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Reinforcement in Denture Base Resins - A Review

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ABSTRACT:

Polymethylmethacrylate is the most commonly used base material for dentures due to its excellent esthetics, ease of processing and repair, and is economical. But it also has certain drawbacks such as residual monomer allergy, poor mechanical strength , low strengths, fragile, poor heat resistance, high thermal expansion coefficient, thermal shrinkage, etc. To overcome this disadvantage many studies have shown that reinforcement or addition of certain materials like fibers, glass, fillers may improve their physical and chemical properties. The fracture resistance of polymethyl methacrylate (PMMA), the most popular denture base material, is not satisfactory. The mechanism of denture fracture is implied by flexural fatigue and impact fracture. The transverse strength of the base materials of the denture can, therefore, be an important indicator of their performance. Acrylic resin dentures are susceptible to fracture after clinical use, which is a problem of concern in prosthodontics. Impact failure outside the mouth and flexure fatigue failure in the mouth are the two most important causes of fracture of the denture base. This reinforcement can be done to get desired properties in denture base resins for stability .This review is based on reinforcements that can be done to denture base material to increase its physical and chemical properties. The relevant articles were collected from the period of 2000 to 2020 (till date) analysed and review was done.This reinforcement can be done to get desired properties in denture base resins for stability .'

Keywords : Denture base, PMMA, Reinforcement, Nanoparticles, Fibers, Fillers

INTRODUCTION:

Dr. Walter Wright and Vernon Brothers invented acrylic resins at Philadelphia. Acrylic was introduced in 1936 as a translucent resin, and in 1937 as the acrylic powder was introduced. By 1940, Dentures were made from them. Polymethyl methacrylate (PMMA) has been the most popular material for the construction of dentures due to its advantages including good aesthetics, accurate fit, oral stability, easy laboratory and clinical handling, and inexpensive equipment[1]. Polymethylmethacrylate (PMMA) was widely used as a base material for dentures[2]. There are many factors that contribute to its widespread use: economical, reliable in the oral climate, and simple to build and repair. Yet its resistance to fractures is not satisfactory [3],[4]. Mechanical failures of PMMA dentures occur frequently. A lot of researchers have therefore tried to improve

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the mechanical properties of denture base resins[5]. To overcome the physical and mechanical limitations of denture base resins, the addition of various types of fiber such as carbon, aramid, polyethylene, and glass fiber products have been evaluated[6],[7]. According to a survey, within 3 years of their provision, 68 percent of dentures had broken. It was reported that 33% of the repairs performed by three laboratories were due to debonded/detached teeth, 29% to midline fractures more commonly observed in the upper dentures, and the rest (38%) to other types of fractures[8]. Most of the fractures had occurred in the mouth while chewing and most dentures were made of acrylic resin while some had some form of the reinforcement [9]. The mechanism of denture fracture is implied by flexural fatigue and impact fracture. The transverse strength of the base materials of the denture can, therefore, be an important indicator of their performance[10].Our team has rich experience in research and we have collaborated with numerous authors over various topics in the past decade [11][12–34].

DENTURE BASE RESIN WITH ARAMID FIBER:

Aromatic polyamides were first commercially applied as meta-aramid fibers in the early 1960s, with the development of para-aramid fibers in the 1960s and 1970s. Aramid fibers are high-performance fibers made by man, with molecules distinguished by relatively rigid polymer chains[35]. These molecules are connected by strong hydrogen bonds which very efficiently transfer mechanical stress, allowing the use of relatively low molecular weight chains[36]. The yellow color of the aramid fibers may restrict their use to some intraoral applications[37]. Due to their high mechanical properties, thermal resistance, and limited solubility in various solutions, aramid fibers have been introduced to strengthen the polymers[38]. An increase in the number of fibers in the polymer matrix enhances the resin's flexural properties[39]. The strength of the acrylic also depends on the location of the fibers within the samples and the direction of the bending force. The amount of water absorbed in a polymer matrix influences the flexural properties of the fiber-reinforced polymers due to the plasticisation.

DENTURE BASE RESIN WITH GLASS FIBER:

For reinforcing denture base resins, two types of glass fibers are used; one is a continuous fiber similar to a woven sheet or a stick-shape, while the other is short-rod glass fiber used as a filler [40]. The former has been widely researched and is accepted as providing high strength and rigidity in a parallel direction to the fibers [41]. However, further technical procedures are needed to orient continuous fibers in order to strengthen dentures in weak regions. It also indicated that the use of continuous fibers for the strengthening of dentures resulted in the formation of voids inside the PMMA resin [42]. On the other hand, glass fibers give identical properties in every direction. As a result, their composites are relatively isotropic and easily used with molding techniques for convenient compression.Our institution is passionate about high quality evidence based research and has excelled in various fields ([29,30,43–51]. However, as opposed to continuous fibers, reinforcement with short-rod glass fibers has not been widely investigated.

