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How 3D Printing Drives Innovation ? : Orthopaedic Perspective

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Editorial commentary :

Designing of an instrument or implant by clinicians is an intricate process involving technological resources, as they have to incorporate their ideas in to CAD designs which they are never used to. This lacunae in having an idea about 2D designing and understanding the details of a 2 dimensional design in CAD, is always challenging for a clinician. This makes the translation of an idea in to reality, a challenging task as always. Having the realistic feel of such a design with respect to size, shape and contours that templates the bony anatomy is appreciable for its designer. 3D printing technology, which is based on additive manufacturing has been a boon in bridging this gap to clinicians. 3D printing helps to get the clinicians, the feel of the design that helps them to give more insight to the design and suggest a futuristic modification that best suits the need. The 3D printer works by printing consecutive rows of material until the final object has been created, with each layer acting as a thin cross section of the overall object or product in question. It truly mimics the original design with respect to size, shape and 3 dimensional surface anatomy except material. For finalisation and conceptualisation stage of a design, 3D printing works wonderful.

Applications of 3D printing in Orthopaedics :

Designing of new instruments and implants :

3D printing can be best utilised to make prototype designs of any new instrument or implant. Until the wide usage of 3D printing, traditional manufacturing of a prototype design use more raw material as it involves cutting pieces out of larger pieces of metal or plastic and results in larger volume of waste or scraps. Also cost of such prototype production was always higher and sometimes not affordable. ABS plastic is commonly used material to check the prototype designs and 3D printers are even capable of printing material out of titanium. Prototypes made can be used to refine the design within low cost frame and helps in finalising the designs for production and further research.

Orthopaedic traumatology - Surgical planning :

Complex trauma and osteotomy surgeries can be well planned pre-operatively by printing the pre operating 3D CT scans and template implants to be used and plan reduction strategies [1]. Complex osteotomy surgeries as well can be well planned with respect to point of osteotomy and translation and calculation of alignment axis. DICOM images of CT scan can be converted to CAD models in STL formats using MIMICS **(Materialise Interactive Medical Image Control System)** software.

Orthopaedic Oncology :

Pre-operative printing of bony tumour and having a concrete plan of resection not only helps in reducing operative time, but also helps to address tumour removal effectively. Some studies have also reported patient confidence levels in understanding their tumours and consenting for operative procedures by seeing the 3D models [2]. Talar reconstruction following resection by 3D printing talus implantation is widely performed paving ways to other regions as well [3].

Patient specific Implants and prosthesis :

Advent of building customised objects in stainless steel, titanium, ceramics or high-performance plastics like poly-ether-ether-ketone (PEEK) paved the way for the creation of customised prostheses and implants in required scenarios. Complex cases with deformities and bone loss requiring customised implants or prosthesis can be better dealt by 3D printing.

Patient specific instrumentation (PSI) :

PSI, has been widely used in total knee arthroplasty in addressing complex condylar defects to make perfect anatomical cuts as required. These PSI have been made from CAD designs of CT scans and analysing the defects. The same now can be readily made available with the advent of biocompatible materials in 3D printing that can be autoclavable and used for intra operative procedures. Thus, 3D printing has added futuristic options in PSI jigs for arthroplasty making near anatomical reconstruction of joints in cases of severe deformities and defects.

Future prospects of 3D printing in Orthopaedics :

3D Bioprinting to produce allografts, cartilaginous matrix embedded in scapholds to address osteochondral defects and early OA are available which needs further testing and implantation. Osseointegrating feature in the form of tantalum pores printed on 3d printed titanium prosthesis is being developed, which helps in implanting without cement in certain joints. The progress in technology may occur to the point that 3D printing can be done quickly in an air conditioning sterile environment of the hospital for easy accessibility of 3D printed, on-request customized parts. With further advancement, it could be possible that even untrained clients can 3D print the parts effectively, or even better, i.e. the whole

procedure of printing from picture taking to model generation. So the medicinal staff would not require 3D printing training or preparation, or they may outsource the parts directly. 3D Printing is the platform for tissue designing in orthopaedic medical procedures. Its capacity to make a "living insert" through coordination of transplanted stem and develop cells shows that this innovation is the fate of tissue building.

3D printing has influenced new innovations and reduced cost in research to a drastic effect and has been widely used by researchers in new innovations and development of new designs.

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