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Review Article

NEWER ADVANCES IN DENTISTRY – 3D PRINTING: A REVIEW

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A B S T R A C T

Three-dimensional (3D) printing is an additive manufacturing technology in which a three-dimensional (3D) object is created by depositing numerous layers of material. 3D printers are machines that make representations of objects that have been designed with CAD software or scanned with a 3D scanner. We may employ SLS, stereolithography, fused deposition modelling, and laminated item production to print a variety of dental items. In dentistry, 3D printing is gaining traction as a promising technology with a wide range of applications. The 3D model is divided into several tiny layers, which is the core concept underlying this breakthrough. Geometric data is used by the manufacturing or assembly equipment to create each layer successively until the final desired product is completed.

INTRODUCTION

3D printing, also known as additive manufacturing, has been dubbed the third industrial revolution, and it has ushered in a paradigm shift in the way products have been produced for years[3]. Additive manufacturing is a technology that involves putting down or adding consecutive layers of material to create a 3D object. 3D printers are specialised machines that use CAD technology or 3D scanners to create 3D models. Endodontics, Periodontology, Maxillofacial surgery, Prosthodontics, Orthodontics, and Paediatric dentistry are all using it. It outperforms manual modelling in the dental lab in terms of efficiency, price, accessibility, speed, and accuracy[3]. The purpose of this review article is to provide information on 3D printing and its use in dentistry[3].

History

- Stereolithography (SLA) 3D printing was invented in 1984. (Charles Hull)[4].
- The selective laser sintering (SLS) technology was invented in 1986. (Carl Deckard)
- 1988 The first commercial SLA 3D printer and bioprinting by 2D micro-positioning of cells (Charles Hull)
- The bladder was the first 3D-printed organ to be utilised for transplantation in 1999. (Wake Forest Institute for Regenerative Medicine)
- EnvisionTEC introduced the first commercial extrusion-based bioprinter in the year 2000. The world's first inkjet bioprinter (modified HP standard inkjet printer)
- 2007 For 3D part creation from fused metal/plastic, a selective laser sintering printer is now available.
- The first 3D-printed blood arteries were created in 2009. (Organovo)
- The first 3D-printed jaw was created in 2012.
- Organovo was the first 3D-printed human liver tissue, and the first desk-top bioprinter was released in 2014. (Allevi)
- In 2015, the first 3D-printed bioresorbable scaffold for periodontal healing was implanted (University of Michigan)
- Poieskin is the first commercially available 3D-printed whole human tissue (skin) replica (Poietis).
- A 3D printer for tailored medicine was available in 2020. M3DIMAKER is a creative+ paraphrase of M3DIMAKE (FabRx).

Techniques for 3d printing

Additive manufacturing or 3D printing techniques are used in dentistry for a variety of applications[2]:

1. Stereo lithography (SLA).
2. Fused Deposition Modelling (FDM).
3. Selective Laser Sintering
4. Photopolymer Jetting
5. Electron Beam Melting (EBM)
6. Power binder printers
7. Direct light processing

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Procedure

- 3D Printing Methodology[3].
- Obtaining a three-dimensional patient model (Physical or Digital Model)
- Using CAD software to create a design model, appliance, or prosthesis.
- Preparing the model for printing When the software creates the necessary support structures, the structure is sliced to create a stack of layers[3].
- Three-dimensional printing
- Post Processing Removal of support/Sandblasting/Jetwashing/Grinding/Heat treatment The sliced data is delivered to the printer, where material is placed down layer by layer (For metal objects)[3].

Applications in the field of pediatric dentistry

Space Maintainer Fabrication

The digital 3D model is stored in STL format and then transferred to a 3D printing facility, where the full 3D object is created layer by layer. An impression was obtained and a cast was created, which was then scanned using a 3D digital dental scanner before the band and loop were designed. The printed SM was placed into the patient's mouth, and after validating its fit, it was cemented with GIC[2].

Custom Tray Fabrication

From computerised scans of imprints or models, custom trays can be built or 3D printed. Model printing, which can be done immediately from an intraoral scan, speeds up prosthesis manufacture[2].

Fabrication of Fixed and Removable Appliances

Restorations in fixed and removable prosthodontics can be created using CAD software, and 3D printers can be used to print crowns, bridges, copings, and abutments, among other things. Making impressions for crowns, fillings, and other dental restorations can be particularly difficult for children and teenagers with gag reflexes or special needs[2].

Pediatric Crown Fabrication

A total of four primary anterior crowns were required. CAD-CAM technology was used to create the left maxillary central and lateral incisors. The model was then scanned using a computer scanner, and a strip crown stent for the right central and lateral incisors was created. The stent was then tested and bonded with composite resin[2].

For the Purposes of Education

Dental students can visualise the true pathology in terms of size, extent, and depth of the decayed lesion, as well as morphological intricacies and particular tooth variation, because the models are constructed from patients' radiographs. As a result, the instructor will be able to change the models to meet the teaching objectives[1].

In Pediatric Endodontic Therapies

In paediatric endodontics, 3D printing can be employed for guided RCTs. This reduces chairside time and eliminates the need for multiple visits[2].

In Sports Dentistry

3D Printing can be utilised to make occlusal guards in sports dentistry. As a result, the prosthesis can be delivered quickly, avoiding the need for several patient visits[2].

In Cleft Lip and Palate Patients

- 3D printing can be utilised to make impressions in the form of a digital scan, reducing the trauma experienced by these patients. It can also be used to make an obturator[2].
- When dealing with patients who require specialised medical care:
- 3D printing has the potential to be a promising solution for patients with particular health-care needs. It will make the impression-taking operation easier for these patients. In addition, prosthesis delivery will be more convenient and hassle-free.

