ORIGINAL RESEARCH PAPER

Prosthodontics

# RAPID PROTOTYPING IN PROSTHODONTICS – A REVIEW

**KEY WORDS:** Prosthesis, Rapid Prototyping, Stereolithography, Three- Dimensional.

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| **Dr. Pavani Lukka** | (Post – graduate student) Kaloji Narayana Rao University Of Health Sciences |
| **Dr. Macha Sujesh*** | MDS, (Professor) Kaloji Narayana Rao University Of Health Sciences*Corresponding Author |
| **Dr. Duggineni Chalapathi Rao** | MDS, (Professor) Kaloji Narayana Rao University Of Health Sciences |
| **Dr. Gurram Sunil Kumar** | MDS, (Professor) Kaloji Narayana Rao University Of Health Sciences |
| **Dr. Gajula Venu Madhav** | MDS, (Professor) Kaloji Narayana Rao University Of Health Sciences |
| **Dr. Guguloth Harilal** | MDS, (Associate Professor) Kaloji Narayana Rao University Of Health Sciences |
| **Dr. Chitturi Ravi Kumar** | MDS (Professor and Head) Kaloji Narayana Rao University Of Health Sciences |

**ABSTRACT**

Dental specialists have utilized Rapid prototyping (RP) procedures in the fields of oral maxillofacial surgery and implantology. With emerging research for molding materials and the framing procedure of RP strategies, this strategy is winding up more appealing in dental prosthesis fabrication; however, couple of researchers have distributed material on the RP innovation of prosthesis design fabrication. This article audits and discusses about the use of RP procedures for prosthodontics including: (1) creation of wax pattern for the dental prosthesis, (2) mold for dental (facial) prosthesis fabrication, (3) fabrication of dental metal prosthesis , and (4)fabrication of zirconia prosthesis. Many individuals could profit by this new innovation through different types of dental prosthesis fabrication. Customary prosthodontic practices could likewise be changed by RP systems in near future.

## INTRODUCTION:

Rapid prototyping (RP) systems, likewise named solid freeform fabrication(SFF) or layered assembling, have been utilized to construct complex 3D models in medicine since the 1990s.1-4 The primary preferred standpoint of RP methods is that medicinal models can be made to have undercuts, voids, and complex interior geometries, for example, neurovascular canals or sinuses.5 at present rapid prototyping is mainly used for accurate surgical planning which will decrease operation time and risk to the patient.[6,7]

As of late, research of RP technique progressed in forming process and molding material. This innovation is never again utilized solely to prototyping, yet can be utilized to produce real functional parts. RP can be used to develop, design and to fabricate dental prosthesis such as crowns, copings and fixed partial dentures. Customarily, dental prosthesis manufacture involves much labor intensive and tedious hands-on work by dental practitioners and specialists. Fabrication of dental prosthesis mostly relies on skills of dentist and technician. Dental prosthesis work can be fabricated using RP techniques without human intervention. The work cost will be generously decreased and better and quicker dental restorations will be accomplished. RP systems are presently viewed as a promising option for dental prosthesis fabrication.

Numerous researchers have concentrated on information procurement by utilizing diverse 3D checking gadgets and utilizing computer aided design (CAD) elaboration for the plan of the prosthesis; however, publications regarding fabrication of prosthesis using RP technology is still rare. In this article, we survey the utilizations of RP systems in prosthodontics. We especially center around the fabrication of wax pattern of the prosthesis, metal prostheses

(including framework for removable and fixed partial dentures), all ceramic crowns and casts for prostheses.

## DENTAL PROSTHESIS WAX PATTERN FABRICATION

Fabrication of wax pattern in making porcelain fused to metal crown, RPD framework and pressed ceramic crown traditionally is a most critical, labor intensive and time consuming step. With the advent and popularity of RP innovation, another methodology is feasible for programmed wax-up manufacture. This methodology rearranges the traditional manufacture process and quickens the generation turnaround period by utilizing 3D imaging, CAD, and RP.8-10 The new procedure includes three stages: (1) digitizing the master models with a 3D optical scanner (2) by using specialized software designing of wax pattern and (3) creating the wax-up with RP techniques such as 3D printing and fused deposition modeling. RP application has four points of interest. The primary advantage is a high generation rate of over 150 units per hour. The second advantage is the quality control of wax copings, which results in a high accuracy fit and constant wall thickness. The third advantage is a lessened spruing time. The last advantage is decreased finishing work on cast copings. The inconsistencies in wax adapting thickness can be kept away from, as they usually make additional work for finishing the metal after the cast.11, 12 The traditional lost wax process is still needed , after the wax pattern is fabricated by RP.

