

Effect of Different Polishing Agents on Surface Finish and Hardness of Denture Base Acrylic Resins: A Comparative Study

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ABSTRACT

Polished dentures obtained from the laboratory require adjustment during insertion. A smooth surface on acrylic resin can be obtained using a chairside protocol for polishing using silicone polishing agents and polishing media. The aim of this paper is to study the effect of three different polishing agents—pumice, universal polishing paste and Brite-O on the surface finish and hardness of two types of denture base acrylic resins—auto polymerizing and heat-activated acrylic resin materials.

Keywords: Polishing agents, Denture base, Autopolymerizing acrylic resin, Heat-activated acrylic resin, Surface roughness, Surface hardness.

INTRODUCTION

It is a well-known fact that rough surface in the mouth promotes the formation of plaque, which is deleterious to oral hygiene. This is especially relevant in case of prosthesis, which is expected to function in the mouth for a long time.¹ The removable complete or partial prosthesis, i.e. when delivered from the laboratory, are highly polished. However, these prostheses require adjustment during insertion. These surfaces which are adjusted using tungsten carbide burs are rough enough to become a nidus for plaque accumulation as well as increase the adherence of microorganisms, such as *Candida albicans*, *Streptococcus oralis*. Hence, it is very important to provide the smoothest possible surface which is also highly polished. Studies have shown that chairside polishing protocol using silicone polishing points can be used to produce smooth surfaces that have been adjusted with burs where there is no access to a laboratory lathe.² The surface roughness of denture base acrylic resin depends on the processing technique *viz* heat cure or cold cure and the type of polishing media used.³ The polishing procedure involves gradual elimination of rough layers. This process may affect the physical properties of acrylic resin, such as surface hardness.⁴ Acrylic resin has been less frequently investigated for its surface roughness, effects of polishing, bacterial adhesion, and plaque formation than other dental materials.^{5,6} The objective of this study was to evaluate the effects of three different polishing pastes on the surface finish and hardness of two types of denture base acrylic resins—autopolymerizing and heat-activated acrylic resin materials.

EXPERIMENTAL BACKGROUND

Specimens of two types of denture base acrylic resins—autopolymerizing and heat-activated acrylic were polished using three different polishing pastes *viz* pumice, universal polishing paste and Brite-O. A chairside finishing and polishing protocol was followed. There were two groups—acrylic specimens that were finished only but not polished served as the control group and acrylic specimens that were finished and polished comprised the test group. There were six specimens per group for three different polishing pastes and for two types of acrylic resin materials. The total sample size was 72. Surface roughness was determined with a profilometer, surface hardness with barcol indenter immediately after finishing with tungsten carbide cutter for control group, and after polishing for test group.

Preparation of Acrylic Resin Specimens

A mold for acrylic resin specimens, 75 × 25 × 2 mm was prepared. Two heat-resistant glass plates measuring 75 × 25 × 2 mm were flaked with dental stone according to conventional procedures. As soon as the stone was set, flasks were separated and the glass plates were removed. Polymerization of acrylic resin materials was performed in compliance with the manufacturer's instructions. Autopolymerizing resin was polymerized for 15 minutes at 40°C under a pressure of 3 × 10⁵ N/m². The flask was bench cooled and then the autopolymerized acrylic resin specimens were retrieved (Fig 1). The flask with heat-activated acrylic resin was polymerized under a pressure of 3 × 10⁵ N/m², heated to 70°C.

This temperature was maintained for 1 hour, and then brought to boil for half hour. The flask was bench cooled and then the heat-cured acrylic resin specimens were retrieved (Fig 2). Thirty-six acrylic resin plates were made each for two types of resins yielding a total of 72 specimens. For each acrylic resin type, the 36 specimens were further equally divided into three groups for each type of polishing pastes yielding a subgroup of 12 specimens each for three types of polishing pastes. Out of the 12 specimens, six specimens were tested, while six served as control.

Finishing and Polishing of Acrylic Resin Specimens

The following procedures were followed in a sequential order.

Step 1: All specimen surfaces were finished with tungsten carbide burs of three grits – black (extra coarse), followed by green and then red at 15,000 rpm for 60 seconds each.

Step 2: The specimens were then finished with silicon carbide water proof papers (Carborandum universal) of grit size 220 (coarse), 320 (medium), 400 (fine).

