Evaluating the Ergonomic Outcomes of Digitally Assisted Vitreo-Retinal Surgery: A Systematic Literature Review

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Introduction

- Conventional microscopy is utilized in ophthalmic procedures to facilitate the visualization of critical tissues during various surgical cases
- While technological and procedural advancements have resulted in low complication and re-operation rates, the limitations of existing technologies — including surgical ergonomic challenges, need for in-procedure adjustments, and additional information/support provided by other surgical devices — can create challenges for surgeons during procedures[1,2,3]
- Recent developments in digitally assisted vitreo-retinal surgery (DAVS) and heads-up setup were introduced to the global ophthalmic surgical community to enhance visualization with digital signal amplification, higher resolution, and increased depth of field, while addressing some of the ergonomic challenges associated with conventional microscopes

Objective

- To assess the published evidence available on the ergonomics associated with a heads-up setup and DAVS compared to conventional microscopy

Methods

Literature Search Approach and Inclusion/Exclusion Criteria

- A systematic search of the PubMed database was performed for studies published between 2009 and 2019 using predefined search terminology focusing on retinal surgery, 3D heads-up visualization, and clinical and economic outcomes
  - An additional search of the Embase database with targeted terms was conducted to supplement the findings of the systematic PubMed search
  - Table 1 presents search terms and combinations used in PubMed and the targeted search terms used in the additional Embase search
- Only studies published in English and conducted in human subjects were included
- Exclusion criteria included: non-original articles, studies not primarily focused on the conditions of interest (oculoplastics, blepharoplasty, and other unrelated surgeries), and technologies that were not of interest (optical coherence tomography (OCT) and other unrelated technologies)
- The final literature pool included clinical trials, retrospective studies, and case reports describing the benefits of DAVS or comparing DAVS to conventional microscopes

Table 1. Search Terms and Combinations Used

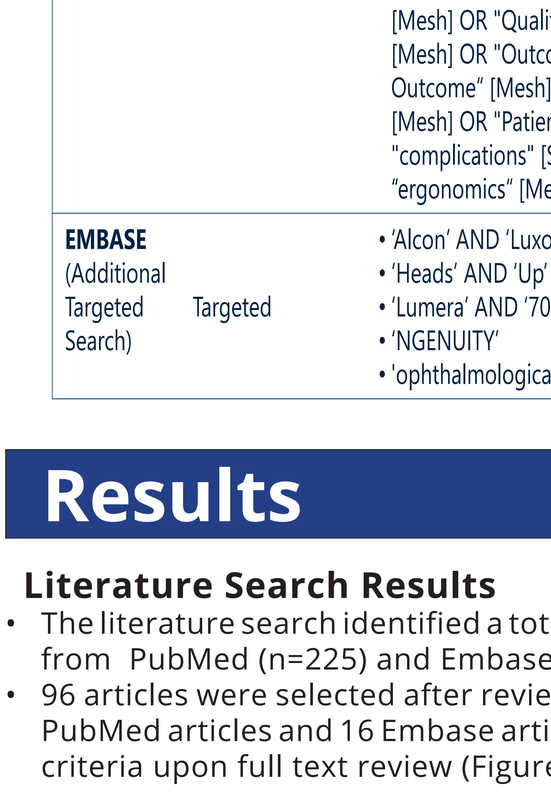
Databases	Topic	Search Terms
PubMed (Primary Search)	Retinal Surgery	"Ophthalmologic Surgical Procedures" [Mesh]
	Treatment	**AND** • "3D Visualization" OR "Ophthalmoscopes" [Mesh] OR "heads up display" OR "heads-up display" OR "heads up surgery"OR • "heads-up surgery" OR "NGENUITY" OR "TrueVision"
	HEOR/Misc.	**AND** • "Retinal Perforation" OR "Economics, Medical" [Mesh] OR "Cost of Illness" [Mesh] OR "Quality of Life" [Mesh] OR "Patient Outcome Assessment" [Mesh] OR "Outcome Assessment (Health Care)" [Mesh] OR "Treatment Outcome" [Mesh] OR "Outcome and Process Assessment (Health Care)" [Mesh] OR "Patient Reported Outcome Measures" [Mesh] OR "complications" [Subheading] OR "Vision Disorders" [Mesh] OR "ergonomics" [Mesh]
EMBASE (Additional Targeted Search)	Targeted	• 'Alcon' AND 'Luxor' • 'Heads' AND 'Up' AND 'Display' • 'Lumera' AND '700' • 'NGENUITY' • 'ophthalmological surgical microscope'

Results

Literature Search Results

- The literature search identified a total of 302 articles after removing duplicates from PubMed (n=225) and Embase (n=87)
- 96 articles were selected after reviewing titles and abstracts (composed of 80 PubMed articles and 16 Embase articles) and 16 articles met the final inclusion criteria upon full text review (Figure 1)

Figure 1. Study Selection Process



Exclusion Criteria	Number of Excluded Records
Unrelated Surgery	150
Unrelated Technology	66
Other (e.g., Animal Study)	40
OCT	21
Drugs or Therapeutics	7
Non-English Language	2

- The focus for this poster was placed on studies which described key components of the surgeon's ergonomic experience, as a result, only 4 studies were included in this poster[4,5,6,7]

The table below (Table 2) summarizes the key evidence for 5 papers, reviewing ergonomic outcomes for DAVS vs. conventional microscopes

