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COMPARATIVE EVALUATION OF DENTURE CLEANSERS ON SURFACE ROUGHNESS AND FLEXURAL STRENGTH OF HEAT CUREDENTURE BASE RESIN

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ABSTRACT

Oral cavity contains variety of microorganisms that are capable of causing various pathological conditions. To avoid these pathological conditions various chemical agents are used to maintain the denture in proper hygiene. **Aim:** To study the effectof different chemical cleansers on surface roughness and flexural strength of heat cure denture base resin. **Material and methodology:** According to ADA Specification No. 12 for heat cure denture base resin, the samples were made. After cleansing protocol with various chemical cleansers, all samples were evaluated for surface roughness and flexural strength by mean of surface analyser (Surftest SJ-210, Mitutoyo, USA) and universal testing machine (Instron). **Results:** Data obtained by testing was compiled and analysed using statistical software SPSS version 19.0. ANOVA and Post-hoc Tukey's tests were used and p-value <0.05 was considered significant in all tests. **Conclusion:** All heat cure denture base resin samples immersed in various chemical cleansers, sodium hypochlorite (4%) showed significant increase in surface roughness and decrease in flexural strength.

INTRODUCTION

Denture hygiene is of utmost importance because dentures are used by the patients throughout the day and are in constant touch with oral environment including various microorganisms.[1] The microbial load of the prosthesis is responsible for increased incidence of oral problems such as denture stomatitis, inflammatory papillary hyperplasia etc.[2] Three methods are advocated for cleaning of dentures that includes mechanical, chemical and combination of both. Mechanical method is routinely and widely used by the patients but many elderly are unable to follow it because of lack of compliance and poor motor coordination due to age and hence, the use of chemical denture cleansers becomes a viable option for such patients. Denture cleansers are either available commercially (sodium hypochlorite solutions) or are any regular household item (vinegar). Many studies have shown that the cleansers may alter the physical properties of denture base resin on prolonged used.[3] Among various physical properties, flexural strength is of prime interest because denture base resins may fail clinically due to flexural fatigue.[4] Effect of cleansers on surface roughness of acrylic resins is also relevant as it can influence the adhesion and retention of microorganisms which can further aggravate oral problems.[5] In developing country like India use of household products as denture cleanser is very common therefore there is need to evaluate the effect of products on surface roughness and flexural strength of the denture base resins.[6] So this study was aimed to evaluate and compare the effect of denture cleanser on heat cure denture base resin.

MATERIALS AND METHODOLOGY

FABRICATION OF STAINLESS STEEL MOULDS

Stainless Steel Mould for Surface Roughness

A custom-made stainless steel circular mould as per ADA Specification No. 12 was prepared for making the study samples. The dimension of the mould was 10 mm x 2 mm. The circular mould was made up of stainless steel block of 15 mm diameter and 10 mm diameter step was carved on its superior surface. The mould had a ring (riser) around its periphery to contain wax pattern and stainless steel lid to press the wax pattern (Fig 1).

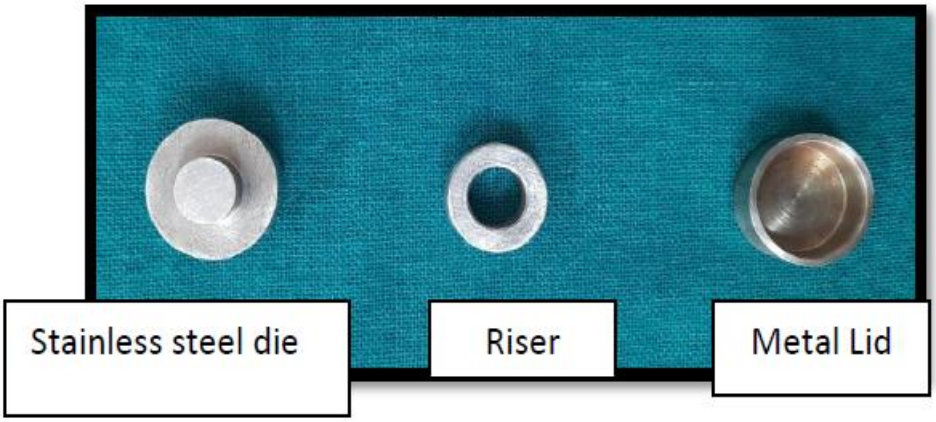


Figure 1: Stainless Steel Mould (10mm X 2mm) for Surface Roughness.