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DENTURE BASE RESIN WITH SHORT GLASS FIBER:

Short glass fiber-enhanced denture base PMMA had higher flexural modulus than smooth resin, while strength was reduced due to weak interfacial adhesion. Other investigators found no significant increase in the overall strength of polyethylene fiber-reinforced acrylic resin. Different forms of glass fibers were used by humans [52]. Strengthening the interface between cellulose and denture base PMMA should further investigate the potential of fibers as reinforcing agents for denture base [53]. It is well recognized that the effects of short-rod fiber reinforcement are regulated by the volume. As for glass fibers and composites of resin, The length of glass fiber is an important determinant of the mechanical properties of a composite material. This is due to the large discrepancy between the flexural moduli of glass fibers and matrix resin [54],[55]. The presence of protruding ends in the finished specimens was a considerable disadvantage of using short fiber, which could show a rough surface. If the surface of the glass fiber was properly silanized, the surface of the denture could be polished to a smooth finish with conventional polishing procedures and reported that an increase in adherence of Candida Albicans was not observed on the polished surface of an E-glass reinforced denture base polymer [56].

DENTURE BASE WITH POLYETHYLENE FIBER IN WOVEN AND KEVLAR:

A previous study clearly showed that glass fiber tensile strength needs to be increased in order to enhance the impact strength of glass fiber reinforced acrylic resin [57]. A new woven glass fiber, which is 5 times stronger per unit width (25 mm) compared to the glass fiber was used in the previous analysis [58]. This woven glass fiber 's increased strength did not result from the strength of the glass itself, but from the increased quantity and diameter of its constituent filaments as a result of adjusting the fiber's weave. It was easily cut with scissors, however, and there were no problems with its workability or bonding to the resin [59]. Kevlar fibers are useful in strengthening PMMA, but they do cause clinical problems such as polishing difficulties and poor esthetics . To the composite, woven polyethylene fibers normally develop aniso-tropical properties. They are more esthetic but the process of etching, preparing, and positioning their layers in the dental office may not be practical.

DENTURE BASE WITH METAL:

Some parts of the denture have also been replaced with cast metal plates [60]. Though
Metal plates increase flexural and impact resistance, can be expensive and susceptible to corrosion, and metal. Dentures can also be unesthetic. Another solution is repairing fiber-based acrylic resin dentures [61].

DENTURE BASE WITH NYLON:

Nylon is a generic name for some types of thermoplastic polymers that belong to the class called polyamides. These polyamides are made by the reactions of condensation between a diamine and a dibasic acid. The use of nylon as a base material for dentures has been identified in the

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literature [62]. While nylon at that time was not approved for general usage, it was used in specific circumstances such as frequent denture fracture and orthodontic appliance construction. Some of the drawbacks mentioned in the early form of nylon included the propensity of the material's base color to deteriorate, stain, high water sorption, and a rough surface after a shoot. A short period of time. The inherent flexibility of nylon was later improved and the stiffness increased by the use of short glass fiber reinforcement [63].

To date, no work has evaluated the lately formed flexible resin system based on nylon for the construction of a denture foundation. FRS is a dental polymer that is flexible and free of monomeric thermoplastics [64]. The manufacturer suggests its use for the manufacture of partial temporary dentures or complete removable small to medium dentures as well as occlusal splints and night guards. The finishing can be done using a normal PMMA denture base procedure. The manufacturer claims as it is lightweight it will provide comfort for the patient. The manufacturer gives a 5-year warranty against breakages when manufactured according to the instructions [65].

DENTURE BASE REINFORCEMENT WITH FILLERS :

Several studies have been conducted on the use of fillers to reinforce the denture base resin, and significant improvements have been found in its properties. Reinforcement of PMMA with metal oxides has improved the material's physical and mechanical properties, as well as the sensation of hot and cold stimuli in patient [66]. Consequently, the addition of metal fillers to denture-base resin was expected to improve food sensation and healthier oral mucosa. Recently, the incorporation of nanofillers has been suggested to improve PMMA properties. The high surface area, fine size, and homogeneous nanofiller distribution improved the thermal properties of PMMAIncreased thermal stability compared to pure PMMA. Resin properties reinforced by nanofillers depend on particle size, shape, type, and concentration [67].

WITH METAL OXIDES :

Alumina (Al2O3):

A recent review studied the effect of the addition of alumina to denture base resin and reported a positive impact on the acrylic resin properties [68]. Adding alumina powder to acrylic resin improved its thermal conductivity, and patient satisfaction was anticipated to increase accordingly. Additionally, reinforcing PMMA with aluminum increased flexural strength, impact strength, tensile strength, compressive strength, and resin surface hardness [69]. Warpage also significantly decreased after aluminum was added to PMMA. On the other hand, some studies have found that adding aluminum reduces both the impact and tensile strength of PMMA. Due to the stress concentration around the embedded metal and its poor adhesion to the polymer, the resin was weaker [70].

