International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2020): 7.803

Dimensional Stability of 3D Printed and Heat Cure Resins for Removable Dentures - A Literature Review

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Abstract: ***Background: Current innovations in digital dentistry have successfully led to the fabrication of removable dental prostheses using CAD/CAM technologies. In comparison with the conventional PMMA dentures, the 3D printed ones have significant advantages and higher dimensional stability. The purpose of this article is to review the available literature on the dimensional changes of three - dimensionally printed complete dentures, in comparison to the conventional acrylic resin in terms of new biomaterials, fabrication techniques and workflow. Materials and methods: The chosen criteria for inclusion of the selected articles have been written in English and published between 2005 and 2021 on 3D printed dentures, technique articles that reported processing, clinical steps with 3D printed dentures. The methodology included applying a search strategy, defining criteria, selecting a number of studies to summarize the results. Results and conclusion: The role of the elapsed time and the degree of polymerization shrinkage for the strength and modulus of elasticity are of great importance for the manufacture of removable prosthetic restorations.3D printing has potential to modernize the denture fabrication techniques, materials and workflows. The advantages of this method consist of easier clinical performance and low cost - effectiveness.***

Keywords: 3D Printing, CAD/CAM, Dimensional Stability, Heat Cure Resins, Removable Dentures, Dental Resins

1. Background

Dental resins are defined as a type of resin, which is one of the first materials used in dentistry. Initially, vulcanized rubber was used for removable dentures, and in 1854 Thomas Evans created the first prosthesis with artificial teeth made of porcelain, and a prosthetic base made of rubber.

The most commonly used material for fabrication of conventional removable dentures has been the polymer polymethyl methacrylate (PMMA). The material has several advantages: easy processing and repair, biocompatibility, good esthetic characteristics and low cost. Thus, this has led to increased acceptability by the patients. Nevertheless, PMMA has numerous disadvantages including high polymerization shrinkage, imbibition, dimensional and color changes over time and allergic reactions due to monomer leaching. [1]

Additive manufacturing (AM), also known as three - dimensional (3D) printing or rapid prototyping (RP), encompasses techniques that fabricate objects layer by layer.3D printing, despite its relative recent introduction, has shown potential in many fields like engineering and medicine including dental medicine. Available 3D printing materials include resins, composites, metals, ceramics, biomaterials and food materials. [2]

2. Materials and Methods

The methodology included applying a search strategy, selecting relevant studies and forming information to summarize the results. The search terms used were “Denture”, ‘‘Removable Dental Prostheses”, “Removable Denture”, “Complete Denture”, “Three - dimensional printed”, “CAD/ CAM”, “CAD - CAM”, “Computer Aided Design and Computer Aided Manufacturing”, “Milled”, “3D Printed” OR “Printed” and “Digital Denture”.

The search strategy for this review involved 3 stages: reviewing titles, abstracts, and final selection of articles for full text analysis. Articles selected from the database search were sorted independently by 4 reviewers, and any differences in selection were discussed until a consensus was reached.

3. Results and Conclusion

Dental resins intended for the manufacture of prosthetic bases must possess a range of qualities such as mechanical strength, chemical inertness, high biocompatibility, as well as good aesthetic characteristics. Many modifications have been made to improve the physical properties, durability, technological modes of operation and reduce the processing time of PMMA acrylics.

This type of material must also be resistant to volume changes under all conditions and must not change its

dimensions over time. The volumetric stability of acrylic plastics is good if a proper polymerization protocol is followed. It was found that in the polymerization of the liquid methyl methacrylate monomer, the volume of the solid polymer of the same type would be 21% smaller than the original, 21% shrinkage was obtained, which was practically unacceptable, as there would be a large discrepancy in the volume of the model and the actual size of the future prosthesis. [3]Volume changes were expressed in polymerization shrinkage, which was compensated by the high sorption of water from this type of material. [4]This could seriously affect its stability during chewing function. [5]Deformation may occur during the polymerization process or at other times thereafter. The reason is the release of internal stresses during the technological process, which can be caused by the shrinkage of the material or by the sudden and rapid cooling during the packaging process. Nowadays, materials made by CAD/CAM technology and 3D printing, have similar mechanical properties and dimensional stability, compared to other types of resins, are increasingly used.

4. List of Abbreviations

AM: Additive manufacturing
CAD/CAM: Computer aided design/computer aided manufacturing
CRDP: Complete removable dental prosthesis
PMMA: Polymer polymethyl methacrylate
RM: Rapid manufacturing
RP: Rapid prototyping
3D: Three dimensional

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