Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies ***NLM ID:*** *101716117*

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Indian Citation Index (ICI) Index Copernicus value = 91.86

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Original Research

Effects of silver nanoparticles addition on flexural strength and surface roughness of heat polymerized acrylic resin- An in-vitro study

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ABSTRACT:
Aim: The purpose of this study was to evaluate and compare the effect of adding two different percentages of silver nanoparticles on flexural strength and surface roughness of heat cure denture base resin. **Methodology:** One of the commonly used Heat cure denture base resin (DPI) was used in this study. 20 acrylic specimens were fabricated without adding silver nanoparticles and denoted as Group A (control group). 20 acrylic specimens were fabricated by Incorporation of 1% by wt of silver nanoparticles to heat cure denture base resin (DPI) and was denoted as Group B. 20 acrylic specimens were fabricated by incorporation of 2% by with silver nanoparticles and was denoted as Group C. Specimens were prepared with dimensions of 65mm X 10mm X 3mm for flexural strength and 12mm X 12mm X 3mm for surface roughness with compression moulding technique. Flexural strength of the specimens was measured using three-point bending test in a universal testing machine and surface roughness was assessed using profilometer. **Results:** One way ANOVA test revealed that there was a significant difference among three groups when checked for flexural strength with P-value of 0.03. Post -hoc Tukey's test revealed that there was greater mean difference in Group A (control group) compared to Group C (polymethyl methacrylate with 2% addition of silver nanoparticles). One way ANOVA test for surface roughness revealed a significant difference among three groups with P-value. **Conclusion:** Within the limitations of this invitro study, Group A showed higher flexural strength when compared to Group B and Group C. With respect to surface roughness Group C showed greater values when compared to group B and Group A.
Keywords: polymethyl methacrylate, denture base resin, silver nanoparticles.

Received: 18 June, 2022 Accepted: 21 July, 2022

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This article may be cited as: Ranjitha V, Reddy KM, Shastry YM. Effects of silver nanoparticles addition on flexural strength and surface roughness of heat polymerized acrylic resin- An in-vitro study. J Adv Med Dent Scie Res 2022;10(8):87-91.

INTRODUCTION

Since the introduction of polymethyl methacrylate (PMMA) by Wright in 1937, it has been used as the main polymer for the fabrication of denture base.[1] Polymethyl methacrylate (PMMA) based resins are widely used in dentistry for different purposes such as removable base plates, functional appliances and denture bases. It has many disadvantages which include, a high thermal expansion and low thermal conductivity, low impact strength and frequent fractures of dentures due to mechanical fatigue and high values for the free energy (hydrophilicity) and roughness of the material surface increase the chances of microbial adhesion, plaque retention and reduce patient's oral hygiene. Stress generated during mastication or gliding movements and distributed over the denture. The palatal aspect of the denture behind the anterior teeth showed highest surface tensile stress. When the polymethyl methacrylate cannot withstand intraoral and extraoral forces, fracture of the dentures occurred. To overcome the drawbacks of inferior mechanical properties, conventional PMMA materials have been incorporated with metallic fillers with varying success. Silver nanoparticles were added in varying concentrations to poly methyl methacrylate to improve the flexural properties and surface roughness. Silver nanoparticles are one of the most commonly used nano particles because of their ductility, electrical and thermal conductivity, and antimicrobial activity. Due to their small size, nanoparticles present larger surface area and appear to be more effective means of prophylaxis than micro sized silver powder. Addition of silver nanoparticles to polymethylmethacrylate will induce antimicrobial and antifungal characteristics to the material. Addition of silver nanoparticles with higher concentration to the polymethyl methacrylate caused discoloration to the material. Flexural strength of material shows its potential to resist failure under a flexural load. High flexural strength is important for the success of dentures.[2] There was not much of literature available on the effect of adding silver nanoparticles to the polymethyl methacrylate. Hence this study aimed to compare the flexural strength and surface roughness of heat polymerized acrylic resin reinforced with silver nanoparticles of varying concentrations that is 1% by weight and 2% by weight.

AIM OF THE PRESENT STUDY

The purpose of this study was to evaluate and compare the effect of adding two different percentages of silver nanoparticles on flexural strength and surface roughness of heat cure denture base resin.

