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3D printing in dentistry: A new dimension of vision

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Abstract
3D printing has been hailed as a disruptive technology which will change manufacturing. Used in aerospace, defence, art and design. The technique now a days gained wide acceptance in various medical fields including dentistry. Three-dimensional (3D) printing is an additive manufacturing method in which a 3D item is formed by laying down successive layers of material. The 3D scan gives information in detail about the anatomical structure to be 3D printed. There are various techniques of 3D printing mainly stereolithography, selective laser printing, fused deposit modelling in dentistry its mainly used in teaching and/or management of cases involving implant, craniofacial, maxillofacial, orthognathic and periodontal treatments, non-surgical and surgical endodontic treatments, and the fabrication of copings and frameworks for implant and dental restorations.

Keywords: 3D printing, copings, stereolithography, selective laser printing

1. Introduction
Recent advances in digital technology and their application to dentistry, mainly in the field of prosthodontics, orthodontics, oral and maxillofacial surgery, endodontics have resulted in the development of techniques that may be used to improve our clinical practice along with patient education. Few important techniques are cone beam computed tomography (CBCT), three-dimensional (3D) printed objects, CAD CAM. CBCT, CAD CAM and other 3-dimensional scanning helps in the assessment of teeth in relation to surrounding hard and soft tissues through the creation of 3D images [1].
Based on the virtual computer-generated renderings of the dentition and associated skeletal tissues. models and guides are produced through automated processes, called the 3D printed objects. 3D printing technology also called additive manufacturing; rapid prototyping uses incremental deposition of material layer by layer [2]. It's an innovative method over the subtractive manufacturing where a block of object is used to cut the material out [3].

2. Mechanism and Production
Various mechanisms are used to create and print a 3D object. The most important technique used is called Stereolithography which was introduced by Charles Hull. Resin polymer is added layer by layer which is cured by UV light. Because of its high mechanical strength, it is used to make implant surgical guides, obturators, surgical stents, duplication of prosthesis and burn stents. The curing is affected by the power of the light source, the scanning speed and the chemistry and amount of the monomer and photo initiators.
Along with these constituents, UV absorbers can be added to the resin to control the depth of Polymerization. The main disadvantage of SLA is the scarcity of biocompatible resins with proper SLA processing properties.
Fused Deposition Modelling (Fig 1) developed by Schott Crump is yet another technique of 3D printing. A thermoplastic filament material is extruded through a nozzle controlled by temperature and the material hardens immediately (within.1 sec) after extrusion. A processor controls the nozzle head and helps in the uniform distribution of material on a platform. Materials such as acrylonitrile butyro-styrene ABS, polycarbonates and poly sulfones are used.
Selective Laser Sintering was developed by university of Texas. A fine material powder is fused by scanning laser, to build up structures incrementally. As a powder bed drops down, a new fine layer of material is spread uniformly over the surface.

A high (60µm) level of resolution may be obtained. No support material is required as the structures that are printed are supported by the surrounding powder.[4] Production of facial prosthesis makes use of polymers scaffolds (poly amide or poly Caprolactone).

