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Review Article

3D Printing In Prosthodontic

Dr. Ahmed Hamid Tahseen[1]*, Dr. Ola Adnan Ali[2], Dr. Zahraa Mohammed Jasim[3], Dr. Baha Ali Sameer[1] and Dr. Mohal Suhiel Saad[4]

[1]*Diploma in Prosthetic Dentistry, Department of Prosthetic Dentistry, BabAlmoadum Specialized Dental Centre, Baghdad, Iraq*

[2]*Diploma in Prosthetic Dentistry, Department of Prosthetic Dentistry, Alaameria Specialized Dental Centre, Baghdad, Iraq*

[3]*Higher Diploma in Prosthetic Dentistry, Department of Prosthetic Dentistry, Asnan-Al-Sadr Specialized Dental Centre, Baghdad, Iraq*

[4]*Higher Diploma Prosthetic Dentistry, Department of Prosthetic Dentistry, Al Baladyat Specialized Dental Center, Baghdad, Iraq*

***Corresponding author:** Dr. Ahmed Hamid Tahseen, Diploma in Prosthetic Dentistry, Department of Prosthetic Dentistry, BabAlmoadum Specialized Dental Centre, Baghdad, Iraq.

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Abstract

Three-dimensional (3D) printing has emerged as a transformative technology in the field of prosthodontics, offering new possibilities for the fabrication of dental prosthetics. 3D printing has become an invaluable tool in prosthodontics, offering numerous advantages over traditional fabrication methods. Ongoing research aims to further improve the mechanical properties and biocompatibility of 3D printed dental materials, paving the way for continued advancements in prosthodontic applications. The integration of 3D printing technology into prosthodontic workflows has the potential to enhance patient care and outcomes. This review aims to provide an overview of the current applications and benefits of 3D printing in prosthodontic treatments.

Keywords: Three-dimensional (3D); Prosthodontics; Classification

Introduction

Digital dentistry is a huge technology that includes procedures such as the use of Computer aided design-computer aided manufacturing (CAD/CAM), rapid prototyping, Three dimensions of scanning and software, virtual articulator, and list is endless to this day [1].The term 3D printing is commonly used to describe a manufacturing technique that constructs objects one layer at a time, adding multiple layers to form an object. This procedure is more accurately described as additive manufacturing.

This procedure is described as additive manufacturing [2]. Additive Manufacturing File(AMF) used for additive manufacturing of 3D objects created by a 3D printer. Shape and composition for color, material, and textures are present in AMF [3].Conventional technique is time-consuming, multiple steps, more chance of errors, (CAD/CAM) technology became important developments in dental field, and also has deficiencies. But 3D printing overcomes these deficiencies [4]. To review 3D printing, Technologies, classification, mechanism of action, and applications of 3D printing in Prosthodontics. That supports the evaluation, diagnostic, and treatment plan.

Definition of 3D Printing

The term "3D printing" refers to the method of making three dimensions of objects from a digital file using a material printer, much like being able to print pictures on paper [4].

History of 3D printing

- In 1983, the first patient was issued for stereolithography apparatus (SLA).
- In 1987, the Selective Laser Sintering (SLS) RP process.
- In 1989, the Fused Deposition Modelling (FDM).
- In 2012, significant advances in applications, and increase in awareness [4].

Advantages of 3D Printing

A. It saves time by the rate and speed with which objects and models are formed.

B. Accurate details and scanning aid in producing high-qualitative works with harmonic results.

C. Designers the ability to quickly convert 2D concepts into 3D models or prototypes.

D. Materials waste is almost non-existent, resulting in clean processing.

E. Because it is an additive techniques as opposed to subtractive techniques as (CAD/CAM), it can create complex models or shapes of objects. This, however, is a limitation of the subtractive technique [5].

Disadvantages of 3D Printing

A. Some component or model created using 3D printing typically lack mechanical strength.

B. Certain materials, such as Zirconia and E-max blocks, may require additional treatment after processing to achieve the final strength.

C. Final product finishing and post process can be time consuming.

D. A Most significant limitation of Stereo lithography apparatus (SLA) is can only be with light curable liquid polymer.

E. Skin irritation due to resin; inhaling powder causes inflammation.

F. Cost of raw materials and the 3D printer.

G. Majority of resins can't be sterilized by heating [5].

Classification of 3D Printing Technologies

According to Kruth, material accretion technologies can be classified based on the state of the prototype material prior to the start of the process, it has the following types:-

1. Photo polymerisation
2. Direct deposition printing/jetting
3. Laser sintering [5]

Types of 3D printing technology

1. Fused Deposition Modelling (FDM).
2. Laminated Object Manufacturing (LOM).
3. Digital Light Processing (DLP).
4. Stereolithography (SLA).
5. Plaster-based 3D Printing (PP).
6. Selective Laser Sintering (SLS).
7. Selective Laser Melting (SLM).
8. Electronic Beam Melting (EBM) [6].

Fused deposition modeling (FDM):- FDM builds parts up layer-by-layer by heating and extruding thermoplastic filament. Building durable components with complex geometries in any shape and size. Modeling materials and colors, including Acrylonitrile Butadiene Styrene (ABS) of medical grade, polycarbonates, and investment casting wax permitted by FDM process. To create models, surgical guides, and templates [6].

