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# Evaluation the Tensile Bond Strength of Acrylic Teeth After Reinforcement the Denture Base by ZnO Nanofillers Materials

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Abstract

Acrylic teeth are chemically bond to the denture base material and are easier to adjust so that preferable on porcelain teeth but the most de bounding between teeth and denture base occur inside the patient mouth during function when the contact area between teeth and denture base was exposed to tensile strength. The Aim of this study: evaluate the tensile bond strength of acrylic teeth after reinforcement the denture base after addition (ZnO) nanofillers materials to PMMA with different concentrations(2%, 4%, and 6%).Materials and methods: Forty specimens of heat cure acrylic resin (PMMA) were prepared and divided into four groups 10 specimens for each groups as follows; Control Group (Group1) without ZnO nanofillers particles ; Group (2) with 2% by weight of ZnO ; Group (3) with 4% by weight of ZnO and Group (4) with 6% by weight of ZnO, wax pattern sample which used for acrylic cylindrical shape fabrication were (25 mm in length and 5mm in diameter ,the base of the cylinder which is 5mm in thickness and 8mm in length). Tensile bond strength of all specimens was evaluated. Results: showed the highest mean value was recorded by PMMA+ZnO 2% (6.4093) while the lowest mean value was recorded by PMMA+ ZnO 6% (3.9824). Conclusions: There were significant difference between control group PMMA and (PMMA+ZnO 4%, and PMMA+ZnO 6%) and there was no significant difference between control group PMMA and PMMA+Zno 2%.

## Introduction:

Acrylic resin available in liquid and powder a good esthetics and restoration of function (partial or complete) [(1)].

The PMMA denture Base Materials showed high toughness, not culture for the growth of fungi and bacteria, good thermal

conductivity, non-toxic or allergic, color stability, dimensional stability, easy and accurate to fabricate and repair, easy to clean, absence of test and odor, low sorption of oral fluids and able to duplicate the oral tissues [2, 3,4], it also has good impact strength, strong and lightweight material [5]. The problem associated with acrylic resin denture base is the fracture between the denture base and the acrylic teeth [6,7]. Latest studies used that nano oxide that they get better the properties of the organic polymer, also this supply resistance to environmental stress-caused cracking [8]. The studies had shown the evaluated the addition of ZnO nanoparticles in differences concentrations on the tensile bond strength between the acrylic resin denture base and the acrylic teeth. Nano zinc oxide (ZnO) has excellent antibacterial, antifungal properties, ZnO in blending with denture base resins can improve the properties of denture base resins, significantly the biological properties of acrylic resins and the nanomaterials provide a wider opportunity in identifying better reinforcement material [9]. The tensile strength of a material is the maximum amount of tensile stress that it can accept before failure (such as breaking or permanent deformation) [10]. The Aims of the study to evaluate the effect of ZnO nanoparticles in differences concentrations of 2%, 4% and 6% on the tensile bond strength between the acrylic resin denture base and the acrylic teeth.

**Abbreviations and Acronyms:** Nano zinc oxide (ZnO), heat cure acrylic resin (PMMA), tensile bond strength (T.S)

**Materials and methods**

Cylindrical shape (25 mm in length and 5mm in diameter) consists of two ends. One end set on it the tooth and the other form the base of the cylinder which is 5mm in thickness and 8mm in length. The specimens were prepared according to Abu-Anseh, 2003 and Al-Huwaizi, 2005 [11,12]. as showed in Fig. (1). 40 acrylic upper central incisors were used. They were had the same shape, size and length of the teeth were measured by used an electronic digital caliper then were cut the cervical third of all the 40 teeth by used a laboratory engine [13] then the teeth are fixed on it place on the wax pattern mold of the specimens at 45° degrees by used Protractor [14]

The addition by weight of nanofillers powder done in Four groups, they contain 2%, 4%, and 6% to monomer, with sensitive balance high accuracy (±0.0000g, Mettle Type AE260-S SNR H50193). The filler was dispersed in the monomer by ultrasonic homogenizer model 300 V/T (BIOLOGICS, INC.) type of mixing using (120W, 60KHz) for three min to had homogeneous mixing. immediately. The suspension of (the monomer with nanofillers) was mixed with acrylic powder to reduce the possibility of particle aggregation and phase separation [15] The proportion of mixing for acrylic resin was (2.5g: 1ml) P/L according to the manufacturer's.

