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3D Printing in Dentistry - Sculpting the Way It Is

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Abstract: One of the most immediate emerging trends is the use of 3D printing in the field of medicine and dentistry. 3D printing technology has the potential to be very beneficial to patients and doctors in terms of patient-specific individualized management. These inventive advances have been gradually advancing into medicinal gadgets, cutting down expenses in the social insurance industry and making it less demanding for patients to oversee interminable conditions. Dental research centers can create crowns, bridges, stone models, implants and different surgical, endodontic and orthodontic appliances by strategies that combine oral scanning, 3D printing, and CAD/CAM design. Current 3D printing has been utilized for the advancement of models for quite a while, and it has started to discover its utilization in the realm of manufacturing. This review is focussed around the advances in Additive Manufacturing and its developing applications in the field of Dentistry.

Keywords: Additive Manufacturing (AM), Stereolithography, 3D printing, Dentistry, CBCT, STL.

I. Introduction

The present world is developing so fast that it is very difficult for anyone to keep pace with it. Relating to the radical changes that our age has found in the previous century, additive manufacturing has started a novel way to deal with utilization of biomaterials [1]. A standout amongst the quickest developing patterns is the utilization of 3D printing in the field of Medicine and dentistry. The idea of Additive Manufacturing (AM) was first presented by Chuck Hull in 1986 by means of a procedure known as 'stereolithography (SLA)' [2, 3]. He made the initial 3D printer that utilized the strategy of stereolithography, and also the main program for virtualization [4]. They got expanded consideration in fields, for example, engineering because of the expanded potential in the immediate development of parts, aeronautics in light of the simplicity of making different little parts utilized as a part of rocket development, and specialized subassemblies utilized as a part of broadcast communications area. Their utilization in territories that require millimetric accuracy has drawn the consideration of specialists in general medicine, who began to execute it since the 1990s [5].

II. Modes of 3D Printing

Various applications in dentistry make use of the following facilities developed in the field of Additive Manufacturing.

(1) Stereolithography (SLA).
(2) Fused Deposition Modeling (FDM).
(4) Selective Laser Sintering
(5) Photo Polymer Jetting
(6) Electron Beam Melting (EBM)

A. Stereolithography (SLA)

Guideline of making solid articles includes progressive printing of thin layers of UV treatable photopolymer layer by layer. It is utilized to make implant surgical guides as a result of high strength, obturators, surgical stents, duplication of prosthesis and burn stents [6]. Stereo lithography has been utilized as a part of the field of maxillo facial prosthodontics as obturators, surgical stents, duplication of prosthesis and consume stents. A soft tissue model is built from CT scan into which a silicone is poured for the obturator. The obturator can fit precisely on the patient requiring less alterations contrasted with the customary impression systems (Fig. 1) [7].

Fig. 1: Surgical Stent for Dental Implant Placement Manufactured using SLA

B. Fused Deposition Modelling

The 3D printer uses a computer-aided model or scan information from which it extrudes and deposits melted thermoplastic

polycarbonate, in a layered fashion, to build objects from bottom to top. The layers of melted plastic instantly combine with each other, thus making very complex parts that are easy to produce. The resulting aspect of the finished object can be used in combination with several materials such as acrylic or wax [8].

C. Selective Laser Sintering

Selective laser melting is a technique of layer by layer addition 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 [9]. Accuracy will depend upon the speed of travel of the extruder, as well as the flow of material and the size of each 'step'. This is the process that is used by most low cost 'home' 3D printers. It takes into consideration the printing of rough anatomical models without a lot of complexity, for instance, printing an edentulous mandible [10].

D. Photo Polymer Jetting

This technology uses either a stationary platform and dynamic print head or a stationary print head and dynamic platform. Light sensitive polymer is flown onto a manufacture stage from an inkjet type print head, and cured layer by layer on an incrementally plunging platform. A support structure is laid down in a friable support material. An extensive variety of resins and waxes for casting, and some silicone-like elastic materials can be printed. This technology gives the resolution of approximately 16 microns and gives the easy access for making complex and fine detailed objects [8].

