DENTAL AND MEDICAL JOURNAL - REVIEW

e-ISSN 2667-7288 **Vol** 2, **Issue** 2, (2020) ***Review Article / Derleme Makale***

REINFORCEMENT OF POLY (METHYL METHACRYLATE) DENTURE BASE MATERIAL: REVIEW

Jamal Moammar Aldabib [1]

[1]Lecturer, Department of Dental Technology, Faculty of Medical Technology, Baniwalid University, Bani Walid, LIBYA

ORCID ID: 0000-0003-2768-760X

Corresponding Author:

Jamal Moammar Aldabib,

Department of Dental Technology, Faculty of Medical Technology, Baniwalid University, Bani Walid, LIBYA

jamalald71@gmail.com +21 891 857 5209

Article Info / Makale Bilgisi

Received / Teslim: 04 April 2020
Accepted / Kabul: 30 June 2020
Online Published / Yayınlanma: 30 June 2020
DOI:

Aldabib JM. Reinforcement of Poly (Methyl Methacrylate) Denture Base Material: Review. Dental and Medical Journal - Review. 2020;2(2):46-53.

DENTAL AND MEDICAL JOURNAL - REVIEW

e-ISSN 2667-7288 **Vol** 2, **Issue** 2, (2020) ***Review Article / Derleme Makale***

Abstract

The current study has focused on reviewing the recent literature on denture base materials in order to link the findings of a large number of experiments conducted under different environment on large conditions. Many materials have been tried but most of them were discarded because they were unsatisfactory from many aspects. It is not the purpose of this review to consider the recording of unsatisfactory materials. However, it is to assess the current constraints on denture base materials and the testing procedures that are used to evaluate these materials. As result, it refers to look elsewhere is likely to be successful in what seems an endless search for material can be used as a denture base adequately in all circumstances. Finally, the alleged faults and improvements in the modified materials that are offered can only be judged in terms of their clinical suitability. If the used tests are not specifically designed to be related to the stress conditions and environment involved in service, any of the proposed material and techniques intended to reinforce the denture base materials would have insignificant value in practical use.

Keywords: *Polymer composites; Denture base reinforcement; Filler loading; Coupling agents; PMMA composites.*

Özet

.

Anahtar Kelimeler: .

DENTAL AND MEDICAL JOURNAL - REVIEW

e-ISSN 2667-7288 Vol 2, Issue 2, (2020) Review Article / Derleme Makale

OVERVIEW / GENEL BAKIŞ

1. Introduction

Polymers can be produced either in rigid or flexible state by changing the composition of monomers. Most of clinicians consider that denture base should be rigid. Poly(methyl methacrylate) PMMA is a rigid resin that provides sufficient structural integrity to be used as a denture base (1, 2). The reaction of the methyl methacrylate monomer with other monomers can produce a much softer polymer which can be used to line the underside of a denture for improved fit and comfort for some patients. The rigid acrylic can also be used to produce a custom-made tray for carrying the impression material into the mouth of the patient to maximize accuracy (3).

There has been a continuous research to fabricate denture base material of natural appearance that would withstand the deterioration during the service. Before the advent of acrylic, vulcanite rubber had been the most satisfactory material available for almost 75 years. Afterwards, celluloid was also used for some time as it initially showed a more encouraging result than vulcanite rubber. However, it was discarded because of its distortion and discoloration during the usage. Currently, the denture bases available are largely acrylic resins. Since its introduction for the use in dentistry there has been a continual search for modified practices in processing the resins which will lead to improved qualities in finished structure (4).