Stainless Steel Mould for Flexural Strength

The stainless steel rectangular mould was prepared with ADA Specification number 12. The dimension of the mould was 65 mm x 10 mm x 2.5 mm. It had two compartments, the upper compartment with locking keys and the lower compartment with a detachable wall. This wall had a key at both the ends and the corresponding keyholes at the other segmented part (Fig 2).

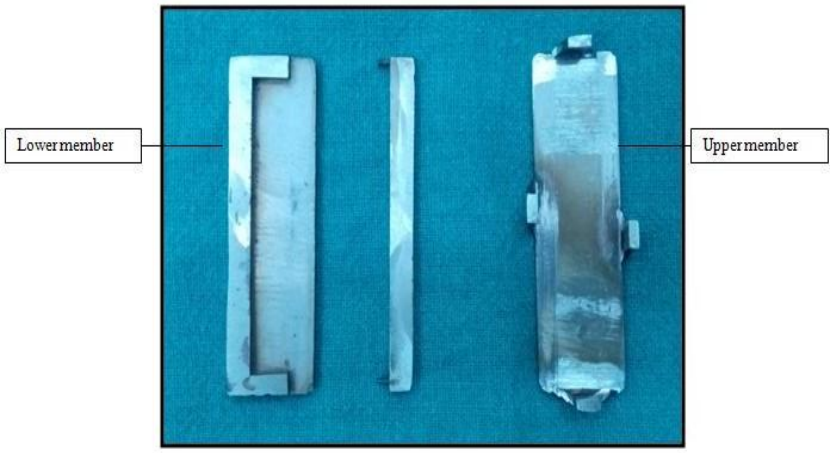


Figure 2: Stainless Steel Mould (65 mm x 10 mm x 2.5 mm) for Flexural Strength.

SAMPLE DISTRIBUTION

For Surface Roughness and flexural strength, a total of 120 samples of heat cure denture base resin were fabricated with the help of stainless steel mould size (10 mm X 2 mm) and (65 mm x 10 mm x 2.5 mm). Further, samples were randomly subdivided into 8 subgroups (n=15) based on the different chemical cleansers used in the study.

METHODOLOGY

Fabrication of Samples for Surface Roughness & Flexural Strength

Disc shaped wax patterns of dimension (10 mm in diameter and 2 mm thickness) for surface roughness testing and rectangular wax patterns of dimension (65 mm x 10 mm x 2.5 mm) for flexural strength testing were fabricated using stainless steel mould according to ADA specification no. 12. These wax patterns were invested in dental plaster in a metallic flask (Fig 3). After setting of the dental plaster (Kaldent, Kalabhai, India), dewaxing was performed followed by application of separating media (Cold mould seal, India). Moulds were packed with heat polymerized acrylic resin (DPI Heat Cure, India) and were processed according to manufacturer's instructions. Long cure cycle of polymerization (74 degree Celsius for 8 hours followed by100 degree Celsius for 1 hour) was done. The specimens were removed from the moulds and trimmed using tungsten steel bur mounted in a handpiece at low speed followed by finishing with 120, 220, 320-grit sandpaper and polishing with wet rag and slurry of pumice. Dimensions of all specimens were checked with digital Vernier caliper and those not accurate were replaced with new specimens. All specimens (Fig 4) thus obtained were immersed in distilled water at 37±1ºC for 24 hours for residual monomer elimination.

