COST SAVINGS ASSOCIATED WITH USE OF 3D HEADS-UP DISPLAY (3D-HUD) IN MACULAR HOLE SURGERIES: AN ACADEMIC HOSPITAL PERSPECTIVE

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Background

225,000 vitrectomy surgeries are performed annually in the U.S.[1] A time-driven, cost analysis conducted at a US academic hospital in 2021 found the average cost of routine vitrectomies (including macular hole (MH) surgeries) is $7,169.79 per patient, $2,000 above CMS's 2019 reimbursed rate.[2] MHs present as a defect near the center of the retina, resulting in significant vision impairment, requiring exceptional precision and delicacy during the procedure.[3] A 3D heads-up display (3D-HUD), compatible with conventional surgical microscopes (CM), provides the significant visualization and depth perception advantages required of retinal surgery.[4] Reddy et al. 2021, a retrospective study conducted with trainee surgeons in India, found that MH closure rates were significantly higher in the 3D-HUD group (86.3%, p<0.004) than in the CM group (60.3%).[5] This system is a 3D, high-definition digital video camera that provides magnified stereoscopic images of objects during surgery, allowing for improved training by enabling the entire surgical team to view the case in real time.[4] This analysis aims to quantify the potential cost impact of improved MH closure rates using a 3D-HUD system at a US academic hospital.

Methods

A focused review of literature from PubMed was conducted to inform the model framework and locate relevant inputs. Papers involving the use of 3D-HUD systems in ophthalmologic procedures from January 2018 to January 2023 were included. Relevant costs and clinical inputs were based on published literature (where available) and 2023 reimbursement rates reported by the Center for Medicare and Medicaid Services fee schedule.[6] Costs are reported in 2023 US dollars. All cost inputs from prior to 2023 were inflated to 2023 US dollars using the Bureau of Labor Statistics' CPI inflation calculator.[7] After inflation, the average cost of routine vitrectomy is $8,763.63, with a reimbursement of $5,096.24 for an initial procedure and $4,076.99 for a follow-up macular hole closure.[2,6-9] A 1-year cost calculator was developed to demonstrate the potential cost impact of the 3D-HUD system for MH closures from a US academic hospital perspective. The cost impact was assessed as the rate of improved MH closures using the 3D-HUD system and the difference between the reimbursed rate for a MH re-closure and the true cost of routine vitrectomy surgeries.

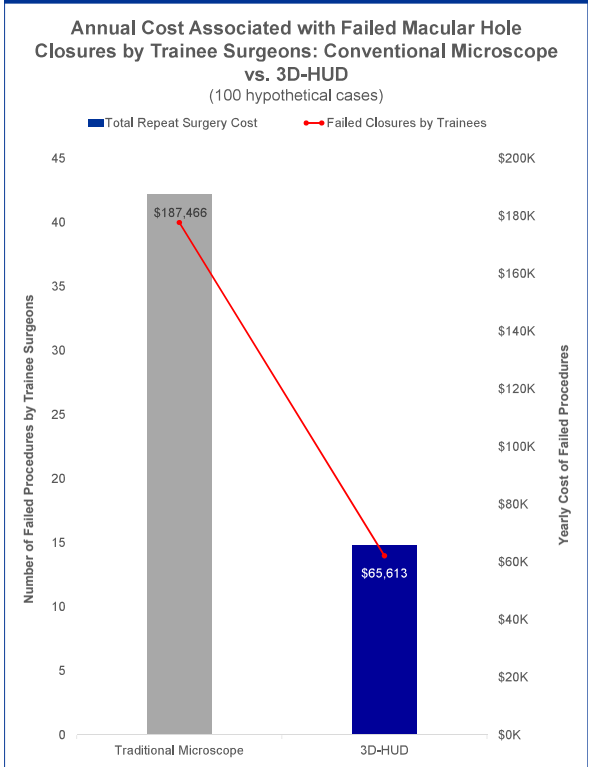
Results

The use of the 3D-HUD system in 100 hypothetical MH closure cases by surgical fellows demonstrated cost savings of $121,853 for a US academic hospital. Savings were driven by a reduction in the number of failed MH surgeries that would require a repeat procedure.

Discussion & Conclusions

This 3D-HUD system provides surgeons performing retinal surgeries with significant advantages to visual field and depth perception. For residents and medical students in training, it provides significant educational value. Because MH surgery-specific costs are not well established in literature, the presented cost analysis utilizes the cost of vitrectomy as a proxy. Results from this cost analysis suggest that the use of the 3D-HUD system in patients requiring a MH closure may result in cost-savings for US academic hospitals. Future studies of this system could examine the potential long-term benefits to surgeons via improved ergonomics or improvements in surgery duration.

Results Continued



Results Continued

Visualization Capabilities

A prospective observational study of four surgeons across 313 eyes found the 3D-HUD system had significantly better image resolution (p<0.0001) and depth of field (p<0.0001) compared to CM.[10] Another study involving 14 surgeons rated the 3D-HUD's image resolution as a 6.71 (p=0.0179), where 5 is equivalent to CM, and 10 is much better.[11]

Reduction in Phototoxicity

The 3D-HUD system reduces the risk of phototoxicity and dye exposure during surgical procedures. The system requires significantly less light compared to CM; 10% power compared to 35% (p<0.001) in vitreoretinal surgeries and 22.7% compared to 39.1% in pars plana vitrectomies, respectively.[12, 13] A study conducted in India reported a reduction in exposure time to harmful dyes: 90 seconds compared to 120 seconds with CM (p = 0.02).[14]

Training and Collaboration

3D-HUD systems were rated significantly better (p=0.000) than CM for teaching by surgeons and observers in Italy.[15] A similar study in Malaysia noted the system allowed for improved communication (p=0.002), increased comfort of the learning environment (p = 0.001), and improved knowledge sharing (p = 0.000).[16]

Ergonomics

When compared to CM, 3D-HUD provides several ergonomic benefits. In a study of 64 US surgeons (p = 0.029), the 3D-HUD was 5.12 times more likely to be associated with improvements in pain and discomfort, with 77% of these surgeons reporting improved overall comfort.[17]

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Disclosure: LCP and CH are employees of Alcon. CS, NM, and OD were contracted by Alcon to conduct the literature review and develop the model.