PMMA is an acrylic colorless and transparent material used widely as a denture base material (5). The adequacy of PMMA's physical the favorable working characteristics, processing ease, accurate fit, and superior esthetics of the PMMA make it the most suitable material for the fabrication of denture base and proved the material's feasibility for dental applications and hence gained its popularity in dentistry (6). Its inherited characteristics of easy handling and processing, low toxicity and cost, together with moderate performance features related to biologic, physical, aesthetic, and handling characteristics, make PMMA preferred in dental applications (7). Nowadays, PMMA is the material of choice for denture base fabrication. Most research activity in the field of denture base materials, has concentrated on attempts to improve fracture toughness and impact strength of acrylic materials (8). Even though PMMA has these good combinations of properties, there is a need for improvements in the fracture resistance of PMMA. In denture, most of these fractures occur inside the oral cavity during using, primarily because of resin fatigue (9).

2. Reinforcement of Acrylic Denture Base Material

Research is currently ongoing to incorporate different materials to overcome the drawbacks and to generally increase the strength of the acrylic. Fibers provide improved properties on strength, fatigue resistance and elastic modulus of acrylic denture base material. Several factors which are related to the reinforcing fiber such as the orientation and quantity of fibers, impregnation of fibers with the matrix and fiber adhesion to the polymer matrix have an impact on the mechanical strength of acrylic resin (10, 11). Ceramic fillers are also widely used to strengthen the acrylic denture base. Reinforcement of the acrylic with ceramic powders showed encouraging result in terms of improving the physical and mechanical properties of the material. The incorporation of ceramic fillers has been strongly recommended to improve the acrylic resin properties. The surface area, particle size, and homogenous distribution of the ceramic fillers particles effect

e-ISSN 2667-7288 Vol 2, Issue 2, (2020) Review Article / Derleme Makale

the thermal properties and increase its thermal stability. The properties of the reinforced resin with ceramic fillers depend on the size, shape, type, and concentration of the incorporated filler particles (8).

2.1 Reinforced with Fibers

Several fibers types such as glass, carbon/graphite, aramid, and ultrahigh-molecular-weight polyethylene have been incorporated to acrylic resin as fiber-reinforcing agents to increase the mechanical and physical properties. Based on investigating the influence of polyethylene fibers, carbon fiber and glass fiber on the acrylic resin material. It was found that denture base acrylic resin is unsuitable for use as a matrix for a fiber-composite material unless adhesion at the fiber-matrix interface can be attained. The improved bending and fatigue resistance properties of the denture resin-carbon fiber composites are related to the effective use of a silane coupling agent to create a bond between the fiber and the acrylic (12).

Ramos et al. (13) conducted study to evaluate the effect with a plasma-treated Polyethylene (PE) fiber manufactured in various widths and lengths on fracture strength of PMMA. It was concluded that enhanced strength of the PMMA reinforced with PE fiber can reduce clinical failures of provisional fixed partial denture without any negative effect on the esthetic in the case of using it in the anterior part of the mouth.

Stipho (14) investigated the effect of glass fiber reinforcement on the strength repaired PMMA acrylic with self-cured acrylic resin. Some mechanical properties were evaluated at different concentrations of glass fiber. It was observed that both the treated and untreated samples showed a considerable reduction in fracture resistance after being repaired. At low glass fiber concentrations, the strengthening effect on PMMA acrylic resin has improved the post-repair the fracture resistance and yield strength of the acrylic material. Whereas, no significant was found on mechanical properties at higher concentrations.

Narva et al. (15) came out with study to evaluate the effect of common available fiber reinforcement in dentistry on the flexural properties of polymeric denture base material. It was found that the in-lab impregnated and pre-impregnated fiber with coupling agent have better strengthening effect on the reinforced material comparing to non-impregnated fiber reinforcements. Placing the fiber on the tension side has resulted in considerable increment in flexural properties comparing to that when placing equal amount of fiber on the compression side.

Vojvodić et al. (16) study the flexural strength of denture base material reinforced with two different types of glass fibers. The first type was silane ready made pre-treated glass fibers to be used with different dental products. Whereas, the other type was industrial glass fiber that was treated with silane coupling agent to be compared with the pre-treated type as denture base material reinforcement. It was concluded that both types of glass fibers have a significant strengthening influence on the flexural properties of the denture base material. However, the low cost of the in-lab silane treated industrial glass fiber comparing to the relatively high costs of the ready made pre-treated glass fibers could make it a better reinforcement agent for denture base material.

