ORIGINAL ARTICLE

COMPARISON OF FLEXURAL STRENGTH OF ZINC NANOPARTICLES REINFORCED RESIN WITH CONVENTIONAL HEAT CURED ACRYLIC RESIN

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ABSTRACT

Poly methyl (methacrylate) is the most commonly used denture base material. The purpose of this study was to determine the flexural strength of zinc nanoparticles reinforced resin and to compare it with conventional heat-cured acrylic.

Twenty five specimens with same dimensions (80 x 10 x 3mm) were prepared and divided into five groups, each group containing 5 specimens: conventional acrylic resin and the same resin reinforced with 5%wt, 10%wt, 15%wt and 20%wt of Zinc powder. Flexural strength was evaluated with a 3-point bending test. The results were analyzed with a one-way Analysis of Variance with a p value set at less than 0.005 as significant.

All the interventional group specimens showed lesser flexural strength than the control group specimens. Specimens loaded with 20% showed the lowest flexural strength, followed by 15%wt, 10% wt and 5% respectively. Conclusion of this study was that the flexural strength of a heat cure PMMA denture resin could not be improved statistically after reinforcement with Zinc powder in different concentrations.

Key Words: *Reinforcement, Denture base, Polymethylmethacrylate.*

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INTRODUCTION

Poly methyl methacrylate (PMMA) is most widely used in dentistry as a denture base material.[1]Its main advantages includes ease in fabrication, good esthetic and low cost. Due to its advantages this material has many applications including biomedical and dental prosthesis. The main disadvantages of PMMA are its poor strength characteristics including flexural and impact strength.[2]

Flexural strength PMMA resin is not adequate to withstand variety of intraoral stresses generated during function.[3] Many people attempted to strengthen the PMMA by reinforcement.[4] These reinforcement methods includes, incorporation of a rubber phase polymer, acrylic elastomer, metal wires, cast metal plates, various types of fibers including carbon, aramid (Kevlar), glass and polyethylene fibers etc, following mechanical problems like reduction instrength, poor adhesion, corrosion and poor aesthetic were observed.[1-5]

Approaches to strengthen the acrylic resin polymer have also included the incorporation of metal powder as fillers like silver, copper and aluminum etc. Though they have increased the strength, yet all of them are capable of producing pathological problems in the human body.[6-9] Zinc is an essential mineral of the human body, non-carcinogenic, non-radioactive and biocompatible.[2] So the purpose of this experimental study was to develop a modified heat cure PMMA resin reinforced with zinc powder having better mechanical properties. The objective of this study was to measure the flexural strength of heat cure acrylic denture base resin after reinforcement with zinc nano particle powder in different concentrations by weight and to compare it with conventional heat cure acrylic resin.

MATERIALS AND METHODS

This *in vitro* experimental study was conducted at

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the Department of Science of Dental Materials, Sardar Begum Dental College, Gandahara University, Peshawar .Twenty five specimens on the basis of three factors i.e. cost, time and logistics were included in the study. They were free from any material defect e.g., visible porosity, cracks, fracture and pre-test bends.

All the 25 samples were divided into five groups and each group had 5 samples.

- Group A-----Control group (zinc free group) = 100 % acrylic
- Group B----- 5% wt zinc reinforced group = 5 gm zinc + 95 gm acrylic resin
- Group C-----10% wt zinc reinforced group = 10 gm zinc + 90 gm acrylic resin
- Group D----15% wt zinc reinforced group = 15 gm zinc + 85 gm acrylic resin
- Group E-----20 % wt zinc reinforced group = 20 gm zinc + 80 gm acrylic resin

For the sample preparation a schematic diagram was developed in Auto CAD software. Later on this visual scheme was materialized by constructing a die with five molds in it.

A low grade steel alloy die was made by milling. A solid block of the alloy was worked on by milling machine to make five rectangular molds. Each mold was 3 mm in depth, 80mm in length and 10 mm in width(ISO 20795-2:2013 , Slandered NO 139). Five silver wafers of (80mm x10mm x3mm) were made in such a manner that they would snuggly fit into their corresponding molds. The purpose of the wafers was to press the material, at dough stage, into each mold in a forceful manner. By employing this technique it was made possible to reduce the chances of porosity in the cured specimens. To extract the extra material out of the molds, two bleed holes of even size were drilled on two sides of each mold 2mm width.

For control group heat cure Poly methyl methacrylate (Meliodent, HeraeusKulzer Ltd, Berkshire, Germany) were mixed according to manufacturer's instruction. The mix was allowed to reach a dough stage. At dough stage the material was packed into the five molds of die. The die was then pressed in a manual press until the extra material bled out of each mold through the bleed holes. The specimens were then transferred to a water bath for curing. Curing was carried out by placing the pressed die in a water bath and processed by heating at 74°C for ninety minutes; the temperature was then raised to 100 ºC for next 30 minutes. It was then allowed to cool slowly to room temperature. It was opened and the specimens were further processed for polishing. The polishing was carried out with 600 grit silicon carbide abrasive paper.