METHODOLOGY

The material used was conventional heat polymerized denture base material (DPI) in a powder and liquid form. Group-A was conventional heat cure denture base resin without any additives. Two concentrates (1% and 2% by wt) of silver nanoparticles were mixed with polymer of conventional heat polymerized denture base material (DPI) of Group B and Group C respectively. The materials were blended with 15 rpm speed for 30 minutes using octagonal blender to get homogenous mixture. An assay was done for checking homogenicity of the mixture using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Cold mould seal (DPI) was applied on the mould with the help of a brush and allowed to dry. The polymer and monomer were mixed by 3:1 ratio in the porcelain jar. A standard mould measuring 65mm x 10 mm x 3mm was obtained for the fabrication of specimens divided into 3 groups of 20 each-

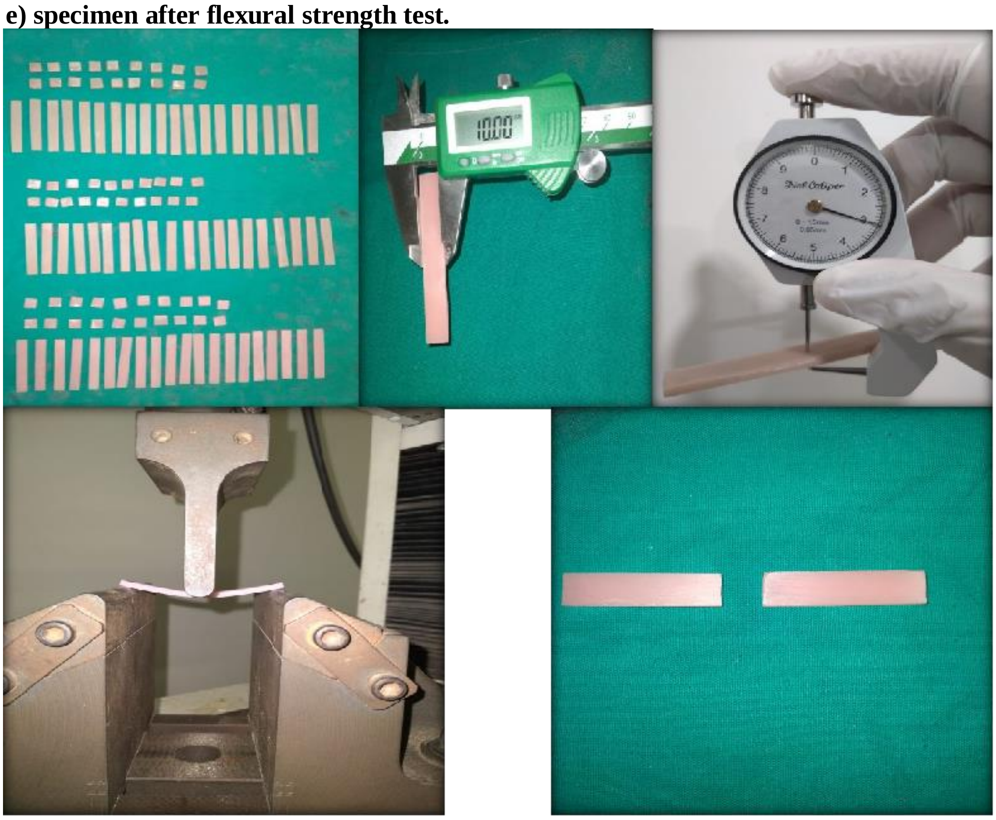
GROUP-A: Unmodified heat cure denture base resin (Control group).

GROUP-B: Modified heat cure denture base resin with addition of 1% by wt silver nanoparticles.

GROUP-C: Modified heat cure denture base resin with addition of 2% by wt silver nanoparticles.

Flexural strength was measured using a three-point bending test on a computerized universal testing machine at a cross head speed of 2mm/minute. The load was applied until the specimen fractured from whom the flexural strength value was computed automatically by the machine. The obtained values were calculated and statistically analyzed. Surface roughness of the acrylic specimens were measured by a profilometer. The obtained values were calculated and statistically analyzed. (Figure 1 a-e)

Figure 1- a) Samples of PMMA, 1%AGNPS,2%AGNPS for flexural strength and surface roughness, b) & c) Measurement of specimen dimensions for flexural strength, d) Placement of sample in universal testing machine, e) specimen after flexural strength test.



