



The Effect of Polishing Techniques on Surface Roughness of Two Different Denture Base Materials

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Abstract

Background: Regarding acrylic resin, a direct link was found between surface roughness, plaque buildup, and microbial adhesion. However, the current polyamide material's surface characteristics are still debatable, especially after utilizing conventional polishing and finishing techniques. Heat curing acrylic resin makes it easy to evaluate the surface characteristics of each material and to follow advice for the best practices.

Objectives: The aim of the current study is to evaluate and compare the surface Roughness of heat cure acrylic resin and flexible acrylic resin materials before and after different surface treatments.

Material and Method: A total of (80) sample were prepared. These samples were divided into two main groups (made from heat cure acrylic resin and flexible acrylic resin). Each group contains (40) samples and were divided into four additional groups according to the surface's polishing treatment. Each group of material have (10) specimens, the first group was polished with pumice, the second groups were polished with pumice and then glazed, the third group was polished with investment (Phosphate bonded investments) and then glazed, and the fourth group was glazed. A digital surface roughness tester meter (TR: 220) device was used to indicate the values of the roughness of specimens before and after surface polishing treatment.

Results: The result of surface roughness of heat cure acrylic resin using t-test analysis revealed that a significance difference among all the study groups ($p < 0.05$). The result of surface roughness of flexible acrylic resin using t-test analysis revealed that a significance difference was reported between all the study groups ($p < 0.05$).

Conclusion: It was concluded the surfaces roughness was decreased in the control group of (heat cure acrylic resin and flexible acrylic resin materials) when polished with pumice, while it was increased in the experimental groups after polished with glaze material. Compared to pumice and burning investment materials, the polishing material (light cure glaze) is noticeably rougher.

Keywords: Surface Roughness; PMMA; Polyamide; Finishing; Polishing

INTRODUCTION

"Poly methyl methacrylate (PMMA)" resin has been commonly used as a denture base material due to its necessary features of stellar aesthetic characteristic, enough force, low toxicity, lower water sorption and solubility, easy processing techniques and ease to repair. However, it has some drawbacks such as low impact strength, weak flexural, lower resistance to fatigue and polymerization shrinkage⁽¹⁾.

"Poly methyl methacrylate" was first used as a denture base material in 1937, according to the topic of the history of denture base materials⁽²⁾. "Poly methyl methacrylate" has desirable physical properties such as being readily available, inexpensive, and easily manipulated, consistency, tissues irritations and toxicity, teeth adhesion, insolvability in body fluid, Dimensional constancy, biocompatibility, lack of flavor and odor⁽³⁾.

Flexible acrylic resins (i.e., polyamides or nylons) became a common exchange to Poly methyl meth PMMA-based materials are widely employed as biomaterials due to their relative simplicity of manipulation, attractive appearance, and color stability. acrylate resin because of their appropriate chemical and physical properties⁽⁴⁾. Such materials are biocompatible and have singular aesthetic and physical properties that offer indefinite design versatility and eliminate the concern concerning acrylic allergies⁽⁵⁾. Flexible denture base materials are nylon-based (polyamide). This material does not bond chemically with any porcelain / acrylic teeth. Therefore, the only technique used in the polyamide denture base materials is mechanic bonding⁽⁶⁾.

The surfaces roughness of denture base material is one of the contributing factors influencing dental prosthesis durability⁽⁷⁾. The roughness of the surfaces and degradation of the acrylic appliances make a major contribution to microorganism adherence, bonding and colonization⁽⁸⁾.

Polishing is the method of making the denture surfaces soft and glossy without causing main alterations to the contour. A roughness of 0.2 μ m is considered the threshold value for polish. However, the surface roughness of polyamide and Poly methyl methacrylate (PMMA) resin is well within the accepted standard of 0.2 μ m Ra⁽⁹⁾. If the roughness is greater than 0.2 μ m Ra, the denture surfaces can attract plaque and germs. It is the dentist's duty to leave a polished surface on dentures and other acrylic applications⁽¹⁰⁾. The purpose of this study was to assess how different polishing methods affected the surface roughness of two different denture base materials.

Materials And Methods

Materials of study

Heat cure acrylic resin, Flexible acrylic resins, Separating Agent, Hard die stone type 4, Sandpaper 320 grain, Light cure glaze, Pumice Fine-Grained 150um, burning investment Fine-Grained 150um, Sprue wax, Vaseline and Normal Saline as shown in Figure 1.

Grouping of the specimens

A total of 80 specimens were prepared. All specimens were measured for accurate dimensions (30 mm x 2 mm) by using an electronic digital calliper. Eighty specimens in total were separated into two groups, each group including forty samples, and each group was further subdivided into four groups, each containing ten samples.

1-The first group was polished with pumice.

2-The second group was polished with pumice and then glazed.

3-The third group was polished with burning investment and then glaze.

4-The fourth group was finished and glazed without adding any polishing material.

The specimens with dimension

For this study, a Plastic patterns mold was prepared with a circular form of 30 mm

diameter x 2 mm thickness for the fabrication of acrylic disc specimens. Specimens were prepared according to the ADA⁽¹¹⁾. A Plastic pattern is designed using Auto CAD 2013 and processed using a computer numerical control machine⁽¹²⁾. For surface roughness as shown in Figure 2.

