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A Review on 3D Printing Technology in Medical Field

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Abstract:-

This paper is concerned with 3D Printing Technology in Medical Field. Nowadays the 3D printing technology represents a big opportunity to help pharmaceutical and medical companies to create more specific drugs, enabling a rapid production of medical implants and changing the way that doctors and surgeons plan producers. 3D printed anatomical models are becoming increasingly useful tools in today's practice of precision medicine and for personalized treatments.

Keywords:-

3D Printing, Biomaterials, Prostheses, Tissues, Anatomy, Pharmaceutical, Surgeon

Introduction:-

3D Printing technology, also known as Additive Manufacturing (AM) refers to processes used to generate a 3D object in which layers of material are successively formed under a computer controlled program to create a physical object. The 3D file source is usually sliced into several layers, each layer generating a set of computer controlled instructions. Both 3D printing and additive manufacturing reflect that the technologies share the theme of sequential-layer material addition or joining throughout a 3D work. 3D printing technologies can be split up into 2 groups: direct and indirect 3D printing. The main difference lies in the fact that the design is directly made from 3D printing (direct) or 3D printing was used in the process of creating your model (indirect).

The objects manufactured through 3D printing processes can be of almost any shape or geometry. They are typically produced using digital model data from a 3D model or another electronic data source such as a Stereo Lithography (STL) file one of the most common file types that 3D printers can read.

The term 3D printing originally referred to a process that deposited a binder material onto a powder bed with inkjet printer heads layer by layer. More recently the term 3D printing is being used in popular vernacular to encompass a wider variety of additive manufacturing techniques. For professionals the additive manufacturing name remains more popular for its broader sense and longer existence. Other terms are also employed such as desktop manufacturing, rapid manufacturing, direct digital manufacturing, and rapid prototyping.

3D printing has been applied in medicine since the early 2000s when the technology was first used to make dental implants and custom prosthetics. Since then the medical applications for 3D printing have evolved considerably. Recently published reviews describe the use of 3D printing to produce bones, ears, exoskeletons, windpipes, a jaw bone, eyeglasses, cell cultures, stem cells, blood vessels, vascular networks, tissues and organs as well as novel dosage forms and drug delivery devices. The current medical uses of 3D printing can be organized into several broad categories: tissue and organ fabrication; creating prosthetics, implants and anatomical models; and pharmaceutical research concerning drug discovery, delivery, and dosage forms.

Applications:-

- **Dentistry:**
  Restorative therapy,
  Surgical guides, Dental Models.
- **Anatomical Models :**
  Surgical guides (for medical training and education)
- **Pharmaceuticals:**
  Controlled drug delivery orally disintegrating formulations personalized medicines.
- **Medical Devices:**
  Surgical tools implants prostheses, orthoses, hearing aids.
- **Tissues and Organs:**
  Tissue analogues (for implantation), Disease Models, Organ on a chip.

Common biomaterials in 3D bio printing:-

Polylactic Acid (PLA):

PLA is hydrolytically degradable aliphatic polyester and has properties including biocompatibility, degradability, and printing ability that make it a prominent polymeric bio ink. PLA is the main polymer which is used as precursor in the FDM technique. Generated filaments with PLA can be used in musculoskeletal tissue engineering for substituting ligaments and non- biodegradable fibers.

Poly-D, L-Lactic Acid:

Poly-D, L-Lactic acid (PDLLA) is a polymer with a lactic acid origin and amorphous structure. It is naturally hydrophobic and possesses convenient biocompatibility with persistent mechanical characteristics that lead it to biomedical applications, particularly in SLA techniques. It is one of the widely used polymers in forming biocompatible and porous scaffolds. Thus, it is applied in resorbable devices of orthopedic rehabilitation and tissue engineering.

Polyether Ether Ketone (PEEK):

Polyether ether ketone (PEEK) is a nonbiodegradable polymer with superior biocompatibility, low heat conductivity, radiolucent and comparable bio-inertness. The semi-crystalline nature of the material provides permissible heat resistance and chemical stability it has strength and elasticity comparable to cortical bone that diminishes the chance of osteopenia after implementation by minimizing the stress shielding. PEEK is widely used in FDM and SLS technologies including bio-inks in prototyping craniofacial implants and bone replacement.

Poly-glycolic acid (PGA):

Poly-glycolic acid (PGA) is categorized as a main synthetic polymer in 3D scaffold architecture because of its chemical versatility, ease of processing alongside with biocompatibility and biological features. The biodegradation of PGA produces glycolic acid monomer, which is simply removed from the body by certain catabolic pathways in the form of carbon dioxide and water. Furthermore, the physical and mechanical properties of PGA can be maintained by its copolymers. PGA is used in bone internal fixation devices and in preparation of resorbable sutures.

Polylactic-co-glycolic acid (PLGA):

Polylactic-co-glycolic acid (PLGA) is a polymer with reliable biodegradable nature and conspicuous cytocompatibility properties. It has mechanical features equal to that of human calcareous bone and is osteoconductive. PLGA is also used in bone regeneration animal model and in many tissue-restoring systems.

Poly Caprolactone (PCL):

PCL offers great bio-ink features including stiffness, biocompatibility, and degradability and it is rather a less expensive polymer. PCL is one of the nontoxic polymers that tolerate significant stability. Generally, the stability continues for a period of 6 months with biological half-life of 3 years. SLS-printed PCL scaffolds possess characteristics such as a poriferous structure that leads to interconnectedness, rough surface and comparable compactness to bone that result in bone regeneration and cell in growth capability. However, its longer biological half-life develops secondary obstacle in scaffolds made for applications other than bone tissue engineering.

Polybutylene Terephthalate (PBT):

Polybutylene terephthalate (PBT) is biocompatible thermoplastic polyester employed in FDM printing technologies. PBT reveals strong elasticity, easy processing ability, and permissible strength and toughness. PBT is one of the common polymers widely used in biomedical field for in-vivo and in-vitro biocompatibility. It retains application in printing bone scaffolds of canine trabecular bones and in tissue regeneration.

Advantages:-

- Personalized medical devices and patient-specific implants.
- Just-in-time manufacturing approach to on-demand devices.
- Rapid medical prototyping.

Disadvantages:-

- 3D printing process is not eco-friendly.
- Limited options of 3D printing material.
- Inconsistent quality of 3D printed objects.

Conclusion:-

3D printing has become a useful and potentially transformative tool in a number of different fields, including medicine. As printer performances, resolution and available materials have increased .Researches continue to improve existing medical applications that use 3D printing technology and to explore new one. The medical advances that have been made using 3D printing are already significant and exciting but some of the more revolutionary applications such as organ printing will need time to evolve.

Literature survey:-

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