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Evaluate and Compare the Effect of Water of Different Hardness Levels on the Surface Irregularity in 3 Different Heat-Polymerized Denture Base Resins

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Abstract

This study aimed to evaluate and compare the effect of water with varying hardness levels on the surface irregularity of three different heat-polymerized denture base resins. The hardness of water used in dental applications has been shown to influence the properties of dental materials, including denture base resins. In this study, three commonly used heat-polymerized denture base resins were subjected to immersion in water with different hardness levels. The surface irregularity of the denture base resins was assessed using profilometric analysis before and after immersion. Results indicated that water hardness significantly impacted the surface irregularity of the denture base resins, with varying effects observed among the different resin materials. Understanding the influence of water hardness on denture base resin properties is crucial for optimizing denture performance and durability in clinical practice. These findings contribute to the knowledge base surrounding dental material science and may inform the development of guidelines for water quality in dental applications.

Keywords: water hardness, denture base resins, polymerization, surface irregularity, profilometric analysis, dental materials, dental applications.

INTRODUCTION

Methods to replace teeth were discovered thousands of years ago. In 700BC complete dentures were made of ivory and bone. During the revolution, they were fabricated with gold and silver. Acrylic resins were the next major revolution in fabrication of the complete dentures for rehabilitation in completely edentulous patients. Complete dentures are the most used treatment to rehabilitate completely edentulous cases and PMMA resin base material is the material of choice. PMMA was introduced in 1937 by Dr. Walter wright and Vernon's brothers having properties such as odorless, low solubility, easy to repair, biocompatible and adequate strength and stability. The oral cavity serves as a habitat for diverse microbial species. Many of these microorganisms thrive in the mouth by adhering to non-shedding surfaces such as the rough surfaces of teeth and the oral mucosa. The surface irregularity of intraoral hard tissues is clinically significant as it relates to bacterial retention.[1]

The surface irregularity of the resin material following the fabrication of complete dentures is also directly linked to bacterial adhesion. An

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elevation in the surface irregularity of denture base resin beyond an Ra value of 2 microns led to a significant rise in bacterial colonization compared to smoother surfaces (Ra = 0.12). Conversely, alterations in surface free energy had minimal influence on bacterial adhesion [2]. Therefore, the impact of surface irregularity [Ra] supersedes the effect of surface free energy. An increased textural irregularity of the denture base has a direct sequela on the oral cavity resulting in denture stomatitis, denture hyperplasia and many more. Hence, in regular dental practice, we need to chart out a review and maintenance protocol for the patients to prevent any post treatment complications.

It is advised to submerge dentures in water after cleaning, especially when they are not in use, to prevent deformation [3]. Most often, during night hours, patients are advised to keep the dentures in tap water. In this scenario the quality of water should be taken into consideration. Water is of different densities depending on its hardness level, such as: extremely soft water, soft water, hard and extremely hard water [2] Many regions in India supplies hard water. The hardness of water may affect the textural irregularities of the denture base resins.

Therefore, the current investigation was conducted to evaluate the impact of different water hardness levels on the surface texture irregularities of three distinct heat-polymerized denture base materials. The aim was to evaluate the appropriate density of water suitable for the denture base resins that can be recommended to the patients for denture storage without any surface changes and improve the longevity of the dentures.

LITERATURE REVIEW

The acrylic material used in this study are of different composition with different physical and chemical properties. Smooth surface acrylic resin denture material is vital, as it can affect oral tissues when the denture surface is coarse. On the other hand, rough surfaces promote adherence of micro-organisms on the acrylic resin material which are the choice of treatment in rehabilitation of oral cavity that may lead to plaque accumulation [4, 5, 6]. Threshold values of surface irregularity of denture material for microorganism adherence was noted to be 0.2 m [5].

Values of Surface texture irregularities more than 0.2 μm may promote adherence of bacteria on the denture surface that may ultimately lead to plaque formation on the denture, during use of denture in oral cavity of patient [3]. Bollen et al. and Radford et al. Stated that increased bacterial colonization occurs on the denture surface when the surface irregularity values surpass 2.0 μm [2, 4]. Studies have shown that the assessment of a polished acrylic resin surface can range from 0.03 μm to 0.75 μm, contingent upon the finishing and polishing method employed for the denture. In our study, after the standardized polishing technique were used in which the optimum polished surface irregularity was obtain by mechanical polishing method [5]. Hence, in our present study to reduce the bias the sample with increased values of surface irregularity before immersion of the acrylic plates compare to the optimal value were discarded.

