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Research Paper

3D Printing: A Look into the Future of Endodontics

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ABSTRACT *:Three dimensional printing is a promising new technology in the field of dentistry. It is an additive manufacturing method in which 3D item is formed by laying down successive layers of material. It is a technology which can design and produce 3D models and is proving to improvise the standards of the treatment to the patients as it is less technique sensitive and more accurate. It works on the concept of additive manufacturing which has its own advantages compared to the substractive manufacturing process.Various dental pieces can be printed using methods like selective laser sintering (SLS), stereolithography, fused deposition modeling and laminated object manufacturing. 3D printing can be combined with oral scanning and CAD/CAM design to produce crowns, bridges, stone models and various orthodontic appliances. Improved success in dental implantology is due to improvement in digital technology and 3D printing.This article provides an overview on 3D printing and its applications in Operative Dentistry and Endodontics.*
Keywords *:3D printing, stereolithography, endodontics*

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I. INTRODUCTION

3D printing is an emerging technology with wide range of applications in dental field. Dental restorations are produced through rapid prototyping and are more adaptive and faster in production compared to those restorations created by dental technicians. In the present era, this technology ensures precision in terms of quality dental care thus making it a preferable modality of treatment.

3D printing started in 1980s when Charles Hull printed a three dimensional object in 1983. He then created the first 3D printer that used the technique of stereolithography. Initially the focus was on the fields of architecture, aeronautics and telecommunications. Later its application in general medicine started drawing attention of specialists in 1990s leading to increased research and better results in this field.

3D printing uses 3 dimensional CAD data sets for producing 3D physical models(1). This method is called as additive manufacturing which means fabricating materials of choice like metal, polymer or resins in incremental layers using CAD/CAM (Computer Aided Design/Computer Aided Manufacturing) digital scans for dual purpose of designing a product and for controlling the manufacturing process.CAD/CAM applicationsinvolve three steps : digital data acquisition using an intraoral scanner and/or a CBCT (cone beam computed tomography, data processing and design within a software application, and manufacturing by milling or printing.

The advantage of a 3D printed restoration/model is that it can be subsequently printed in the material chosen based on the area of application. The 3D objects helps in studying the reconstruction, the patients jaw or tooth morphology on the table top. Thus, it enables better preclinical training, case analysis and preoperative planning as it is done digitally with more accuracy and reduced time.

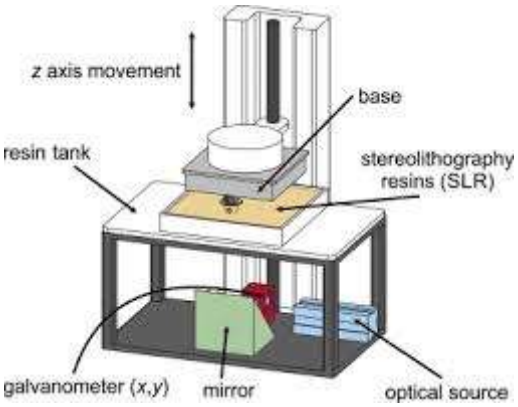
Methods used for printing 3D models are :

- Stereolithography

- Fused Deposition Modeling
- Multijet Printing
- Photopolymer Jetting
- ColorjetPrinting
- Digital Light Processing
- Selective laser sintering also known as selective laser melting

