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Evaluation of roughness produced by commercially available dentifrices on denture base resins- *in vitro* study

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ABSTRACT

Denture cleanliness is essential to prevent malodor, poor esthetics, and the accumulation of plaque/calculus and biofilms. Several methods like brushing with dentifrice, soaking dentures in effervescent solutions and ultrasonic treatment have been suggested for physical removal of surface contaminants to reduce plaque and biofilms. Implementation of these methods depends on patient's social, financial and educational background and awareness for the maintenance of denture hygiene. Initially the overzealous patients meticulously try to clean plaque by using the abrasive agents and hard brush to remove plaque. This approach results in increase in the roughness of the denture surface causes faster accumulation of plaque and accelerated growth of micro organisms which results in denture stomatitis. Keeping this in mind the study was undertaken to establish which dentifrice is most and which is least abrasive on denture base resins and would create less surface roughness.

Keywords: Dentifrice, Denture base resin, Roughness

Introduction

Acrylic resins and resin-based restorative materials have been used widely in dentistry, especially in the field of prosthodontics, to fabricate different type prostheses, including complete and partial dentures, implant-supported overdentures, and maxillofacial prostheses. Acrylic resins may be heat-cured (HC), autocured, or microwave-cured. The surface finish of any dental prosthesis is an important factor that determines patient's comfort, prosthesis longevity, and esthetics.Abrasion of denture acrylic resins is an important and undesirable phenomenon both aesthetically and biologically because it modifies acrylic surface conditions, making it rougher and more susceptible to stains and biofilm accumulation, and may also interfere in its adaptation. The magnitude of the abrasiveness by brushing depends on some factors: dentifrice abrasiveness, characteristics of the brush bristles, brushing technique and frequency, strength applied on the brush and hardness of the brushed substrate.

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Microbial plaque on dentures should be scrupulously removed, since it may be detrimental to the health of the oral tissues. Accumulation of plaque on the denture surface occurs even after taking the meticulous care for finishing and polishing. The plaque gets deposited on the dentures due to poor oral hygiene. Dentures can be cleaned mechanically, chemically, or through a combination of both. Mechanical methods are comprised of brushing (associated with water, soap, dentifrice or abrasives) and ultrasonic treatment. Chemical methods are classified according to their composition and mechanism of action, i.e., hypochlorides, peroxides, enzymes, acids, crude drugs and mouth washes (oral rinses) for dentures. This study is to evaluate the effect of some commercially available dentifrices on the surface roughness of denture base resins.

Aims and Objectives

- To determine the least abrasive nature of a dentifrice on acrylic denture base resin.
- To measure the abrasion caused by the dentifrice on acrylic denture base resin

- To evaluate and compare the different resins, which when polymerized by a specific method is most resistant to abrasive degradation.
- To determine the least abrasive nature of brush on acrylic denture base resin
- To corroborate the findings to determine the method of curing which is more resistant to abrasion.

Materials and methods

This study was conducted, to quantitatively analyze the amount of surface roughness of denture base materials caused by different dentifrices. The processing technique was conventional heat cure.

Materials used were

- Two brands of polymethyl methacrylates i.e Stellon, Acralyn 'H'
- Two types of brushes that were used i.e. Senolin, Oral B and their specification are as follows in Table I

Table 1: Specifications of toothbrush

	Senolin	**Oral B**
Filament shape	Rounded	Rounded
Filament Diameter	0.20mm	0.16mm
Filament per tuft	40	35
Tuft end shape	Rounded flat	Rounded flat
Tuft Diameter	3mm	2.1mm
Tuft length	14mm	11mm
Head shape	Rectangular with rounded tip	rectangular
Tuft rows	4 x 4 2 x 3	13 x 4 1 x 3
No. of tufts	22	55
Tuft spacing along	3.4mm	12mm
Across	3.1mm	2.1mm
Row configuration	Parallel and converge towards tip and bottom	parallel
Brushing surface size	25 x 12mm	32 x 10mm

- Four types of toothpastes with their abrasive contents and particle size were as follows
  Promise with abrasion % 80 and particle size 9.27µm.
  Forhans with abrasion % 95 and particle size 4.3µm.
  Colgate with abrasion % 85 and particle size 8µm.
  Pepsodent with abrasion % 90 and particle size 4.5µm.

The percentage of the abrasives was found by dissolving 10gms of paste in 30ml of xylene in a beaker. The paste and xylene was continuously stirred with the glass rod till the paste gets dissolved in xylene completely. Then the solution was filtered using a whatman filter paper no.6 supported in funnel into a conical flask. The filter paper and precipitate was dried and weighed. The weight of precipitate gives the amount of abrasive present in toothpaste. This precipitate was smeared on to the glass slide and subjected to microscopic examination at 400 magnifications and the size of the abrasive particles were compared.

