aspects of "magnification, focus, depth of field, zoom, the ability to focus on something in the macula but also see its effects on the periphery."[5] VR surgeons are also able to overlay ocular computerized tomography intraoperatively to promote surgical decision making.[11] Additionally, 3D technology has been found to provide ergonomic benefit compared to SOM surgical methods.[2,3,12] The wide-angle stereoscopic view of 3D visualization as well as additional freedom of movement and positioning with use of 3D glasses (Figure 2) provides an added benefit of "freeing the surgeon from the physical confines of [SOM] eyepieces"[2] so they can operate with proper ergonomics. This is especially of importance to VR surgeons, who have high rates of spinal pain, possibly due to the frequent adoption of poor body mechanics.[13]

As with any new advancement in a field, enthusiasm for 3D visualization technology is not universal. There is no surprise that shiny new technology comes with a shiny new price tag, but surprisingly, there is a lack of discourse surrounding cost-effective evaluation of 3D surgery. A lack of use, however, is evident. Only half of the training institutions with access to an NGenuity Alcon 3D surgical system, the current 3D technology system used by VR surgeons, have ever used it![14] This discouraged use may be due to the observation of a lag between a user's actions and the feedback shown on the screen. However, one study found the latency of the system to be 70ms, which was detectable by 0% of users during internal limiting membrane peeling and 4% of users during external suturing.[14] For both actions, there were no clinical implications of the 70ms lag.[4,14] The lack of use may also be due to a perceived learning curve, which is often thought to be much more difficult to adapt to than research suggests. Some studies report proficiency after one day's cases.[15] Dr. Ho also expresses, "I think people will become adept and adapt very quickly, faster than they think they will."[5] He adds that fellows under his teaching adapt to the technology after just a couple of cases with it.[5]

Despite some hesitancy, the future of 3D VR surgery still provokes enthusiasm for what may come. VR surgeons who utilize 3D visualization technology openly encourage its expansion, even creating best practice tips and guides to help facilitate an easier transition and more rapid learning curve.[15] Some individuals are excited by findings of improved vitrectomy[16] or the potential of

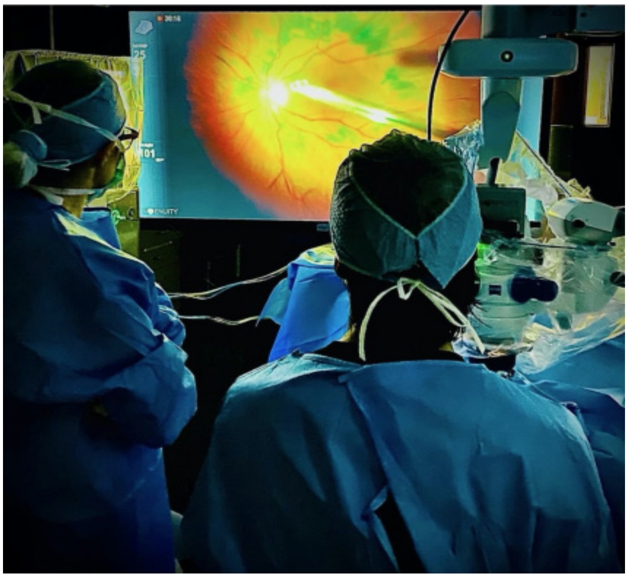

Figure 3. *Dr. Allen C. Ho performing retinal surgery using the NGenuity Alcon 3D visualization system.*

more safe and efficient procedures,[11] and others are hopeful that 3D VR surgery may be a gateway to "telesurgery"[17] in which a surgeon can operate, via joystick, from anywhere in the world. And even in the shadow of science fiction in near reach, some individuals might just be holding onto the possibility of 3D observation experiences helping them perform better on anatomy examinations.[18] Regardless, the future of 3D VR surgeries are sure to remain in sight.

