Evaluating the efficacy of denture cleansing materials in removal of tea and turmeric stains: An in vitro study

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ABSTRACT

Context: Extrinsic staining of acrylic resin dentures could be a major esthetic problem for denture wearers. Tea, coffee, cola, turmeric, and tobacco often cause extrinsic staining of dentures.

Aim: To evaluate the efficacy of various denture cleansing materials in the removal of tea and turmeric stains and to compare the efficacy of those denture cleansers with each other in the removal of tea and turmeric stains.

Materials and Methods: Heat-cured acrylic resin specimens were stained using tea and turmeric solutions. The spectrophotometer was used to determine the reflectance values of the samples and to evaluate the efficacy of various denture cleansing materials in removal of tea and turmeric stains. Three denture cleansers, namely, sodium hypochlorite, Safe plus, and Clinsoindent were used in the study. Water was used as a control.

Statistical Analysis Used: ANOVA test and post hoc Tukey's test were used to determine the statistical difference between the groups.

Result: A statistically significant difference was found (p ≤ 0.05) between the different denture cleansing materials used. Products containing sodium perborate along with trisodium phosphate had the highest stain removing capability.

Conclusion: It was found that all the denture cleansing materials used in the study were effective in removing tea and turmeric stains. Products containing sodium perborate along with trisodium phosphate had a comparatively greater stain removal capability than products containing sodium perborate along with sodium bicarbonate followed by products containing sodium hypochlorite followed by water (control).

Key words: Acrylic resin denture base, denture cleansers, spectrophotometer, tea, turmeric stains.

Acrylic resin bases on both removable partial and complete dentures attract stains and odor-producing organic and inorganic deposits. The rate at which the deposits accumulate on dentures may vary between individuals and can be affected by factors such as salivary composition, dietary intake, surface texture and porosity of the denture base material, duration for which the dentures are worn, and the denture cleansing regimen adopted by the wearer.

Denture cleansing is necessary to remove extrinsic stains and soft and hard deposits from dentures. The microporous surface of an acrylic resin denture base material provides an environment that supports the growth of microorganisms that may add to further staining of dentures. Proper cleaning and maintenance of denture prostheses are therefore important for the oral health of patients and to maintain odorless and stain-free prostheses.

Over the years, various materials and techniques classified as mechanical (soaps/pastes/powders/tablets used with/without a denture brush, sonic cleansers) and chemical (commercially available products) have been developed to remove stains and soft and hard deposits from dentures.
available liquid cleansers – alkaline peroxides, alkaline hypochlorites, disinfecting agents, and enzymes) have been used for cleaning dentures.\(^{[4,5]}\)

Unfortunately, the knowledge and awareness regarding the cleaning of dentures is less in the Indian scenario. The denture cleaners used by the Indian population are the ones most commonly available in Indian markets without knowing the most effective stain removing denture cleaner that causes the least harm on the properties of an acrylic resin material. In addition, tea and turmeric are most commonly used by Indian population and hence its effect on the denture base acrylic resins is much more compared to other foodstuffs.

The aim of this study was to evaluate and compare the efficacy of three different denture cleansing materials in removal of tea and turmeric stains.

**MATERIALS AND METHODS**

This *in vitro* study was carried out on 160 polished heat-cured acrylic resin samples of size 10 mm × 10 mm × 2 mm (according to the requirement of spectrophotometer). To standardize the sample thickness of 2 mm, a glass plate of size 65 mm × 55 mm × 2 mm was sealed to a glass slab of 65 mm × 55 mm × 11 mm with modeling wax and was embedded in the base flask keeping the glass plate up. Soluble alginate separating media was applied to the plaster of the base flask. The counter flask was then poured with dental plaster (Neelkanth) and was allowed to set.

After the assembly was set, the dental flask was opened, and the glass plate along with the modeling wax was removed leaving the glass slab embedded in the base flask. Soluble alginate separating media was applied to the dental plaster and heat cure acrylic denture base resin (Trevalon, Dentsply) was packed using dough method using powder – liquid ratio as per manufacturer’s instructions.

