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Head-Mounted Virtual Reality Display: A Feasible Visualization Tool for Minimally Invasive Surgery

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ABSTRACT

Head Mount devices (Virtual Reality platform) can be used as an alternative display device during minimal invasive surgery. Augmentation reality will be the future of navigation guided surgery and virtual reality is the first step towards the future. We report our experience with the use of virtual reality platform in minimal invasive surgery. Head mount device is feasible and replicable approach for better display during minimal invasive surgery and additional augmentation reality will be the next step for navigation-based surgery in future.

Keywords
Artificial intelligence; head mount devices; minimally invasive surgery; virtual reality

INTRODUCTION

The use of artificial intelligence (AI) in surgery is still in developmental phase.[1] Virtual reality (VR) System is one of the technological advancements which have been used in different surgical platforms.[2] Researchers have expanded the use of VR system on physical rehabilitation, pain management, surgery training, anatomical education and treatment of psychiatric disorders and they have found its use to be more cost effective and efficient.[3]

VR simulation and surgical training is one of the well-practised surgical training approaches, which have shown to be safe and effective.[4] Heads-up, See-through, and Non-see-through are three types of display in Head mount system.[5] There are many head mount display available in the market. We had chosen Virtual Reality (Head mount display) from Meta. Meta Quest 3S head mount device was used in our study as it was affordable, compatible and user friendly.[6] This device was also used along with Levita® MARS® robotic platform to perform world first Meta Quest assisted robotic surgery in Santiago, Chile.[7]

Here in this study, we have described on how to use the VR set for the

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creation of see-through real-time display in surgery and our experience with its use in minimal invasive surgery.

METHODS

Meta Quest 3S was used to create virtual see through images during surgery. We have divided our work into four phases.

Interoperability

First hurdle for us was to evaluate the compatibility of our laparoscopic system (Richard Wolf, 2017) with the Meta Quest 3S (Figure 1). Real time laparoscopic feed rendering in VR was not possible even after multiple attempts. After the use of HDMI video capture card (Figure 2) laparoscopic video streaming to VR was possible.

Observation

During this phase we used head mount device (HMD) to observe the live surgery performed by surgeon. The surgeon with the HMD was not actively involved in surgery during this phase (Figure 3a and 3b). Main purpose of this phase was to get used to with the device, its interface and applications. There was none to minimal time lag, the picture quality was improved with better magnification and definition.

Figure 1. *Meta Quest 3S (Virtual Reality Device)*

Figure 2. *Video capture card*

Coordination

The surgeon with HMD was actually involved in the surgery only after the completion of the critical steps of the surgery. We used HMD during live surgery only after the completion of calots dissection and cystic duct and artery clipping during laparoscopic cholecystectomy (figure 4a and 4b). The main purpose of this phase was to see the feasibility of its use during surgery, hand eye coordination, coordination between main surgeon and assistant and ease of instrument exchange.

Complete surgery using HMD

We performed three laparoscopic cholecystectomy using HMD (figure 5). All three cases were female patient aged 34, 36 and 45 years of age without prior history of acute or chronic cholecystitis. Mean operation time was 30 minutes. All patients were discharged without complications on postoperative day two.

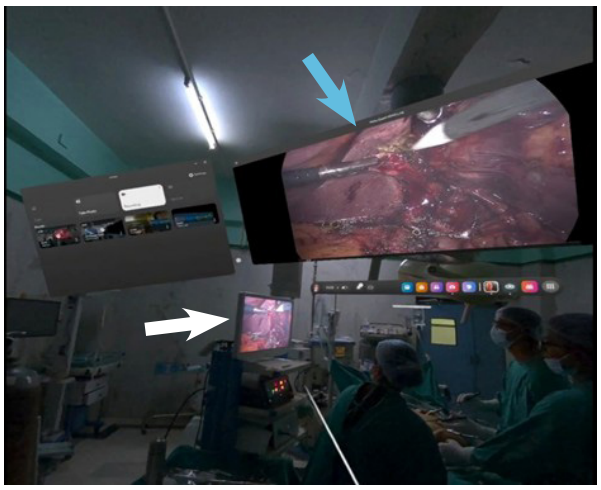

Figure 3a. *Observation by Using HMD. (White arrow showing Surgeon with HMD and Blue arrow showing surgery team performing surgery.)*