Vojdani and Giti (4) conducted a review study to evaluate the influence of fiber as reinforcement of polyamide denture base materials. They stated that several studies have dealt with effect of different fibers on the overall mechanical properties of polymeric denture base materials. It is a general common sense that the incorporation of synthetic fibers to the polymers has strengthening effect on the resulted polymer composites.

e-ISSN 2667-7288 Vol 2, Issue 2, (2020) Review Article / Derleme Makale

Several types of fibers have been investigated and the glass fibers found to be the most appropriate reinforcement for the polymeric denture base materials.

Abdullah et al. (17) conducted a study to investigate the effect of silane coupling agent treatment on the mechanical properties of polyester and polyamide fibers as a reinforcement filler to poly (methyl methacrylate) denture base material. The transverse, impact and hardness tests were conducted. It was found that the addition of salinized polyester, polyamide has strengthening effect on the overall mechanical properties of denture base material.

2.2 Reinforced with Ceramic Powders

A number of ceramic powders used for PMMA reinforcing, e.g., barium titanate, zirconium oxide, alumina and hydroxyapatite (HA) (8). The biodegradation, osteoconduction, osteointegration and biocompatibility of the HA is the promise behind the used of HA reinforcement material. Moreover, the stiffness, density, and bioactivity of HA make it a preferred reinforcement (18).

Mohamed (19) studied the effect of the incorporation of different concentration of hydroxyapatite into PMMA denture base material on the mechanical, physical and biological properties. It was found that the use of HA as reinforcement into the PMMA improved the overall mechanical properties of the material at lower filler concentration. Moreover, the modified material showed improvement in the radiopacity and the biocompatibility of the denture base.

Elshereksi et al. (20) evaluated the influence of simulated body fluid (SBF) on fracture toughness of poly (methyl methacrylate)/ barium titanate composites and concluded that the fracture resistance of the acrylic denture base material was significantly influenced after immersion in SBF. If a crack is generated in the matrix when the swelling exceeds its elongation to break, then the process is irreversible. Consequently, the composite will not recover its original properties.

Asam (21) evaluated the effect of use of the opaque dental porcelain as a filler into PMMA acrylic denture base material on the physical, mechanical, environmental and radiopacity properties and concluded that the modified material showed insignificant radiopacity. The poor radiopacity has been attributed to the low chemical contact of heavy metals in the samples. Additionally, the use of silane coupling agent had resulted in improving in the overall mechanical and environment properties compared to the unfilled samples.

In various dental materials studied, significant improvements in the physical and mechanical properties were achieved as a result of the incorporation of zirconia ceramic powder (22-24). However, there is a lack of the studies about the role of the zirconia as reinforcement of acrylic denture base material (8, 25). Ayad et al. (26) investigated the effect of zirconia filler loading on solubility, water sorption and some physical and mechanical properties of high impact poly (methyl methacrylate). It was concluded that the transverse strength of the modified acrylic resin was improved as a function of the incorporation of the zirconia. However, the impact strength, water solubility and surface hardness were not significantly different comparing to the unfilled samples.

According to Zidan et al. (27) the incorporation of zirconium oxide nanoparticles into a conventional high-impact heat cured acrylic denture base material has a significant effect on the mechanical properties. An improvement in the over all mechanical properties was observed at very low filler loading (3-5 wt%) of zirconia. However, a decrease in the impact resistance was recorded as a function of increasing the filler loading.

e-ISSN 2667-7288 Vol 2, Issue 2, (2020) Review Article / Derleme Makale

Tham et al. (28) came out with study to investigate the effect of planetary ball mill grinding time on the flexural and morphological properties of poly (methyl methacrylate)/hydroxyapatite composites through preparing fine and homogeneous PMMA/HA composite and concluded that a homogeneous distribution of the fine HA fillers within the poly (methyl methacrylate) matrix was achieved which led to an increase in the flexural modulus. The presence of the microporosity (voids) on the fractured surface of PMMA/HA can be controlled.