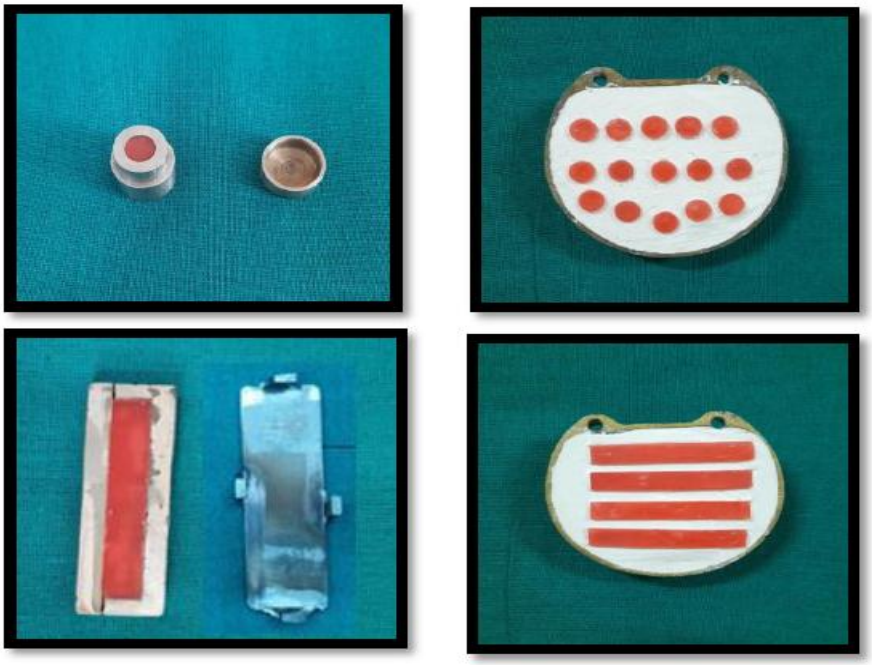


Fig 3: Fabrication of wax patterns.

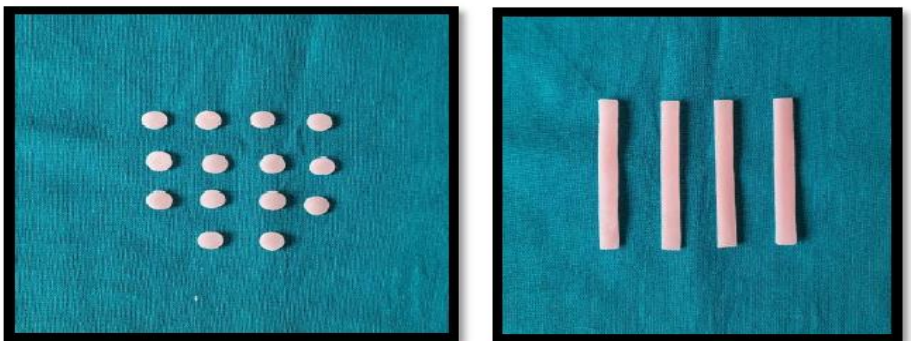


Fig 4: Finished and polished samples.

Cleansing Protocol

All samples in each group were subjected to daily cleansing for 10 minutes by immersion in 100 ml solution of respective chemical cleansers (sodium hypochlorite, vinegar, Chlorhexidine Gluconate, Dettol, Baking soda, Glutaraldehyde and Fittydent tablet) for a time period of 3 months. Chemical cleansing solutions were changed every week. Samples immersed in distilled water were served as control.

S.NO.	NAME	CONCENTRATION	BRAND	IMMERSIONTIME
1.	Sodium hypochlorite	4%	Rin Ala bleach,Hindustan Unilever, India	10 minutes
2.	Vinegar	5%	American garden Co, NewYork, USA	10 minutes
3.	Mouthwash (Chlorhexidine)	0.2%	Clohex mouthwash, Dr. Reddy's, India	10 minutes
4.	Dettol	4.8%	Dettol, ReckittBenckiser, UK	10 minutes
5.	Baking soda	8.5%	Nutroactive Industries Pvt.Ltd., India	10 minutes
6.	Glutaraldehyde	2%	CDH, Delhi,India	10 minutes
7.	Fittydent tablet	1 tablet	Fittydent,Austria	10 minutes

Test for Surface Roughness

Surface analyser (Surftest SJ-210, Mitutoyo, USA) was used to measure the surface roughness of each samples at the beginning of the study (day 1) and at the end of the study day (day 90). The stylus of analyser moved across the specimen surface and analyser measured the stylus

displacement through the inductance of the sensor inductor. The mean roughness (Ra) of the samples was calculated after cleansing protocol with every chemical agent (Fig 5).