Mold preparation

After the Plastic patterns were fabricated, the mold was constructed⁽¹³⁾ by combining dental hard die stone in the amount recommended by the manufacturer (water/powder (w/p) ratio: 25ml/100g). Plastic patterns were embedded in the hard die stone that filled the lower portion of the dental flask, which was filled with die stone. Both the plastic design and the dental hard die stone were painted with a separating medium before being set. The flask's upper portion was fixed to its lower portions, which contained die stone. As indicated in Figure 3, the plastic designs were removed from the molds after the type four die stone was set and the flask was unlocked.

Group one: Heat-cured PMMA specimens

The mixing of die stone was made according to manufacturer instructions (P/L ratio 3g powder/1 ml liquid). The liquids of die stone were placed in a clean and dry mixing glass jar followed by slow adding of powder. The mixture was then stirred with a wax knife for 45 seconds which was tightly closed to avoid monomer evaporation and left to stand at room temperature until reaching the dough stage (ADA specification No. 12 for denture base resins, 1972). The acrylic resin packed was started when the acrylic reached to dough stage, the resins was detached from the jar and rolled, then located inside the molds. The two halves of the flask were finally closed under pressure (hydraulic press) until metal-to-metal contact had been established and left under press 20 bar for 5 min⁽¹⁴⁾. This was done by insertion the clamped flask in a digital water bath as seen in (Figure 4) and processed by heating at 74°C for about one hour and a half and the

temperature then elevated to boiling point for 30 minutes. The metal flask was allowable to cool down at room temperature in the water bath then deflasking and removing the acrylic specimens from the die stone molds. Specimens were finished due to the methods suggested by⁽¹⁵⁾. Use an acrylic bur for two minutes at a low speed, followed by a tungsten carbide bur for two minutes, and then 320-grit sandpaper for one minute. Actions on the sandpaper were randomly directed. To ensure parallel cutting or grinding of the bur to the surface of the samples (to reduce irregularities and equalize the pressure), all of the burs used for finishing procedures were cylindrical in shape⁽¹⁶⁾.

Group two: Flexible acrylic resin (VALPLAST) specimens

After the Plastic patterns were fabricated, the stone slurry was prepared and poured in the poorer half of the special flask designed for the injection molding technique. Before the stone was hardened, the Plastic disc was positioned above the stone surface, where the Plastic disc level would be with the level of the stone surface. When the stone started to set, the sprue formers were used to create a path for resin to flow into the mold. A separating medium was used to lubricate the stone's surface. The upper part of the special flask was then placed over the lower half, and another mixture was added to the flask. After removing the entire set of tooth stones, the wax was removed by submerging the flask for five minutes in hot water to dissolve the wax. The flask was opened and cleaned with fresh, hot water to get rid of any leftover wax. The flask was opened, and the model was given a thin layer of separating media that was applied and allowed to completely dry.⁽¹⁷⁾ cartridges of suitable size were chosen and spray (wax surface reducing agent) was applied to the cartridge, the cartridge carrier was then placed in a plastic injection machine which is used for softening the flexible material (VALPLAST) at a temperature of 287°C for 20 minutes

(according to manufacturer instructions) in (Figure 5). The sprue former is cut with a special category of disk and hand-finished using progressively finer degrees of silicon carbide paper (degrees 320 μ m) with continuous draining water for one minute.

Preparation Burning Investment

After the crown and bridge casting process in a dental lab was finished, the investment material was obtained. As instructed by the manufacturer, the investment material was blended. The investment material was burned in this study at 950°C. After burning the investment, it was crushed with a hand hammer and ground using a (Retch. PM 100) device. Finally, the burning investment was sifted from any impurities using a sieve analysis device to determine the particle size (150 micron)⁽¹⁸⁾.

Polishing Procedure

As seen in the dental lathe unit security check, the samples (Figure 6). A set distance of 1-2 mm separated the samples from the brush. The dental lathe was set to run at a low-speed of 1425 rpm for the duration of the polishing process, which took 2 minutes for each specimen. Using a plastic disposable syringe to measure the water added to each of these polishing materials (pumice, burning investment), the weight of the pumice was 2.45g, and the weight of the burning investment was (2.42g)⁽¹⁹⁾. After the Polishing Procedures, the sample test groups (second group, third group and the last group) were glazed using light-cured glaze (Vertex) with a soft brush. A layer of glaze was applied to the sample surfaces using a soft brush by a light-cured device for 3 min. All specimens were placed in a glass jar with a plastic cap of 100 ml containing distilled water and placed in the incubator at 37°C for (48 hours) before testing⁽²⁰⁾.

Testing Procedure

An appropriate profilometer tester unit was used for measuring surfaces roughness (Ra). The T.R.220 devices are used to test the surfaces roughness of the specimens which

are located on a stable and fixed base then attuned the device by making the stylus just touch the specimen surfaces, the stylus crossed toward the right directions along the specimen surfaces of 11mm length at end, the reading appeared on the digital scale, as shown in Figure 7.

Statistical Methods

A t-test was used to assess the study's data, with a 95% level of confidence and a significance P-value of (p0.05).

