



Evaluation of effect of various denture cleansers on flexural strength of heat cure acrylic denture base resin

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Abstract

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

Aim: To evaluate and compare the effect of various denture cleansers on flexural strength of heat cure acrylic denture base resin.

Methodology: A total of 36 rectangular specimens (65 mm x 10 mm x 2.5 mm) and 32 disc shaped specimens (10 mm x 2 mm) were fabricated from heat cure denture base resin (DPI Heat Cure) for evaluation of flexural strength. The specimens immersed in distil water served as control whereas other specimens were subjected to daily cleansing with one of the three cleansers (Thyme oil 0.5%, Lemongrass oil 0.5% and Alkaline peroxide). Also, flexural strength (S) of specimens after cleansing was evaluated by subjecting the specimens to load of universal testing machine. Data analysis was done using software SPSS version 21. One way ANOVA and Post-hoc Tukey's tests were used for inferential statistics. p-value <0.05 was considered statistically significant.

Results: No significant difference was seen in the mean fracture strength of the specimens immersed in thyme oil, lemon grass oil, alkaline peroxide and distill water.

Conclusion: When samples were kept in distilled water as a cleansing solution, flexural strength was found to be maximum as compared to when the samples were immersed in thyme oil, lemongrass oil or alkaline peroxide solution. Statistically significant results were not obtained in any of the tested groups. No effect of time interaction was seen on the resultant flexural strength of the samples.

Keywords: Thyme oil, lemon grass oil, alkaline peroxide, denture cleansers

Introduction

Denture cleanliness is essential to prevent malodour, poor aesthetics and the accumulation of plaque/calculus with its deleterious effects on the mucosa. There are a large number of solutions, pastes and powders available for cleaning dentures with a variety of claims for their relative efficacies. Denture cleansers in common use can broadly be divided into those having mechanical or chemical effects. Surveys show that some denture wearers experience difficulty in cleaning their dentures satisfactorily and many wear dirty dentures. Replacement dentures are sometimes necessary due to general deterioration of the denture base material because of the misuse or abuse of a range of approved denture cleaning methods or do-it-yourself cleaning methods such as the use of household bleach^[1].

Nevertheless, several studies indicate that denture cleanliness and oral hygiene of denture wearers are generally poor, thereby facilitating the formation and accumulation of an oral biofilm, resulting to risk of denture stomatitis. Denture cleanliness is, thus, of paramount importance to prevent the various oral diseases and also for treatment of denture stomatitis among edentulous patients. The combination of mechanical and chemical methods is routinely recommended for denture cleansing^[2].

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. These plant extracts have shown efficient antimicrobial and antifungal properties and are being added as constituents in mouth rinses, toothpastes, etc.^[3] Natural products can be an alternative to synthetic chemical substances and the interest in medicinal plants as a source of antimicrobial agents has increased^[4].

High flexural strength is one of the desirable properties for denture base resins. Flexural strength also known as modulus of rupture or bend strength or transverse rupture strength. Flexural strength is a material property defined as the stress in a material before it yields. It has been shown that immersion in certain cleansing solutions can affect the strength and the structure of denture base resin. If denture cleansers affect negatively the resins decreasing the strength, greater incidence of denture fractures might occur both outside and inside of the mouth. Outside the mouth failure occurs due to the impact if the denture is dropped. Inside the mouth, occlusal forces may also cause fracture for example midline fracture of the denture may occur as a consequence of flexural fatigue, resulting from cyclic deformation of the base during function. A supposed increased frequency of this type of failure, due to use of denture cleansers, can be demonstrated by the flexural strength testing^[5]. The hypothesis of the study lies in that plant essential oils and extracts that have been used in food preservation, pharmaceuticals, alternative medicine, and natural therapies for many years. Natural products can be an alternative to synthetic chemical substances and the interest in medicinal plants as a source of antimicrobial agents has grown dramatically. Natural products and essential oils are promising therapeutic tools for oral infection. These oils are complex mixtures of volatile compounds obtained from plant with antioxidant and antimicrobial properties against wide range of pathogens, including *Candida albicans* and dermatophytes^[6]. Plant extracts have been playing a useful role for centuries and are a well-established source for novel antimicrobial compounds. Studies comparing various plant extracts have shown that thyme essential oil and lemon grass oil is a potent antimicrobial agent against *Candida albicans* and thus is used for denture cleansing. Although the antimicrobial properties are established, there is not enough research done to evaluate the effect of plant extracts on the physical properties of denture base materials when used as a denture cleanser. Thus present study was conducted with the aim to evaluate and compare the effect of various denture cleansers on flexural strength of heat cure acrylic denture base resin.