Zirconia (ZrO2):

Several studies found that the incorporation of zirconia (ZrO2) fillers in PMMA significantly increased its flexural strength [71]. However, a slight decrease in flexural strength was also

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reported; this could result from the clustering of particles within the resin, which weakened the material. Moreover, PMMA's impact strength, fracture toughness, and hardness were significantly improved by adding ZrO2 [72]. On the other hand, one study observed an insignificant increase in impact strength and surface hardness of zirconia-reinforced resin relative to unreinforced PMMA. There was also a decrease in both impact strength and surface hardness [73].

In addition, ZrO2 significantly increased the thermal conductivity of PMMA [74]. Various findings have been obtained regarding the effect of ZrO2 on PMMA 's water sorption and solubility. It was found that the addition of ZrO2 significantly reduced PMMA 's water sorption and solubility, while there was also an insignificant difference in water solubility and an increase in water sorption within the limit of ADA specifications [75].

Titanium (TiO2):

Several studies have explored the effect of adding titanium dioxide (TiO2) to PMMA 's properties. Adding TiO2 particles could improve flexural strength, fracture toughness, PMMA hardness, as well as thermal conductivity [76]. Additionally, a significant increase in impact strength and a significant decrease in water sorption and solubility were found when adding TiO2 to PMMA [77]. Conversely, some studies found that TiO2 did not improve PMMA's flexural strength, which could be attributed to the clustering of particles within the resin, causing its weakness.

Silver (Ag):

Several studies found that the addition of silver NPs (AgNPs) to denture-based acrylic resin exhibited antifungal properties, particularly at high concentrations,and acted as a latent antifungal material with low release Ag+. In contrast, found that the incorporation of silver NPs into PMMA did not affect the adhesion of C. Albicans, and the accumulation of biofilms[78].

Silver has an antimicrobial effect; its addition to PMMA could reduce microbial adhesion and colonization [79]. Previously, its use could benefit immune-compromised and geriatric patients. Moreover, silver-reinforced PMMA resin has increased flexural and fatigue strength and improved thermal conductivity [80]. It was noticed, however, that injecting 0.5 percent of antimicrobial silver-zinc zeolite into heat-curing acrylic resin did not affect its impact and transverse strength, surface hardness, and resin surface roughness [81]. It did not change its color, but the acrylic resin found a significant reduction in water sorption and an increase in water solubility [82]. On the other hand, it has been suggested that the addition of silver may negatively affect the mechanical properties of denture base resin, depending on its percentage [83]. Incorporating silane-treated silver particles significantly increased PMMA's compressive strength [84]. Adding 10 percent and 20 percent silane-treated silver fillers also increased PMMA's tensile and flexural strength. Adding silver powder to PMMA significantly increased thermal conductivity; PMMA 's flexural strength values had not changed significantly [85].

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LIMITATION:

There are certain limitations of acrylics, such as residual monomer allergy, poor mechanical strength , low fatigue strength, brittle on impact, poor heat conductors, low hardness, high thermal expansion coefficient, thermal shrinkage, poor color stability of self-curing resins, porosity, poor metal and porcelain adhesion and mechanical retention requirements.But they are also the most commonly used denture base materials to date .

FUTURE SCOPE:

Reinforcing denture base resins with different fibers and fillers will enhance the physical and mechanical properties as well as biocompatibility. nylon fibers can be reinforced but its is difficult to polish . nanoparticles can be added so that its antimicrobial property,antioxidant property could be detected.reinforcement with natural substance can used as it does not have much adverse effect.but its colour may be changed.Aramid fiber reinforcement increases the strength but again they are unesthetic & difficult to polish so limited to locations where aesthetics is not important.

CONCLUSION:

Multiple fillers and fibers have been reinforced in denture base materials which provides an increase in the strength and flexibility of denture base.The diverse advances in denture base resins have yielded promising results. Today many limitations have been overcome of the poly-methyl methacrylate denture base resins. And it's sure to have additional new technologies in the future, to give patients better treatment & care.

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The authors have carried out the study by collecting data from search engines and drafted the manuscript by necessary information.They have Aided in conception of the topic, has participated in the review and has supervised in preparation of manuscript. The authors have participated in the study design and have coordinated in developing the manuscript. All authors have discussed the study details among themselves and contribute to the final manuscript.

AUTHORS CONTRIBUTION:

A.S.Pavithra has contributed for, execution of the work, data collection and drafting of manuscript. Dr.Jayalakshmi has contributed for concept and design of the study, validation of the data collection, revision and proof-reading of the review.Dr.Anjali.A.K has contributed for validation of the data collection, revision and proof-reading of the review.

CONFLICT OF INTEREST:

Authors declare no conflict of interest.