Applications in other fields of dentistry

Field Application Prosthodontics

- Custom trays are made to order.
- Resin frame work fabrication.
- Printing Crowns, bridges, and copin.
- Fabrication of interim crowns and bridges.
- Fabrication and reproduction of RPD metal frames[2].

Implant dentistry

- Assists in the manufacturing of complex geometries for dental implants, surgical guides, and drill guides in implant dentistry.
- Prints bone tissue tailored to the patient's needs, which can be used as a biomimetic scaffold in the mouth to promote bone cell proliferation, differentiation, and augmentation.
- Biocompatible materials such as PEEK (polyetheretherketone) can be used to replace weak parts in 3D printed bone implants, reducing stress on the bone.
- 3D printing can produce implants with bone-like morphology, reducing stress on the bone. Prefabricated dental implant surgical guides can be used to check or guide the proper location, angulation, and rotational positioning of the implant before it is placed, resulting in a more aesthetically pleasing and functionally stable prosthesis[2].

Surgery

- Trauma surgery, pathology-induced abnormalities, tissue engineering, difficult temporomandibular joint restoration, and treatment of intricate facial asymmetry are some of the current applications of 3D printing in oral maxilla-facial surgery[1].
- Customized occlusal splints save time in the lab, are more exact, and decrease manual errors in the production process.
- Anatomical models can be created and used as a new method of surgical treatment planning and simulation.
- To create personalised reconstruction plates and morphological reconstruction of the bony defect area in fracture and reconstruction surgery instances[2].

- To design and build a special titanium mesh non-absorbable barrier[2].

Restorative dentistry and endodontics

- For guided cavity access, root canal treatment, and endo guided surgical operations.
- During conventional root canal treatment, an access guide stent gives proper directing towards the destroyed root canal[2].

Periodontics

- Patient-specific surgical guides are employed for gingivectomy and smile designing, allowing for a precise and personalised approach[1].
- To produce bio-active scaffolding systems for tissue restoration, 3D scaffolding technologies can be combined with biologic or cell therapies[1].

In orthodontics

- Manufacturing of orthodontic braces.
- Brackets are custom-made and adapted to individual tooth surfaces, and they may be precisely positioned using 3D printed guides.The use of a 3D printed orthodontic aligner decreases the number of visits to the dentist and chairside consultations[2].
- Hawley retainer, splints, functional appliances, arch expansion appliances, transparent aligners, retainers, arch wires, brackets, set up models that will make lingual orthodontics and mock surgeries fast and uncomplicated, as well as study models[2].

Orthognathic surgery

Surgical wafer fabrication employing orthodontic software linked to 3D printing technology for dental model fabrication[2].

Educational purposes

- Provides excellent chances for students and practitioners to learn how to execute various maxillofacial procedures by accurately duplicating orofacial anatomy and complex geometry.
- Intraoral scans of patients are used to produce 3D models that are tailored to each individual patient. These customised models are used to teach dentists how to prepare veneers and crowns in prosthodontics[1].

Maxillofacial prosthesis

- Zygomatic bones, temporal bones, including ear ossicles, calvarial bones, and mandibles are all replaced and rebuilt with 3D printed implants[2].
- Also utilised in head and neck soft tissue restoration.
- These are better for after a trauma or a tumour resection. Cosmetic faults related with these operations have been considerably decreased because to 3D implants[2].

The Material Used

- Stereolithography: a wide range of photopolymerization resins, ceramic-filled resins, and so on.
- Thermoplastic polymers such as polylactic acid (PLA), acrylonitrile butadiene styrene (ABS), polycarbonate (PC), polyether ether ketone (PEEK), and others are utilised in fused deposition modelling[1].
- Selective Laser Sintering: Alumide, polyamide, glass-particle packed polyamide, rubber-like polyurethane, and other powders.
- Cell-loaded gels and inks based on collagen, photopolymer resins, agarose, alginate, hyaluronan, chitosan, and other photopolymers [1].
- Polyjet printing and Bioprinting: a variety of photopolymers Cell-loaded gels and inks based on collagen, photopolymer resins, agarose, alginate, hyaluronan, chitosan, and other photo-

3D Printing Advantages

3D printing has the following benefits:

1. Design flexibility: 3D printing enables the creation and printing of increasingly complex designs[2].
2. On-Demand Print
3. Rapid Prototyping: 3D printing produces prototypes in a matter of hours.
4. Parts that are both strong and light
5. Cutting down on waste
6. Accessibility
7. Ecologically friendly
8. It's used in high-tech healthcare.

3D Printing's Disadvantages

3D printing has the following drawbacks:

1. Materials are scarce.
2. Restricted access Print chamber size: Currently, printers have small print chambers, limiting the size of parts that can be printed. Anything larger will have to be printed in multiple parts and then put together afterward[2].
3. Part structure: Parts are printed layer by layer with 3D printing. It means that under specific loads or orientations, they can delaminate[2].
4. Job losses in the manufacturing sector
5. Inaccuracies in design: Another issue with 3D printing is that the final product may change from the original design. It is directly tied to the machine or process that is being used. This can be corrected in post-production, but keep in mind that this will add to the overall production time and expense[2].

CONCLUSION

3D printing technology has the potential to change dentistry. It has a lot of potential to be used as a teaching tool. The ultimate goal in dental practise is to give the most technologically advanced dental treatment to patients with high accuracy and little discomfort. g. Complex cranio-facial procedures have become more predictable, less invasive, more precise thanks to 3D printed models and surgical guideline

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