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VICKER`S-HARDNESS EVALUATION OF LIGHT CURED RESIN IMPREGNATED FIBER GLASS REINFORCED COMPLETE DENTURE

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ABSTRACT

Background: Hardness could found to be sensitive to the residual monomer content in the polymerized resins; the hardness is an effective method to evaluate the polymerization depth of resin materials. In addition, hardness had used to predict the wear resistance of dental materials. **Materials and Methods:** Acrylic resin specimens had divided into two groups according to the type of material tested (group I: conventional heat cured acrylic resin, group II: resin impregnated fiberglass reinforced complete denture base). Vicker`s micro hardness tester was used to measure Vicker`s hardness number (VH) of the acrylic specimens in which diamond indenter was applied under 25 g load for 10 seconds time evaluated by 20 x objective lens. **Results:** The VH values of resin impregnated fiberglass reinforced acrylic resin showed statistically insignificant lower values (as $P > 0.05$) than conventional heat cured acrylic resin. **Conclusion:** Unreacted monomer would act as a plasticizer and weaken the matrix. Heat cured PMMA could perform better in this aspect that the residual monomer content was less when compared to PMMA reinforced through other mechanisms.

Key words: Hardness, Fiber, Reinforce, Denture.

INTRODUCTION

A clinically acceptable denture base material should fulfill the following criteria: strength and durability, satisfactory thermal properties, processing accuracy, dimensional stability, chemical stability, insolubility and low sorption in oral fluids, absence of taste and odor, biocompatibility, natural appearance, color stability, adhesion to plastics, metals or porcelain, moderate cost and easy in fabrication and repair [(1)].

The polymethyl methacrylate is not ideal in every aspect as a denture base material. The combination of virtues rather than one single desirable property accounts for its popularity and usage. Despite its popularity in satisfying esthetic demands, it is still far from ideal in fulfilling the mechanical requirements of prosthesis [(2)].

The most commonly used material for complete denture fabrication is heat-cured polymethylmethacrylate (PMMA). Due to its low cost, ease of fabrication and polishing made the PMMA a preferred base material [(3)].

Flexural fatigue stress exerted due to repeated masticatory forces is one of the primary causes of PMMA resin denture base fractures. Majority of PMMA resin dentures fracture at the end of three years in service or gradually during function. Alternatively, fractures occurred intra orally for more than 1 year but less than 3 years. Uneven resorption of residual ridges may further contribute to resin base fracturing during clinical service. Such conditions, midline fracture might occur [(4)].

Several studies had investigated the incidence and types of denture fractures. It reported that

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33% of repairs were carried out due to debonded / detached teeth and 29 % were repairs to midline fractures which more commonly seen in lower complete dentures. The midline fracture in a denture is often a result of flexural fatigue. Impact failures usually occurred due to sudden blow of the denture due to accidental dropping [5].

Fiber reinforced composites were universally used materials in aircraft and in space applications, in the marine and automotive industries, infrastructure and building construction and medical applications. They were made of plastic matrix that reinforced by fine thin fibers, which have high tensile strength and high flexural modulus. It also called fiber-reinforced polymer or glass reinforced plastic [6].

The polymeric plastic matrix, consisting of polymerized monomers, had the function of holding the fibers together in the composite structure. It also transfers stresses between fibers and protects the fibers from the outside environment such as chemicals, moisture and mechanical shocks. Thus, the matrix may influence the compressive strength, inter-laminar shear and in-plate shear properties, interaction between the matrix and the fiber and defects in the composite. Two types of resins; the cross-linked or linear, were used in FRCs. The cross linking polymer was also called a thermoset polymer, referring to mono-functional methacrylate polymers [7].

A fiber might be described as an elongated uniform material with a more or less equiaxed and uniform transverse cross sectional diameter or thickness less than 250 μm, and with an aspect ratio, i.e length to cross-sectional diameter or thickness ration, which was usually greater than about 100 [8].

However, in some cases, such as short fibers, chopped fibers, whiskers of staple fibers, the fibers aspect ratio can be smaller than 100. The fiber orientation, content, distribution and the ability to maintain these parameters were significant for the enforcement and thereby clinical success. The fiber`s type, length, orientation and volume fraction influence the following properties of the FRC: their tensile strength and modulus, compressive strength and modulus, fatigue strength and fatigue failure mechanism, density, electrical and thermal conductivity, and finally their cost. Some typical fibers used were glass, polyethylene, polyester, carbon/ graphite, aramid, Quartz and ceramic fibers[9].

Organo functional silanes were the most widely used coupling agents for improvement of the interfacial adhesion in glass-reinforced materials. Their effectiveness depends on the nature and pretreatment of the substrate, the silane type, and the silane layer thickness and application process[10].

