

## 3D Visualization for Vitreoretinal Surgery

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Terminology is a crucial when introducing new techniques and technology. "Heads up surgery" is a misnomer; tilt oculars have been available for operating microscopes for decades; there was not a significant ergonomic problem to solve. Current implementation of 3D visualization actually requires a slight head turn when the large OLED display is located at the optimal 4 feet from the patient. Operating microscopes have been stereo (3D) since they were introduced over 60 years ago, we are still looking for a compelling name for this exciting new technology. Alcon NGENUITY has been referred to as digital visualization; although this is correct it addresses technology implementation not the clinical benefit; understanding the difference between features and benefits is essential to adoption of new technology. The benefit is better visualization. The Alcon NGENUITY system utilizes a stereo pair of single chip CMOS cameras and small apertures which provides greater depth of field 4.5X greater than a conventional optical operating microscope. Increased depth of field is the feature that enables the benefit; use of much greater magnification enabling significantly better visualization. The small CMOS sensors have been matched to the point spread function of the optical system so the resolution is the same at the periphery of the displayed image as it is in the center. This is not the case with a conventional optical operating microscope where resolution decreases and aberrations increase as a function of angular displacement from the viewing axis.

Effective use of greater magnification requires attention to several specific details. Unless the patient is moving excessively; the image should vertically fill the 55 inch NGENUITY display; the circular image on 16:9 display leaves space to the side for imported digital images or intra-operative OCT, office EMR, and CONSTELLATION parameters. Use of lesser magnification defeats the purpose of 3D visualization.

Precise focus is essential to using high magnification and must always be optimized at high magnification. Initial focus should be on the cannulas, the site of introduction of the infusion cannula and tools. The infusion cannula must be inspected at high magnification to make sure non-pigmented ciliary epithelium, choroid or retina is not stretched over the tip. Focus should be moved down progressively as vitreous removal is accomplished. Ultimately focus must again be optimized, always at very magnification, while working on the retinal surface.

The high sensitivity single chip, CMOS camera pair enables use of much lower light levels, typically 15 - 20% on Constellation for vitrectomy and 1 - 5% for macular surgery eliminating any question of light toxicity. Light levels should be constantly optimized by moving the endoilluminator closer and farther from the target, especially during macular surgery. This benefit is made possible by electronically decoupling light exposure on the retina from brightness on the OLED display. OLED displays, unlike AMLCD displays, do not utilize backlighting, therefore black is black thereby increasing dynamic range.

NGENUITY is ideal for team coordination in the operating room and for teaching because everyone sees the surgeon's view. Viewing distance is crucial to utilizing high magnification; the 55 inch OLED display should be positioned 4 feet (1.2 meters) from the surgeon. Use of a smaller display closer to the surgeon causes vergence-accommodation conflict. The surgeon should wear glasses with full distance correction with an additional +0.50D because of the viewing distance. If the assistant surgeon holds the surgical contact lens they must view through a stereo observer scope not the 3D system.

Too much has been made of the heads-up metaphor in the context of fighter jets; principally by surgeons that learn about aviation from Hollywood movies. The world of the fighter pilot is spherical, the viewpoint rotates with respect to the horizon and changes constantly. In surgery the horizon never changes, the viewpoint is the pupil and the vantage point is either constant or varies slightly in pitch and yaw to view the peripheral retina or angle for glaucoma surgery. Image overly from en face OCT or angiography would obscure the view of the retina; in the cockpit, forward looking infrared or synthetic vision heads-up displays are useful when there is minimal or no view out the cockpit window.

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