References

1. Radianti J, Majchrzak TA, Fromm J, et al. A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. Comput Educ. 2020;1(147):103778.
2. Talcott KE, Adam MK, et al. Comparison of a three-dimensional heads-up display surgical platform with a standard operating microscope for macular surgery. Ophthalmol Retina. 2019;3(3):244-51.
3. Romano MR, Cennamo G, Comune C, et al. Evaluation of 3D heads-up vitrectomy: Outcomes of psychometric skills testing and surgeon satisfaction. Eye (Lond). 2018;32(6):1093-8.
4. Adam MK, Ho AC. The pros and cons of heads-up surgery. Review of Ophthalmology. Published September 12, 2017.
5. 3D Surgery and the Digital OR. Bryn Mawr Communications; 2017. https://eyetube.net/meeting-coverage/snowmass-2017-mar/3-d-surgery-and-the-digital-or.
6. Epiretinal Membrane and Internal Limiting Membrane Peel. Bryn Mawr Communications; 2020. https://eyetube.net/videos/epiretinal-membrane-and-internal-limiting-membrane-peel.
7. Roberts JE. Ocular phototoxicity. J Photochem Photobiol B, Biol. 2001;64(2-3):136-43.
8. Glickman RD. Phototoxicity to the retina: Mechanisms of damage. Int J Toxicol. 2002;21(6):473-90.
9. Verma L, Venkatesh P, Tewari HK. Phototoxic retinopathy. Ophthalmol Clin North Am. 2001;14(4):601-9.
10. Van den Biesen PR, Berenschot T, Verdaasdonk RM, et al. Endoillumination during vitrectomy and phototoxicity thresholds. Br J Ophthalmol. 2000;84(12):1372-5.
11. Read SP, Fortun JA. Visualization of the retina and vitreous during vitreoretinal surgery: New technologies. Curr Opin Ophthalmol. 2017;28(3):238-41.
12. Mendez BM, Chiodo MV, Vandevender D, et al. Heads-up 3D microscopy: An ergonomic and educational approach to microsurgery. Plast Reconstr Surg Glob Open. 2016;4(5):e717.
13. Shaw C, Bourkiza R, Wickham L, et al. Mechanical exposure of ophthalmic surgeons: A quantitative ergonomic evaluation of indirect ophthalmoscopy and slit-lamp biomicroscopy. Can J Ophthalmol. 2017;52(3):302-7.
14. Chow DR. Maximizing the performance of 3D visualization systems. Retina Today. Published April 2021.
15. Houston SKS. Real-world experience with 3D surgical viewing. Retina Today. Published October 2018.
16. Mura M, Martin W, Williams KK, et al. Comparison of 3D digitally assisted visualization system with current standard visualization for the removal of vitreous in a preclinical model. Clin
17. Ophthalmol. 2021;15:4499-4505.Koçak N, Kaya M, Ozturk T, et al. Digitally assisted surgery for retinal detachment with giant retinal tear. Retina Today. Published February 2021.
18. Chhaya N, Helmy O, Piri N, et al. Comparison of 2D and 3D video displays for teaching vitreoretinal surgery. Retina. 2018;38(8):1556-61.

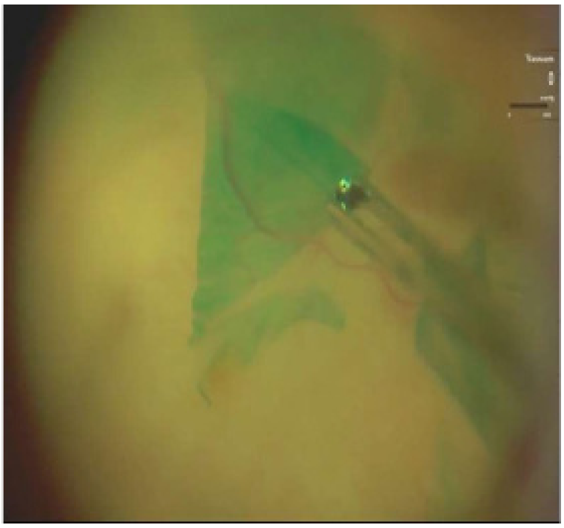

Figure 4. *3D digitized visualization of an indocyanine green dye-assisted epiretinal membrane and internal limiting membrane peel from an Ngenuity Alcon 3D visualization system.*