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Review Article

Fiber Reinforced Denture Base Resin

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ABSTRACT:
The accuracy of fit of dentures or the exactness of the duplication of the contours of the final impression is more difficult to determine, however, with degree of precision. A number of different denture-base materials and processing methods have been introduced within recent years. The ability of a denture base material to withstand crack propagation and impact forces is an important factor which affects its performance. Hence; in the present review, we aim to summarize some of the important aspects of fiber reinforced denture base resin.
Keywords: Fiber, Denture, Resin

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INTRODUCTION

The accuracy of fit of dentures or the exactness of the duplication of the contours of the final impression is more difficult to determine, however, with degree of precision. A number of different denture-base materials and processing methods have been introduced within recent years.[1]

A range of materials have been used for denture base fabrication, such as vulcanite, epoxy resins, vinyl resin, polycarbonate, polystyrene, nylon, Bakelite and cellulose products.[2, 3] Vulcanite was the material utilised for the mass construction of dentures. Vulcanite was fabricated by heating sulphur and natural rubber to provide a good surface material; however, its drawback was the un- desirable appearance.[4, 5]

Vinyl resins possess low fracture resistance due to poor fatigue resistance. In the 20th century, Bakelite and cellulose nitrates were introduced and developed as denture base materials. However, those materials had the limitations of unstable colour and difficult processing. In 1937, Walter Wright introduced PMMA resin onto the market as an alterna- tive denture base material to Vulcanite.[6, 7] PMMA has been extensively used as a denture base material because of its desirable properties. Satisfying aesthetics, ease of processing, durability, chemical stability, light weight, and acceptable cost are some of the favorable properties.[2] Polymethyl methacrylate has many advantages, being easy to use and repair. It is well tolerated by the majority of patients and, by adding pigments and so on, can give excellent aesthetic results. However, the strength and stiffness of these resins are still a cause for concern. A further deficiency of PMMA relates to its rela- tively low flexural stiffness and the tendency for the denture base to deform under load, influencing changes to the underlying tissue surface and bone.[8]

Therefore, the ability of a denture base material to withstand crack propagation and impact forces is an important factor which affects its performance. Hence, there is a need for enhancement of the mechanical properties of PMMA based materials to achieve stronger and more fracture-resistant dentures

Rubber reinforced poly(methyl methacrylate) (PMMA)

Adequate impact strength and fracture toughness are 2 of the most important requirements for denture based resins. One of the main drawbacks of PMMA denture bases is low fracture toughness; thus, the conventional denture base polymers are susceptible to breakage with high mastication forces and during accidents. Many studies have been performed to evaluate the toughness and mechanisms of toughness improvement in rubber-modi ed acrylic polymers[9, 10]. In rubber-reinforced polymers, the resin matrix is lled with a rubbery particle which has a modulus of elasticity lower than that of the polymer matrix and a higher Poisson's ratio than the matrix. Therefore the reinforced polymer will have a lower modulus and a higher Poisson's ratio compared to the unmodified polymer. The most significant advantage of this modification is an increase in toughness as well as ultimate elongation in comparison with the relatively brittle resin acrylic material.[11]

FIBERS

Reinforcement of denture bases with carbon fibres

Several researchers have investigated the reinforcement of acrylic resins with carbon fibres to improve flexural and impact strength, as well as to prevent fatigue fracture. Further work included Wylegala's method for the production of acrylic dentures rein- forced with carbon fibre. However, this material has some potential disadvantages, namely the unsightly appearance of the fibre within the denture and its obvious effect on aesthetics, as well as some doubts about their biocompatibility if fibres become exposed on the surface of the denture base. This may happen as a consequence of fibre displacement during processing, polishing, or repeated cleaning over long periods of time. Bowman" suggested confining the carbon fibres to the area directly behind the anterior teeth to reduce these problems. However, this method puts restraints on the place- ment of the reinforcement necessary to achieve dentures with optimum properties[8].