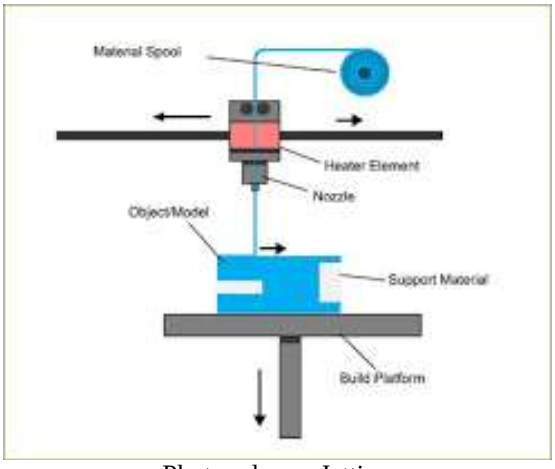
Stereolithography

Stereolithography device was invented by Charles Hull in the 1980's. It has become one of the most popular rapid prototyping technology. This device was the first commercially available printer for rapid prototyping. It is a form of additive manufacturing which converts liquid material (photosensitive monomer resin) into solid parts (polymer resin) using a ultraviolet light source through photopolymerization. The reaction takes place on the surface of the material and the materials used must be photo curable like acrylics, epoxies, fabrication of titanium implants[2-5]. The curing time and the thickness of the layer polymerized is affected by the dynamics involved in the entire procedure. The kinetics can be controlled by the power of the light source, the scanning speed and the chemistry and amount of the monomer and photo initiators. The depth of polymerization can be controlled by adding UV absorbers to the resin.



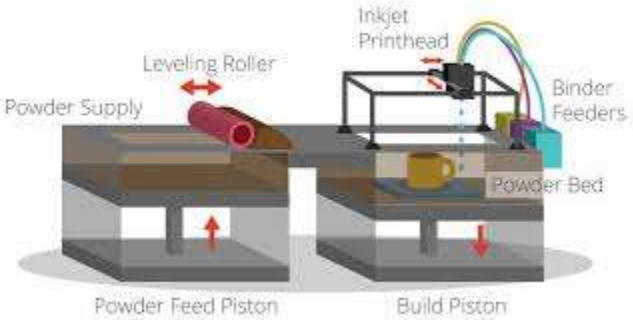
Fused Deposition Modeling

It was developed by Schott C rump. In this model, the object is built in a layered fashion by deposition of melted thermoplastic polycarbonate. Since the layers of melted plastic instantly combine with each other, the making of complex parts are easy to produce. The basic structure of the machine includes nozzles through which the material is deposited in a layer by layer which later gets fused together[5-7].Fused deposition modeling uses biocompatible polymers, bioactive glass composites, Poly Methyl Methacrylate (PMMA).Buiding complex geometries usually necessitates the usage of a second extruder , for example, might extrude a water soluble support material. Accuracy depends on the speed of travel of the extruder, the flow of material and the size of each step. This process is used by most low cost 3D printers. It enables printing of crude anatomical models without much complexities like printing of an edentulous mandible.



Photopolymer Jetting

This method uses either a stationary platform and dynamic print head or a stationary print head and dynamic platform. Light sensitive polymer is jetted onto a build platform from an inkjet type print head and cured layer by layer on an incrementally descending platform. Photopolymer jetting can be used for printing a wide range of resins and waxes for casting and also for silicone like rubber material. Resolution of approximately 16 microns is given by this technology and it gives an easy access for making complex and fine detailed objects. It can be used in making implant drill guides and manufacturing of indirect orthodontic bracket splints[3]. 3D Jet printers may have a single print head like a computer printer or they may have multiple heads to cover the width of the working platform. UV lamp or a light source is used by the 3D systems and printers to harden the resin or wax after each layer is jetted. Advantages of this method is that it is fast and cost effective and can give a high resolution and high quality finish. Disadvantages are tenacious support material can be difficult to remove completely, it may cause skin irritation and cannot be heat sterilized.

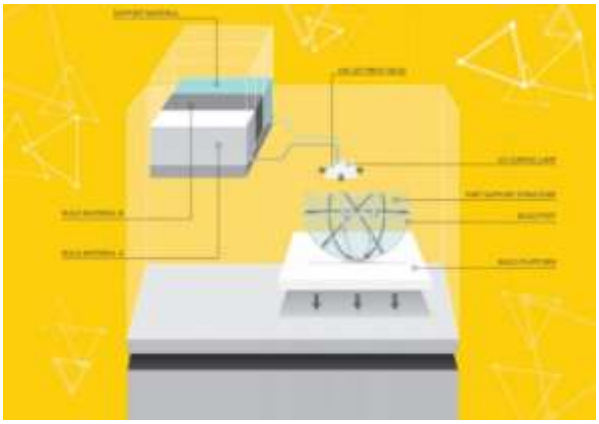


ColorjetPrintiing

ColorJet Printing (CJP) is an additive manufacturing technology which involves two major components – core and binder. The Core™ material is spread in thin layers over the build platform with a roller. After each layer is spread, color binder is selectively jetted from inkjet print heads over the core layer, which causes the core to solidify. The build platform lowers with every subsequent layer which is spread and printed, resulting in a full-color three-dimensional model.
Colorjet and polyjet are similar technologies, owned by two different companies. Since they couldnt copy, they made a different way to do it.