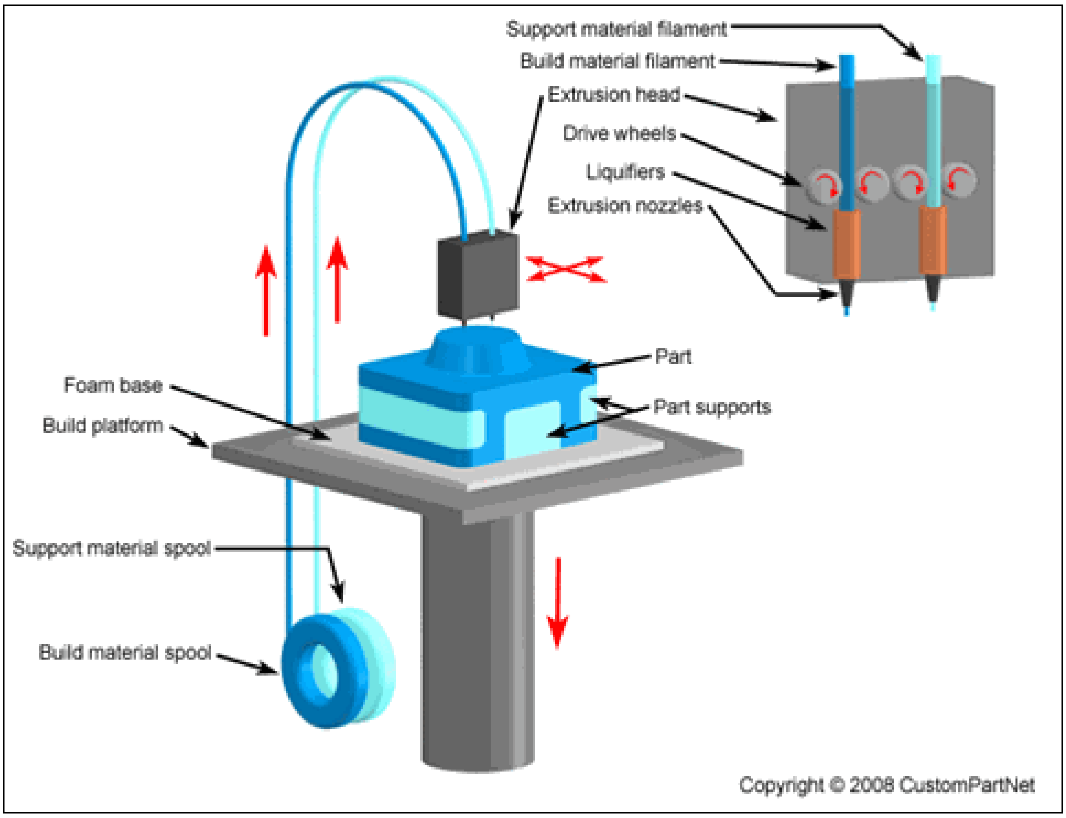

Fig 1: Fusion Deposition Modeling

Selective laser sintering (Fig. 2) is used in fabrication of anatomical study models, cutting and drilling guides, dental models, and also for engineering/design prototypes. Photopolymer Jetting 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.

