Effects of aluminum oxide addition on the surface roughness and hardness of acrylic resin denture base

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Key words
Acrylic resin denture base, Aluminum oxide, surface roughness, surface hardness.
.

Abstract

Problem: Acrylic dentures frequently fracture during service due to their poor strength characteristic. Several attempts have been carried out to improve strength of acrylic by addition some materials such as fibers or Aluminum oxide. The purpose of this study was to evaluate the effect of adding Aluminum oxide (AL2O3) on the surface roughness and hardness of heat cure acrylic resin denture base material.

Materials and Methods: 60 specimens were made from the heat cure acrylic resin denture base after being cured in microwave oven, 30 specimens prepared for surface roughness test and these where subdivided according to concentration of AL2O3 into three subgroups as follow:

Group (A): 10 specimens of acrylic resin without AL2O3 (control group)
Group (B): 10 specimens of acrylic resin+2.5% by weight AL2O3
Group (C): 10 specimens of acrylic resin +5% by weight AL2O3

30 specimens prepared for surface hardness test and these where subdivided according to concentration of AL2O3 into three subgroups as follow:

Group (A): 10 specimens of acrylic resin without AL2O3 (control group)
Group (B): 10 specimens of acrylic resin+2.5% by weight AL2O3
Group (C): 10 specimens of acrylic resin +5% by weight AL2O3

The average of the surface roughness of the samples has been determined with using the profilometer (surface roughness tester), also the average of the surface hardness of the samples has been determined with using surface hardness tester (digital micro Vickers).

Result: The results showed that there were no statistically significant differences in the surface roughness and hardness.

Conclusion: The addition of aluminum oxide in low percentage not affected on the surface roughness and hardness of heat cure acrylic resin.

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Introduction

One of the most widely used materials in prosthetic dentistry is polymethyl methacrylate (PMMA). Since its introduction to dentistry, it has been successfully used for denture bases because of its ease of processing, low cost, light weight, and color-matching ability. However, acrylic resin denture base materials have poor strength, including low impact strength and low fatigue resistance. (1, 2) .Many attempts have been made to enhance the strength of acrylic denture bases including the addition of metal wires and cast metal plates. Although metal plates increase the strength, they may be expensive and prone to corrosion (3). Modifications of the chemical structure, by adding cross linking agents or copolymerization with rubber, result in significant increases in impact strength. However, stiffness, fatigue resistance, and transverse strength are reduced (4). Mechanical reinforcement of acrylics has also been attempted through the inclusion of fibers and metal inserts (5). The incorporation of Aluminum oxide in various dental materials has been studied and found to be biocompatible, and it also improves mechanical properties (6). In addition, the white color of the Aluminum oxide is not expected to compromise aesthetic appearances (7). However, reinforcement methods should not have adverse effects on the mechanical properties of denture materials (8). The roughness of acrylic resin surfaces is a critical property because surface irregularities increase the likelihood of microorganisms remaining on the denture surface after the prosthesis is cleaned (9). Another property that can influence the surface characteristics of acrylic resins is the hardness, which indicates the ease of finishing a material and its resistance to in-service scratching during cleaning procedures (10). Some authors have been investigated the effect of AL2O3 powder on the mechanical properties of a conventional heat-cured acrylic resin (11). In this study we evaluated the effects of AL2O3 in different concentrations on the surface roughness and hardness of a conventional heat-cured acrylic resin.

Material and Methods

60 specimens were prepared from heat cure acrylic resin (Rodex-Turkey). Specimens were grouped into30 specimens made for surface roughness test and 30 specimens made for surface hardness test and these sub grouped according to the concentration of aluminum oxide (Johnson chemicals, England).

For Preparation of acrylic resin specimens' two different metal patterns were constructed by cutting stainless steel plate into desired shape and dimension using turning machine:

A- Surface roughness test with dimension of (80mm x10mm x2.5-3mm) length, width and thickness respectively (12).Figure (1).

B- Surface hardness test with dimension of (60 mmx10 mm x2.5.3mm) length, width and thickness respectively (ADA No.12.1999) (13).Figure (2).