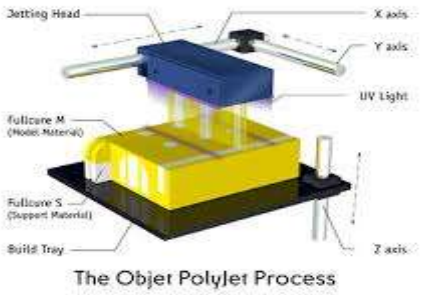
Multijet Printing

MJP or MultiJet Printing is an inkjet printing process that uses piezo printhead technology to deposit either photocurable plastic resin or casting wax materials layer by layer. MJP is used to build parts, patterns and molds with fine feature detail to address a wide range of applications. These high-resolution printers are economical to own and operate and use a separate, meltable or dissolvable support material to make post-processing a breeze. Another big benefit is that removing support material is virtually a hands-free operation and allows even the most delicate features and complex internal cavities to be thoroughly cleaned without damage.



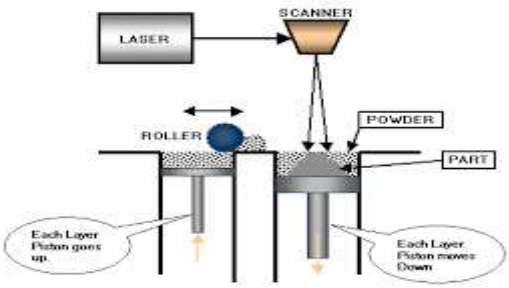
Digital Light Processing

A projector light source is used to cure the liquid resin in a layered fashion. The object is constructed on an elevating platform and the layer is created upside down. The polymer is layered pending the object is constructed and the residual liquid polymer is drained off[8].



Selective laser sintering

This technology was developed in the university of Texas and was being used since 1980s. It is one of the most promising technology for solving various problems encountered during casting alloys[9]. A fine material powder is fused by scanning laser to build up structures incrementally. A new fine layer of material spreads uniformly over the surface as a powder bed drops down. It involves making of metallic frameworks by selective laser, melting in a layered manner that generates 3D pieces by strengthening selective and successive layers of powder material, one above the other, using heat generated by a computer controlled laser radiation[10].No support material is required as the structures that are printed are supported by the surrounding powder. Production of facial prosthesis makes use of polymers scaffolds. Selective laser sintering can be used in fabrication of anatomical study models, cutting and drilling guides, dental models and also for engineering/design prototypes. Materials used can be titanium, cobalt chrome, stainless steel etc. It has various applications in areas needing high fracture toughness and mechanical strength like metallic implants facilitating bone ingrowths and regeneration. Advantages are that the materials used can be autoclaved, printed objects have full mechanical functionality and use of lower cost materials in large volume. Disadvantages are powders are messy with increased inhalation risk, technology is expensive and requires of compressed air.



II. APPLICATIONS

The use of 3D printing and digital technology have significantly increased the rate of success and also improved the quality and precision of dental operative work.Also, it will affect clinical practice on how quickly and efficiently the dental surgeon will be able to operate. For the dental laboratories, it will affect the marketing strategy to clients and for the patients, it will affect which dentist to choose- the one who has adopted this new technology which allows more comfortable diagnosis and faster results or the one who uses traditional methods.

Reconstruction of 3D Models

3D printing can be used to take a 3D image of the teeth and upload to a computer software program which can be accessed and desirable model can be adjusted or altered as per the needed requirement and can be printed in a few hours time. This model can be hand held and can replicate the area of interest for superior observation.

