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### **Short Communication**

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# 3D modelling for realistic training and learning



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#### **Abstract**

**Objectives:** Three-dimensional (3D) reconstruction and modelling techniques based on computer vision have shown significant progress in recent years. Patient-specific models, which are derived from the imaging data set and are anatomically consistent with each other, are important for the development of knowledge and skills. The purpose of this article is to share information about three-dimensional (3D) reconstruction and modelling techniques and its importance in medical education.

**Methods:** As 3D printing technology develops and costs are lower, adaptation to the original model will increase, thus making models suitable for the anatomical structure and texture. 3D printing has emerged as an innovative way to help surgeons implement more complex procedures.

**Results:** Recent studies have shown that 3D modelling is a powerful tool for pre-operative planning, proofing, and decision-making. 3D models have excellent potential for alternative interventions and surgical training on both normal and pathological anatomy. 3D printing is an attractive, powerful and versatile technology.

**Conclusions:** Patient-specific models can improve performance and improve learning faster, while improving the knowledge, management and confidence of trainees, whatever their area of expertise. Physical interaction with models has proven to be the key to gaining the necessary motor skills for surgical intervention.

**Keywords:** 3D printing technology; learning; medical education; surgical training.

#### Öz

**Amaç:** Bilgisayar vizyonuna dayanan üç boyutlu rekonstrüksiyon ve modelleme teknikleri son yıllarda önemli

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ilerlemeler göstermiştir. Görüntüleme veri havuzundan türetilen ve anatomik olarak birbiriyle uyumlu olan hastaya özgü modeller, bilgi ve becerilerin geliştirilmesi açısından önemlidir.

**Yöntem:** 3D baskı teknolojisi geliştikçe ve maliyetler düştükçe, orjinal modele uyum artacak, böylece anatomik yapı ve dokuya uygun modeller yapılacaktır. 3D baskı, cerrahların karmaşık uygulamalarına yardımcı olmak için yenilikçi bir yol olarak ortaya çıkmıştır.

**Sonuçlar:** Son çalışmalar 3D modellemenin ameliyat öncesi planlamada, provada ve karar vermede güçlü bir araç olduğunu göstermektedir. 3D modeller, normal ve patolojik anatomi üzerinde alternatif müdahaleler ve cerrahi eğitim için mükemmel bir potansiyele sahiptir. 3D baskı, çekici, güçlü ve çok yönlü bir teknolojidir.

**Tartışma:** Hastaya özgü modeller, uzmanlık alanları ne olursa olsun, öğrencilerin bilgi, yönetim ve güvenini geliştirirken performansa ve öğrenmeye daha hızlı katkı sağlayabilir. Modellerle fiziksel etkileşimin cerrahi müdahale için gerekli motor becerileri kazanmanın anahtarı olduğu kanıtlanmıstır.

**Anahtar kelimeler:** 3D baskı teknolojisi; tıp eğitimi; öğrenme; cerrahi eğitim.

## Introduction

Human body and anatomy is complex and highly variable which creates a challenge in medical education. Animals, cadavers, plastinated specimens and anatomical models have been used to overcome this challenge however all have limitations such as providing only an approximate of human body without live tissue characteristics and/or high cost and/or requiring a controlled environment and/or ethical, legal and cultural issues [1].

Nevertheless, for many years, dissection of the human body to support anatomy education has been the only tool that provided visual and tactile experience. Dissection is the approach that best gives a real perception of anatomical structures and the relationships with surrounding veins and tissues thus reinforcing the knowledge learned in the lessons. However, it has been reported that for some students, the unpleasant feelings related to aversion, anxiety, aesthetic, formalin use, terrible stench, or coexistence in same rooms with cadavers may cause psychological impacts which may serve as an obstacle to learning [2].

The need for a relatively cheap, scalable, easy to store, reproducible, capable of showing surrounding environment, dissectible, and not entailing the same ethical/legal issues as the traditional methods of teaching anatomy was one of the main concerns for medical educators.

