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RAPID PROTOTYPING TECHNOLOGY – A REVIEW

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ABSTRACT

Rapid Prototyping technology has been exploited to build complex 3D models in medicine since 1990s. Rapid Prototyping technologies proposed successful applications in various dental fields, such as fabrication of implant surgical guides, frameworks for fixed and removable partial dentures, wax patterns for the dental prosthesis, zirconia prosthesis, molds for metal castings, maxillofacial prosthesis and complete dentures.

INTRODUCTION

CAD/CAM systems have three functional components:

1. A digitalization tool/scanner that transforms geometry into digital data that can be processed by a computer.
2. Software which processes scanner data and produces a data set readable by a fabrication machine.
3. A manufacturing technology that takes the data set and transforms it into the desired product by fabricating the restoration.

To fabricate a physical prototype in industry or medicine, two different approaches have been utilized: subtractive and additive.

1. In a subtractive method, material is subtracted from an initial block of material to leave the desired shaped part (dental restoration).

CAD/CAM systems relied almost exclusively on cutting a restoration from a prefabricated block with the use of burs, diamonds or diamond disks. This is usually accomplished by conventional numeric control (NC) machining such as milling.

Subtractive processes use carefully-planned tool movements to cut material. The numeric control [NC] machining is used typically in small model-making machines for which they are used to fabricate metallic and ceramic crowns in dentistry. The subtractive fabrication can create a complete shape effectively, though at the expense of material being wasted. In a typical subtractive method in dentistry, approximately 90 percent of the initial bock is removed to create a typical dental restoration.

Torabi *et al.* in their studies concluded that the CAD/CAM system could compete well with conventional systems for clinical fit and fracture resistance and can achieve acceptable results in vitro.

Vojdani *et al.* compared the marginal and internal fit of metal copings cast from wax patterns fabricated with a CAD/CAM system and the conventional method. Their findings showed that only conventional method could result in copings with clinically acceptable margins of less than 120 µm.

2. Additive fabrication is a process in which the final desired part is manufactured by adding multiple layers of material on top of one another. The idea of this innovative method is that the three dimensional CAD (3D-CAD) model is sliced into many thin layers and the manufacturing equipment uses this geometric data to build each layer sequentially until the part is completed. Hence, additive fabrication is often referred as "layered manufacturing", "direct digital manufacturing", "three-dimensional printing", or "solid freeform fabrication". Additive technology scan yield arbitrarily complex shapes with cavities and undercuts.

Subtractive methods have some limitations in comparison with additive techniques: The precision fit of the inside contour of the restoration depends on the size of the smallest usable tool for each material and if the cutting tool was larger in diameter than some parts of the tooth preparation, it will result in reduction of internal fit precision or inferior marginal properties.

a. A considerable amount of raw material is wasted because the unused portions of the mono-blocks must be discarded after milling and recycling of the excess ceramic material is not feasible.
b. Milling tools are exposed to heavy abrasion and wear, therefore withstands only short running cycles.
c. Microscopic cracks can be introduced into ceramic surfaces due to machining of this brittle material.
d. It is neither easy nor economic for big, full undercuts and complex milling parts.

Rapid prototyping (RP) techniques, so-called "generative manufacturing techniques", exhibit the potential to overcome the shortages.

Rapid Prototyping consists of two phases:

- Virtual phase (modeling and simulating) and physical phase (fabrication).
- Virtual prototyping is development of model by dynamic and interactive simulation.

The course of forming the physical model is formation of 3D physical model by CAD.
Process can be stated as:
Objects can be produced with different geometrical intricacy without involving the setup of the machine or final assembly. Objects can be produced by employing different types of materials such as composites. Moreover, with a controlled conduction, different materials can be used at different places in an object. The construction of complex objects can be fast, convenient and uncomplicated by additive fabrication systems.

Rapid Prototyping techniques have been employed to build complex 3D models. The chief benefit of Rapid Prototyping techniques is the medical models that can be produced with undercuts, voids, intricate internal geometrical details and anatomical landmarks such as facial sinuses and neurovascular canals. The Rapid Prototyping model is currently employed to improve medical diagnosis and to provide a precise surgical treatment plan. The technique would shorten the surgery time and reducing the patients risk.

CONCLUSION

Rapid Prototyping Technology is becoming more appealing for dental purposes. The innovations in molding materials and forming procedure have improved the Rapid Prototyping techniques. The feasibility of this technique is increasing in different dental practice fields such as Maxillofacial Prosthesis, production of surgical guide or physical models in dental implant treatment. Rapid Prototyping techniques can also be employed to develop dental prosthesis such as crowns, fixed and removable partial dentures and also copings. This technique would eliminate any faults caused by human skills and intervention in traditional fabrication of dental prosthesis and comparably is time saving.

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