Results

A-Surface Roughness for the PMMA

Generally, there were a significance differences in the surface roughness were noticed among all the study groups of PMMA ($p < 0.05$) as shown in Table (1) and Figure (8).

B- Surface Roughness for The Flexible

In the present study of flexible acrylic resin material, there were a significance differences in the surface roughness were founded among the four study groups of Flexible ($p < 0.05$). In Table (2) and Figure (9).

Discussion

The goal of the polishing technique for dental material is to generate an appropriately smooth and shiny surfaces and thereby prevent the formation of bacterial plaque by gradually removing rough layer from the surfaces⁽²¹⁾. Rougher surfaces can lead to discolorations of the prosthesis, be a source of discomfort for the patient, and they may also encourage the colonization of germs and the growth of biofilm. Rough denture base material is more likely to encourage the growth of bacterial and fungal types of organisms. Prior studies proposed a roughness threshold of Ra = 0.2 m for dental materials utilized in the oral cavity below which no further reduction in plaque accumulations is anticipated.⁽²²⁾ Typically, the goals of the polishing procedure for dental materials are to produce sufficiently soft and glossy surfaces and so prevent the

development of bacterial plaque by gradually removing rough layers from the surfaces.⁽¹⁶⁾ The most frequent fine abrasive used in dentistry was pumice, which was also used to polish flexible and acrylic samples and was thought to be a beneficial polishing agent. In place of traditional pumice, an investment material that has been burned is employed as an abrasive material to assess its impact on acrylic resin and flexible resin specimens. With the exception of the control group, all samples were polished with pumice, investment materials burned, and light-cured glazing material. To reduce variables in this investigation, the finishing method employed for flexible acrylic resin material was the same as the finishing of heat cure acrylic resin specimens utilizing silicon carbide paper (grades 320 m), carbides bur, and acrylic bur. Roughness is the evaluation of the fine surface defects which represent surface texture⁽²³⁾. Corrosion or crack of the materials may refer to surface irregularities that would increase the chance of microorganism survival on the surface even after the prosthesis has been cleaned. One of the determinant factors in the clinical longevity of dental prosthesis is the surface roughness of the dental base material. Therefore, roughness is an important indicator of the physical properties of the material⁽²⁴⁾. In this study, SEM images show that the surface roughness of PMMA and Flexible materials in the control group was a smooth surface, uniform surface, smooth texture, no micro crack, less porosity and there are no scratches on the surface as shown in (Figure 10). This is in agreement with the outcomes of previous studies⁽²⁵⁾. the results were statistically a significant difference. We conclude from this that there is a positive effect when we polish with pumice only. This gives comfort to the patient and does not adhere to bacteria on the surfaces of the material and maintains the complete health of the patient's mouth, however there was an increase in the surface roughness in the experimental groups polish with glaze material. This effect is considered

a negative effect on the denture's base materials, under SEM images we show a rough surface, Irregular surface, micro crack, voids, scratches on the surface and porosity in (Figure 11). This may be due to the difference in the (mechanical and physical features) of the material (light-cure glaze) that have been used as a polisher, such as hardness, (since the hardness of the material was often used to give an approximate indication of the abrasion resistance). This is in agreement with Goiato et al. (2017).⁽²⁶⁾ The glaze polished group presented higher surface roughness results. Also agrees with Sesma et al. (2005)⁽²⁷⁾, the glazed surface was not smooth and imperfection was found in the surfaces of denture base materials. The present study findings concluded that the glaze material increases surface roughness which was observed after microscopic examination of the two categories of denture base materials like (PMMA, and Flexible).

Conclusion

Within the limitation of current study, it can be concluded:

- 1-The surfaces roughness was decreased in the control group of PMMA and flexible materials, while it was increased in the experimental groups after polishing with glaze material.
- 2-The surfaces roughness of the control group of two materials was not affected by pumice polishing material and it became soft and shiny without any scratches remember under SEM.
- 3-The surfaces roughness of the experimental group was "significantly" affected by glaze polishing material and contain bubbles, rough surface, micro crack and scratches under SEM.
- 4-The polishing material (light cure glaze) is significantly Rougher than pumice and burning investment materials.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Table (1): T-Test showing the surface roughness of the tested group specimens.

Surface Roughness PMMA		t-test for Equality of Means						
		T	df	Sig. (2-taild)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Pumice Polish	Equal variances assumed	13.739	18	0.000	1.68645	0.12275	1.42857	1.94433
	Equal variances not assumed	13.739	9.22	0.000	1.68645	0.12275	1.40979	1.96311
Pumice Polish + Glaze	Equal variances assumed	24.817	18	.000	1.47355	.05938	1.34881	1.59829
	Equal variances not assumed	24.817	10.059	.000	1.47355	.05938	1.34136	1.60574
Invest. Polish + Glaze	Equal variances assumed	25.501	18	.000	1.63060	.06394	1.49626	1.76494
	Equal variances not assumed	25.501	9.890	.000	1.63060	.06394	1.48791	1.77329
Glaze	Equal variances assumed	21.672	18	.000	1.42680	.06584	1.28848	1.56512
	Equal variances not assumed	21.672	11.002	.000	1.42680	.06584	1.28190	1.57170

Table (2): T-Test showing the surface roughness of the tested group specimens.