The fiber reinforce plastic flask technique was used during the mould preparation. The lower portion of the flask was filled with dental stone and mixed according to approximately the manufacturer's instruction. The metal pattern were inserted to approximate one half of their depth, after the stone sets, it was coated with separating medium and allowed to dry .Then the upper half of the flask was filled with stone and vibrated to prevent air entrapped. After setting of the stone the metal patterns were removed from the mould carefully and the two portions of the flask were coated with separating medium (cold mold seal) to be ready for packing with acrylic dough. The proportion for mixing of acrylic resin (Rodex-Turkey) was 2.5-1 by weigh (P/L) the mixing and manipulation was according to manufacturer's instructions ,mixing was carried out in a clean dry jar with mixing spatula, and the mixture was then covered and left to stand until a dough stage was reached (11). Two percentage of AL2O3 (Johnson chemicals, England) was selected in this study (2.5% and 5%), the required weight of the powder of the polymer and AL2O3 was weighted by the electronic balance for each group as shown in table (1).

The diameter or the particle size of AL2O3 was determine by the use of microscope at the university of technology department of Applied sciences .The diameter was obtained by dividing the diameter of the particle at the screen to the percentage of magnification. This was below 30 µm , and the practical size of the PMMA was also be determined by the same way it was below 50µm , then mixing of polymer and AL2O3 powder was done by mortar and pestle until a homogenous color was attained within approximately 5 minutes (14).

Packing was started when the acrylic reached to dough stage. The resin removed from the jar and rolled, then packed into the mold previously coated with separating medium with the aid of the polyether sheets. The two portions of the flask were closed together and placed under the hydraulic press(85-90 bar for 1minute), and the pressure was slowly applied on the flask so that the dough evenly flow throughout the mould space, the pressure was released , the flask was opened and the excess material was removed by sharp scalpel. A second trail closure was performed and the poly ethylene sheet was removed, finally the two portions of the flask were closed in an intimate contact obtained, and left under press for 5 minute then transferred to the microwave, this was done by placing the fiber reinforce plastic flask in the microwave as shown in figure (3) and processed by heating at 5000C for about 3 minutes. The flask was allowed to cool at room temperature for one day for complete cooling and for prevent shrinkage .Then deflasking and removing all the acrylic specimens from the stone mould, figure (4).

The acrylic plate was removed from the flask and hand finished using progressively finer grades of silicon carbide paper (grades 120 to 40µm) with continuous draining water. Acrylic plates of surface roughness was cut into equal square plates with an acrylic separating disk to obtain the final measurement of 10x10x2.5 mm length, width & thickness) the thickness of 2.5mm represent the average thickness of acrylic denture base. While the length and width coincides for suitable measurement in the surface roughness tester (12). All specimens were finished and polished by using bristle brush and pumice with lathe polishing machine. The specimens were conditioned in distilled water at 37Cº for 7 days before they were tested according to ADA specification NO.12 (1999) (13).

The specimens were analyzed by using surface roughness tester (Held roughness tester, Germany) for determine & held recording surface roughness as shown in figure (5).The sample surface was fixed in a very flat position top the horizontal base of the profilometer and the stylus (Profile meters needle) was moved across the sample surface three time in three direction for a distances of (1.7 millimeter). According to the apparatus design .The data was collected and obtain from the screen part of the profilometer which was subjected to statistical analysis.

Digital micro hardness tester device (Vickers, Germany) was used in this study for measuring procedure (figure6) .The test was set to50 N for digital micro hardness tester H.V., this is suitable for acrylic resin material. The contact surface of the digital micro hardness tester must be parallel to the specimen’s support of the stand to prevent errors in measurement. The distance between the specimen's surface and the indenter of the hardness tester was set to be 5-12 mm during carrying out the test. The contact period between the specimens and the indenter was six seconds. After that the measurement were taken directly for the scale, three reading were done on different areas of each specimen and the mean of the three reading was calculated.

Results

The mean of surface roughness for each group is listed in table (2) the mean of surface roughness for group A (control group) was 1.6212 µm and for group B was (1.1962 µm) while the mean of surface roughness of group C was (1.0532 μm). Also table (2) show the ANOVA test for surface roughness for all tested groups and it was found that there is a non significant difference among tested groups at ($P>0.05$) .

The mean of surface hardness for each group is listed in table (3). The mean of surface hardness for group A (control group) was (4.311) and for group B was (4.408) while the mean of surface hardness of group C was (4.237), also table (3) show the ANOVA test for surface hardness for all tested groups and it was found that there is a non significant difference among tested groups at ($P>0.05$).

