3d Printing – A Boon to Dentistry

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Review Article

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Abstract: 3D Printing is one of the most revolutionary technologies of the 21th century and it is re-shaping the world. 3D printing is the additive process that builds objects layer by layer to form a three dimensional object. 3D printing, on the other hand, can enable fast, reliable, and repeatable. It takes digital input from 3D data and creates solid, 3D parts. It is used extensively by designers, engineers, architectures for concept development and product design objects. Use of 3D printing in dentistry has created its own significance with an elevated success rate. This paper reviews the types of 3D printing technologies available and their various applications in dentistry and in maxillofacial surgery.
**Keywords:** 3D Printing, Stereolithography, Selective Laser Melting.

INTRODUCTION

Technological developments have made remarkable influence and benefactions to the field of dentistry. Digital dentistry has procured lionization because of its versatile applications. The concept of three dimensional printing (3D) is taking the world by storm. The potential applications are endless, with particularly promising advances in the medical and dental fields. 3D printing gained popularity in various other fields such as aerospace, defense, art. Recently it has become a concern of great intrigue in virtual surgical planning.

The term 3D printing is generally used to describe a manufacturing approach that builds objects one layer at a time, adding multiple layers under computer control to create a three dimensional object.

3D printing is also known as additive manufacturing (AM), rapid prototyping, layered manufacturing or solid free form fabrication [1].

The core idea of this futuristic method is that the three dimensional model is sliced into many thin layers and this geometric data is used by the manufacturing equipment to build each layer sequentially until final desired product is completed. This process is more correctly described as additive manufacturing, also referred to as rapid prototyping [2].
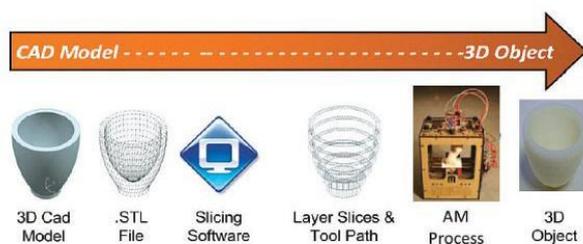
Generalized Additive Manufacturing Process.

It all starts with the formation of an effective design of the object. A 3D model is produced by scanning the buildings, rock formations, prepared tooth surfaces, etc by a scanner. The 3D model is sliced and it is then ready to feed into the 3D printer of compatible brand and type by using USB, SD or Wi-Fi. When a file is uploaded in a 3D printer, the object is ready to be 3D printed layer by layer. The 3D printer reads every slice

(2D image) and produces a three dimensional object. Any geometrical objects can be created by this technology. This is what is called slicing [3].

HISTORY

Although 3D printing is not a new concept, it has been used progressively in the early 1980's. A three dimensional object, for the first time was printed in 1983 by Charles Hull using ultraviolet (UV) light to harden the surface coatings. In 1986, he created the first 3D printer which used the technique called as 'Stereolithography' (SL). It works on the principle of making solid objects by successively printing thin layers of UV curable photopolymer on top of the each layer [4, 5].

DISCUSSION

3D Printing Technologies & Materials

Currently most frequently used applied additive technologies in dentistry are [6]
• Stereolithography (SL)
• Photopolymer jetting (PPJ)
• Powder binder printers (PBP)
• Selective laser melting (SLM)
• Fused deposition modelling (FDM)

Stereolithography

Stereolithography is an additive manufacturing process that works by focusing an ultraviolet (UV) laser to build parts one layer at a time, in a vat of light-cured photopolymer resin. The laser traces-out each layer on the surface of the liquid resin, at a point where 'build platform' descends, a layer of resin over the surface is wiped, and the process is repeated. With the help of computer aided manufacturing or computer aided design (CAM/CAD) software, the UV laser is used to draw a pre-programmed design or shape on to the surface of the photopolymer vat [1].
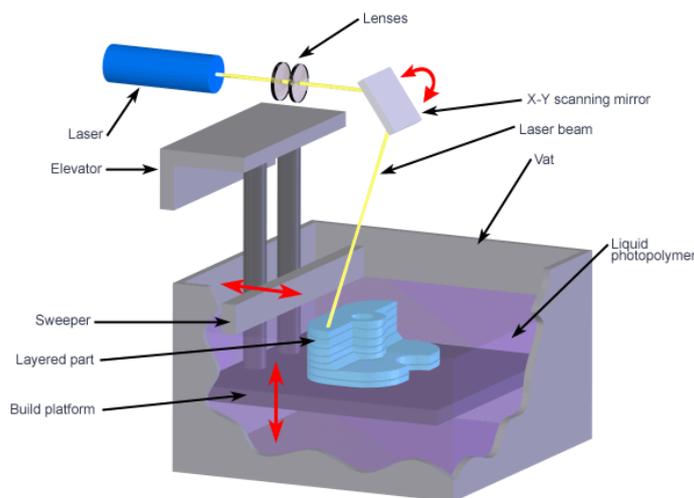