Step 3: The finished specimens were further smoothed with silicone polishing points (Eve, Germany) in a color coded

sequence of green (coarse), black (medium), and yellow (fine) at 3000 rpm each for 60 seconds at 5000 to 7000 rpm.

Step 4: For polishing, separate cotton buffs for each type of polishing paste in a straight handpiece compatible with the chairside micromotor were used.

For the control specimens, step 1 to step 3 were followed. Only the test specimens were followed through step 4. Pumice paste was made by mixing pumice powder with plain water. Universal polishing paste and Brite-O were directly dispensed from the tubes. Six specimens each for the three types of polishing pastes were polished in the test group for each type of resin (Figs 3 and 4).

Surface Roughness Measurements

Surface roughness of the acrylic resin specimens was measured using a contact profilometer (Taylor Hobson Form Talysurf PGI-840, USA). Surface roughness (Ra), measured in μm , was determined by the instrument's diamond stylus as it moved across the specimen surface. The path of the diamond stylus was perpendicular to the direction of finishing and polishing. The cut off length of each tracing was 2 mm. Three measurements of surface roughness were performed for each

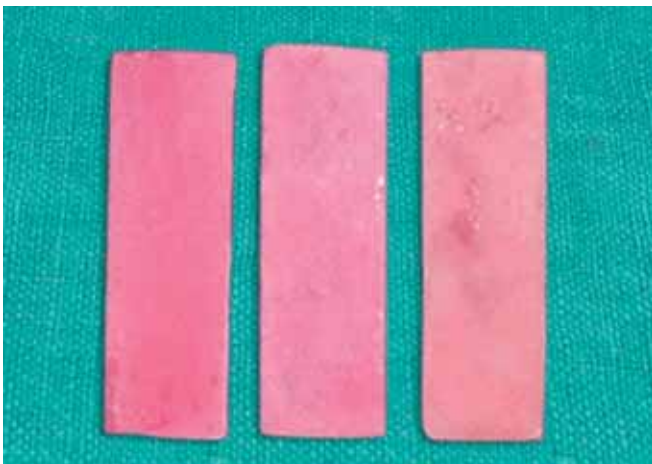


Fig. 1: Autopolymerized acrylic resin plates

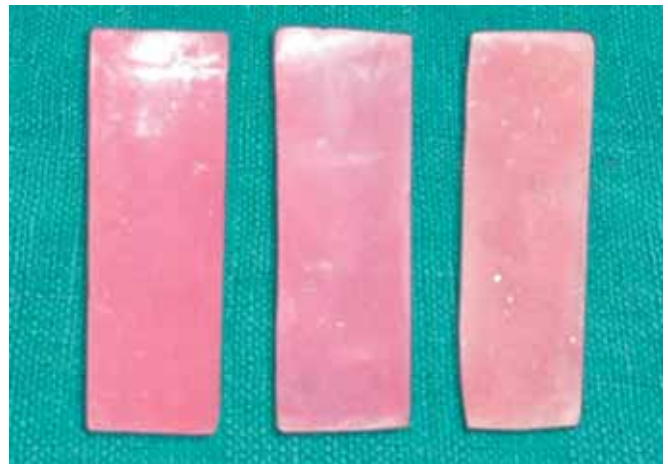


Fig. 3: Polished autopolymerized acrylic resin plates



Fig. 2: Heat-polymerized acrylic resin plates

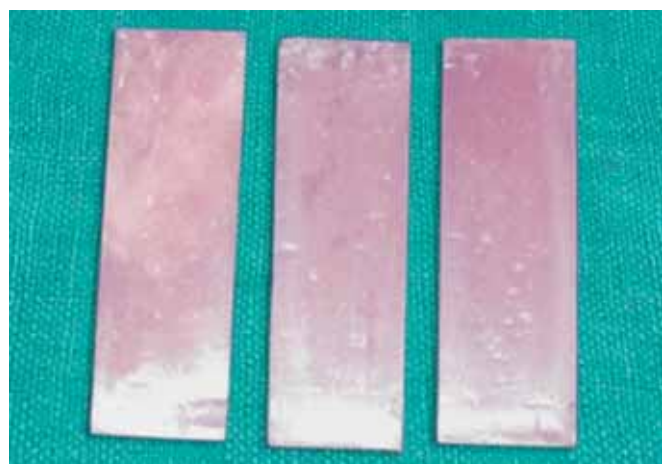


Fig. 4: Polished heat-polymerized acrylic resin plates

specimen, and mean average Ra values were used for the statistical analysis.