REFERENCES:

[1] Ariga P, Nallaswamy D, Jain AR, Ganapathy DM. Determination of Correlation of Width of Maxillary Anterior Teeth using Extraoral and Intraoral Factors in Indian Population: A Systematic Review. World Journal of Dentistry 2018;9:68–75. https://doi.org/10.5005/jp-journals-10015-1509.

[2] Duraisamy R, Krishnan CS, Ramasubramanian H, Sampathkumar J, Mariappan S, Navarasampatti Sivaprakasam A. Compatibility of Nonoriginal Abutments With Implants: Evaluation of Microgap at the Implant-Abutment Interface, With Original and Nonoriginal Abutments. Implant Dent 2019;28:289–95. https://doi.org/10.1097/ID.0000000000000885.

[3] Jyothi S, Robin PK, Ganapathy D, Anandiselvaraj. Periodontal Health Status of Three Different Groups Wearing Temporary Partial Denture. Research Journal of Pharmacy and Technology 2017;10:4339. https://doi.org/10.5958/0974-360x.2017.00795.8.

[4] Selvan SR, Ganapathy D. Efficacy of fifth generation cephalosporins against methicillin-resistant Staphylococcus aureus-A review. Research Journal of Pharmacy and Technology 2016;9:1815. https://doi.org/10.5958/0974-360x.2016.00369.3.

[5] Subasree S, Murthykumar K, Dhanraj. Effect of Aloe Vera in Oral Health-A Review. Research Journal of Pharmacy and Technology 2016;9:609. https://doi.org/10.5958/0974-360x.2016.00116.5.

[6] Ranganathan H, Ganapathy DM, Jain AR. Cervical and Incisal Marginal Discrepancy in Ceramic Laminate Veneering Materials: A SEM Analysis. Contemp Clin Dent 2017;8:272–8. https://doi.org/10.4103/ccd.ccd_156_17.

[7] Ashok V, Suvitha S. Awareness of all ceramic restoration in rural population. Research Journal of Pharmacy and Technology 2016;9:1691. https://doi.org/10.5958/0974-360x.2016.00340.1.

[8] Ashok V, Nallaswamy D, Benazir Begum S, Nesappan T. Lip Bumper Prosthesis for an Acromegaly Patient: A Clinical Report. The Journal of Indian Prosthodontic Society 2014;14:279–82. https://doi.org/10.1007/s13191-013-0339-6.

[9] Venugopalan S, Ariga P, Aggarwal P, Viswanath A. Magnetically retained silicone facial prosthesis. Niger J Clin Pract 2014;17:260–4. https://doi.org/10.4103/1119-3077.127575.

[10] Kannan A, Venugopalan S. A systematic review on the effect of use of impregnated retraction cords on gingiva. Research Journal of Pharmacy and Technology 2018;11:2121. https://doi.org/10.5958/0974-360x.2018.00393.1.

[11] Subramanyam D, Gurunathan D, Gaayathri R, Vishnu Priya V. Comparative evaluation of salivary malondialdehyde levels as a marker of lipid peroxidation in early childhood caries. Eur J Dent 2018;12:67–70. https://doi.org/10.4103/ejd.ejd_266_17.

[12] Panchal V, Jeevanandan G, Subramanian E. Comparison of instrumentation time and obturation quality between hand K-file, H-files, and rotary Kedo-S in root canal treatment of primary teeth: A randomized controlled trial. J Indian Soc Pedod Prev Dent 2019;37:75–9. https://doi.org/10.4103/JISPPD.JISPPD_72_18.

[13] Rajeshkumar S, Kumar SV, Ramaiah A, Agarwal H, Lakshmi T, Roopan SM.

Biosynthesis of zinc oxide nanoparticles usingMangifera indica leaves and evaluation of their antioxidant and cytotoxic properties in lung cancer (A549) cells. Enzyme Microb Technol 2018;117:91–5. https://doi.org/10.1016/j.enzmictec.2018.06.009.

[14] Abhinav RP, Selvarasu K, Maheswari GU, Taltia AA. The Patterns and Etiology of Maxillofacial Trauma in South India. Ann Maxillofac Surg 2019;9:114–7. https://doi.org/10.4103/ams.ams_233_18.

[15] Marimuthu M, Andiappan M, Wahab A, Muthusekhar MR, Balakrishnan A, Shanmugam S. Canonical Wnt pathway gene expression and their clinical correlation in oral squamous cell carcinoma. Indian J Dent Res 2018;29:291–7. https://doi.org/10.4103/ijdr.IJDR_375_17.

[16] Kavarthapu A, Thamaraiselvan M. Assessing the variation in course and position of inferior alveolar nerve among south Indian population: A cone beam computed tomographic study. Indian J Dent Res 2018;29:405–9. https://doi.org/10.4103/ijdr.IJDR_418_17.

