Review Article

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Role of Rapid Prototyping In Prosthodontics

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ABSTRACT

Background: Biological models have three important characteristics: low volume,complex shape, and Can be customized. These characteristics suit very well with rapid prototyping(rp) and rapid manufacturing (rm) processes. Rp/rm processes are fabricated part layer-by-layer until complete shape finished from 3d. RP is two decade old technology to quickly produce prototypes directly from a 3D CAD(Computer aided design)model and involves adding material successively in layers, to create a solid of a predefined shape.It is being used to shorten and simplify, product development cycle for many applications-aerospace,automobile,homeappliances etc.,. Advent of RP technology also has opened up new perspectives for design & production in the field of dentistry.

Keywords: RP, CAD/CAM Technology, CNC machining, Digital Maxillofacial Prosthesis, Simplant.

INTRODUCTION

RAPID PROTOTYPING: It is the automatic construction of physical objects using additive manufacturing te chnology (or) it is a group of techniques used to quickly fabricate a scale model of a physical part (or) assembly using 3D CAD data.[1]

What is prototype: A prototypeis an early sample, model (or) release of a product built to test a concept (or) process (or) to act as a thing to be replicated (or) learned form. There are 3 phases of prototyping as follows:

1) First phase of prototyping:- During this phase, manual prototyping used to be done by skilled Craftsman.It was an age old practice for many centuries.

2) Second phase of prototyping:- (Started around mid-1970's) a soft prototype modeled by a 3D Curves and surfaces could be stressed in virtual environment, simulated and tested with exact material and other properties.

3) Third phase of prototyping:- (Started during early 1980's)The third and latest phase of Prototyping came in which layer by layer deposition is done to make a prototype when is Then later tested.Rapid prototyping started with the enormous growth in CAD/CAM technologies.[2]

Historical development of rapid prototyping (Chua & Leong 2000)-[2]

S.NO	Year of inception	Technology
1)	1770	Mechanization
2)	1946	First computer
3)	1952	First numerical control(NC)machine tool
4)	1960	First commercial
5)	1961	laser
6)	1963	First commercial

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7)	1988	robot First interative graphic system (early version of computer aided design) First commercial rapid prototyping system.

Various rapid prototyping techniques important in the field of dentistry are as follows:-

1)Stereolithography
2)3-D printing
3)Fused deposition modeling(FDM)
4)Solid ground curing
5)Laminated object manufacturing
6)Selective laser sintering[2]

Stereolithography- It is a technique (or) process for creating three dimensional objects in which a computer controlled moving laser beam is used to build up the required structure, layer by layer, from a liquid.

-It is an additive manufacturing 3D printing technology.
-It is also known as "optical fabrication , photo solidification, solid free form fabrication and solid imaging.
-The advantage of stereolithography is highly accurate,has high mechanical strength and it gives a good surface finish.[2]

Its applications in dentistry are-

-For impression purposes in reconstructive surgeries and sub perosteal dental implant surgery.

-Fabrication of surgical drilling templates during dental implant insertion.

-The high accuracy of this technology made, the transparency of the model and the recent development of colour resins allow distinct visualization of anatomical structure.[1]

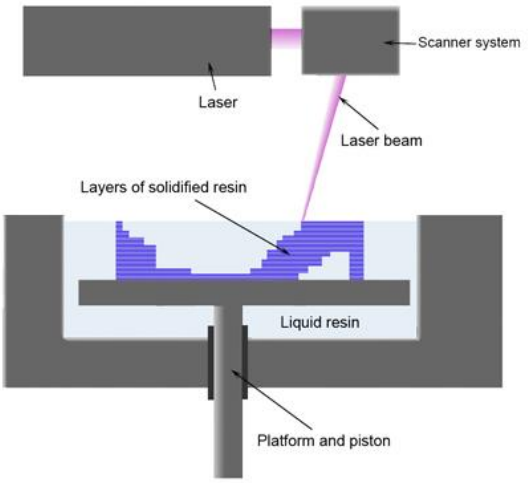


Fig 1: Schematic depiction of SLA.