The specimens of the interventional groups were prepared by the same protocol which was adopted for the preparation of control group except the addition of zinc powder(General Purpose Reagent, BDH Ltd Poole, England) which was added in 5%, 10%, 15%, and 20% w/w to acrylic resin respectively.

After curing and cooling all the specimens were removed from the mold. All the specimens were thoroughly examined for any discrepancy and porosity. The correct samples were polished with 600 grit silicon carbide paper in wet conditions to avoid temperature induced distortions in specimens.The polishing was then carried out of all samples. Finally the widths and thicknesses of all specimens were measured with digital vernier caliper. The finished specimens were stored in deionized water at room temperature for two weeks prior to testing.

After the fabrication and polishing, all the specimens were tested with three point bending test machine (100KG-2T Tensile Test Machine) to determine the flexural strength value for each specimen. After fixing the specimen in the machine an incremental load was applied with a cross head speed 5mm/min until fracture occurred. The ultimate flexural force was that load on which the specimen got fractured.

All specimens were tested and the results were recorded on pre structured proforma. The following formula was used to calculate the modulus of rupture (Mr), as follows

$$M_r = \frac{3WL}{2bd^2}$$

Where W is the fracture load (N); L is the test span (80 mm), B is the width of the specimen (10 mm); D is the thickness of the specimen (3 mm). The mean value of each group was calculated. One-way analysis of variance (ANOVA) with 95% significance was applied by using SPSS version 21 with a p value less than 0.005 as significant and F value l.

RESULTS

The flexural strength of each sample in a group was determined individually. (Table 1).One way ANOVA test was applied to compare the flexural strength of each interventional group with the group A(Control group).

The findings of the ANOVA test of group A with B group showed insignificant result with F value of 0.294 and the P value was 0.224. F and P values indicate that there are no significant differences between the flexural strength values of group A and Group B. The ANOVA analysis between group A with C also showed

TABLE 1: FLEXURAL STRENGTH VALUES OF ALL SPECIMENS

No	Control group	Group B	Group C	Group D	Group E
1	960.56MPa	908.24MPa	870.64MPa	788.89MPa	657.96MPa
2	930.40MPa	910.45MPa	830.56MPa	760.78MPa	640.56MPa
3	920.76MPa	882.90MPa	799.54MPa	765.42MPa	689.34MPa
4	944.21MPa	915.60MPa	895.16MPa	713.78MPa	670.45MPa
5	948.30MPa	873.91MPa	891.08MPa	762.87MPa	645.49MPa

insignificant F 0.268 and P value 0.203. The statistical analysis of control group A versus group D showed was also insignificant (F=0.196 P= 0.194). There was a significant difference found in the strength between the groupsA and E with F value 0.018 and P value 0.015. The flexure strength of E was reduced approximately 2/3rd.

DISCUSSION

The commonly and most widely used resin for denture base is PMMA.[11-13] Several materials and methods have been used to improve the strength of the acrylic resin. [1-6]These additions have increased the flexural strength of PMMA. The flexural strength was improved after reinforcement with carbon graphite, aramid and glass fibers.[10] Study showed that the calculated flexural strength of the denture base PMMA reinforced with metal or glass rod was higher than that of the unreinforced denture base PMMA.[10]Another study found that the flexural strength of denture polymer material reinforced with carbon fiber increased by 35% compared to that of unreinforced.[3] It was concluded that the flexural strength increased 6% by reinforcement with carbon fiber and aramid fiber. [4]But as compared to studies mentioned above this study results showed that flexural strength had decreased with addition of Zinc nano powder. This decrease of flexural strength of modified acrylic resin may be due to irregular distribution of Zinc powder particles into the acrylic resin which caused stress concentration due to filler agglomeration.[2]Previous studies[14-20] reported that chemical bonding or chemical affinity increased the flexural strength of the test specimens reinforced with carbon fiber. The bond between the filler and matrix is essential to the longevity of the material. The second reason for this low strength may be that zinc powder and PMMA powder are chemically different with no affinity for each other. [3-6,10] The Zinc particles remain as a distinct phase in cured PMMA matrix providing weak fault lines in finished prosthesis when it is subjected to heavy compressive/tensile stresses. The third reason for the low calculated strength of the zinc modified groups is lack of coupling agent between the Zinc powder and PMMA powder which decreases the bonding between filler particles and the acrylic resin. This suggests that to get a strong PMMA resin better bonding between the zinc particles and acrylic resin should be established between the two subjects with bonding agent. From the present study, it is concluded that: The specimens of heat-curing acrylic resin reinforced with different loading ratio of zinc powder provided inferior flexural strength than those with normal acrylic resin.