Surface Roughness Flexible Acrylic Resin		t-test for Equality of Means						
		T	df	Sig. (2-taild)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Pumice Polish	Equal variances assumed	30.824	18	.000	1.36035	.04413	1.26763	1.45307
	Equal variances not assumed	30.824	9.470	.000	1.36035	.04413	1.26127	1.45943
Pumice Polish + Glaze	Equal variances assumed	23.545	18	.000	1.15295	.04897	1.05007	1.25583
	Equal variances not assumed	23.545	9.601	.000	1.15295	.04897	1.04322	1.26268
Invest. Polish + Glaze	Equal variances assumed	36.692	18	.000	1.27973	.03488	1.20646	1.35301
	Equal variances not assumed	36.692	9.552	.000	1.27973	.03488	1.20152	1.35794
Glaze	Equal variances assumed	24.280	18	.000	1.10918	.04568	1.01321	1.20516
	Equal variances not assumed	24.280	9.566	.000	1.10918	.04568	1.00676	1.21160



Figure 1: Materials used in this study.

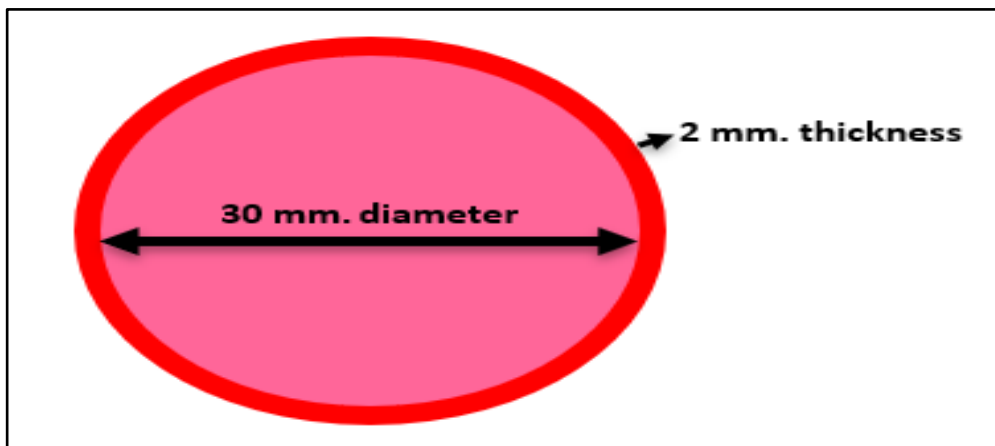


Figure 2: The mold of the specimen's shape for the plastic pattern.

