

Evaluation of the colour stability of denture base resins after different staining and cleansing regimens- An in vitro study

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Abstract

Background: Several studies have been done to check the staining potential of various agents on denture base resins. However, the staining potential of substances endemic to the local population of Kerala as such has not been verified before. While the routinely employed cleansing mechanism is mechanical cleansing, several chemical agents are available which claim to be superior. The purpose of this study is to evaluate the colour stability of heat-activated acrylic resin materials when subjected to different agents like black tea, paan, nicotine and an ayurvedic tonic followed by mechanical and/or chemical cleansing regimen.

Methods: An experimental in vitro study was conducted in which a total of 130 heat-cure acrylic resin samples were fabricated. These samples were then subjected to staining with different agents such as black tea, Draksharishtam, betel nut mixture, and nicotine solutions and, mechanical and cleansing regimens. The

specimens were tested for the colour measurements using a UV- Vis spectrophotometer.

Results: The highest ΔE value was obtained for the tea group and the lowest value was obtained for the nicotine solution. After undergoing both the cleansing regimen, the change was more pronounced in the specimens stained by betel nut mixture and nicotine solution.

Conclusion: The present study establishes the fact that certain agents regularly involved in the diet and lifestyle of the Malayali population can cause significant staining. While mechanical methods are more common, a combination of mechanical method and chemical method is proved to be the most effective from the results of this study.

Keywords: Heat cure denture base resins, colour stability, staining, chemical cleansing agents, mechanical cleansing, spectrophotometry.

Introduction

Prosthetic rehabilitation of any kind requires the combination of both functional and aesthetic features to

maximise patient satisfaction. Despite breakthroughs in fixed prosthodontic therapy, rehabilitation with removable prostheses remains widely popular; mainly due to its cost-effectiveness and long-standing success stories. Heat cure acrylic denture base resins are thus one of the predominant materials used in the whole of dentistry.

Denture base resins must, however, match the colour and appearance of the oral tissues to be aesthetic in nature. Clinically it has been noted that several factors can cause the staining of dentures such as the consumption of certain beverages and addictive agents. Tea is a known staining agent among denture wearers and certain habits like smoking and betel nut chewing could also lead to staining of denture base materials. Even the use of certain ayurvedic medicines, which is a common occurrence in the geriatric population of Kerala, can cause staining of dentures. The staining potential of such ayurvedic medicines has not been researched much as per the author's knowledge.

The maintenance of denture prostheses is important for the health of patients and to maintain an aesthetic, odour-free appliance.¹ Denture hygiene is carried out using mechanical or chemical cleansers or a combination of the two. An ideal denture cleanser should fulfil many requirements, including the ability to remove both organic and inorganic deposits together with any associated stains.² A plethora of commercial denture cleansing agents are available in the market today. However, their usage in the general population is limited. Mechanical cleansing with a toothbrush and soap/ paste is the most common method of denture cleansing among most denture wearers.

The purpose of this in vitro study is to evaluate the colour stability of heat-activated denture base resin materials when subjected to different stains like tea,

betel nut mixture, nicotine and an ayurvedic tonic followed by mechanical cleansing or a combination of mechanical and chemical cleansing regimen.

Methodology

130 square acrylic blocks of one cm × one cm × two mm size were fabricated by conventional compression moulding technique. The samples were then allocated to 13 groups of 10 samples each.

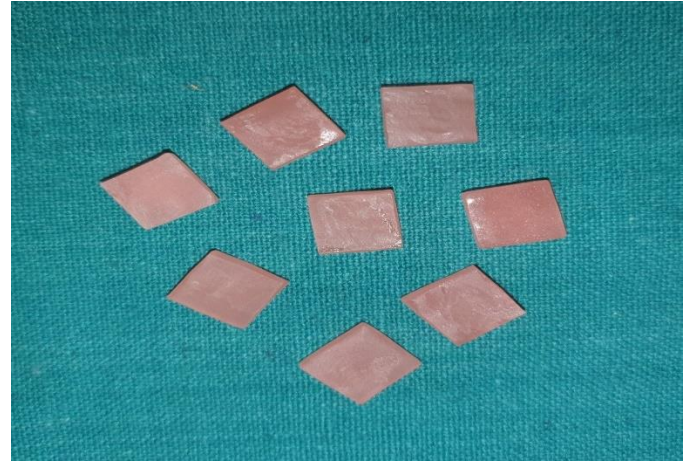


Figure 1: Prepared Specimens

Solutions of tea, betel nut mixture and nicotine were prepared as per previous literature,^{3,4,5} and the ayurvedic tonic, Draksharishtam, was used as the fourth solution. The chemical cleansing solution was prepared by dissolving Secure denture cleansing tablet in 250 ml of warm water. Each tablet consists of 700 mg Sodium Perborate Monohydrate.