Fig 5: Surface roughness testing in Surface Profilometer.

Test for Flexural Strength

For testing flexural strength, specimens were subjected to three point bending test by mounting specimens on Universal testing machine (Instron, India) and loading with 50 Kgf (Kilogram – force) at a crosshead speed of 5 mm/min (Fig 6). Peak load was noted at which the specimens fracture. The flexural strength (S) of each rectangular specimen was calculated using the following formula,

$$S = \frac{3PL}{2bd^2}$$

Where S = flexural strength (MPa), P = peak load, L = distance between the supports (50 mm), b = width of specimen (10 mm), d = specimen thickness (2.5 mm).

Fig 6: Flexural strength testing in Universal Testing Machine.

RESULTS

In the present study the statistical software SPSS 19.0 was used to analyse the data. Results on continuous measurements are presented on Mean ± SD. Significance is assessed at 5% level of significance. ANOVA test with post hoc Bonferroni for multiple comparisons has been used to find the significance of study parameters on ordinal scale between more than two groups.

The results of the study indicated that Surface Roughness values of heat cure denture base resin samples after immersion in different denture cleansers in descending order can be written as; Sodium Hypochroide > Chlorhexidine > Vinegar > Baking soda > Fittydent tablet > Glutaraldehyde > Dettol > Control.

Table 1, 2 and Graph 1 show the mean and standard deviation for each denture cleanser. The one-way ANOVA analysis data showed statistically significant difference ($p<0.001$) in surface roughness of groups. Further analysis with the Post hoc Bonferroni test indicated significantly higher surface roughness for specimens immersed in sodium hypochlorite compared to other groups.

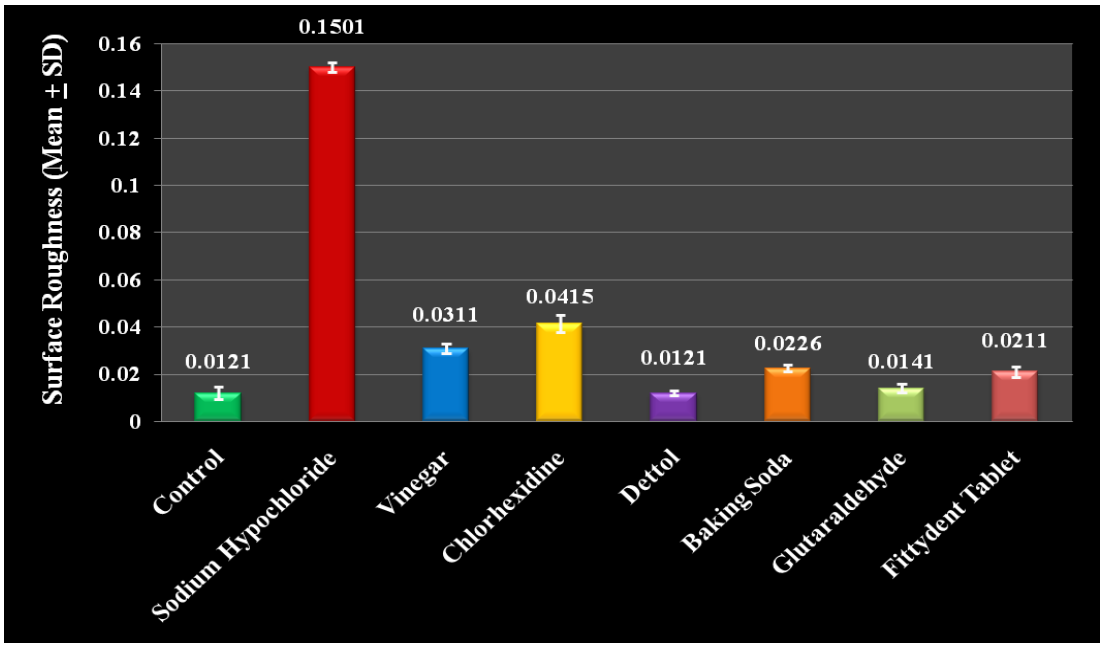
Table 1: Surface Roughness of heat-cure denture base resin with various cleansers.