Figure 3b. *Observation by Using HMD. (White arrow pointing the real screen of laparoscopic monitor, Blue arrow head showing magnified and high-definition Virtual monitor)*

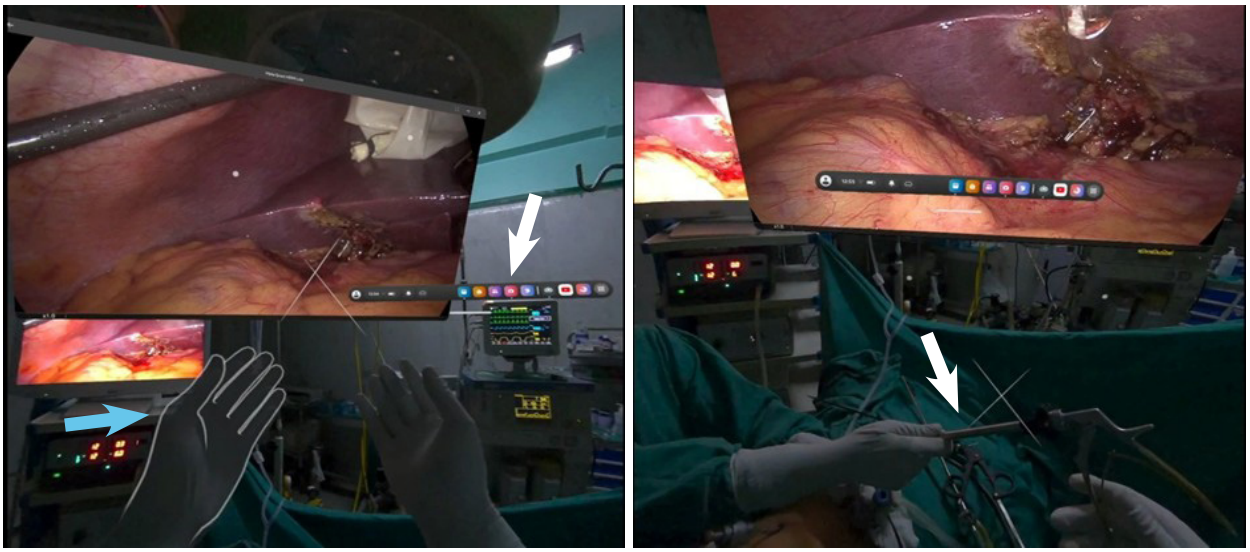

Figure 4a. Evaluation of Hand gesture coordination with the virtual monitor and application interface. (White arrow: virtual monitor tool bar, blue arrow: hand gesture control of the virtual interface) 4b. Coordination with assisting surgeon and nurse during instrument exchange and manipulation. (White arrow: Instrument exchange during the use of HMD)

DISCUSSION

There is continuous development in the field of surgery. There is improvement not only on the knowledge and approach to diseases but also rapid improvement in tools used for their diagnosis and treatment. Surgery has evolved in the same pace, where minimal invasive surgery and later robotic surgery have become standard of care for many diseases[8]. Artificial intelligence has come in rapid pace and incorporated in every aspect of human life from work to home. In the medical field, AI is finding its increasing applications in various areas, including medical imaging, diagnosis, and open or minimal invasive surgery[9].

