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3D Printing: A Boon to Dentistry

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Abstract

Curiosity is the mother of innovation. The connecting link between technologies and dentistry has often resulted in innovation in manufacturing of dental restoration initiated right from Taggarts lost wax techniques to the latest CAD/CAM, 3D printing restoration. Advent of rapid prototyping technology has opened up new perspective for design and production in field of Dentistry. 3D printing technology is an extremely versatile and rapid process. It has accelerated innovation, reduced energy, minimized material usage. This paper discusses various types of 3D printing technology using different materials and its various applications in the field of Prosthodontics.

Keywords: CAD –Computer aided design, CAM – Computer aided manufacturing, AM – Additive manufacturing, 3D – 3 Dimensional

Introduction

A new technology of fabrication of 3Dimensional prosthesis has proven to be very promising and is called Rapid prototyping[1]. Rapid prototyping (RP) is a term which embraces a range of new technologies for producing accurate parts directly from CAD models in a few hours, with little need for human intervention.[2] As this technology has shift from visual to the visual-tactile representation of anatomical objects introduces a new kind of interaction called 'Touch to comprehend.' In the early days of Rapid Prototyping had predominantly application in automotive and aerospace industries only. [3] The difference between traditional manufacturing and 3D printing is that - The traditional manufacturing processes involve subtractive approach that includes a combination of grinding, bending, forging , moulding, cutting, gluing, welding and assembling. 3d printer involves additive approach of creating an object with material layer by layer in three dimension formations .[3] The technology has been substantially improved and has evolved into a useful tool for many fields like researchers, manufacturers, designers, engineers and scientists. Collaborating different fields in single package formed 3D printer.[4] what is rapid prototyping?

Rapid prototyping refers to automatic construction in mechanical models from graphical computer data.

Rapid prototyping is a type of computer aided manufacturing (CAM) and is one of the components.

Two main methods of rapid prototyping are:

Additive - widely used

Subtractive – least common[5]

The only subtractive technique used for medical applications is Milling, which is derived from numerically controlled (NC) machine processing.

Additive manufacturing according to the American Society for Testing and Materials (ASTM) is the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies.[6]

Review of literature

Authors	Year	Discovery
Charles W. (Chuck) Hull	1984	First working robotic 3D printer
S. Scott and Lisa Crump	1989	Patented fused deposition modelling (FDM) and co-founded the printer manufacturer Stratasys, Ltd. This technology (more generically called FFF, for fused filament fabrication)
Bowyer	2005	Publish design for the 3d printer and called the RepRap project and named first printer as Darwin in 2007.
	2009	“desktop” 3D printers were readily available to the public
Morea et al.	2011	Used the SLA technique for accurate insertion of the orthodontic mini screws
Stratasys	2013	Maker Bot became one of the earlier commercial consumer printer companies and was purchased.

Principle of 3D Printing

The key idea of this innovative method is that the three dimensional CAD (3D-CAD) model is sliced into many thin layers and the manufacturing equipment uses this geometric data to build each layer sequentially until the part is completed. 3DP is a process of producing 3D solid objects from a digital file in STL format (surface tesselation language file or standard triangulation language file) by a 3D printer by joining, bonding, sintering or polymerizing small volume elements. Each slice is printed one on top of the other to create the 3 dimensional objects with an advantage of minimal wastage.Hence, additive fabrication is often referred as “layered manufacturing”, “direct digital manufacturing”, “three-dimensional printing”, or “solid freeform fabrication.

Depending on the 3D Printing Process, Additive Manufacturing Can Be Classified As

Name of Technique	Principle On With It Works	Advantages	Disadvantages	Materials
Extrusion Printing: Fused Deposition Modeling (FDM)	Small beads of thermoplastic material are released from a nozzle to construct the model. The3D printers adopting this technique find the highest penetration at the domestic level; often nick	-Variable mechanical strength. -Material must be removed. Low to mid range cost materials and equipment. -Some materials may be heat sterilised.	Low cost but limited materials - only thermoplastics. Limited shape complexity for biological materials. Support	Materials: acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), nylon
Material Sintering: Selective Laser Sintering (SLS)	A laser beam hits the powder and creates a melt pool and the powder particles fuse together layer by layer to form an object.	-High strength objects can control porosity. -Variety of materials may be recycled. -Fine detail possible.	-Elaborated infrastructure requirements. -Extremely costly technology moderately costly materials. -Dust and nanoparticle condensate may be hazardous to health. -Explosive risk. Rough surface. -Elaborate postprocessing is required: Heat treatment to relieve internal stresses in printed objects. -Hard to remove support materials.	Materials: Nylon, polyamide.
Electron Beam	EBM is similar to SLS, except for high power	High temperature process, so no	Extremely costly technology moderately	Materials: titanium,

Manufacturing (EBM)	Electron beam is used to fuse the powdered particles.	Support or heat treatment needed afterwards. High speed. Dense parts with controlled porosity.	Costly materials. Dust may be hazardous to health. -Explosive risk. -Rough surface. Less postprocessing required. - Lower resolution.	Cobalt−chrome alloy.
Stereo lithography (SLA)	A UV laser beam selectively hardens the photo-polymer resin in layers. Each layer is solidified and built on top of next until the object is formed.	-Rapid fabrication. -Able to create complex shapes with high feature resolution. -Lower cost materials if used in bulk.	-Only available with light curable liquid polymers. -Support materials must be removed. -Resin is messy and can cause skin sensitisation, and may be irritant by contact and inhalation. -Limited shelf life and vat life.	Materials: photopolym ers.
Continuous Liquid Interface Production (CLIP) [3]	CLIP is similar to SLA, except for UV beam is passed through a transparent window at the bottom of the resin and builds platform raises upwards holding the 3D printed object.	-Show complex solid parts drawn out of the resin at rates of hundreds of millimeters per hour. - Increase the printing speed with higher quality and a wider variety of colors and materials. -The print speeds allow parts to be produced in minutes instead of hours.	-uses several thermoplastic engineering technologies to produce great finishes and resolution.	Materials: photopolym ers.

