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EFFECT OF NANO-GOLD REINFORCEMENT OF POLYMETHYL METHACRYLATE AND FLEXIBLE POLYAMIDE DENTURE BASE MATERIALS ON IMPACT STRENGTH#

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ABSTRACT

The purpose of this study was to evaluate the effect of nano gold (AuNps) reinforcement of polymethyl methacrylate (PMMA) and polyamide flexible denture base materials on the impact strength. Denture base specimens were fabricated from Acrostone PMMA, AuNps reinforced PMMA, thermopress flexible polymeric (bre. flex 2nd edition) and AuNps reinforced flexible polymeric resin. The impact strength was evaluated as one of the most important mechanical properties of the denture base materials. Significant difference was observed between all denture base materials tested. The AuNps reinforcement of the bre. Flex polymeric denture base material improved impact strength.

INTRODUCTION

The majority of denture bases are fabricated using PMMA. Due to factors ranging from cost to psychology, many patients choose removable partial dentures that became popular many decades ago with the introduction of acrylic polymers and chrome cobalt alloys (1). The acrylic resins and processing methods have been modified to improve physical and mechanical properties of denture bases such as injection-molding technique (2).

Thermoplastic resins have high physical strength, heat resistance, chemical resistance and it can be easily modified to increase stiffness and wear resistance. Different kinds of thermoplastic resins are available like: thermoplastic acetal, thermoplastic polycarbonate, thermoplastic acrylic and thermoplastic nylon (1). Polyamide resin is preferable to be used only for the denture base and the buccal part of the retainer and metal to be used for the connector, rest, and lingual arm that is to maintain mechanical strength of the denture (3).

The strength of denture materials can be assessed by a variety of mechanical properties. The impact strength (the ability of a material to resist a sudden high-level force or shock) test is one of the most common tests used. High impact strength is one of the main requirements because of the risk of denture fracture (4).

The Charpy impact strength was found in a descending order, polyamide (Nylon PACM12) > polycarbonate > polyamide (Nylon 12), polyethylene terephthalate > conventional PMMA. The injection-molded thermoplastic resins had significantly higher or similar impact strength compared to the PMMA (5).

The impact strength of flexible denture base material (Valplast) was found to be the highest than (De-flex, Lucitone FRS) and (Bre-flex) had the lowest impact strength (4).

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The impact strength values of pink heat-cured PMMA acrylic resin were significantly improved by various metal oxides reinforcement (1% titanium oxide and 1% zirconium oxide, 2% aluminum oxide, 2% TiO_2, and 2% ZrO_2 by volume [6]. Denture base specimens reinforced with polyethylene fibers followed by glass fibers, stainless steel mesh improved the impact strength [7]. The impact strength was significantly reduced with the addition of glass flakes in 10% and 20% to the conventional heat cured resin [8].

The AuNps has low toxicity to biological systems. AuNps exhibited different inhibitory effects by changing surface modifications agents. AuNps display excellent antibacterial potential for some Gram-negative and Gram-positive bacteria [9].

MATERIAL AND METHODS

This in-vitro study evaluated two denture base materials with and without AuNps reinforcement.

Five denture base specimens were fabricated (for each group) from Acrostone heat cured PMMA (Cross linked heat cured pink denture base material, Acrostone manufacture, Egypt, Licensed by WHW, England) (group A), AuNps reinforced PMMA (group B), thermopress flexible polymeric [bre. flex 2nd edition (Bredent, 5400F605, GmbH & Co.KG. Weissenhorner Str. 2, 89250 Senden, Germany)] (group C) and AuNps reinforced thermopress flexible polymeric resin (group D).

Spherical shape AuNps with 23±2 nm particle size in concentration of 400μg/ml (NanoTech Egypt for Photo-Electronics, El-Wahaat Road, Dream Land City, Entrance 3, City of 6 October, Al Giza) were incorporated within the pink heat cured PMMA (powder to monomer mixing ratio was 3:1 by volume).

AuNps dissolved in ethanol was mixed with a ratio of 10% by volume to the total powder and monomer volume. AuNps was mixed with monomer just prior to powder/monomer mixing, packing and curing. Six ml ethanol AuNps were added to 9 ml monomer, shake well and mixed with 45 ml powder.

AuNps were incorporated within the polymer crystals. AuNps dissolved in ethanol was mixed with a ratio of 10% by volume to the pink flexible thermopress injection moulding polyamide crystals volume (bre. flex 2nd edition) just prior to manufacturing.