SUMMARY / SONUÇ

In order to get the maximum benefit from using the reinforcing agents, it should be homogeneously distributed through the PMMA particles. Therefore, the physical mixing of the powder components (PMMA and the filler) is strongly preferred to provide the required dispersion of the filler in the matrix. Strong bonding between the ceramic filler particles and the PMMA matrix was achieved by both chemical adhesion and tight mechanical interfacing which subsequently lead to improve the mechanical properties of the denture base material.

Finally, the alleged faults and improvements in the modified material that are offered can only be judged in terms of their clinical suitability. Any proposed tests designed to reveal the effects of manipulative variables or to compare different materials have little practical value unless the tests are specifically related to the stress conditions and environment involved in service. Therefore, it is strongly recommended to test the modified material under natural condition at the mouth temperature and by subjection of the material to natural dynamic forces (mastication forces).

Acknowledgements / Teşekkür

References / Referanslar

1. Akın H, Tugut F, Mutaf B, Guney U, Ozdemir A. Effect of sandblasting with different size of aluminum oxide particles on tensile bond strength of resilient liner to denture base. Cumhuriyet Dental Journal. 2011;14(1):5-11.
2. Gad MM, Abualsaud R. Behavior of PMMA Denture Base Materials Containing Titanium Dioxide Nanoparticles: A Literature Review. International journal of biomaterials. 2019;2019.
3. Ajay R, Suma K, Ali SA. Monomer Modifications of Denture Base Acrylic Resin: A Systematic Review and Meta-analysis. J Pharm Bioallied Sci. 2019;11(Suppl 2):S112-S25.
4. Vojdani M, Giti R. Polyamide as a Denture Base Material: A Literature Review. J Dent (Shiraz). 2015;16(1 Suppl):1-9.
5. Sayan Basak D, Datta P. Application of Polymers in Denture and Its Developments. International Journal of Engineering Science. 2018;8(4):16655-8.
6. Gad MM, Al-Thobity AM, Rahoma A, Abualsaud R, Al-Harbi FA, Akhtar S. Reinforcement of PMMA Denture Base Material with a Mixture of ZrO2 Nanoparticles and Glass Fibers. International Journal of Dentistry. 2019;2019:11.