Fabrication of Tooth Restorations

3D printing can be utilized for tooth fillings which will reduce the treatment costs in comparison to CAD-CAM (Computer Aided Design/Computer Aided manufacturing) restoratives and decrease the technique sensitivity of placement of the restorative material. It can be used to restore a complex cavity involving multiple surfaces that cannot be restored directly. The steps to fabricate a 3D printed restoration are as follows[11] :

- Tooth preparation according to the cavity is done, it can be two or three surface preparations.
- Scanning of preparation and uploading the data on computer.
- Printing the filling with appropriate material of choice of restoration.
- Lastly, cementation of the prepared 3D filling into the scanned cavity with suitable adhesive material.

3D printed guides and models help the clinician in esthetic treatment planning and also aid them in minimal intervention and skill acquisition.

Reconstruction of tooth models (Atypical anterior tooth)

In cases of atypical anterior tooth, a physical tooth model is fabricated to guide the treatment procedure favourably. A translucent tooth model is built carrying the information regarding the internal root canal structure through a 3 step process :

- Data collection through CBCT (Cone Beam Computed Tomography) scanning.
- Virtual modeling by image processing.
- Manufacturing through 3D printers.

A customized guide jig is fabricated to get a safe and precise working path to the root canal and follow up after few months can be done for complete healing of the periapical region.

Guided Implant Surgery

3D printed templates can give high accuracy for guided implant surgery when used as alternatives to laboratory manufactured templates[12]. The guides offer better precision of placement of the implant as compared with free hand placement which is completely dependent on the clinician's skill and experience.

Guided Endodontics

3D printed templates can be utilized to gain guided access to root canals and various in vitro research studies proved that accurate access cavity preparation upto apical third of the root could be obtained through 3D template guided Endodontic procedures[13]. This would be useful to clinicians while facing challenging canal morphologies. 3D guided access stent which is digitally designed to fit each tooth could pave the way to minimally invasive endodontic access and minimize the chances of iatrogenic errors.

Repair of bony/soft tissue defects

The defects caused by accidents, surgery or birth can be repaired by fabricating 3D scaffolds of various geometric shapes through customized tissue engineering. Rapid prototyping or solid free form fabrication techniques are very useful in designing customized scaffolds. Polyethylene oxide and polyethylene glycol dimethacrylatephotopolymerisable hydrogels were used to fabricate scaffolds resulting in constructs that were comparable with soft tissues in terms of elasticity and high cell viability which was achieved along with high density constructs[14].

Dental pulp regeneration

3D cell printing technique can be utilized for replacing pulp tissue. The structure of the pulp tissue can be recreated by using an ink jet device by dispensing layers of cells that are suspended in hydrogel. This helps in precisely positioning the cells and this mimics the natural pulp tissue of the tooth. This is achieved by systematic positioning of cells that includes positioning of the odontoblastic cells at the periphery and fibroblasts within the core with a supportive network of vascular and neural cells. Research is focusing on in vivo creating a functional tissue like pulp[15,16].

Preclinical Training

3D printing would enable students to discover and improve clinical skills in contrast to the current use of extracted teeth used for learning purposes. Multiple model tooth copies can be printed from any selected micro CT (Computed Tomography) scan which can be used by dentists and dental trainees, as there is limited availability for extracted teeth for the same. Also, 3D printed tooth models can mimic conditions like pulp stones, internal and external root resorptive defects, dens in dente and many more anomalies which will help them visualize, improvise and advance in the science and art of endodontics[17]. One more important application of 3D printing in dentistry is creating digital scans of full or partial arches into durable plastic model casts. This reduces the effort and inconvenience to the operator as well as to the patient in using impression materials for recording impressions followed by fabrication of casts with stone.

Other uses

Autotransplantation :3D printing can be useful in this as image of tooth can be scanned before extraction and the recipient tooth can be modified accordindly and placed in the extraction socket. The recipient tooth can be prepared for crown and temporary crown can be placed immediatey after placing the tooth in desired site. This minimizes the chances of errors during autotransplantation.

Night guard trays: Images obtained from scanning are used to prepare 3D model of dentition on which tray can be prepared.
Template : `For restoration of fractured anterior teeth 3D printed templates can be prepared which help in easy and convinent placement of composite.
Instruments : 3D printed instruments are now becoming a reality. They are at present being used in medical field. So fabrication of dental instruments can be seen in near future.