Curing was done in the digitally controlled acrylizer (Dent-Cure, Puneet Industries) using the following curing cycle, 74°C for 1½ h, and then increasing the temperature of the water bath to boiling for 1 h. Bench cooling was done by allowing the flask to cool at room temperature for 1 h and then immersing under tap water for 15 min.

The sample was removed from the flask. All the samples were made in a similar manner. The surface of the sample in contact with the dental plaster mimicking the tissue surface of the denture was cleaned and markings measuring 11 mm × 11 mm were made on the samples. The samples were cut with a separating disc according to the markings and were adjusted to the required dimensions.

The reflectance of these samples was measured using a reflectance spectrophotometer [Figure 1] and 5 samples out of 165 having porosity and surface roughness beyond the acceptable limit of reflectance were excluded from the study. Then, the samples were stained with tea and turmeric, and baseline reflectance of 160 stained samples was measured. These samples were then divided into four groups of 40 samples [Figure 2] each according to the denture cleanser [Figure 3] to be used as follows:

- Group A - Distilled water (control)
- Group B - Sodium hypochlorite
- Group C - Sodium perborate, citric acid, sodium lauryl sulfate, lactose monohydrate, sodium bicarbonate, sodium carbonate, sodium chloride, flavor (Safe plus)
- Group D - Sodium perborate, sodium carbonate, trisodium phosphate, zeofree, sodium lauryl sulfate (Clinsodent).

For testing, each sample was placed in 10 mm × 10 mm slit [Figure 4] of UV/Vis (ultraviolet/visible) reflectance spectrophotometer (FluoroMax – 3). It measured the reflectance of the sample and a standard for every 1 nm over the wavelength range of 380–780 nm. Standard illuminant D65 was used for all measurements, and standard observer was taken at 10°. After the reflectance curve was obtained for a sample, mathematics was applied to map the color onto a color space, and \(L^*a^*b^*\) values were calculated.

Once the \(L^*a^*b^*\) values were obtained, all the samples were treated with fresh human saliva to form an initial pellicle layer. The samples were then stained for 1 h with freshly prepared tea solution [Figure 5] and then for 1 h with freshly prepared turmeric solution [Figure 6]. The solutions were prepared by adding 8 g of colorant to 400 ml of boiling distilled water.

The reflectance values of these stained 160 samples were again measured [Figure 7], and the \(L^*a^*b^*\) values of each of 160 samples were calculated.

These 160 samples were then exposed to each of the 3 denture cleansers [Figure 8] and water (control) for 30 min. The reflectance values of these 160 samples were again measured [Figure 9], and the \(L^*a^*b^*\) values of each of 160 samples were calculated.

![Figure 1: Reflectance spectrophotometer](image-url)
The color difference of the samples was calculated using the following formula:

$$\Delta E^* = (\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2)^{1/2}$$

Where,

$\Delta L^*$ is the difference in lightness ($L^*$) of the sample after staining and putting it in denture cleansers.

$\Delta a^*$ is the difference in $a^*$ value (chroma on red-green axis) of the sample after staining and putting it in denture cleansers.

$\Delta b^*$ is the difference in $b^*$ value (chroma on yellow-blue axis) of the sample after staining and putting it in denture cleansers.

To find the changes in the efficacy of the four groups and to compare the other three groups with the control, it was preferred to apply one-way ANOVA and Tukey test for testing the differences of mean in between the groups.

RESULTS

Mean, standard deviation, standard error, 95% confidence interval for mean, and the range was calculated for all groups.
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Table 1: Mean and National Bureau of Standards (NBS) unit values between different groups were compared [Table 2].

According to the NBS unit, results showed that there was a slight color change with Group A, noticeable color change with Group B and Group C, and appreciable color change with Group D. The graphs drawn from the readings showed a difference in the mean color change among different cleaning materials from Group A–D [Graphs 1 and 2].

ANOVA test and post hoc Tukey’s test were used to determine the statistical difference between the groups [Tables 3 and 4]. ANOVA test showed the result to be significant with a $p = 0.000$. On comparing the results by Tukey’s test, it was found that the results were statistically significant on comparison of Group C and Group D to Group A (control group) and statistically nonsignificant on comparison of Group B to Group A (control group).

