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Evaluation of Surface Hardness of Heat Cure Acrylic Resin Reinforce by Nano Al_2O_3 After Polishing with Different Materials

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Abstract

The goal of this research was to determine the surface hardness of heat cure acrylic resin reinforced with Nano Al2O3 after polishing with various materials. Materials and methods: - The 70 rectangular samples were made of a pink impact resistant thermoset acrylic (Vertex, Implacryl, The Netherlands) (65mm long x 10mm diameter x 3mm thick). Following polishing with each material (pumice stone, diamond suspension, colloidal silica), the surface roughness of each sample was determined using the Profilometer surface roughness instrument. The sample surface was glued to the profiler's horizontal base in a very flat position, and the stylus (the profiler's needle) was moved across each sample surface three times in three different directions over a distance of 1.7 mm. were separated into (7) groups were determined by the concentration of Nano powder, Group (A) Control without adding Nano filler of (Al_2O_3) (10) specimens, Group (B) Polishing with pumice Al_2O_3 (1%) (10) specimens, Group (C) Polishing with pumice Al_2O_3 (1.5 %) (10) specimens, Group (D) Polishing with Colloidal Al_2O_3 (1%) (10) specimens, Group (E) Polishing with Colloidal Al_2O_3 (1.5%) (10) specimens, Group (F) Polishing with Diamond Al_2O_3 (1%) (10) specimens, and Group (G) Polishing with Diamond Al_2O_3 (1.5%) (10) specimens. Data were statistically analyzed using statistical package for social science (SPSS), and the (ANOVA) test is used to determine whether the statistical hypothesis is true. Results: - For the hardness readings the higher mean value of hardness test found in group(D) (1%) polished by colloidal silica (82.74), then group (F)(1.5%)polished by colloidal(82.18), then group (F)(1%)polished by diamond(81.12), then group(G)(1.5%)polished by diamond(80.62),then group(C)(1.5%)polished with pumice(80.34),then group(B)(1%) polished with pumice(80.2),then at least group (A)control(80.18). Each of the three groups had a statistically significant difference with Highly sign. ($P<0.01$). Conclusions: -Specimens of acrylic reinforcement with adding 1.5% of Nano AL_2O_3 and polished with (colloidal silica, diamond suspension, and pumice, respectively) sequentially showed highly surface hardness then followed group (1%) low surface hardness then group control.

Introduction:

Because of its superior mechanical and physical properties, compatibility with oral tissue, aesthetics, ease of repair, and low cost, polymethyl methacrylate (PMMA) acrylic resin has been the most often used denture base material. However, this resin has a few but significant drawbacks, including poor strength, particularly when fatigue failure occurs inside the mouth, a high coefficient of thermal expansion, which causes internal stresses to be released during processing, resulting in dimensional inaccuracy, and some problems, such as denture fracture and denture tooth wear. Nevertheless, PMMA has a low thermal conductivity as compared to gold or cobalt alloy denture base material, which might pose issues during denture fabrication since heat produced cannot escape, producing a temperature rise and perhaps porosity.(1). Lately, there has been a lot of interest in incorporating inorganic nanoparticles into PMMA in order to improve its mechanical and physical qualities(2). The use of alumina or aluminum oxide (Al2O3) in different dental materials has been examined and shown to be biocompatible while also increasing mechanical qualities. Additionally, the Al2O3's white tint is not expected to interfere with cosmetic aspects. Nevertheless, reinforcement methods should not have a negative influence on the mechanical qualities of denture materials.(3, 4). Hardness is a measure of a substance's resistance to plastic deformation, and it is generally tested using an indentation charge. The current study revealed that a rise in reinforced PMMA hardness was related to the quantity of filler loading in the polymer matrix, as well as the dispersion uniformity of hard and stiff Nano Aluminum inside the material. An increase in cross-linking density might also explain the increase in nanocomposite hardness, which makes the polymer stiffer and more resistant to penetration.(5). Friction and wear materials are a beneficial area of material development. It is crucial because wear and other friction phenomena can result in large operational losses over time. Materials have the potential to minimize energy and wear losses directly. Nevertheless, abrasion resistance is especially important in long-term usage in polluted locations.(6). Hardness measurement is the most often used approach for managing the mechanical characteristics of materials. Hardness is not a single value, but rather a complicated characteristic connected with the major mechanical properties of materials, depending on the test techniques. The static hardness values are functionally connected to the average contact pressure beneath the indenter p, which is calculated by the ratio of the applied load to the predicted area of contact of the indenter with the test surface. Stationary laboratory testers are commonly used to evaluate hardness levels on static scales. When checking big components or equipment elements, special samples must be cut, resulting in integrity damage, which is usually difficult or impractical. Weld and wall quality control and inspection(7). The goal of this study was to investigate the surface hardness of heat-cured acrylic resin supplemented with Nano Al2O3 fillers after polishing with different abrasives.

