Orthopaedic Surgical TRaining with Virtual Reality: OySTeR-VR

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Abstract

Manchester University NHS Foundation Trust developed and completed the OySTeR-VR project, comprising of the recording and production of 360° virtual reality videos of orthopaedic surgical procedures. These were collated into a library of high quality educational films, enabling a fully immersive educational experience for the training and development of orthopaedic trainees.

Keywords

Virtual Reality · Orthopaedics · Surgery · Training · Innovation

1 Company Description

Manchester University NHS Foundation Trust is one of the largest acute care trusts in the UK, providing comprehensive care to a population of 750,000 over 9 hospitals. Our vision is to improve the health and quality of life of our diverse population by building an organisation that excels in quality, safety, patient experience, research, innovation and teaching.

The Trauma and Orthopaedic (T&O) department delivers care to patients with a variety of musculoskeletal conditions from major trauma to chronic osteoarthritis. Through a large multidisciplinary team, we provide care to these patients, and our services include both emergency and planned surgery.

The NHS is responsible not only for the healthcare of patients throughout the UK, but also the training of the next generation of healthcare professionals. The training of consultant trauma and orthopaedic surgeons takes a minimum of 10 years after

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graduation from medical school. Manchester University NHS Foundation Trust provides training to these doctors, at various stages of their progression, as they rotate through a programme around the North West of England.

2 Project Summary

In collaboration with Manchester Metropolitan University and Mativision, the OySTeR-VR project was established to create a video library of surgical techniques, for a number of orthopaedic procedures. During the project, surgery was filmed in 360° high definition, and via a production team an educational virtual reality video was created, allowing the trainee to be 'inside' the operating theatre.

3 Project Details

3.1 Challenge

The application of virtual reality (VR) in surgery has been established for over 20 years, with particular interest in the role it can play in surgical training (Coleman et al., 1994). Traditionally surgical training has taken a master-apprentice model to develop the skills required for operating, however, over the past two decades there has been change due to a number of factors affecting training (Torkington et al., 2000). Around the world there have been restrictions on the number of hours surgeons can work, increased focus on patient safety and drive towards a more consultant-led service (Torkington et al., 2000; Badash et al., 2016; McCloy & Stone, 2001), which have led to a need for more training outside the operating theatre, and the dramatic advance in technology has enabled the use of virtual reality and simulators to have an expanded role.

Randomised Controlled Trials have reported the benefits of improved operating room performance following training on VR simulators for many years (Seymour et al., 2002), and a recent meta-analysis of trials investigating the use of VR in surgical training reported that it can reduce the operative time and improve operative performance in laparoscopic surgery (Nagendran et al., 2013). VR use has been expanded in surgical training in a number of fields including neurosurgery, vascular surgery, facial reconstruction (Badash et al., 2016) and orthopaedics, with reviews having found benefits in training for knee and shoulder arthroscopy using VR (Bartlett et al., 2018).

Medical applications and internet resources are increasingly used in training and clinical practice, and platforms such as YouTube and VuMedi allow clinicians to access videos to better understand surgical procedures and techniques (Vosburgh et al., 2013). The near universal ownership of smartphones amongst healthcare professionals and increasing number of devices with native AR and VR functionality, has allowed mainstream adoption of VR. Surgical videos can now be recorded in 360°and the next step is to stream such immersive videos as part of surgical training.

Throughout the process, it is vital to maintain attention to patient safety and anonymity. Informed consent of both the patient and healthcare professionals involved must be carefully considered and recorded. As with any electronic patient record, clinicians have a duty of care to maintain and protect patient confidentiality. Healthcare professionals must abide by the code of practice for confidentiality (NHS, 2003), and regulatory authorities for hospitals and clinicians highlight the importance of security for electronically stored patient data and has extensive guidance on handling patient information (GMC, 2017). In most countries, there are legal requirements to protect personal data, such as the GDPR across Europe, and all parties involved should be familiar with these (General Data Protection Regulation, 2016).

3.2 Solution

We present a case study of our experiences in recording shoulder surgery, for the development of virtual reality educational videos, and how we utilise a standard operating procedure to regulate the process of preparing and filming in an operating theatre using a 360° camera and close-up camera.

1. Pre-production meeting:
   A pre-production meeting or meetings where relevant with everyone involved in the project.
2. Meeting objectives:
   - Project brief is outlined discussing what is going to be filmed
   - Ideas, questions and concerns will be established including camera-rigging ideas, maintaining sterility and patient confidentiality.
3. Filming environment assessment:
   Assess the operating theatre where filming will take place. Considerations include:
   - Patient safety must be at the forefront
   - What steps can be taken to ensure patient confidentiality
   - Consider camera-rigging options
4. Pre-surgery preparations and rehearsal:
   Long before shooting the first film, practice or rehearsal sessions must take place in the operating theatre where filming will take place. This will serve as a great opportunity to
   - Practice camera and equipment positioning.
   - Test camera lighting settings and controls.
   - Learn and practice how to use recording and downloading functions on arthroscopic or endoscopic stack systems.

We worked through multiple set ups and found the following was the best set up for recording in our case, which was an arthroscopic shoulder procedure (Figs. 1 and

Fig. 1 Theatre set up for recording, with sterile drape for camera stand, and confidential information hidden

2). This will vary depending on the set up of the theatre and the operation being recorded. We found the best position for the 360° was level with the patient on the operating table, ensuring that the viewer using a VR headset can see this in a neutral head position, making viewing more comfortable. The camera stands were covered with a sterile drape, allowing positioning to a central location, without compromising sterility.

5. On the day of surgery:
   - Patient and actor consent forms must be completed before the patient comes to the operating theatre.
   - Be considerate and aware of sterility in the operating theatre.
   - Once set up is complete, an agreed upon signal (such as 2 loud claps) will identify the start of the recording, and allow the post-production team to sync the various recording devices.
6. Editing and voice over commentary:
   Post production editing is a key part of the final production and the clinicians should work closely with the film editing team to develop a clip that delivers the most educational value.
   - Films must be synchronized so that the 360° recording is compatible with the close-up views and overlays.
   - Post filming voice over commentary rather than live commentary.

Fig. 2 Theatre set up for recording, showing position of close up camera

- The final production should highlight the steps in the surgery that are of most educational benefit, and we recommend limiting it to 15 min.
- The main focus during the filming can be overlaid and should be positioned centrally (Fig. 3). Accessory information, such as radiology images or anatomical diagrams should be available in the periphery.

3.3 Benefits

Recent changes in surgical training, and the way healthcare is delivered throughout the world have led to need for more training outside the operating theatre. The videos created allowed an immersive experience for trainees to see operations in a virtual reality setting. Through the video library, trainees were able to access these to supplement the training received in the operating theatre and the classroom.

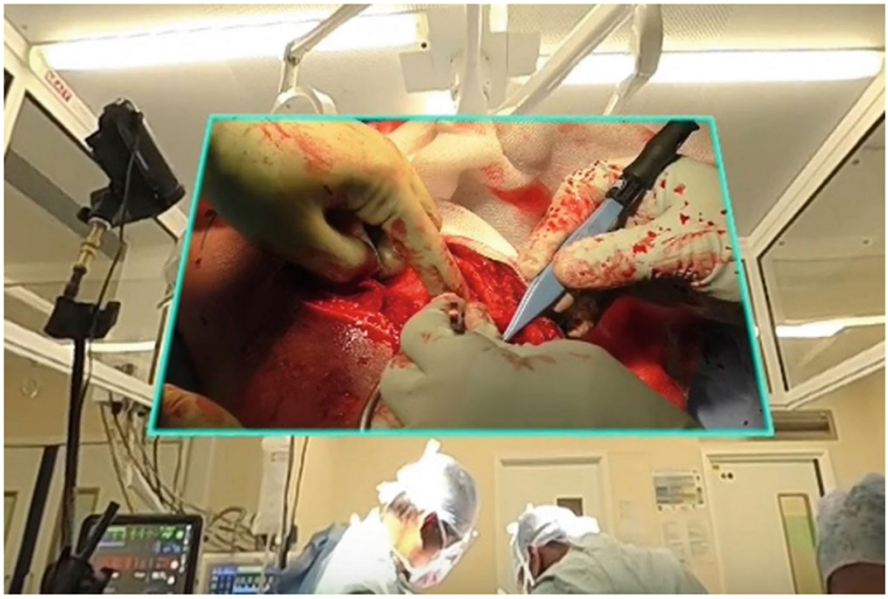

Fig. 3 Close up of surgery overlaid onto 360° film of operating theatre

4 Feedback from End Users

Following the production of the videos, trainees were interviewed on their experience with the virtual reality. Responses were very positive, and all participants enjoyed using the VR video. It was felt that this 360-degree video could be effective in providing a more detailed insight along with a clear explanation with the parallel PowerPoint presentation, when compared with a 2D video.

5 Future Outlook/Roadmap

There are multiple applications for VR in medical education, such as in the teaching of anatomy and virtual reality immersive recording of operations for training purposes (Khor et al., 2016). The training modalities outside of the operating room now include surgical simulators and multimedia presentations including surgical technique videos. Recent advances in VR technology and recording equipment has enabled the integration of surgical training videos with rich, interactive multimedia presentations in a truly immersive 360° virtual environment.

Further developments have included the first operation to be live streamed in 360° VR around the world in 2016 (Davis, 2016). This has since been replicated by many teams, and live surgery now forms part of many educational meetings (Khor et al., 2016). With the recent exponential increase in the role of VR in surgical training,

there are now over 400 commercially available surgical simulators (Bartlett et al., 2018). It is estimated that the global augmented reality (AR) and virtual reality healthcare industry is already worth $769 m and projected to be worth $4.9b by 2023 (BusinessWire, 2018).

Manchester University NHS Foundation Trust, through its ongoing collaboration with Manchester Metropolitan University, is working on a number of projects to explore further uses of VR in healthcare. Such projects include the researching of VR and gamification in rehabilitation of musculoskeletal conditions, and further analysis of the use of VR in surgical training.

6 Conclusion

The OySTeR-VR project has been very successful in creating educational videos for surgical trainees. As the use and application of VR in medical education continues to grow, our case study demonstrates and provides a framework of how operations can be filmed in 360° in a safe manner, whilst protecting patient confidentiality and the laws governing data management, to create high quality immersive learning experiences.

The ever-improving technology combined with its increasing affordability means that the role of VR in surgical training will expand significantly over the next decade.

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