[17] Ramesh A, Vellayappan R, Ravi S, Gurumoorthy K. Esthetic lip repositioning: A cosmetic approach for correction of gummy smile - A case series. J Indian Soc Periodontol 2019;23:290–4. https://doi.org/10.4103/jisp.jisp_548_18.

[18] Sweta VR, Abhinav RP, Ramesh A. Role of virtual reality in pain perception of patients following the administration of local anesthesia. Ann Maxillofac Surg 2019;9:110–3. https://doi.org/10.4103/ams.ams_263_18.

[19] Felicita AS. Orthodontic extrusion of Ellis Class VIII fracture of maxillary lateral incisor - The sling shot method. Saudi Dent J 2018;30:265–9. https://doi.org/10.1016/j.sdentj.2018.05.001.

[20] Rao TD, Kumar MPS. Analgesic efficacy of paracetamol vs ketorolac after dental extractions. J Adv Pharm Technol Res 2018;11:3375. https://doi.org/10.5958/0974-360x.2018.00621.2.

[21] Fluoride, fluoridated toothpaste efficacy and its safety in children - review. Int J Pharm Res 2018;10. https://doi.org/10.31838/ijpr/2018.10.04.017.

[22] Ponnulakshmi R, Shyamaladevi B, Vijayalakshmi P, Selvaraj J. In silico and in vivo analysis to identify the antidiabetic activity of beta sitosterol in adipose tissue of high fat diet and sucrose induced type-2 diabetic experimental rats. Toxicol Mech Methods 2019;29:276–90. https://doi.org/10.1080/15376516.2018.1545815.

[23] Paramasivam A, Vijayashree Priyadharsini J, Raghunandhakumar S. N6-adenosine methylation (m6A): a promising new molecular target in hypertension and cardiovascular diseases. Hypertens Res 2020;43:153–4. https://doi.org/10.1038/s41440-019-0338-z.

[24] Mehta M, Deeksha, Tewari D, Gupta G, Awasthi R, Singh H, et al. Oligonucleotide therapy: An emerging focus area for drug delivery in chronic inflammatory respiratory diseases. Chem Biol Interact 2019;308:206–15. https://doi.org/10.1016/j.cbi.2019.05.028.

[25] Padavala S, Sukumaran G. Molar Incisor Hypomineralization and Its Prevalence. Contemp Clin Dent 2018;9:S246–50. https://doi.org/10.4103/ccd.ccd_161_18.

[26] Pandian KS, Krishnan S, Kumar SA. Angular photogrammetric analysis of the soft-tissue facial profile of Indian adults. Indian J Dent Res 2018;29:137–43.

https://doi.org/10.4103/ijdr.IJDR_496_16.
[27] Nair M, Jeevanandan G, R V, Emg S. Comparative evaluation of post-operative pain after pulpectomy with k-files, kedo-s files and mtwo files in deciduous molars -a randomized clinical trial. Braz Dent Sci 2018;21:411. https://doi.org/10.14295/bds.2018.v21i4.1617.
[28] Ke Y, Al Aboody MS, Alturaiki W, Alsagaby SA, Alfaiz FA, Veeraraghavan VP, et al. Photosynthesized gold nanoparticles from Catharanthus roseus induces caspase-mediated apoptosis in cervical cancer cells (HeLa). Artif Cells Nanomed Biotechnol 2019;47:1938–46. https://doi.org/10.1080/21691401.2019.1614017.
[29] Sridharan G, Ramani P, Patankar S, Vijayaraghavan R. Evaluation of salivary metabolomics in oral leukoplakia and oral squamous cell carcinoma. J Oral Pathol Med 2019;48:299–306. https://doi.org/10.1111/jop.12835.
[30] Vijayashree Priyadharsini J, Smiline Girija AS, Paramasivam A. In silico analysis of virulence genes in an emerging dental pathogen A. baumannii and related species. Arch Oral Biol 2018;94:93–8. https://doi.org/10.1016/j.archoralbio.2018.07.001.
[31] Krishnan RP, Ramani P, Sherlin HJ, Sukumaran G, Ramasubramanian A, Jayaraj G, et al. Surgical Specimen Handover from Operation Theater to Laboratory: A Survey. Ann Maxillofac Surg 2018;8:234–8. https://doi.org/10.4103/ams.ams_51_18.
[32] Ezhilarasan D. Oxidative stress is bane in chronic liver diseases: Clinical and experimental perspective. Arab J Gastroenterol 2018;19:56–64. https://doi.org/10.1016/j.ajg.2018.03.002.
[33] Palati S, Ramani P, Shrelin HJ, Sukumaran G, Ramasubramanian A, Don KR, et al. Knowledge, Attitude and practice survey on the perspective of oral lesions and dental health in geriatric patients residing in old age homes. Indian J Dent Res 2020;31:22–5. https://doi.org/10.4103/ijdr.IJDR_195_18.
[34] Wu F, Zhu J, Li G, Wang J, Veeraraghavan VP, Krishna Mohan S, et al. Biologically synthesized green gold nanoparticles from induce growth-inhibitory effect on melanoma cells (B16). Artif Cells Nanomed Biotechnol 2019;47:3297–305. https://doi.org/10.1080/21691401.2019.1647224.
[35] Basha FYS, Ganapathy D, Venugopalan S. Oral Hygiene Status among Pregnant Women. Research Journal of Pharmacy and Technology 2018;11:3099. https://doi.org/10.5958/0974-360x.2018.00569.3.
[36] Ajay R, Suma K, Ali S, Sivakumar JK, Rakshagan V, Devaki V, et al. Effect of surface modifications on the retention of cement-retained implant crowns under fatigue loads: An In vitro study. Journal of Pharmacy And Bioallied Sciences 2017;9:154. https://doi.org/10.4103/jpbs.jpbs_146_17.
[37] El Naggar SM, El Nasr MIS, Sakr HM, Eissa SM, Elboraey AN, Moussa AR. Effect of Denture Base Reinforcement Using Light Cured E- Glass Fibers on the Level of Salivary Immunoglobulin A. Open Access Maced J Med Sci 2018;6:2168–72. https://doi.org/10.3889/oamjms.2018.419.
[38] Pattanaik S, Pattanaik B. Characterization of a denture base using autopolymerized pour-

