Original Article

Comparative evaluation of the effect of plant extract, *Thymus vulgaris* and commercially available denture cleanser on the flexural strength and surface roughness of denture base resin

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Abstract

Aim: This study aims to evaluate and compare the effect of plant extract (thyme essential oil solution) and commercially available denture cleanser on the flexural strength and surface roughness of denture base resin.

Settings and Design: Comparative *In-vitro* study. Chemical denture cleansers play a vital role in maintaining the hygiene and serviceability of the dentures. Bacterial resistance to these chemical agents paved way to plant-extracts as novel denture cleansing agents. However, the effect of these plant-extract denture cleansers on the physical and surface characteristics of denture base resins has not been evaluated.

Material and Methods: A total of 90 heat polymerizing denture base material (Trevalon, Dentsply) samples were fabricated and divided into 3 groups with 30 samples each. Samples from each group were immersed in their respective denture cleanser solution (Group A- Distilled water(control); Group B- Fittydent denture cleanser; Group C- Thyme essential oil solution denture cleanser) for a simulated overnight 8hr immersion for 180 days. The samples were evaluated for increase in surface roughness and flexural strength using Tally-surf Surface Profiler and Instron Universal Testing Machine respectively. Results obtained were statistically analyzed using one-way ANOVA.

Statistical Analysis Used: Oneway ANOVA , *Post hoc* Tukey's test.

Results: Thyme essential oil solution group showed minimal increase in surface roughness (ΔRa) with values comparable to that of the control group which had the least increase in surface roughness and Fittydent group showed significant increase ($P < 0.05$) in surface roughness. For flexural strength, statistically significant difference ($P < 0.05$) was observed among the three groups with Fittydent group showing the highest flexural strength followed by control group and Thyme essential oil solution group. However, the decrease in the flexural strength was not of clinical significance.

Conclusion: Plant extract - thyme essential oil denture cleanser was superior in preserving the surface roughness of denture base resins compared to commercially available denture cleanser. Clinically significant difference in flexural strength was not observed between the denture cleanser groups.

Keywords: Antimicrobial, cleanser, denture, mechanical properties, thyme essential oil

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INTRODUCTION

Denture cleansing plays a pivotal role in maintaining the denture free from microflora. It is crucial both for esthetic concerns and in maintaining health of the patient by preventing denture-related stomatitis. It is a known fact that the dentures that are cared for daily, heighten patient's sense of well-being by keeping the tissues in the mouth healthy and free from unfavorable changes.[1]

Among various methods, mechanical cleansing with a soft denture brush and water is considered an effective method for denture hygiene that contributes to a healthy mucosa as a denture bearing tissue surface.[2] Insufficient cleaning by the elderly patients who are under long-term hospitalization, or those who have poor dexterity allows pathogenic microbiota to multiply on dentures, thus serving as a niche for disseminating infections.[3] In such situations, chemical denture cleansers can be an alternative to maintain denture cleanliness.

An ideal denture cleanser must be biocompatible, bactericidal, and fungicidal, harmless to the structure of denture, should effectively remove organic and inorganic deposits, and should be easy to use.[1]

Denture cleansers can be oxidizing agents (alkaline perborates), reducing solutions (sodium hypochlorite), effervescent agents (perborates and carbonates), chelating agents (ethylenediaminetetraacetic acid), detergents (sodium polyphosphate), enzymes (protease, amylase), and disinfectants (glutaraldehyde).[4] The most commonly used among these are alkaline peroxides.[1] However, studies have shown that denture cleansers which are currently used have deteriorating effects on the physical properties of denture base resins. Of late, there has been an increased resistance shown against these chemical agents by pathogenic microorganisms, thus giving center stage to plant extracts as novel antimicrobial and antifungal agents.[5]

Plant extracts have been playing a useful role for centuries and are a well-established source for novel antimicrobial compounds.[6] Studies comparing various plant extracts have shown that thyme essential oil is a potent antimicrobial agent against *Candida albicans* and thus be used for denture cleansing.[7]