The specimens were grouped as following:

**1.**First group (group1): control group 10 samples (without any addition).
**2.**Second group(group2): addition 2% ZnO nanoparticles 10 samples.
**3.**Third group (group3): addition 4% ZnO nanoparticles 10 samples.
**4-**Fourth group(group4): addition 6% ZnO nanoparticles 10 samples.

Packing and Curing were started when the acrylic reached to dough stage. The resin removed from the Jar and rolled. The teeth were properly positioned within the mould then placed the acrylic into the mould. The two halves of the flask closed under pressure (hydraulic press) until metal-to-metal contact then left under press 20 bar for 5 min and carried to the water bath this was done by putting the clamped flask in a water bath and cured by heating at 74°C for about one hour and a half and the temperature then growing to boiling point for 30 minutes [16]. Then deflasking and removing the acrylic specimens from the die stone mould.

Any excess of acrylic was removed by strong engine for laboratory using and an acrylic bur. Stone bur was used followed

by (120) grain sandpaper to get smooth surface with continuous cooling (submerge in cold water in rubber bowl). Polishing was skillful by using bristle brush(vertex) with pumice then used POLI-R polishing gel with the rouge wheel in lathe polishing machine, a brightness surface was obtained. Then the specimens put in container glass with aluminum cap 25ML contain distilled water and inserted them in the incubator at 37°C for (48 hours) before testing [15].

Tensile bond strength test was then performed using a 200 kg. (load cell with a crosshead speed 0.5 mm/min with a chart speed) 20 mm/min. Specimens were loaded until fracture. The data was recorded in kilograms by (mode lwdw50 manufactured by Laryee) as seen in Fig. (2). The tensile bond strength was calculated based on the load (F) in (N) At fracture, and adhesive surface area (S) in ($mm^2$) and converted to MPA. [17]. In the following formula:

T. S=F/S

$S= \pi /4. D^2$ where $\pi = 22/7$

D (diameter) =5 mm, S= 19.64 $mm^2$

T. S= tensile strength ($Nmm^2$)

F=force at failure

S= area of cross section

After testing tensile the PMMA with addition difference percentage of ZnO nanoparticles, the site of the fractures was examined under SEM (Inspect S50) in the university of technology department of applied sciences. The Surfaces and morphology after addition ZnO nanoparticles to PMMA in different concentration were examined by ANOVA (LSD).

## Result:

Table (1) showed the descriptive of groups, number, mean, and S.D. value of tensile bond strength of all groups. The highest mean value was recorded by PMMA+ZnO 2% (6.4093) while the lowest mean value was recorded by PMMA+ ZnO 6% (3.9824).

Table (2) showed the Multiple Comparisons (LSD) between groups (Mean Different (I-J), Std. Error, P-Value, Sig., Lower Bound and Upper Bound) of tensile bond strength of groups (group1, group2, group3 and group4). There was significant difference between group1 and (group3, group4) and there was no significant difference between group1 and group2 and in Fig. (3) showed the bar chart of the tensile bond strength test for the group1, group2, group3 and group4.

Further statistical analysis Showed in Table (3) the Dependent Variable (Tensile Bond Strength of groups) involved: Mean, Std. Error, Lower Bound and Upper Bound of group1, group2, group3 and group4. Appeared the mean value of tensile bond strength test were varied according to the concentration of nanofillers powder, the group2 showed the maximum mean value of upper bound of tensile bond strength which was equaled to (7.868) while the group4 recorded the minimum value of lower bound of tensile bond strength (2.524).

SEM showed the fracture site of PMMA, after adding the different concentration of ZnO nanoparticles to the PMMA to assess tensile bond strengths between acrylic teeth and denture base, the distribution of nanoparticles we can show by scanning electron microscopic and the surface morphology of specimen as seen as in Fig. (4,5 and 6).

