



3D printing and its applications in Orthopedics



Dear Editor,

The world is moving towards patient-specific instrumentation which is not only useful but can also be cost-effective and the 3 Dimensional (D) printing has proven to be a promising contender. It has been successfully used in many fields however it is relatively newer to Medicine and Orthopaedic Surgery. Chuck Hall¹ is considered the father of 3D printing being the first one to develop stereolithography (STL) in 1984, which is a critical element of this technology.

It is mandatory to have a 3D file on the computer to print a model, and it can be achieved in two ways. Firstly, it can be designed on a computer using various available software and is known as computer-aided design (CAD). The other way is to convert a computed tomography (CT) scan images into 3D printable format images, using other software. From both techniques, an STL file is generated which can be further checked for errors and fixed according to one's specifications and needs to make it ready for final printing. Before this can be achieved this STL file, have to run through a slicer software which slices this 3D model into thin layers and generates a G-code² which is a standard language for most 3D printers where most of the commands start with the letter G and hence the name.

There are various 3D printing devices available which work on either an additive or subtractive principles. In additive manufacturing, the material is added layer by layer to manufacture a model, whereas insubtractive manufacturing the printer

deletes the unwanted material. There are variety of materials used to make a 3D model, like ABS printable polymers, Plastics (PLA, TPTE, Resin, High detail resin flexible, nylon) and metal composite (aluminum, bronze, copper, brass, gold, titanium) are available.³ Apart from the difference in the materials and technology, the 3D printers also have different resolutions. As a rule of thumb, higher the resolution better is the end product fineness, and it depends on the dots of material per inch of building board used. Most machines use a minimum dpi of 250 and the maximum being 1600.

3D printers have been used successfully in various fields, such as craniofacial, plastic, urology, dental surgery and in aerospace but its use in Orthopedics is relatively recent and not well known to most surgeons, although it has tremendous implications and benefits. It is known that the operative complications in the majority of the complex orthopedic cases are due to prolonged operative time, intraoperative bleeding, extended anesthesia time and high doses of medications⁴ and it happens due to inaccurate pre-operative planning. These problems can be avoided by pre-operative planning using a 3D printed model. A 3D printed model can help the surgical team to understand the problem accurately and also plan the procedure to be performed in vitro with precision.⁵ It not only improves the execution of a surgical procedure but also helps in making the necessary arrangements such as equipment and implants, in advance. 3D printing technology may be a blessing for the patients with the complex problem and also assists the doctors to perform surgery accurately and may save from unnecessary medico-legal problems. 3D printing is being currently used for bioprinting, creating prostheses, implants and in pharmaceutical research (Table 1).

Table 1

Uses of 3D printing.

Table 1 : Uses of 3D printing	
1) Tissue and organ fabrication (Bioprinting)	<ul style="list-style-type: none"> • Cornea • Organs- Skin, heart, kidney, liver • Bones • Cartilage
2) Creating Prosthesis, Implants and anatomical Models	<p>A) Complex trauma : Upper limb – Shoulder, Elbow, Wrist : Lower limb- Hip, Pelvis, Foot and Ankle</p> <p>B) Deformity Correction</p> <ul style="list-style-type: none"> • Patient specific jigs • Pre contoured plates <p>C) Patient specific orthosis</p> <p>D) Patient specific implants for arthroplasty</p>
3) Pharmaceutical research concerning drug discoveries, delivery and dosage forms	

At present, 3D printing technology is in its primitive form in the field of Orthopaedics as the knowledge is limited, the learning curve is high, and the cost is a factor. However, we believe that the future holds bright for it due to its wide uses in Orthopaedics and other surgical branches only (viz. faciomaxillary, dental, cardiac and neuro surgery). Orthopaedic surgeons would not only be able to use 3D printed model for surgical planning but would be able to use 3D printed implants for their complicated cases.

Conflict of interest

None.

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