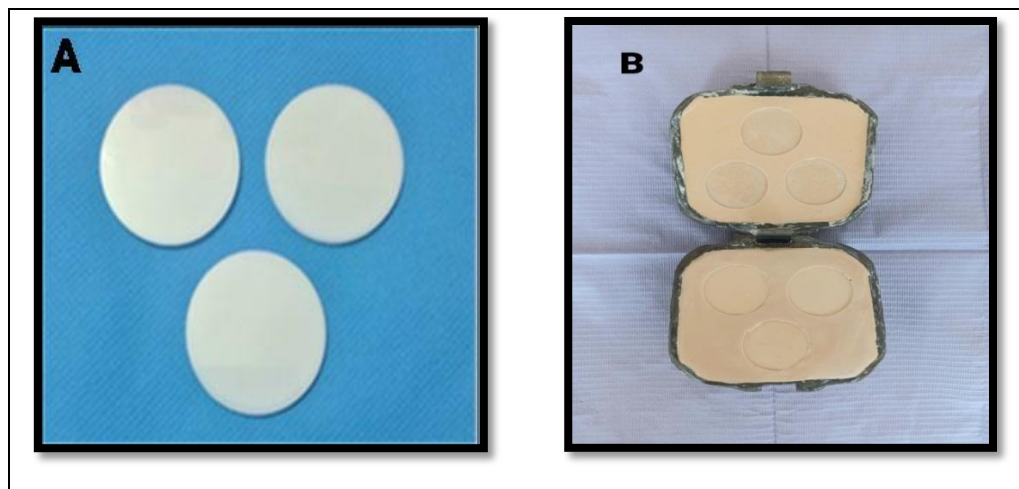


Figure 3: (A) Plastic pattern sample; (B) dental flask mold

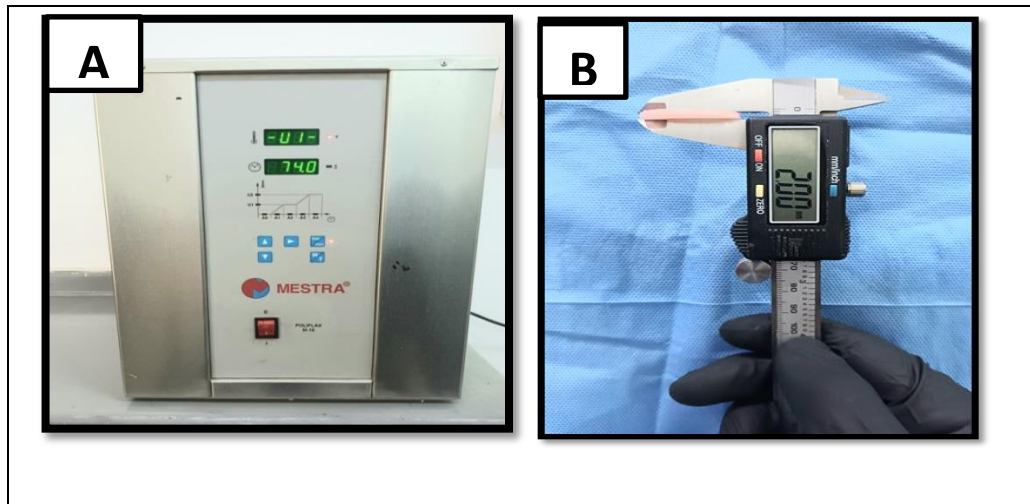


Figure 4: (A) digital water bath device;(B) 30 mm x 2 mm diameter and thickness for acrylic disc specimens by using an Electronic digital caliper

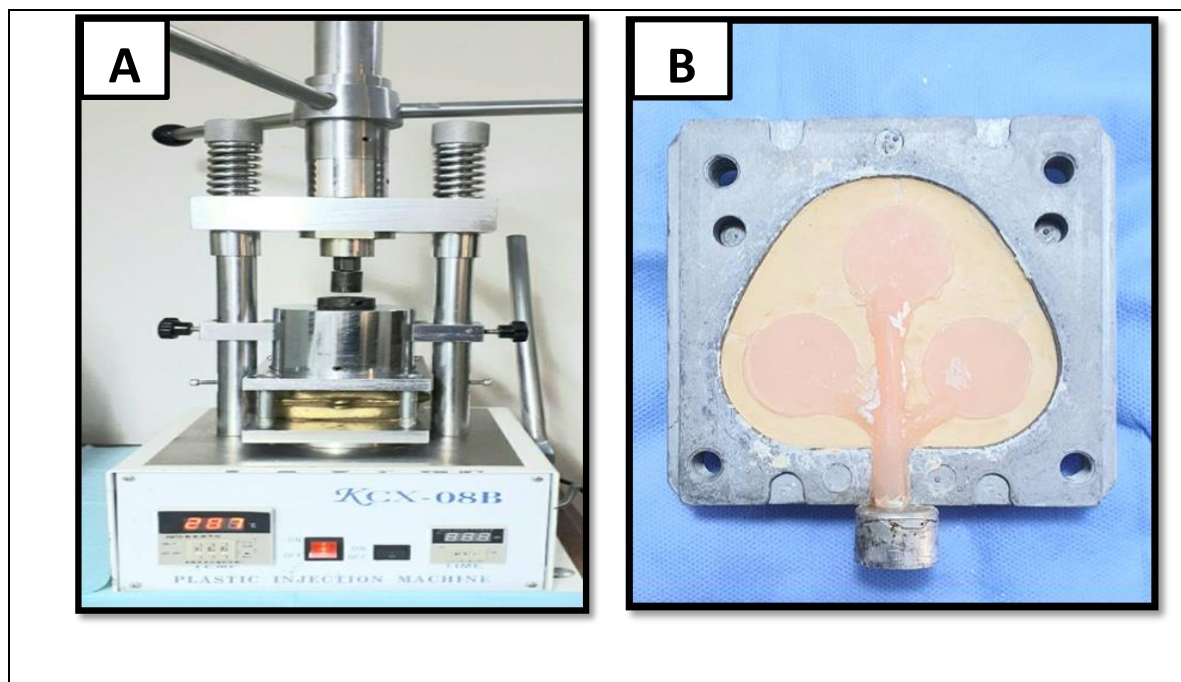


Figure 5: (A) Plastic Injection Machine, Cartridge in Cartridge Carrier with Place the Special Flask at Temperature 287°C; (B) The Sprues and Polyamide Resin Specimens.

