Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 1, Jan 2022

Emerging Use of 3D Printing Technique in the Healthcare Sector

Rupal Gupta, Assistant Professor
College Of Computing Sciences And Information Technolog, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email id- r4rupal@yahoo.com

ABSTRACT: One of the advancements brought forth by the industrial age is 3D printing technology. It has been a part of our life for a long time. It is quickly evolving and employed in a variety of industries, including the aviation and defense sectors. In recent years, the medical industry has frequently favored this miraculous production technique. This paper introduces 3D printer technology, discusses various 3D printing techniques, and refers to the usage of this technology in biomedical applications. The present work reviews the use of 3D Printing technology in the major areas of medical fields like prosthetics, medical devices, implants, novel drug delivery systems, and personalized drugs. The findings of this review revealed that 3D printing has received a lot of attention in the medical field in recent years due to several characteristic features like flexibility, ease of production, and finally the cost-effectiveness of the technology. However, there are still safety and efficacy concerns about the same which need to be resolved in the future.

KEYWORDS: 3D Printing, Implant, Medical Device, Healthcare, Stereolithography (SLA).

1. INTRODUCTION

In three-dimensional (3D) printing, materials such as metal, ceramics, plastic, liquids, powders, or even cell lines are fused or deposited in layers to create an object. This method is also known as solid free-form technology (SFF), additive manufacturing (AM), or rapid prototyping (RP). Several 3D printers are comparable to conventional inkjet printers; but, the final product varies in that a 3D object is generated. Similar to how the printing press revolutionized publishing, 3D printing is predicted to revolutionize other industries as well, including medical[1].

There are around 20 different 3D printing techniques, each of which uses a different printer technology, selection of materials, resolution, and printing speed. Almost any geometry that can be represented in a computer-aided design (CAD) file may be used by these technologies to create a 3D object. In a fundamental setup, the 3D printer moves the print head all along the x-y plane as it initially builds the object's framework following the CAD file's instructions. To create the item vertically layer by layer, the printer then carries out the rest of the commands by rotating the print head down the z-axis. It is crucial to highlight that two-dimensional (2D) radiography pictures, such as those obtained from MRIs, x-rays, or computed tomography (CT) scanning, can be turned into digital 3D printing files, enabling the creation of intricate, specifically designed anatomic and biological structures [2].

1.1. History of 3D Printing

The first known iterations of 3D printing may be found in Japan in the early 1980s. Hideo Kodama was looking for a technique to design a quick prototype system in 1981. He devised a layer-by-layer manufacturing method based on a photo-sensitive resin polymerized by UV radiation. Even

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **UGC CARE Listed (Group -I) Journal Volume 11, Iss 1, Jan 2022**

though Kodama was unable to submit the patent required for this technique, he is widely regarded as the original and the first inventor of this production method, which is an early prototype of the present SLA machine. Just a few years later, a group of French researchers was also attempting to develop a quick prototyping machine. They intended to develop a technique that used a laser to convert liquid monomers into solids rather than resin. Similar to Kodama, they were unable to submit a patent application for this technique, but they are still given credit for developing it. Charles Hull submitted the first stereolithography (SLA) patent in the same year. Hull, an American furniture maker who was dissatisfied with his inability to quickly produce small custom components, invented a method for building 3D models by layering the curing of photosensitive resin. He filed his patent application for the invention in 1986, and he later established the 3D Systems Corporation in 1988. His company introduced the SLA-1, the first commercial SLA 3D printer, in 1988. However, other additive manufacturing techniques were being investigated at the same time as SLA [3], [4].

Technology for Selective Laser Sintering (SLS) was patented in 1988 by Carl Deckard at the University of Texas. Through the use of a laser, this technique fused particles as opposed to liquid. Scott Crump also obtained a patent for a technique known as fused deposition modeling (FDM) at about the same time[5]. A heated nozzle is utilized to directly extrude the filament in FDM, also known as fused filament fabrication, as opposed to SLS and SLA, which use light to do so. Today's most prevalent type of 3D printing is now made possible by FFF technology. Three-dimensional printing techniques are not limited to these three technologies. However, it is these three that would act as the cornerstones for the development of the technology and the upheaval of the industry.

1.2. Advantages of 3D Printing in Comparison to Conventional Technologies

3D printing has many benefits over traditional manufacturing processes like subtractive manufacturing (such as computerized numerical control machining), injection molding including the ability to create 3D structures with incredibly intricate shapes and sizes as well as with a variety of different functions, a dramatic decrease in material and tool waste, shortened development cycles of products, and many more. Because of this, over the past thirty years, 3D printing has grown in popularity in both the marketplace and society, moving beyond its initial application in quick prototyping of product designs to a variety of fields such as consumer products, aerospace, science, and general manufacturing, and educational sector. For example, 3D dispensing systems may be used to print jewelry, electrical components, and bicycle parts. A laser-engineered net shaping method is used to create intricate metal parts for aircraft, helicopters, and jet engines. Furthermore, 3D printing has made it possible for archaeologists and anthropologists to duplicate valuable specimens or artifacts and then make them accessible to others. Architects have also found it to be a wonderful tool for creating intricate and high-resolution architectural designs [6].