So, there was a higher chance of bias such as the increased values of surface irregularity before immersion of the plates in different water density samples, while those acrylic plate samples with surface irregularity higher than the optimal values as mentioned above were discarded for the study.

In our natural habitat, we use water of different densities such as soft and hard water. There are many geographical areas in India which have hard water that contain high level of solutes. Water with calcium carbonate concentrations below 60 mg/l is typically labeled as soft; 60–120 mg/l is categorized as moderately hard; 120–180 mg/l is classified as hard; and concentrations exceeding 180 mg/l are termed very hard [6].

Packaged water

Packaged water is available as spring or mineral water or bottled tap water. The mineral composition of marketed bottled water has extreme variation in the mineral composition with solids dissolved

ranging from thousands milligram/liter to almost zero. The ideal range of density is 60- 120micron. Hence, it is of extreme importance that the public should have access to the content displayed.

Collected rainwater

Gathering water at home or within the local community for local consumption is commonly known as rainwater collection. Rainwater is typically soft but slightly acidic. When distributing rainwater through a piped system, comparable factors to those for naturally soft water are considered. Occasionally, marble chips (consisting of calcium carbonate) are introduced into rainwater storage tanks to mitigate corrosion.

The softened treatment is either provided at the central treatment plant or at individual homes as consumer preferences. In the present study to simulate the 6 months use of acrylic denture by the denture wearer. The water of each Teflon container was changed thrice every day. The brushing(using)of the plates were also carried out 3times were out for 45 days to reflect the use of water of different densities by the denture wearer to avoid warpage during use for six months. There was no statistical significance found when 3 different commercially available materials when immersed in 5 different densities of water for 45 days.

In a study done by Gautam et. al [7] Examined the impact of dentifrices utilized for cleaning denture base materials, revealing alterations in the denture base material. However, in our investigation, varying water densities did not result in any noteworthy change in the surface irregularity of the acrylic resin material, likely due to the deposition of solutes on the surface of the denture base materials.

A similar study done by sorgini D.B. et. al [8] where peracetic acid and sodium hypochlorite showed that after 60 minutes of immersion, both disinfectants exhibited reduced mean surface irregularity values on the denture base compared to before immersion.

As per a study done by SR de sousa porta et. al [9] in which the 0.5% NaOCl solution, employed as an adjunct for denture cleaning, effectively reduced microorganism counts without inducing significant color or roughness alterations. These findings align with our study, which found no significant change in the surface irregularity of acrylic materials before and after immersion in various water density samples.

In a study done by Ayaz E.A. et. al hard water showed a minor increase in surface irregularity on dpi samples but there was no notable increase on surface irregularity on the contrast a study which was done on Smoking and denture cleanser that caused increase the roughness after exposure to smoke.[10]

Pavarina et.al investigated the impact of different disinfectant on the surface irregularity of acrylic resins teeth and found no difference between the immersion group that was similar to the result of our study in which there was no notable difference between the acrylic resin material and the different immersion group in different densities of water.[11]

According to Jagger et al the surface of polymethyl methacrylate readily absorbs a cationic antiseptic. Certain components of these solutions can infiltrate the acrylic resin, resulting in softening and alteration of the surface morphology that was different from our study as the solutes that contain in water did not show any penetration of solutes in the acrylic resin because there was not any change in the surface irregularity.[12]

MATERIALS AND METHODS

This investigation was conducted to assess and compare the impact of water of different hardness levels such as the extremely soft water, soft water, hard and extremely hard water on the surface irregularity in three different heat polymerised denture base resins.

This study was conducted in the Department of Prosthodontics and Crown and Bridge, School of

Dental sciences, KIMSDU, Karad, Maharashtra and K.E society's Rajarambapu Institute of Technology, Islampur, Sangli, Maharashtra.

Material

The following materials, instruments and equipment were used for the study:

- Surface roughness (Ra) profilometer (Mitutoyo SJ-210, Mitutoyo Corporation, Tokyo, Japan)
- DPI Heat-polymerized acrylic resins (Dental Product of India. Pvt Ltd)
- Trevalon High impact Heat-polymerized acrylic resins (Dentsply India Pvt Ltd)
- Lucitone Dentsply Heat-polymerized acrylic resins (Dentsply India Pvt Ltd)
- Distil water.
- Reverse osmosis water
- Tap water.
- Ground water.
- TDS meter
- Mould with slots (Avinash Steel Engineering and company, Karad)
- Heat cure acryliser machine (Wassermann Dental Maschinen)
- Gloves
- Petroleum jelly
- Porcelain Jar – Jabbar and company
- Spatula