Preparation of the mold

A stainless steel strip 304 of 20mm width and 2mm in thickness is cut into 50mm length using a machine to obtain a rectangular die of 50mm x 20mm x 2mm dimensions. Three notches were made at a distance of 12.5mm on either side of the strip length wise. When two notches were joined they will be in the straight line. The dies were fixed on the glass slab using adhesive and taking care that they are actually spaced in a metal ring of 11.5cms in diameter. Then addition silicon duplicating material was mixed in the ratio of (1:1) as per manufacturer's directions and was poured in the metal ring taking care that no air bubbles get entrapped around the dies. The mould with the die is

left for 48 hours for complete polymerization. The dies were carefully taken out using a spray.

Preparation of the specimen

Modeling wax was melted at 48-52^{o}C in a double walled container with constant stirring. The molten wax is poured into the mould space taking care that no air is entrapped. After the wax hardens completely, it is carefully retrieved using air spray.The patterns were invested in the dental plaster and half the specimens were cured using conventional curing cycle and the other half were processed by microwave. In conventional curing the acralyzer was adjusted for initial polymerization process at 75^{o}C for 11/2 hours and final 100^{o}C for half an hour. In microwave processing, the flask is placed in the microwave oven at 500 watt power for 3 minutes after packing the acrylic. After curing the samples were retrieved from the flask. The samples were finished to remove any irregularities on the surface. Samples were sand papered and polished with the help of felt cone and fine pumice using a wet rag wheel. The prepared samples were placed in distilled water at room temperature.A total of 320 specimens were processed using two types of acrylic resin i.e. Stellon and Acralyn H and two types of curing cycles i.e. conventional heat curing and microwave curing. The samples were coded as per shown in Table 2,3.

Table 2: Coding of samples

B1	**P1**				**P2**				**P3**				**P4**			
	C		M		C		M		C		M		C		M	
	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A

Table 3: Coding of samples

B2	**P1**				**P2**				**P3**				**P4**			
	C		M		C		M		C		M		C		M	
	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A

B1- Senolin denture brush
B2- Oral B medium hard brush
P1- Promise
P2- Forhans
P3- Colgate
P4- Pepsodent
C- Conventional heat curing
M- Microwave curing
S- Stellon
A- Acralyn 'H'

Measurement of surface roughness

The Perthometer M4pi is an instrument, which is used for measuring surface roughness. Measurements were taken using the stylus method. A pick-up drawn slightly and at constant speed over the surface to be traced. The pick-up generated a two dimensional image of the profile by assessing the surface structure via the mechanical movements of the stylus tip which then converted into the digital values and into M4pi profile memory. The initial three roughness readings per sample were obtained before the samples were subjected to abrasive action. After the initial average roughness readings the samples were subjected to abrasive action using a brushing machine.

Creating the abrasiveness

Electrically operated brushing machine was fabricated. The machine was capable of giving 120 horizontal strokes per minute. The samples to be subjected for abrasion was placed on the platform in their respective slots. A total of four samples were tested at a time. The brushes were attached the movable part of the machine and pressure of 225gms on the brushes was adjusted by incorporating the spring between the brush and mechanical arm of the machine. Each sample was subjected to 20 minutes of abrasive action with brush and dentifrices. Total time machine was in operation was 20 minutes with an interval of every minutes of operation, just to clean the samples with distilled water and the slurry of fresh abrasive agent was applied.

After all the specimens have undergone abrasion, they are cleaned with after and dried and checked for surface roughness using Perthometer. 3 readings were made per specimen. The final average roughness reading of 10 samples per group is given in Table 4,5

Table 4 : Mean abrasion values for brush 1, Stellon and Acralyn H resins when polymerized by Conventional and Microwave methods

P1				P2				P3				P4			
S		A		S		A		S		A		S		A	
C RA	M RA	C RA	M RA	C RA	M RA	C RA	M RA	C RA	M RA	C RA	M RA	C RA	M RA	C RA	M RA
.06	.04	.08	.06	.16	.14	.19	.15	.07	.06	.09	.08	.14	.12	.14	.12

Table 5: Mean abrasion values for brush 2, Stellon and Acralyn H resins when polymerized by Conventional and Microwave methods

P1				P2				P3				P4			
S		A		S		A		S		A		S		A	
C RA	M RA	C RA	M RA	C RA	M RA	C RA	M RA	C RA	M RA	C RA	M RA	C RA	M RA	C RA	M RA
.02	.01	.03	.02	.13	.11	.16	.13	.05	.03	.05	.04	.12	.09	.13	.10