Discussion:

In the present study some properties of acrylic denture base material were evaluated after the addition of aluminum oxide powder with two different percentages. Al_2O_3 powder was used because it's a well-known biocompatible material, also because of being white less likely to alter esthetic, and have good thermal conductivity (30 W/m.c0); from the patient point of view the problem with a low coefficient of thermal conductivity is that the denture isolated the oral soft tissue from any sensation of temperature this can lead to a patient consuming a drink that is far too hot without realizing it, which may lead to the back of the throat and possibly even the esophagus being scalded (15) .This material is inexpensive, abundant and light .Particle size of the powder was less than 30 μm so that samples could be finished by conventional means also this size matched the particle size of the matrix (16, 17).

Surface roughness test:

In the present study profilometer device was used to estimate the effect of adding Al_2O_3 on surface geometry of the specimens because this device appear to be excellent device to evaluate surface roughness by giving quantitative measurement that can be evaluated and compared statistically. Increase surface roughness has a detrimental effect on the aesthetic of the denture, also smooth surface of acrylic resin help resist the buildup of stain, debris and plaque. Table (2) show that surface roughness of acrylic denture base was not significantly increased with the addition of Al_2O_3 with percentages 2.5% and 5 % by weight, and this could be explained on the bases that when small percentages of alumina were added to acrylic resin only few particles will be involved with the surface of the specimen and as the percentage increased up to 10% more particles will be found on the surface of the specimen which lead to increase in surface roughness. The results of this study agree with the result obtained by Abdul Ameer 2006 (14) and Ali 2011 (18), and disagree with Mahroo et al.2012 (11). This could be due to difference in roughness of alumina particle and acrylic denture base matrix and also probably attributed to the difference in micro structural characteristics of the materials and the form of the particles.

Surface hardness test:

Hardness is a term used to describe the resistance of the material to indentation and also it's a measure of the resistance to wear or scratching .In this study Digital micro hardness tester device was used which is suitable for acrylic resin material (19) Statistical analysis of the results showed a non significant difference in surface hardness among groups. This may be attributed to the undistributed particle of Alumina into acrylic matrix and also may be due to the percentage of alumina powder as the percentage of alumina powder increases, surface hardness may be increases.

The result of this study agrees with abdul-Ameer 2006 (14). And disagree with Ali 2011 (18) and Al Momen 2002 (20).This could be due to difference in the types of acrylic material and difference in the percentage of Aluminum oxide used; increase percentage may provide resistance to the indenter of the device and increase surface hardness.

Conclusion

According to the result obtained in this study, it may be concluded that the addition of aluminum oxide in low percentage not effected on the surface roughness and hardness of heat cure acrylic resin

Table (1): Percentage and mount of polymer and aluminum oxide used in this study

Studied groups	**Amount of polymer**	**A mount of alumina**
Group A	**100 g**	**----**
Group B	**97.5 g**	**2.5g**
Group C	**95g**	**5g**

Table (2): Descriptive statistics & ANOVA test for surface roughness of studied group

Studied group	**Mean(μm)**	**SD**	**SE**	**min**	**Max**	**ANOVA**
Group A (control group)	**1.6212**	**0.735**	**0.232**	**0.544**	**2.596**	**F-test=2.556**
Group B (2.5% by weight AL2O3)	**1.1962**	**0.599**	**0.189**	**0.246**	**2.006**	**Non Significant**
Group C (5% by weight AL2O3)	**1.0532**	**0.638**	**0.201**	**0.132**	**1.916**	**Non Significant**

Table (3): Descriptive statistics & ANOVA test for surface hardness of studied group

Studied group	**Mean**	**SD**	**SE**	**min**	**Max**	**ANOVA**
Group A (control group)	**4.311**	**0.129**	**0.041**	**4.15**	**4.57**	**F=0.169**
Group B (2.5% by weight AL2O3)	**4.48**	**0.045**	**0.014**	**4.34**	**4.47**	**Non-Significant**
Group C (5% by weight AL2O3)	**4.237**	**0.060**	**0.019**	**4.18**	**4.33**	**Non-Significant**

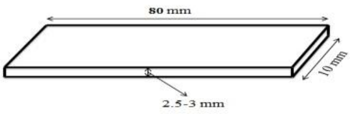

Figure (1): surface roughness test

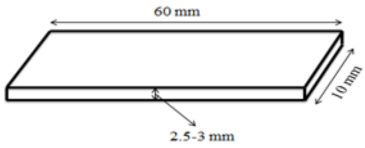

Figure (2): surface hardness test

Figure (3): microwave oven

Figure (4): Acrylic resin specimens after removal from the microwave oven

Figure (5): Surface roughness tester device

Figure(6): Digital micro hardness tester device

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