Stereolithography

Photopolymer Jetting

In this technology either a stationary platform and dynamic print head or a stationary print head and dynamic platform is used. Light sensitive polymer is jetted onto a build platform from an inkjet type print head, and layer by layer is cured on an incrementally descending platform. A support structure is laid down in a friable support material. A wide range of resins and waxes for casting, as well as some silicone-like rubber materials can be printed [3, 4].
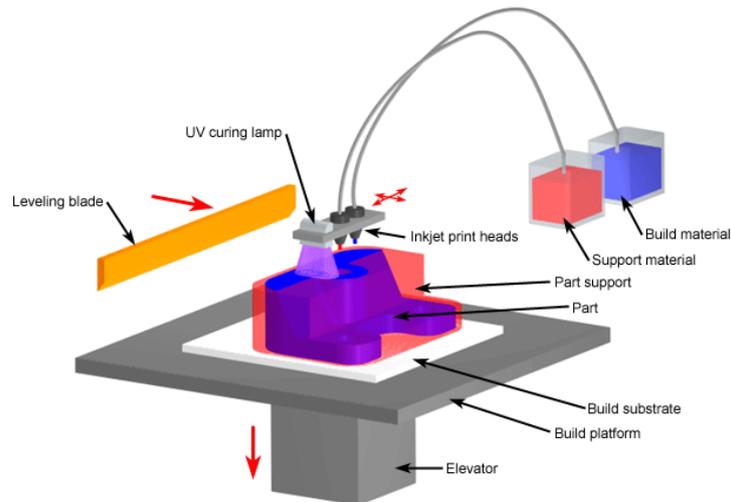
Photopolymer jetting

Powder Binding Printers

A modified inkjet head is used for powder binding printer to print using. In this typically, pigmented liquid droplets, which is commonly water is used to infiltrate a layer of powder, mostly plaster of paris, layer by layer. Again, a model is built up in layers as the powder bed drops incrementally, and a new fine layer of powder is swept over the surface. The model is supported by un-infiltrated powder, and so no support material is required. Post-processing to infiltrate the delicate printed model with a cyanoacrylate or epoxy resin will improve strength and surface hardness [1, 6].
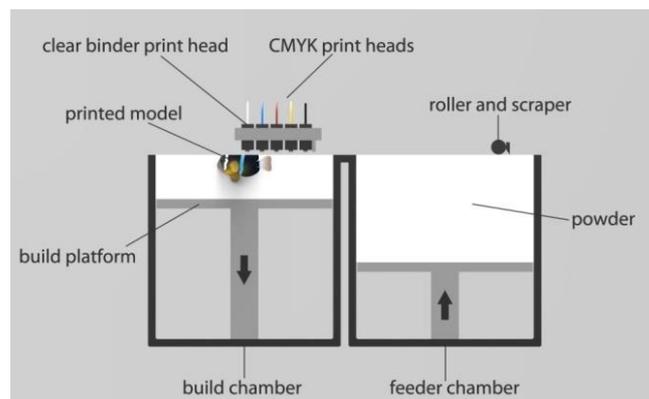

Powder Binding Printers

Selective Laser Melting

In laser powder forming technology, scanning laser beam hits the powder particles which fuse together to build up the structures by adding layers after layers. New fine layers are formed spreading evenly as the powder bed drops down incrementally. High level resolution is created and no support material is required since the structures that are obtained are supported by the surrounding material. Oxygen must be strictly excluded from this SLM process to create a protected atmosphere in order to avoid formation of oxide layer inside a 3D object [1, 4].
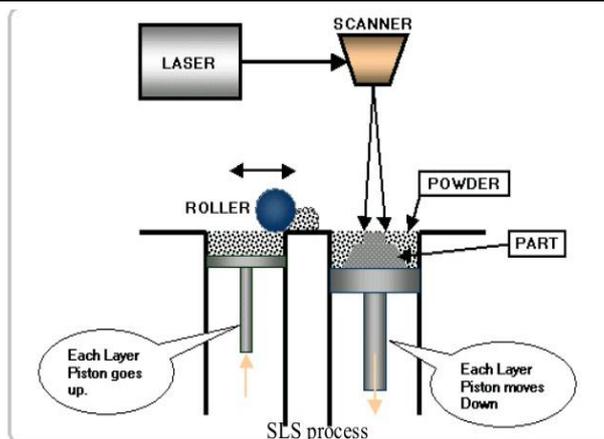
Selective Laser Melting

