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Review Article

Rapid prototyping in prosthodontics: Review of literature and implications for future research

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ABSTRACT:

Dentists have used rapid prototyping (RP) techniques in the fields of prosthodontics for past few decades. Rapid prototyping (RP) techniques have long been in use to build complex 3D models in medicine. However, publications regarding the dental application of RP technologies are still uncommon. This paper reviews and discusses the basics and applications of RP techniques in field of prosthodontics

Keywords-rapid prototyping, Prosthodontics, Computer aided design

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INTRODUCTION

The term rapid prototyping (RP) was primary used in mechanical engineering field in the early 1980s to explain the act of producing a prototype as a reference model. Prototypes can also be utilised for specialised, limited purposes, in which case they are called as preseries models. The disadvantages of subtractive digital techniques have been overcome by RP techniques, also known as generative manufacturing techniques[1]. RP is a type of computer-aided manufacturing (CAM) and is one of the components of rapid manufacturing. It is a technology that is capable of making physical objects directly from three-dimensional (3D) computer data by adding a layer upon layer[2].

In recent years, RP technique research development rapidly in the molding material and the forming process. This technology is no longer used entirely for prototyping, but can be used to assemble real functional parts. In manufacturing, models are usually designed on the computer screen, then converted to physical models. In the field of medicine, the object or parts often be present physically. Building medical models fundamentally starts with acquiring data such as computed tomography (CT) cross sectional images. Earlier to part building, this highly complex data needs to be pre-processed to make available a format that a CAD package or a RP system can distinguish. The data scanning and processing technologies must be associated with RP technologies to attain the preferred physical models. The data has to undergo numerous processes: data acquisition, image processing and model fabrication As a result, RP is becoming more attractive in dental applications.

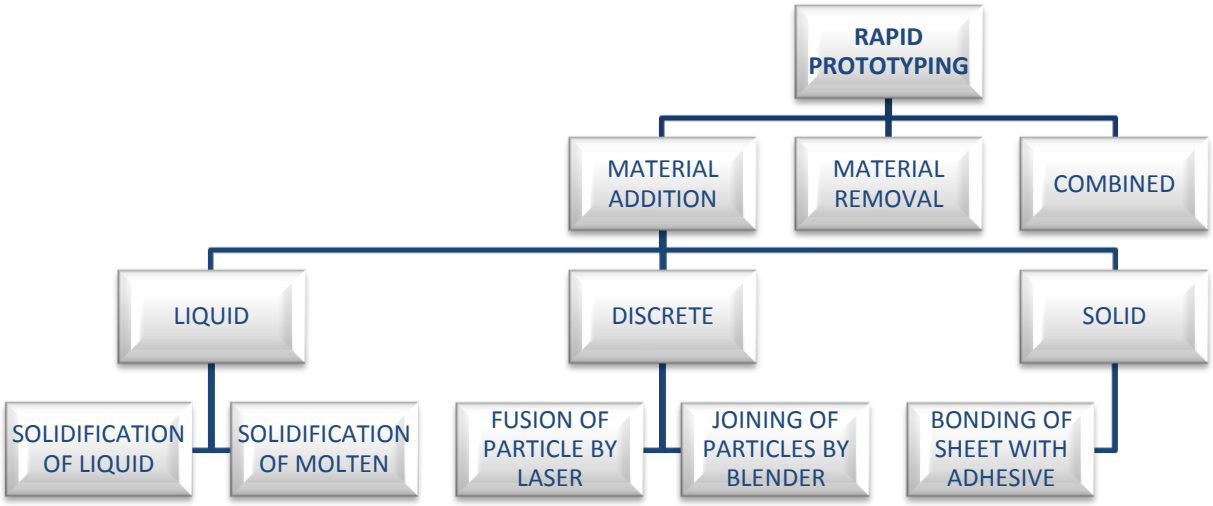
RP model is now used mainly for an improved, cost-effective medical diagnosis and accurate surgical planning, which shortens the operation time and significantly reduces risk to the patient[3,4].RP techniques can also be used to design, develop, and manufacture dental prostheses such as copings, crowns, and fixed partial dentures (FPDs). The introduction of RP technology into prosthodontics has revolutionised clinical and laboratory procedures by removing or eliminating some intermediate steps and decoupling the quality of the results from the practitioner's abilities. This demonstrates the novel method's potential as a replacement for the classic "impression-taking and waxing" approach.

RP is still innovative with much attempt to be prolonged on increasing the speed, accuracy and reliability of the system and widen the range of materials for prototype construction. This article reviews and discusses the basics and applications of rapid prototyping techniques in field of prosthodontics.

BASICS IN RAPID PROTOTYPING

The deconstruction of three-dimensional computer models in the layers section transverse thin, followed by physically creating layers and stacking layer by layer, is the basis of RP technology. The idea of creating three-dimensional objects in this way dates back practically to the dawn of civilisation. Since the Egyptian pyramids, progress has most likely been block by block, layer by layer.

CLASSIFICATION OF RAPID PROTOTYPING



TECHNOLOGIES IN RAPID PROTOTYPING

The frequent technologies that are adopted in dental practice are:

- Selective laser sintering (SLS)
- Stereolithography
- Inkjet-based system (3D printers [3DP])
- Fused deposition modeling [5,6,7.]