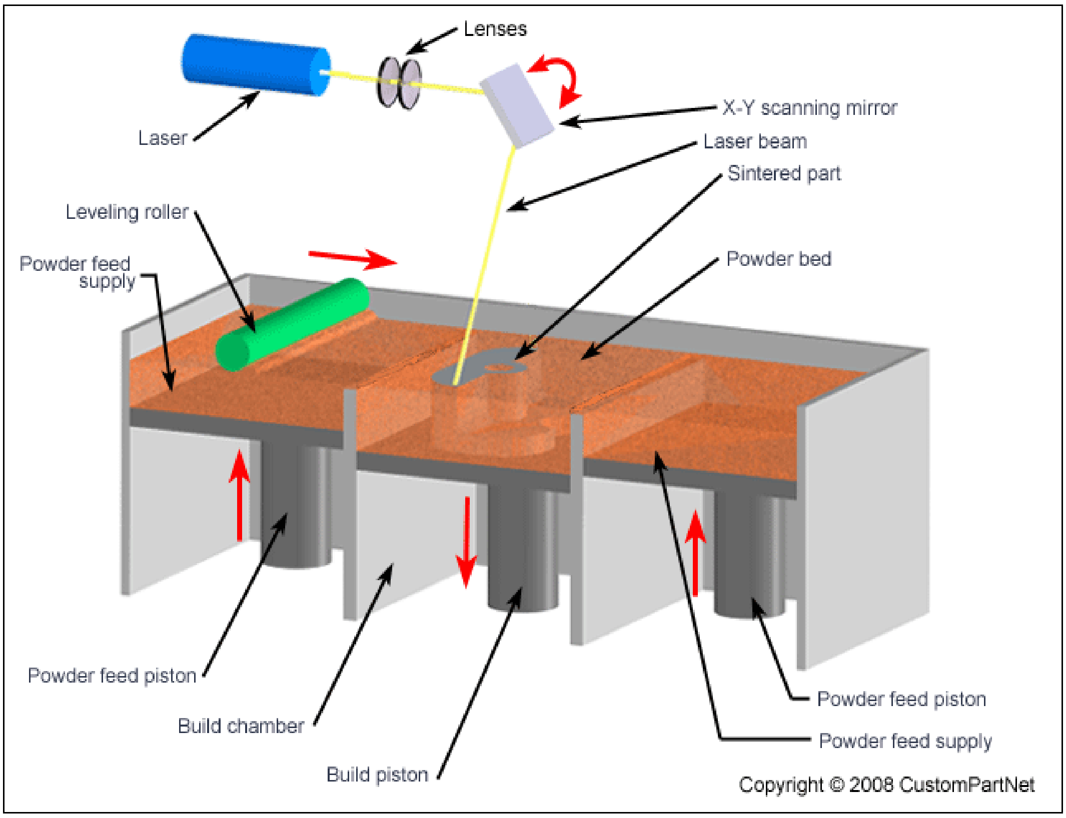

Fig 2: Selective Laser Sintering

Powder Binder Printer uses a modified inkjet head to print. Liquid droplets are made to infiltrate a uniform and single layer of powder one after the other. Powder bed drops incrementally and a final model is ready.
Digital light processing (DLP), which is similar to SLG except that it uses a Digital Micromirror Device™ (Texas Instruments, Dallas, TX, USA) to project a cross-sectional UV image instead of a moving beam [1].
The material to be 3d printed is subjected to a 3d scan and the volumetric data (DICOM format) is converted to the Standard Tessellation Language (STL) file format representing the virtual 3D surface shape.[1] Specialized softwares are then used to match the STL file with the CBCT volumetric data to avoid streak and voids or any form of artefacts. Using an implant planning software a blueprint of the 3d printed object is created. The finalized design is then digitally sliced and exported to a 3D printer for fabrication.

3. Review of Dental Applications

3D printed objects, based on 3D imaging scans, designed by 3D virtual planning software and produced using 3D printing processes have been successfully used in various medical fields including dentistry mainly prosthodontic, orthodontic, orthognathic, craniofacial, and oral and maxillofacial procedures [1].

3.1 3D printed models (Fig 3)

Plaster models serve as an educational tool for students and if helpful for patient education. They can also be used for treatment planning, record keeping, assessing potential management difficulties and to fabricate custom guides or splints. However, plaster models cannot replicate internal anatomical structures, accurately duplicated and fabricated. 3d printed models reproduce the exact details of the anatomical structure and also overcomes the limitations of plaster models. The data of the 3d model can be stored and also exchanged electronically [1].

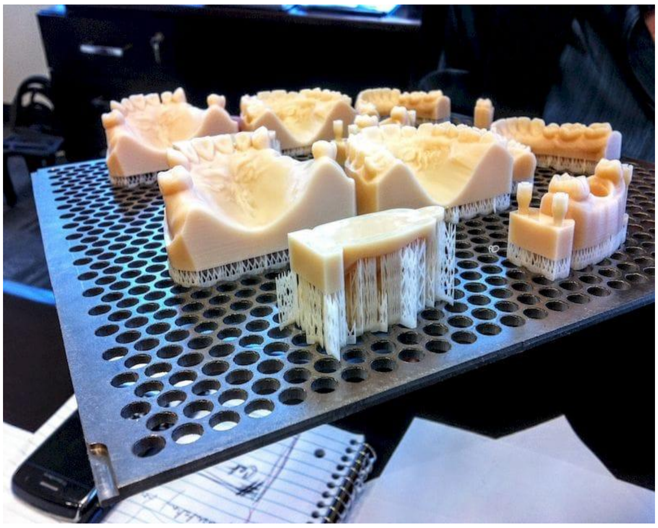

Fig 3: 3D Printed Models

3.2 3D printed guides

Endodontic treatment for the Pulp canal obliterated tooth is a challenging task for a clinician. To locate the canal orifice in such tooth is of utmost difficult task. In such clinical scenarios, a 3d printed guide of the teeth helps in easier canal orifice location. It helps in avoiding procedural errors like root perforation or other iatrogenic errors (Fig 4).

Fig 4: 3D Model for locating canal orifices

3d printed guide helps in proper placement and angulation of bur, in case of pulpal canal obliteration [1]. 3 d guides are of a helping aid in in few other clinical scenarios where the lesions may have perforated cortical plates. It helps us in the exact location of the lesion along with the amount of cortical bone to be resected. The guide also help in the implant placement and should incorporate adequate support from bone, teeth or mucosa with guidance for the implant preparation and fixture placement procedures provided by specifically orientated guide sleeves. During treatment, the position of the guide sleeve over the cortical plate helps to identify the osteotomy site. Depth calibrated drills or piezoelectric instruments used to perform the osteotomy maintain parallelism with the guide sleeve, thereby limiting its size to 4 mm [1]. 3D guides ensure for a less invasive, more predictable and safe operative procedure [2].

