

## Commentary: Three-dimensional heads-up display system for cataract surgery

Three-dimensional heads-up display (3D HUD) microscopes mark a quantum leap in the technological advancements in ophthalmic microsurgery. The 3D HUD systems are based on the principle of passive reconstruction of 3D images by horizontal mixing of two images, followed by separating them using polarized 3D glasses.<sup>[1]</sup> The NGENUITY 3D Visualization System (Alcon Laboratories) and ARTEVO 800 (Carl Zeiss Meditec) are commonly available for commercial use, and their applications in posterior segment surgeries are well-documented.<sup>[2,3]</sup>

The ergonomic advantage offered by the heads-up display is associated with a significant reduction in back strain, especially during prolonged vitreoretinal procedures.<sup>[2-4]</sup> In addition, it allows greater magnification than the conventional binocular operating microscopes and enhances the visibility of the surgical field without inducing any distortions. The 4K OLED display screens relay high-definition real-time intraoperative video, and the clarity of the display is not affected even at lower illumination levels.<sup>[2-4]</sup> This is especially useful when operating under topical anesthesia, as lower illumination levels enhance patient comfort and cooperation without adversely affecting the visibility of the surgical field.

The 3D HUD systems have an excellent potential to develop as a training tool, wherein the trainees experience the same field of view and depth perception as the operating surgeon. It has an increased utility in the current times when the health care

community is striving to maintain the standard of teaching amid handling the pandemic and patient care.<sup>[5]</sup> Trainee fellows and residents are faced with decreased opportunities for assisting as well as performing hands-on surgeries, and heads-up display provides an invaluable method of interactive training wherein the viewer can gain an understanding of the surgical dynamics as well as depth perception.

The cost associated with acquiring the setup may be prohibitive especially for stand-alone ophthalmic setups. Additional space required in the operating room to maneuver the microscope, display screens, and machines may not be feasible in different setups. However, the advantages far outweigh the cost, especially in teaching institutions.

The authors report a learning curve with the 3D HUD microscopes, with a significantly increased surgical duration in the initial 25 cases as compared with later cases.<sup>[6]</sup> In addition, they observed a higher total duration of surgeries with the HUD system compared with the conventional operating microscopes.<sup>[6]</sup> The ergonomics involved in a 3D HUD system are completely different from that of a conventional operating microscope, and there is a period of getting accustomed to the machine and the different postures. The increased duration in initial cases may be in part related to the time spent by the surgeon in adjusting the display screen angulation and distance. There are more degrees of movement feasible in an HUD system, and the surgeon is more aware of the surroundings that may be distracting initially. In our experience, we did not observe a significant learning curve in adapting to the HUD. We observed that the duration of the learning curve may also be affected by the surgeon's experience. Experienced surgeons could easily adapt to the new dynamics in the initial four to five cases, with

subsequent cases having a similar surgical duration as those operated using conventional microscopes. Of importance, the operation theater layout needs to be restructured in order to prevent undue movements of the operating microscope and 3D display screens in between consecutive cases. Instead, the operating tables may be mobilized to facilitate patient movement. This cuts down on the surgical duration by minimizing the time required to align the surgeon's position and display screens.

The authors have emphasized the adjustment period required by the operating surgeon.<sup>[6]</sup> In addition, the learning curve of the surgical assistant and nursing staff is equally important.<sup>[5]</sup> The surgical assistant conventionally sits perpendicular to the operating surgeon at the head end during phacoemulsification. A significant neck strain is induced due to the positioning of the screen, as the display is at right angles to the assistant. In addition, the assistant requires time to get accustomed to the spatial orientation as the line of sight and hand movements are also at an angle and not along the same axis. The nursing staff often reports difficulties while loading the intraocular lens (IOL), as the operation theater lights are switched off to enhance the contrast of the display screen.

The authors report the need to shift from the HUD to a conventional operating microscope during surgery in seven eyes due to low illumination, difficulty in depth perception, and intraoperative miosis.<sup>[6]</sup> The reasons for switching to a conventional microscope may instead be attributed to the still-evolving surgeon's comfort with the system. Proper centration is essential to ensure clarity of display and adequate depth perception with 3D HUD, and the difficulties faced by the authors may in part be related to poor centration during surgery. The 3D HUD system provides a magnified view of the surgical field, which is not possible with conventional microscopes, and may be more useful in challenging cases such as those with small pupil. It provides enhanced depth perception and magnification, and the illumination may be adjusted as per patient's comfort and surgeon's requirements. The need to shift to a conventional microscope in challenging scenarios points toward surgeon's inexperience and a significant learning curve with the new system rather than technical inadequacies.

The intraoperative manipulations during phacoemulsification are faster as compared with the vitreoretinal procedures, and the impact of a time lag in the display will be potentially more hazardous for anterior segment surgeries.<sup>[7]</sup> The authors did not report any significant time lag with the ARTEVO system, which is in accordance with previous experience with the system.<sup>[7,8]</sup> However, the same may not hold true for all 3D HUD systems, and caution must be employed especially during capsulorhexis or deep trenching.<sup>[5]</sup>

To conclude, the ergonomic advantages, high magnification, and enhanced depth perception of 3D HUD systems mark a significant step forward in ophthalmic microsurgery. In our experience, the transition from conventional to 3D HUD system is more or less seamless. The initial brief learning curve usually translates into an increased surgical duration without a significant increase in complications. Once the surgeon gets accustomed to the advantages offered by the 3D HUD, the conventional operating microscopes seem uncomfortable. The 3D HUD technology heralds a new future for ophthalmic surgeries and has the potential to emerge as an excellent teaching and training tool.

### Manpreet Kaur, Sridevi Nair, Jeewan S Titiyal

Cornea, Cataract and Refractive Surgery Services,  
Dr. Rajendra Prasad Centre for Ophthalmic Sciences,  
All India Institute of Medical Sciences, New Delhi, India

**Correspondence to:** Jeewan S Titiyal,  
Professor & Head, Cornea, Cataract and Refractive Surgery Services,  
Dr. Rajendra Prasad Centre for Ophthalmic Sciences,  
All India Institute of Medical Sciences,  
New Delhi - 110 029, India.  
E-mail: titiyal@gmail.com

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