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# 3D Printing in Prosthodontics – A Review

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**ABSTRACT**:
Three-dimensional printing, the anonym of additive manufacturing , is an advanced manufacturing technology. It is based on computer-aided design (CAD) digital models, which uses standardized materials to create personalized 3D objects by specific automatic processes. It's applications varies from prosthodontics, oral and maxillofacial surgery, and oral implantology to orthodontics, endodontics, and periodontology in the field of dentistry.
The aim of the present paper is to make a review of the applications of 3D-printing technologies in prosthodontic treatment.
**Key words:** 3D printing, prosthodontics, CAD.

## I. INTRODUCTION:

Charles Hull introduced the first three-dimensional (3D) printing technology in 1986, and the industry developed many different manufacturing technologies, which have been applied to numerous fields[1]. Three-dimensional printing, the anonym of additive manufacturing , is an advanced manufacturing technology. It is based on computer-aided design (CAD) digital models, which uses standardized materials to create personalized 3D objects by specific automatic processes[2]. Synonymous terms that are frequently used in different science sources are: "layered manufacturing", "freeform fabrication", "rapid prototyping", "rapid manufacturing" [3]. In the field of medicine, such as traumatology, cardiology, neurosurgery, plastic surgery, and craniomaxillofacial surgery, 3D printing is usually used for digital imaging in surgical planning, custom surgical devices, and patient-physician communication [4]. Its applications varies from prosthodontics, oral and maxillofacial surgery, and oral implantology to orthodontics, endodontics, and periodontology in the field of dentistry [5]. It has many advantages, such as high material usage, high economic benefits, and the production of certain scale products on demand. Though, it has some disadvantages, such as high cost of processing and material and time-consuming post processing. Despite that 3D printing has been successfully applied in the medical field in general[6,7] . The first step of the process is the creation of a 3D digital model of the future construction which is fabricated by the CAD. Then the real object is produced by the CAM unit. The data for the CAD is attained either from indirect scanning of a plaster model or through intraoral scanning of the prosthetic field [8]. Nowadays the most often used additive technologies in Prosthetic Dentistry are stereo lithography (SLA), inkjet-based system (3DP), selective laser sintering (SLS) and fused deposition modelling (FDM) usually with wax, metal alloys, resin materials and ceramics [9,10].
The aim of the present paper is to make a review of the applications of 3D-printing technologies in prosthodontic treatment.

## ADDITIVE MANUFACTURING:

American Society for Testing and Materials (ASTM) defined the term additive manufacturing as: "the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies" [11,12]. The "joining" of each new predetermined layer upon the previous layer is based on melting, fusing or a polymerization process. Engineering has designed various technologies for additive manufacturing. Stereo lithography, fused deposition modeling, selective electron beam melting, laser powder forming and inkjet printing are the commonly used methods in dentistry [3]. For the result of layer-by-layer structuring of the real dental restoration, first, the digital image of the object is segmented in the CAD unit through special software. Then the fabrication of the 3D prosthesis continues with a process almost indistinguishable to printing on paper – one layer on top of another. It is the so-called "3D-printing" [8,13]. The first additive technology that was created by Charles Hull for manufacturing of prototypes, models and casting patterns is Stereo lithography (SLA)[1].Hence it gave the name of the term "rapid prototyping".
The following seven process categories can be differentiated within additive manufacturing [15]:

- Vat photopolymerization (VPP)
- Material extrusion (MEX)
- Material jetting (MJT)
- Binder jetting (BJT)
- Powder-bed fusion (PBF)

- Directed energy deposition (DED)
- Sheet lamination (SHL)

**APPLICATIONS OF 3D PRINTING IN PROSTHODONTICS:**

**CROWN AND BRIDGE DENTURES:**

Crown and bridge dentures can be processed using resinbased 3D printing technologies such as SLA or DLP[16]. The amount of materials used in 3D printing technologies is less, with almost no material loss when compared to milling,[17]. It can print a variety of materials concurrently with favourable detail reproducibility [18] . A good fit is important to guarantee the mechanical stability, durability, and health of surrounding soft tissues [19]. Insufficient adaptability can cause dental plaque accumulation, microleakage of adhesive, discoloration of edges, and lack of esthetics, tooth sensitivity, dental caries, and periodontal disease [20].

**COMPLETE DENTURES:**

The 3D printing technologies can directly obtain CAD data and quickly produce a new digital model, which can be applied to the fabrication of a complete denture resin base without molds, cutting tools, or tooling fixtures [21].The 3D printing technology has the benefits of faster production of dentures and there are fewer stages in the work process, which can decrease the possibility of errors [22]. yet, the use of 3D printing in the design and development of complete dentures is still under study [23].

**REMOVABLE PARTIAL DENTURE FRAMEWORKS:**

Rapid advances in CAD/CAM have opened up new paths of additive and subtractive processes for the production of removable partial denture (RPD) frames [24].

**SURGICAL IMPLANTS:**

Among various 3D printing technologies, laser sintering and direct beam melting is commonly used in the manufacture of customized porous implants such as customized Ti mesh and reconstruction [25,26]. The SLS technology has a completely biodegradable and bone conductive nano composite scaffold with adjustable porosity and mechanical properties [27].

**ORAL IMPLANTOLOGY:**

The application of 3D printing technologies in oral implantology is to progress oral implantology from conventional pure experience modes to digital and accurate modes. They can enhance and simplify the medical treatment process, reduce the technical difficulty and technical risk, and improve the competence of dentists. This part mainly introduces applications in oral implantology, including manufacturing surgical guides and 3D printing custom trays.

**THREE-DIMENSIONAL PRINTED CUSTOM TRAYS:**

It is important to obtain accurate implant impressions for fabricating prostheses, and accurate edentulous impressions are the basis to assure that the restoration has good support, retention, stability, restored function, and the capacity to protect oral tissue health. The stable position of the trays in the mouth is one of the essential factors for making accurate impressions. Accurate and stable trays can provide uniform thickness and sufficient space for imprinting materials [28].

## II. CONCLUSION:

The appearance and disruptive development of 3D printing technologies bring favourable conditions to the fabrication of complex equipment in all walks of life. In the field of dentistry, 3D printing has a wide range of applications, making it possible to create new and more effective methods for manufacturing dental products. The most common application is to produce working models for diagnosis and surgery, followed by a variety of implantable devices, which can help dentists to render patients with more predictable, less invasive, and less costly procedures. For products with complex structures, fine structures, and inconveniences to use mechanical processing technology, 3D printing can utilize a large number of material types and rely on digital data to create complex geometric shapes and precisely fulfill the complex and personalized needs in the dental field. The application of 3D printing technology and CAD software based on 3D imaging and modeling can provide complex geometric shapes and has the advantage of high material usage.

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