	n	Surface Roughness		ANOVA	p - value
		Mean	SD		
Control	15	0.0121	.0026	6291.686	**< 0.001***
Sodium Hypochloride	15	0.1501	.0021		
Vinegar	15	0.0311	.0021		
Chlorhexidine	15	0.0415	.0037		
Dettol	15	0.0121	.0011		
Baking Soda	15	0.0226	.0015		
Glutaraldehyde	15	0.0141	.0019		
Fittydent Tablet	15	0.0211	.0021		

SD – Standard Deviation, * - Very Highly Significant

Table 2: Multiple Comparison (Post hoc Bonferroni).

	p - value
Control vs Sodium Hypochloride	< 0.001*
Control vs Vinegar	< 0.001*
Control vs Chlorhexidine	< 0.001*
Control vs Dettol	1.000 (NS)
Control vs Baking Soda	< 0.001*
Control vs Glutaraldehyde	0.592 (NS)
Control vs Fittydent Tablet	< 0.001*
Sodium Hypochloride vs Vinegar	< 0.001*
Sodium Hypochloride vs Chlorhexidine	< 0.001*
Sodium Hypochloride vs Dettol	< 0.001*
Sodium Hypochloride vs Baking Soda	< 0.001*
Sodium Hypochloride vs Glutaraldehyde	< 0.001*
Sodium Hypochloride vs Fittydent Tablet	< 0.001*
Vinegar vs Chlorhexidine	< 0.001*
Vinegar vs Dettol	< 0.001*
Vinegar vs Baking Soda	< 0.001*
Vinegar vs Glutaraldehyde	< 0.001*
Vinegar vs Fittydent Tablet	< 0.001*
Chlorhexidine vs Dettol	< 0.001*
Chlorhexidine vs Baking Soda	< 0.001*
Chlorhexidine vs Glutaraldehyde	< 0.001*
Chlorhexidine vs Fittydent Tablet	< 0.001*
Dettol vs Baking Soda	< 0.001*
Dettol vs Glutaraldehyde	0.592 (NS)
Dettol vs Fittydent Tablet	< 0.001*
Baking Soda vs Glutaraldehyde	< 0.001*
Baking Soda vs Fittydent Tablet	1.000 (NS)
Glutaraldehyde vs Fittydent Tablet	< 0.001*



Graph 1: Mean difference in Surface Roughness (µm).

Table 3, 4 and Graph 2 shows the mean flexural strength (S) and standard deviation for each denture cleanser. The one-way ANOVA analysis data showed statistically significant decrease ($p<0.001$) in flexural strength.

Further analysis with the Post hoc Bonferroni test indicated significant decrease in the flexural strength of specimens immersed in sodium hypochlorite compared to other groups; Flexural Strength of heat cure denture base resin specimens after immersion in different denture cleansers in descending order can be written as; Control > Fittydent tablet > Glutaraldehyde > Dettol > Baking soda > Vinegar > Chlorhexidine > Sodium Hypochroide.