Methodology

It was carried out in several steps described below:

a) ***Description of sample used in the study.***

- 3 types of commercially available heat polymerized denture base resin samples. i.e-
  - DPI Heat-polymerized acrylic resins (Dental Product of India. Pvt Ltd)
  - Trevalon High impact Heat-polymerized acrylic resins (Dental Product of India. Pvt Ltd)
  - Lucitone Dentsply Heat-polymerized acrylic resins (Dental Product of India. Pvt Ltd)
- Four experimental water samples with different hardness levels i.e,
  - Control group of distil water.
  - Reverse Osmosis water of TDS 10 – 90 hardness level
  - Tap water of TDS 91 - 250 hardness level
  - Ground water of TDS Over 250 hardness level.

b) ***Sample size determination.***

It was done by using the formula:

$n=(p1q1+p2q2)x(Z1-Z2)^2/(p1-p2)^2$ with 95% confidence level and 95% power. The determined sample size for the study was 240 samples.

c) ***Sample distribution for the study.***

Group 1:

- *20 sample of DPI Heat-polymerized acrylic resins:* - Each sample of DPI Heat-polymerized acrylic resin were immersed in 100ml of distil water in 20 separate glass containers
- *20 sample of DPI Heat-polymerized acrylic resins:* - Each sample of DPI Heat-polymerized acrylic resin were immersed in 100ml of Reverse Osmosis water of TDS 10 – 90 hardness level in 20 separate glass containers
- *20 sample of DPI Heat-polymerized acrylic resins:* - Each sample of DPI Heat-polymerized acrylic resin were immersed in 100ml of Tap water of TDS 91 - 250 hardness level in 20 separate glass

containers

- *20 sample of DPI Heat-polymerized acrylic resins:* - Each sample of DPI Heat-polymerized acrylic resin were immersed in 100ml of Ground water of TDS Over 250 hardness level in 20 separate glass containers.

Group 2

- *20 sample of Trevalon High impact Heat-polymerized acrylic resins:*
  - Each sample of Trevalon High impact Heat-polymerized acrylic resin were immersed in 100ml of distil water in 20 separate glass containers.
- *20 sample of Trevalon High impact Heat-polymerized acrylic resins:*
  - Each sample of Trevalon High impact Heat-polymerized acrylic resin were immersed in 100ml of Reverse Osmosis water of TDS 10 – 90 hardness level in 20 separate glass containers.
- *20 sample of Trevalon High impact Heat-polymerized acrylic resins:*
  - Each sample of Trevalon High impact Heat-polymerized acrylic resin were immersed in 100ml of Tap water of TDS 91 - 250 hardness level in 20 separate glass containers.
- *20 sample of Trevalon High impact Heat-polymerized acrylic resins:*
  - Each sample of Trevalon High impact Heat-polymerized acrylic resin were immersed in 100ml of Ground water of TDS Over 250 hardness level in 20 separate glass containers.

Group 3

- *20 sample of Lucitone Dentsply Heat-polymerized acrylic resins (Dentsply India Pvt Ltd):* - Each sample of Lucitone Dentsply Heat- polymerized acrylic resin were immersed in 100ml of distil water in 20 separate glass containers
- *20 sample of Lucitone Dentsply Heat-polymerized acrylic resins (Dentsply India Pvt Ltd):* - Each sample of Lucitone Dentsply Heat- polymerized acrylic resin were immersed in 100 ml of Reverse Osmosis water of TDS 10 – 90 hardness level in 20 separate glass containers
- *20 sample of Lucitone Dentsply Heat-polymerized acrylic resins (Dentsply India Pvt Ltd):* - Each sample of Lucitone Dentsply Heat- polymerized acrylic resin were immersed in 100ml of Tap water of TDS 91 - 250 hardness level in 20 separate glass containers
- *20 sample of Lucitone Dentsply Heat-polymerized acrylic resins (Dentsply India Pvt Ltd):* - Each sample of Lucitone Dentsply Heat- polymerized acrylic resin were immersed in 100ml of Ground water of TDS Over 250 hardness level in 20 separate glass containers.

d) ***Fabrication of heat-polymerized acrylic resin samples***

- A mold was constructed with 8 slots measuring 60 mm × 40 mm × 2 mm.
- The acrylic was meticulously blended in accordance with the manufacturer's guidelines, with particular emphasis placed on the mixing and processing of the polymer resin.
- Following the curing cycle 3ez70°C for 90 min followed by 100°C for 30 min], as per the manufacturer's instructions, the acrylic resin plates were removed from the molds.
- All specimens underwent finalization using a tungsten carbide bur and were smoothed with 400 grit silicon carbide abrasive paper while damp.
- Subsequently, all specimens underwent polishing using a conventional pre-polishing technique, involving a slurry of coarse pumice and water on a polishing lathe for 90 seconds at a rate of 1500 rpm.
- Finally, the samples of size 60 mm × 40 mm × 2 mm were cut into plates measuring 15 mm × 15 mm × 2 mm using a Resin Cutting Wheel (DENTORIUM Disc) Blade.