Surface Hardness Measurements

Surface hardness of the acrylic resin specimens was measured using a Barcol hardness tester—The impressor (Barber Coleman Company, USA). It is a hand held portable hardness tester, which gives the hardness value by measuring the depth of penetration of sharp steel point under a spring load. The specimen was placed under the indenter of the impressor and pressure was applied until the dial indication reached maximum. Results were tabulated. Data was statistically analyzed using factorial ANOVA. Minitab software was employed.

RESULTS

Surface Roughness

The surface roughness was influenced greatly by the polishing procedures (Table 1). In general, autopolymerizing resin specimens exhibited significantly ($p < 0.01$) higher surface roughness ($Ra = 0.35$) compared to heat-activated acrylic resin ($Ra = 0.27$) specimens. In autopolymerizing resin specimens, surface roughness ($Ra = 0.47$) reduced significantly ($p < 0.01$) after polishing ($Ra = 0.23$). Among the polishing pastes, specimens polished with pumice exhibited significantly ($p < 0.05$) higher roughness ($Ra = 0.36$) followed by Brite-O ($Ra = 0.23$) and universal polishing paste produced smoothest ($Ra = 0.1$) surfaces.

In heat-activated acrylic resin specimens, surface roughness ($Ra = 0.40$) reduced significantly ($p < 0.01$) after polishing ($Ra = 0.14$). Among the polishing pastes, specimens polished with Brite-O exhibited significantly ($p < 0.05$) higher roughness ($Ra = 0.18$) followed by pumice ($Ra = 0.14$) and universal polishing paste produced smoothest ($Ra = 0.1$) surfaces. Polishing the acrylic specimens with pumice ($Ra = 0.25$) produced higher mean surface roughness, followed by Brite-O ($Ra = 0.20$). Universal polishing paste produced the smoothest surfaces ($Ra = 0.10$). This was statistically significant ($p < 0.05$). Universal polishing paste produced smoothest ($Ra = 0.1$) surfaces in both heat activated and autopolymerising resins. However, this difference was not statistically significant ($p > 0.05$).

Surface Hardness

Statistical analysis showed that the surface hardness was influenced to the greatest extent by the type of resin (Table 2). Irrespective of type of polishing pastes used, heat-cured resin (29.02) specimens exhibited significantly ($p < 0.01$) higher surface mean average hardness compared to autopolymerized (14.38) specimens. In autopolymerizing resin, hardness (15.82) reduced significantly ($p < 0.01$) after polishing (12.94). In autopolymerizing resin, specimens polished with Brite-O (18.17) showed significantly ($p < 0.01$) higher hardness compared to universal polishing paste (11.33) and pumice (9.33) showed the least hardness. In heat-cured resin, hardness

Table 1: Surface roughness (Ra in μm) of autopolymerized and heat-cured acrylic specimens without (control) and with polishing (test) using universal polishing paste, Pumice slurry and Brite-O polishing paste

Polishing pastes	Heat-cured acrylic specimens				Autopolymerized acrylic specimens			
	Control		Test		Control		Test	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Universal Polishing paste	0.53	± 0.24	0.109	± 0.013	0.33	± 0.10	0.10	± 0.005
Pumice slurry	0.31	± 0.17	0.145	± 0.11	0.63	± 0.16	0.36	± 0.10
Brite-O Polishing paste	0.38	± 0.05	0.18	± 0.05	0.46	± 0.04	0.23	± 0.02
Mean (avg) Surface roughness	0.40	± 0.15	0.14	± 0.05	0.47	± 0.17	0.23	± 0.04

Table 2: Surface hardness of autopolymerized and heat-cured acrylic specimens without (control) and with polishing (test) using universal polishing paste, Pumice slurry and Brite-O polishing paste

Polishing pastes	Heat-cured acrylic specimens				Autopolymerized acrylic specimens			
	Control		Test		Control		Test	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Universal Polishing paste	30	± 1.78	29.33	± 1.03	18.66	± 1.63	11.33	± 2.42
Pumice slurry	30.66	± 1.03	34	± 1.26	6.66	± 1.03	9.33	± 3.50
Brite-O Polishing paste	26.16	± 1.6	24	± 1.41	22.16	± 2.78	18.17	± 1.3
Mean (avg) Surface hardness	28.94	± 1.47	29.11	± 1.2	15.82	± 1.81	12.94	± 2.04

(28.94) increased after polishing (29.11). However, this was not statistically significantly ($p > 0.05$)

In the heat-cured resin, specimens polished with pumice (34) exhibited higher hardness, followed by universal polishing paste (29) and Brite-O (24) showed least hardness values.