Rapid prototyping of dental (facial) prosthesis mold (shell)
Mold (shell) for metal casting

Compared to traditional techniques of casting production, directly CAD models are used to produce ceramic molds. These molds are made on computer screen by utilizing RP

procedures such as three dimensional layer by layer printing process. 13-15 The procedure includes a multijet print head depositing fluid fastener onto a layer of ceramic powder. After printing of mold to create rigid ceramic mold it is fired.it is poured in molten metal to produce functional metal cast part. Curodeau et al utilized 3DP to create clay molds with installed surface macro textures and to cast utilitarian orthopedic implants out of high-opposition cobalt-chrome alloy.16RP procedures dispense most of the time consuming procedures of conventional investment casting process. They additionally sidestep the requirement for structure and assembling of wax and core tooling, wax and center embellishment, wax assembly, shell plunging and drying, and wax expulsion.

**MOLD FOR FACIAL PROSTHESIS**

RP strategies have been connected effectively to the manufacture of a facial prosthesis. 17-19Fabrication of pattern by means of RP has been viable. But still investing procedures and conventional flasking were needed to fabricate actual prosthesis. An imaginative structure and generation strategy (of the negative form of the facial prosthesis) for casting the actual prosthesis with silicon specifically (by utilizing CAD and RP methods) has been proposed. Rather than manufacturing a positive RP pattern of the prosthesis (after the design and fitting stages), the computer model prosthesis is referenced to produce a CAD model of a mold. The negative profile of actual prosthesis was created by molds cavity. The manufactured mold is utilized to cast the prosthesis in polyurethane, medicinal grade elastomer. This disposes of traditional flasking and investment procedures. Likewise, the created mold can be preserved because it is durable and allow multiple pourings.20 As silicon prosthesis require frequent replacement , preservation of mold has become an important step.(because of staining or weakening of the silicone elastomer). Qiu et al revealed that a patient with total rhinectomy

was booked for a nasal prosthesis. A four piece mold of nasal prosthesis was prototyped using RP and CAD procedure based on 3D model of patients face. With this mold traditional silicone was processed to fabricate nasal prosthesis. 21 Ciocca et al made a negative volume (of a planned .STL document) of the external ear and changed this example into another STL document for the shape structure. Three-dimensional printing was then used to create the mold for actual silicone prosthesis.[22]

**MOLD FOR COMPLETE DENTURE**

Only ten publications were found by us (written within the last 20 years) on the field of computer designed and fabricated complete denture. This reveals lack of advancement in utilizing this technology in fabrication of complete denture.23-25 Researchers at Peking University developed a novel CAD and RP system to make individualized flasks (molds) for a complete denture. The procedure includes getting 3D data of edentulous models with occlusal rims in centric relation, establishment of artificial teeth 3D graphic data base, developing software for complete dentures by exploring a CAD route, fabricating molds by 3D printing. Finishing of complete denture is done by conventional laboratory method.26 Five complete dentures have been successfully designed and fabricated using this system even though it is still in experimental set-up phase. These dentures had a good fit. Clinical experiments and laboratory quantitative test should be conducted as a next step to improve the system.

**DIRECT DENTAL METAL PROSTHESIS FABRICATION**

Metal prostheses are regularly utilized in a dental prosthetic center. The lost-wax casting technique is the conventional method to create a metal prosthesis. This process is an

extensive and work concentrated process that includes numerous manual steps, for example, fabricating, installing and burning out of wax pattern, metal casting, and post processing. A metal prosthesis can be fabricated by milling using CAD/CAM milling system. In this system milling tools were exposed to more abrasion, procedure is time consuming, spatial restrictions limit the production of RPD framework. Material wastage is more.[27,28]

As of late, RP innovation, particularly selective laser melting (SLM) and selective laser sintering (SLS) , has pulled in consideration among analysts for its brisk fabrication of high-accuracy metal parts with various materials and shapes.29 SLS/SLM are layer-wise, material-addition methods that permit production of complex 3D parts by specifically combining progressive layers of powder material over one another, utilizing thermal energy provided by focused and computer controlled laser beam. Likewise, the remaining unprocessed powder can be reused. Dental prostheses are entirely appropriate for preparing by methods for SLS/SLM because of their complex geometry and their capacity to be modified without long manual pre-or post-processing.