2) Selective laser sintering(SLS):

It is an additive manufacturing technique which was developed and patented by Dr. Joe Beaman in the mid- 1980's .Its involves the use of high power laser to fuse small particles of plastic,metal, ceramic (or) glass powders into a mass that has a desired three dimensional shape. The SLS machine preheats the bulk powder material in powder bed below its melting point by infra red heating inorder to minimize thermal distortion and facilitate fusion to the previous layer.

The laser selectively fuses powdered material by scanning cross sections from a 3D digital description of the part on surface of a powder bed.

⇩

After each cross section is scanned, powder bed is lowered by one layer thickness.

⇩

A new layer of material is applied on top, and the process is repeated until the part is completed.

⇩

The laser is modulated in such a way that only those grains, which are in direct contact with the beam, are affected.

Various materials such as-Polystyrene,polycarbonate (or) polyamide etc,can be used.[2]

Its application in dentistry are:

1) Margin line placement, cement gaps, coping thickness and pontic designs can all be customized.

2) It produces more consistent results with improved marginal fit for multiunit cast frameworks.

3) Designs can be sectioned on the computer screen and analysed for strength before committing to manufacture.[1]

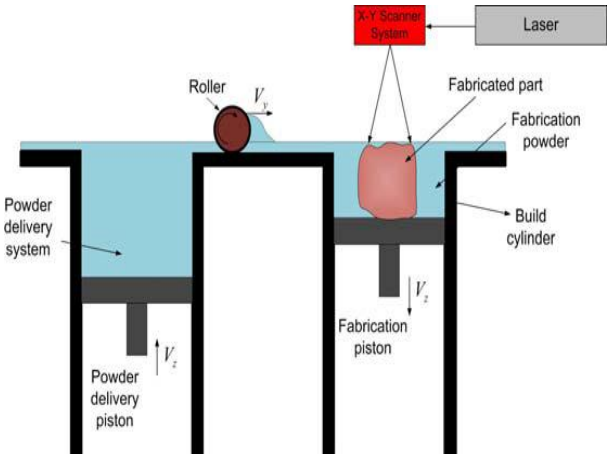


Fig 2: A Schematic image of SLS technique

3) 3-D printing: It is a different additive rapid prototyping technique in terms of design and print a wax pattern of a restoration.

The wax pattern subsequently is castor pressed in the same manner as manually waxed restorations would be. It operates like an inkjet printer.[2]

Its application in dentistry:

1)A tailored Zirconia based ceramic suspension with 27v% solid content was synthesized.

2)For build up of dense components of size of a posterior crown.

3)The novel technique has great potential to produce cost efficiently, all ceramic Restoration at high accuracy.[1]

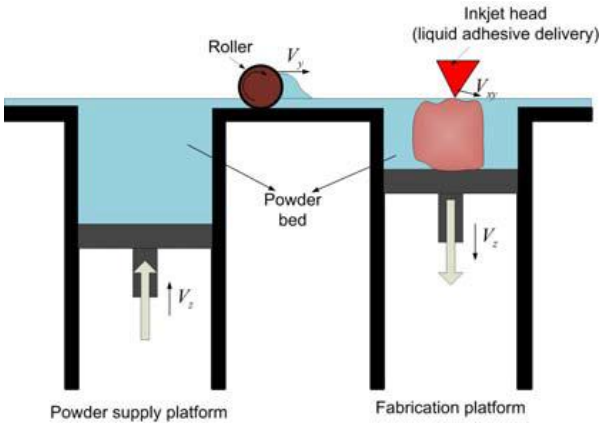


Fig 3: A schematic representation of 3DP technique

4) **Laminated object manufacturing**: This system is developed by Helisysinc in which,materials that are relatively cheaper like paper, plastic roll etc.,can be used. Layers of adhesive coated paper (or) plastic are successively glued together and cut to shape with a knife (or) laser cutter.The slices are cut to in required contour from roll of material by using a 25-50watt co_2 laser beam.

