The use of a microscope integrated three-dimensional camera display system as a valuable aid in delivering human anatomy workshops

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**Abstract**

**Introduction:** Whole body dissection significantly improves a student's knowledge of anatomy, but the costs associated with utilising human cadavers are often prohibitive. This study introduces innovative three-dimensional (3D) anatomical image display to aid the learning process.

**Methods:** Small-group prosection demonstrations were delivered to second year pre-clinical medical students using 3D microscope and display.

**Results:** Students were shown different head and neck structures and their anatomical relations. Hundred and fifty students (94.3%) agreed that 3D image display was useful for learning anatomy. Difficulties in viewing 3D content were reported by 21 students (13.2%). Students highlighted the usefulness of 3D derived imaging in viewing small structures and that it helped with consolidating their spatial anatomical knowledge.

**Conclusion:** 3D technology is becoming popular in clinical medicine, training and education. This study has shown that anatomy demonstrations delivered using innovative 3D microscope derived images are well received by undergraduate students and are valuable adjuncts to human anatomy teaching.

**Keywords:** Undegraduate; Anatomy; Workshops; Prosections; Three-dimensional; 3D

**Introduction**

Human anatomy is complex and requires many hours of diligent study in order to acquire the necessary knowledge for safe clinical practice. While whole body dissection was shown to significantly improve a student's knowledge of
anatomy and should form an integral part of medical education (Ramsey-Stewart, Burgess and Hill, 2010), the costs associated with utilising human cadavers are often prohibitive. Currently, only a few universities in the United Kingdom offer students the opportunity of hands-on cadaveric dissection (Ali et al., 2015). This is why anatomical prosections are invaluable teaching resources, as they allow students to clearly visualise specific structures and are now commonly used in teaching (Ashdown et al., 2013). However, large groups of students, time constraints and insufficient numbers of anatomy demonstrators may create difficulties with facilitating appropriate teaching sessions. Although additional study aids, such as on-line videos, presentations and textbooks may be used to aid the learning process, these materials may not always present complex three-dimensional (3D) relationships clearly to students. Stereoscopic 3D imaging creates an illusion of depth in an image, and can be helpful in improving spatial knowledge acquisition (Estevez, Lindgren and Bergethon, 2010; Hoyek et al., 2014). Even though 3D technology, in various forms, is now widely applied in healthcare, to our knowledge 3D technology is not generally used in anatomy teaching programmes, partly due to uncertainty over its effectiveness and its acceptance by students. This study aims to introduce 3D anatomical image capture and display in small-group anatomy tutorials, after which student feedback was obtained.

Methods

Relevant prosections were placed under Zeiss operating microscope (S7) with integrated TruVision® 3D camera system. The images from the camera were transmitted onto a passive 3D 50-inch flat screen TV using proprietary software, with students wearing compatible 3D glasses in order to view the images in 3D. Three demonstrations (middle ear, the orbit, and anatomy of cranial nerves exiting the brain steam) were delivered to groups of 15-20 second year pre-clinical medical students. Each demonstration lasted approximately 15 minutes. Students were shown different structures, their anatomical relations and clinical significance. Students were encouraged to ask questions throughout the demonstration, which was designed to be interactive. An evaluation questionnaire was sent to all the students at the end of the course, where they rated the following statements on a 5-point Likert scale, ranging from 'Strongly Disagree' to 'Strongly Agree':

1. The 3D imaging station was useful for learning head & neck anatomy
2. I believe 3D microscope imaging to be useful for viewing small anatomical structures
3. I have experienced difficulties watching 3D imaging sessions
4. More 3D imaging sessions would be helpful

In addition, the students could also specify any problems they might have experienced with 3D imaging, such as headaches or blurred vision, and to provide any additional feedback in free text.

Results

Completed evaluations were received from 159 students, which approximated to 56% response rate. On a scale of "Strongly Disagree" (1) to "Strongly Agree" (5), 150 students (94.3%) either 'strongly agreed' or 'agreed' that 3D image display was useful for learning anatomy and 155 (97.5%) believed that 3D microscope imaging was useful for viewing and learning small anatomical structures (Fig. 1). Difficulties in viewing 3D content were reported by 21 students (13.2%), specifically problems with focusing on images (most commonly reported), wearing 3D glasses over prescription glasses, dizziness, and headache. Furthermore, 127 students (79.9%) indicated that they would like to have more sessions delivered in 3D, with only 24 students (15.1%) being 'indifferent'. In the free comments section, students highlighted the usefulness of 3D microscope derived imaging in viewing small structures; that the sessions could have been longer, and that they helped with consolidating their spatial anatomical knowledge.
Figure 1. Results from an evaluation questionnaire, which was a 5-point Likert scale, ranging from ‘Strongly Disagree (1)’ to ‘Strongly Agree (5)’.