Thymus vulgaris has been used extensively in traditional medicine.[8] The extract or oil derived out of this wonder plant works therapeutically to treat sore throat, tonsillitis, bronchitis, gum diseases, rheumatism, whooping cough, upper respiratory congestion, and arthritis.[9] Several reports validate the *in vitro* antibacterial and antifungal effects on pathogenic organisms such as *Staphylococcus aureus, Escherichia coli, C. albicans, Mycobacterium smegmatis, and Salmonella* species.[10] The two main components of thyme essential oil showing antimicrobial properties are thymol (2-isopropyl-5-methylphenol) and carvacrol (5-isopropyl-2-methylphenol).[11]

Although the antimicrobial properties are established, there is not enough research done to evaluate the effect of thyme essential oil on the physical properties of denture base material when used as a denture cleanser. The present study was to evaluate the effect of plant extract on flexural strength and increase in surface roughness of denture base resins and compare it with that of commercially available fittydent denture cleanser.

MATERIALS AND METHODS

This *in vitro* study was conducted in the Department of Prosthodontics, Manipal College of Dental Sciences, MAHE, Manipal, India, during June 2017–2018. Ethical clearance (IEC 894/2016) was obtained before the study from Institutional Ethics Committee, Kasturba Hospital, Manipal, India.

Fabrication of polymethyl methacrylate samples

90 samples[12] measuring 65 mm × 10 mm × 3 mm were fabricated using pink polymethyl methacrylate heat-polymerizing denture base resin (Trevalon, Dentsply, Karnataka) as per manufacturer's instructions (Polymer:Monomer ratio - 2.4). The acrylized samples were trimmed, polished using 180,220 and 400 grit sandpapers, and finished using pumice.

Immersion in solutions

The 90 samples were divided into three groups randomly with 30 samples each and were immersed in their respective

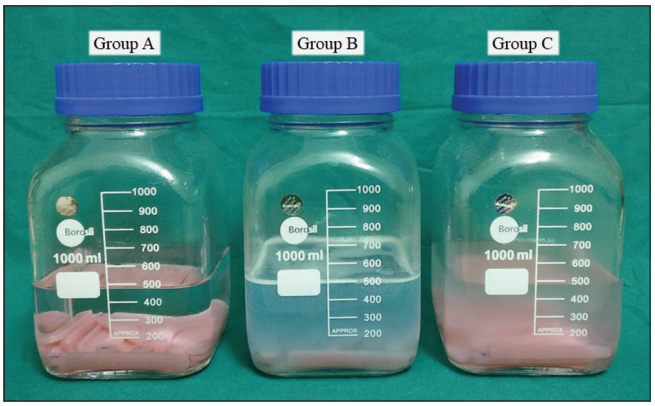

Figure 1: Samples immersed in denture cleansers

solutions [Figures 1 and 2]. For Group A (control group), specimens were immersed in distilled water. For Group B, specimens were immersed in distilled water with one tablet of fittydent (Dr. Reddy's Laboratories) dissolved in it. For Group C, specimens were immersed in thyme essential oil solution, made by dilution method (mixing thyme essential oil [allin exporters] and polysorbate 20 at 1:1 ratio and then diluting in distilled water to 0.5 µl/ml concentration). Immersion was done for 60 days changing the solution every 8 h simulating overnight immersion for 180 days.

Testing for increase in surface roughness and flexural strength

Evaluation of surface roughness and flexural strength was done using surface profiler (Form Talysurf Intra, Taylor Hobson, Ametek Inc. USA) and universal testing machine (INSTRON 3366, Norwood USA), respectively.

Increase in surface roughness determination: testing for surface roughness was conducted before and after immersion in denture cleanser for simulated 180-day period. Each sample was subjected to surface roughness measurement three times, and their mean was taken as the surface roughness (Ra) measured in µm. The increase in the surface roughness ΔRa was measured by calculating the difference between surface roughness values before immersion and after immersion in the denture cleanser.