Material binder Binder Jetting/Inkjet	A liquid binding material is selectively dropped into the powder bed in alternative layers	-Relatively fast. -High resolution, - -High-quality finish possible.	Tenacious support material can be difficult to remove completely. Support	Materials: starch or gypsum (powder bed) and water
	of powder– binding liquid– powder, until the final object is formed.	-Multiple materials available in various colours and physical properties including elastic materials. -Lower cost technology.	material may cause skin irritation. Cannot be heat sterilised. High cost materials.	(binding agent
Polyjet	Polyjet printing is similar to inkjet, but instead of binding agents, photopolymer liquid is sprayed in layers on to the build platform and is instantaneously cured using UV light	-Creats smooth detailed prototyping that convey final product aesthetically. -Achieve complex shapes. -Produce accurate molds.	-Have worsen mechanical properties. -Expensive printer	. Materials: polypropyle ne, polystyrene, polycarbona te. Lamination
Laminated Object Manufacturi ng (LOM)	Layers of adhesive coated material are successively glued together and cut in	-Very low internal tension of LOM parts prevents distortion,	-A high effort must be applied for decubing finishing and sealing the part. -The part accuracy is	Materials: thin sheets of paper, polyvinyl caprolactam (PVC)
	Required shapes using a laser.	Shrinkage and deformation. -parts have high durability low brittleness and fragility.	Limited due to comparably simple machine design.	plastic, or metal laminates

Application

Medical uses for 3-D printing can be categorized into three segments.

- Bioprinting tissue and organ;
- Creation of customized prosthetics, implantable devices and medical models

- Pharmaceuticals

Its applications stretch across the fields of dentistry

- Fabrication of surgical guides,
- Prosthodontics(fabrication of crown copings, partial denture frame works),
- Oral and maxillofacial (surgical instruments)
- Forensic odontology,
- Restorative dentistry,
- Orthodontics use in digital orthodontics is Invisalign. (The

Invisalign system digitally realigns the patient's teeth to make a series of 3D printed models for the manufacture of 'aligners', which progressively reposition the teeth over a period of months/years),

Implantology (Porous titanium implants can be fabricated with ease using 3DP. Focusing a high-power laser beam that fuses metal particles on a powder bed generates the desired implant design layer by layer, with no postprocessing steps required)and instrument manufacturing.

Applications in maxillofacial prosthodontics

- Production of auricular and nasal prosthesis
- Obturator
- Duplication of existing maxillary/mandibular prosthesis especially crucial when an accurate fit to natural teeth or an osseointegrated implant is needed
- Manufacturing of surgical stents for patients with large tumors scheduled for excision
- Manufacturing of lead shields to protect healthy tissue during radiotherapy treatment
- Fabrications of burn stents, where burned area can be scanned rather than subjecting delicate, sensitive burn tissue to impression taking procedures.

Conclusion

3D printing will have an increasingly important role to play in dentistry. 3DP is transforming digital dentistry by extensively penetrating opportunities in diagnosis, treatment and education. 3D printing makes it possible to accurately make one-off, complex geometrical forms from the digital data. The accelerated research in this industry and optimism would open more doors to help revolutionize digital dentistry.

References

1. Kamran M, Saxena A. A comprehensive study on 3D printing technology. MIT Int J Mech Eng. 2016 Aug;6(2):63-9.
2. Pham DT, Gault RS. A comparison of rapid prototyping technologies. International Journal of machine tools and manufacture. 1998 Oct 1;38(10-11):1257-87.
3. Nayar S, Bhuminathan S, Bhat WM. Rapid prototyping and stereolithography in dentistry. Journal of pharmacy & bioallied sciences. 2015 Apr;7(Suppl 1):S216.
4. Kamran M, Saxena A. A comprehensive study on 3D printing technology. MIT Int J Mech Eng. 2016 Aug;6(2):63-9.
5. Joshi MD, Dange SP, Khalikar AN. Rapid prototyping technology in maxillofacial prosthodontics: Basics and applications. The Journal of Indian Prosthodontic Society. 2006 Oct 1;6(4):175.
6. Gali S, Sirsi S. 3D Printing: the future technology in prosthodontics. Journal of Dental and Orofacial Research. 2015;11(1):37-40.
7. Tappa K, Jammalamadaka U. Novel biomaterials used in medical 3D printing techniques. Journal of functional biomaterials. 2018 Mar;9(1):17.
8. Tumbleston JR, Shirvanyants D, Ermoshkin N, Janusziewicz R,

Johnson AR, Kelly D, Chen K, Pinschmidt R, Rolland JP, Ermoshkin A, Samulski ET. Continuous liquid interface production of 3D objects. Science. 2015 Mar 20;347(6228):1349-52.

9. Mueller B, Kochan D. Laminated object manufacturing for rapid tooling and patternmaking in foundry industry. Computers in Industry. 1999 Jun 1;39(1):47-53.
10. Joseph Krajekian, 3D Printing Role in Oral and Maxillofacial
Surgery Current and Future Trends Adv Dent & Oral Health