Laminated object manufacturing(LOM):- Layers of adhesive-coated paper, plastic, or metal laminates are fused together using heat and pressure and then cut into the desired shape with a computer-controlled laser or knife. The low price of raw materials is one reason why printing is affordable. Due to the relatively large size of objects that can be printed using LOM, printing large parts does not require a chemical reaction [6].

Digital light processing (DLP):- DLP works with a vat of liquid polymer that is exposed to light from a DLP projector. DLP projector displays image of 3-D model onto liquid polymer, exposed liquid polymer hardens as built plate moves down and liquid polymer is once more exposed to light. The process repeated until 3-D model complete and vat drained of liquid, revealing solidified model [6].

Stereo lithography apparatus (SLA):- Converts liquid plastic into solid 3-D objects. Material's self-adhesive quality leads layers to adhere to one another and then come together to form 3D object. After being taken out of bath, the model is placed in a UV cabinet to complete curing process [6].

Plaster-based 3DPrinting (PP):- Called binder jetting. This process uses two materials (both the support material and build material), and powder material binder. The binder is used as an adhesive between layers, usually in liquid form, and the build material in powder form [6].

Selective laser sintering (SLS):- Small powdered pieces of plastic, metal, ceramic, or glass are fused together using a powerful laser [6].

Selective Laser Melting (SLM):- High power-density laser to melt and fuse metallic powders together. SLM can only be used to fully melt metal, meaning the powder is not being fused together but liquefied [6].

Electron beam melting (EBM):- Used for metal parts. It is similar to laser melting but works with an electron beam instead of a laser [6].

Mechanism of action of 3D Printing

CAD or a 3D scanning of the mouth, dental and soft tissue, imprint, and model can be used to build models. Data gathering, either physically or digitally, is one of the steps of 3D printing. The next step is to create a tessellation (STL) Standard Transformation Language file and transfer it to a 3D printer for creating the required model. After transferring the STL file to the 3D printer, The model is constructed in layers .After the printing of the finished models, post processing processes such as support removal, jet cleaning, and heat treatment are performed [7].

Applications:

1. Fabrication of complete denture prosthesis.

Clinical session–Impression making:- In the first appointment, primary impression compound using stock trays and pouring in dental plaster. Custom trays fabricated, border molding done, and secondary impressions made in light body elastomeric impression material. Using (type IV) dental stone. Next clinical appointment Maxillomandibular relationship (MMR) registered [8].

Laboratory step-Scanning of Maxillo Mandibular relation(MMR)

Casts and established MMR were scanned separately with an 3Shape lab scanner. Occlusal plane was determined by digitized wax rim in the Dental System 2019 program 3Shape.

Laboratory step-Teeth arrangement and Tryin

Functional borders of the denture were selected and designed. The marking of the appropriate reference points on the alveolar ridge, followed for tooth set-up. Monolithic trial denture was manufactured utilizing a 3D printer designated for rapid prototypes

Laboratory steps–Digital fabrication technique

Denture base and artificial teeth printed individually using 3D printer (Next dent 5100). Denture base milled in a 30 mm PMMA pink puck, while teeth milled in a 20 mm tooth-colored multilayered resin puck. Teeth temporarily mounted with hard wax to check for occlusion.

Laboratory steps–Digital fabrication technique

Teeth sockets and cervical part of teeth abraded with 50 μm aluminum oxide sandblasting, chemically activated with methyl-methacrylate monomer, and bonded with a specially designed PMMA cold-curing resin for digital denture teeth bonding [8].

2. Fabrication of removable partial denture

3D printed frameworks fit more precisely than conventional frameworks. Fabrication process includes data collecting, digital designing and digital wax-up of framework, converting designed data, and manufacture of framework utilizing selective laser sintering (SLS) [9].

3. Fabrication in fixed prosthodontic

a) Fabrication of wax pattern for future prosthesis construction.

b) Fabrication of crown coping.

Optical scanner to obtain digital master model. Full arch and opposing arch scanning. Next stage is digital design wax pattern by CAD software using (FDM) and a 3D printer [10].

4. Fabrication in implantology

3D printing technology can manufacture small details of complicated anatomical features, and 3D printing technology can be employed in the manufacturing of dental implants [11].

5. Fabrication of surgical guide

Provide accuracy and safety to therapy, allowing implants to be inserted precisely [12].

6. Fabrication in maxillofacial prosthodontic

Now widely applied in management of craniofacial defects and manufacture of complicated orofacial structures involves complex geometrical shapes [13].

7. Fabrication in orthodontics

Development of 3D printed clear aligners, 3D printed brackets, orthodontic wire, mouth guard, palatal expander, and 3D printed models [9].

8. Fabrication in endodontics

Creation of 3D printed surgical guides for apicectomy procedures and study models for locating canal orifices and learning [9].

Intraoral scanner

It helps patients with gag reflexes and for selective areas where impression is unclear or distortion and expansion of plaster. Send patient data to dental technicians on the internet [14].

Conclusion

1. Dentistry is one of the fields where 3D printing is becoming more popular.

2. 3D printing is quickly evolving into an accessible technology that has the potential to alter not only the way that medical and dental models, but also society as a whole.

3. Reduce production cycle time, and final restoration cost and encourages cooperation between dental office and laboratory.

4. The prosthetic field can simply be scanned and the model printed directly without causing any tissue disruption, which is an important aspect of modern technology that eliminates the risk of dimensional changes of the impressions and casts.

5. Everything is simply stored on the computer hard drive.

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Conflict of Interest

No Conflict of Interest.

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