3.3 Auto transplantation

Conventional methods of autotransplantation use the transplant tooth as a template for preparation of the recipient site, often requiring multiple ‘fitting’ attempts with adjustments to the alveolar bone that increase extra-oral time and risk damage to the PDL. Extra oral time and the damage to the pdl fibers determine the success of autotransplantation. 3d printing technology has been introduced in this field. Computer aided rapid prototyping (CARP) was used to print replicas of teeth (Fig 5) such that manipulation of the recipient bone sites could be completed prior to extraction of the transplanted teeth without PDL damage from repeated insertion and removal.[3]

Fig 5: Autotransplantation of Premolars with a 3D printed Titanium replica of the donor tooth, acting as a surgical guide

3.4 Crown copings and partial denture frameworks

With the use of intraoral optical scanners or laboratory scanners a precise virtual model is created of the prepared tooth, implant position or the dental arch. In fixed and removable prosthodontics (Fig 6A-6D), treatment may be planned and restorations can be designed in CAD software. This scan data and CAD design may be used to mill or print crown or bridge copings, implant abutments, and bridge structures [2].

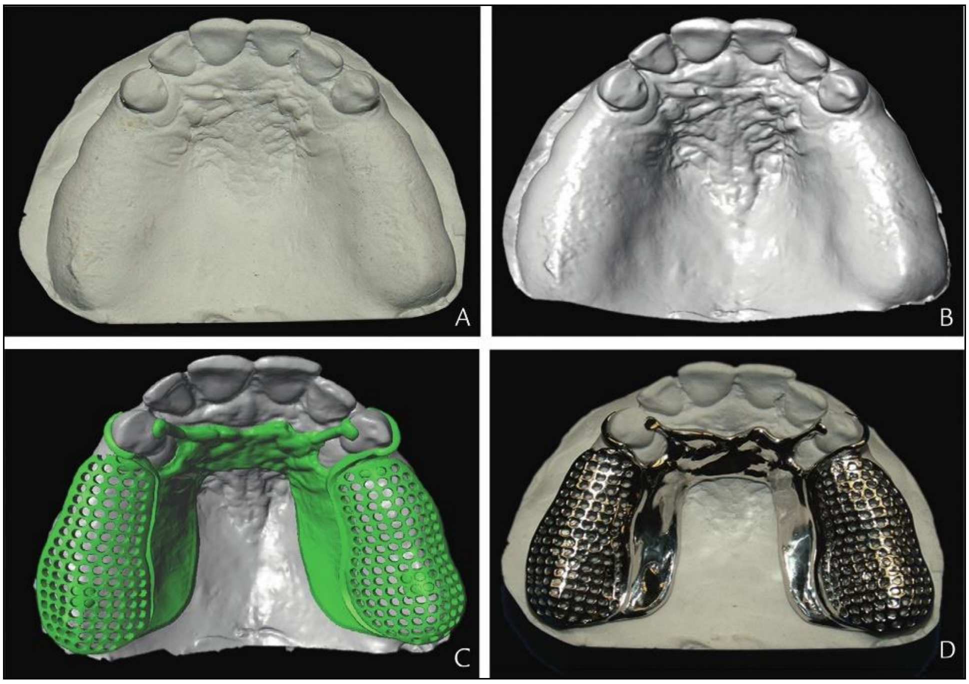

Fig 6A-6D: Sequential fabrication of cast partial denture from (A) Cast taken from the patient, (B) 3D image of the cast, (C) 3D image of the Partial Denture framework, (D) completed 3D model

3.5 Digital orthodontics

In orthodontics, treatment may be planned and appliances created, or wires bent robotically based upon a digital workflow using intra oral or laboratory optical scanning or even CBCT to capture patient data. The Invisalign®, system digitally realigns the patient's teeth to make a series of 3D printed models for the manufacture of 'aligners'(Fig 7), which progressively reposition the teeth over a period of months/years [5].

Fig 7: Clear aligners

3.6 Dental implants

3D printing technology to create dental implants have been used by manufacturers widely [6]. 3D printing has the ability to reproduce the minute details of the anatomical structure (Fig 8) along with the surrounding structures associated with it, such as a bone-like morphology, which may not be produced by milling alone – although milling/machining may also be used to refine the printed form [7].