Irrespective of the type of resin, pumice (21.08), Brite-O (21.66) and universal polishing paste (20.33) exhibited equal surface hardness. No statistically significant difference was found among the three pastes.

DISCUSSION

A well-established protocol for polishing acrylic resins advocates the use of free abrasives after divesting the prosthesis.⁷ The smoothest surface on acrylic resin in the laboratory can be achieved using a series of abrasive stones of increasing fineness and then felt cones with a pumice slurry, finished with fine chalk power and a soft brush.⁸ Many protocols for polishing acrylic resin in the laboratory are found in the literature. However, these highly polished prostheses delivered from the laboratory to the dental office require adjustments during insertion. This process warrants chairside polishing of the prosthesis before final insertion. Though there are few chairside polishing protocols in the literature, the materials used in these studies were not easily procurable and most of the time not available locally. So, following the general guidelines for polishing, this study attempted to formulate a protocol for chairside polishing using materials that are locally available easily. Tungsten carbide burs (Kamed, Russia), Silicone polishing points (Eve, Germany), universal polishing paste (Ivoclar Vivadent), pumice, silicone carbide papers are readily available in the local dental market. Brite-O (Pidilite Industries Ltd.) is available as a household polishing agent. Pumice mixed with water is the most commonly used polishing medium. Universal polishing paste (Ivoclar Vivadent) containing aluminium oxide dissolved in solvents claiming superior polishability is introduced recently in the market. Brite-O is an economical conventional polishing paste used to polish household brass items. Prostheses made from autopolymerizing resin are as widely used as heat-activated acrylic resin prosthesis. Polishing basically involves removing rough surfaces incrementally. This may affect the physical and mechanical properties of acrylic resin, such as surface hardness. Hence, the objective of this study was to study the effect of polishing on surface finish and surface hardness using three different polishing pastes, and two types of resins.

The autopolymerized resins exhibited higher roughness compared to the heat-polymerized specimens (Fig. 5). An SEM study on the effect of polishing techniques on surface roughness of acrylic resins revealed greater porosity of autopolymerizing resin surfaces might be the primary reason for higher surface roughness values of this type of acrylic resin. Because of this reason, the authors have cautioned dentists to be aware of the fact that autopolymerizing resin surfaces are very likely to remain porous and, consequently,

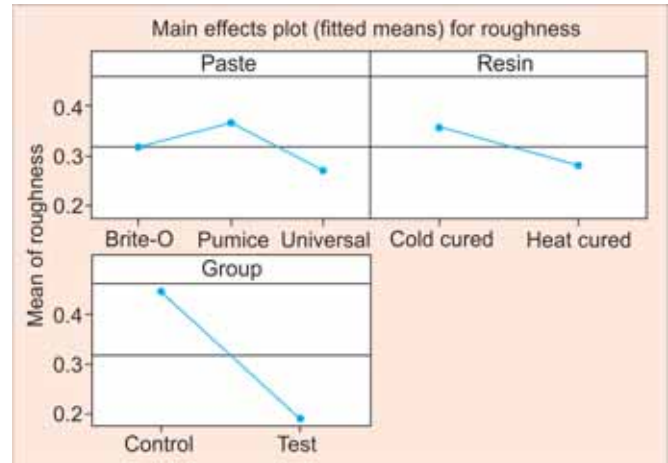


Fig. 5: The mean roughness recorded in different types of pastes, resins and groups

rougher than surfaces of heat-polymerizing resin even after adequate polishing.⁹

Pumice slurry produced a significantly rough surface compared to Brite-O and universal polishing paste. This may be due to the presence of loose abrasives in pumice slurry compared to the Brite-O and universal polishing paste in which the abrasives are dissolved and bound to the solvents and so dispensed as creams. The Moh's hardness value for pumice is 6 to 7 and for aluminum oxide is 9.¹⁰ As aluminium oxide is harder abrasive compared to pumice, universal polishing pastes have produced smoother acrylic surfaces. According to *in vivo* studies by Bollen et al,¹¹ clinically acceptable roughness (Ra) of hard surfaces in the oral environment after polishing should not exceed $0.2 \mu\text{m}$. The roughness values obtained in the present study irrespective of the type of resin and type of polishing paste used ranged from maximum of 0.36 ± 0.10 to minimum of $0.10 \pm 0.005 \mu\text{m}$.