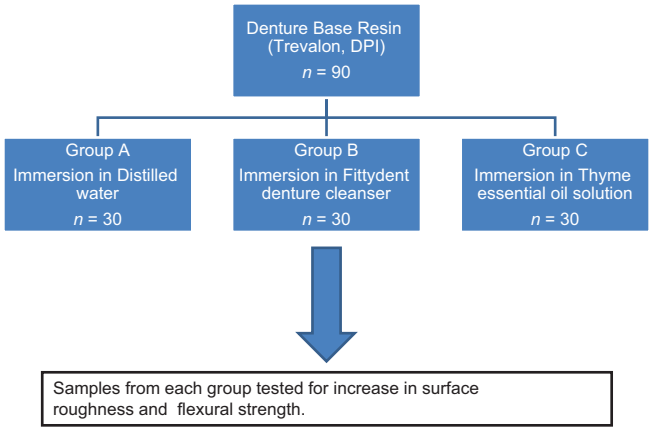

Figure 2: Study design

Flexural strength determination: each sample was placed in a 50 mm-long support for 3-point flexural testing. A vertical load was then applied at the midpoint of the specimen at a crosshead speed of 5 mm/min on the load testing machine until failure [Figure 3]. The built-in software of the Instron universal testing machine recorded the flexural strength of the samples.

Statistical analysis

Descriptive statistics was used to summarize increase in surface roughness and flexural strength, and one-way ANOVA was performed using Statistical Package for the Social Sciences version 20.0 (IBM Corp., Armonk, NY). Value of $P < 0.05$ was considered as statistically significant. *Post hoc* Tukey's test was used for intergroup comparison.

RESULTS

Means and standard deviation for each group were calculated [Tables 1 and 2]. For increase in surface roughness (ΔRa), Group C (thyme essential oil solution) showed minimal values comparable to that of the Group A (control), and no significant difference was observed between the two ($P = 0.971$) [Table 3]. Group B (fittydent) showed significant increase ($P = 0.024$) in surface roughness than control group. For flexural strength, statistically significant difference ($P = 0.000$) [Table 3] was observed among the three groups with Group B (fittydent) showing the highest flexural strength followed by Group A (control) and Group C (thyme essential oil solution). However, the difference in the flexural strength was not clinically significant as all the values recorded were above

Table 1: Mean and standard deviations for maximum flexural strength and increase in surface roughness

	Group A		Group B		Group C	
	Mean	SD	Mean	SD	Mean	SD
Maximum flexural strength (MPa)	98.125333	9.0223847	106.906333	13.2589750	87.789000	11.1238800
Increase in Surface roughness ΔRa (µm)	0.0307239	0.01907958	0.0440260	0.01724450	0.0318827	0.02124122

SD: Standard deviation

Table 2: ANOVA analysis

	Sum of squares	Df	Mean square	*F*	Significant
Maximum flexural strength (MPa)					
Between groups	5494.182	2	2747.091	21.634	0.000
Within groups	11047.392	87	126.982		
Increase in surface roughness ΔRa (µm)					
Between groups	0.003	2	0.002	4.392	0.015
Within groups	0.032	87	0.000		

Table 3: *Post hoc* Tukey's analysis for intergroup comparison

	Group (I)	Group (J)	Mean difference (I-J)	SE	Significant	95% CI	
						Lower bound	Upper bound
Maximum flexural strength (MPa)	Group B	Group A	8.7810000	2.9095420	0.009	−15.718743	−1.843257
	Group C	Group A	−10.3363333	2.9095420	0.002	3.398590	17.274077
	Group B	Group C	19.1173333	2.9095420	0.000	12.179590	26.055077
Increase in surface roughness ΔRa (μm)	Group B	Group A	0.0133021	0.0049724	0.024	−0.0251586	−0.0014456
	Group C	Group A	0.0011588	0.0049724	0.971	−0.0130152	0.0106977
	Group B	Group C	0.0121433	0.0049724	0.043	0.0002869	0.0239998

