

The effect of polishing agents on the transverse strength of heat cured acrylic resin bases

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ABSTRACT

Introduction: Heat cured acrylic resin is frequently used denture base material whereby transverse strength is one of the mechanical properties that must be observed. A rough surface absorbs water, reduces strength of denture bases, thus polishing should be done. Pumice is the most abrasive material used in dentistry. Eggshell and toothpaste can be used as alternative abrasive materials. This study aims to determine the differences in value of transverse strength of HCA resin once polished using pumice, eggshells, and toothpaste. **Method:** This laboratory experimental study using sample sized 65x10x2.5 mm with 30 samples in total for 3 groups. Transverse strength was measured using Universal Testing Machine. The data were analyzed using one-way Anova. **Result:** The comparison ratio of transverse strength between HCA resin after polishing with pumice, eggshells and tooth paste is 93.63 : 118.42 : 105.91 MPa. It shows there were significant differences in transverse strength between groups with significant value p was 0.001 which less than 0.05. **Conclusion:** The value of transverse strength varies according to polishing material used. Eggshell has the highest transverse strength value compared to pumice and toothpaste. **Key words:** heat cured acrylic resin, denture bases, transverse strength, polishing materials

INTRODUCTION

Since first polymerized in 1936 by Walter Bauer, heat cured acrylic resin became the most commonly used denture base material because it is inexpensive, ease processing, good color stability and easy to polish.^{1,2} One of the characteristics of heat cured acrylic resin that should be observed is the mechanical properties which is the transverse strength.² The minimum transverse strength of denture base materials should not be less than 65 MPa.³ The transverse strength of acrylic resins depends on several factors such as polymer molecular weight, residual monomer level, plasticizer composition, denture base thickness, type of polishing and porosity.⁴ Rough surfaces increases water absorption because water acts as a plasticizer until acrylic resin material becomes soft and flexible.^{5,6} To get a smooth surface, polishing process should be done. Traditionally, acrylic resin is polished by mechanical procedure using abrasive materials because it produces a smoother base surface. Abrasive material that is often used as a polishing material in the field of dentistry is pumice. Pumice is the powdered form of volcanic rock that has a holey texture.⁷ Pumice consists of 60-67% silica, 13-17% alumina, 7-8% sodium oxide-potassium oxide and minimal amount of iron oxide, calcium oxide and titanium dioxide.⁸

Other alternative abrasive materials that can be used as polishing agent are eggshell and toothpaste. The eggshell is the outer part of the egg with a

hard and porous texture consisting of 94% calcium carbonate, 1% magnesium carbonate, 1% calcium phosphate and 4% organic matter.⁹ Henusset states calcite from calcium carbonate has abrasive properties which can be used to polish the surface of acrylic resins.¹⁰

Toothpaste is generally used for tooth surfaces and mechanical cleaning of artificial teeth. Toothpaste contains a variety of abrasive substances such as calcium carbonate, dicalcium phosphate, alumina, calcium pyrophosphate, sodium bicarbonate, perlite and silica. Generally, the abrasive material in a toothpaste is around 20-55%.¹¹ According to Hefferen and Forward, abrasive material is added to toothpaste to remove plaque, stain and food debris.¹² According to Pisani et al, toothpaste has polishing effect on the surface of acrylic resin denture bases because of the silica content.¹³

Based on this, the idea arose to utilize eggshells and toothpaste as a polishing agent for heat cured acrylic resin bases.

METHOD

In this experimental laboratory research, the eggshells were collected from various food outlets, washed under running water and then soaked for 6 hours in 2.5% sodium hypochlorite solution. Eggshells were dried using electric oven (Naberthem, USA) for 6 minutes at 250°C. The eggshells were crushed with a blender and 15 g of sodium lauryl sulfate added to 300 g of eggshell and blended until

homogeneous. The use of ball-mill (Retsch PM200 Series, Germany) to produce fine particle size was carried out for 60 minutes at a speed of 400 rpm. The powder was then sieved with mesh 100 and continued with mesh 400.

