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RESEARCH ARTICLE - MEDICAL TECHNIQUES

The Effects of Polishing Techniques on Surface Roughness of De-flex Denture Base

Ahmed Hazim Kassoob[1*], Ihab Nafea Yaseen[2]

[1] Minstry of Iraqi health, Baghdad, Iraq.

[2] College of Health & Medical Technology - Baghdad, Middle Technical University, Baghdad, Iraq.

[*] Corresponding author E-mail: ecc0013@mtu.edu.iq

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Abstract

Background: Materials are being developed to meet the needs of patients, such as flexible injectable thermoplastic resins that improve the esthetics of patients wearing removable partial dentures.
Aim: To compare the surface roughness of thermoplastic resin materials before and after polishing with different surface treatments.
Materials and methods: A total of 40 circle specimens of De-flex thermoplastic resin with dimensions (30 mm X 2 mm) were divided into four groups according to the surface's polishing treatment. Each group of material has (10) specimens, the first group was polished with pumice, the second group was polished with pumice and then glazed, the third group was polished with investment (Phosphate bonded investments) and then glaze, 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 using t-test analysis revealed that a significant difference was reported among all the study groups ($P < 0.05$), the highest mean values were achieved in the group treated by Glaze only (2.6800± 0.8439 µm), while the lowest mean values were obtained in the group treated pumice control group (2.4266± 0.5532µm).
Conclusion: It was concluded that surface roughness was decreased in the control group of De-flex material when polished with pumice, while it was increased in the experimental groups after polished with Glaze material. The polishing material (Light Cure Glaze) is significantly rougher than pumice and burning investment materials.

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Keywords: De-flex; Surface Roughness; Denture Glaze; Finishing; Polishing.

1. Introduction

Although traditional acrylic resin has acceptable visual qualities, the association with staples for removable partial dentures retention does not always delight patients. A material called flexible thermoplastic resin was introduced into dentistry to meet the requirement for denture retention while also meeting the aesthetic demands of patients [1]. Due to its basic structure, which contradicts established biomechanical concepts, such as the absence of supports and structural flexibility, some professionals dispute the use of this resin in the creation of removable partial dentures [2]. However, the use of thermoplastic resin for the manufacture of flexible removable partial dentures has increased over the years [3]. Every year, the number of thermoplastic removable partial dentures on the market grows, reflecting their growing popularity in dental practice. However, they are still viewed with some reservations in the academic community, particularly because the number of productions analyzing the physical and mechanical properties of these materials is still limited in the literature. To present, existing research has yielded promising findings, showing that this can be used in clinical practice [4]. Recently, one injection molded thermoplastic material: De-Flex modern polymer-based thermoplastic material for universal use. this material has increased hardness compared to other thermoplastic materials. Low contraction (0.6 %) guarantees a good fit for the denture. It is chemically combined with a cold cure acrylic so that the material can be repaired and relined conventionally. These materials have been supposed by the manufacturer to have enhanced hardness and have been suggested for use by a patient who has a sensitivity reaction to PMMA monomer. One of the significant aspects impacting dental prosthesis endurance is the surface roughness of the denture base material [5]." Polishing is the process of making the denture surface smooth and glossy without causing major changes to the contour". A roughness of 0.2 µm is considered the threshold value for polish. However, the surface roughness of polyamide and Poly methyl methacrylate (PMMA) resin is well within the accepted norm of 0.2 µm roughness [6]. If the roughness is above this, the denture surface can attract plaque and microorganisms. This study was designed for evaluating the effect of different polishing techniques on the Surface Roughness of De-flex denture base material.

Nomenclature			
P	P-Value	mm	Millimeter
PMMA	Poly methyl methacrylate	CAD	Computer-aided design
S	Significant	rpm	Revolutions per minute
µm	Micrometer	SPSS	Statistical Package for Social Science
g	Gram	T.R.220	Tester roughness
SEM	Scanning Electron Microscope		

2. Materials and Methods

2.1. Preparation of Custom-Made Plastic Mold

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 40 De-flex (the Company of material is De-flex M10 $_{XR}$ and the origin in the Argentina) disc specimens' specification [7]. A Plastic pattern is designed using Auto CAD 2013 (Autodesk) and processed using a computer numerical control machine for 10 minutes [8].