## Discussion:

The addition of ZnO 2% to PMMA, nanoparticles enhanced the surface texture by confirm chains polymer as shown in Fig. (5). High tensile strength in group2 as shown in Fig. (3). This was attributed to the good distribution of particles that enable them to inter between liner macromolecules chains [18]. The presence of nanoparticles within acrylic resin results in increasing its density. It was found that there was an adverse relationship between the density and porosity where an increase in the density results in a decrease in porosity and lead to increase strength and rigidity of the resin, this enhanced the fractural

resistance and lead to improving tensile bond strength [19].

At the (group3 and group4) decrease in the mean values of tensile strength in comparison to the group1 as seen in Fig. (3). This reduction may result from the brittleness of ZnO nanoparticles and their inability to resist the tensile strength. It may also be due to Vander walls force of interfacial adhesion between inorganic nanofillers and PMMA matrix. These weak bonds will reduce the elastic modulus of the modified polymer at lower stresses tend to do break. The material more brittle (decease the toughness) this study agree with Thoalnorain, 2018 [20].

The Surface roughness of the acrylic denture base significantly increased with the addition of ZnO (4%, and 6%) to PMMA by weight. This may due to differences in the roughness of ZnO nanoparticles and acrylic denture base matrix and also probably attributed to the difference in the microstructural characterization of material form at particles when increased the concentration of nano roughness increased because more particles will be found on the surface of the specimen in Fig. (6)**,** which lead to increase surface roughness, increase porosity and lead to a decrease in tensile bond strength [21].

## Conclusions

1) The better result was recorded by group2 in comparison to the control group, the highest mean value was recorded by group2 (6.4093), while the lowest mean value was recorded by group4 (3.9824).
2) The group2 showed the maximum mean value of upper bound of tensile bond strength which was equaled to (7.868), while the group4 recorded the minimum value of lower bound of tensile bond strength (2.524).
3) There was significant difference between group1 and (group3, group4) and there was no significant difference between group1 and group2.

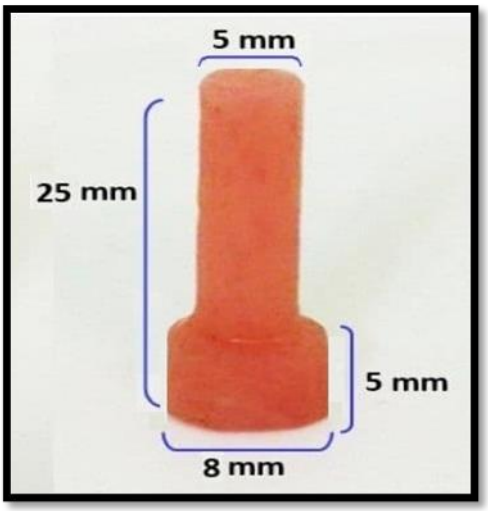


Fig. (1): The specimens shape wax pattern.

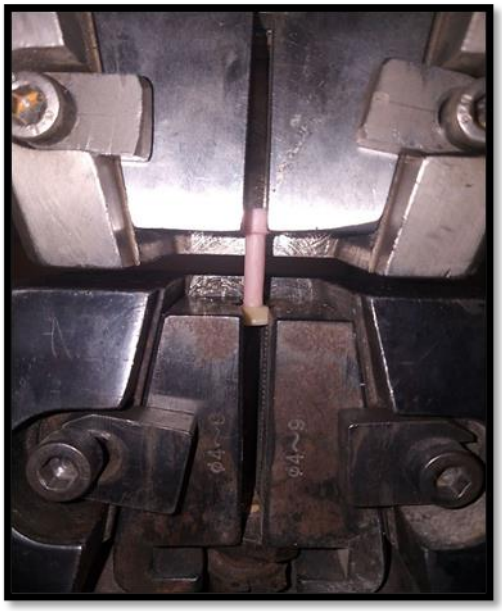

Fig. (2): The specimens inside the testing equipment.

