INTRAOPERATIVE HEAD-MOUNTED DISPLAY USE FOR MINIMALLY INVASIVE SURGERY - A LITERATURE REVIEW

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Introduction

The goal of this work is to review the literature on the use of head-mounted displays (HMDs) during the minimally invasive surgical task, both in the operating room (OR) and in simulation settings, and to investigate the influence of using HMDs on performance and physical and cognitive workload compared to conventional monitors.

Search Methods

Databases: PubMed, MEDLINE, and Web of Science

Search Terms: ("head mounted display" OR "head up display" OR "face mounted display" OR headset) AND (laparoscop* OR "minimally invasive surgery" OR endoscop*)

No restriction of language or publication year were applied at the search point

Search was completed in May 2020

Data extracted: (1) HMD information, (2) Task performed and performance results, (3) HMD-related physical discomfort and visual fatigue, (4) User information

Results

Of the 420 publications initially identified, 54 publications were included in the final analysis (Figure 1)

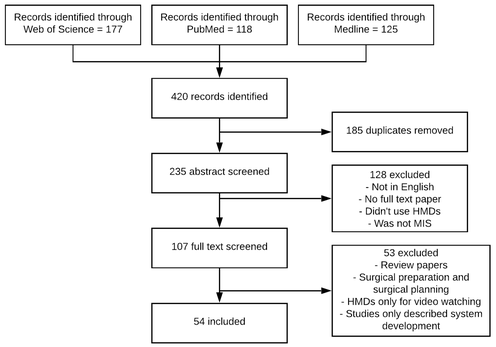


Figure 1. Article screening procedure

- 47 studies used VR HMDs → 28 in the OR, 19 in simulation settings
- 7 studies used optical see-through (OST) HMDs (Figure 2) → 3 in the OR, 4 in simulation settings



Figure 2. Example OST-HMD

Results, cont.

The number of studies investigating the use of HMDs has increased in the last 10 years, due to new HMDs and added features (Figure 3)

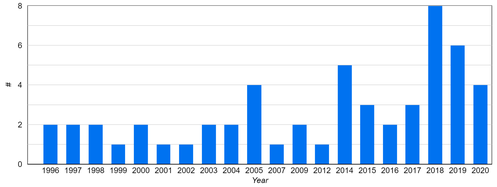


Figure 3. Number of articles published per year

Important characteristics of the studied HMDs that emerged were: (1) weight of the device, (2) the small field of view (FOV), (3) image quality, and (4) connection stability (Table 1)

Table 1. Characteristics of included HMDs

HMDs Device	Weight (g)	Device Type	Field of View	Resolution	Record Count (OR / Simulation)
Microsoft HoloLens 1	579	3D Binocular OST-HMD	34° diagonal (30° × 17.5°)[1]	1280 × 720 (per eye)	5 (2 / 3)
Sony HMM-3000MT	490	3D Binocular VR HMD	45° horizontal	1280 × 720 (per eye)	5 (5 / 0)
Sony HMS-3000MT	480	3D Binocular VR HMD	45° horizontal	1280 × 720 (per eye)	4 (4 / 0)
Sony HMZ-T1	420	3D Binocular VR HMD	45° horizontal, 51.6° diagonal[2]	1280 × 720 (per eye)	4 (4 / 0)
HTC Vive	468	3D Binocular VR HMD	110°	1080 × 1200 (per eye)	3 (0 / 3)
Sony HMZ-T2	330	3D Binocular VR HMD	45° horizontal	1280 × 720 (per eye)	3 (2 / 1)
Stryker Endoscopy Stryker OptiVu	<170	Binocular VR HMD	30° diagonal	800 × 600 (per eye)	3 (1 / 2)
Brother AiRScouter WD-200B	~145	Monocular VR HMD	17.8°	1280 × 720	2 (1 / 1)
Oculus Rift	470	3D Binocular VR HMD	110°	1080 × 1200 (per eye)	2 (0 / 2)
Olympus EyeTrek FMD-700	105	Binocular VR HMD	30° horizontal, 23° vertical	180,000 (per eye)	2 (0 / 2)
Optics 1	<397	3D Binocular VR HMD	27.5° diagonal, 22° horizontal, 19° vertical	420 × 230	2 (2 / 0)
Vista Medical Technologies StereoSite HMD	950	3D Binocular VR HMD	n/a	640 × 480	2 (1 / 1)
Epson Moverio unknown model	74	3D Binocular OST-HMD	n/a	n/a	1 (1 / 0)
Kopin MSpecs MSP-209	32	Binocular VR HMD	n/a	320 × 240	1 (0 / 1)
Microvision Nomad ND2000	n/a	Monocular OST-HMD	28.75° diagonal (23° × 17.25°	800 × 600[3]	1 (0 / 1)
MyVu	145	Binocular VR HMD	n/a	640 × 480	1 (0 / 1)
Oculus Rift Development Kit 2	440	3D Binocular VR HMD	~90° horizontal	1920 × 1080 (960 × 1080 per eye)	1 (0 / 1)
Olympus EyeTrek FMD-011	110	Binocular VR HMD	n/a	180,000 pixels	1 (0 / 1)
Olympus EyeTrek FMD-100	110	Binocular VR HMD	35° horizontal, 26.6° vertical	180,000 (per eye)	1 (1 / 0)
Olympus unknown model	110	Binocular VR HMD	35° horizontal, 26.6° vertical	180,000 (per eye); 240,000 (per eye)	1 (1 / 0)

Results, cont.

- 15 studies reported wearing HMDs for more than 30 minutes
  - 11 (78.6%) had overall positive feedback regarding physical discomfort
  - 2 reported significant physical or visual discomfort
  - 2 reported discomfort in a subset of participants[4] or after longer usage (> 80 min)[5]
- 28 studies reported surgical outcomes → successful cases without complications attributable to HMD use; completed within normal operative time
- 13 studies reported difference in performance between using an HMD and conventional monitor,
  - 5 reported better performance on HMDs
  - 3 reported worse performance on HMDs
  - 5 reported mixed or no significant difference

Discussion and Conclusions

- HMDs have the potential of being used to replace conventional monitors in surgery
- Reviewed studies that used HMDs in the OR had overall positive feedback of using HMDs, however, studies with larger user sample sizes are still needed
- Studies using HMDs for an extended duration are limited, especially for assessing the influence on physical workload
- Most of the reviewed studies measured physical workload using a subjective rating; objective assessments with more controlled experiments are needed to support the current conclusions

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