Denture bases typically fabricated from polymer (powder) and monomer (liquid) for form a multi-phase acrylic resin by polymerization. Glass fibers could use in two ways to reinforce a multiphase denture base acrylic. These included using the glass fibers in the entire denture base, termed as total fiber reinforcement (TFR) or partially placing the fibers accurately at the weak site of the PMMA resin denture base, termed as partial fiber reinforcement (PFR). A clinical survey of the performance of the glass fibers in reinforcing PMMA resin removable dentures concluded that PFR and TFR could prevent recurrent fractures in PMMA resin dentures [11].

MATERIALS AND METHODS

Total 120 specimens were preliminary designed and fabricated; 60 for each group. In each group, 10 specimens used to evaluate each mechanical property.

Following ADA specification NO.12, the following five metal patterns constructed for acrylic resin specimen's preparation and milled using 3D milling machine with 3D image software.

Mold constructed throughout using metal flask of denture processing. Using standard three pour technique, the lower portion of the dental flask was filled with dental plaster mixed according to manufacturer`s instructions. Separating medium applied by a thin brush on the metal pattern. Then, a second layer of plaster mix coated on metal pattern to prevent entrapment of air during the pouring process. The third pour of dental plaster applied after setting of the second pour (30 min).

All the previous pours performed by using laboratory vibrator for assurance of no entrapment of air bubbles during mixing. Once the plaster and metal patterns coated with separating medium, the upper half of the flask tightened in place to assure metal-to-metal contact. Finally, the flask was carefully deflasked to avoid damaging of the mold, metal pattern removed and the mold obtained.

For group I, conventional non-reinforced heat cured acrylic resin was mixed and packed following the manufacturer's instructions. Powder/Liquid of 3:1 by volume mixed with compatible inert metal spatula to avoid any unwanted retardation reactions and then kept in a sealed jar to reach desired dough stage.

The material packed into the plaster mold with excess material. Then, the metal flask was compressed with the hydraulic press under 100-150 bar to remove excess resin fins and to check any deficient material inside the mold as a trial packing. Placing into the water path for 30 minutes at 72 °C and extended for another 60 minutes at 100 °C for long cycle heat curing.

After curing, the flask removed from the water path and allowed to bench cool at room temperature. After deflasking, the specimens were finished and polished using rubber wheel stone to remove excess materials and to avoid distrubting measurements taken by ADA specification NO. 12.

For group II, a light cured resin impregnated fiberglass used as a reinforcement mesh for conventional heat cured acrylic resin specimens.

Before setting and application, a suitable size of the fiber meshwork cut according to the size of the used mold, adapted gently inside the mold, and fixed in place using light cured resin supplied by the manufacturer, figure (1).

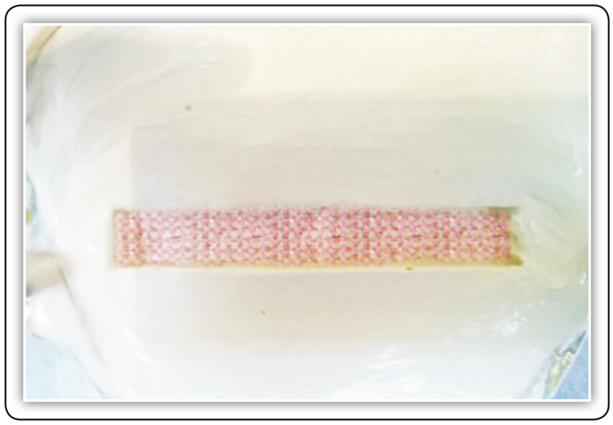

FIG (1)

Using LED light curing unit, the applied fiber meshwork cured by wavelength Using LED light curing unit, the applied fiber meshwork cured by wavelength ranged from 430 to 500 nm for a fixed definite time (at least two minutes). After complete curing, standard mix performed until reaching dough stage and pressurized using hydraulic press into the flask to obtain intimate mechanical interlocking between acrylic resin specimen and light cured fiber meshwork. Finishing and polishing performed using usual standards of group I.

Vicker`s micro hardness tester was used to measure Vicker`s hardness number of the acrylic specimens in which diamond indenter was applied under 25 g load for 10 seconds time evaluated by 20 x objective lens, figure (2).