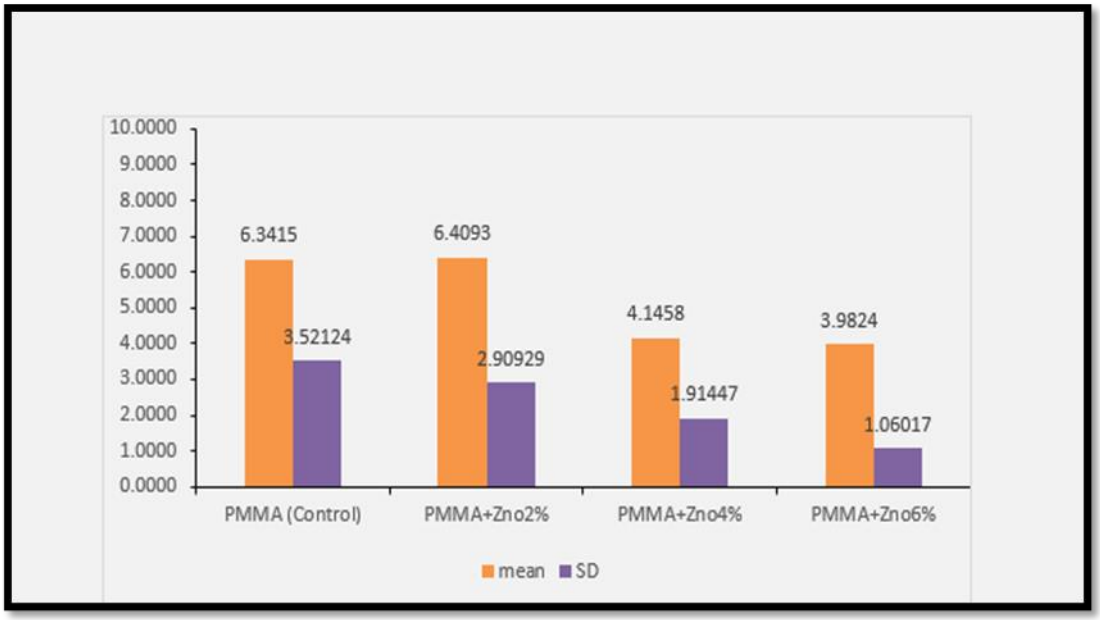


Fig. (3): The bar chart for tensile bond strength (Mpa) for PMMA+ZnO.

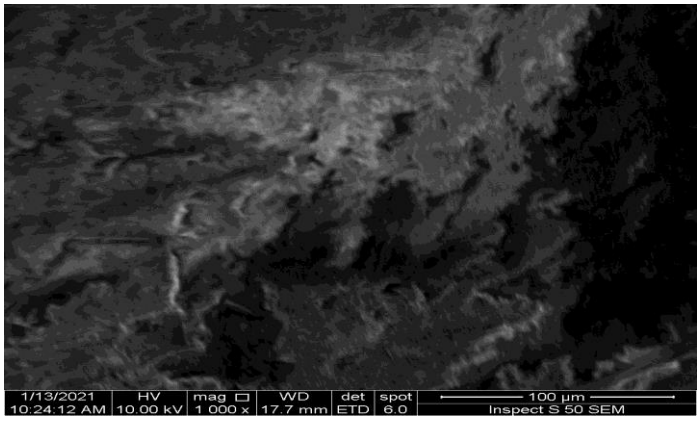


Fig. (4): SEM for PMMA control group (tensile bond strength).