RA - A1 – A; A1 - After abrasion action;A - Before abrasion action

Observation and Results

A total number of 320 specimens, 160 for denture base acrylic material cured by two different methods and 10 in each group are prepared.The mean abrasion values significantly differed for brush Senolin and Oral B were 0.103 & 0.072 respectively ('t' value=5.394). From the mean values it is clear that abrasion is found to be more in Senolin compared to that of Oral B. One – way ANOVA revealed a significant difference among mean abrasion values for different pastes (F=357.495; p<0.000). The respective mean abrasion values for Promise, Colgate, Pepsodent and Forhans Pastes are 0.037, 0.056, 1.116, and 0.140 respectively. Further Scheffe's post hoc test clearly revealed that Promise paste had least abrasion values, followed by Colgate, Pepsodent and Forhans paste had maximum abrasion value. The mean abrasion values significantly differed for conventional and microwave methods. Independent samples't' test revealed a significant difference ('t' value=4.550; p<0.000). From the mean it is clear that abrasion is found to be more in conventional method (mean 0.099) compared to that of microwave method (mean 0.075).The mean abrasion values significantly differed for Acralyn H and Stellon materials. Independent samples't' test revealed a significant difference ('t' value= 2.414;p<0.016). From the mean values it is clear that abrasion is found to be more in Acralyn material (mean 0.094) compared to that of stellon (mean 0.081).

Table 6: The mean abrasion values for different brushes with reference to different pastes.

Paste	Brushes		
	Senolin	**Oral B**	**Average**
Promise	0.054	0.020	0.037
Forhans	0.155	0.126	0.140
Colgate	0.074	0.038	0.056
Pepsodent	0.128	0.105	0.116
Average	0.103	0.072	0.087

The 2-way ANOVA clearly revealed a significant difference among mean abrasion values of brushes and pastes. The interaction effect between brush and pastes is found to be non significant (F=2.094; p<0.101), indicating a similarity in the pattern of abrasion values of different pastes irrespective of the different brushes used.

Table 7 shows the mean abrasion values for different brushes with reference to different methods.

Table 7: Mean abrasion values for different brushes with reference to different methods

Method	Senolin	Oral B	Average
Conventional	0.115	0.083	0.099
Microwave	0.090	0.061	0.075
Average	0.103	0.072	0.087

The 2- way ANOVA clearly revealed a significant difference among mean abrasion values of brushes and materials .the interaction between the brush and materials is found to be non significant (F=0.003;p<0.953), indicating a similarity in the pattern of abrasion values of different materials irrespective of the different brushes used. Table 8 shows the mean abrasion values for different brushes with reference to different methods.

Table 8: Mean abrasion values for different brushes with reference to different methods

Method	Senolin	Oral B	Average
Acralyn H	0.109	0.079	0.094
Stellon	0.096	0.066	0.081
Average	0.103	0.072	0.087

Table 9: Mean abrasion values for different brushes with reference to different methods/materials

Method/Material	Senolin	Oral B	Average
Con Acralyn H	0.120	0.077	0.099
Con Stellon	0.111	0.090	0.100
Micro Stellon	0.082	0.054	0.068
Micro Acralyn H	0.097	0.068	0.083
Average	0.130	0.072	0.087

The 2-way ANOVA clearly revealed a significant difference among mean abrasion values of brushes and method/materials. F value of 9.225 with 1 and 312 is found to be significant at 0.000 levels. The mean abrasion values for different method/materials like conventional Acralyn H, Conventional Stellon are found to be 0.099,0.083 respectively. Table 10 shows further Scheffe's post hoc test that revealed that microwave Stellon and Acralyn H had least abrasion values. The interaction effect between brush and method/ materials is found to be non significant (F=0.910; p<0.437), indicating a similarity in the pattern of abrasion values of different method/materials irrespective of the different brushes used.

Table 10: Scheffe's post hoc test

Method/Material	N	Subset for alpha = 0.05	
		1	2
Micro Stellon	80	0.068	
Micro Acralyn H	80	0.083	0.083
Con Acralyn H	80		0.099
Con Stellon	80		0.100