This implies that Group B, Group C, and Group D have a comparatively greater stain removal capability than Group A (control). Group C and Group D have a comparatively greater stain removal capability than Group B. In addition, Group D has a comparatively greater stain removal capability than Group C.

Thus, Group D (Clinsodent) was found most effective in removing tea and turmeric stains followed by Group C (Safe plus), Group B (sodium hypochlorite) and Group A (water), respectively.

DISCUSSION

Complete dentures are fabricated using heat-cured acrylic resin because of its low cost, its appearance, and relative ease of manipulation. Color stability is one of the most important clinical properties for all dental materials. Several factors may contribute to the discoloration of dental materials after long-term use. These factors include stain accumulation, water sorption, dissolution of the ingredients, degradation of intrinsic pigments, and surface roughness. It is well-known that beverages such as tea, coffee, wine, and some artificial dyes used in food may increase the discoloration of denture base polymers.

To determine and quantify the changes in the color of dental materials, an understanding of color space and differential colorimetry is required. Current photometric and colorimetric instruments are capable of reliably quantifying the color of acrylic resin specimens.\(^6\) Numeric description of color permits precise definition of the magnitude of the color difference between objects.\(^7\)

The present study was carried out on 160 polished heat-cured acrylic resin samples of size 10 mm x 10 mm x 2 mm (according to the requirement of spectrophotometer).
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Some authors [8,9] evaluated the color change of various acrylic resins when stained with tomato paste, grape juice, coffee – tea infusion, or orange juice while others [10-15] evaluated the color change of certain brands of denture base acrylic resin when immersed in either tea, coffee, turmeric solutions, chlorhexidine, cola or wine solutions. 

In the present study, tea and turmeric solutions have been used to evaluate the color change of heat-cured acrylic resin similar to the studies of Thakral et al. [16] and Singh and Aggarwal [14]. Tea and turmeric are the most common staining foodstuffs used by the Indian population. In addition, in a day, a denture is exposed to both tea and turmeric in Indian population without any intermediate cleaning intervals. Similar to the studies conducted by Jagger et al. [3], the samples were placed in staining solutions for 1 h. Thus, heat-cured acrylic resin samples in the present study were put in tea solution for 1 h and then a turmeric solution for 1 h.

Studies [4,17-20] were carried to evaluate the most effective denture cleansing material in stain removal. The results obtained varied depending on the methods used to evaluate the efficacy of denture cleansers among in vivo and in vitro assays.

Mechanical denture cleansing included brush which was the most common method of routine denture cleansing followed by pastes, powders, and ultrasonic agitation. Chemical denture cleansing included immersion type chemical denture cleaners such as alkaline peroxides (percarbonate/perborate), alkaline hypochlorites, dilute organic or inorganic acids, disinfectants, and enzymes.

It was found that daily, overnight immersion of dentures in an alkaline peroxide solution provided a safe and relatively effective means of cleaning dentures. Hypochlorite cleansers also provide an effective means of cleaning acrylic dentures by overnight immersion. [21-24]

Although the most widely used method of denture cleansing seems to be the usage of soap and brush, with increasing age, a large number of geriatric patients (who form the majority of complete denture wearers) have a loss of manual dexterity and are physically challenged, hence being unable to accomplish denture cleansing effectively.

Conventional alkaline peroxide soak type denture cleansers are by far more widely used by the public than other denture cleansers. The usage of immersion type of cleansers helps them to keep the dentures clean and devoid of any deposits. Keeping all this in perspective, immersion denture cleaners Clinsodent containing sodium perborate, sodium carbonate, trisodium phosphate, zeofree, sodium lauryl sulfate and Safe plus containing sodium perborate, citric acid, sodium lauryl sulfate, lactose monohydrate, sodium bicarbonate, sodium carbonate, sodium chloride, flavor were used in the study. In addition, alkaline hypochlorite, i.e., sodium hypochlorite was used in the present study. These materials are commonly available in Indian market for testing their efficacy in stain removal.