Two and half ml ethanol AuNps was added to a crystals half-filled cartilage (15g=22.5ml) and inserted in a 70°C preheated hot dry oven for 30 mins with intermitted shaking every 5 mins and confirmation of ethanol complete evaporation was done. Every two half-filled cartilages were collected together in one cartilage. The fully filled AuNps flexible thermoplastic crystals cartilages (45ml) was caped and ready for immediate heating, injection and manufacturing.

Metal strip was fabricated according to ISO 179-1 [type 1 un-notched test specimens with the dimensions (80 ± 2 mm length, 10.0 ± 0.2 mm width and 4.0 ± 0.2 mm thickness)] [10]. The metal strip was converted to each one of the denture base material specimens according to the manufacturer`s instruction.

The Charpy impact test was done according to ISO 179-1[10] [type 1 specimen with flatwise blow direction of unnotched specimens (ISO 179-1/1fU)] using Zwick/Roell HIT50P (Pendulum impact tester) with 7.5 J (nominal pendulum energy) pendulum hammer and 3.807 m/s impact velocity. The specimens may show complete break, hinge break, partial break and non-break behavior.

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 20. The comparison between two independent groups was done by using *Independent t-test*.

Fig. (1) Impact strength test.

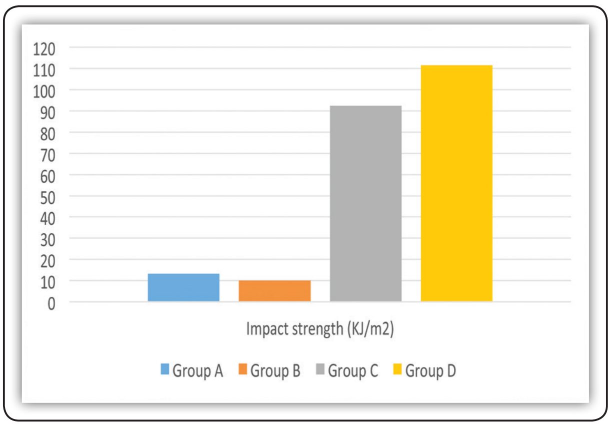

Fig. (2) Impact strength values (KJ/m^2)

RESULTS

The independent t-test showed that there was highly significant difference in the Impact strength (KJ/m^2) values of:

The PMMA (group A) and AuNps reinforced PMMA (group B) RPD denture base materials.

The PMMA (group A) and flexible (group C) RPD denture base materials.

The PMMA (group A) and AuNps reinforced flexible (group D) RPD denture base materials.

The flexible (group C) and AuNps reinforced flexible (group D) RPD denture base materials.

The AuNps reinforced PMMA (group B) and AuNps reinforced flexible (group D) RPD denture base materials.

DISCUSSION

The heat cured PMMA and thermoplastic flexible polyamide resin were evaluated in this study to represent different alternatives for prosthetic denture base materials.

Adding AuNps to the thermopress bre. flex crystals were performed with crystals half-filled cartilage to allow adequate shaking for proper distribution of the ethanol AuNps. Every two half-filled cartilages collected after complete evaporation of ethanol providing a full-filled cartilage suitable for injection.

The present study investigated the heat cured PMMA because it is the most commonly used denture base material. Polyamide resins were investigated also as it exhibits high flexibility, physical strength, heat and chemical resistance and the exceedingly rare allergy response. All the materials tested were a shade of pink due to its common use in prosthodontic practice [11].

The PMMA is the most commonly used denture base material, even though it has weak impact strength which lead to denture failure when it is dropped [12]. Effort was conducted on enhance the strength of PMMA. Reinforcement of denture materials with the addition of filling materials, altering the chemistry of PMMA resin materials and manufacturing alternative denture base material were the most common modification to improve mechanical properties [13-15].

The results of the present study showed that the AuNps reinforced bre.flex flexible thermopress polyamide had the highest impact strength values with four non-break specimens and one specimens perform complete break in a range of (109.71 – 113.68 KJ/m^2). The bre.flex flexible thermopress polyamide exhibiting the same behavior (87.65 – 95.16 KJ/m^2) then the Acrostone heat cured PMMA which showed complete break (11.29 – 14.94 KJ/m^2) and finally the AuNps reinforced heat cured PMMA showed the lowest values with complete break (9.67 – 10.46 KJ/m^2).

The previous values came in agreement with Hamanaka et al [5], Soygun et al [16] which revealed that the values of maximum impact strength were the highest in the bre. flex thermopress flexible polyamide groups and it was much higher than those of the Acrostone PMMA groups. This could be attributed to the chemical structure properties of polyamide, enabling it to better absorb forces, which is different from those of PMMA.

CONCLUSION

The AuNps incorporation within the polyamide increase the impact strength values, while it was decreased after PMMA AuNps incorporation.

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