This newly proposed CAD/RP technique comprises of three main steps: the computerized geometry catches and processes the dental cast; the component shape for dental framework are digitally modeled; and the structure is delivered through a computer by SLS/SLM.30 A CAD/RP (SLM) process for RPD metal structure fabrication has been performed at Peking University. This procedure streamlines the conventional framework fabrication process and quickens the generation turnaround period (1.5 hours) by utilizing 3D imaging, CAD, and RP. In this procedure, specially created CAD bundles are utilized to build the framework, and a SLM system is utilized to manufacture the planned metal RPD framework.31 Although enhancement research of the processing parameters and clinical applications are as yet

important, this proposed CAD/RP technique gives an efficient and quick strategy to carefully design and make biocompatible metal systems for complex dental prosthesis.

**ALL CERAMIC RESTORATION FABRICATION**

Since the 1980s, innovative work of dental CAD/CAM milling systems has been effectively sought after worldwide.32 Recently, commercial dental CAD/CAM processing frameworks have been effectively presented for specific fields, for example, all ceramic restorations. These processing frameworks empowered zirconia ceramics to be utilized as a standard material for dental prosthetic restorations. The drawback of this system was wastage of raw material as unused part of monoblock has to be discarded after milling and recycling of excess ceramic material was not feasible. Exposure of milling tools to heavy abrasion. Moreover, due to tooling process of brittle ceramic material, microscopic cracks can be introduced.[33]

RP techniques overcome the described deficiencies. 34-37 A direct inkjet fabrication technique (for the manufacture of the green-zirconia all-ceramic dental restoration by means of a slurry micro extrusion process) has been proposed.34 After manufacture of the green restoration, the complete restoration is gotten by a sintering or laser-assisted densification process. This procedure is a promising CAD/RP system with good potential to create all-ceramic dental restorations with high accuracy, cost productivity, and least material utilization. This procedure is still in the exploratory stage.

The direct inkjet system considers the printing of a suspension with a high strong substance of zirconia powder and drop on-demand inkjet printheads. The perfect pseudoplastic and expulsion nature of zirconia powder slurries are controlled by the solids stacking, ph value,

and drying speed of the slurries after conveyance. This control allows the slurry to be expelled at low expulsion pressure and have great shape-keeping capacity. The dimensional precision of the restoration is likewise influenced by the expulsion parameters. For example, the nozzle size, expulsion rate, distance between nozzle head and substrate and nozzle travelling speed.[38-41]

After the slurry expulsion, a green part of the dental restoration should be sintered in the furnace at a temperature of 900 C to 950 C for 5 to 8 minutes. In the wake of sintering, the crown must have shrinkage, about 27% in height and about 25% in width. The microstructure of the sintered restoration indistinguishable to that made by means of the conventional dental restoration process. Another laser-assisted densification process for creating dental zirconia restoration was produced at the University of Connecticut. These dental zirconia restorations are delivered by a slurry expulsion, trailed by laser densification of the expelled slurries. A custom fitted direct inkjet printing process was produced by Ebert et al. 33 This procedure takes into consideration the printing of a suspension with a high strong substance of zirconia powder. The procedure additionally permits the utilization of direct inkjet printing innovation with conventional drop-on-demand inkjet printheads, to develop dental prosthetic restorations (made of high-quality zirconia ceramics).33 However, the CAD/RP systems for fabrication of dental all-ceramic restoration is still in its testing stage. The specific zirconia powder slurries with reasonable rheological nature and expulsion conditions, and also streamlining of the drying procedure and a custom fitted different stage sintering process, still can't seem to be explored and developed.

## CONCLUSION

RP systems have been generously utilized in dentistry, yet utilizations of RP in prosthodontics are generally uncommon. This article discussed about the utilizations of RP procedures in prosthodontics. Dental prostheses can be manufactured layer by layer specifically from a computer model effortlessly and quickly by different RP systems without part-explicit tooling and human mediation. This system is a progressive change for fabrication of dental prosthesis. With the advancement and research of the decent variety for RP systems and correspondingly constructed materials, it is conceivable to create various types of dental prostheses for various applications. These applications incorporate dental prosthesis wax pattern, dental (facial) prosthesis mold (shell), dental metal prosthesis, and zirconia prostheses. We trust that RP procedures are assuming a more essential job in prosthodontics and will wind up one of the standard advances for computerized manufacture of dental prostheses.

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