type denture base resin and acrylic stain. Journal of Prosthodontic Research 2013;57:145–6. https://doi.org/10.1016/j.jpor.2012.08.007.

[39] Cheng Y-Y. Denture base resin reinforced with highly drawn linear polyethylene fibres n.d. https://doi.org/10.5353/th_b3862799.

[40] Kurt M, Saraç YŞ, Ural Ç, Saraç D. Effect of pre-processing methods on bond strength between acrylic resin teeth and acrylic denture base resin. Gerodontology 2012;29:e357–62. https://doi.org/10.1111/j.1741-2358.2011.00480.x.

[41] Song R, Jiao X, Lin L. Improvement of mechanical and antimicrobial properties of denture base resin by nano- titanium dioxide and nano- silicon dioxide particles. Pigment & Resin Technology 2011;40:393–8. https://doi.org/10.1108/03699421111180545.

[42] Gooch JW. Glass Filler. Encyclopedic Dictionary of Polymers 2011:341–341. https://doi.org/10.1007/978-1-4419-6247-8_5510.

[43] Vijayashree Priyadharsini J. In silico validation of the non-antibiotic drugs acetaminophen and ibuprofen as antibacterial agents against red complex pathogens. J Periodontol 2019;90:1441–8. https://doi.org/10.1002/JPER.18-0673.

[44] Pc J, Marimuthu T, Devadoss P. Prevalence and measurement of anterior loop of the mandibular canal using CBCT: A cross sectional study. Clin Implant Dent Relat Res 2018.

[45] Ramesh A, Varghese S, Jayakumar ND, Malaiappan S. Comparative estimation of sulfiredoxin levels between chronic periodontitis and healthy patients - A case-control study. J Periodontol 2018;89:1241–8. https://doi.org/10.1002/JPER.17-0445.

[46] Ramadurai N, Gurunathan D, Samuel AV, Subramanian E, Rodrigues SJL. Effectiveness of 2% Articaine as an anesthetic agent in children: randomized controlled trial. Clin Oral Investig 2019;23:3543–50. https://doi.org/10.1007/s00784-018-2775-5.

[47] Ezhilarasan D, Apoorva VS, Ashok Vardhan N. Syzygium cumini extract induced reactive oxygen species-mediated apoptosis in human oral squamous carcinoma cells. J Oral Pathol Med 2019;48:115–21. https://doi.org/10.1111/jop.12806.

[48] Mathew MG, Samuel SR, Soni AJ, Roopa KB. Evaluation of adhesion of Streptococcus mutans, plaque accumulation on zirconia and stainless steel crowns, and surrounding gingival inflammation in primary molars: Randomized controlled trial. Clin Oral Investig 2020:1–6.

[49] Samuel SR. Can 5-year-olds sensibly self-report the impact of developmental enamel defects on their quality of life? Int J Paediatr Dent 2021;31:285–6. https://doi.org/10.1111/ipd.12662.

[50] R H, Hannah R, Ramani P, Ramanathan A, R JM, Gheena S, et al. CYP2 C9 polymorphism among patients with oral squamous cell carcinoma and its role in altering the metabolism of benzo[a]pyrene. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology 2020;130:306–12. https://doi.org/10.1016/j.oooo.2020.06.021.