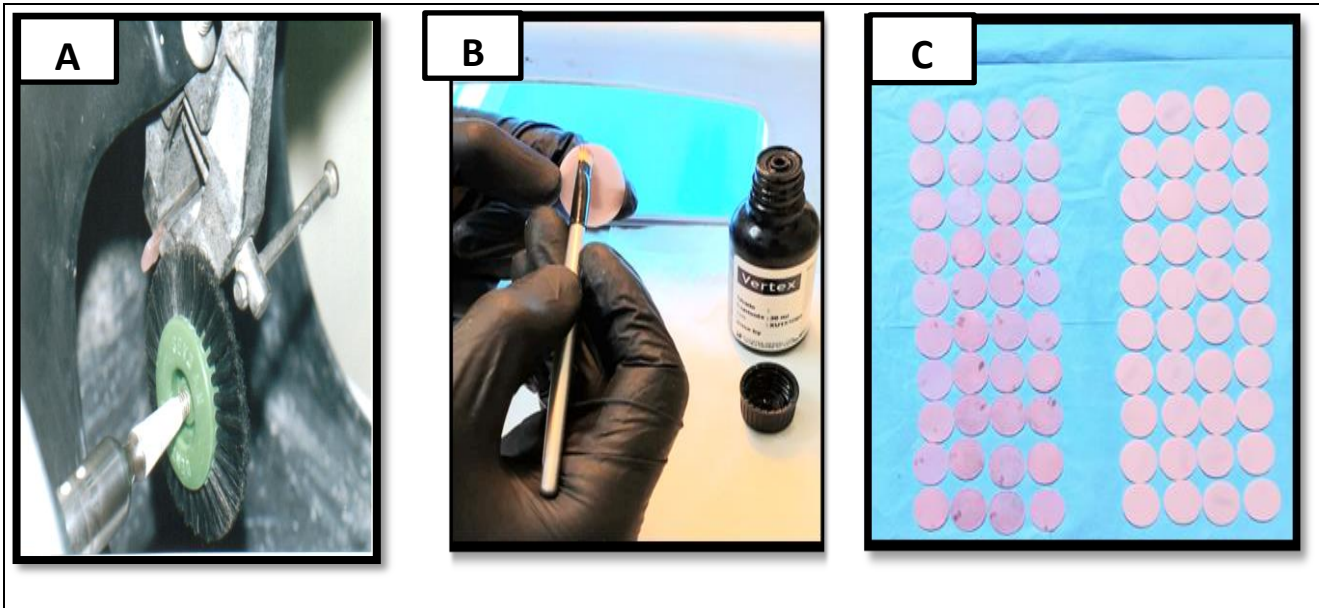


Figure 6: (A) Bristle brush with the specimen; (B) layer of a light-cured glaze (vertex) with a soft brush for 3 min;(C) Specimens after finishing and polishing.



Figure 7: Specimens under profilometer surface roughness testing unit.

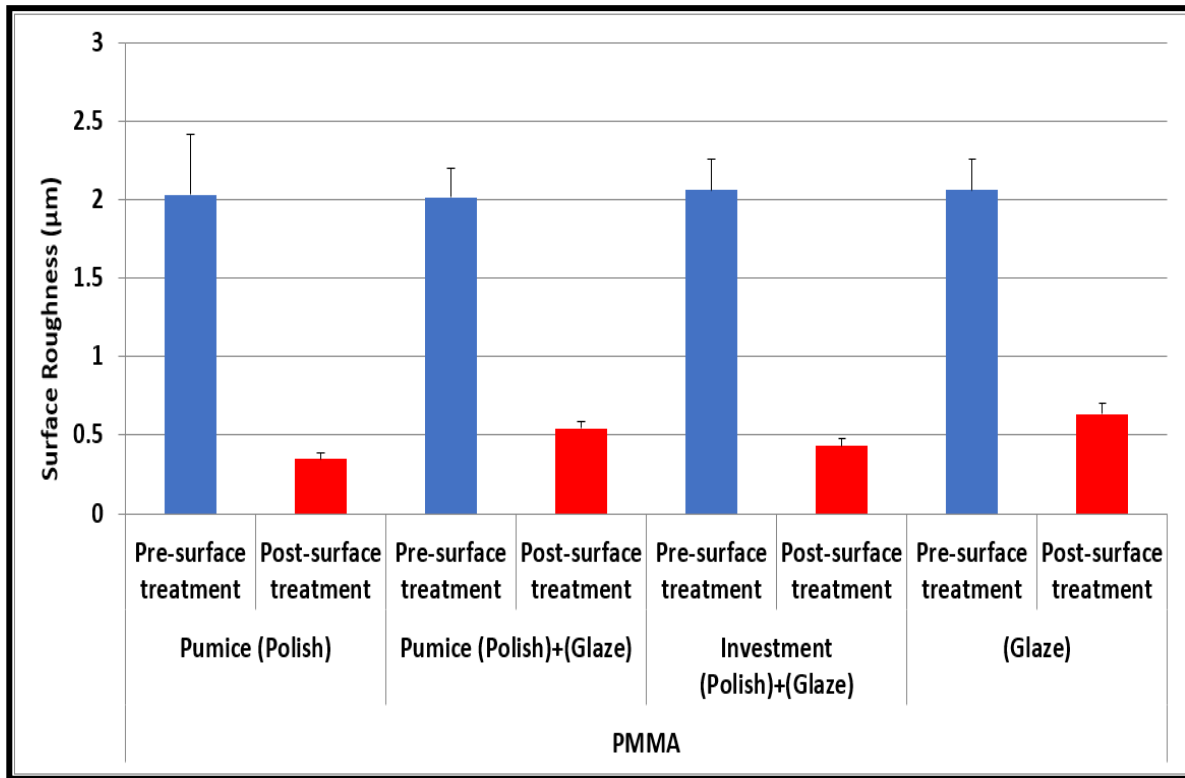


Figure 8: Bar-chart showing the mean distribution of the surface roughness of the tested groups.