SE: Standard deviation, CI: Confidence interval

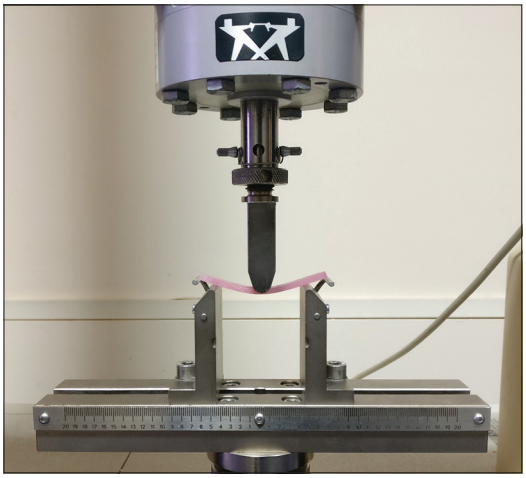

Figure 3: Test for flexural strength

the minimum requirement of 65 MPa (American Dental Association specification no. 12).

DISCUSSION

Chemical denture cleansing methods are often used in addition to physical cleaning methods to maintain the denture cleanliness and hygiene. Geriatric patients with severe debilitating conditions, impaired manual dexterity, and neuromuscular dysfunction tend to depend entirely on the chemical methods for denture maintenance. Traditional chemical denture cleansers, although being effective antimicrobials, are being replaced with natural plant extracts due to the developing resistance shown by microbes against them.[2] These plant extracts have shown efficient antimicrobial and antifungal properties and are being added as constituents in mouth rinses, toothpastes, etc.

Thyme essential oil was chosen as the plant extract denture cleanser to be used. This was in accordance with studies conducted by Liu *et al.*[13] and Hammer *et al.*,[7] who concluded thyme essential oil to be the best antifungal and antimicrobial with least minimum inhibitory concentration (MIC) values.

Fittydent (perborate) was shown to have better properties among the commercially available denture cleansers in studies conducted by Peracini *et al.*,[14] Raj and D'souza,[15] Paranhos Hde *et al.*,[16] and Sharma *et al.*[17] when compared with hypochlorites and alkaline peroxides – not causing any significant differences in flexural strength and surface roughness in denture base resins. Hence, it was used for comparison with *T. vulgaris* plant extract denture cleanser.

Duration of immersion in the denture cleanser was chosen to be simulating the overnight immersion (8 h) which represents a common situation, recommended by dentists for patients to remove denture during the sleeping period and immerse in solutions for relieving the underlying tissues and clean the dentures.[16] Sato *et al.*[18] in their study concluded that no significant difference is seen in flexural strength for different immersion periods of 15 min and 8 h for a simulated 30-day use.

The commercial denture cleanser chosen (fittydent) was shown to have the least effect on the surface properties of denture base resins when compared to the other commercially available denture cleansers as observed by Sharma *et al.*[17] However, it still had significant effect in increasing the surface roughness when compared to the thyme essential oil denture cleanser. This increase in surface roughness may be attributed to the surface degeneration due to the effervescent action by the perborate content of the fittydent denture cleanser.

The results observed for flexural strength in fittydent denture cleanser group were in accordance with studies by Sharma *et al.*[17] and Anjum *et al.*[19] These studies observed no reduction in flexural strength when compared to the control group which is similar to our current observations. However, the reduction in flexural strength seen in thyme essential oil denture cleanser group is contradicting to the observations by Anjum *et al.*, who had found increase in the flexural strength after immersion for 30 days. This reduction in the flexural strength might be attributed to the longer duration of the current study, i.e., simulated 180-day usage. Studies conducted by Paranhos Hde *et al.*[16] and Carolina Arruda *et al.*[20] have shown similar reduction in

the flexural strength due to longer duration of immersion, i.e., simulated 1½ immersion.

Thyme essential oil used in the study was a single concentration (0.5 µl/ml) which was based on the available literature which proved this concentration to be the MIC against *Candida*. Further studies using different concentrations and scanning electron microscope analysis could be done to better understand the effect of denture cleansers on the surface of polymethyl methacrylate.

CONCLUSION

Within the limitations of this study, it was found that the plant extract – thyme essential oil denture cleanser was superior in preserving the surface properties of denture base resins compared to commercially available denture cleanser. Clinically significant difference in mechanical properties of the denture base resin was not observed between the denture cleanser groups.

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Conflicts of interest
There are no conflicts of interest.

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