Methodology

The present in vitro study was conducted in the Department of Prosthodontics, Sudha Rustagi College of Dental Sciences and Research, Faridabad, India. Sample size estimation was done by using G Power software (version 3.0). A minimum total sample size of 34 was found to be sufficient for an alpha of 0.05, power of 95 %, 0.98 as effect size (assessed from a similar study). Thus final sample size was rounded off to 36 i.e., 9 in each group. To conduct this study, a total of 36 samples using heat cured acrylic resins according to ADA specification no. 12 were prepared and separate samples were made.

A stainless steel master die measuring 65 mm in length, 10 mm in width and 3.3 mm in thickness was fabricated. For the preparation of gypsum moulds, metal dies were invested in a metallic flask. A thin layer of petroleum jelly was applied over the die, and it was invested with dental stone (Type IV gypsum product) in the dental flask. Ensuring metal to metal contact between the base and its counterpart, the flask was closed under constant pressure on bench clamp. After stone was set, the flask was opened and dies were carefully teased out from the investing material. The moulds were then evaluated for any porosities and roughness. After that the prepared moulds were immersed in hot water to remove any trace of impurities and to facilitate the application of separating medium (cold mould seal, DPI). The mould cavities obtained were then used for the preparation of acrylic resin test specimens.

The prepared gypsum mould was coated with a thin layer of cold mould seal and allowed to dry. The polymer and monomer for the PMMA resin were mixed in a clean glass jar with stainless steel spatula in the ratio of 2:1, as recommended by the manufacturers. When the mix reached the dough stage, it was packed into the mould cavity slowly to avoid entrapment of air. The two halves of the flask were closed ensuring metal to metal contact. Trial closure was done. After overnight bench curing, polymerization was carried out by a short curing cycle (74 degree Celsius for one and a half hour and then at 100 degree Celsius for 30 minutes). After completion of polymerization cycle, the flask was allowed to cool in the water bath to room temperature before deflasking. The acrylic specimens were then retrieved and checked for any voids and defective specimens were discarded. Appropriate specimens were then finished and polished following standard procedures.

The 36 specimens were immersed in respective solutions of Thyme oil, Lemongrass oil solution, Alkaline peroxide solution and Distil water. Dilution of cleansing agent to be tested was done by dilution method (10 ml of diluted solution is made by adding 1 ml of essential oil, 1 ml of ethanol, 1 ml of 0.5% tween [it increases the solubility], and 7 ml of distilled water). To make 1000 ml of diluted solution for immersion procedures, 5 ml of thyme essential oil, 5 ml of 0.5% tween, 80 ml ethanol, and 910 ml distilled water was added.

Specimens were immersed in distilled water (Group 4) for 8 hours, 3 times a day for 60 days (simulating 8 hours, daily soaking for 180 days) changing distilled water for every immersion. Specimens were immersed in thyme essential oil/lemongrass oil, alkaline peroxide solution (Group 1,2 and 3) for 8 hours, 3 times a day for 60 days.(simulating 8 hours, daily soaking for 180 days) changing solution for every immersion.

