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COMPARATIVE EVALUATION OF SURFACE ROUGHNESS OF HEAT CURE POLY METHYL METHACRYLATE RESIN USING FOUR DIFFERENT ABRASIVES : AN IN VITRO STUDY

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ABSTRACT

OBJECTIVE: The objective of this in vitro study was to compare the efficacy of an eggshell abrasive material to the conventionally used pumice, garnet and aluminium oxide abrasives in reducing the surface roughness of dental prostheses

MATERIAL AND METHODS: Fourty poly methyl methacrylate specimens were fabricated and divided into four groups (n=10) based on finished methods they are subjected. Group I: Egg shell powder, Group II: Pumice powder, Group III: Garnet, Group IV: Aluminium oxide powder. Later, the surface roughness for the entire specimen was evaluated using Profilometer. Data were tabulated and statistically analyzed using analysis of variance and Tukey's test at significance level of 0.001.

RESULTS: Significant differences in the Ra values were observed between four groups (p-0.001). No significant differences were found between pumice and the eggshell powder abrasive (P>.092). Specimens polished with aluminium oxide had the highest Ra values, whereas specimens polished with the eggshell powder abrasive had the lowest Ra values.

SIGNIFICANCE : By connecting the Ra values to the threshold limit value of 0.2 mm, eggshell powder abrasive showed least surface roughness than conventionally used pumice, garnet and aluminium oxide.

INTRODUCTION

Since 1937, acrylic resins have been widely used in dentistry, especially in the field of Prosthodontics to fabricate different types prostheses including complete and partial dentures, temporary fixed partial dentures, implant retained over dentures, and maxillofacial prostheses.[1] Acrylic resins may be processed by heat-curing (HC), autocuring, or microwave- curing techniques.[2] Conventional resins that are used in dentistry are based on poly-methyl methacrylate (poly-MMA). Poly methyl methacylate resin has been widely used as a denture base material due to its excellent esthetics, low water sorption, relative lack of toxicity, ability to repair and simple processing techniques.

Proper finishing and polishing of dental materials are important aspects of clinical restorative procedures. Microorganisms which are present intraorally, especially those responsible for caries, periodontal disease, and denture-related stomatitis, can only survive in the mouth if they adhere to non shedding oral surfaces and start forming colonies. Bacterial adhesion on hard dental surfaces is followed by the accumulation of dental plaque.[3] Surface roughness and the surface free energy play a key role during this process.[4] Changes in these clinically important variables might have a significant influence on bacterial adhesion and retention. Surface free energy varies for different dental materials. A thin biofilm of the acquired salivary pellicle can significantly reduce free energy on hard intraoral surfaces.[5,6] Several studies have demonstrated that rough acrylic resin surfaces are significantly more prone to bacterial accumulation and plaque formation than smooth surfaces.[3-5]

Studies have also demonstrated that the calcium present in eggshells is similar to that of bone and teeth, thereby recommending its use as an abrasive in toothpastes to remove dental plaque.[7-9] In particular, and as demonstrated by Chen,[10] eggshell particles between 0.1 mm and 10 nm produce an ultrafine powder that can be used in toothpaste. Henuset[8] and Brandy-Garny[11] further revealed that eggshells are being used in the manufacture of abrasive paper, abrading wheels, bands and disks, and cosmetics. Despite the diverse use of eggshells, limited evidence is available for the abrasive potential of eggshell powder in the polishing of removable dental prostheses.Therefore, the aim of this in vitro study was to compare the efficacy of an eggshell abrasive material to the conventionally used pumice, garnet and aluminium oxide abrasives in reducing the surface roughness of dental prostheses.

MATERIAL AND METHODS

Preparation of PMMA specimens

A custom- made stainless steel mold (15 x 15 mm) was used to prepare 40 poly methyl methacrylate (PMMA) specimens (Figure 1). All specimens were polymerized according to the manufacturer's recommendations. After polymerizing, the specimens were trimmed with a tungsten carbide bur (Cross-cut, coarse-ISO No. 500104237065; Bredent GmbH & Co KG) at 18 000 rpm. Prior to final polishing, all specimens were finished with abrasive paper (CC768 silicon carbide; Deer Abrasives).

Development of an eggshell powder for polishing PMMA specimens

Eggshells collected from various food outlets were washed and disinfected by storing them for 6 hours in a diluted solution of household sodium hypochlorite. They were then vacuum dried for 6 to 9 minutes at 250C and crushed to a powder using a blender. Sodium lauryl surfactant which is used as surfactant was added to the eggshell powder to improve its solubility in water. In accordance with the American National Standards Institute/American Dental Association specification no. 37, the powder was sieved (Labotec sieving mesh, SABS 197-1971) to 0.3 mm.