Surgeon Ergonomics

- Studies by Eckardt et al. (2016), Zhang et al. (2018), Palácios et al. (2019), and Rizzo et al. (2018) suggest that heads-up displays provide improved surgical ergonomics and comfort for the primary surgeon[4,5,6,7]
- Eckardt et al., Zhang et al., and Palácios et al. asked users to rate the general ergonomics of DAVS via a subjective questionnaire and all three studies demonstrated that DAVS was associated with statistically significantly higher ergonomic ratings than conventional microscopes[4,5,6]
- Additionally, Rizzo et al. asked the primary surgeon about their neck and back pain post-surgery, and asked the second surgeon, the anesthetist, and operating room nurses about their comfort during surgery[7]
- While most responded positively in favor of DAVS, secondary surgeons expressed dissatisfaction in having to rotate their head to view the screen. This rotation is likely due to screen placement which is optimally located for the primary surgeon, but not for the secondary surgeon[7]

Table 2. Literature Review Findings

First Author, Year Sample Size and Type Study Design	Surgery Type	Endpoints	Results Compared to Conventional Microscopes	Favors HUD/DAVS
Eckardt, C., et al., 2016 20 resident surgeons completing 3 tasks Prospective controlled trial	PPV for macular hole	Custom Questionnaire - Speed	Eleven (Tasks 1 and 2) and 12 (Task 3) of the residents estimated they performed the tasks more quickly using HUD.	🟠
		Custom Questionnaire - Comfort	18 (Tasks 1 and 2) and 19 (Task 3) of the 20 residents considered the HUD as more comfortable than the CM (P = 0.000402 to 0.000040)	🟢
		Custom Questionnaire - Ease of Operation	10 (Task 1) and 12 (Tasks 2 and 3) considered the tasks were easier to perform using HUD	🟠
Zhang, Z., et al., 2018 N=59 eyes Prospective controlled trial	PPV, silicone oil removal, phacoemulsification with/without intraocular lens implantation, membrane peeling, retinotomy, and silicone oil infusion.	Surgeon and residents' preference and ergonomics	Statistically significant improvement for 3D HUD compared to CM Surgeon and residents expressed overwhelming preference with the 3D HUD in both groups. Improved ergonomics was rated higher with the 3D HUD (4.4 ± 0.8 vs 3.2 ± 1.0, P < 0.001)	🟢
		Difficulty Rating	No statistically significant differences were observed between the HUD and TM groups in difficulty rating. In the HUD group, the mean general difficulty rating as graded by the surgeon was 1.6 ± 0.8; the TM rating was 1.6 ± 0.7.	🟠
Palácios, R. M., et al., 2019 40 eyes Prospective controlled trial	Vitreoretinal surgery associated with facetomy, Ahmed glaucoma valve implantation, or minimally invasive glaucoma surgery using an iStent	Results of the Questionnaire - Ergonomics	Statistically significant improvement for 3D procedures compared to TM	🟢
Rizzo et al., 2018 200 surgical cases Survey of surgeons and other staff	PPV (23 or 25 gauge) for retinal detachment, vitrectomies (25 or 27 gauge) for epiretinal membrane or macular hole, and the remaining operations were phacoemulsifications, ocular trauma, corneal graft, or squint surgery	Custom Questionnaire – Presence of back and neck ache after surgery for primary surgeon	No primary surgeons reported symptoms (Score 0) in 185 operations lasting 60 minutes or less, whereas mild pain (Score 1 or 2) was recorded for all 14 operations of more than 60 minutes	🟠
		Custom Questionnaire - Comfort during surgery for second surgeon	Score of one or two with greater dissatisfaction for general anesthesia (P < 0.001) Total dissatisfaction was recorded in 19/23 cases for general anesthesia while moderate dissatisfaction was recorded in 21 cases for local anesthesia Moreover, total dissatisfaction was recorded in 54/155 cases for retrobulbar block and was also recorded in 4/81 (5%) operations of less than 50 minutes and 50/74 (68%) of those lasting 50 minutes or more (P < 0.001)	🔴
		Custom Questionnaire - Anesthetist's comfort during surgery	Recorded a score of 4 or 5 in 136/199 (68%) operations Their greatest dissatisfaction was observed during general anesthesia with 19 scores as "1" for 19 patients who received general anesthesia Greater dissatisfaction with longer operations (OR: 0.35 for each 30 minutes more, P < 0.001)	🔴
		Custom Questionnaire - Theatre nurse's comfort during surgery	Nurses were very satisfied (score 5) in 175/199 cases	🟠

Abbreviations: CM = conventional microscope; HUD = heads-up display; PPV = Pars plana vitrectomy; VS = vitreoretinal surgery

🟢 = Favors HUD/DAVS with statistical significance 🟠 = Favors HUD/DAVS, but no statistical tests done 🔴 = Does not favor HUD/DAVS with statistical significance

Conclusions

- This systematic review of literature illustrated the relative dearth of literature on ergonomics of novel ophthalmic surgical visualization systems compared to other therapy areas
- Existing literature comparing DAVS to conventional microscopes highlights the improvements with DAVS in ergonomics/comfort for the primary surgeon compared to conventional microscopes[4,5,6,7]
  - Physician surveys also highlight the physician preference for DAVS over conventional microscopes from a teaching and surgical collaboration perspective[4]
- Future studies utilizing more objective measures of ergonomics are warranted. Additionally, potential ways for improving ergonomics of DAVS for the secondary surgeons as well as other professionals involved in ophthalmic surgeries should be sought

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Disclosures

V. Sandwick was an employee and C. Lathia, N. Hadker, and K. Hennegan are current employees of Trinity Life Sciences at the time of research. Trinity Life Sciences has conducted this research for Alcon, Inc.; D. Abulon was an employee and L. Morris, and H. Cheng are employees of Alcon, Inc.

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