E. Electron Beam Melting

This strategy utilizes an electron beam as the power source rather than a laser to 3D print metal. An electron beam liquefies metal powder layer by layer inside a high vacuum and can accomplish full liquefying of the metal powder. Mechanical properties, granulate capacity and corrosion of dental implants produced by electron bar liquefying were observed to be similar to the precious and non-precious metal combinations. Fatigue resistance was affected by electron beam orientation and the crack propogation. This technology has found more wide application in orthopaedics and oral maxillofacial surgery as customized implants in the form of porous scaffolds [7].

III. 3D Printing Process

Advancements in computer innovation and programming applications are particularly a piece of the groundswell of mechanical change that has taken 3D printing to where it is today. For 3D printing to have esteem we should have the capacity to make articles to print; CAD programming enables us to make objects from scratch [11], but in dentistry and medical procedure we likewise have ready access to volumetric data as computed tomography (CT) information, cone beam tomography (CBCT) data, and intraoral or laboratory optical surface scan data. Late advancements in CBCT and optical scan technology, specifically, have altered, and are significantly changing numerous parts of therapeutic, restorative and implant dentistry. These powerful innovative tools are at the circumspection of a class of people – dental specialists and dental experts - who are frequently polymaths, having an expansive level of imagination and a comprehension of technology, including designing and material skills that expand well past that of numerous others working in singular fields of attempt [8]. 3D printing, however, makes its mark for the precise coincidental creation of complex structures in an assortment of materials with properties that are profoundly attractive in dentistry and in medical procedure [12].

The procedure of 3D printing in dentistry incorporates the accompanying strides: After the patient is scanned via computed tomography (CT/CBCT), DICOM records ought to be sent out. Less than a 1-mm CT/CBCT slice thickness is recommended. DICOM information is foreign made and changed over to stereolithograhy (STL) documents. Changed over 3D documents are transferred into the 3D printer. Fast prototyping takes after utilizing layer-by-layer stereolithographic gathering. The fast model is then created on by means of streaming of the materials. At last, unsintered segments ought to be removed (Fig. 2).

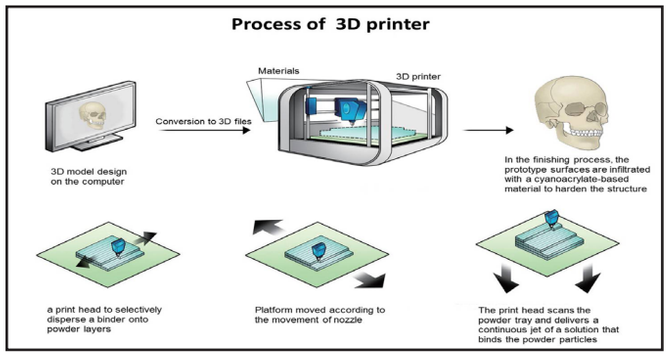

Fig. 2: Process of 3D Printing

IV. Applications of 3D Printing in Dentistry

3D printing holds vast applications in the field of dentistry. General applications are illustrated in Fig. 3. Apart from general applications, there are various advanced applications of 3D printing in the field of oral & maxillofacial pathologies which include:

A. CT-Guided Stereolithography as a New Tool in Craniofacial Surgery

CT- guided stereolithography as another tool in craniofacial surgery which can create exceptionally exact impression of the current structure. The advantages are diminishment of the surgical hazard, estimating and touching the contours by hand,

ideal planning of osteotomy lines and moving of bone grafts correct preparation of bone unions, ideal documentation of healing and development in follow-up studies and in addition for teaching purposes.

B. Stereolithography in Orbital Reconstruction

In orbital recreation, the relationship of bony defects to vital orbital structures must be painstakingly analysed preoperatively to keep away from basic surgical traps and boost the postoperative result. Stereolithography gives unrivaled internal anatomic detail, surface finish, and accuracy not achievable by current processing methods. Along these lines, cavaties, for example, sinuses, trenches, and foramina, are precisely made. Using a semilucent acrylic, sinus cavities may be visualized through the SLA model [13]. This enables the specialist to see the exact area of surgical incisions or screw placement relative to other anatomic landmarks.