APPLICATION OF RAPID PROTOTYPING IN PROSTHODONTICS

1. DIRECT DENTAL METAL PROSTHESIS FABRICATION

RP technologies together with selective laser melting (SLM) and SLS technology are used for the quick fabrication of high-precision metal parts.RP techniques are attractive an alternative way. For example, patterns for dental crowns and implant structures can be fabricated using an RP machine. The purpose of dental crowns can be used to restore damaged or missing teeth[8].

A dental crown model can be creating from the inner surface to the outer surface. The inner geometrical data can be attained either by scanning the surface of the tooth after tooth preparation or based on the profile of the implant, while the outer surface can be designed based on the scanned data from neighboring teeth and the teeth on the opposite side of the mouth and esthetics consideration.

After construction, the model can be sliced and transferred to an RP machine to fabricate the crown pattern. The crown model is then investment cast to a metallic or ceramic crown. Before the dental crown is created, the patient's feedback on the design of the dental crown can be taken into account through this method. Dental prosthesis made with the SLS/SLM technique are ideal for their complicated shape and flexibility to be adjusted without the need for lengthy manual pre- or post processing processes.

2. ALL-CERAMIC RESTORATION FABRICATION

Commercial dental CAD/CAM milling systems for sp ecialised fields, like as all
ceramic restorations, have recently been successfully i ntroduced. Dental CAD/CAM milling systems have been actively researched and developed since the 1980s all over the world[9]. These milling systems enabled zirconia ceramics to be used as a standard material for dental prosthetic restorations. Milling tools are subjected to significant wear as well, therefore they can only withstand short running cycles. Furthermore, the fragile material's tooling process might generate tiny fractures in the wafer surface. RP approaches, also known as generative manufacturing techniques, have the ability to solve the aforementioned flaws.

A direct inkjet fabrication approach (using a slurry microextrusion process) has been developed for the manufacture of green-zirconia all-ceramic dental restorations. This new approach is a promising CAD/RP system with a lot of promise for producing all-ceramic dental restorations with high accuracy, economic effectiveness, and minimal material waste. This technology is currently in its early stages of development[10-12].

3. COMPLETE DENTURE

Establishing a 3D graphic database of artificial teeth for parameterization positioning, obtaining 3D data of edentulous models and rims in centric relation, investigating a CAD route and developing software for complete dentures, fabricating physical flasks (moulds) by 3DP, and finishing the complete denture using a traditional laboratory procedure are all part of the process[13].

4. FACIAL PROSTHESIS

The actual prosthesis was still made using traditional flasking and investing techniques. A novel design and manufacturing approach (for the negative mould of the face prosthesis) has been proposed for casting the actual prosthesis with silicon directly (using CAD and RP techniques). The mold's cavity then forms the negative profile of the actual prosthesis. The fabricated mold is used to cast the actual prosthesis in polyurethane, medical-grade elastomer, or silastic materials. The mold helps to eliminates conventional flasking and investment procedures, and shortens the prosthesis-making process[14]. Three-dimensional printing was then used to fabricate the mold for the actual prosthesis with silicon[15].The application are

- Production of auricular and nasal prosthesis
- Obturators
- Duplication of existing maxillary/mandibular prosthesis especially crucial when an accurate fit to natural teeth or an osseointegrated implant is needed
- Manufacturing of surgical stents for patients with large tumors scheduled for excision
- Manufacturing of lead shields to protect healthy tissue during radiotherapy treatment
- Fabrications of burn stents, where burned area can be scanned rather than subjecting delicate, sensitive burn tissue to impression-taking procedures.

5. METAL CASTING

Ceramic moulds for metal parts can be made directly from CAD models, as opposed to traditional techniques of casting production (which include the construction of tooling and the pouring of a casting). Three-dimensional printing, such as the direct shell production casting process, produces ceramic casting molds for metal casting using a layer-by-layer printing process[16,17]. A multijet print head deposits liquid binder onto a layer of ceramic powder in this process. A mould is "printed" and then burned to produce a firm ceramic mould. The molten metal can then be poured into the mould (shell), resulting in a functional metal cast item. RP techniques eliminate most of the labor-intensive and time-consuming steps of the traditional investment casting process[18].

6. DENTAL IMPLANTS

In implant dentistry, the use of computer-aided design (CAD)/computer-aided manufacturing (CAM) technologies has grown in popularity. The use of RP in implantology is limited to 3D imaging and treatment planning with 3D software. Additive RP is used to make surgical guides, while subtractive RP is used to make all-ceramic restorations. With the introduction of RP technology, automatic waxup construction is now possible. The traditional lost-wax method is still required once RP fabricates the wax pattern. This procedure is more cost-effective than laser melting or sintering direct manufacturing processes, which are out of reach for most dental facilities[19-22].

CONCLUSION

The use of RP techniques in prosthodontics was discussed in this article. Complicated machinery and reliance on knowledge to run the machinery during production are two of the RP technology's downsides or limits, as is the expensive cost of the tools. In the near future, RP techniques will become one of the mainstream technologies for digital fabrication of dental prostheses, since they are becoming increasingly important in dentistry.

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