Discussion

A wide variety of agents are used by patients for cleaning denture. The studies of effect of these cleansing agents on the denture base resin, showed varying degrees of abrasivity. Various studies were carried out with different dentifrices and brushes that are widely used by the denture wearers for cleaning their dentures. This study was undertaken to evaluate the surface roughness of the denture base resins by selecting four dentifrices and two brushes randomly out of which that were available in the market. Dayer D *et al*[1] reported in his study that soft filament tooth brushes produced more tooth abrasion of hard substrates than hard brushes. This could be explained by soft brushes retaining more paste among the narrower diameter filaments and having a greater contact surface area with the substrate. It could be that brushes which maintain a high contact surface area of filaments to substrate will clean more effectively. Increasing filament contact area could be achieved through differences in head filament density, reducing filament stiffness or changing filament cross sectional shape. In the present study it was observed that medium tooth brush that had softer bristles than the denture cleaning brush caused less abrasion. Both the brushes had circular bristle ends. All the bristles in each brush were of same length, density and stiffness. He also conducted a study on acrylic that was abraded by tooth brush and paste. Two types of motion were used, linear and rotary. Abrasion was determined by profilometer. Linear motion showed the abrasion between 0.41-4.32 µm. while rotary motion showed the abrasion between 0.11-3.41µm.In the present study denture base resin strip was the substrate to be abraded. The motion used was linear and the amount of substrate loss was found out by perthometer to 0.01-0.16µm.Forward GC[2] in his study of role of tooth pastes in the cleaning of tooth, found that the abrasivity of materials could be controlled by varying particle size. Generally, the lower particle size, the lower the abrasivity.The present study showed that the dentifrices with smaller particle size abrasive agents caused more abrasion than the dentifrices with large particle size. This could be attributed the percentage of abrasive agent present in a dentifrice.Bull WH *et al*[3] did studies on the abrasion of crown and root. The loss was calculated by counting the radioactive decay using end –window Geiger counter. The result showed 1.2x10-8 g/brush stroke loss in enamel whereas dentin loss was 98x10-8. g/brush stroke.In the present study the abrasion of denture base resin was found out by perthometer that was 0.01-0.16µm.Goldstein GR and Lerner T[4] conducted a study on the abrasion of hybrid composite resin by tooth brush and dentifrice. The surface roughness was evaluated profilometrically after the specimen was subjected to 20,000 strokes. It was found out to be between 57.88-226.22 µm. In the present denture base resin was subjected to 2400 strokes. The loss of acrylic was 0.01-0.16 µm. Wright HN and Fenske EL[5] conducted a study on enamel and dentin of freshly extracted non carious teeth. Teeth were subjected to abrasion and the loss was determined. The loss of enamel, dentin and CEJ was 0.011- 0.032 µm, 0.073-0.831 µm and 0.053-0.646 µm respectively. In the present study the loss of denture base resin was 0.01-0.16 µm. this must be due to lower hardness of resin when compared to enamel, dentin and CEJ. Harrington E. *et al*[6] conducted a study on tooth brush dentifrice abrasion on conventional composite, silicate cement, amalgam, self cure acrylic and glass ionomer. Composite resin having a hardness of 50-60 KHN showed a loss of 9.1- 15 µm, silicate cement which has the hardness of 70 KHN showed a loss of 12.3 µm, amalgam which has the hardness of 100 KHN showed a loss of 14.5 µm and glass ionomer having a hardness of 48 KHN showed a loss of 27 µm while self cure acrylic which has got a hardness of 16-18 KHN showed a loss of 120 µm. In the present study the denture base acrylic resin has KHN 20. It showed the loss between 0.01-0.16 µm. Heath JR, Davenport JC and Jones PA[7] studied that the rate of abrasion decreased as the temperature of the slurry was raised. It was considered that the filaments softened more than the specimen with a rise in temperature, thus reducing the load applied to the abrasive system, and resulting in the decline in the wear produced. He conducted an experiment with a mechanical brushing machine on acrylic blanks. The average roughness produced was between 0.02-0.1 µm after 1000 strokes that is equivalent to 1 year of brushing twice daily.In the present study the abrasion test was conducted on denture base resin. It was abraded for 2400 strokes that is equivalent to 6 months of brushing twice daily. The wear produced was between 0.01-0.16 µm. the temperature of the slurry was constant at 37ºC.

Summary and conclusion

In this study 4 dentifrices and 2 brushes were used for abrading 2 types of denture base resins when polymerized by microwave and conventional methods.
It was concluded that;

- The specimen cured by microwave was more abrasion resistant than conventionally cured ones. The mean abrasion value for microwave

was 0.075µm while for conventional it was 0.099 µm.

- Senolin denture brush created more abrasion than Oral B brush. The mean abrasion value for Senolin was 0.103 µm while for Oral B it was 0.072 µm.
- Stellon denture base acrylic resin was more resistant than Acralyn H. The mean abrasion value for Stellon was 0.081 µm while for Acralyn H it was 0.094 µm.

Among the dentifrices;
-Promise that has abrasive agent particle size 9.27 µm and 80% of abrasive showed minimum abrasion. The mean abrasion value was 0.037 µm.
-Colgate that has abrasive agent particle size 8 µm and 85% of abrasive showed a greater amount of abrasion compared to Promise. The mean abrasion value was 0.056 µm.
-Pepsodent that has abrasive agent particle size 4.5 µm and 90% of abrasive showed a greater amount of abrasion compared to promise and Colgate. The mean abrasion value was 1.116 µm.
-Forhans that has abrasive agent particle size 4.3 µm AND 95% of abrasive showed maximum abrasion compared to all other dentifrices used in this study. The mean abrasion value was 1.140 µm. Accelerated aging of six months was calculated on the basis of cleaning the denture once in day.

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Conflict of Interest: None

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