[51] Chandrasekar R, Chandrasekhar S, Sundari KKS, Ravi P. Development and validation of a formula for objective assessment of cervical vertebral bone age. Prog Orthod 2020;21:38. https://doi.org/10.1186/s40510-020-00338-0.

[52] Walterbach FR. ADVANTAGES OF GLASS MICROBALLOONS AS FILLER

MATERIAL 1960. https://doi.org/10.2172/4671537.
[53] Tsutsumi C, Takakuda K, Wakabayashi N. Reduction of Candida biofilm adhesion by incorporation of prereacted glass ionomer filler in denture base resin. Journal of Dentistry 2016;44:37–43. https://doi.org/10.1016/j.jdent.2015.11.010.
[54] Bocalon ACE, Mita D, Narumyia I, Shouha P, Xavier TA, Braga RR. Replacement of glass particles by multidirectional short glass fibers in experimental composites: Effects on degree of conversion, mechanical properties and polymerization shrinkage. Dent Mater 2016;32:e204–10. https://doi.org/10.1016/j.dental.2016.06.008.
[55] Marei MK. Reinforcement of Denture Base Resin with Glass Fillers. Journal of Prosthodontics 1999;8:18–26. https://doi.org/10.1111/j.1532-849x.1999.tb00004.x.
[56] Hasan R, Abdulla M. Reinforced Microwave - Cured Acrylic Resin Denture Base Material with Glass Fibers. Al-Rafidain Dental Journal 2010;10:314–21. https://doi.org/10.33899/rden.2010.45447.
[57] Kang H, Ji M-K, Cho H-S, Park S-W, Yun K-D, Park C, et al. Effect of Plasma Surface Treatment on Shear Bond Strength with Denture Base Resin in Co-Cr Alloy, Ti-6Al-4V Alloy, and CP-Ti Alloy. J Nanosci Nanotechnol 2020;20:5771–4. https://doi.org/10.1166/jnn.2020.17630.
[58] Gupta S. Effect of Surface Treatment on the Flexural Strength of Denture Base Resin and Tensile Strength of Autopolymerizing Silicone Based Denture Liner Bonded to Denture Base Resin: An In Vitro Study. The Journal of Indian Prosthodontic Society 2010;10:208–12. https://doi.org/10.1007/s13191-011-0050-4.
[59] Chander NG, Gopi Chander N, Jayaraman V, Sriram V. Comparison of ISO and ASTM standards in determining the flexural strength of denture base resin. European Oral Research 2019:137–40. https://doi.org/10.26650/eor.20190072.
[60] Mm B, Beyari MM, Professor A, Branch P, Department of Oral and Maxillofacial Surgery & Rehabilitation, Faculty of Dentistry, et al. Effect of Glass Fibers or Metallic Filler on the Linear Dimensional Changes and Water Sorption of Acrylic Resin Denture Base Material. International Journal of Dentistry and Oral Science 2015:26–9. https://doi.org/10.19070/2377-8075-si02005.
[61] Gad MM, Abualsaud R, Al-Thobity AM, Baba NZ, Al-Harbi FA. Influence of Addition of Different Nanoparticles on the Surface Properties of Poly(methylmethacrylate) Denture Base Material. J Prosthodont 2020. https://doi.org/10.1111/jopr.13168.
[62] McCracken WL. An Evaluation of Activated Methyl Methacrylate Denture Base Materials. 1952.
[63] Uzun G, Hersek N, Tinçer T. Effect of five woven fiber reinforcements on the impact and transverse strength of a denture base resin. J Prosthet Dent 1999;81:616–20. https://doi.org/10.1016/s0022-3913(99)70218-0.
[64] Dixon DL, Breeding LC. The transverse strengths of three denture base resins reinforced with polyethylene fibers. J Prosthet Dent 1992;67:417–9. https://doi.org/10.1016/0022-3913(92)90261-8.