Surface roughness analysis

The surface roughness (Ra values) of PMMA specimens was analyzed using a Wintrace surface analysis system profilometer (Figure 2)(Taylor Hobson Ltd). Surface roughness measurements were made on each specimen (figure 3), and the mean average Ra values were used for the statistical analysis. The data were tabulated and statistically analyzed using analysis of variance (ANOVA) and Tukey's test at a significance level of 0.001.

Figure 1 : Heat cure Polymethyl methacrylate specimens

Figure 2 : Prolifometer

Figure 3: surface roughness testing with prolifometer

RESULTS

The means and standard deviations for Ra readings can be seen in Table 1. Mean Ra readings ranged from 0.28 (egg shell powder) to 1.30 (aluminium oxide). Statistical tests revealed that interaction of all four groups were significant ($F = 49.11, p < 0.001$) for Ra. Table 2 shows Pairwise comparisions between all the four groups. It shows that no significant differences was found between specimens polished with eggshell (Group 1) and pumice (Group II). And significant differences are found between samples polished with Pumice (Group II) and Garnet (Group III), and between Garnet (Group III) and Aluminium oxide (Group 1V).

Table 1:- Comparison of denture surface roughness between 4 different abrasives

Study Groups	N	Mean	Std. Deviation	Minimum	Maximum	ANOVA	
						F	p-value
Egg Shell	10	0.28	0.03	0.24	0.32	49.11	<0.001*
Pumice	10	0.34	0.03	0.28	0.38		
Garnet	10	0.70	0.32	0.46	1.28		
Aluminium Oxide	10	1.30	0.27	0.98	1.98		

*p<0.05 Statistically Significant, p>0.05 Non Significant, NS

Table 2:- Pairwise comparison of denture surface roughness between 4 different abrasives

(I) Study Groups	(J) Study Groups	Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Egg Shell	Pumice	-0.06	0.09	0.92(NS)	-0.31	0.19
	Garnet	-0.41	0.09	0.001*	-0.67	-0.16
	Aluminium Oxide	-1.02	0.09	<0.001*	-1.27	-0.76
Pumice	Garnet	-0.35	0.09	0.003*	-0.61	-0.10
	Aluminium Oxide	-0.96	0.09	<0.001*	-1.21	-0.70
Garnet	Aluminium Oxide	-0.61	0.09	<0.001*	-0.86	-0.35

Tukey Post Hoc Test

*p<0.05 Statistically Significant, p>0.05 Non Significant, NS

DISCUSSION:

The present study evaluated and compared abrasive potential of four different abrasives on surface roughness of PMMA resin. To fully characterize the quality of the surface finish and polish of the polished PMMA resins, a different surface measurement approach has been suggested in literature.[12-14] In the present study, profilometry analysis was performed using a contacting stylus to measure the surface roughness of the PMMA resins. The data was then subjected to statistical analysis. As highlighted in International Standards Organization standard 4287,[15] Ra corresponds to the average peak and valley distance. The formulated hypothesis was accepted on the basis of the study results. The data demonstrated that the polishing material used significantly affected the surface roughness (Ra) of the polished PMMA specimens. Overall, the Ra values measured in all PMMA groups were below the acceptable threshold value of 0.2 mm. It can therefore be inferred that eggshell powder is effective in reducing the surface roughness of removable dental appliances.

The surface roughness of the PMMA group polished with fine eggshell powder and pumice was not statistically different (P<.0.92). Generally, the Mohs hardness value of pumice is 6 to 7, which is harder than eggshell (3.5-4). This indicates that pumice will provide a smoother surface finish.[16] The results of this study, however, revealed that eggshell powder are more likely to produce a better polish than pumice, garnet and aluminium oxide.

The highest mean average of Ra values was measured in the group 4 (Table 1), polished with Aluminium oxide, and the lowest with eggshell powder. This could, however, be attributed to the surfactant composition of the eggshell powder that is lacking in aluminium oxide.

In reviewing the articles related to the present study, the mean average Ra value measured in the group polished with pumice was found to be lower than those reported. Furthermore, the results of the present study, particularly with regard to pumice, are consistent with the findings of Srividya et al. They reported a mean Ra value between 0.36 and 0.14 mm, which is similar to the results of this study. Therefore, the use of eggshell powder can be recommended as effective denture abrasive material.

CONCLUSION:

Within the limitations, the following conclusions were made:

1. Eggshell powder effectively reduced the surface roughness of denture base resin to below the threshold limit value of 0.2 mm.
2. Specimens polished with eggshell powder abrasive

showed least surface roughness than pumice. However the results were statistically nonsignificant.

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