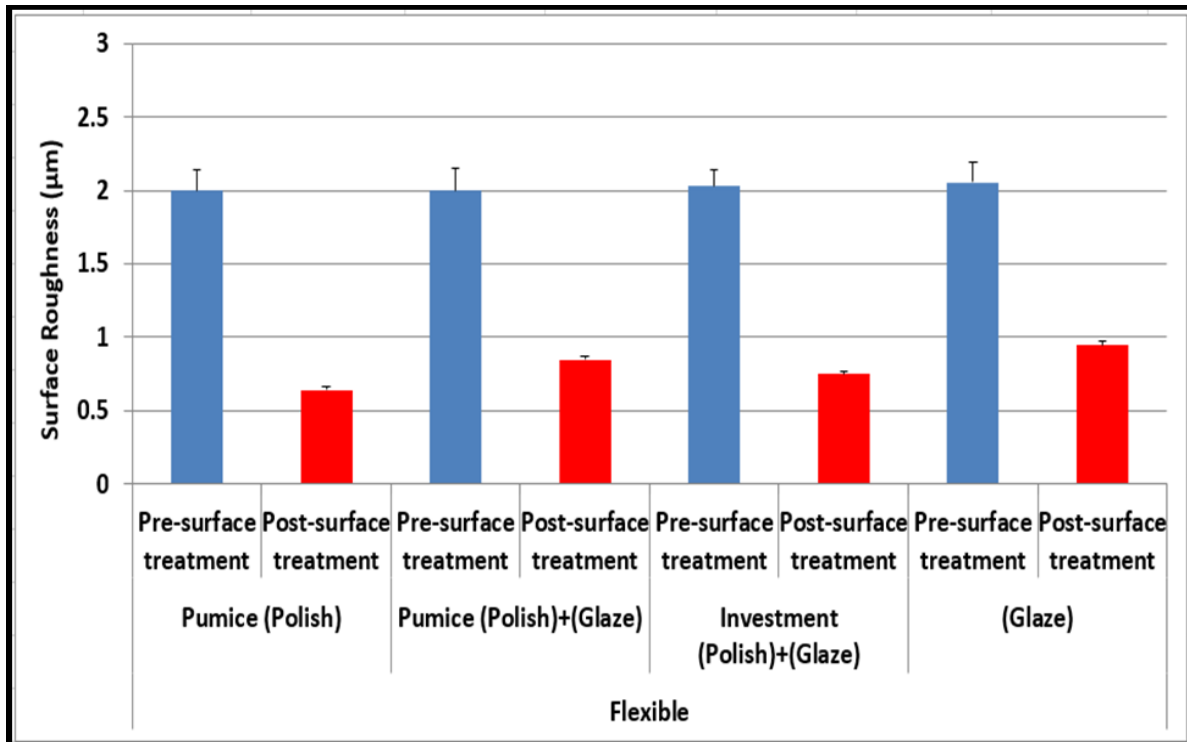


Figure 9: Bar-chart showing the mean distribution of the surface roughness of the tested groups.