Surface hardness of a material is its ability to resist abrasion or wear while this is measured by the material's ability to resist indentation. In the present study, surface hardness of acrylic resins was measured using Barcol Hardness Tester. Surface hardness of a material is influenced by many factors, including surface roughness. Irrespective of the polishing procedure and type of polishing pastes used, the heat-cured specimens were significantly ($p < 0.01$) harder than the self-cured specimens (Fig. 6). This finding is in accordance with Von Fraunhofer and Suchatlampong, who found higher hardness values for heat-cured acrylic resins than for self-cured ones.⁹ The higher surface hardness values can be attributed to higher degree of polymerization in heat-cured acrylic resin. The high degree of residual monomer content and generalized porous surface of autopolymerized acrylic resin may contribute to its lesser value of surface hardness. Effect of polishing on surface hardness varied with the type of resin. Surface hardness significantly reduced after polishing in autopolymerizing specimens ($p < 0.01$). This may be attributed to the incomplete polymerization and presence of residual monomer. Surface hardness increased after polishing in heat-cured specimens. But

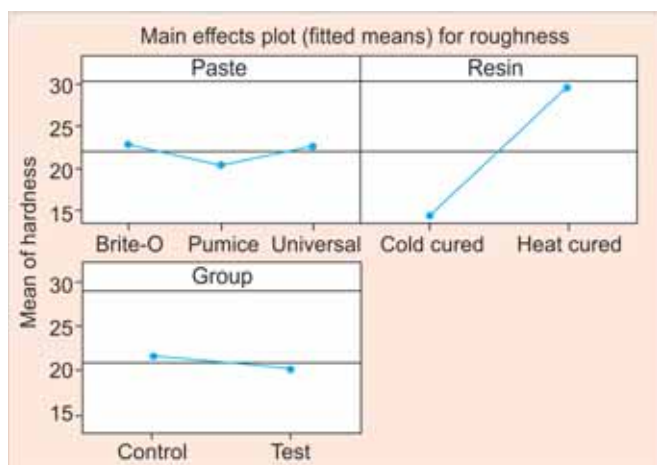


Fig. 6: The mean hardness recorded in different types of pastes, resins and groups

this was not statistically significant ($p > 0.05$). The type of polishing paste on surface hardness did not have any significant effect on surface roughness.

CONCLUSIONS

1. The surface roughness is significantly ($p < 0.01$) reduced by polishing procedures.
2. Autopolymerizing resin specimens exhibited significantly ($p < 0.01$) higher surface roughness compared to heat-cured resin specimens.
3. In autopolymerizing resin sample, specimens polished with pumice exhibited significantly ($p < 0.05$) higher roughness followed by Brite-O and universal polishing paste produced smoothest surfaces.
4. In heat-cured resin group, specimens polished with Brite-O exhibited significantly ($p < 0.05$) higher roughness followed by pumice and universal polishing paste produced smoothest surfaces.
5. In both autopolymerized and heat-cured resin specimens, universal polishing paste produced smoothest surfaces. However, this was not statistically significant ($p > 0.05$).
6. Polishing the acrylic specimens with pumice produced significantly ($p < 0.05$) higher mean surface roughness, followed by Brite-O. Universal polishing paste produced the smoothest surfaces.
7. The surface hardness was highly influenced by the type of resin. Heat-cured resin specimens exhibited significantly ($p < 0.01$) higher surface mean average hardness compared to autopolymerised specimens.
8. Surface hardness significantly ($p < 0.01$) reduced after polishing in autopolymerized resin specimens.

9. Surface hardness increased after polishing in heat-cured resin specimens. However, this difference was not statistically significant ($p > 0.05$)
10. The surface hardness was influenced by the polishing procedures but varied in the two resin types.
11. Autopolymerized acrylic specimens polished with Brite-O had significantly ($p < 0.05$) higher surface hardness, followed by universal polishing paste. Specimens polished with pumice exhibited significantly ($p < 0.05$) less surface hardness
12. Heat-cured acrylic specimens polished with pumice had significantly ($p < 0.05$) higher surface hardness, followed by universal polishing paste. Specimens polished with Brite-O exhibited significantly ($p < 0.05$) less surface hardness
13. Irrespective of the type of resin, Pumice, Brite-O, Universal polishing paste exhibited equal surface hardness.

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