

Review Article:

Three-dimensional (3D) Printing applications in Healthcare sector in India

¹Miss Pratibha M Karandikar , ²Dr Motilal C Tayade*, ³Dr Rahul Kunkolol

¹ Assistant Professor , Department of Mechanical Engineering , Pravara Rural Engineering College, Loni , Tal Rahata ,
Dist.Ahmednager , Maharashtra , India

² Associate Professor , Department of Physiology , Rural Medical College , Pravara Institute of Medical Sciences (DU) ,
Loni , Tal Rahata , Dist.Ahmednager , Maharashtra , India

³ Head and Professor, Department of Pharmacology , Rural Medical College , Pravara Institute of Medical Sciences (DU)
Loni , Tal Rahata , Dist.Ahmednager , Maharashtra , India

Corresponding author: Dr Motilal C Tayade; Email: drmctayade@gmail.com



Creative Commons Attribution
4.0 International License

CC BY 4.0

Abstract:

Worldwide in today's technology based decade number of newer hybrid applications, innovations, smart utilities are changing and enhancing our life making more simplified. India with advantage of high number of youth population are attracting towards these opportunities. Our healthcare sector is adapting these technologies with more intensify and core working model. 3D printing in Healthcare sector is mainly used for making draft or cells that can be directly used in clinical practice. However there is huge scope of their applications in medical education and research in India. Medical uses for the 3D printing, both actual and future based, can be organized into various broad categories. We observed number of opportunities in healthcare sector in India and discussed herewith. In conclusion, 3D printing has broad future for development in India in healthcare sector and our intention was to highlight these aspects to researchers mainly working in Engineering filed as well as in healthcare and bringing them together for better collaboration.

Keywords: Three-dimensional Printing, Educational models, Tissue regeneration

Introduction:

Worldwide in today's technology based decade number of newer hybrid applications, innovations, smart utilities are changing and enhancing our life making more simplified. India with advantage of high number of youth population are attracting towards these opportunities.¹ Our healthcare sector is adapting these technologies with more intensify and core working model. However three-dimensional (3D) Printing applications are at initial stage and it has sky line

opportunities in healthcare sector from education, research and clinical base applications in practice. It's the technology, in which objects or models are made by fusing or depositing materials like plastic, metal, ceramics, powders, liquids, or even living cells—in layers to produce a 3D model or material for our utility. 3D printing has been applied in medicine since in early 2000s, when the technology was first used to make dental implants and custom prosthetics with limited use.² Very interesting, some of 3D printers are

similar to traditional inkjet printers but output product differs in that a 3D object or model proposed by us. With this objective in mind, present review article highlights the area, applications, strength and new windows in healthcare sector in Indian scenario.

For a longer time, the main issue with 3D printing was that it has demanded very high entry level costs, which does not allow profitable implementation to mass-manufacturers when compared to standard processes. However, recent market trends spotted have found that this is finally changing. As the market for 3D printing has shown some of the quickest growth within the manufacturing industry in recent years.³

Basic understanding of 3D printing:³

In nearly 50% times, 3D-printing process used material extrusion technique (MET) called as fused deposition modeling (FDM). Basically it is highly cheap compare to other techniques.

3D printable models or objects are generally made with a computer-aided design (CAD) package, using 3D scanner, or by digital camera and photogrammetry software. The manual modeling process of the preparing geometric data for 3D computer graphics is exactly similar to the plastic arts such as sculpting. These digital data is collected and desire shape is prepared using appropriate software.

CAD models are saved in the stereolithography file format (.STL file),

Once we created these STL file, we need to be processed by a piece of software called a "slicer," which converts the model into series of number of thin layers and produces a G-code file containing instructions tailored to a specific type of 3D printer. Further this G-code file can then be printed with 3D printing client software. Final step is Finishing – it is process, that can be adjusted internally using software or externally.

Generally 3D Printing mainly focused on polymers material for printing, due to the easiness of manufacturing and handling

polymeric materials. However any other material can be also used.

There are number of 3D printing techniques or methods:

- 1) Sheet Lamination
- 2) Powder Bed Fusion
- 3) Direct Energy Deposition
- 4) Binder Jetting
- 5) Material Jetting
- 6) Vat Photopolymerization

Utility of 3D printing in Healthcare sector:

3D printing technology in Healthcare sector is mainly used for making draft or cells that can be directly used in clinical practice. However there is huge scope of their applications in medical education and research in India. Medical uses for the 3D printing technology, both actual and future based, can be organized into various broad categories like tissue and organ fabrication, creation of customized prosthetics, implants, anatomical models, educational physiology and pathology models, simulation materials, improving student centered skill based materials and in pharmaceutical research related to drug dosage forms, delivery, and discovery, experiments etc.^{2,4}

In healthcare sector, following areas are highlighted on the basis of their utility.

