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

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failures of PMMA dentures occur frequently. A lot of researchers have therefore tried to improve 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].

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[11]. These molecules are connected by strong hydrogen bonds which very efficiently transfer mechanical stress, allowing the use of relatively low molecular weight chains[12]. The yellow color of the aramid fibers may restrict their use to some intraoral applications[13]. Due to their high mechanical properties, thermal resistance, and limited solubility in various solutions, aramid fibers have been introduced to strengthen the polymers[14]. An increase in the number of fibers in the polymer matrix enhances the resin’s flexural properties[15]. 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 [16]. The former has been widely researched and is accepted as providing high strength and rigidity in a parallel direction to the fibers [17]. 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 [18]. 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. However, as opposed to continuous fibers, reinforcement with short-rod glass fibers has not been widely investigated.

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 [19]. Strengthening the interface between cellulose and denture base PMMA should further investigate the potential of fibers as reinforcing agents for denture base [20]. 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 [21],[22]. 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 [23].

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 [24]. 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 [25]. 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 [26]. 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 [27]. 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 [28].

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 literature [29]. 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 [30].
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 [31]. 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 [32].

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 [33]. 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 [34].

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 [35]. 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 [36]. 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 [37].

Zirconia (ZrO2):

Several studies found that the incorporation of zirconia (ZrO2) fillers in PMMA significantly increased its flexural strength [38]. However, a slight decrease in flexural strength was also 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 [39]. 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 [40].

In addition, ZrO2 significantly increased the thermal conductivity of PMMA [41]. 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 [42].

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 [43]. Additionally, a significant increase in impact strength and a significant decrease in water sorption and solubility were found when adding TiO2 to PMMA [44]. 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[45].

Silver has an antimicrobial effect; its addition to PMMA could reduce microbial adhesion and colonization [46]. 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 [47]. 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 [48]. It did not change its color, but the acrylic resin found a significant reduction in water sorption and an increase in water solubility [49]. 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 [50]. Incorporating silane-treated silver particles significantly increased PMMA's compressive strength [51]. 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 [52].

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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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.

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