Forty acrylic blocks were suspended in the different staining solutions- black tea, betel nut, nicotine and ayurvedic tonic for 12 hours and then in distilled water for 12 hours. This cycle was carried on for 10 days in the incubator. The stains were changed every day to avoid any microbial growth. A similar procedure was carried out for the other eighty samples as well with an added mechanical cleansing step with the aid of a soft toothbrush, soap, and water for one minute. The last forty blocks were subjected to chemical cleansing for five minutes apart from the above procedures.

Testing of specimen

The testing of the specimen was conducted using Konica Minolta UV Vis Spectrophotometer and the CIELAB colour space was used to record the colour differences.



Figure 2: Reading of L* A* B* values

Results

The L*, a* and b* values of each of the specimens were obtained after testing the specimen using a UV-Vis spectrophotometer. These values represent colour in a quantifiable way by means of measurements in terms of the lightness/ darkness of an object (L*), the red-green scale (a*) and the yellow-blue scale (b*).^6 The mean L*, a* and b* values of each group were then calculated.

The first four tables indicate the L*, a* and b* values for each group after staining, and cleansing protocol. The final quantification is possible only after assessing the ΔE from the mean L*, a* and b* values and these are reflected in the table 6.

The mean ΔE values which indicate the difference between the groups were then calculated from the above values using the formula $\Delta E = (L_1^* - L_2^*)^2 + (a_1^* - a_2^*)^2 + (b_1^* - b_2^*)^2$. Inferential statistics to find out the difference between the groups was done using One- way Anova followed by Post Hoc Tukey's HSD (table 6).

From the above data, the highest ΔE value was obtained for the tea group which indicates its high staining potential. The lowest value was obtained for the nicotine solution (5.22 ± 0.94) thereby proving to be the group with the least amount of staining capability. The staining potential of the Draksharishtam (ayurvedic tonic) group was also significantly high (6.24 ± 1.01).

Except for the nicotine solution group (ΔE value = 4.4 ± 1.04), significant changes were achieved at the end of mechanical cleansing in all the test groups as indicated by their p values. The best results were achieved by mechanical cleansing in the betel mixture group (2.75 ± 0.75).

After chemical cleansing, highly significant changes were obtained for all the test groups ($p=0.0001$) with the highest change in the tea group and the least difference in the nicotine solution group.

A visually perceptible colour difference from the control group was seen in all the test specimens even after undergoing both the cleansing regimen. This change was more pronounced in the specimens stained by betel nut mixture and nicotine solution as indicated by their ΔE values.

Discussion

The current study focuses on the colour changes in heat cure acrylic resin caused by extrinsic factors that are common in the lifestyle of the people of Kerala. Black tea is a beverage that is regularly consumed in all Malayali households during and in between mealtimes. Tea leaves contain a considerable amount of flavonoid, which gives tea its functional properties and flavour; however, teaflavins in the leaves are reported to be a cause of discolouration.^3

Ayurvedic tonics are another common product in Kerala, especially among older individuals for their supposed health benefits. It has been noted that the chronic use of

such products leads to distinctive staining in denture wearers. Draksharishtam, one such tonic made with raisins as its principal ingredient is popular for its benefits in the improvement of general strength and for the betterment of respiratory ailments and was thus, considered for this study.^{7,8}

Apart from its many deleterious effects, addictive substances like betel nut mixture and nicotine also lead to a significant amount of staining in denture wearers. Betel quid chewing stains dentures as well as the natural teeth, gingiva, and oral mucosa. The colour of the stain varies from deep red to black, depending on its preparation and the longevity of use.⁹ Nicotine, which is colourless on its own turn yellowish on exposure to oxygen and is also known for its staining effects.¹⁰

To date, not many studies have been conducted comparing the staining effects of the above-mentioned agents to the author's knowledge and thus, these agents are considered in this study.

Another important aspect of the maintenance of dentures is the cleansing mechanism adopted by the patients. Most patients exhibit poor denture hygiene due to inadequate knowledge of optimal/correct cleaning techniques and a lack of standardisation in denture hygiene assessments; dentists infrequently assess and record patients' denture hygiene status.¹¹ Improper denture care negatively impacts denture clinical longevity and increases denture plaque aggregation. Therefore, the current study also included a comparison between the effectiveness of stain removal by mechanical methods and a combination of mechanical and chemical methods. Mechanical methods include the use of manual- (using a brush) and/or vibrational-based (using an ultrasonic or sonic bath) cleaning aids.¹¹

Paranhos *et al.*, Neppelenbroek *et al.*, Ural *et al.*, and Gornitsky *et al.* Found sodium hypochlorite and sodium

perborate as appropriate denture cleansers for protecting prosthesis from microbial colonization and maintaining oral and denture health.¹²⁻¹⁵ About 5.25% sodium hypochlorite solution is an effective method for killing adherent microorganisms. Amin *et al.*, Neppelenbroek *et al.*, and Ural *et al.* Found that with 10 min of immersion daily, sodium perborate denture cleanser solutions could completely disinfect the denture.^{13,14,16} For the above-mentioned reasons, the chemical cleanser used in this study contained sodium perborate, which is a peroxide type of denture cleanser.