Glass fiber

Glass fiber reinforcement has been found to significantly increase the flexural strength, impact strength, toughness, and Vickers hardness of acrylic resin.Also, a significant reduction in deformation of the denture base to less than 1% deformation was found.Moreover, a recent study found that the position of glass fiber within the denture base affects its flexural properties. Improvement of flexural strength, tough- ness, and flexural modulus was obtained from placement of glass fiber close to the surface of the denture base on its tensile stress side. When glass fiber was placed in neutral stress area, only flexural toughness was improved, and when placed in the compressive side, surface flexural modulus was increased. However, one study indicated that glass fiber impregnation into acrylic resin did not affect its linear dimensional stability.[12]

Preimpregnated and silane [3-(Trimethoxysilyl) propyl methacrylate (TMSPM)]-treated glass fiber also increased the flexural strength and impact strength of acrylic resin. Silanized glass fiber was found to be biocompatible when added to heat-cured and light-cured resins. Moreover, fiber-reinforced nanopigmented PMMA showed reduced porosity and Candida albicans adherence.[12]

Polyamide fiber

Polyamide fiber includes both Nylon and Aramid (Kevlar, DuPont, Wilmington, DE, USA) fiber. Aramid fiber- reinforced denture base resin was found biocompatible, and additionally its flexural strength and flexural modulus were increased.[13] However, the hardness of the resin decreased with increasing fiber concentration. Also, its yellow color is considered a drawback.[14,15] Nylon increased the fracture resis- tance of PMMA, as it has high resistance to continual stress. Therefore, incorporating nylon fiber in PMMA increased its structural elasticity.

Polyethylene and polypropylene fibers

Polyethylene fiber significantly increased the impact strength of PMMA, and a further increase was observed with fiber surface treatment.[16- 18] Woven polyethylene fiber reinforcement can significantly increase the elastic modulus and toughness of PMMA. However, the procedures of woven fiber etching, preparing, and positioning were found impractical.[18] Poly- propylene fiber increased the impact strength of PMMA, and surface treatment of the fiber resulted in a further increase in its impact strength. The highest impact strength was obtained with polypropylene fibers treated with plasma, which can be used to strengthen acrylic resin and reduce fracturing.[17] A recent study found that incorporating silanized polypropylene fiber in heat-cured PMMA resin significantly improved its transverse, tensile, and impact strengths, but its wear resistance was highly decreased.[19]

Natural fibers

Natural fibers were suggested to reinforce denture base resins, among which are, oil palm empty fruit bunch (OPEFB) and vegetable fiber (ramie fiber). OPEFB significantly increased the flexural strength and flexural modulus of acrylic resin. Short ramie fiber also increased the flexural modulus of acrylic resin compared with conventional PMMA, but its flexural strength decreased as a result of weak interfacial bonding. The drawback of this fiber was its presentation in a long form, which requires extra work, ie, cutting and preparation.[20, 21]

Nano fibers

It has been suggested that extreme reduction in fiber diameter size to the nanometer scale causes improvements in strength, modulus, and toughness. Fibers are the preferred reinforced materials compared to particles since they can provide a larger area for load transfer and promote toughening mechanisms such as fiber bridging and fiber pullout[22].

One of the limitations for the use of nano fibers as a reinforcing agent is their incomplete wetting by resin, which compromises strength as the result of air inclusion and voids [23]. Another drawback of nano fibers is inadequate dispersion into the resin matrix that leads to the creation of bundles. These bundles may even act as defects and adversely inuence the mechanical properties of the resin matrix and resultant composite[24].

The nano-scaled glass fibers have desired properties of small fiber diameter, large aspect ratio, and high mechanical properties. When a micro-crack in the dental resin matrix is formed under an applied stress across the crack planes, the thin and long nano-scaled glass fibers remain intact and support the applied load. Therefore, crack propagation is inhibited by the fibers with simultaneous reinforcement of the matrix. In comparison with micron-sized glass fibers, the glass nano bers are over 10-times thinner and contain significant surface Si–OH groups that can readily interact with different silane coupling agents. Consequently, the interfacial bonding between the resin matrix and the nanoscaled silanized glass fiber can be extremely powerful[25].

Good dispersion of HA nano fibers into a resin matrix at low mass can signi ficantly improve the mechanical properties of the composite, while a higher mass fraction of the nano fibers cannot effectively reinforce the resin due to the formation of bundles that may even serve as defects. Chen eta al. have reported that good dispersion of HA nano fibers could be obtained by surface treating of nano fibers with glyoxylic acid (GA)[24].