Materials and Methods:

Grouping of samples: -

Seventy specimens made from pink high impact heat-cure acrylic resin (Vertex, Implacryl, Netherlands) were separated into seven groups as following:

1- Group (A): Control without adding Nano filler (10) specimens

2-Group (B) Polishing with pumice and adding Al_2O_3 (1 %) (10) specimens

3- Group (C) Polishing with pumice and adding Al_2O_3 (1.5 %) (10) specimens

4- Group (D) Polishing with Colloidal and adding Al_2O_3 (1%) (10) specimens

5-Group (E) Polishing with Colloidal and adding Al_2O_3 (1.5%) (10) specimens

6-Group (F) Polishing with Diamond and adding Al_2O_3 (1%) (10) specimens

7-Group(G) Polishing with Diamond and adding Al_2O_3 (1.5%) (10) specimens.

Specimen description: -
The hardness test was done at room temperature using the Dorumeter 3120 hardness test apparatus, type (Shore D), produced in Germany, after polishing with each substance (pumice, diamond suspension, and colloidal silica) (ASTM D2240). The imposed load was approximately precisely (5Kg). The depressing measurement time was approximately identical to the (10sec). All of the specimens were the same size (65 mm length x 10 mm diameter x 3 mm thickness)(8).

Designing of specimens

The prepared samples were rectangular in shape and had dimensions (65 mm length x 10 mm diameter x 3 mm thickness)(8). They were made of plastic, and a plastic pattern (solid plastic block) was developed in AutoCAD 2015 (Autodesk) and processed for 10 minutes on a computer numerical control machine. (9, 10).Can showed in Fig. (1).

Specimen fabrication

Fill the bottom half of the with stones (type 4) (100 g/25 ml) (p/w), then set the plastic model on top. There was a collection of stones. Apply the releasing agent using a large brush. When the release medium has dried, stack the top and bottom parts of the flask and add a second layer of stamps on top of the first layer until the top half of the flask is entirely covered with stamps, with the clamps open after setting. A cloth should be used to cover the flask. Remove the plastic design and stamp the plungers' second layer. The mold is then finished and ready for packaging.

Addition of Nano-filler
The addition of Nano-filler powder was done by weight in two groups, the addition includes 1%, and 1.5% to powder(11), sensitive balance high accuracy (±0.0000g, Mettle Type AE260-S SNR H50193) was used as seen in Fig. (2), the filler well dispersed in the powder by amalgamator device company (sinalident) made in china using (300vibration/minute) for two minute**s** as seen in Fig. (3) to had homogeneous mixing. To decrease the likelihood of particle agglomeration, Nano-filled powder solutions were immediately combined with acrylic powders.

Mixing ratio
Table(1) shows the percentages and amounts of polymers, monomers, and Nano filler materials used in the study(11).

Packing of acrylic resin
The acrylic resin packing process began when the acrylic reached the dough stage. Before placing the molds, the resin was withdrawn from the Jar and rolled. After making metal-on-metal contact, the flask's two sides were closed under pressure (hydraulic press) for 5 minutes. The clamping and transport to the water bath follows. (12, 13).

Curing
This was achieved by submerging the clamped flask in a water bath and heating it for 90 minutes at 20 C-70 C and 30 minutes at 100 C. Before deflasking and extracting the acrylic specimens from the die stone molds, the metal flask was allowed to cool in the water bath to room temperature.(14, 15).

Finishing and polishing
To get a smooth surface, always use (120) grain sandpaper for touch-ups (soaking the rubber tube in cold water). The procedure for polishing. An example test was created using a gear lathe. The distance between the sample and the brush was limited to a minimum of 1-2 mm. The dental lathe speed was tuned to a comfortable relatively low speed by polishing with a bristle brush (Vertex) containing pumice, diamond slurry, and colloidal silica (1425 rpm). The sample was polished using 50ml of pumice stone (50g x 100ml), diamond, and colloidal silica, and the polishing period was 2 minutes.)(16).