Immersion were done for 60 days changing the solution every 8 hours simulating overnight immersion for 180 days. After immersion, specimens were subjected to three point bending test in Universal testing machine) and evaluated for changes in flexural strength. The device consisted of a loading wedge and a pair of adjustable supporting rods. A load was applied by a centrally located rod until fracture occurred.

The Flexural strength was calculated using the formula

$$S = 3 PL/2bd$$

Where S= flexural strength (N/mm), P = peak load applied (N), B = specimen width (mm) and d = specimen thickness (mm)

Data analysis

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 21, IBM Inc. Shapiro Wilk test was used to check which all variables were following normal distribution. As Data was found to be normally distributed (p-value was more than 0.05) bivariate analyses was performed using one way ANOVA for inferential statistics. Level of statistical significance will be set at p-value less than 0.05

Results

No significant difference was seen in the mean fracture strength of the specimens immersed in thyme oil, lemon grass oil, alkaline peroxide and distill water (Table 1). Post hoc comparison using Tukey's test showed no significant difference were seen in the mean fracture strength when Group I was compared with Group II, III and IV, when group II was compared with III and IV and when group III was compared with IV.

Table 1: Intergroup comparison of fracture strength

	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum Flex strength(Mpa)	Maximum Flex strength(Mpa)
				Lower Bound	Upper Bound		
THYME OIL 0.5%	82.3078	4.87338	1.62446	78.5618	86.0538	76.00	90.00
LEMONGRASS 0.5%	83.3222	4.61892	1.53964	79.7718	86.8726	76.00	90.00
ALKALINE PEROXIDE	82.2556	2.00319	.66773	80.7158	83.7953	80.00	85.00
CONTROL (Distill water)	85.0856	5.70994	1.90331	80.6965	89.4746	77.00	97.00
P value	0.418 NS						