- 1) **Educational models – for learning** – 3D printing technology has extensive scope in preparation of large scale educational models or materials useful in medical education. There is an opportunity to make number models in Anatomy like organs, bones, embryology models, histological tissues etc. Physiology education can be become more simplified using 3D models in education understanding systemic physiology more interesting. Difficult topics like tracts, brain parts functions, procedure parts can be targeted. Basic clinical skills like venepuncture, bandaging, intramuscular injection practice can become more effective with 3D printer based models and materials.⁴

- 2) **Skill enhancing materials** - for improving skills – we can use target based organs, tissue or any form of material in daily practice sessions. Students can practice on this material. The major strength of this is an cost-effective and small scale manufacturing of these aids as per our needs. Patient specific preparation of anatomical models for learning and skill enhancement.^{3,4,5}
- 3) **Experimental models** – for checking or revision of adopted skills – Teachers can prepare and use experiments models to understand complex systems in medical education like understanding mechanism of memory , reticular formation function, visual pathway , physiology of hearing , coagulation mechanism etc.⁶
- 4) **Implants, prosthesis - for patient benefits** – Number of implants, prosthesis can be use in patient care and treatment. In dentistry, dental practioners are using these items very effectively. These can be use by orthopedics, surgeons.⁷
- 5) **Regeneration of cell material – for patient benefits** – There in great possibility of utility of regeneration of cell material in clinical practice.^{8,9}
- 6) **Tissue Bio-printing** - Production of exoskeleton, bones, ears, cell cultures, stem cells, blood vessels and organs etc. These parts or organs can be use in education, research, and improving skills of doctor as well as in clinical practice directly for patient benefits and making more effective output of patients. There is extensive scope of production of tissue bio printing and hope this will be greatest specialty in future in India as well as worldwide. It is very great to make patient specific implants.^{7,9}
- 7) 3D printing technology has bigger strength that it can make any kind of shape or object as desired by expert. All these orders can be easily control by computers. There are huge options in material utilization, input technology based software etc. All this can be handling easily with computer-aided design (CAD) file. The instructions can be easily

prepare , modify using CAD file for any output.²

- 8) It is very important to know that any two-dimensional (2D) radiographic images, like x-rays, magnetic resonance imaging (MRI), or computerized tomography (CT) scans, can be easily converted into digital 3D print files, allows the creation of complex, customized anatomical and medical structures.²
- 9) **Clinical Education and training:** This technology will be highly beneficial in clinical base education and various training of doctors. Dedicated workshops, CMEs can be arranged for clinicians and using customized products can make your intention or topic more effective like Pharmacovigilence etc.¹⁰ Various surgical techniques can be easily demonstrated and practiced by doctors.¹¹

Benefits of utilization of 3D printing:

- 1) **Cost effectiveness** – This is highly cost effective technology with great intension to make products at small scale levels for any purpose. In Medical education, we can use hundreds of models dedicated for students understanding and making them more competent.¹¹
- 2) **Improve quality** - These utilities can improve overall qualities of healthcare survives in different ways. As today, Indian medical education sector is transforming and adopted competency based medical education (CBME) model from 2019 , provide us extensive opportunities to be implement this area more effectively in education and research. Medical students skills can be improve with practicing these models and materials.^{11,12}
- 3) **Increases productivity** - This technology has ability to make objects in record time at small scale level with individuals needs. This can be print as per your choice , need and customization.¹³
- 4) **Easiness** – Its highly possible to make frames, objects , models with using number computer ready software or making collaboration with Engineering colleges across India.

- 5) **Customization benefit** – Researchers has scope to develop his own models or materials as per his own needs and requirements. This is one of the big benefits of use of this technology. Application of computer based technology is rewarding in medical education.

Utility Challenges of 3D printing applications in healthcare sector in India:

- 1) Proper collaboration of units
- 2) Regulatory bodies directives and working in their framework.
- 3) Will of medical experts
- 4) Policymakers thinking
- 5) Bridging competency of technology and clinical filed
- 6) Provision of dedicated funds
- 7) Publicity of experiments or models

Strength of healthcare sector in India:

Despite above challenges, we have huge strength to easily overcome these gaps and it is possible to make it more effective in utility basis.

