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DIGITAL 3D PRINTING: A BOON TO DENTAL INDUSTRY: A REVIEW

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ABSTRACT
Three-dimensional (3D) printing technologies are advanced manufacturing technologies based on computer-aided design digital models to create personalized 3D objects automatically. They have been widely used in the industry, design, engineering, and manufacturing fields for nearly 30 years. Three-dimensional printing has many advantages in process engineering, with applications in dentistry ranging from the field of prosthodontics, oral and maxillofacial surgery, and oral implantology to orthodontics, endodontics, and periodontology. This review provides a practical and scientific overview of 3D printing technologies. This review provides a practical and scientific overview of 3D printing technologies.

Key words- 3D printing, technologies, oral implantology, endodontics, periodontology.

INTRODUCTION

The advent of 3-D (3-Dimensional) printing technology into dentistry has expanded the practitioner's possibilities, which were previously only available in dental labs.

The cost of 3D printing technology has decreased over the past ten years, making it more accessible to doctors and has made it possible for them to provide patients with treatments that are more precise, economical, and time-efficient.[1,2,3] Working models, prosthodontic restorations, orthodontic devices, surgical guides for implant placement, and maxillofacial prosthesis can all be produced using this innovative technique.[4,5,6]

The information gathered from cone beam computed tomography (CBCT) and intraoral optical scanner (IOS) pictures serves as the basis for 3D printing technology. Then, this data is transformed into a standard tessellation language (STL) file so that it can be imported into 3D modelling software and modified to match the needs of the doctors for manufacture. Clinicians then modify the files and upload them to their preferred printer.

In dentistry, stereolithography (SLA), digital light processing (DLP), and LCD are the three most used 3D printing technologies.

THE BENEFITS OF A DIGITAL WORKFLOW FOR DENTAL LABORATORIES

a. Allows dental labs to receive information in digital form
b. Previously information was supplied as impressions with case notes and instructions.
c. Often the case information can be delayed, damaged or lost in transport.
d. It allows for greater accuracy of the final product and avoids having to retake impressions.
e. Use of digital techniques helps in more accurate presentation of the case to the dental lab
f. Using digital data allows for easy use of 3D printing and milling.
g. It also helps in manufacturing surgical guides.

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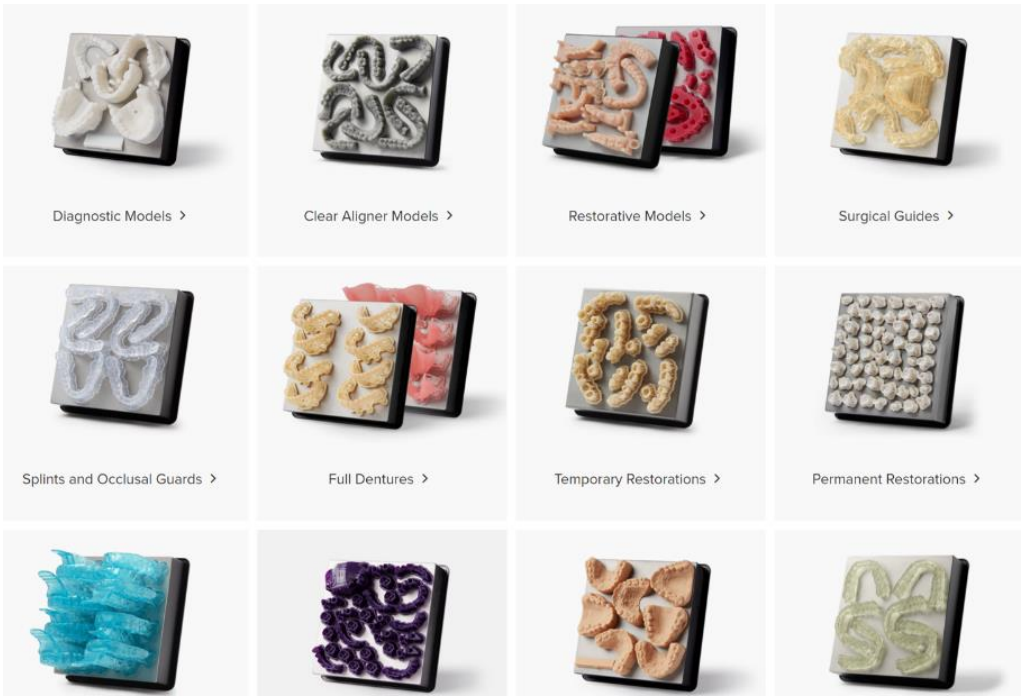
In 1986, Charles Hull introduced the first 3D printing technology. 3D printing helps in rapid production, high precision, personal customization. Before 3D printing became popular, the restoration was generally fabricated by milling. Additive manufacturing , is an advanced manufacturing technology. It uses standardized materials . 3D printing lowers fabrication cost and provides personalized services. It also simplifies the complex workflows.