Head mount device which was initially developed for entertainment and sports purpose have broadened their applications in different aspects of medicine and surgery[10]. VR has been favored in surgical education and it has shown to be more effective and reduce training hours for students compared to traditional methods[11]. Head mount devices are widely used by urologist and neurosurgeon[12]. Its

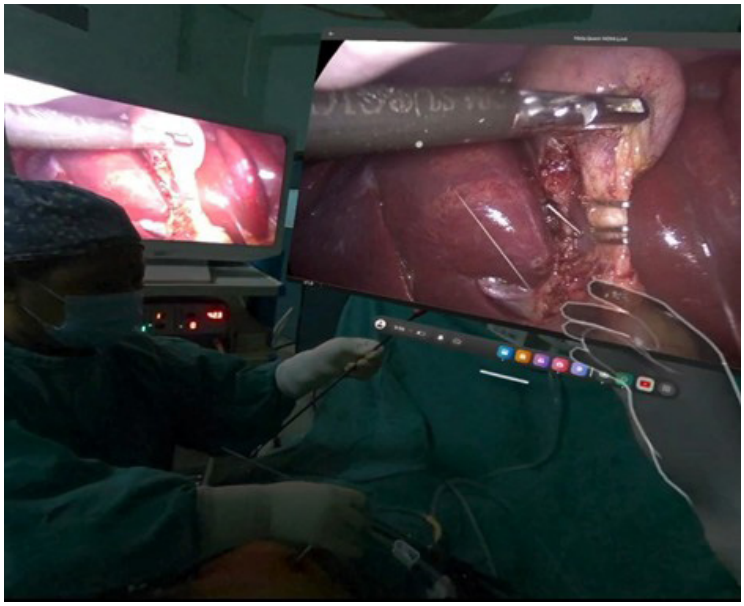

Figure 5. Performing laparoscopic cholecystectomy using HMD

use in diagnostic and therapeutic endoscopy is also increasing, with excellent results and user compliance[13]. Head mount devices (Virtual Reality device) can be used to integrate AI in medicine and surgery.

Almost all of high-end head mount devices comes with many important features. The ultra-high quality user interface comes with 3D spatial interfaces with floating panels. The recent updated applications make it well connected with internet and opens for wide range of AI integrated applications. Inside out head tacking and hand gesture commands make its use safer and user friendly in operation theater[14]. In short, head mount virtual reality system functions like wearable 3D computer with infinite possibilities.

Laparoscopic surgery has some ergonomic disadvantages, a) The strain to neck and shoulders on long surgery, b) The vision is away from the actual site of surgery, and c) The restricted magnification and aspect ratio of video output. The HMD will have less strain to neck, shoulders and the visual quality is excellen t[15].

We performed three basic laparoscopic surgery using head mount devices. The image quality and magnification were excellent. We could adjust the size and site of the display according to the need of the surgery. Moreover, we could live telecast and record the operation for academic purpose and personal surgical review. There were smooth instrument exchange and coordination with the theater assistant and staff. M Patrzyk and team compared conventional 2D laparoscopic system with the 3D HMD, and found the image sharpness and contrast to be better in HMD compared to conventional laparoscopic system[16].

There were few drawbacks of the HMD that we used. The size of the device was heavy, which in longer surgery could have more strain to neck and eyes. The device has older Fresnel lens system which has blur vision towards the periphery of the image. The virtual reality glasses might be lighter and more affordable option in future and with added augmentation reality it might change the way we operate in coming decades[17].

CONCLUSION

The use of head mount display provides excellent magnified vision and opens door for possible future AI assisted and navigated surgical and other interventional procedures.

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CONFLICT OF INTEREST

The author(s) declare that they do not have any conflicts of interest with respect to the research, authorship, and/or publication of this article.

AUTHOR CONTRIBUTIONS

- Sujan Shrestha (Main Author)- Research Concept, design, literature review, manuscript writing
- Sandesh Doranga- Literature review, data collection
- Sushil Mishra- Literature review, data collection
- Shiba Shrestha- Research concept, manuscript writing
- Binod Bade Shrestha- Literature review, data collection, manuscript writing
- Pradeep Ghimire- Literature review, manuscript writing

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