Fused Deposition Modelling

This technology was developed by Schott Crump. It is mostly used for modelling and prototyping applications. It works on the principle where a thermoplastic filament material is extruded through a nozzle controlled by temperature. The deposition occurs in a layered fashion, to build objects from the bottom to top by instantly combining all the layers of melted material and the material hardens immediately (within .1 sec) after extrusion. Materials like acrylonitrile butyro styrene ABS, polycarbonates, polysulfones, acrylics or waxes are used in this technology [3, 7].
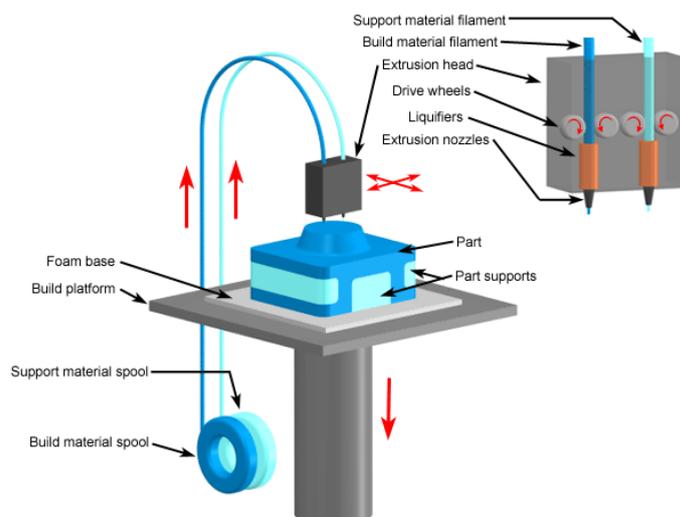
Fused Deposition Modelling

APPLICATIONS

3D printing is presented with increased attention in fields such as architecture due to the increased potential in the direct construction of parts, aeronautics because of the ease of making various small parts used in spacecraft construction, and technical subassemblies used in telecommunications domain. Their use in areas that require milli metric precision has drawn the attention of specialists in general medicine, who started to implement it since the 1990s [7].

3D printers can provide a precise virtual model of the prepared tooth, the implant position, and the dental arch. The scan data and CAD design can be used to mill or print crown or bridge copings and partial denture frameworks, models for restorative dentistry, implant abutments, and bridge structures. In addition,

drilling or cutting guides printed using 3D technology can lead to faster, less invasive, and more predictable surgery. Also in digital orthodontics where printing with multiple materials is in the manufacture of 3D printed, indirect bracket bonding splints, printed in rigid and flexible materials for precise bracket placement using orthodontic CAD software. 3D printing may be used to print the implanted structure directly in maxillofacial prosthesis. Recent advances have an ability to produce lower stiff ness scaffolds with high resolution features that allows its application in soft tissue engineering [4, 7].

CONCLUSION

3D imaging and modelling, and CAD technologies are hugely impacting on all aspects of dentistry. High-performance programs and processors

have been developed that enable rapid mirror control and a high degree of manufacturing precision. They provide the possibility of high quality restorations with quick and easy fabrication. With the evolution of 3D printing it has become possible to replicate desired geometry without an expensive mold and tooling which were not feasible with conventional techniques. Health and safety protocols must be strictly followed. 3D printing takes the efficiencies of digital design to the production stage. The congruence of scanning, visualization, CAD, milling and 3D printing, along with the professions innate curiosity and creativity makes this an exceptionally exciting time to be in dentistry.

REFERENCES

1. Dawood A, Marti BM, Sauret-Jackson V, Darwood A. 3D printing in dentistry. British dental journal. 2015 Dec;219(11):521.
2. Kalnad C. A review on 3D printing. International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE). July 2016: 5(7); 2001-2004.
3. Jain R, Supriya, Bindra S, Gupta K. Recent Trends of 3-D Printing in Dentistry- A review. Annals of Prosthodontics & Restorative Dentistry, October-December 2016:2(4):101-104.
4. Vonsee C, Meindorfer M. 3D printing: Additive processes in dentistry. Available on https://www.bego.com/fileadmin/user_downloads/... /Lab_May_-_3Dprinting.pdf
5. Sivaranjani G, Sharad S. 3D Printing: the future technology in prosthodontics. Journal of Dental & Oro-facial Research. 2015 Jan;11(1):37-40.
6. Dawood A, Marti BM, Sauret-Jackson V, Darwood A. 3D printing in dentistry. British dental journal. 2015 Dec;219(11):521.
7. Zaharia C, Gabor AG, Gavrilovici A, Stan AT, Idorasi L, Sinescu C, Negruțiu ML. Digital Dentistry—3D Printing Applications. Journal of Interdisciplinary Medicine. 2017 Mar 1;2(1):50-3.