The immersion time of 30 min was chosen to determine whether optimum stain removing action takes place within this period, similar to the study by Jacob et al. [25] and as recommended by manufacturers of the denture cleansers used in this study.

Several methods are used for the evaluation of color change including photographic method, [10,26,27] quantitative

| Graph 1: Expression of mean of color change between Group A (control) and Groups B, C, and D |
| Graph 2: Expression of mean color change in NBS unit between Group A (control) and Groups B, C, and D |

### Table 4: Comparison of groups using Tukey test

| Group      | Compared to | Probability (P)* | Significance** |
|------------|-------------|------------------|----------------|
| A (water)  | Group B     | 0.532            | NS             |
|            | Group C     | 0.000            | HS             |
|            | Group D     | 0.000            | HS             |
| B (sodium hypochlorite) | Group A     | 0.532            | NS             |
|            | Group C     | 0.004            | Significant    |
|            | Group D     | 0.000            | HS             |
| C (safe plus) | Group A     | 0.000            | HS             |
|            | Group B     | 0.004            | Significant    |
|            | Group D     | 0.022            | Significant    |
| D (Clinsodent) | Group A    | 0.000            | HS             |
|            | Group B     | 0.000            | HS             |
|            | Group C     | 0.022            | Significant    |

*P ≤ 0.05 = Significant, **HS = Highly significant, NS = Not significant
light-induced fluorescence analysis,\textsuperscript{(28)} gloss meter,\textsuperscript{(9)} colorimeter,\textsuperscript{[12,29]} and spectrophotometer.\textsuperscript{[3,11,13-15,30]}

Testing of samples in the present study was carried out using a reflectance spectrophotometer. This method is more accurate than subjective assessment of color and a quantitative method for staining can be obtained. The reflectance of the samples was measured, and the readings were then converted to obtain the CIE \(L^*a^*b^*\) values.

It was found that the results were statistically significant on comparison of Group C and Group D to Group A (control group) and statistically nonsignificant on comparison of Group B to Group A (control group). Group D (Clinsodent) was found most effective in removing tea and turmeric stains than other denture cleansers used in the study.

The results were found in accordance with the studies conducted by Budtz-Jørgensen\textsuperscript{(10)} and Jagger and Harrison,\textsuperscript{(23)} who found that immersion of dentures in alkaline peroxide solution provided a safe and relatively effective means of cleaning dentures while hypochlorite cleansers are effective but because of their bleaching effect they should be used once a week and Joseph,\textsuperscript{(31)} who found that a cleanser containing sodium perborate was more effective in removing turmeric stains than a cleanser containing sodium hypochlorite in both 20 min as well as 8 h.

In contrast, Neill\textsuperscript{(23)} and Jagger et al.,\textsuperscript{(30)} found that products containing alkaline hypochlorite and those containing alkaline perborate were similarly effective in removing stains.

Clinsodent and Safe plus contain sodium perborate, which is a peroxide type of denture cleanser. When dissolved in water, it forms a solution of hydrogen peroxide. This type of cleanser combines alkaline detergents to reduce surface tension and chemicals which release oxygen from the solution. The oxygen bubbles exert a mechanical cleansing effect. Sodium hypochlorite when dissolved in water, it cleanses by a bleaching action as a result of the release of chloride ions into the solution.

The results vary according to the rate of accumulation of deposits, dietary intake, surface texture of the dentures, the time interval of wearing the dentures, and cleansing regimen adopted by the wearer. To fully understand the efficacy of denture cleansers on the stain removal capabilities on heat- cured acrylic resin, further studies are needed to determine as to which type of cleansers are more effective.

**CONCLUSION**

It was found that all the denture cleansing materials used in the study were effective in removing tea and turmeric stains. A statistically significant difference \((p < 0.05)\) was found between the different denture cleansing materials used. Within the limitations of the study, it was concluded that products containing sodium perborate along with trisodium phosphate have a comparatively greater stain removal capability than products containing sodium perborate along with sodium bicarbonate followed by products containing sodium hypochlorite followed by water (control).

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**Conflicts of interest**

There are no conflicts of interest.

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