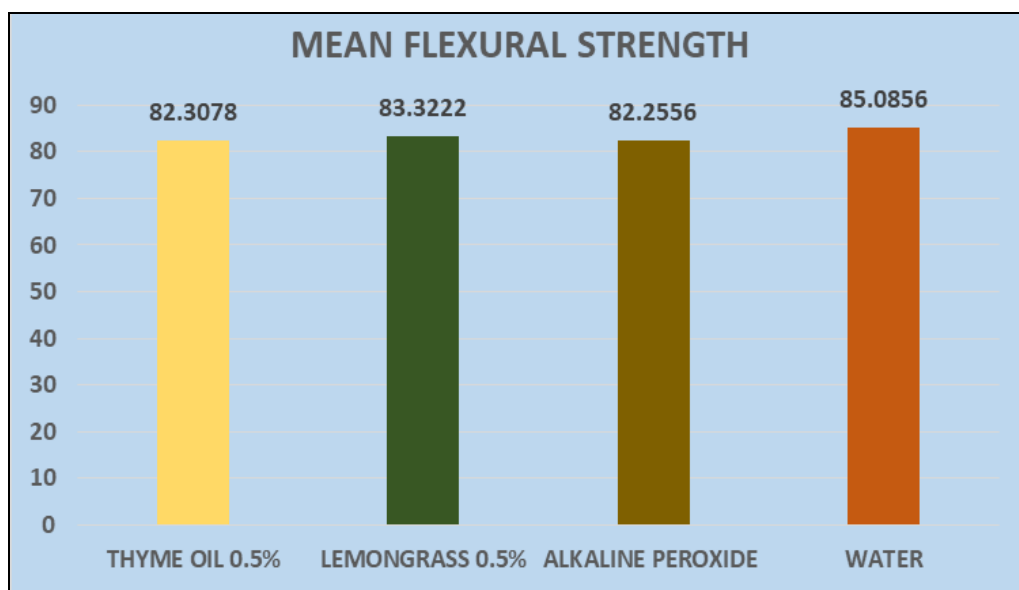


Fig 1: Intergroup comparison of fracture strength

Table 2: Post hoc comparison using Tukey's test

Groups	Mean Difference	Std. Error	P value	95% Confidence Interval	
				Lower Bound	Upper Bound
Group I vs II	-1.01444	2.34251	.992	-7.7049	5.6760
Group I vs III	.05222	2.34251	1.000	-6.6382	6.7426
Group I vs IV	-2.77778	2.34251	.759	-9.4682	3.9126
Group II vs III	1.06667	2.34251	.991	-5.6238	7.7571
Group II vs IV	-1.76333	2.34251	.942	-8.4538	4.9271
Group III vs IV	-2.83000	2.34251	.747	-9.5204	3.8604

Discussion

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. 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. 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. In such situations, chemical denture cleansers can be an alternative to maintain denture cleanliness^[7].

Acrylic resins have different physical and mechanical properties, hence the marked differences in how they react when exposed to diverse environments such as water, disinfectants and denture cleansers. Repetitive masticatory forces on denture cause flexural fatigue of the acrylic denture base. The flexural strength is indicative of the compressive, tensile and shear strengths, which translates as stiffness and resistance of a material to fracture. Therefore flexural strength determines the longevity and success of a denture. Among various physical properties that can be affected by use of cleansers, flexural strength is of prime interest because denture base resins may fail clinically due to flexural fatigue. Inappropriate choice and use of chemical cleansers can however cause damage to dentures. Guidance on the selection of cleanser is therefore of high importance.^[8]

It is hypothesised that the very high levels of porosity observed in auto-polymerising resin reduce their flexural strength and weaken the resin. Other effects of porosity include compromised aesthetic properties and increased propensity to harbour and promote growth of *Candida* in these dentures. Ultimately inflammation and soreness of the soft tissues often occurs underneath the denture.

An ideal denture cleanser should be biocompatible, bactericidal, fungicidal, non-toxic to the anatomic structure underlying the denture bases, should be effective in removing deposits and should be easy to use. Natural products and essential oils are promising therapeutic tools for oral infections. These oils are complex mixtures of volatile compounds obtained from plants with antioxidants and antimicrobial properties against wide range of pathogens, including *Candida albicans* and dermatophytes. Higher and aromatics plants have been used and showed inhibition against bacteria, fungi, and yeasts. Plant-derived products as disease control agents have low mammalian toxicity, less environmental effects, and wide public acceptance.^[9]

Liu *et al*^[10] had stated that thyme essential oil is the best among plant extracts. Gutiérrez *et al*^[11] had proved that thymol showed complete inhibition of microorganisms such as *C. albicans*, *Aspergillus flavus*, and Goncalve *et al*^[12] had concluded that thyme oil was efficient against *Streptococcus mutans*. Studies have been done on the thyme essential oil and its properties, but few studies have been done on the effect of thyme essential oil on denture base resin. Therefore, plant extract thyme essential oil and lemon grass essential oil was used in this study, and its influence on flexural strength of heat-cured acrylic denture base resin was evaluated.

Denture cleansers remove debris on denture surfaces, and for individuals with impaired dexterity the use of these chemicals is highly recommended. Inappropriate choice and use of chemical cleansers can, however, cause damage to dentures. Guidance on the selection of cleanser is therefore of high importance. It is also hypothesized that plant based cleanser are better than chemical cleansers.

For the present research, Samples were immersed in respective cleansing solution at the same time ensuring that specimens are completely immersed. Immersion was done for 60 days changing the solution every 8 hours simulating overnight immersion for 180 days. Subsequently, the samples were tested by the three point bending test in universal testing machine and evaluated for changes in flexural strength.

Results of the present study showed that though Flexural strength of the samples was maximum when immersed in distilled water as compared to samples which were immersed in thyme oil, lemon grass oil or alkaline peroxide solution. Intergroup comparison showed no significant difference in the mean fracture strength of the specimens immersed in various cleansing solution i.e. thyme oil, lemon grass oil, alkaline peroxide and distilled water.