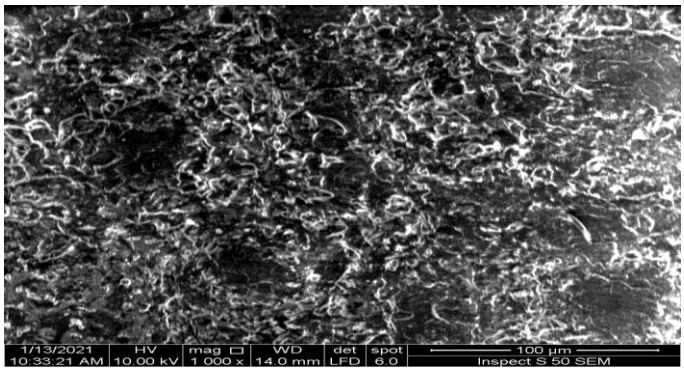


Fig. (5): SEM for PMMA+ZnO 2% (tensile bond strength).

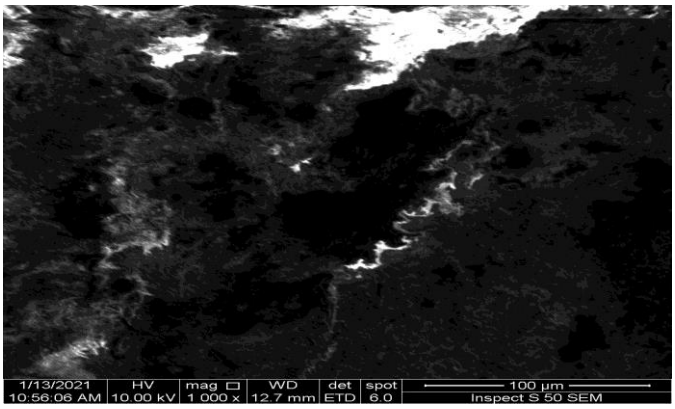


Fig. (6): SEM for PMMA+ZnO 6% (tensile bond strength).

Table (1): The descriptive Statistic for tensile bond strength.

| Descriptive Statistics<br>Dependent Variable: Tensile Bond Strength | | | |
|---|---|---|---|
| **Groups** | **N** | **Mean** | **Std. Deviation** |
| PMMA | 10 | 6.3415 | 3.52124 |
| PMMA+Zno2% | 10 | 6.4093 | 2.90929 |
| PMMA+Zno4% | 10 | 4.1458 | 1.91447 |
| PMMA+Zno6% | 10 | 3.9824 | 1.06017 |
| Total | 40 | 5.2197 | 2.35129 |

Table (2): Multiple Comparisons Tensile PMMA to PMMA+ZnO.

| Multiple Comparisons | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dependent Variable: Tensile Bond Strength LSD | | | | | | | |
| **(I) Groups** | **(J) Groups** | **Mean Difference (I-J)** | **Std. Error** | **P-Value** | **Sig.** | **95% Confidence Interval** | |
| | | | | | | **Lower Bound** | **Upper Bound** |
| PMMA control group | PMMA+ ZnO 2% | -.0678 | 1.03243 | .948 | NS | -2.1309 | 1.9953 |
| | PMMA+ ZnO 4% | 2.1957* | 1.03243 | .037 | S | .1326 | 4.2588 |
| | PMMA+ ZnO 6% | 2.3591* | 1.03243 | .026 | S | .2960 | 4.4222 |
| *. The mean difference is significant at the .05 level. | | | | | | | |

Table (3): Dependent Variable (Tensile Bond Strength of groups).

| Groups | | | | |
|---|---|---|---|---|
| **Dependent Variable: Tensile Bond Strength** | | | | |
| **Groups** | **Mean** | **Std. Error** | **95% Confidence Interval** | |
| | | | **Lower Bound** | **Upper Bound** |
| PMMA | 6.342 | .730 | 4.883 | 7.800 |
| PMMA+ZnO 2% | 6.409 | .730 | 4.950 | 7.868 |
| PMMA+ZnO 4% | 4.146 | .730 | 2.687 | 5.605 |
| PMMA+ZnO 6% | 3.982 | .730 | 2.524 | 5.441 |

## References


1- American dental association specification No. 12 (1983) for denture base polymers. Chicago. : Council on dental materials and devices.

2- Craig RG; Power JM (2002): "Restorative dental material" llthedition. ST. Louis: Mosby, p.50, 185-195.