Fig 8: 3D prototype of dental implants for its precise positioning

3.7 3D printed antimicrobial composite resin

Monomers containing antimicrobial, positively charged quaternary ammonium groups with an alkyl chain are either directly copolymerized with conventional diurethane-dimethacrylate/glycerol dimethacrylate (UDMA/GDMA) resin components by photocuring or prepolymerized as a linear chain for incorporation into a semi-interpenetrating polymer network by light-induced polymerization. 3D-printed objects are fabricated by stereolithography. Positively charged quaternary ammonium groups are incorporated into the photocurable UDMA/GDMA resins [8]. These act as bactericidal and kills bacteria on contact.

3.8 Regenerative Dentistry

3D printer can print bone tissue tailored to requirement of patients act as biomimetic scaffold. These days there are 3d printed alginate peptide hybrid scaffold, which act as a stable medium for the optimal growth of stem cells. Calcium sulphate, calcium phosphate and composite powders can be printed which act as augmentation material [3].

4. Conclusion

3D imaging and modelling, are widely influencing all aspects of dentistry. Any complex geometrical anatomical structures can be accurately rebuilt with the 3d scans obtained. Even now, nearly everything we make for our patients can be made by a 3D printer, but no single technology is sufficient for all our patient's needs. The technology is already widely used in orthodontics for patient education, treatment planning and other further treatment procedures.

This technology is used to print models for restorative dentistry and patterns for the lost wax process which is becoming increasingly important with the rise of intraoral scanning systems. It's also used in the field of endodontics mainly in surgical and non-surgical endodontics. In maxillofacial and implant surgery, it is becoming commonplace and prerequisite to use anatomical models made by any number of different 3D printing techniques to assist with the planning of complex treatments allowing for a less invasive, and more predictable safe surgeries and better outcome [9].

The need for skilled operators is a major requisite for 3D printing. The cost of running machine and maintenance should also be considered., as well as the need for post-processing and adherence to strict health and safety protocols. Despite these concerns it is clear that 3D printing will have an increasingly important role to play in dentistry. The visualization, scanning, building and slicing, and printing along with creativity and professional expertise has made 3D printing widely acceptable in all aspects of dentistry.

5. References

1. Wenfeng Hao, Ye Liu, Hao Zhou, Haosen Chenb, Daining Fang. Preparation and characterization of 3D printed continuous carbon fiber reinforced thermosetting composites. Polymer Testing. 2018; 65:29-34.
2. Pratik Shah, Chong BS. 3D imaging, 3D printing and 3D virtual planning in endodontics. Clin oral Invest. 2018; 1:10-4.
3. Cristian Zaharia, Alin-Gabriel Gabor, Andrei Gavrilovici, Adrian Tudor Stan, Laura Idorasi, Cosmin Sinescu *et al*. Digital Dentistry —3D Printing Applications. J Int Med. 2017; 2(1):50-53.
4. Jun Yue, Pei Zhao, Jennifer Y. Gerasimov, Marieke van de Lagemaat, Arjen Grotenhuis, Minie Rustema-Abbing, Henny C. van der Mei, Henk J. Busscher, Andreas Herrmann, and Yijin Ren. 3D-Printable Antimicrobial Composite Resins. Adv. Funct. Mater. 2015, 25:6756-6767.
5. Anderson J, Wealleans J, Ray J. Endodontic applications of 3D printing. Int Endod J. 2018; 1(1):1-14.
6. Dawood B, Marti Marti, Sauret-Jackson V, Darwood A. 3d printing in dentistry. Bri Dent J. 2015; 219(11):521-529.
7. Ayar MK. Is a three-dimensional-printed tooth filling possible? Dent Hypotheses. 2016; 7:53-5.
8. Reeta Jain, Supriya, Shweta Bindra, Kimmi Gupta. Recent Trends of 3-D Printing in Dentistry- A review. Annals of Prosthodontics & Restorative Dentistry. 2016; 2(4):101-104.
9. Joerg R, Strub E, Dianne Rekow, Siegbert Witkowski. Computer-aided design and fabrication of dental restorations Current systems and future possibilities. JADA. 2006; 137(9):1289-96.