Samples were made from HCA resin of size $65 \times 10 \times 2.5$ mm.^{3,5} The total number of sample was 30 and divided into 3 groups: the pumice group, the eggshell group and the toothpaste group. The cuvette containing the mold comes from the parent model which was planted in a cast. The mold was filled with acrylic resin dough then the cuvette was closed, pressed then cured in a water bath. Samples were removed from the cuvette and trimmed with a fraser bur, grinded with 400, 800 and 1200 sandpaper using a rotary grinder and followed by polishing using a rag wheel mounted to polishing motor, using pumice, eggshell and toothpaste. Each sample was polished for 2 minutes, then were immersed in distilled water for 2 days at 37°C in an incubator (Mettler, Germany).

Transverse strength testing was performed using the Universal Testing Machine (Torsee's Electronic System). Data analysis was performed with Univariate test and one-way Anova test.

RESULT

The results show that the value of transverse strength analyzed by the Univariate test whereby the pumice group has a mean value of 93.63 MPa and with a standard deviation of 10.22. The mean value of eggshell group was 118.42 MPa with a standard deviation of 12.66. The mean value of the toothpaste group was 105.91 MPa with a standard deviation of 9.80. Based on the one-way Anova test, there were significant differences in the value of transverse strength in the three groups with a value of p was 0.001, less than 0.05 (Table 1).

Table 1 Anova test results on the value of transverse strength between the pumice, eggshell and toothpaste groups.

Groups	Transverse Strength (MPa)		
	n	$\bar{x} \pm SD$	p
Pumice	10	93,63 \pm 10,22	0,001*
Eggshell	10	118,42 \pm 12,66	
Toothpaste	10	105,91 \pm 9,80	

Note: *significant

Based on least significant difference (LSD) test, the value of transverse strength between the pumice group and the eggshell group with a value of p was 0.001; less than 0.05, the pumice group with toothpaste group with a value of p was 0.019; less

than 0.05, eggshell with toothpaste group with p value was 0.017; less than 0.05 (Table 2).

Table 2 LSD test results for each group

	Pumice	Eggshell	Toothpaste
Pumice	-	0.001*	0.019*
Eggshell	0.001*	-	0.017*
Toothpaste	0.019*	0.017*	-

Note: *significant

The results show that the three groups have transverse strength values above the standard value accepted in dentistry, which is 65 MPa. Based on the statistical test results, the eggshell group has the highest transverse strength value compared to the pumice group and toothpaste group. There was a significant difference between the eggshell group with the pumice group and toothpaste group.

DISCUSSION

The results show that the value of transverse strength varies in the same group. The acquisition of these varied results can be caused by a rough surface that increases the capacity of water absorption.⁶ Acrylic resins have the characteristics of absorbing water slowly over a period of time by the mechanism of water absorption through the diffusion of water molecules according to the diffusion law. Absorption occurs because water molecules penetrate the mass of polymethyl methacrylate and occupy the positions between the polymer chains which causes disruptions to the polymer chains.¹⁴ The water absorbed acts as a plasticizer which affects the surface hardness, dimensional stability, colour stability, fatigue limit and transverse strength.⁵

Research by Hasanah shows that the surface roughness values of HCA resin polished with alumina were $0.3488 \pm 0.0767 \mu\text{m}$.¹⁵ Sahin stated that HCA resin polished with alumina and immersed in aquades for 2 days produces transverse strength value of 64.27 ± 4.30 MPa.¹⁶ The acquisition of a low transverse strength value is due to the rough surface of the acrylic resin resulting in high water absorption. Study conducted by Oliveira obtained that the HCA resin polished with pumice and chalk resulting in surface roughness value of $0.0427 \pm 0.25 \mu\text{m}$.¹⁷ Braun stated that the HCA resin polished with pumice and chalk and soaked in aquades for 2 days resulted in a transverse strength value of 89.05 ± 0.73 MPa.¹⁸ The acquisition of high transverse strength value is due to the smooth surface of acrylic resin resulting in low water absorption. This is supported by Rahal et al stating that high water absorption occurs on rough surfaces where

water enters through the surface porosity of acrylic resin after polishing.¹⁹

Based on the data obtained, the mean and the standard deviation value of transverse strength of pumice group was 93.63 ± 10.22 MPa. The value of transverse strength of eggshell group was 118.42 ± 12.66 MPa. The transverse strength value of toothpaste group was 105.91 ± 9.80 MPa. From the one-way Anova test in Table 1, it can be seen that there were minimal significant differences in the two groups because the significance of p was 0.001 and less than 0.05.