According to the results of this study, the staining potential was found to be the most for black tea and Draksharishtam, followed by the others. Ironically, the nicotine solution had the least staining potential. This could be because of the method by which nicotine was used in this study. The method of checking the staining potential of nicotine employed here is by making a solution of the substance as previously done by Imirzalioglu *et al.*³ The staining action of nicotine most often is due to the tar caused by smoking cigarettes. However, employing the smoke caused by cigarettes for testing purposes is quite quixotic in an in vitro setting and possibly, unethical in vivo. So, the results of the study can be considered as an indication of the real-life scenario with respect to the staining potential of nicotine.

The results obtained in this study regarding the staining capabilities of black tea are in accordance with a previous study by Um and Ruyter¹⁷ who had reported in a study comparing the staining effects of tea and coffee, that tea caused more discolouration than coffee after 48 hours but, the discolouration due to tea can be easily removed. In another study by Robin Mathai Joseph¹⁸ who used stains like tea, coffee, turmeric and paan mixture, residual stains were found to be more for tea

than for paan mixture. In the above-mentioned study, the pH levels of the agents were measured which exposed the acidic nature of tea in comparison to the paan mixture. This indicated the influence of the acidic nature of tea on the acrylic samples, possibly eroding the polished surface layer and facilitating more stain uptake. This finding is in accordance with the result of Gispin and Caputo¹⁹ who claimed the same while using grapes as a staining solution (being highly acidic). The principal ingredient of the ayurvedic tonic used in the study is dried grapes, indicating its possible acidic nature. On the other hand, paan and nicotine were towards the alkaline side of the pH scale, and could be an explanation for the lesser degree of staining with these stains.

Mechanical cleansing alone could cause significant changes ($P=0.0001$) in three of the test groups; that is among the samples stained with tea, tonic and betel nut mixture. However, no significant change could be made by mechanical cleansing alone in the samples stained with nicotine solution. At the end of chemical cleansing, significant changes were obtained in all the test groups. The ΔE value was the least for the tea group after chemical cleansing indicating the most efficient stain removal pertaining to this group.

While this study could prove that the chemical cleansing agent with sodium perborate as its chief ingredient was more effective in its cleansing capabilities in comparison to regular cleansing with toothbrush and soap, further evaluation is necessary in order to identify the extent to which it can help. The scope of the study can further be improved by checking the surface topography of acrylic on exposure to the cleansers. This can identify the degrading effect, if any, of the different chemical.

Cleansers available. The use of these cleansing tablets can be highlighted for individuals with deteriorated

motor skills for whom effective maintenance with brushing might prove to be an issue.

Conclusion

Long-term aesthetics is a requirement for any kind of prosthesis. Heat cure acrylic denture base resins which are commonly used for the fabrication of removable prostheses, are known to be relatively colour stable for long periods of time. However, prolonged exposure to certain agents causes colour changes in them. The present study establishes the fact that certain agents regularly involved in the diet and lifestyle of the Malayali population such as black tea, Draksharishtam, betel nut mixture and nicotine can cause significant staining.

The long-term colour stability of denture base resins is also significantly affected by the cleansing mechanisms that are adopted by the patients. While mechanical methods are more common, a combination of mechanical methods with toothbrush and soap/paste and chemical methods by way of immersion in sodium perborate cleanser proved to be the most effective from the results of this study.

For these cleansing methods to come into regular practice, it is necessary to educate the patients about the possibility of the occurrence of staining and the importance of such chemical agents in its removal. This can be done by the dentists by taking the initiative to properly educate each patient once they undergo treatment with any such removable prosthesis.

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Legend Tables

Table 1: Test groups

Group No.	Stain Applied	Cleansing Regimen
1(Control)	Nil	Nil
2	Black Tea	Nil
3	Black Tea	Mechanical Cleansing
4	Black Tea	Mechanical Cleansing + Chemical cleansing
5	Betel Nut Mixture	Nil
6	Betel Nut Mixture	Mechanical Cleansing
7	Betel Nut Mixture	Mechanical Cleansing + