Virtually a surgeon – An elective in Melbourne

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Virtual reality (VR) is increasingly becoming part of our lives whether it be for recreation, education, or vocational training. VR is a computer generated environment, providing the user with a range of sensory stimuli, including auditory, visual, and touch, to immerse them in an experience. No longer is VR confined to the classified training of NASA's astronauts, anyone with a smartphone and £15 to spare can experience VR with 'Google cardboard' or other similar products. A growing number of fields are incorporating VR simulation into training their employees, ranging from Walmart's supermarket employees, to airline pilots, to police officers, and of course surgeons.

The University of Melbourne VR Temporal Bone Simulator has been developed to provide a risk free environment for learning ear surgery. The simulator presents the user with a 3D image with which they can 'feel' and interact with using a virtual drill provided by a haptic arm. It was first validated in 2008 and is one of five such systems to have been developed worldwide. I decided to go to the Department of Otolaryngology at the University of Melbourne, based in the Royal Victorian Eye and Ear Hospital, to get a better understanding of how this technology is being applied to surgical training.

Throughout my placement, I worked on a research project with the VR simulator as well as observing a wide range of ear pathology and surgery as an observer in the hospital.

The Royal Victorian Eye and Ear Hospital is a tertiary referral centre, which allowed me to see a diverse selection of ear pathology and surgery ranging from the routine, such as myringoplasties, to the rare such as a superior semicircular canal dehiscence repair. This was an interesting contrast to my medical school ENT placement at a small general district hospital. As you would expect from the department that carried out the first cochlear implant operation in 1978, the hospital remains a major cochlear implant centre and continues to lead innovations of this life-changing technology. The weekly cochlear implant meetings gave me an overview of the cases being referred to the department and the many considerations of ENT surgeons and audiologists when planning and following up this procedure. As part of the ongoing research output of this department I saw several cochlear implant operations incorporating novel experimental techniques, including electrocochleography and impedance measurements to detect intracochlear trauma during electrode insertion. It was exciting to be immersed in such a dynamic environment and to gain a preview of where the specialty is heading, reconfirming my aspiration to pursue an academic career in ENT.

As a temporary member of the research department I attended the weekly research group meetings, where the group reported the progress of the diverse array of projects going on in the department, ranging from experimental surgery in animal models to novel ways of measuring cochlear electrode insertion angles. These meetings highlighted the benefits of having interdisciplinary research teams, as researchers from assorted backgrounds (including engineering, medicine, biology, and computer science) worked together to solve problems. I also represented the department at "Melbourne Knowledge Week", demonstrating the simulator to the estimated 2000 attendees of the "AI and robotics showcase". This was an enjoyable introduction to the public engagement element of research that is an important component of an academic career.

My research project investigated the effect of patient-specific VR preoperative rehearsal on cortical mastoidectomy performance. Rehearsal is common in many spheres of society, including music, sport, and aviation. Like surgery, these areas depend on manual dexterity and skill for optimal performance. The study involved recruiting 40 University students and training them to complete a cortical mastoidectomy on the University of Melbourne VR simulator over two consecutive days, before asking them to perform the procedure on two 3D printed bones (figure 1). These 3D printed bones were built using micro-CT scans, with segmented internal structures, from the VR simulator. I was involved in preparing the models for printing and manufacturing them for the study, which taught me much about 3D printing techniques. Through carrying out this randomised controlled trial, I further learnt a lot about designing a study, applying for ethics, recruiting study participants, and data analysis. Additionally, this project gave me the opportunity to learn the stages of a cortical mastoidectomy and practice them extensively on the VR simulator and 3D printed bones. This not only gave me an insight into the experience of operating, but will undoubtedly be helpful if I succeed in my aspiration to enter ENT training. As background for the project I gained familiarity with current surgical training techniques, reading surgical temporal bone dissection manuals, attending a temporal bone dissection course, and watching operations in theatre. Whilst the project itself gave me experience working with the emerging surgical training modalities provided by VR and 3D printed bones. These activities have greatly improved my understanding of what surgical training currently involves and filled me with ideas about how it might be modernised to incorporate emerging technologies.

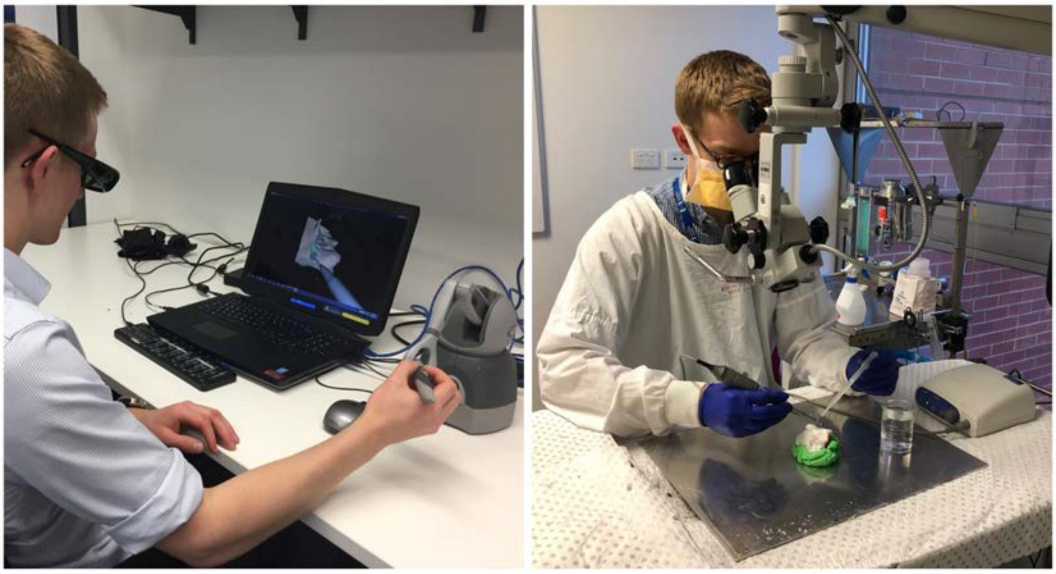

Figure 1: The author working on his surgical skills on the University of Melbourne Virtual Reality Temporal Bone Simulator on the left and on a 3D printed temporal bone on the right.

The study participants were split evenly into a rehearsal and control group; the rehearsal group received 3D printed bones they had already practiced on in VR the same day, whereas the control group received two previously unseen 3D printed bones (figure 2). The bones were graded using the recently developed Melbourne Mastoidectomy Score, that I was involved in creating. The standardised grading of temporal bone dissections was an informative process, emphasising the technical features of a high quality dissection, and further demonstrating a system for competency based training. With validated objective performance scores also comes the possibility of automating surgical performance metrics. Automated feedback would free trainees from the time restrictions of the apprenticeship model of surgical training, where trainees are supervised by an expert surgeon, allowing surgical training to become more flexible and self-directed than ever before.

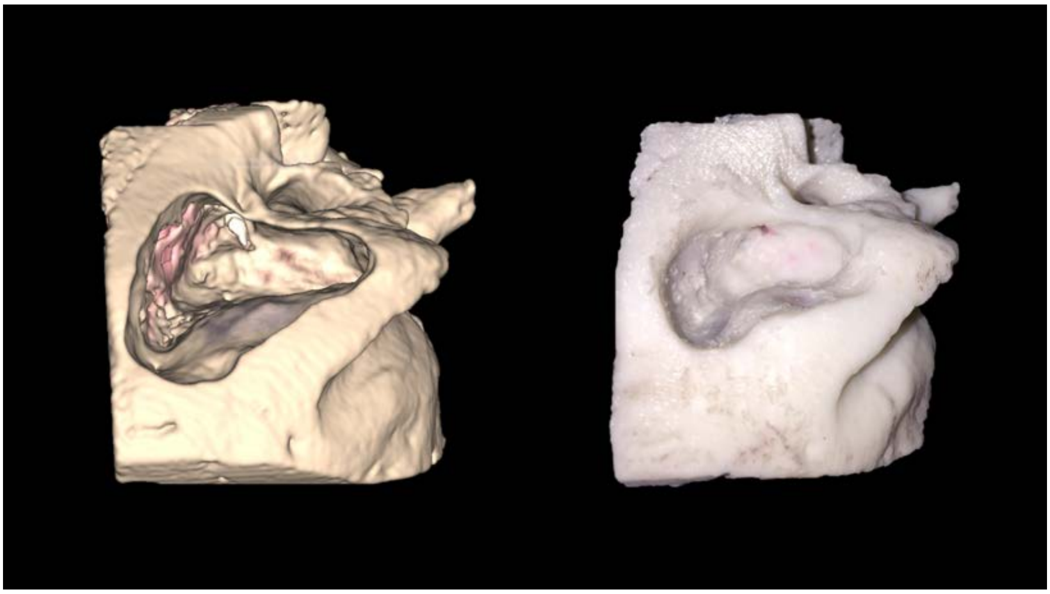

Figure 2. A cortical mastoidectomy completed on the same bone in virtual reality on the left and on a 3D printed bone on the right.

After spending this time working on novel forms of surgical simulation (VR and 3D printed bones) it's hard to not be excited by their potential to revolutionise surgical training into a high volume, low risk curriculum. Malcom Gladwell popularised the 10,000 hour rule in his book "Outliers", it describes the length of time engaged in practice required to become a world expert in a field. These new training modalities offer surgeons the potential to achieve the idealised 10,000 hours of operating experience, despite shortening working hours and limited cadaveric bone availability. Would you rather your surgeon had performed a single cortical mastoidectomy on a cadaveric bone or 1000 on a VR simulator? Surgical training is already shifting to a competency rather than time based system; new technology combined with objective, validated scoring systems could expand this practice much further. Could future surgical portfolios become like that of artists (figure 3), showcasing their finest work?

In addition to giving me optimism for the future of surgical training, this elective caused me to reflect on what the current limitations are to modernising training programmes. A frequent limitation of new technology is its real or perceived cost, highlighting the need for good quality evidence of its effectiveness to justify and optimise its incorporation into routine practice. Despite initial investment required to purchase a VR simulator or 3D printer, both these technologies potentially offer long term cost saving options. VR simulators allow trainees to have an unlimited environment to practicing their surgical skills in, whilst building a library of simulator models from CT-data of pathological temporal bones could help prepare trainees for rare conditions and diversify their training load. 3D printers also offer the possibility of high volume operative practice (figure 3), with the dual benefit of preserving the precious resource cadaveric temporal bones for more senior trainees who will gain the greatest benefit from this valuable resource. The use of cheap printing materials, such as PLA, can bring the cost per temporal bone model down to less than £1.

Figure 3. Could future surgical portfolios include examples of your work? A box full of drilled 3D printed temporal bone models: 80 cortical mastoidectomies for ~£50 of plastic.

Another undeniable benefit of my elective was the opportunity to travel around Australia; Victoria is a beautiful state perfect for the outdoor enthusiast. The weekends offered the opportunity to explore the towering sandstone of the prehistoric sea cliffs of Mount Arapiles and the Grampians National Parks (figure 4).

Figure 4. The author exploring the surrounding rock climbing of Victoria at the weekend.

In conclusion, my elective has given me the opportunity to visit a world-renowned ENT department, gain a detailed knowledge of a common ENT procedure, familiarise myself with current and emerging surgical training techniques, and to broaden my research skill set gaining experience working with VR and 3D printing. The experience has confirmed both my desire to pursue a career in ENT and to apply for an academic training job, and above all it was a lot of fun.

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