In dentistry, stereolithography (SLA), digital light processing (DLP), and material jetting (MJ) are the three most popular types of 3D printing technology. On top of the printer's build platform, these machines produce a product using additive manufacturing methods. the capacity to generate a range of materials, including metal, thermoplastic resin, and ceramic. After production is finished, post-manufacturing procedures are carried out to guarantee that the product is flawless and has been properly cured; the scope of these procedures depends on the given material and printer type. It should be noted that each printer type's accuracy and precision heavily depend on the 3D printer's quality, technology, the materials it uses, the settings it uses in the software, and the post-manufacturing refining process.

USES OF 3D PRINTING



- printers are less expensive than milling units
- some are mid-range “desktop” printers like the formlabs form3 or sprintray pro
- others are professional-type printers like the nextdent 5100 or asiga max.

3D PRINTING TECHNOLOGIES CAN BE DIVIDED INTO THREE CATEGORIES

A. SLA (sterolithiographic)
B. DLP
C. LCD

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SLA PRINTERS

SLA is the most popular and established 3D printing method in dentistry. Liquid photopolymer resin can be cured into layers using an ultraviolet (UV) laser. While the laser polymerizes each layer of the resin it meets, liquid resin is kept in a vat. The build platform is lowered after curing the first layer of resin, and succeeding layers of resin are cured on top of one another. The finished product needs to be polished to remove extra resin.support struts, followed by a solvent bath or UV oven to harden them.

BENEFITS OF SLA PRINTING ARE:

a. It gives quick output, excellent resolution, comparably inexpensive cost to other 3D printer , and capacity for complex design construction.
b. High quality SLA printers can make orthodontic aligners, surgical guides, splints, occlusal guards, full dentures, and temporary and permanent crowns.
c. The most common 3D printer in the area of dentistry is a SLA printer because of its capacity to create a wide variety of goods with incredibly exact outcomes.

SLA-FOAMLAB PRINTER

DLP PRINTERS

DLP technology is similar to SLA printing techniques in that it uses the same curing, polymerization, and build-up processes, but uses a different light source digital projectors in its printers. When printing on a wide scale, digital printers enable simultaneous complete polymerization of a whole material layer in the x-y axis, making this a far faster fabrication process. On DLP large-scale printing operations, speed is exchanged for a loss of resolution and surface detailing; however, when build volume is decreased, resolution and surface detailing are recovered.

However, voxel lines are frequently produced on items by digital projector light sources. These lines result in tiny rectangular steps and have an impact on how curved edges are formed. To obtain clearly defined surface details, post-manufacturing modification or fusing/detailing agents require the refinement of voxels. Sandblasting is the primary method used for post-manufacturing alteration, while fusing/detailing agents are special liquids used to fuse/melt voxels together, both of which produce a more desirable surface quality. Despite this shortcoming, small-scale DLP printing operations can nevertheless achieve very good feature resolution down to several micrometres, making them perfect for items that need exceptional accuracy.

On full and partial dentures, thermoform models, surgical guides, single and multi-unit wax-ups, and DLP printers, this accuracy is possible. Costs are associated with this accuracy, volume, and speed; generally speaking, DLP printers are more expensive than their SLA equivalents.

DLP -ASIGA PRINTER

DLP has the following advantages over its LCD counterparts:

a. DLP is a mature technology, with very accurate high-end printers available.
b. DLP is more common than LCD.
c. DLP fits a wider range of use in cases than LCD.
d. DLP has higher print speeds than LCD.
e. DLP requires less maintenance than LCD.