1.3. Medical Applications of 3D Printing

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 1, Jan 2022

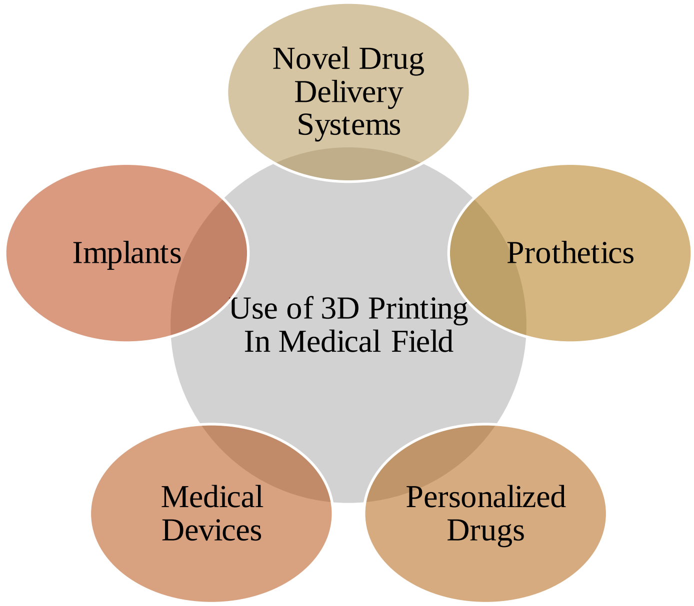

Figure 1: Illustrating the various use of 3D printing Techniques in Medical Field.

1.3.1. Implants and Medical Devices

Due to its versatility in printing and shaping most materials, accuracy, flexibility to meet individualized and other customized needs, and high material utilization rate throughout the printing process, 3D printing technology is playing an increasingly significant role in implantable medical devices. The use of 3D printing enables the development of novel geometries, like trabecular crystal lattice to promote bone formation on a specific implant. The technique not only makes it possible to design and test these geometries but also to swiftly prototype them using the chosen production method. The implant may be produced as soon as the ideal design is determined.

The industry and medical sectors have made extensive use of this technology, which has also been widely marketed. X-rays, CT scans, MRI scans, and ultrasounds are just a few examples of the medical imaging methods that are being improved upon to make this technology more flexible. Medical devices with intricate forms and structures may be made for each patient using the 3D printing process. Stainless steel and 3D-printed surgical tools with a variety of profiles can also be developed [7] (Figure 1).

1.3.2. Prosthetics

Prosthetic devices have evolved even further as a result of current technological advancements. It can now physically carry out actions that were before difficult or impossible. Advanced prosthetics are more expensive, thus many individuals cannot afford them. The expensive cost of complex prosthetics can be reduced using 3D printing. The material is built up in stages by 3D printers using a CAD model. For a better fit, the CAD model and anatomical information of the user or the wearer can be combined. The use of 3D printing technology makes prosthetics completely

Research paper **UGC CARE Listed (Group -I) Journal Volume 11, Iss 1, Jan 2022**

printable, extra convenient, comfortable, and completely customizable. The user consequently exudes more self-assurance while trying to move or walk around.

1.3.3. Personalized Drugs

Since 3D printing can provide personalized drugs to address specific patient populations, it offers tailored treatment options for specific individuals or populations. To effectively treat complicated disorders including Alzheimer's disease, epilepsy, and cancer in both pediatric and elderly patient groups, 3D printing can be employed. The idea of personalized therapy makes the promise that each patient will receive the right dose at the right time, maximizing the therapeutic effects of medication and causing desired pharmacodynamic (PD) and pharmacokinetic (PK) responses. Additional considerations for this type of therapy include age, genetic make-up, gender, and weight for dose adjustment and dosage formulation. Conventional dose forms, on the other hand, are exclusively based on predetermined strengths to serve the bulk of the patient population. Furthermore, 3D printing allows for on-site manufacture, while traditional treatment requires the installation of comprehensive manufacturing setup with high-end equipment. As a result, 3D printing has the potential to shift therapy toward an individual-centric rather than a population-centric strategy [8].