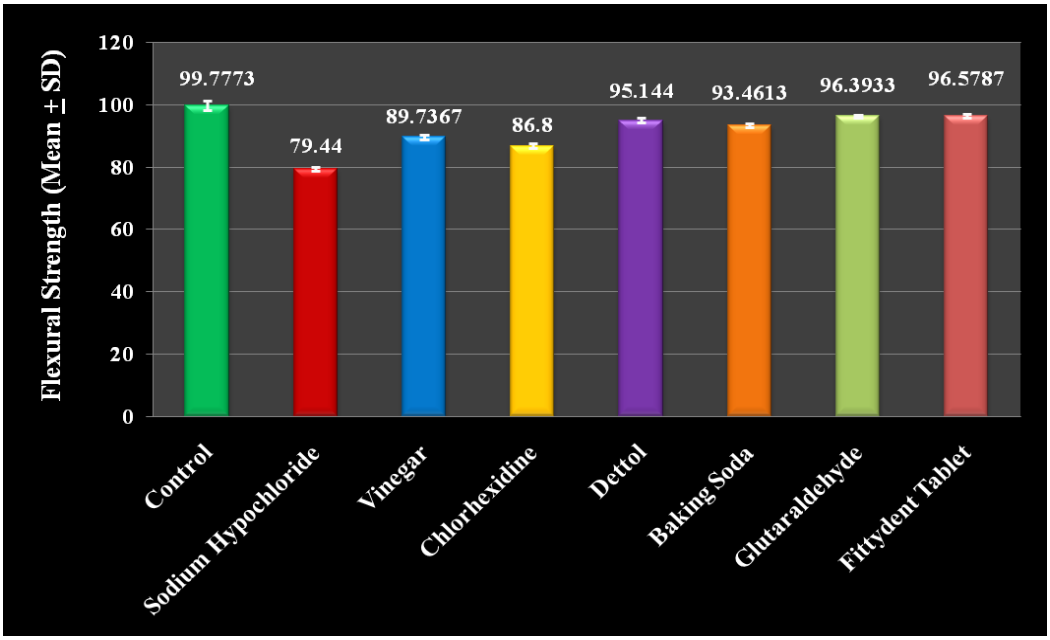
Table 3: Flexural Strength of heat-cure denture base resin with various cleansers.

	n	Flexural Strength		ANOVA	p - value
		Mean	SD		
Control	15	99.7773	1.5393	943.000	**< 0.001***
Sodium Hypochloride	15	79.4400	0.6898		
Vinegar	15	89.7367	0.7717		
Chlorhexidine	15	86.8000	0.7622		
Dettol	15	95.1440	0.7232		
Baking Soda	15	93.4613	0.5412		
Glutaraldehyde	15	96.3933	0.5749		
Fittydent Tablet	15	96.5787	0.5748		

SD – Standard Deviation, * - Very Highly Significant

Table 4: Multiple Comparison (Post hoc Bonferroni).

	p - value
Control vs Sodium Hypochloride	< 0.001*
Control vs Vinegar	< 0.001*
Control vs Chlorhexidine	< 0.001*
Control vs Dettol	< 0.001*
Control vs Baking Soda	< 0.001*
Control vs Glutaraldehyde	< 0.001*
Control vs Fittydent Tablet	< 0.001*
Sodium Hypochloride vs Vinegar	< 0.001*
Sodium Hypochloride vs Chlorhexidine	< 0.001*
Sodium Hypochloride vs Dettol	< 0.001*
Sodium Hypochloride vs Baking Soda	< 0.001*
Sodium Hypochloride vs Glutaraldehyde	< 0.001*
Sodium Hypochloride vs Fittydent Tablet	< 0.001*
Vinegar vs Chlorhexidine	< 0.001*
Vinegar vs Dettol	< 0.001*
Vinegar vs Baking Soda	< 0.001*
Vinegar vs Glutaraldehyde	< 0.001*
Vinegar vs Fittydent Tablet	< 0.001*
Chlorhexidine vs Dettol	< 0.001*
Chlorhexidine vs Baking Soda	< 0.001*
Chlorhexidine vs Glutaraldehyde	< 0.001*
Chlorhexidine vs Fittydent Tablet	< 0.001*
Dettol vs Baking Soda	< 0.001*
Dettol vs Glutaraldehyde	0.002 (HS)
Dettol vs Fittydent Tablet	< 0.001*
Baking Soda vs Glutaraldehyde	**< 0.001***
Baking Soda vs Fittydent Tablet	**< 0.001***
Glutaraldehyde vs Fittydent Tablet	1.000 (NS)



Graph 2: Mean difference in Flexural Strength (MPa).