DLP has the following disadvantages compared to LCD:

a. Cheaper DLP 3D printers may suffer from distortion in certain use cases.
b. Because DLP employs lenses to scale the 'image,' distortion of voxels is common, especially at the edges of the build area.

LCD PRINTERS

LCD 3D printing (also known as MSLA or Masked Stereolithography) is a relatively new technology, designed as an affordable alternative to DLP and stereolithography. It is similar to DLP in that an entire layer of resin can be cured at once. However, unlike DLP, LCD uses an array of ultraviolet LEDs as a light source. It also uses an LCD to selectively mask the UV light to ensure that only selected areas of the resin are cured in the layer. A higher LCD density means that the mask has more available pixels and can thus create sharper images and higher-resolution parts.

It is important to distinguish between LCD printers with mono-LCD and color LCD screens. Mono-LCD screens last much longer and print much faster than their color counterparts. This is because monochrome LCD screens allow more light through and feature better thermal resistance. The overall result is a faster resin curing rate and a longer lifetime than traditional color screens. The mono-LCD screen was specifically designed to address some shortcomings of regular color LCDs and takes LCD 3D printing to a new level.

LCD- ANYCUBIC PRINTER

LCD Have The Following Advantages Over Their DLP Counterparts:

a. LCD tends to have better print quality than low-end DLP machines.
b. LCD is a better option for large components that don't have fine details.

LCD has the following disadvantages compared to DLP:

a. LCD printers have shorter lifespans than DLP ones. The LCD screens must be replaced more often than DLP DMDs. This increases the lifetime cost of LCD printers.
b. LCD printing tends to be slower than DLP.
c. LCD results are less precise than DLP, especially when comparing high-end versions of both systems.

COMPARISION OF DIFFERENT TYPES OF PRINTING TECHNOLOGIES

PARAMETERS	SLA	DLP	LCD
ACCURACY	ACCURATE	ACCURATE	LESS ACCURATE
SPEED	SLOW	FAST	FAST
TYPE OF SYSTEM	CLOSED	OPEN	OPEN
COST	EXPENSIVE	EXPENSIVE	CHEAPER
BRAND	FOAMLAB	ASIGA	ANY CUBIC

DMLS PRINTING

Direct Metal Laser Sintering (DMLS) is an additive manufacturing technique that involves melting and fusing layers of metallic powder using a computer-controlled, high-power laser beam.

DMLS is the leading additive method for making metal prototypes and falls under Powder Bed Fusion. It is similar to selective laser sintering of plastic resin but is suitable for use with metals including aluminium, stainless steel, titanium, cobalt chrome and Inconel. It offers good accuracy and detail and excellent mechanical properties.

DMLS Is Used To Manufacture

Titanium dental implants, Custom subperiosteal Ti implants, Custom Ti mesh for bone grafting-techniques , Co-Cr and Ti frames for dental implant supported prosthesis, Coping, partial denture frameworks

DMLS PRINTING

UV CURING MACHINES ARE NECESSARY STEP OF 3D PRINTING.

- The printed material is washed and dried
- Later it is UV cured to ensure the object isn't sticky.
- There are many different curing settings for each individual resin

UV Curing Machines – FormCure (left), Nextdent LC-3DPrint Box (middle), Sprintray ProCure (right)

CONCLUSION

Clinicians have just recently become aware of the actual potential that 3D printing offers dentistry. It is anticipated that product milling, a subtractive manufacturing process, would give way to additive 3D printing processes in the upcoming years.

Although 3D printing and the materials it uses are still in their infancy, the market for dental production is constantly being introduced to new methods and materials.

In today's era a lot of experiments are being undertaken to print materials like zirconia, and research is being carried out[7,8]. Successful invention of 3D printing with zirconia materials can give a boom to printing technology in dentistry in our daily practice. Therefore, digital approach can boost patient satisfaction due to its efficiency and potential to reduce time and achieve predictable results. [9]

Declaration of Competing Interest

The authors have no conflicts of interest relevant to this article.

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