[65] Chen SY, Liang WM, Yen PS. Reinforcement of acrylic denture base resin by incorporation of various fibers. J Biomed Mater Res 2001;58:203–8. https://doi.org/3.0.co;2-g">10.1002/1097-4636(2001)58:2<203::aid-jbm1008>3.0.co;2-g.
[66] Mamatha N, Madineni PK, Sisir R, Sravani S, Nallamilli S, Jyothy JR. Evaluation of Transverse Strength of Heat Cure Denture Bases Repaired with Different Joint Surface Contours: An Study. J Contemp Dent Pract 2020;21:166–70.
[67] Nagai E, Otani K, Satoh Y, Suzuki S. Repair of denture base resin using woven metal and glass fiber: Effect of methylene chloride pretreatment. J Prosthet Dent 2001;85:496–500. https://doi.org/10.1067/mpr.2001.115183.
[68] Köroğlu A, Özdemir T, Usanmaz A. Comparative study of the mechanical properties of fiber-reinforced denture base resin. Journal of Applied Polymer Science 2009;113:716–20. https://doi.org/10.1002/app.30123.
[69] Alla RK, Sajjan S, Alluri VR, Ginjupalli K, Upadhya N. Influence of Fiber Reinforcement on the Properties of Denture Base Resins. Journal of Biomaterials and Nanobiotechnology 2013;04:91–7. https://doi.org/10.4236/jbnb.2013.41012.
[70] Zhang X-Y, Zhang X-J, Huang Z-L, Bang-Shang ZHU, Chen R-R. Hybrid effects of zirconia nanoparticles with aluminum borate whiskers on mechanical properties of denture base resin PMMA. Dental Materials Journal 2014;33:141–6. https://doi.org/10.4012/dmj.2013-054.
[71] John J, Gangadhar SA, Shah I. Flexural strength of heat-polymerized polymethyl methacrylate denture resin reinforced with glass, aramid, or nylon fibers. J Prosthet Dent 2001;86:424–7. https://doi.org/10.1067/mpr.2001.118564.
[72] Polat TN, Karacaer O, Tezvergil A, Lassila LVJ, Vallittu PK. Water sorption, solubility and dimensional changes of denture base polymers reinforced with short glass fibers. J Biomater Appl 2003;17:321–35. https://doi.org/10.1177/0885328203017004006.
[73] Tuloglu N, Akay CG, Bayrak S. Shear bond strength of zirconia ceramic to the primary tooth dentin. Niger J Clin Pract 2020;23:792–7. https://doi.org/10.4103/njcp.njcp_567_19.
[74] Vallittu PK, Lassila VP. Reinforcement of acrylic resin denture base material with metal or fibre strengtheners. J Oral Rehabil 1992;19:225–30. https://doi.org/10.1111/j.1365-2842.1992.tb01096.x.
[75] Vallittu PK, Lassila VP. Effect of metal strengthener's surface roughness on fracture resistance of acrylic denture base material. Journal of Oral Rehabilitation 1992;19:385–91. https://doi.org/10.1111/j.1365-2842.1992.tb01580.x.
[76] Sipahi C, Ozen J, Ugur Ural A, Dalkiz M, Beydemir B. The effect of two fibre impregnation methods on the cytotoxicity of a glass and carbon fibre-reinforced acrylic resin denture base material on oral epithelial cells and fibroblasts. Journal of Oral Rehabilitation 2006;33:666–73. https://doi.org/10.1111/j.1365-2842.2006.01648.x.
[77] Vallittu PK. Comparison of two different silane compounds used for improving adhesion between fibres and acrylic denture base material. Journal of Oral Rehabilitation 1993;20:533–9. https://doi.org/10.1111/j.1365-2842.1993.tb01640.x.
[78] Jagger D, Harrison A, Jagger R, Milward P. The effect of the addition of poly(methyl

methacrylate) fibres on some properties of high strength heat-cured acrylic resin denture base material. Journal of Oral Rehabilitation 2003;30:231–5. https://doi.org/10.1046/j.1365-2842.2003.01011.x.

[79] Ganapathy DM, Kannan A, Venugopalan S. Effect of Coated Surfaces influencing Screw Loosening in Implants: A Systematic Review and Meta-analysis. World Journal of Dentistry 2017;8:496–502. https://doi.org/10.5005/jp-journals-10015-1493.

[80] Ahmad N, Jafri Z, Khan ZH. Evaluation of nanomaterials to prevent oral Candidiasis in PMMA based denture wearing patients. A systematic analysis. J Oral Biol Craniofac Res 2020;10:189–93. https://doi.org/10.1016/j.jobcr.2020.04.012.

[81] Ganapathy D. Effect of Resin Bonded Luting Agents Influencing Marginal Discrepancy in All Ceramic Complete Veneer Crowns. JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH 2016. https://doi.org/10.7860/jcdr/2016/21447.9028.

[82] Kobayashi N, Komiyama O, Kimoto S, Kawara M. Reduction of shrinkage on heat-activated acrylic denture base resin obtaining gradual cooling after processing. Journal of Oral Rehabilitation 2004;31:710–6. https://doi.org/10.1111/j.1365-2842.2004.01393.x.

[83] Vijayalakshmi B, Ganapathy D. Medical management of cellulitis. Research Journal of Pharmacy and Technology 2016;9:2067. https://doi.org/10.5958/0974-360x.2016.00422.4.

[84] Kawaguchi T, Lassila LVJ, Vallittu PK, Takahashi Y. Mechanical properties of denture base resin cross-linked with methacrylated dendrimer. Dental Materials 2011;27:755–61. https://doi.org/10.1016/j.dental.2011.03.015.

[85] AL-Omari A. Visible Light Cure Fiber Frame Work Reinforcement of Acrylic Resin Denture Base Material. A Comparative Study. Al-Rafidain Dental Journal 2014;14:173–81. https://doi.org/10.33899/rden.2014.160898.