2.2. Specimen Preparation

The stone slurry was prepared and poured into the flask's lower half, which was built for the injection molding technique. The Plastic disc was positioned above the stone surface before it was hardened, with the level of the plastic disc matching the level of the stone surface. When the stone started to solidify, the sprue formers were connected to produce a channel for the fluid resin to flow into the mold. A separating medium was used to lubricate the stone's surface. The upper half of the special flask was then placed over the lower part, and another mix was poured into the flask. Following the completion of the dental stone set, the wax was removed by immersing the flask in boiling water for 5 minutes to soften the wax. The flask was opened and rinsed with clean boiling water to remove any remaining wax. A thin coat of separating media was put on the model and allowed to dry completely once the flask was opened [9]. A cartridge of suitable size was selected and spray (wax surface reducing agent) was applied to the cartridge, the cartridges carrier was then located in an automatic plastic injection machine which is used for softening the De-flex material at a temperature of 305 ºC for 15 minutes according to manufacturer instructions Fig. 1. The sprue formers are cut with a specific disk and hand-finished with increasingly finer grades of silicon carbide paper (grades 320 microns) with continuous draining water.

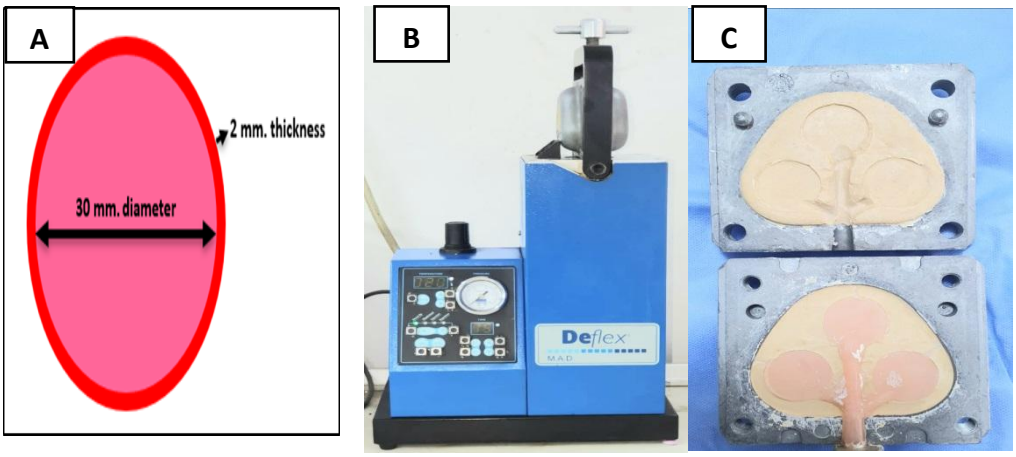

Fig 1. (A) The mold of the specimen's shape for the plastic pattern, (B) Automatic injection of De-flex material, and (C) Dental flask mold and the specimens.

2.3. Preparation Burning Investment

After finishing, the investment material was obtained after it had been burned. The investment material was blended to the manufacturer's specifications. The burning temperature which is used for burning the investment material in this study was **950 °C**, after burning the investment it was crushed with a hand hammer and grinding it by using Retch. Planetary Ball mill 100 Then sifting grind burning investment from any impurities by using the sieve analysis device to get particle size (150 microns) [10].

2.4. Specimens grouping

A total number 40 of specimens were distributed into four groups according to the surface treatments.
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.

2.5. Polishing Procedure

The sample test was fixed in the dental lathe machine. The distance between the sample and the brush was kept to a minimum of 1-2 mm. The dental lathe's speed was set to a relatively low speed, which was convenient (1425 rpm) The polishing process took 2 minutes for each

specimen. The amount of water added to each of these polishing materials (pumice, burning investment) was 2ml measured by using a plastic disposable syringe and the weight of pumice was (2.45 g), and the burning investment was (2.42 g). [11,19]. 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 surface using a soft brush by a light-cured device for 3 minutes [12]. 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 [13].

2.6. Testing procedure

An appropriate profilometer tester unit was used for measuring surface roughness (Ra). The T.R.220 device is used to test the surfaces roughness of specimens that were positioned on a stable and fixed base, then adjusted by simply touching the specimen surface with the stylus, the stylus traversed toward the right directions along the specimen surfaces of 11mm length at the end, and the reading appeared on the digital scale [14].

2.7.SEM Examination and procedure

After testing the surface roughness of De-flex with different polishing materials groups, the surfaces and morphology after polishing with the light cure glaze and examining the behavior of materials were examined under SEM (Inspect S50) in the University of Technology Department of Applied Sciences. There is an effect on surface roughness between the polishing materials.

3. Results

3.1. Statistical analysis

To analyze the results statistically, "SPSS statistical program Version 20" was used, and Microsoft Excel 2010 for graphical representation. In Fig. 2 and Table 1, the results of surface roughness data for the De-Flex were compared using the student t-test. The student t-test revealed significant differences in surface roughness between the tested groups ($P < 0.05$).