CONCLUSION

Conclusion of this study was that the flexural strength of a heat cure PMMA denture resin could not be improved statistically after reinforcement with Zinc powder in different concentrations.

REFERENCES

1 Xu J, Li Y, Yu T, Cong L. Reinforcement of denture base resin with short vegetable fiber. Dent Mater. 2013;29:1273–79

2 Mohamed Ashour Ahmed1, Mohamed I, Ebrahim .Effect of zirconium oxide nano-fillers addition on the flexural strength, fracture toughness, and hardness of heat-Polymerized Acrylic Resin. World J of Nano Sci and Engg, 2014, 54, 50-57

3 Alla R, Raghavendra KN, Vyas R, Konakanchi A. Conventional and contemporary polymers for the fabrication of denture prosthesis: part I – overview, composition and properties. Int J Appl Dent Sci. 2015;101:82–89

4 Alla R, Sajjan S, Alluri V, Ginjupalli K, Padhya NU. Influence of fiber reinforcement on the properties of denture base resins. J Biomat Nano-Biotechnol. 2013;34:91–97.

5 Hamouda IM, Beyari MM. Addition of glass fibers and titanium dioxide nanoparticles to the acrylic resin denture base material: comparative study with the conventional and high impact types. Oral Health Dent Manag. 2014;43:107–12.

6 Agha H, Flinton R, Vaidyanathan T. Optimization of fracture resistance and stiffness of heat-polymerized high impact acrylic resin with localized e-glass fiber reinforcement at different stress points. J Prosthodont. 2016;25(8):647–55

7 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 BaghColl Dent. 2015;27:40–47.

8 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;24:233–38

9 Jasim BS, Ismail IJ. The effect of silanized alumina nano-fillers addition on some physical and mechanical properties of heat cured polymethylmethacrylate denture base material. J BaghColl Dent. 2014;26:18–23.

10 Vallittu PK, Lassila VP. Reinforcement of acrylic resin denture

base material with metal or fiber strengtheners. J of Oral Rehab1992; 19: 225–30.

11 Raza M, Wahid A, Ullah F, Iqbal M. (2018). Occlusal splint therapy in the treatment of Myofacial pain dysfunction syndrome (MPDS). Pak Oral & Dent J. 2018;38: 274-77.

12 Gul H, Aslam A, Nayyer M, Kaleem M. (2017). Possible errors in acrylic denture fabrication leading to teeth- denture base interface failure. Pak Oral & Dent J. 2017; 37: 510-15.

13 Mehreen S, Mahmood H, Saleem T, Allah NUM, Naeem S. (2019). Periodontal health status of fixed self cure denture abutments. Pak Oral & Dent J. 2019; 39: 51-55.

14 Heidari B, Firouz F, Izadi A, Ahmadvand S, Radan P. Flexural Strength of Cold and Heat Cure Acrylic Resins Reinforced with Different Materials. J Dent (Tehran). 2015;12(5):316–23.

15 Somani MV, Khandelwal M, Punia V, Sharma V. The effect of incorporating various reinforcement materials on flexural strength and impact strength of polymethylmethacrylate: A meta-analysis. J Indian Prosthodont Soc. 2019; 19(2):101-12.

16 Ajay R, Suma K, Ali SA. Monomer Modifications of Denture Base Acrylic Resin: A Systematic Review and Meta-analysis. J Pharm Bioallied Sci. 2019; 40 (2):112-25.

17 Galav A, Deogade SC, Mantri S, Sumathi K, Galav S .Effect of Water Storage on the Flexural Strength of Heat-cured Denture Base Resin Reinforced with Stick (s) Glass Fibers. Contemp Clin Dent. 2017; 48(2):264271.

18 Praveen B, Babaji HV, Prasanna BG, Rajalbandi SK, Shreeharsha TV, Prashant GM. Comparison of impact strength and fracture morphology of different heat cure denture acrylic resins: An in vitro study. J Int Oral Health 2014;36:12-16

19 Asar NV, Albayrak H, Korkmaz T, Turkyilmaz I. Influence of various metal oxides on mechanical and physical properties of heat-cured polymethyl methacrylate denture base resins. J Adv Prosthodont 2013;35:241-47.

20 Murthy HB, Shaik S, Sachdeva H, Khare S, Haralur SB, Roopa KT. Effect of reinforcement using stainless steel mesh, glass fibers, and polyethylene on the impact strength of heat cure denture base resin – An in vitro study. J Int Oral Health 2015;37:71-79.

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1 Hasham Khan:	Principal Investigator.
2 Muhammad Raza:	Objective setting, study designing, Drafting.
3 Tahir Ali Khan:	Supervision of the study, Drafting.