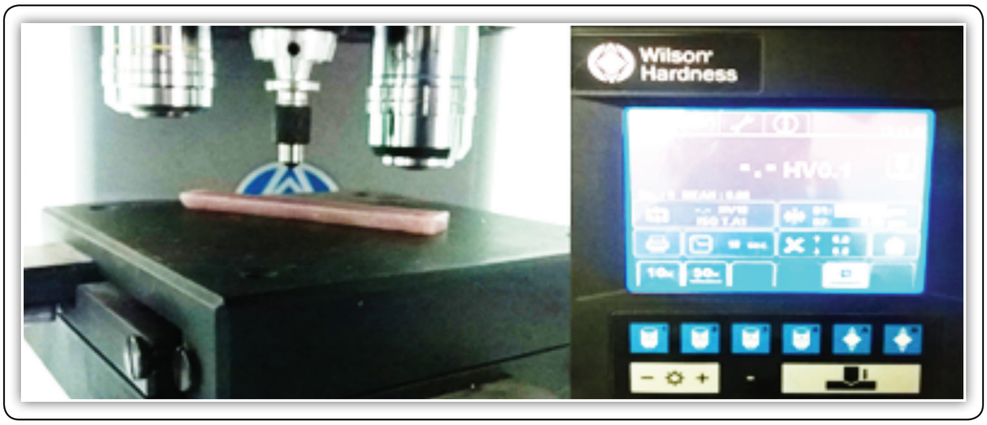

FIG (2)

RESULTS

Three equally indentations applied with minimum 0.5 mm distance on the surface of the specimen. Length of the indentations was measured using built in scaled microscope. Microhardness obtained using the following equation: **HV = 1.854 P /d²** as **HV**; Vickers hardness in Kgf/mm², **P**; load in Kgf and **d**; the length of the diagonals in mm.

Mean ± SD values of VH for conventional heat cured acrylic resin (group I) were (22.758 ± 2.84) while for resin impregnated fiberglass reinforced acrylic resin (group II) were (25.7 ± 3.42).

At level of probability $P \le 0.05$, independent t-test was performed to evaluate the significance between both groups which revealed that there was insignificant difference between both groups as $P = 0.1054 > 0.05$, table (1) and figure (3).

TABLE (1): Mean, standard deviation (SD) values of Vicker`s Hardness (VH) for comparison between Conventional Heat-Cured Acrylic Resin (Group I) and Resin Impregnated Fiber Glass Reinforced Acrylic Resin (Group II):

Mean ± SD	Conventional Heat-Cured Acrylic Resin (Group I)	Resin Impregnated Fiber Glass Reinforced Acrylic Resin (Group II)	P- value
Vicker's Hardness	22.758 ± 2.84	25.7 ± 3.42	**0.1054***

M; Mean, SD; Standard Deviation, P; Probability Level

***insignificant Difference*

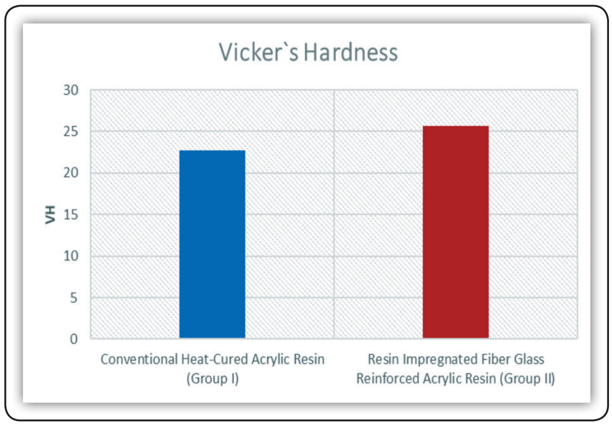

FIG (3)

DISCUSSION

Surface hardness was essential to measure the resistance of the material to scratch. Using digital Vicker`s microhardness tester after standardized finishing and polishing of specimens, to obtain flat and smooth mirror like surface for equal distribution of load without causing any scratches to guarantee accurate measurements (12).

Thus, the main purpose of increasing the hardness of acrylic resin used to fabricate denture base was to avoid loss of smoothness, reduce plaque retention, pigmentation and aesthetic problems, leading to a longer period of serviceability (13).

The resin impregnated fiberglass reinforced acrylic resin denture base showed higher insignificant mean value than conventional one as mean ± standard deviation values were 25.7 ± 3.42 and 22.76 ± 2.84 Kgf/mm2 respectively. These results explained that it related to residual monomer release in acrylic resin specimen [14].

It revealed that unreacted monomer would act as a plasticizer and weaken the matrix. Heat cured PMMA could perform better in this aspect that the residual monomer content was less when compared to PMMA reinforced through other mechanisms. Moreover, they explained that the higher insignificant difference might be because surface hardness was a mechanical property and the microhardness tests demonstrated the ability of the material to resist surface plastic deformation in a limited area [12].

It demonstrated that there was an increase in hardness of heat cured PMMA when glass fibers added to it due to the effect of silane treated E glass fiber weight percentage and aspect ratio on Vicker`s hardness number of PMMA. In addition, they revealed that inorganic materials like glass fibers had poor compatibility with fiber matrix interface[14].

CONCLUSION

Within the limitations regarding Vicker`s hardness study, the conventional heat cured denture base is proved to be higher than the resin impregnated light cured fiber glass reinforced one within certain limits.

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