Anew slice is bonded to previously deposited slice by using a hot roller,which activates a heat sensitive adhesive.

⇩

Once one slice is completed platform can be lowered and roll of material can be advanced by winding this excess onto a second roller.

⇩

After completion of the part they are sealed with a urethane lacquer, Silicone fluid (or) epoxy resin to prevent paper distortion through water absorption.[2]

Its application in dentistry:

1) Parts of fibre reinforced glass ceramics can be produced.
2) Large models can be produced.[1]

5) FUSED DEPOSITION MODELING(FDM):

FDM is the second most widely used rapid prototyping technology, after stereolithography. Aplastic / wax filament is 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. The nozzle is mounted to a mechanical stage which can be moved in both horizontal and verticaldirections.

As the nozzle is moved over the table in therequired geometry, it deposits a thin bead of extrudedplastic/wax to form each layer. The plastic/wax hardensimmediately after being squirted from the nozzle and bonds to the layer below.

The entire system is contained within achamber which is held at a temperature just below the meltingpoint of the material

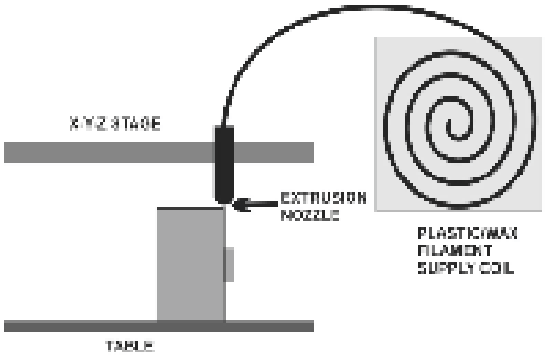


Fig 4: Schematic diagram showing fused deposition modeling

Its application in dentistry:

1) FDM can produce models, as wellas surgical guides and templates, out of medical grade ABS,which is gamma-sterilizable and translucent.

2) This process gives direct waxpatterns, and is fast and speedy.[1]

6) **Solid ground curing:**

It is a type of additive technique in which laser polymerises successive layers of resin through a stensil. They all use ultraviolet light to selectively harden photosensitive polymers. SGC cures entire layer a time unlike, (SLA)selective laser sintering

The photosensitive resin is sprayed to build platform.

The machine develops a photomask of layer to be built which is Printed on glass plate using an electrostatic process.

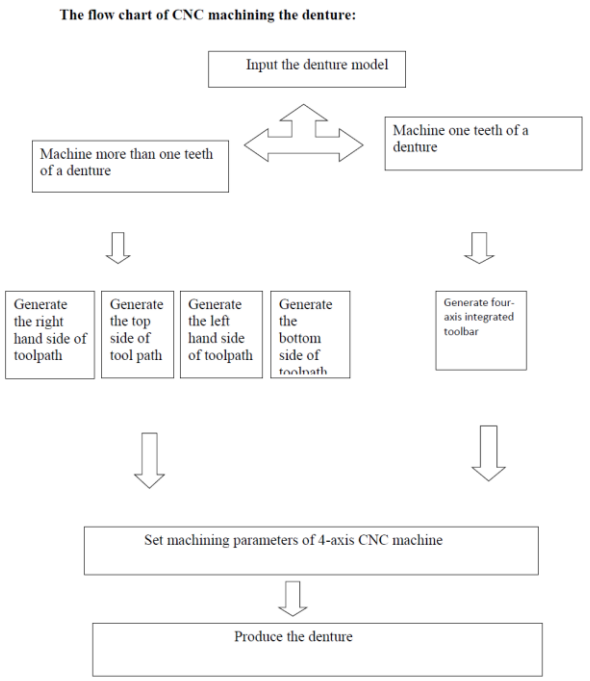
Then mask is exposed to uv light, which only passes through transparent portions of mask to selectively harden shape of current layer.