DISCUSSION

Many author studied the effect of various chemicals solution on physical and mechanical properties of heat cure denture base resin.[6] However in the present study some household materials were included along with known chemical disinfectants to evaluate their effect on physical properties of denture base material.

In the present study, 4% sodium hypochlorite solution Showed significant decrease in flexural strength due to leaching out of the plasticizer (dibutyl phthalate) from the PMMA resin.[11] The samples also showed increase in surface roughness when compared to control group as the leaching out of the plasticiser (dibutyl phthalate) from PMMA causes pitting of the surface of heat cure PMMA resin.[12] The heat cure denture base resin sample when immersed in 5% vinegar (acetic acid) showed significant decrease in flexural strength when compared to control group. Acetic acid though, a weak acid, reacts with heat cure acrylic resin, resulting in increased solubility of glycol dimethacrylate (cross linking agent) thereby causing weakening.[13] These samples also showed increase in surface roughness due to disruption of bond present between methyl methacrylate and glycol dimethacrylate.[13] Sample immersed in 0.2% Chlorhexidine showed Decrease in flexural strength due to Disruption of the bonds present between polymer chains of PMMA[13] and increase in surface roughness compared to control group due to Anions and cations of chlorine compounds released form 0.2% Chlorhexidine causes bleaching of the surface of the PMMA resin results in surface irregularities.[15]

When sample immersed in Dettol (4.8% Chloroxylenol) showed decrease in flexural strength and Increase in surface roughness as compared to control group due to Diffusion of molecules from cleansing solution into PMMA. Thus, results in the termination of polymer chains of PMMA[16], softening of resin and causes pitting of the surface of heat cure PMMA resin.[13,17] Sample immersed in 8.5% sodium bicarbonate solution showed Increase in surface roughness due to release of carbon dioxide when it is dissolved in water. This carbon dioxide with its effervescent action causes loosening of debris along with minute physical damage to the external surface of PMMA resin.[13, 18] Also showed decrease in flexural strength due to the peroxide solution that is formed after sodium bicarbonate is dissolved in water leads to increased water sorption of the PMMA resin which leads to softening of the PMMA resin.[18]

In the present study, 2% Glutaraldehyde responsible for causing decrease in flexural strength and increase in surface roughness when compared to control group due to progressive release of polymer chain[19] and polymer chain release causing pitting of the external surface of the PMMA resin.[20] Commercially available Fittydent (Sodium Perborate) tablet also causing decrease in flexural strength because When sodium perborate is dissolved in water a alkaline peroxide solution is formed. This alkaline peroxide solution further gets decomposed into soldium metaborate, hydrogen peroxide and nascent oxygen. The nascent oxygen leads to increased water sorption of the PMMA resin.[21] This nascent oxygen also responsible for causing irreversible damage to the external surface of the PMMA resin thus, results in increased surface roughness.[13,21]

Thus, it has been observed, in current study that chemical immersion technique causes reduction in the surface roughness and flexural strength. However in the current study both the parameters surface roughness and flexural strength were evaluated after 3 months. Further, other physical parameters such as color, surface hardness and impact strength may be included.

CONCLUSION

Within the scope of the study, following conclusion were drawn.

1. Among all denture cleansers, Surface roughness of Sodium hypochlorite (0.1501 µm) samples seen to be highest when compare to samples immersed in, Chlorhexidine(0.0415 µm), vinegar (0.0311 µm), Baking Soda (0.0226 µm), Fittydent Tablet (0.0211 µm) Glutaraldehyde (0.0141 µm) and Dettol (0.0121 µm).
2. Among all denture cleansers, Flexural Strength of Sodium hypochlorite (79.4400 MPa) samples seen to be lowest when compare to samples immersed in Chlorhexidine (86.8000 MPa), vinegar (89.7367 MPa), Baking Soda (93.4613 MPa), Dettol (95.1440 MPa), Glutaraldehyde (96.3933 MPa) and Fittydent Tablet (96.5787 MPa).

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