Discussion

Three-dimensional (3D) technology is becoming popular in clinical medicine, training and education, and this qualitative pilot study shows positive responses from medical students on a human anatomy course. While our study does not investigate the impact of ‘3D image based teaching’ on knowledge acquisition and retention, the literature suggests that positive attitudes, enthusiasm and engagement correlate with better academic performance (Valiente, Swanson and Eisenberg, 2012; Casuso-Holgado et al., 2013). This study shows that nearly 80% of respondents expressed interest in having more and longer sessions conducted using 3D technology. The students believed it was a helpful addition to the curriculum, the sessions were interactive, and they appreciated the technology, which they described as "innovative".

The 3D demonstration evaluated in this study was one of several stations that the students rotated through during head and neck anatomy module. Other stations included prosections, models and clinical or radiological images. Therefore, students participated in the 3D demonstration at different times during the session, and thus it is possible that their evaluation could have been influenced by their experiences from earlier stations, i.e. an order bias. Several students praised the workshop for clarifying misunderstandings from previous stations, which would not necessarily be true to those who started on the 3D demonstration first. Furthermore, with increasing number of medical students, it is not uncommon to have self-directed stations where students have less interaction with anatomy demonstrators. With the 3D demonstration, when the facilitator was always present, the students felt that it was more interactive, although this could also be due to differing teaching techniques employed by the demonstrators. This study also highlighted some problems which may some people may experience when viewing images (or movies) in 3D. The most commonly reported symptoms in the literature are nausea and headache, as well as eye strain, difficulty focusing, and dizziness (Solimini, 2013). In this study, 21 students had trouble with viewing 3D images, reporting similar side effects as described in the literature. Even though only a small proportion of students experienced side effects, and the majority of students found these demonstrations useful, students who had difficulties may potentially be disadvantaged compared to their peers. One of the ways to minimise this risk would be to provide a hand out, which would be in 2D, or have a complimentary station with similar specimens where the students could approach after the 3D workshop.
Additionally, the complete set up for the workshop requires a microscope, 3D camera and ways of projecting the images, which could be either a 3D TV screen or 3D projector, and specialised 3D glasses. This equipment is not inexpensive, despite the fact that 3D technology has been available for several years. However, prices are decreasing, and second hand equipment, such as microscopes or older model 3D TV screens, could be a solution for high cost. However, a more time efficient alternative would be to utilise a 3D projector (and glasses) and to conduct the workshops in a larger space, which can accommodate large numbers of students, such as a lecture theatre.

Lectures delivered in 3D have been shown to be beneficial for anatomy learning and increase test scores in undergraduate training (Müller-Stich et al., 2013), as well as enhance postgraduate surgical training (Clark et al., 2017). There are resources available online to download 3D images free of charge, however, these are limited to selected body parts, such as the brain. Anatomy departments could acquire their own 3D images of existing and new prosections in order to expand this library, although this would incur further costs. A major advantage of the demonstration is that the teaching is done ‘live’ and can be adjusted according to students’ expectations or questions, compared to standard lectures where the material is set and there is often very little room to manoeuvre.

Conclusion

Three-dimensional (3D) technology is becoming a popular tool in undergraduate and postgraduate education, especially in anatomy teaching and surgical training. This pilot study has shown that anatomy demonstrations delivered using 3D microscope derived images are well received by undergraduate students, results in strong positive feedback, and constitute a valuable adjunct in anatomy teaching.

Take Home Messages

1. 3D technology is a useful adjunct to traditional anatomy teaching workshops
2. This technology helps student to consolidate their spatial anatomical knowledge
3. Students acknowledged the usefulness of 3D technology
4. More 3D workshops are desired by the students

Notes On Contributors

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Appendices

None.
Declarations

The author has declared that there are no conflicts of interest.

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Ethics Statement

Responses were collected as a part of the curriculum review that is performed every year by the faculty members delivering anatomy teachings at University of Cambridge. Ethical approval was therefore not required for collection and publication of the data.

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