C. Head and Neck Oncology

A tumor can be delineated on the SLA model, and the extent of the defect to be reconstructed can be visualized. The models might be utilized to design osteotomy for distraction osteogenesis in bony orbital development medical procedure and for remaking contracted circles after radiation treatment given amid early stages. Additionally, these models allow the surgeon to bend plates preoperatively. Simulating surgical procedures preoperatively on SLA models may decrease overall treatment costs by decreasing operative time [1,13].

D. The Potential Role of Stereolithography in the Study of Facial Aging

Mathematical techniques for describing the 3- dimensional (3-D) morphology of the facial skeleton are becoming increasingly sophisticated [14]. In this respect, the use of rapid prototyping offers the ability to further study craniofacial aging. All the more as of late, this strategy has been connected to the creation of replica human skulls for treatment planning and for the utilization in anthropology [15].

E. Stereolithography in Oral and Maxillofacial Operation Planning

As indicated by the necessities in oral and maxillofacial medical procedure STL demonstrates its advantages in exact portrayal of complex hard structures of the whole skull for precise preparation of surgeries with better spatial introduction and in the choice to make implant reconstruction preceding medical procedure. A further benefit is the possibility to sterilize STL models, so that they can be used during the surgical procedure.

F. Preoperative Diagnosis of Craniofacial Deformities and Planning of Surgical Corrections

The most appealing part of the models is the point of view that the specialist can deal with a realistic model, hence empowering a three-dimensional investigation of the anomaly and planning of the correction preoperatively and also amid medical procedure. This is likewise the primary explanation behind building a gathering of stereolithographic models of uncommon craniomaxillofacial deformations, so as to make this unique pathology available for educating and research purposes.

G. Biomodelling of Skull Base Tumours

Several investigators have inspected the utilization of biomodelling in cranio-maxillo-facial medical procedure and report clinical utility, in spite of the fact that these examinations are restricted to a modest bunch of clinical cases [16].

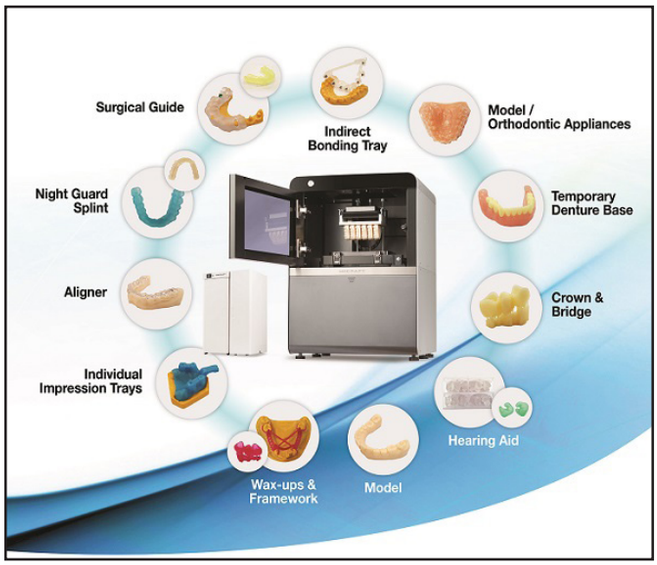

Fig. 3: Dental Applications of 3D Printing

V. Conclusion

The expected surge in the market for added substance fabricating in the coming years should be productive for dentistry also. In dentistry, 3D printing as of now has differing applicabilities and holds a lot of guarantee to make conceivable numerous new and energizing medicines and ways to deal with manufacturing dental restorations. Considering the scope of indications for 3D imprinting in dentistry, and the calling's long involvement of filtering and processing innovation, it may be said that dental practitioners and dental technologists have a more extensive experience of these 3D fabricating advances than some other calling. The national administrative bodies have not yet actualized direction in the utilization of 3D imprinting in surgery [17], or in dentistry, yet at some phase there will be a requirement for controllers to center around this innovation to set suitable measures.

Despite the fact that 3D printers are becoming more reasonable, the cost of running, materials, support, and the requirement for talented operators should likewise be deliberately considered,

and the requirement for present handling and adherence on strict wellbeing and security protocols. The consistency of examining, perception, CAD, processing and 3D printing innovations, alongside the callings natural interest and inventiveness of the professional makes this an uncommonly energizing time to be in dentistry.

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