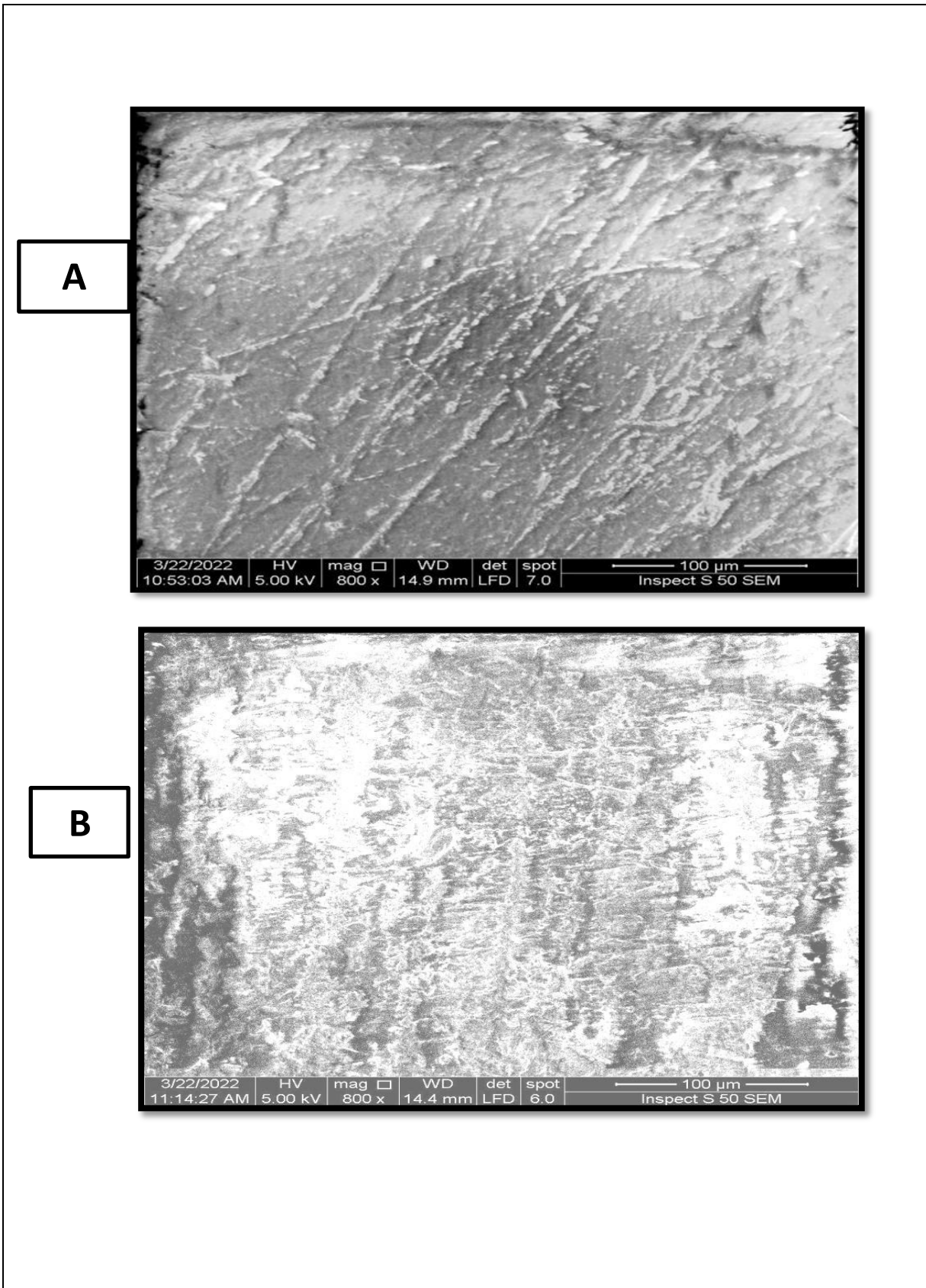


Figure 10 : (A) SEM for a control group of PMMA;(B) SEM for a control group of flexible.

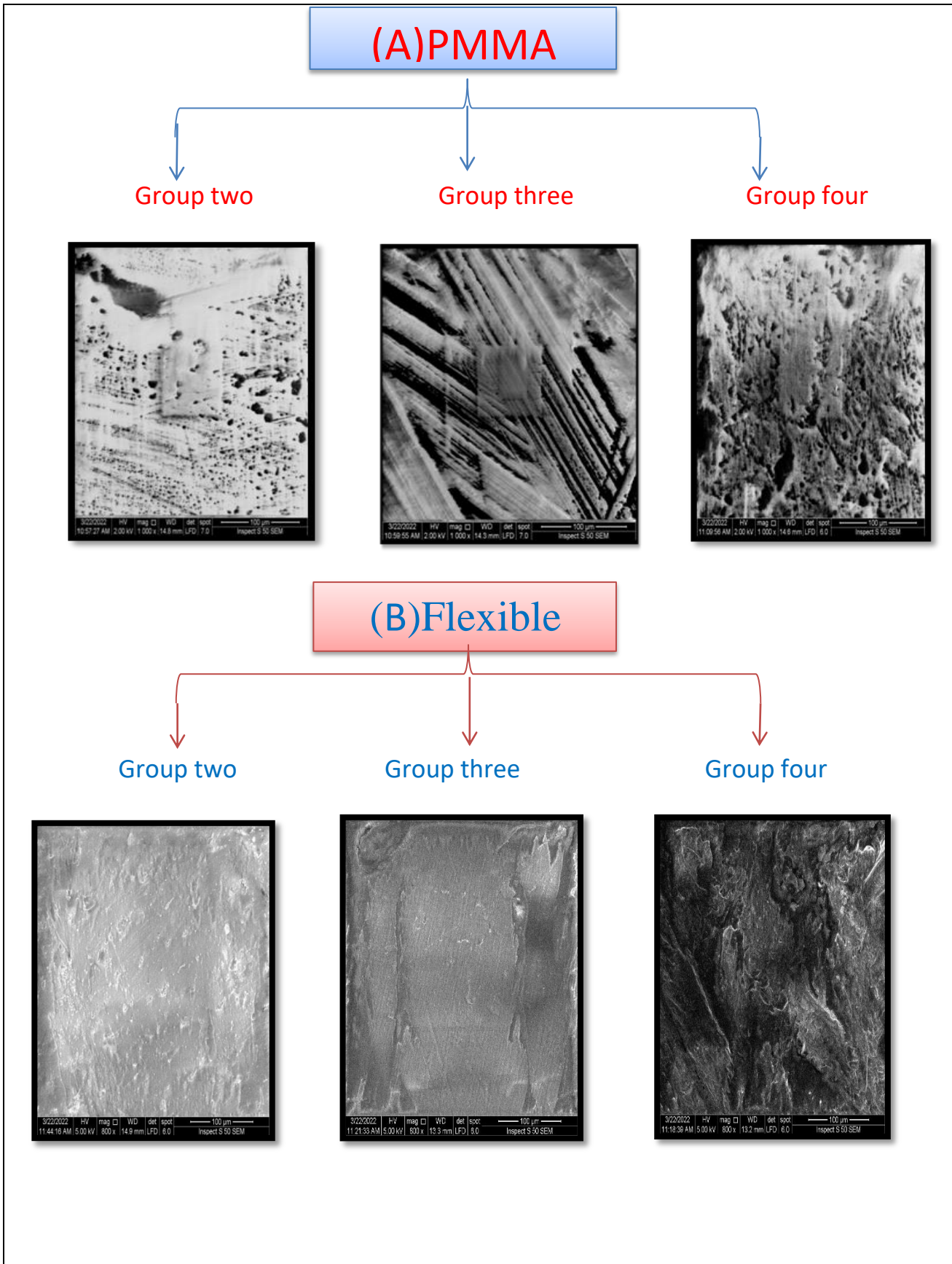


Figure 11: (A) SEM for experimental groups of PMMA;(B) SEM for experimental groups of flexible.