

"DIGITAL SIXTH SENSE TECHNOLOGY" - Rapid Prototyping and its Application in Prosthodontics

*Amalorpavam V., *Jithin, **T. Sreelal, ***Giri Chandramohan, ***Aparna Mohan ****Allen Jim Hines

*PG Students, **Professor and Head of the department, ***Reader, ****Senior Lecturer, Dept of Prosthodontics, Sree Mookambika Institute of Dental Science, Kulasekaram, Kanyakumari, Tamilnadu | Corresponding Author: Dr. Amalorpavam V.: Email: amalor.dr@gmail.com

Abstract:

In the perfect world things do change. Advances in electronic technology and materials have influenced every aspect in the field of dentistry including prosthodontics. Incorporating these advances into dental practice enables the practitioners to offer a wide range of services and additional treatment options. Among that Rapid Prototyping (RP) techniques, becoming more attractive compared to others advancement. Rapid prototyping processes are fabricated part layer by-layer until complete shape finished from 3D model. Biocompatible materials, such as Titanium and Titanium alloy, Zirconium, Cobalt Chromium, PEEK, etc, are used for fabrication process. Main RP techniques used in Dentistry are Stereo Lithography Apparatus (SLA), Fused Deposition Modeling (FDM), Selective Laser Sintering (SLS), and ink jet printing. This article reviews the changing scenario of technology in dentistry with special emphasis on Rapid Prototyping and its various applications in Prosthodontics.

Introduction

Novelty is the mother of innovation, advent of CAD-CAM technology has opened up new perspectives for design of production in the field of prosthodontics. CAD-CAM technology has developed to solve 3 challenges. First challenge was to ensure adequate strength of the restoration,

especially for posterior teeth. Second challenge was to create restoration with a natural appearance and with good aesthetics. Third challenge was to make tooth restoration easier, faster and accurate. History says that first CAD-CAM were developed in 1960s for use in aircraft and automotive industries. First person to develop a dental CAD-CAM device by Dr. Durett. The developer of the first commercial CAD-CAM system by Dr. Mormann and Dr. Anderson developed the PROCERA system. In CAD-CAM system in dentistry we have two different approaches. They are subtractive and additive. Subtractive technique is usually accomplished by conventional numerical code machining generally milling which can capture only the external surface data of the anatomy and not the internal tissue structure of the proposed object. Hence they are used typically in small model making machines. This is the main reason for using them to fabricate metallic or ceramic crowns in dentistry. On other hand additive technologies which can capture internal as well as external surface of the human anatomy which can produce complex shapes. It is also called as layered manufacturing or solid free form fabrication. According to GPT 9 –Rapid prototyping is a process that creates part in an additive, layer by layer manner.

Advantages of rapid prototyping

- Main advantage of rapid prototyping is speed – less time consuming.

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- Quickly delivers a model with better design communication tool.
- Facilitates early detection and correction of design flaws.
- It gives confidence in the integrity of the design².

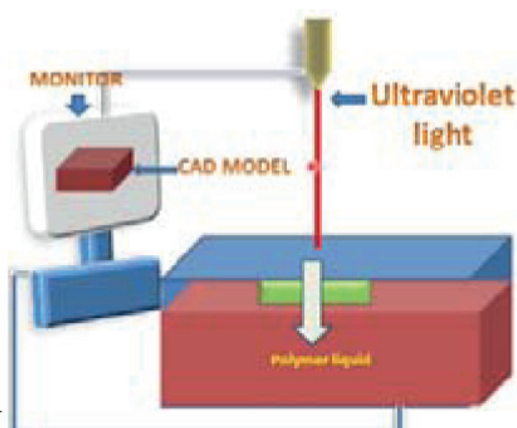
Common technologies used in dentistry:

1. Stereolithography (SLA)
2. Selective Laser Sintering (SLS)
3. Fused deposition modelling (FDM)
4. Inkjet-based system (3D printing- 3DP)

Stereolithography:

It was first patented by Hull in 1984, which can produce 3D models from photopolymer resins. The parts of stereolithography which includes

- Computer monitor on which CAD model is designed.
- 3D-printer attached to the computer monitor.
- Ultra violet laser – UV light produced.
- Model building platform which moves down.



Mechanism:

Laser solidfy the layer of polymer liquid, platform will go down carry first layer and laser work on the second layer again and again process

will repeated. These layers are formed and fused together to form final model^{2,3}.

Applications:

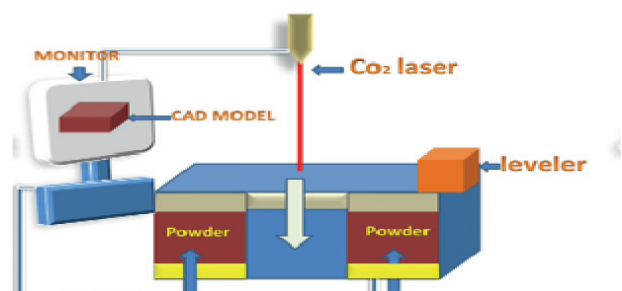
- ☐ RP models – In Reconstructive surgery
- ☐ Digital impression incase of reconstructive surgery &sub periosteal implant surgery.
- ☐ Fabrication of surgical drilling templates which can act as dental implant insertion.



Selective laser sintering:

It is a process of fusing together layer of specified powder material into a 3D model by a computer -directed laser. The parts of selective laser sintering includes

- Computer monitor – on which CAD model is designed.
- 3D printer attached to the computer monitor.
- Powder deliver system – right & left side.
- Two pistons on right and left side for upward motion to deliver the powder.
- Platform which moves downwards on which prototype model fabricated.
- Leveler- which will level the powder,
- Laser- Co2 laser.