1.3.4. Drug Delivery Systems

Solid pharmaceutical dosage formulations have undergone substantial change as a result of 3D printing. When compared to traditional methods, it offers a great deal of efficiency and flexibility in the development of pharmaceutical formulations of dosage. For the most part, batch-wise processes including granulation, compaction, milling, mixing, and compression are used in the traditional manufacturing of solid dosage forms. Decreased process robustness and significant batch-to-batch variability are thus characteristics of multistep conventional manufacturing. Quick ideation, design, and optimization process along with high resolution are all made possible by 3D printing, which makes product development simple[9].

2. DISCUSSION

Medical device production has advanced quickly, even though 3D printing in the pharmaceutical industry is still in its infancy. The marketplace for 3D printing is thought to be enormous and growing rapidly every year. The market for medical 3D printing is anticipated to reach US$3692 million by 2026, expanding at a compound annual growth rate (CAGR) of 18.2% between 2019 and 2026. Worldwide pharmaceutical manufacturers, particularly those in China, North America, Europe, and Japan, displayed intense interest following the approval of Spritam®. Regulatory bodies must have a thorough awareness of the technical specifics and review processes to expedite product approval. To further translate theory into practical and ground-breaking solutions, it is necessary to bridge the gaps between all stakeholders, including authorities, pharmaceutical manufacturers, academicians, and researchers. To produce extremely flexible and customized dosage forms on demand, an assessment of the real-time efficacy and safety of 3D-printed drugs in medical care is also necessary[10].

Research paper **UGC CARE Listed (Group -I) Journal Volume 11, Iss 1, Jan 2022**

Although 3D printing was first used for engineering rather than medicine, medical-focused 3D printing techniques have progressed quickly recently, necessitating a multidisciplinary understanding. The advancement of this technology for healthcare has been somewhat constrained by the relatively autonomous study areas and structural frameworks that engineering and healthcare researchers now have. Cell induction and ethical concerns must not be overlooked. As a result, the practical deployment of 3D printing for medical purposes will necessitate a long-term commitment.

3. CONCLUSION

Due to its ability to make complex-shaped parts that are challenging to create using conventional techniques more quickly, easily, and affordably, 3D printing technology is becoming more and more utilized in a wide range of industries. The development of personalized medication that is centered on the demands of the patient is made possible by the use of 3D printing technology in the pharmaceutical sector. Other than that it has also resulted in a wide range of applications in the medical sector. Therefore, Manufacturing has transformed due to 3D printing. It enhances production design, cuts down on lead times, and lowers tooling costs for new products. However, there is still a need to determine and study the safety and efficacy of the products made from 3D printing technology.

REFERENCES:

[1] P. Wu, J. Wang, and X. Wang, "A critical review of the use of 3-D printing in the construction industry," *Automation in Construction*. 2016. doi: 10.1016/j.autcon.2016.04.005.

[2] A. A. Zadpoor and R. Hedayati, "Analytical relationships for prediction of the mechanical properties of additively manufactured porous biomaterials," *Journal of Biomedical Materials Research - Part A*. 2016. doi: 10.1002/jbm.a.35855.

[3] "History of Additive Manufacturing," 2017. doi: 10.4018/978-1-5225-2289-8.ch001.

[4] T. Wohlers and T. Gornet, "History of Additive Manufacturing 2014," *Wohlers Rep. 2014 - 3D Print. Addit. Manuf. State Ind.*, 2014.

[5] F. Fina, A. Goyanes, S. Gaisford, and A. W. Basit, "Selective laser sintering (SLS) 3D printing of medicines," *Int. J. Pharm.*, 2017, doi: 10.1016/j.ijpharm.2017.06.082.

[6] F. C. Godoi, S. Prakash, and B. R. Bhandari, "3d printing technologies applied for food design: Status and prospects," *Journal of Food Engineering*. 2016. doi: 10.1016/j.jfoodeng.2016.01.025.

[7] A. A. Zadpoor and J. Malda, "Additive Manufacturing of Biomaterials, Tissues, and Organs," *Annals of Biomedical Engineering*. 2017. doi: 10.1007/s10439-016-1719-y.

[8] A. Dhyani, N. Singh, V. Kumar, and A. Dhyani, "Applications of 3 dimensional (3D) printing in biomedical field," *Int. J. Curr. Res. Rev.*, 2020, doi: 10.31782/IJCRR.2020.121918.

[9] A. Jackson, L. A. Ray, S. Dangi, Y. K. Ben-Zikri, and C. A. Linte, "3D printing for orthopedic applications: from high resolution cone beam CT images to life size physical models," 2017. doi: 10.1117/12.2256181.

[10] N. A. Sears, D. R. Seshadri, P. S. Dhavalikar, and E. Cosgriff-Hernandez, "A Review of Three-Dimensional Printing in Tissue Engineering," *Tissue Engineering - Part B: Reviews*. 2016. doi: 10.1089/ten.teb.2015.0464.