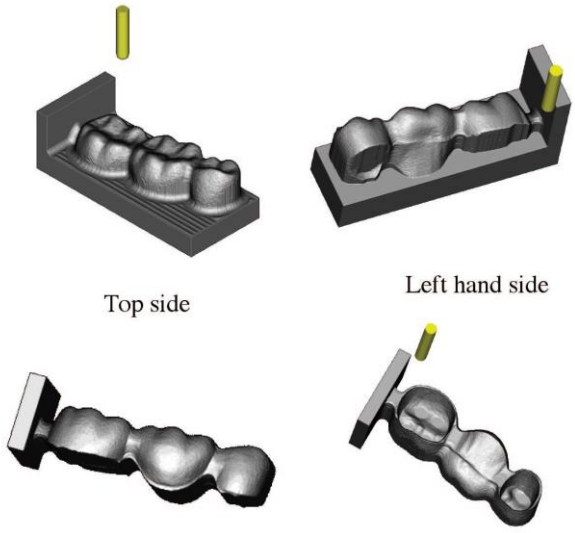
Later machine vaccums up excess liquid resin and sprays wax in its place to support model.

When the part is complete, it must be dewaxed by immersing in solvent bath.[2]

Rapid prototyping applications in Prosthodontics:

Digital denture design with new abrasive computer tomography and rapid prototyping technologies. [3]





Four different toolpaths of three teeth

I) Uses in oral & maxillofacial implants:

Placement of dental implants require precise planning that accounts for anatomic limitation and restorative goals. Diagnosis can be made by' CT' but transfer of planning to the surgical field is limited which has been overcome by RPtechnology that makes' surgiguides' which helps the precise placement of implants.

Surgiguide in oral and maxillofacial implants:

Surgiguide concept converts the simulated implants exact dimension, including width, angulation and depth to a surgi guide.

Types of surgiguides:

1)Tooth supported
2)Bone supported
3)Mucosa supported
4)Special implants.

1**) Faster treatment with high end esthetics-** A three dimensional plan, in combination with the use of surgiguides.

2) **Enhance predictability and safety-** Complete information about quality and Quantity of bone makes it possible to determine ideal location of implants.

Knowledge of exact location of important anatomy such as mandibular nerve and maxillary sinus cavities provide confidence.

3) **Reduced operating time:** Surgiguide decreases the time we spend in surgery and prevents implant complication.

Limitations of surgiguide:

1) Surgiguide require sufficient vertical space to place the implant drill and head of the handpiece.

2)Limited mouth opening when working distal to the canine limits its use.

3)One surgiguide, cannot accommodate the ascending sizes of implant drills requiring multiple surgiguide fabrication.[4]

II**) Uses in maxillofacial prosthesis:**

The surgical ablative treatment of maxillofacial cancer may cause facial disfigurement and consequently psychologic disturbances. Several methods have been used to fabricate an auricular prosthesis when a preoperative cast is not available.

These methods include the following:

1) Using the "**donor technique**", in which a relative (or) a person with ear contours that mimic those of the patient acts as the donor to make an ear impression.

2) Dividing the cast of remaining ear into small squares to facilitate sculpting the missing ear.

3) Using **imaging editing software** to assist in sculpting of the prosthesis.

4) Using a colour slide.

5) Obtaining a **mirror image of the cast of** the patient's remaining ear, using transparent sheets and a copy machine to aid in the sculpting process and

6) **Sectioning the wax pattern** of the opposite ear, using a wax saw, into 1-mm thick slices, then reversing each section and placed it on top of the previous one to create a mirror image of the original pattern.[5]

CONCLUSION

It is noteworthy that working with RP technologies in the medical/dental field differs considerably from using them in the industrial

environment. Some of the shortcomings which must be fully revolutionized in future are the delivery time which must be further shortened if RP and resin manufacturers can develop direct prototyping biomedical material and the total cost of the finished product must be lowered inorder to be used in every day practice.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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