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Mechanism:

Thermoplastic powder is spread by a roller over the surface of a build cylinder. The piston in the cylinder moves down one object layer thickness to accommodate the new layer of powder. The powder delivery system is similar in function to the build cylinder. Here, a piston moves upward incrementally to supply a measured quantity of powder for each layer. A laser beam is then traced over the surface of this tightly compacted powder to selectively melt and bond it to form a layer of the object. The fabrication chamber is maintained at a temperature just below the melting point of temperature slightly to cause sintering. This greatly speeds up the process. The process is repeated until the entire object is fabricated. After the object is fully formed, the piston is raised to elevate it. Excess powder is simply brushed away and final manual finishing may be carried out.

Applications:

- ☐ Solid copings and metal Frame works.
- ☐ Direct Metal Laser Sintering (DMLS) crowns.
- ☐ Removable partial denture (RPD) frame works^{3,4}.



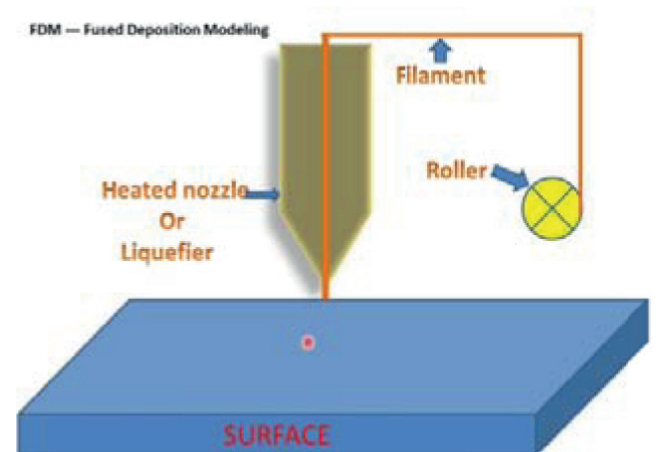
Fused deposition modeling (fdm):

Fused deposition modeling is the second most widely used rapid prototyping technology after stereolithography. The parts of Fused deposition modeling includes

- ☐ A plastic / wax filament - unwound from a coil and supplies material to an extrusion nozzle.
- ☐ The nozzle is heated to melt the plastic and has a mechanism which allows the flow of the melted

plastic to be turned on and off.

- ☐ Mechanical stage - The nozzle is mounted to it which can be moved in both horizontal and vertical directions.



Mechanism:

As the nozzle is moved over the table in the required geometry, it deposits a thin bead of extruded plastic/wax to form each layer. The plastic/wax hardens immediately after being squirted from the nozzle and bonds to the layer below. The entire system is contained within a chamber which is held at a temperature just below the melting point of the material.

Applications:

- ☐ Medical grade – ABS-(Acrylonitrile Butadiene Styrene)
 - Cardiovascular stents
 - Drug delivery systems
 - Renal dialysers
 - Respiratory devices
- ☐ Polycarbonates.

TRADE NAME:

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. Makrolon

. Bay blend

❑ Surgical guides and templates.



Cardiovascular



Drug Delivery



Renal / Dialysis

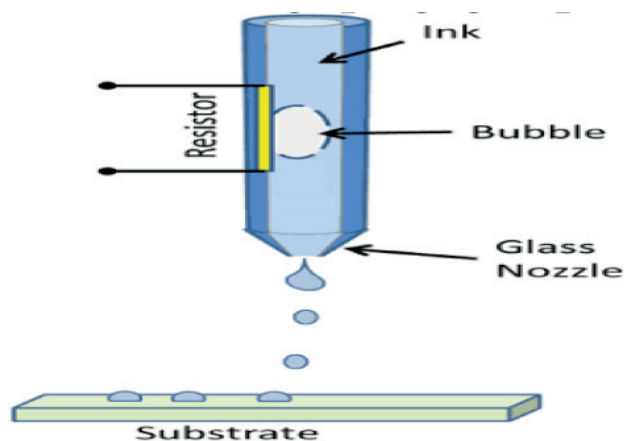


Respiratory Devices

Inkjet (thermal phase change):

The working principle is basically similar to the conventional 2D inkjet printer. The parts of inkjet printer includes

- Single jet - plastic build material and a wax-like support material, which are held in a melted liquid state in reservoirs.



Mechanism:

The liquids are fed to individual jetting heads which squirt tiny droplets of the materials as they are moved in X-Y fashion in the required pattern to form a layer of the object. The materials harden by rapidly dropping in temperature as they are deposited. After an entire layer of the object is formed by jetting, a milling head is passed over the layer to make it a uniform thickness. Particles

are vacuumed away as the milling head cuts and are captured in a filter. The working principle is basically similar to the conventional 2D inkjet printer. The process is repeated to form the entire object. After the object is completed, the wax support material is either melted or dissolved away. The most outstanding characteristic of inkjet systems is the ability to produce extremely fine resolution and surface finishes, essentially equivalent to CNC machines.



Applications:

- ❑ All ceramic dental restoration
- ZIRCONIA CROWNS⁹

. A cleaning unit and a drying device allowed for the build-up of dense components of the size of a posterior crown. A characteristic strength of 763 MPa and a mean fracture toughness of 6.7 MPam^{0.5} were determined on 3D-printed and subsequently sintered specimens. The novel technique has great potential to produce, cost-efficiently, all-ceramic dental restorations at high accuracy and with a minimum of materials consumption¹⁰.

Conclusion:

In a world that's becoming increasingly divided on just about everything, there is one thing that we can all agree on—"Esthetics and comfort is of prime importance". With the digital Sixth sense technology, you can achieve perfection for the patient but also a good comfort through ergonomics. It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change.

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