# 3D modelling and importance

Three-dimensional (3D) reconstruction and modelling techniques are based on uploading a digital (CAD) file to a 3D printer, which then prints a solid 3D object. The technology is also known as 'additive manufacturing', because it adds layer upon layer of material (thermoplastics, photopolymers, human cells and gelatin, epoxy resins, metals, etc.) to build an object. Significant developments in the field led to the introduction of the 3D technology as a new learning and teaching tool for undergraduate and postgraduate medical education as well [3].

The benefit of this technology is similar to the plastination technique in which the human tissue has been preserved using a plastic material to produce a flexible and vigorous anatomic model. However, its use and preservation is easier to produce than plastinated samples, cheaper to manufacture and does not require special laboratory [4].

As 3D has been used in anatomy education, its use in clinical education (preprocedural planning or technical skills) has come to stage. By using 3D models in clinics, students are provided with a more tactile experience (like palpating a soft tissue with a rigid mass).

Traditionally, surgeons plan operations based on the CT and MRI images of patients' conditions. While these images can illustrate a patient's organ from different angles, they might not show all tissues and blood vessels that may be blocked by larger organs. However, realistic, accurate and versatile models can be prepared in less time and at a fraction of the cost with 3D printing technology from Digital Imaging and Communications in Medicine (DICOM) data derived during CT, MRI or ultrasound scanning. CT and MRI are widely used in 2D imaging of human body in radiology. Better models can be prepared by combining data from multiple imaging sources. The medical imaging process is like many 2D images taken sequentially and separated by a predetermined thickness. 3D models are created by stacking these images in successive layers. As the thickness between each layer increases, the accuracy of the 3D model is reduced. While preparing 3D models; the size of the model, surrounding structures, surgical intervention and the details required for the targeted procedure should be considered. Models combining soft tissues and skeleton, such as the lungs and thorax, are made from CT images and require imaging optimisation for multiple tissue densities [1, 5, 6].

n the production of models; selection of the anatomical area, creation of 3D geometry, arrangement for printing, selection of 3D printer and printing materials are important technical steps [5]. Creating a 3D model requires multidisciplinary expertise and an efficient teamwork between surgeon, radiologist and engineer. By using appropriate printing materials and printers, this team can produce models that best imitate the characteristics required by organs and tissues. As 3D printing technology evolves and costs are reduced, it is possible to use printing materials and printer options that are compatible with the original structure [1, 5, 6].

Patient-specific models, which are based on the imaging data and are anatomically consistent with each other, are valuable for the acquirement of knowledge and skills. These can increase performance and learning, while improving the knowledge and self-confidence of trainees, whatever their area of expertise is. Physical interaction also provides the basis for the acquisition of psychomotor skills required for surgical intervention [5, 6]. Thus, 3D printing has emerged as an innovative preoperative training tool that provides multi-planar visualisation of anatomy and its relevant pathology. With the use of 3D models not only deeper learning is enabled in undergraduate and postgraduate medical education but also more complex surgical procedures can be planned by surgeons.

Some anatomical variations and pathological changes in the clinical conditions, where postoperative complications are common, make the problem more complex, challenging and patient-specific [6, 7]. In such cases, it is critical to see and understand coarse pathology and structural relationships before the surgery. Furthermore, the disease process and the severity vary in different individuals which require a training with innovative techniques that supplements the current traditional training methods. Recent studies have shown that 3D modelling is a powerful tool for pre-operative planning, testing, and decision-making. 3D models are highly valuable for alternative interventions and surgical training in both normal and pathological anatomy [5, 6]. In addition, these 3D printed models are used as tools when communicating the operation process to patients, thus providing a better understanding of the procedure.

# Results and discussion

3D printing is an appealing, powerful, versatile and accessible technology that can be used in teaching anatomy, planning surgery or practising procedures and medical manipulations [5]. The rapid prototyping technology applied in 3D printing provides significant support in the field of research, practice and education [1].

It is stated that the use of body parts prepared with 3D printing is like 2D images presented as a source of learning in textbooks and learning environments thus will not create an ethical problem. Medical schools may give information to transmitters for the use of their images in education [1].

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