3- Manappallil JJ. : "Basic dental material". 2ndedition, JAYPEE brothers. Medical publisher , New Delhi (2007); p 100-142

4- McCabe J.F. and Walls A.W.G.:"Applied dental material", 9th edition. Black well scientific publication, London (2008).ch.l3, p110-123

5-Rohm and Haas Innovation – Plexiglas Triumphs. Rohmhaas.com. 2010.

6- Mohamed, R., Noufal, P., Shenoy, D., Reddy, P. S., Varma, A., & Jain, A. R. (2017). A Comparitive Study on the Tensile Bond Strength of Conventional Denture Base Resin to Cross Linked Acrylic Tooth using two Different Curing Cycles–an invitro Study. Biomedical and Pharmacology Journal, 10(1), 447-454.

7-Schomover, I.C., Fischer ,T .E., Serio , A.F., and Sweeny, A.B (Bonding of plastic teeth to heat cure acrylic denture base)JAM Dent Assoc,1952,P44-285

8- Liu G, Li YF, Yan FY, Zhao ZX, Zhou LC, Xue QJ. Effect of nanoscale SiO2 and TiO2 as the fillers on the mechanical properties and aging behavior of linear low-density polyethylene/ low-density polyethylene blends. J Polym Environ 2005;13:339-48

9- Vikram, S., & Chander, N. G. (2020). Effect of zinc oxide nanoparticles on the flexural strength of polymethylmethacrylate denture base resin. European Oral Research, 54(1), 31.

10- (Corrosionpedia,2013) Definition - What does Tensile Strength mean

11-Abu- Anzeh M.L(2003):Evaluation of tensile bond strength of tooth-denture base resin as a function at different surface treatment and processing regimes .M.Sc . Thesis. College of Dentistry, University of Baghdad.

12-Al-Huwaizi, A. F. (2005). An evaluation of the effect of retention means on increasing the debonding strength of the denture acrylic teeth attached to the denture base resin. Journal of baghdad college of dentistry, 17(1), 14-17.

13- Yaseen, I. N. (2016). Effect of different surface treatments on the tensile bond strength between acrylic resin teeth and denture base material. Iraqi Dental Journal, 38(3), 142-146

14-Aljudy, H. J., Hussein, A. N., & Safi, I. N. (2013). Effect of surface treatments and thermocycling on shear bond strength of various artificial teeth with different denture base materials. Journal of baghdad college of dentistry, 25(1), 5-13

15-Alnamel, H. A., & Mudhaffer, M. (2014). The effect of Silicon di oxide Nano-Fillers reinforcement on some properties of heat cure polymethyl methacrylate denture base material. Journal of baghdad college of dentistry, 26(1), 32-36

16-Craig R.G; John M. Powers; John C.W. "dental material properties and manipulation", Eight edition, 2004, p.270-280.

17-Rashid A.A. Effect of (sio2) on the tensile bond strength between acrylic resin teeth and acrylic denture base resin .The 4th International scientific conference of midical and health specialties7-8March (2018).NO.21P:353-360

18-Alrazzaq, W. A. (2019). The impact of ZnO Fillers on the Tensile Strength of Self-Polymerizing Acrylic Resins Specific for Orthodontic Appliance. Indian Journal of Public Health Research & Development, 10(11), 4975-4978.

19- Yassin, I. N., Abdulmajeed, A. A., & Al-Shammari, F. (2016). The effect of adding micro zinc oxide filler to heat-polymerizing acrylic resin on some physical properties. Muthanna Med J, 3(2), 80-86

20- Thoalnorain A. Shakir, B.D.S.1, Shorouq M. Abass (2018). The Effect of Magnesium Oxide (MgO) NanoFillers on the Antibacterial Activity and Some Properties of Heat Cured Acrylic Resin . International Journal of Science and Research (IJSR) Paper ID: ART2018979 DOI: 10.21275/ART2018979

21-Abdul Ameer. Ali .S. “Evolution of changes in some properties of acrylic denture base material due to addition of radio-opaque fillers", M.Sc. Thesis, University of Baghdad, college of dentistry, 2006.