Advantages

Conventional substractive manufacturing techniques like milling are known to create high wastage which can be minimized using techniques in adjunction with additive manufacturing. 3D printing is clearly the best available digital processing method for this purpose. Its higher efficiency, passivity, flexibility and superior material utilization makes it distinct from other techniques. Also, it is time saving, less technique sensitive and many models can be prepared using this technique.

Disadvantages

The limitations of 3D printing is its high cost, the occurrence of staircase effect(created by layered deposition), inconsistent reproduction and requirement of support materials that is difficult to remove post processing. Other disadvantages are requirement of trained person and there is no gold standard and no ethical and legal clearance as of now.

III. CONCLUSION

3D printing could establish itself as a milestone in the field of dentistry due to its accuracy, efficacy, potency and minimal time consumption in the fabrication process. Its utility in treatment planning and analysis of treatment outcomes improvises the quality of treatment provided by the dentist to the patient enhancing the patient satisfaction. 3D printing is transforming digital dentistry by extensively giving opportunities in diagnosis, treatment and education. Further research in this would revolutionize digital dentistry and contribute to overall benefit in patient care.

REFERENCES

[1]. Rengier F, Mehndiratta A, von Tengg-Kobligk H et al. 3D printing based on imaging data: Review of medical applications. Int J CARS. 2010; 5(4):335–41.
[2]. Jacob GS. Three-Dimensional Printing of Dentures Using Fused Deposition Modeling. Inside Dental Technology. 2013;4.
[3]. Dawood A, Marti B, Jackson VS, et al. 3D printing in dentistry. British Dental Journal. 2015; 219:521–9.
[4]. Mawere C. The impact and application of 3D printing technology. International Journal of Science and Research (IJSR). 2014; 3(6):2148–52.
[5]. Chia HN, Wu MB. Recent advances of 3D printing of biomaterials. Chia and Wu Journal of Biological Engineering. 2015; 9:4.
[6]. Van Noort R. The future of dental devices is digital. Dent Mater. 2012; 28(1):3–12.
[7]. Zein I, Hutmacher DW, Tan KC, Teoh SH. Fused deposition modeling of novel scaffold architectures for tissue engineering applications. Biomaterials. 2002; 23:1169–85.
[8]. Nayar S, Bhuminathan S, Bhat WM. Rapid prototyping and stereolithography in dentistry. J Pharm Bioallied Sci. 2015;7:S216-S219.
[9]. Kruth JP, Vandenbroucke B, van Vaerenbergh J, Naert I. Digital manufacturing of biocompatible metal frameworks for complex dental prostheses by means of SLS/SLM. In: Da Silva Bartolo PJ: Virtual modeling and rapid manufacturing. London/Taylor & Francis Group; 2005.
[10]. Xu F, Wong YS, Loh TH. Toward generic models for comparative evaluation and process selection in rapid prototyping and manufacturing. J Manuf Syst. 2000;19:283-296.
[11]. Ayar MK. Is a three-dimensional-printed tooth filling possible? Dent Hypotheses. 2016; 7:53–5. s
[12]. Kuhl S et al. Technical accuracy of printed surgical templates for guided implant surgery with the co DiagnostiX software. Clin Implant Dent Relat Res. 2015; 17(Suppl1):e177-82.
[13]. Zenhnder MS et al. Guided endodontics: Accuracy of a novel method for guided accsess cavity preparation and root canal location. Int Endod J. 2016; 49(10):966–72.
[14]. Dhariwala B et al. Rapid prototyping of tissue-engineering constructs, using photopolymerizable hydrogels and stereolithography. Tissue Eng. 2004; 10(9-10):1316–22.
[15]. Sureshchandra B, Roma M. Regeneration of dental pulp: A myth or hype. Endodontology. 2013; 25(1):139–55.
[16]. Yelick PC, Vacanti JP. Bioengineered teeth from tooth bud cells. Dent Clin N Am. 2006; 50(2):191–203.
[17]. Jacob GS. 3D Printing for education and training in Endodontics. Inside Dentistry. 2016; 12(1).

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