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5D printing and its expected applications in Orthopaedics

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Dear Editor,

In the past few years, 3D printing has explored its potential applications in the different field of engineering, medical, dentistry, aerospace, and their associated areas.[1] The concept of 4D printing was introduced recently in 2014, and the need is to undertake associated research on its applications in different fields. American universities gave the concept of 5D printing in 2016. Today, it is being implemented by Mitsubishi Electric Research Labs (MERL) through their senior principal research scientist, William Yerazunis.[2]

5D printing is a new branch of additive manufacturing. In this technology, the print head & the printable object have five degrees of freedom. Instead of the flat layer, it produces curved layers. In this process, the print part moves while the printer head is printing. So, printing undertakes the curve path of the part being printed rather than moving through a straight layer as in the case of 3D printers. The main advantage of this technology is to create a part with a curved layer with improved strength.

Instead of 3 axes used in 3D printing, 5D printing technologies use five-axis printing technique which produces objects in multiple dimensions. In this five-axis printing, the print bed can move back and forth on two axes besides of X, Y and Z axis of the 3D printing technologies. Thus this technology is highly capable of producing stronger products in comparison to parts made through 3D printing. A Bengaluru based Etherea, in India, is in the business of 3D printing technology for the last few years. They got the idea to develop a 5D printer, which they could make it successfully and also win the best innovation CES award.[3]

A 5D printed model provides potential to fabricate artificial bone for surgery. Because human bones are not flat and having a curved surface, so there is a requirement to manufacture artificial bones with 5D printing to provide excellent strength to these bone implants. This technology has great potential to fulfill this primary requirement.

3D printing is not very good in the manufacturing of complex curved Orthopaedic implants as it uses flat layers. Results of the test conducted shows that 5D printed objects are 3–5 times stronger than a 3D printed object. It has also been analyzed 5D printed cap is also stronger and handle four times megapascals of pressure than 3D printed cap. There is the force of material during curved layers that make printable object stronger.[4] Therefore there is a lesser requirement of raw material as compared to 3D printing for making implants of the same strength.

In Orthopaedic surgery, there is an essential requirement of complex & strong implants having curved surfaces. 5D printing prints these complex surgical implants as per actual surgery of patient and also applicable in surgical planning, teaching, and learning. So, 5D printing can easily create a sophisticated and curved structure which requires a lot of strength.[5]

The main difference between 3D printing and 5D printing is that 5D printing creates a stronger part with a curved layer whereas 3D printing creates the part with a flat surface. Rest both the process use same set of technologies such as input of 3D CAD file, 3D scanner, and 3D printing material. However, 4D printing is different from these two technologies. It uses different kind of material which is programmable and can change its shape and function concerning time and temperature. These materials are called smart materials, as they have thermo-mechanical properties.[6]

In Orthopaedic, these smart materials can be utilized well for the manufacturing of implants for complex surgical case by taking data from Computer tomography (CT), Magnetic Resonance Imaging (MRI) scanning technique. This data can easily be modified to 3D CAD file format using different software like 3D slicer, Mimics, OsiriX Imaging Software, Magics, 3D doctor and InVesalius towards using for 5D printing.[5]

In the future, like 3D and 4D printing, this technology could create disruptive innovation in Orthopaedics. It will create endless possibilities and provide excellent service to save the life of the patient. This technology seems to have the capability of making complex shaped implants to fulfill immediate requirements of Medical and Orthopaedics.

Conflicts of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcot.2018.11.014.

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