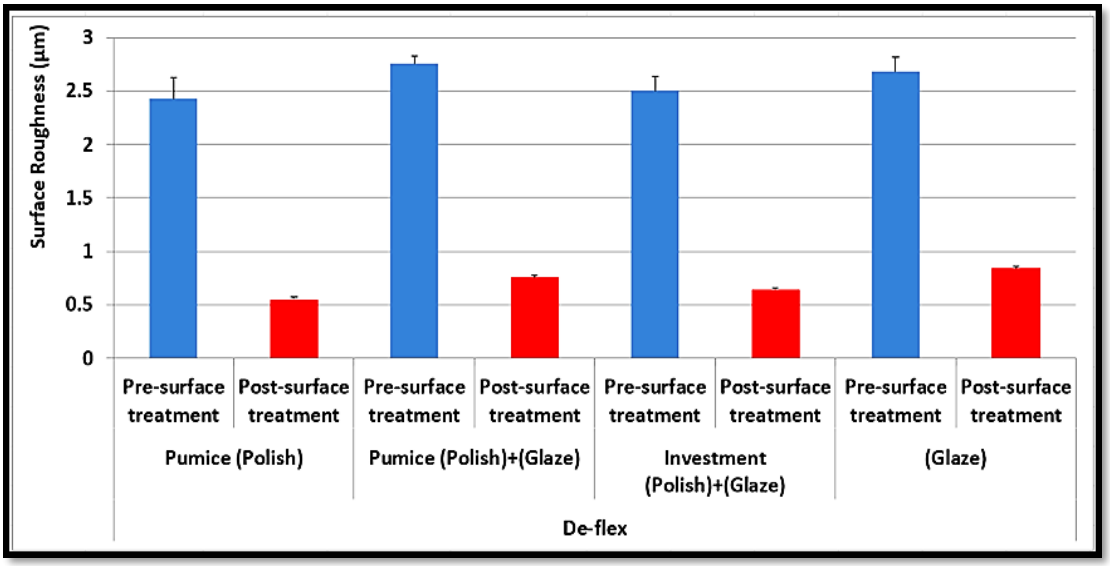

Fig 2. Bar chart showing the mean distribution of the surface roughness of the tested groups.

Table 1 Student t-test showing the surface roughness results of the tested specimens.

Surface Roughness De-flex Material		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Pumice Polish	Equal variances assumed	29.161	18	.000	1.87333	.06424	1.73837	2.00830
	Equal variances not assumed	29.161	9.131	.000	1.87333	.06424	1.72833	2.01834
Pumice Polish + Glaze	Equal variances assumed	84.276	18	.000	1.99990	.02373	1.95004	2.04976
	Equal variances not assumed	84.276	9.940	.000	1.99990	.02373	1.94698	2.05282

Invest. Polish + Glaze	Equal variances assumed	43.140	18	.000	1.85600	.04302	1.76561	1.94639
	Equal variances not assumed	43.140	9.271	.000	1.85600	.04302	1.75911	1.95289
Glaze	Equal variances assumed	43.544	18	.000	1.83613	.04217	1.74754	1.92472
	Equal variances not assumed	43.544	9.220	.000	1.83613	.04217	1.74109	1.93118

3.2. Scanning Electron Microscope (SEM)

Results clearly showed the surfaces roughness of De-flex denture base materials in the first group (control group) that was polished with pumice only appeared smooth, with no micro crack, less porosity present, and a uniform surface without scratches on the surface of the material under SEM as in Fig. 3-A. After polishing with light cure Glaze The experimental groups (group two, group three and group four) appeared with a high surface roughness on the sample's surface, a complete loss of smoothness, high crack, porosity and many scratches in all areas of the sample, indicating that the glaze material increased the roughness of the surface, as shown in Fig. 3-B.