e-ISSN 2667-7288 Vol 2, Issue 2, (2020) Review Article / Derleme Makale

7. Matsuo H, Suenaga H, Takahashi M, Suzuki O, Sasaki K, Takahashi N. Deterioration of polymethyl methacrylate dentures in the oral cavity. Dental materials journal. 2015:2014-089.
8. Gad MM, Fouda SM, Al-Harbi FA, Näpänkangas R, Raustia A. PMMA denture base material enhancement: a review of fiber, filler, and nanofiller addition. Int J Nanomedicine. 2017;12:3801-12.
9. Elshereksi NW, Ghazali MJ, Muchtar A, Azhari CH. Perspectives for Titanium-Derived Fillers Usage on Denture Base Composite Construction: A Review Article. Advances in Materials Science and Engineering. 2014;2014:13.
10. Nandal S, Ghalaut P, Shekhawat H, Manmeet S, Gulati. New Era in Denture Base Resins: A Review. Dental Journal of Advance Studies. 2013;01.
11. John J, Gangadhar S, Shah I. Flexural strength of heat-polymerized polymethyl methacrylate denture resin reinforced with glass, aramid, or nylon fibers. The Journal of prosthetic dentistry. 2001;86:424-7.
12. Vallittu PK, Lassila VP, Lappalainen R. Acrylic resin-fiber composite—part I: The effect of fiber concentration on fracture resistance. J PROSTHET DENT. 1994;71(6):607-12.
13. Ramos V, Runyan DA, Christensen LC. The effect of plasma-treated polyethylene fiber on the fracture strength of polymethyl methacrylate. J PROSTHET DENT. 1996;76(1):94-6.
14. Stipho HD. Repair of acrylic resin denture base reinforced with glass fiber. J PROSTHET DENT. 1998;80(5):546-50.
15. Narva KK, Lassila LV, Vallittu PK. The static strength and modulus of fiber reinforced denture base polymer. Dent Mater. 2005;21(5):421-8.
16. Vojvodić D, Komar D, Schauperl Z, Čelebić A, Mehulić K, Žabarović D. Influence of different glass fiber reinforcements on denture base polymer strength (Fiber reinforcements of dental polymer). Official Publication of the Medical Association of Zenica-Doboj Canton Bosnia and Herzegovina. 2009;6(2):227-34.
17. Abdullah ZS, Fatihallah AA, Jani GH. Reinforcement of Heat Cured Denture Base Material with Combination of Silanized Polyamide and Polyester Fibers and its Effect on Some Mechanical Properties. International Journal of Medical Research & Health Sciences. 2018;7(8):34-9.
18. Eliaz N, Metoki N. Calcium Phosphate Bioceramics: A Review of Their History, Structure, Properties, Coating Technologies and Biomedical Applications. Materials (Basel). 2017;10(4):1-104.
19. Mohamed SH. Mechanical, Physical and Biological Properties of Denture Base Poly (Methyl Methacrylate) Filled Ceramic Fillers: University Science Malaysia USM; 2005.
20. Elshereksi N, Mohamed S, Arifin A, Mohd Ishak Z. Effect of filler incorporation on the fracture toughness properties of denture base poly (methyl methacrylate). J Phys Sci. 2009;20:1-12.
21. Asam M. Preparation and Characterization of Opaque Dental Porcelain Powder as A Filler In Denture Base Poly (Methylmethacrylate). Pinang: Universiti Sains Malaysia; 2008.
22. Bajraktarova-Valjakova E, Korunoska-Stevkovska V, Kapusevska B, Gigovski N, Bajraktarova-Misevska C, Grozdanov A. Contemporary Dental Ceramic Materials, A Review: Chemical Composition, Physical and Mechanical Properties, Indications for Use. Open Access Maced J Med Sci. 2018;6(9):1742-55.
23. Zhang Y, Lawn BR. Novel Zirconia Materials in Dentistry. J Dent Res. 2018;97(2):140-7.
24. Arango Santander S PVA, Saldarriaga Escobar J, Monteiro F J, Restrepo Tamayo L F. Ceramics for dental restorations - An introduction. DYNA. 2010;77:26-36.
25. Asopa V, Suresh S, Khandelwal M, Sharma V, Asopa S, Kaira L. A comparative evaluation of properties of zirconia reinforced high impact acrylic resin with that of high impact acrylic resin. The Saudi Journal for Dental Research. 2015;14.

e-ISSN 2667-7288 **Vol** 2, **Issue** 2, (2020) *Review Article / Derleme Makale*

26. Ayad NM, Badawi MF, Fatah AA. Effect of reinforcement of high-impact acrylic resin with zirconia on some physical and mechanical properties. Archives of Oral Research. 2008;4(3).
27. Zidan S, Silikas N, Alhotan A, Haider J, Yates J. Investigating the Mechanical Properties of ZrO2-Impregnated PMMA Nanocomposite for Denture-Based Applications. Mater. 2019;12(8).
28. Tham WL, Chow WS, Mohd Ishak ZA. Flexural and Morphological Properties of Poly(Methyl Methacrylate)/ Hydroxyapatite Composites: Effects of Planetary Ball Mill Grinding Time. Journal of Reinforced Plastics and Composites. 2010;29(13):2065-75.