Following are our basic strength to overcome these challenges.

- 1) Techno savvy youth population working in healthcare sector
- 2) Start up awareness in country
- 3) Better collaborative environment
- 4) Extensive use of data and internet in India
- 5) Hybrid thinking of researchers
- 6) Opportunity based cluster business models

Conclusion:

3D printing has broad future for development in India in healthcare sector and our intention was to highlight these aspects to researchers mainly working in Engineering field as well as in healthcare and bringing them together for better collaboration.

Abbreviations:

- FDM: Fused deposition modeling
CAD: Computer aided design
CT: Computerized tomography
MRI: Magnetic resonance imaging
CBME: Competency based medical education

References:

1. Schubert C, van Langeveld MC, Donoso LA. Innovations in 3D printing: a 3D overview from optics to organs. *Br J Ophthalmol*. 2014;98(2):159–161.
2. Ventola CL. Medical Applications for 3D Printing: Current and Projected Uses. *P T*. 2014;39(10):704–711.
3. Applications of 3D printing , Wikipedia , Link : https://en.wikipedia.org/wiki/Applications_of_3D_printing
4. Trenfield SJ, Madla CM, Basit AW, Gaisford S. The shape of things to come: emerging applications of 3D printing in healthcare. In: Basit AW, Gaisford S, editors. *3D Printing of Pharmaceuticals*. Switzerland: Springer; 2018. pp. 1–19.
5. Diment LE, Thompson MS, Bergmann JHM. Clinical efficacy and effectiveness of 3D printing: A systematic review. *BMJ Open*. 2017;7(12):e016891.
6. Zadpoor AA, Malda J. Additive manufacturing of biomaterials, tissues, and organs. *Ann Biomed Eng*. 2017;45(1):1–11.
7. Nayar S, Bhuminathan S, Bhat WM. Rapid prototyping and stereolithography in dentistry. *J Pharm Bioallied Sci*. 2015;7(Suppl 1):S216–219.
8. Malik HH, Darwood AR, Shaunak S, et al. Three-dimensional printing in surgery: a review of current surgical applications. *J Surg Res*. 2015;199(2):512–522.
9. Martelli N, Serrano C, van den Brink H, et al. Advantages and disadvantages of 3-dimensional printing in surgery: a systematic review. *Surgery*. 2016;159(6):1485–1500
10. D H Nandal , S N Mahajan, S P Narwane , R R Kunkulo , Study of ADR (Adverse Drug Reactions) Reporting in Pravara Rural Hospital, Loni , Pravara Med Rev 2019;11(1) , 4 -7
11. Lal H, Patralekh MK. 3D printing and its applications in orthopaedic trauma: a technological marvel. *J Clin Orthop Trauma*. 2018;9(3):260–268
12. Wilcox B, Mobbs RJ, Wu AM, Phan K. Systematic review of 3D printing in spinal surgery: the current state of play. *J Spine Surg*. 2017;3(3):433–443
13. Bartlett S. Printing organs on demand. *Lancet Respir Med*. 2013;1(9):684–687

Date of Submission : 18 December 2019
Date of Peer Review : 22 January 2020
Date of Acceptance : 07 March 2020
Date of Publishing : 30 March 2020

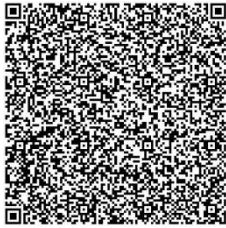
Author Declaration : Source of support : Nil , Conflict of interest : Nil
Ethics Committee Approval obtained for this study? NA
Was informed consent obtained from the subjects involved in the study? NA
For any images presented appropriate consent has been obtained from the subjects : NA
Plagiarism Checked : Urkund Software
Author work published under a Creative Commons Attribution 4.0 International License.



Creative Commons Attribution
4.0 International license

CC BY 4.0

DOI: 10.36848/PMR/2020/12125.51225



PMR QR CODE MARCH 2020 12/01/07

Cite this article as: Pratibha M Karandikar , Motilal C Tayade , Rahul Kunkolol, Three-dimensional (3D) Printing applications in Healthcare sector in India , Pravara Med Rev; March 2020, 12(01) , 51-56 DOI: 10.36848/PMR/2020/12125.51225