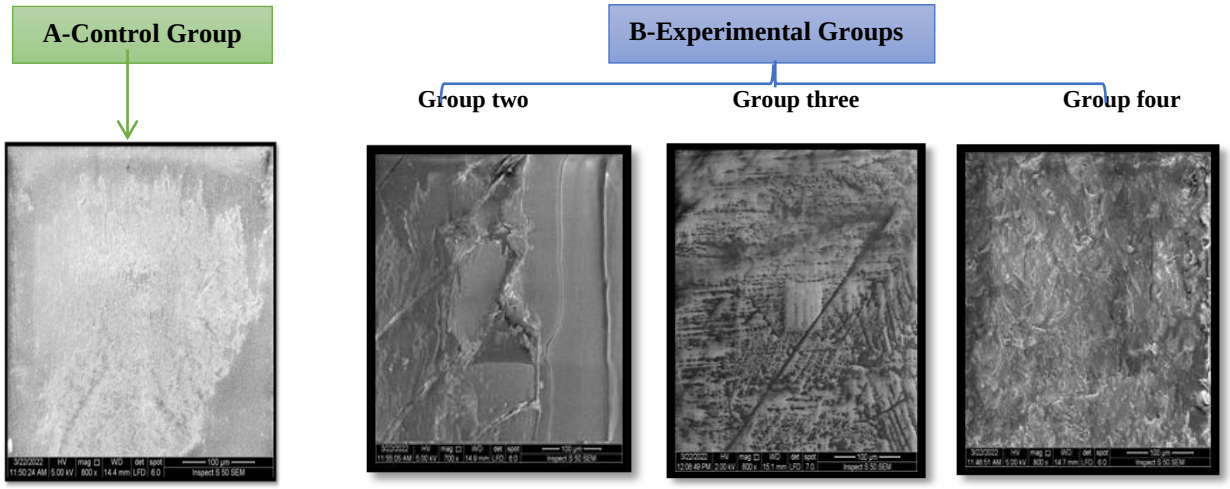

Fig 3. SEM images for; (A) Control specimens of De-flex and (B) SEM of experimental groups for De-flex

4. Discussion

The goal of the polishing technique for dental material is to generate appropriately smooth and shiny surfaces and thereby prevent the formation of bacterial plaque by gradually removing a rough layer from the surfaces [15]. There is also agreement on the importance of surface roughness in the early adhesion phase, with surface roughness being linked to the rate of bacterial/fungal colonization of biomaterials. Such rougher surfaces may be more susceptible to fungal adhesion and biofilm growth, which can result in infection if they are revealed to the oral environment [16]. It was difficult to make a direct comparison of surface roughness (Ra) value with results from other studies due to variations in experimental methods, polishing and measuring techniques, and the type of flexible material used in combination with other types of thermoplastic polymers. These difficulties may lead to a difference in Ra readings [17]. It is essential to choose a cartridge that contains thermoplastic material to avoid any deficiencies that are conceivable but difficult to rectify. Oversized cartridges can lead to additional leakage of the substance between the flask and the cartridge opening. It was chosen depending on the prosthesis or specimens' type and size. To avoid cartridge adhesion to the cartridge carrier and allow seamless separation, the outside surface of the thermoplastic material cartridge was covered with a melting agent. The injection molding technique was used to mold the thermoplastic materials in this investigation [18]. A roughness of 0.2 µm is considered the threshold value for polish. However, the surface roughness of polyamide resin is well within the acceptable normal of 0.2 µm Ra [6]. In this study, SEM images show that the surfaces roughness of De-flex denture base materials in the control group was smooth, uniform, with a smooth texture, no micro crack, less porosity, and no scratches on the surface this is in agreement with the results of previous studies AL-Majeed (The pumice for polishing acrylic specimen and polyamide resin gave smoother surface) This may be due to the moderate and quickly broken up grains size of pumice Although the small particle size may cut way rapidly because of the sharpness and hardness of the particle. In such a case the rate at which particular material would be removed from a surface depends to a considerable degree upon the properties of the material being polished [19, 20], whereas, in the experimental groups, SEM images show a rough surface, irregular surface, micro crack, voids, scratches on the surface, and porosity. This is in agreement with Sesma et al [12], the glazed surfaces were not smooth and imperfections were found in the surfaces of denture base materials because of an area in which the glaze layer was cracked so that the glaze cracks acted as microniches that favored bacterial plaque retention. The effects of f investment particles on the surface roughness of polyamide are the same effects of PMMA because of is the same particle size user (150 microns). However, there were no further studies in previous research concerning this work, by using burning investment material as a polishing material for polyamide. According to the findings of this study, there is a positive effect when we polish with pumice because it

provides comfort to the patient, does not adhere to bacteria on the surfaces of the material, and maintains the complete health of the patient's mouth. Glaze polishing reduces the bacterial viable count [21] but there was a rise in the surface's roughness in the experimental groups after the application of the glaze material. This effect is considered a negative effect on the denture base materials. The present study findings concluded that the Glaze material increases surface roughness which was observed after SEM investigation of the De-flex denture base material.

5. Conclusion

Within the boundaries of this study: -

1. It was concluded the surface roughness was decreased in the control group of De-flex material when polished with pumice, while it was increased in the experimental groups after polished with Glaze material.
2. The polishing material (Light Cure Glaze) is significantly rougher than pumice and burning investment materials.

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