According to ISO 1567, the minimum FS of heat-polymerizing acrylic resin should be 65 MPa or more, and the minimum FM should be 2 GPa or more. Therefore, we complied with the requirement of ISO 1567 regarding study parameters.

Similar to the results of our present study, Anjum R *et al*^[13] conducted a study to compare and evaluate the flexural strength of heat cure acrylic denture base resin by combination method of denture cleansing and plant extract immersion. The study concluded that plant extract namely thyme oil showed better flexural strength than immersion in denture cleanser and control group but statistically no significant result was found. Studies conducted by Paranhos Hde *et al*^[14] and Carolina Arruda *et al*^[15] have shown similar reduction in the flexural strength due to longer duration of immersion, i.e., simulated 1½ immersion. Sharma *et al*^[16] in their research compared hypochlorites and alkaline peroxides and found no significant differences in flexural strength and surface roughness in denture base resins. Also in this study, 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. 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.

Namala BB *et al*^[17] did a 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.

The study concluded that plant extract was superior in preserving the surface roughness of denture base resins compared to commercially available denture cleansers and clinically significant difference in flexural strength was not observed between the denture cleanser groups. Sudan S *et al* ^[18] conducted study to evaluate flexural strength of heat cure acrylic denture base resin by denture cleansing and plant extract immersion. The study concluded that thyme essential oil showed better flexural strength than combination method and can be effectively used as denture cleanser.

Madeira PL *et al* ^[19] in an *in vitro* study, studied the effects of lemongrass extract on *Candida albicans* biofilms in human cells viability, and on denture surface. There were no verified differences in color perception, roughness, or flexural strength after immersion in LGE at MIC compared to the control ($p > 0.05$). Similarly, Paranhos Hde *et al* ^[14] also concluded that overnight immersion in a denture cleansing solution did not alter the flexural strength. This could be attributed to the fact that flexural strength depends on bulk of material, and insignificant change in flexural strength indicates that the bulk of the material remained intact from the influence of cleansers. The results of present study also concluded that acrylic resins demonstrated a decline in flexural strength when immersed in denture cleansers yet no significant difference. In a study conducted by Sharma *et al*, ^[16] immersion in 1% NaOCl resulted in significant decrease ($p < 0.05$) in flexural strength.

In contrast to the results of the present study, Stafford *et al* ^[20] and Yunus *et al*. ^[21] found out statistically significant change in flexural strength after immersion in all denture cleansers. Peracini *et al* ^[22] in their study also measured the color change, surface roughness and flexural strength of heat-polymerized acrylic resin after its immersion in denture cleansers, simulating a 180-day use. Specimens from heat-polymerized acrylic resin were immersed in Sodium Bicarbonate containing cleanser and distilled water. They found out that both effervescent tablets containing sodium bicarbonate significantly diminished the flexural strength of the acrylic resin.

In concordance with the results obtained from our study, it was found that no significant difference was observed amongst plant extract based and commercially available denture cleansers on flexural strength of heat cure acrylic resins. However, with the recent advances in material sciences, more research needs to be done with an aim to explore the avenues of denture cleansing further.

No research comes without limitation. One of the major limitation is that the present study being *in vitro* study were not exposed to harsh oral environment and cyclic loading associated with mastication. Doing so could have resulted in different findings. More variability in the testing solution could be obtained by using commercially available denture cleansers to compare the ability of these essential oils to clean the denture against them. Also, the sample size and immersion criteria was comparatively lesser. Thus further studies with longer duration and larger sample size should be conducted to generalize the results.

Conclusion

When samples were kept in distilled water as a cleansing solution, flexural strength was found to be maximum as compared to when the samples were immersed in thyme oil, lemongrass oil or alkaline peroxide solution. Statistically significant results were not obtained in any of the tested groups. No effect of time interaction was seen on the resultant flexural strength of the samples.

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