Fong used nylon 6 nano fiber to reinforce dental restorative resin composites and obtained higher mechanical properties in reinforced samples. This study suggested that when a heavy force was imposed on the composite, the existent nano fibers effectively dected the crack due to the powerful linking force between the nylon 6 nano fibers and resin matrix. When the crack broke away from the nylon 6 nano fibers, a large number of fracture lines were created on the fracture surface that caused tremendous energy consumption during the fracture[26]

It has been reported that incorporation of PAN nano fibers into BisGMA, Triethylene glycol dimethacrylate (TEGDMA) resin blends increased the toughness of the material. This toughening effect depended on the resin monomer solution composition and nano fiber/resin ratio[27].

Hybrid reinforcement

Reinforcement of PMMA by more than one type of fiber was first suggested by Vallittu in 1997[28]. The combination may be between different fibers, different metal oxides and ceramics,[29] and fibers with metal oxides, or ceramic materials.

Hybrid fiber reinforcement significantly increased the flexural strength and toughness of reinforced acrylic resin. Similar results were also obtained by incorporating metal oxides and ceramics, especially NPs, in PMMA. In addi- tion to improving surface roughness, tensile strength, flexural modulus, hardness, and thermal conductivity, and radiopacity as well as reducing shrinkage, it has antibacterial properties without showing cytotoxicity. A combination of fibers and other fillers also increased impact strength, hardness, surface roughness, and ther- mal conductivity, as well as compressive and fatigue strengths.[30]

Table 1: Classification of fillers and nano fillers used in hybrid reinforcement

Additives	Filler (size micro meter)	Nano filler (size nano meter)
Metal oxides	Aluminum oxide	
	Zirconium oxide	
	Titanium oxide	
Nobel metals	silver	AgNPs
		Gold
		Platinum
		Palladium
Mineral	HA	HA
	Silicon Dioxide	SiO2
	Mica	
Carbon		Nano-carbon

Table 2: Summary effect of different fibre on denture base resin

Fiber	Effect	
	Increase	Decrease (no effect)
Glass fibre	Flexural strength, impact strength, toughness and hardness	No effect
Silanized glass fibre	Flextural and impact strength	No effect
Aramid	Flexural strength and impact strength	Hardness, yellow colour
Nylon		
Polyethylene	Impact strength, elastic modulus and toughness	
Polypropylene	Impact strength	
OPEFB	Flexural strength amp flexural modulus	
Vegetable fiber	Flexural modulus	Flexural strength
Nano dimond	Hardness, thermal conductivity, impact strength, fracture toughness and scratch toughness.	Fatigue resistance
Hybrid fiber	Flexural strength, toughness.	

Conclusion

Based on this comprehensive review it can be concluded that: Glass fiber reinforcement significantly increases the mechanical properties of PMMA. Natural fibers (OPEFB) and vegetable fiber can be used, but further investiga- tions are needed. Obvious enhancement in the properties of denture base resin material properties was found with the addition of NPs and nanotubes, depending on the application and manipulation. Silane coupling agents play a central role in improving bonding between fillers and the resin matrix, and they subsequently improved the resin's properties. The newest reinforcement system is a hybrid one. Hybrid fiber, hybrid fillers, or hybrid fiber and filler may considerably enhance the properties of PMMA. Multiple studies were conducted in vitro, so further studies in vivo are needed, as well as clinical studies.

