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Innovative 3D visualisation and artificial intelligence tools augment medical education and clinical practice

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EDITOR NOTE

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ABSTRACT

Three-dimensional (3D) visualisations including 3D printing, virtual reality (VR), augmented reality (AR) or mixed reality (MR) are increasingly used in the medical field with evidence proving their value in many applications, ranging from medical education to pre-operative planning and simulation of complex surgical procedures, enhancing communication between doctor-patients and with clinical colleagues[1-30]. 3D printed models derived from medical imaging datasets, mainly from computed tomography (CT) and magnetic resonance imaging (MRI) replicate anatomical structures and pathologies with high accuracy and reliability, thus serving as a very useful tool in medical education such as learning anatomy and pathology when compared to the traditional teaching methods using cadavers and specimens. 3D printed models also provide the user with tactile experience when holding the physical models in hand and this is extremely useful for clinicians to explain the diseased conditions to patients. Further, with models printed using soft and elastic materials, 3D printed models can be used as a training tool for young or inexperienced doctors or trainees to improve their practical skills on surgical procedures before they operative on patients[31-33].

VR/AR/MR represents another innovative 3D visualisation tool by providing immersive environment to demonstrate realistic 3D relationship between different structures. These visualisations are showing great promise in the medical domain with increasing reports in the literature[34-36]. Studies have shown the usefulness of using these visualisations in medical education and clinical practice such as pre-operative planning for outcome improvement[37]. A recent study comparing MR and 3D printing technologies with original CT imaging in the assessment of congenital heart disease (CHD) has further highlighted the clinical value of these novel visualisation tools[38]. Lau et al compared these two modalities with the standard image visualisation in the diagnostic assessment of two types of CHD, atrial septal defect and double outlet right ventricle which represent simple and complex CHD conditions. Authors recruited 34 clinicians to assess the value of these modalities in terms of education, preoperative planning and intraoperative guidance. Their results showed MR was ranked as the best modality for understanding complex CHD lesions by providing depth perception, displaying 3D spatial relationship between cardiac structures, serving as an educational tool for pathology and facilitating preoperative planning of CHD surgeries. 3D printed heart models were ranked as the best modality for enhancing communication with patients. This study emphasises the additional value of using both 3D printing and MR in improving clinical diagnosis and management of CHD.

Artificial intelligence (AI), in particular machine learning (ML) and deep learning (DL) tools have shown huge potential in medical applications and clinical value of using ML and DL in medicine has been validated in many studies across a wide spectrum of areas, ranging from diagnosis to disease prediction and outcome improvement[39-47]. The main advantages of ML and DL algorithms lie in their rapid, efficient and reliable automated detection and analysis of large datasets with results comparable to human observers. Some examples of these applications include automated detection or quantification of disease such as coronary calcium or stenosis which represents one of the common applications in cardiovascular field. It is generally agreed that AI can serve as a complementary tool to increase workflow and clinical performance.

In the March issue of AMJ, there are three student articles reporting their experience of using these modalities in medical applications[48-50]. The article by Williams et al reported the student experience of using open source software tools for image post-processing and segmentation of a sample MRI brain dataset. As detailed in the article, the whole image processing process involves a combination of manual and semi- and automatic segmentation steps with cerebral lobes, cerebellum, brain stem and ventricle systems successfully segmented. These structures were printed with different colours and assembled together for excellent demonstration of 3D printed brain models. The models can be used for medical education and clinical practice which will be explored in further studies as highlighted in the article.

The article by Delpech et al reported the clinical value of applying VR visualisation tool in pre-surgical planning of malignant hepatic tumours[49]. Researcher's first chose two sample cases with one being hepatocellular carcinoma with multiple focal lesions in the liver while another one cholangiocarcinoma. Similar to what Williams et al described, they also used manual and semi-automatic approaches to process CT images of these cases. In addition to segmenting the tumours, they also segmented liver parenchyma, portal veins and hepatic veins, as well as dilated bile ducts (for the cholangiocarcinoma case only). VR views were successfully generated to demonstrate realistic relationship between tumours and surrounding hepatic structures. Initial experience shows potential value in pre-operative planning when compared to the routine 2D/3D visualisations, although further research is needed to determine if the VR tool can enhance specialists (liver surgeons) in managing patients with improved clinical outcomes.

The article by Silberstein and Sun presented the usefulness of using a recently developed AI for automated detection of osteoporotic vertebral fractures (OVFs) in elderly women who had chest x-ray examinations not referred for spinal disorders[50]. The new AI tool, Ofeye 1.0 has been tested and validated at a multi-site study in China showing high diagnostic value in the detection of OVFs[51]. This student paper reported the initial experience of using the Ofeye 1.0 in the analysis of chest radiographs from Caucasian populations which has not been reported in the literature. The AI tool is able to detect or highlight potential OVFs, even with mild degree such as less than 20% vertebral height loss on the lateral chest radiographs which are commonly missed on the radiological reports. Given its efficiency and accuracy, the AI tool can be used as a complementary method to routine diagnostic reports as chest x-ray is a very common imaging procedure, thus increasing workflow and clinical performance.

In summary, these three student papers highlight the novel and innovative 3D visualisation and AI tools in medical applications. Although these early reports presented some preliminary findings, the results showcase the potential value of these modalities in improving both education and clinical practice. Given the ongoing research of these studies presented in these articles, we expect more robust findings to be available very soon.

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