RESULTS

The flexural strength of all the specimens of 3 groups-Group A (PMMA without AgNps), Group B (PMMA with 1% AgNps) and Group C (PMMA with AgNps) were recorded. All the data obtained were tabulated and subjected to statistical analysis using SPSS statistics software v25. One way ANOVA test was performed to compare mean difference of flexural strength amongst three groups. A further Tukey's post hoc test was performed to know which groups differed. The surface roughness of all the specimens of 3 groups-Group A (PMMA without AgNps), Group B (PMMA with 1% AgNps) and Group C (PMMA with AgNps) were recorded. All the data obtained were tabulated and subjected to statistical analysis using SPSS statistics software v25. One way ANOVA test was performed to compare mean difference of surface roughness amongst three groups. A further Tukey's post hoc test was performed to know which groups differed. The maximum value of force was 127.01 N and the minimum value of force was 77.53 N and average being 93.45 N. (Table 1)

Table 1- Mean and standard deviation of force of three groups

Material	Mean	SD	F	One way ANOVA	Tukeys post hoc
Group A (control)	93.45	12.20	3.84	0.03	PMMA> SNP2
Group B (PMMA + 1%wt AgNps)	92.84	6.76			
Group C (PMMA +2%wt AgNps)	86.43	6.43			

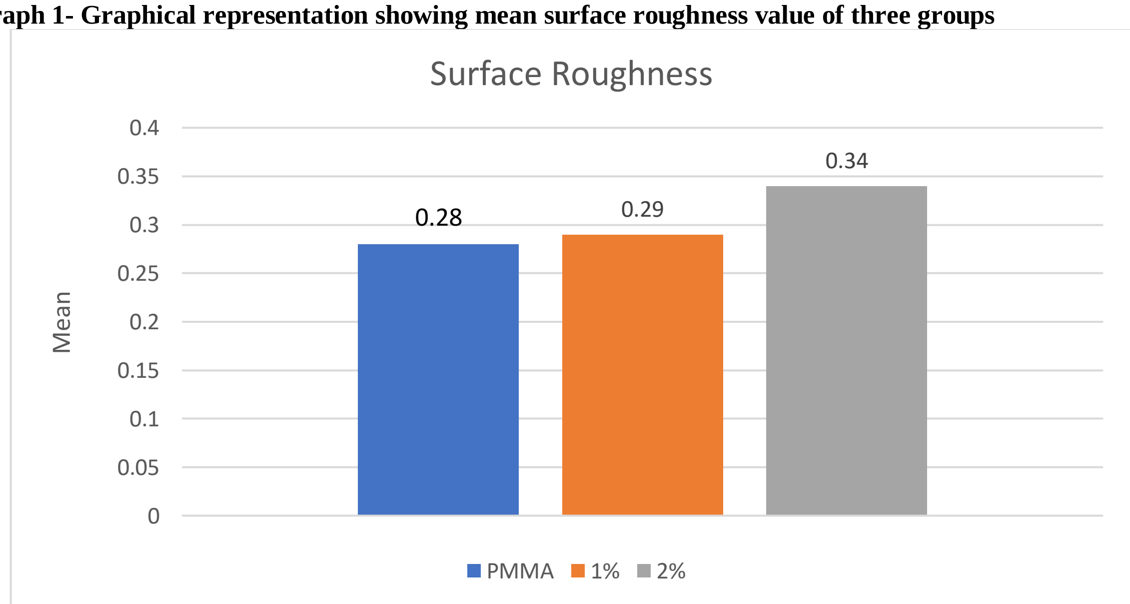
The maximum value of flexural strength was 105.84 MPa and minimum value of flexural strength was 64.6 MPa and average being 77.88 MPa.The mean of Group A (PMMA) sample was 93.45 and standard deviation was 12.20. The mean of Group B sample was 92.84 and standard deviation was 6.76. The mean of Group C sample was 86.43 and standard deviation was 6.43. One-way ANOVA test was performed to compare the mean difference amongst three different groups. It was observed that Group A had highest force among three groups. Post - hoc Tukey's test revealed that there was greater mean difference in Group A (control group) compared to Group C (polymethyl methacrylate with 2% addition of silver nanoparticles). The mean of Group A sample was 0.28 and standard deviation was 0.04. The mean of Group B sample was 0.29 and standard deviation was 0.03. The mean of Group C sample was 0.34 and standard deviation was 0.05. (Table 2)

Table 2- Mean flexural strength of groups

Material	Mean	SD	F	One way ANOVA	Tukeys post hoc
Group A (control)	77.88	10.16	3.85	0.03	PMMA> SNP2
Group B (PMMA + 1%wt AgNps)	77.36	5.63			
Group C (PMMA +2%wt AgNps)	72.03	5.36			