The pumice group has transverse strength value above the standard required in dentistry. In this study, the pumice group has a mean transverse strength value of 93.63 ± 10.22 MPa, this value was not much different from previous study which had a transverse strength value of 94.77 ± 9.45 MPa.⁴ Although the value of transverse strength in the pumice group is more than the required standard value but the value is lower than the eggshell and the toothpaste group due to the high water absorption in the pumice group. Water absorption occurs on rough surfaces where water enters through the surface porosity on acrylic resin.¹⁹ Yudi's study obtained that the HCA resin polished with pumice results in higher surface roughness value compared to eggshell and toothpaste group.²⁰ This is due to the differences in particle size, particle shape, particle hardness and abrasive material content of each polishing agent is different.^{10,13} Pumice with an irregular particle shape has a particle size of 5-8 μm and particle hardness of 6-7 according to the Mohs scale. High particle hardness and size produces higher surface roughness of acrylic resin, to the extent that when acrylic resin is immersed in distilled water, high water absorption occurs and the transverse strength decreases because water acts as a plasticizer which results in HCA being flexible.

The eggshell group has a mean transverse strength value of 118.42 ± 12.66 MPa higher than the pumice and toothpaste group. Yudi's research found that eggshell produces smoother surface.²⁰ According to Areeg & Bassam et al, physical properties of abrasive materials such as particle size and hardness are directly proportional to the quality of surface roughness.¹⁰ In this study, ball mill was used for 60 minutes. Wu SC et al stated that grinding eggshell using a ball mill for 60 minutes can produce an average particle size of 2.21 μm . Based on that study, it was known that longer grinding time with a ball mill produces smaller particle size.²¹ The hardness of eggshell particle is

4 according to Mohs scale. Smaller particle size and lower particle hardness of polishing materials have an advantage that is to produce smoother surface. In addition, the abrasiveness of eggshell material is influenced by the calcite content in calcium carbonate ranging 94-98.2%, calcite acts as an abrasive.¹⁰ With this, the water absorption that occurs in acrylic resin is low. This results in acrylic resin having great strength and being able to reduce deflection when force is applied which produces high transverse strength value.

The toothpaste group has a transverse strength value of 105.91 ± 9.80 MPa. Yudi's study found that toothpaste showed a lower surface value than pumice group but higher surface roughness value than eggshell group.²⁰ Pisani et al after experimenting the effect of abrasive toothpaste on surface roughness of acrylic resin, stated that toothpaste which contains silica has polishing effect on the surface of denture bases.¹³ The shape of the toothpaste particle is square or slightly rounded and the hardness of the particles according to the Mohs scale is 5.²² Although the amount of abrasive material in toothpaste ranges 20-55%, it is less than the pumice and eggshell group which makes the abrasive ability of toothpaste to be low thus the effectiveness when polishing is reduced, however the particle size is smaller than pumice and eggshell group which is an advantage for the toothpaste group. Toothpaste produces smoother surface compared to pumice group. Water absorption is high, thus resulting in lower transverse strength value compared to eggshell but higher transverse strength value than pumice group.

The LSD test shows a significant difference between the pumice group and eggshell group with p was 0.001, pumice group and toothpaste group with p was 0.019 and the eggshell group with the toothpaste group with a value of p was 0.017. Based on this, it can be statistically seen that the 4 eggshell group produced the highest transverse strength value compared to pumice and toothpaste group, while the toothpaste group produced higher transverse strength value compared to pumice group. Eggshells have an advantage, whereby it has the highest amount of abrasive material compared to other polishing material in which it has calcium carbonate content 94-98.2%.¹⁰

Clinically, the standard transverse strength value of denture base is not less than 65 MPa. Based on this, all three groups have fulfilled the standard transverse strength value requirement.

Pumice is the most widely used polishing material for acrylic resins because it has been proven that the transverse strength is more than 65 MPa, however the transverse strength value is still not better compared to eggshell and toothpaste. Eggshell produces better transverse strength value compared to pumice and toothpaste. Toothpaste produces better transverse strength value com-

pared to pumice, however it is still not better compared to eggshell.

It was concluded that the use of different polishing materials on heat cured acrylic bases has an influence on the value of transverse strength. Heat cured acrylic resin which was polished using eggshell has higher transverse strength value than that which was polished using pumice and toothpaste.

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