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Review Article

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APPLICATION OF 3D PRINTING IN DENTISTRY- REVIEW

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ABSTRACT
Over the past 30 years, 3D printing and prototyping has gained popularity within medical and dental profession and among patients alike. Three-dimensional (3D) printing is an additive manufacturing methods in which 3D objects are formed by laying layer by layer material. 3D printers are machines that produce representations of objects either planned with a CAD program or scanned with a 3D scanner. This review article highlights the history and current application of 3D printers in dentistry.

KEYWORDS: 3D printing, rapid prototyping, CAD/CAM, surgical guide, 3d scanner.

INTRODUCTION

The origins of 3D printing be traced back to 1986. Charles (chuck) Hull who is first invented his SLA (stereo lithography apparatus) machine in 1983. In the earlier at1980s 3D technologies were called as rapid prototyping technologies. A host of new technologies continued to introduce in 1990s and early 2000s. In 1909 the first commercially available 3D Printer in kit form, based on the Rep Rap concept. Alternative 3D printing processes were introduced at entry level of the market in 2012.

The three dimensional (3-D) printing is also known additive manufacturing or desktop fabrication. In 3-D printer a layer by layer design of an entire 3-D objects is formed and the whole process by which 3D solid objects of any shape or geometry can be created from a digital file. Each of this these layers represent a thinly sliced horizontal cross-section of the eventual object, in contrast to traditional subtractive manufacturing methods which relies upon the removal of material to create something.

Application of 3D printing covers various sectors from education to industry. Digital dentistry has shown significant application in clinical and laboratory techniques in many areas of dentistry. As 3-D printing can replicate the human form more accurately than traditional manufacturing technique.3D printing has provided comfort and better quality treatment and enhanced treatment procedure to dentist. Patients treatment becomes fast, smooth and with greater precision.[1, 2] The aim of this article is to highlight the current application of 3 D printing in dentistry.

3-D printing technologies used in dentistry

Oral surgery – current application in oral maxilla-facial surgery includes trauma surgery, (fig 1and 2) pathology induced defects, tissue engineering, complex temporomandibular joint reconstruction and correction of complicated facial asymmetry.[4,5]

Fig 1: Boarders of surgical resection marked on 3 Dmodel.

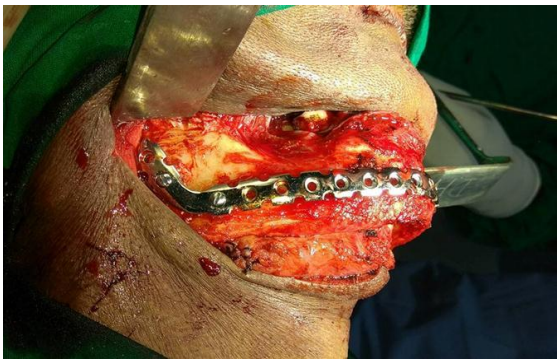

Fig 2: reconstruction plate adaptation shows 100% precision from model adaptation.

Orthodontic application

digitization as made orthodontic treatment easy and faster. Unlike conventional fixed orthodontic treatment, 3D printed orthodontic aligners play a major role in treatment outcome and predictability. Main advantage lies in reduction of clinical visits and reduction of chair side appointments.

Splint therapy in TMJ disorders, manufacturing of customized splints save time required for laboratory work, are more precise and reduce manual errors in fabrication.

After the 3 D scan is done, it is transferred to the computer to get 3D image of patient's teeth. These files can be sent out to labs for fabrication where 3-D CAD files are dragged in to 3D printer. Various removable appliances like Hawley retainer, splints, functional appliances, arch expansion appliances, clear aligners, retainers, arch wires, brackets, set up models which will make lingual orthodontics and mock surgeries fast and easy (fig 3), also study models. 3d printed brackets are custom built and tailored to individual tooth surface.[2,11]

Fig 3: Orthognathic surgery 3D printed models reconstructed from CBCT Scan.

Prosthodontics

Application of 3D printing in prosthodontics has been increasing in the last years, for fabrication of implant surgical guides (fig 4), frame works for fixed and removable partial denture, wax patterns for the dental prosthesis, zirconia prosthesis and complete dentures.[3,7]

One of the pioneers CAD/CAM manufactured denture for treatment of edentulous patients is 3D printed dentures.3d printing combined with CAD/CAM method can automate fabrication of dentures. Studies have shown 3D printing technology for dentures makes not only denture bas but denture teeth. 3D printed resin teeth had fractured resistance and biomechanical pattern comparable to conventional prefabricated denture teeth.[9]

Fig 4.3D: printed Implant surgical guides.

Endodontics

Endodontic challenges like pulp canal obliteration, auto transplantation, educational models and clinical stimulation are overcome with 3d imaging and procedures.[4]

Obliteration of root canal system due to acceletrated dentinogenesis and dystrophic calcification, through 3D digital planning a custom made endodontic guides are created for predictable navigation of obliterated pulp. This avoids iatrogenic damage to the root and decreases the risk of excessive dentine destruction/root proforation.[8]

Periodontics

3D printed guides are commonly used for aesthetic gingival reconstruction. Patient specific surgical guides are utilized for gingivectomy and smile designing enables a precise and customized approach.

3-D imaging and modelling can create a huge impact in generative periodontics. 3D scaffolding technologies can be used in combination with either biologic or cell therapies to create bio-active scaffolding systems for tissue repair. Further clinical trials are required to prove the efficacy of this 3D printed scaffolding system.[3]

Pediatric dentistry

kids and teens with gag reflexes and special needs can especially find difficult for making impressions for crowns, fillings and other dental restoration. Scanning and 3D printing treatment not only faster but friendly and more comfortable.[6]

Educational application of 3D models

3D printing is the ultimate tool for educational and training of students in oral surgery, endodontic and prosthodontics. This is achieved by using high end 3D printers that allow both hard and soft tissue replication in a single training jaw. This offers great opportunities in the field of replicating orofacial anatomy and complex geometry with highest precision that can be employed to train students and practitioners for performimg various maxillofacial operations.

3D printed tooth models base on computerized tomographic images of extracted teeth are more realistic anatomical root canal structure compared to plastic typodont teeth. Thus 3D printing has a challenging role in advancement in surgical and non-surgical endodontics.

Intra oral scans of the patients are utilized to print 3d models that are custom real patient based models. These customized models are used for training dentist in prosthodontics for veneer and crown preparation.[10]

CONCLUSION

3-D printing and prototyping has gained popularity with in the profession and among patients alike. As it offers efficiency, affordability, accessibility, speed, accuracy and eliminate dental labs manual modeling. Digital process keeps all cases for as long as needed, there is no need to store bulky physical models. By further research and technological advances, rapid prototyping will become a widely used method for 3-D reconstructions in the dental laboratory and let the business grow.

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