One-way ANOVA test was performed to compare the mean difference amongst three different groups. It was observed Group C had highest surface roughness among three groups. Post - hoc Tukey's test revealed that there was mean difference which was greater in Group C, moderate in Group B and lowest in Group A. It shows that surface roughness of Group C was highest when compared to Group A and B. (Graph 1)

Graph 1- Graphical representation showing mean surface roughness value of three groups



DISCUSSION

Poly methyl methacrylate (PMMA) resin was introduced in 1937 by "Walter Wright". Acrylic resin denture bases have got some inherent shortcomings such as frequent fracture of dentures because of fatigue, low thermal conductivity and ease of microbial adherence to the intaglio surface as reported by Alla R K [3], Darbar U R [4] and Arikan A[5]. Several researchers have attempted to improve the mechanical properties of denture base by adding different metal and non-metal fillers. Silver nanoparticles are one of the most commonly used nano particles because of their ductility, electrical and thermal conductivity, and antimicrobial activity. They have shown antimicrobial effects on many microorganisms such as E. coli, Staphylococcus aureus, Staphylococcus epidermidis, Candida albicans and Streptococcus mutants as reported by Kim KJ [6], Morones JR[7] and Lara HH [8]. Therefore, it seems that using AgNps in acrylic resins, induces antimicrobial property in them. Flexural strength is an important physical property for polymethyl methacrylate, so it is necessary for us to know the bend strength of the material. It helps us to know the stress in the material just before it yields in a flexural strength. Flexural strength (or the modulus of rupture) is defined as the amount of force an object can take without breaking or permanently deforming. Flexural strength represents the highest stress experienced within the material at its moment of rupture. Transverse strength is another term used to describe flexural strength, though they are measured the same way. Given the intraoral function of the denture base, a high flexural strength is required to prevent catastrophic failure under load. The ability to withstand high flexural loads is paramount for the success of a denture. High flexural strength is a desirable property for denture base resins. The flexural strength of denture base resins is an important property because when the flexural, or transverse, strength of a material is exceeded, you are also analysing the compressive, tensile, and shear strengths. Flexural strength is a combination of these three mechanical properties. Subjecting a denture base to a three-point bend test simulates its ability to succeed intra-orally under high functional loads during mastication and parafunction as reported by Machado AL[9]. The prime and most frequent site of fracture in the upper denture is in the medial line. The surface properties of any denture base material are of particular concern as studies of denture base materials have shown a direct link between surface roughness, the accumulation of plaque and the adherence of Candida albicans as reported by Yamuchi M[10] and Radford DR [11] increased presence of Candida species are reported in denture related stomatitis as reported by Barbeau J[12]. Jefferies SR[13] reported that the surface roughness of dental materials including acrylic denture base materials is influenced by either mechanical or chemical polishing techniques. Mechanical polishing using abrasives is intended to produce wear of the surface in a selective controlled manner thereby reducing the surface roughness of the material. Kuhar M[14] reported that mechanical methods using pumice and lathe polishing of PMMA provides an average Ra value below the threshold of 0.2 μm. A clinically acceptable threshold level of surface roughness (Ra) of 0.2 μm where no further reduction in plaque accumulation is expected in prosthetic and dental restorative materials. Ghafari et al., determined the effect of adding silver nanoparticles (AgNPs) to PMMA at 2% and 0.2% concentrations on compressive and tensile strengths of PMMA. They reported that the mean compressive strength of PMMA reinforced with silver nanoparticles was significantly higher than that of the unmodified PMMA.[15] The tensile strength was not significantly different between the 0.2% Group and unmodified PMMA and it decreased significantly after incorporation of 2% silver nanoparticles. In the present study results for flexural strength and surface roughness were interpreted. For flexural strength, the mean of Group A sample was 77.88. The mean of Group B sample was 77.36. The mean of Group C sample was 72.03. One-way ANOVA test results observed Group A had highest flexural strength among three Groups. Post -hoc Tukey's test revealed that there was greater mean difference in Group A (control Group) compared to Group C (polymethyl methacrylate with 2% addition of silver nanoparticles).

CONCLUSION

Addition of both 1% and 2% of silver nanoparticles to polymethyl methacrylate can be used safely for obtaining antifungal and antimicrobial properties along with the mechanical properties of the material.

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