Hardness test
Hardness is a characteristic of solid materials that may be described as the surface resistance to penetration, wear, and scratching. The hardness value may be utilized to anticipate dental material

strength, structural coherence, and wear resistance. Temperature, intermolecular connections, structure such as crosslinks in chains, particle volume fraction reinforcement, and particle size all have an impact on hardness tests. (17)**.** The hardness test was carried out at room temperature using the Dorumeter 3120 hardness test apparatus, type (Shore D), made in Germany, in accordance with (ASTM D2240), as shown in fig (4). The applied load was nearly accurate (5Kg). The depressing measurement time was almost same to the (10sec). All of the specimens have measurements (65 mm length x 10 mm diameter x 3 mm thickness)(17).

Results

Statistical package of social science (SPSS) software version (70 samples) was utilized to analyze this study. Also, Microsoft excel 2016 was used for graphics presentation.

Table (2) Descriptive statistics of hardness of all groups. For seven groups of 70 specimens showed the higher mean value of hardness test found in group(D) (1%) polished by colloidal silica (82.74), then group (F) (1.5%)polished by colloidal (82.18), then group (F)(1%)polished by diamond(81.12),then group(G)(1.5%)polished by diamond(80.62),then group(C)(1.5%)polished with pumice(80.34),then group(B)(1%) polished with pumice(80.2),then at least group (A)control(80.18). There was a statistically significant difference between each three groups with Highly sign. (P<0.01). Table (3) and Fig. (5) LSD test (P-value) Levene's test for homogeneity showed highly statistically significant difference between the variances of the groups for roughness with P-value P<0.01)**.**

Discussion:

Hardness is a term used to describe a material's resistance to indentation, as well as its resistance to wear and scratching, and it is one of the physical properties of dental materials chosen for this study because wear during function or cleaning as wear due to surface abrasion is a major factor that affects the dental prosthesis. As a result, germs thrive on the microporous surface of an acrylic denture, putting the patient's health at risk.(18). The Shore D hardness of all groups materials was examined in the current study, which employed seven groups of acrylic (six groups blended with Nano Aluminum oxide in percentages (1% and 1.5%) and a control group pure acrylic without additives). The current study's findings revealed a highly significant difference in surface hardness between seven groups P = 0.00 Extremely sign. (P<0.01). This finding might be related to the fact that they used a different amount of alumina powder; as the percentage of alumina powder increases, so does the surface hardness. The hardness rose according to the weight % of the Al2O3 filler, we observed. The hardness rose dramatically after introducing 1% and 1.5% wt.% Al2O3. This finding supports earlier studies.(19, 20), It was discovered that incorporating ceramic particles into dental restorative resins and acrylic resin might boost surface hardness. This increase in hardness might be due to the intrinsic properties of Al2O3particles. Al2O3 possesses strong ionic interatomic bonding, which contributes to its favorable hardness and strength qualities. (21). The effect of a 2% filler of nanoparticles combined at a ratio of (2%Al2O3) by weight on the hardness, roughness, and denture base adaption of heat-cured acrylic resin was studied.(12). Another research (Abdulhamed et al.,) revealed that a particular addition of alumina reduces both the tensile and impact strength of PMMA while increasing its hardness. (21).

Conclusion:

According to the findings of this study, it can be inferred that a low proportion of aluminum oxide had an influence on the surface hardness of heat cure acrylic resin, and polishing materials increased surface hardness.

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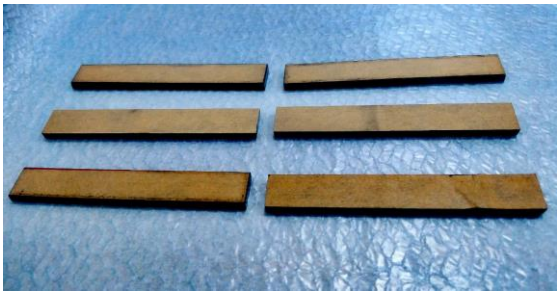

Fig. (1) Plastic specimens used in this study for preparation of molds.

Fig. (2) Sensitive balance high accuracy.

Fig. (3) Amalgamator device.

Fig. (4) Dorumeter 3120 hardness test device, type (Shore D)