References

1. Anthony DH. Dimensional accuracy of various denture base material. The journal of Prosthetic dentistry.1962; 12(1): 67-81.
2. Wiskott HW, Nicholls JI, Belser UC. Stress fatigue: basic principles and prosthodontic implications. Int J Prosthodont. 1995;8:105-1
3. Nejatian T, Johnson A, and Van Noort R. Reinforcement of denture base resin. Advances in Sci and Tech 2006; 49: 124-129.
4. Van Noort R. Introduction to dental materials. 3rd ed. Edinburgh: Mosby 2007
5. Kumar M V, Bhagath S and Jei J B. Historical interest of denture base materials. J of Dent Sci 2010; 1:103-105.
6. Peyton F A. History of resins in dentistry. Dent Clin N Amer 1975; 19:211-22.
7. Tandon R, Gupts S and Argwal S K. Denture base materials: From past to future. Indi J Dent Sci 2010; 2:33-39.
8. D.A. Clarke* N. H. Ladizeskyt T. W. Chow$ acrylic resins reinforced with highly drawn linear polyethylene woven fibres. Australian Dental Journal 1992;37(5):394-99
9. Rodford R. The development of high impact strength denture-base materials. J Dent. 1986;14:214-7.
10. Rodford RA. Further development and evaluation of high impact strength denture base materials. J Dent. 1990;18:151-7.
11. Broutman LJ, Panizza G. Micromechanics studies of rubber-reinforced glassy polymers. Int J Polym Mater. 1971;1:95-109.
12. Moreno MV, Acosta-Torres LS, Barcel O-Santana FH, Vanegas-Lanc RD, Plata-Rodr ́ıguez ME, Casta VM. Fiber-reinforced nano-pigmented poly (methyl methacrylate) as improved denture base. J Appl Polym Sci. 2012;126:289-296.
13. Yu SH, Ahn DH, Park JS, et al. Comparison of denture base resin reinforced with polyaromatic polyamide fibers of different orientations. Dental Mater J. 2013;32:332–340.
14. Jagger DC, Harrison A, Jandt KD. The reinforcement of dentures. J Oral Rehab. 1999;26:185–194.
15. Chen SY, Liang WM, Yen PS. Reinforcement of acrylic denture base resin by incorporation of various fibers. J Biomed Mater Res. 2001;58: 203–208.
16. Soygun K, Bolayir G, Boztug A. Mechanical and thermal properties of polyamide versus reinforced PMMA denture base materials. J Adv Prosthodont. 2013;5:153–160.
17. Mowade TK, Dange SP, Thakre MB, Kamble VD. Effect of fiber reinforcement on impact strength of heat polymerized polymethyl- methacrylate denture base resin: in vitro study and SEM analysis. J Adv Prosthodont. 2012;4:30–36.
18. UzunG,HersekN,TinçerT.Effectoffivewovenfiberreinforcements on the impact and transverse strength of a denture base resin. J Prosthet Dent. 1999;81:616–620.
19. Ismaeel IJ, Alalwan HA, Mustafa MJ. The effect of the addition of silanated polypropylene fiber to polymethylmethacrylate denture base material on some of its mechanical properties. J Bagh Coll Dent. 2015; 27:40–47.
20. John J, Ann Mani S, Palaniswamy K, Ramanathan A, Razak AA. Flexural properties of poly (Methyl Methacrylate) resin reinforced with oil palm empty fruit bunch fibers: a preliminary finding. J Prosthodont. 2015; 24:233–238.
21. Xu J, Li Y, Yu T, Cong L. Reinforcement of denture base resin with short vegetable fiber. Dent Mater. 2013;29:1273–1279.
22. Chen L, Yu Q, Wang Y, et al. BisGMA/ TEGDMA dental composite containing high aspect-ratio hydroxyapatite nano bers. Dent Mater. 2011;27:1187-95.
23. Boyd SA, Su B, Sandy JR, et al. Cellulose nano bre mesh for use in dental materials. Coatings. 2012;2:120-37.
24. Chen L, Xu C, Wang Y, et al. BisGMA/TEGDMA dental nanocomposites containing glyoxylic acid-modi ed high-aspect ratio hydroxyapatite nano bers with enhanced dispersion. Biomed Mater. 2012;7:045014.
25. Gao Y, Sagi S, Zhang L, et al. Electrospun nano-scaledglass fiber reinforcementofbis-GMA/ TEGDMA dental composites. J Appl Polym Sci. 2008;110:2063-70.
26. Fong H. Electrospun nylon 6 nano ber reinforced BIS-GMA/TEGDMA dental restorative composite resins. Polymer. 2004;45:2427-32.
27. Vidotti HA, Manso AP, Leung V, et al. Flexural properties of experimental nano fiber reinforced composite are affected by resin composition and nano ber/resin ratio. Dent Mater. 2015;31:1132- 41.
28. Vallittu PK, Narva K. Impact strength of a modified continuous glass fiber polymethylmethacrylate. Int J Prosthodont. 1997;10: 142–148.
29. Safarabadia M, Khansarib NM, Rezaeic A. An experimental inves- tigation of HA/AL2O3 nanoparticles on mechanical properties of restoration materials. Eng Solid Mech. 2014;2:173–182.
30. Salman TA, Khalaf HA. The influence of adding of modified ZrO2- TiO2 nanoparticles on certain physical and mechanical properties of heat polymerized acrylic resin. J Bagh Coll Dent. 2015;27:33–39.