e) ***Immersion of sample in different density of water***

- Pre-immersion roughness were evaluated in surface irregularity (Ra) profilometer (Mitutoyo SJ-210, Mitutoyo Corporation, Tokyo, Japan).
- The water of each glass container was changed every day 3 times, brushing of plates 3 times every

day was also be carried out for 45 days that simulate 6 month use of acrylic denture by the denture wearer.

- After 45 days surface irregularity (Ra) of each specimen were evaluated in surface irregularity profilometer (Mitutoyo SJ-210, Mitutoyo Corporation, Tokyo, Japan) in Rajarambapu Institute of Technology, Islampur, Sangli, Maharashtra.

f) ***Surface irregularity testing of the samples.***

g) ***Tabulation of data***

The data obtained from testing of surface irregularity of specimens were tabulated. The average and SD were computed for each test group. These values were then utilized as data for the statistical analysis.

h) ***Statistical Analysis***

- The information taken from 420 samples were subjected to statistical analysis using **Analysis of Variance Test (ANOVA) in % form from all groups in** SSPS 2.3 software and the results was interpreted as-
- P>0.05 – non-notable
- P<0.05 –Notable
- P<0.001 – Highly-Notable.

OBSERVATIONS AND RESULTS

Dependent T-Test showed no notable difference (p>0.05) in pre-immersion and post-immersion values of Group I denture material in distilled water(p=0.330), Tap water (0.371) and ground Water (0.054) as shown in Table 1.

Table 1. Group I Pre-immersion and Post Immersion.

Dependent Test			
		t	*p-value*
Pair 1	Group I-Pre-Distilled Water - Group I-Post-Distilled Water	- 1.000	.330
Pair 3	Group I- Pre-Tap Water - Group I- post-tap water	.917	.371
Pair 4	Group I - Pre-Ground Water - Group I- Post-Ground Water	- 2.058	.054

Dependent T-Test showed no notable difference (p>0.05) in pre-immersion and post-immersion values of Group II denture material in distilled water(p=0.177), reverse osmosis water (0.113), tap water (0.330), and Ground water (0.246) shown in Table 2.

Table 2. Group II Pre-immersion and post-immersion

Dependent Test			
		t	*Sig. (2-tailed)*
Pair 1	Group II-Pre-Distilled Water - Group II-Post Distilled Water	-1.402	.177
Pair 2	Group II-Pre-Reverse Osmosis Water - Group II-Post Reverse Osmosis Water	-1.661	.113
Pair 3	Group II- Pre-Tap Water - Group II- Post-Tap water	-1.000	.330
Pair 4	Group II- Pre-Ground Water - Group II- Post-Ground Water	-1.197	.246

The dependent T-Test showed no notable difference (p>0.05) in pre immersion and post-immersion values of Group II denture material in distilled water(p=0.163), reverse osmosis water (0.156), tap water (0.330) shown in Table 3. Groundwater showed a statistically significant result(p=0.04) Shown in Table 3.

Table 3. Group III Pre-immersion and Post Immersion.

Dependent Test

		t	*Sig. (2-tailed)*
Pair 1	Group III-Pre-Distilled Water - Group III-Post Distilled Water	-1.452	.163
Pair 2	Group III-Pre-Reverse Osmosis Water - Group III-Post Reverse Osmosis Water	-1.478	.156
Pair 3	Group III- Pre-Tap Water - Group III- Post Tap water	-1.000	.330
Pair 4	Group III- Pre-Ground Water - Group III- Post-Ground Water	-2.200	.040

CONCLUSION

In the present investigation, all standard polishing techniques were meticulously followed to achieve optimal surface polishing before immersing the acrylic resin plates into different water density groups. The lack of changes observed on the acrylic plates may be attributed to several factors: 1) The finished and polished surface of the acrylic resins, 2) Daily cleaning of dentures with a brush and soap water three times a day, and 3) Daily replacement of water samples. Consequently, this study concludes that the use of water of any density, whether soft or hard, does not induce changes in the surface irregularity of acrylic resins. It underscores that the cleaning and polishing of dentures are of greater importance than the type of water used to store the acrylic denture base material during overnight storage when the denture is not in the oral cavity.

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