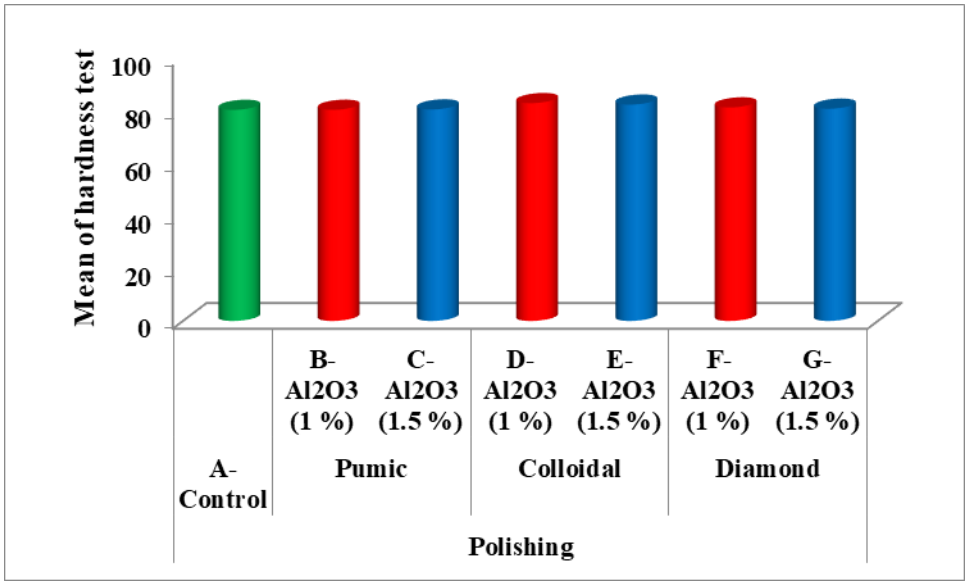

Fig. (5) Bar-chart showing the mean distribution of the surface hardness test in (µm) of the tested groups.

Table (1): The weight percentages (wt.%) and amounts of polymer (powder), monomer, and Nano filler of Al_2O_3 material used in this study(11).

Amount of polymer	Amount of monomer	Al_2O_3 wt.% percentage	Amount of Al_2O_3
21.000g	10ml	0%	0
20.790g	10ml	1%	0.210 wt.%
20.685g	10ml	1.5%	0.3150wt.%

Table (2): Descriptive Statistics of hardness of all groups with means in micrometer (µm).

Hardness								
Polishing	Studied groups	N	Mean	Std. Deviation	Std. Error	Range		ANOVA test (P-value)
						Mini.	Maxi.	
A- Control		10	80.18	0.457	0.144	79.2	80.8	P = 0.00 Highly sign. (P<0.01)
Pumice	B- Al_2o_3 (1 %)	10	80.2	0.566	0.179	79.4	81.2	
	C- Al_2O_3 (1.5 %)	10	80.34	0.597	0.189	79.8	81.6	
Colloidal	D- Al_2O_3 (1 %)	10	82.74	1.170	0.370	81	84	
	E- Al_2O_3 (1.5 %)	10	82.18	0.751	0.238	81	83.4	
Diamond	F- Al_2O_3 (1 %)	10	81.12	1.059	0.335	79.6	82.8	
	G- Al_2O_3 (1.5 %)	10	80.62	0.663	0.209	79.6	81.6	
Total		70						

*P<0.001 High significant

Table (3): LSD test of all tested groups.

Studied groups (Hardness)		LSD test (P-value)
A Control	B 1 % Al_2o_3 (Pumice)	P = 0.955 Non sign. (P>0.05)
	C 1.5 % Al_2o_3 (Pumice)	P = 0.653 Non sign. (P>0.05)
	D 1 % Al2o3 (Colloidal)	P = 0.00 Highly sign. (P<0.01)
	E 1.5 % Al_2o_3 (Colloidal)	P = 0.00 Highly sign. (P<0.01)
	F 1 % Al_2o_3 (Diamond)	P = 0.009 Highly sign. (P<0.01)
	G 1.5 % Al_2o_3 (Diamond)	P = 0.218 Non sign. (P>0.05)
B 1 % Al2o3 (Pumice)	C 1.5 % Al_2o_3 (Pumice)	P = 0.694 Non sign. (P>0.05)
	D 1 % Al_2o_3 (Colloidal)	P = 0.00 Highly sign. (P<0.01)
	F 1 % Al_2o_3 (Diamond)	P = 0.012 sign. (P<0.05)
C 1.5 % Al2o3 (Pumice)	E 1.5 % Al_2o_3 (Colloidal)	P = 0.00 Highly sign. (P<0.01)
	G 1.5 % Al_2o_3 (Diamond)	P = 0.432 Non sign. (P>0.05)
D 1 % Al2o3 (Colloidal)	E 1.5 % Al_2o_3 (Colloidal)	P = 0.118 Non sign. (P>0.05)
	F 1 % Al_2o_3 (Diamond)	P = 0.00 Highly sign. (P<0.01)
E 1.5 % Al2o3 (Colloidal)	G 1.5 % Al_2o_3 (Diamond)	P = 0.00 Highly sign. (P<0.01)
F 1 % Al2o3 (Diamond)	G 1.5 % Al_2o_3 (Diamond)	P = 0.162 Non sign. (P>0.05)

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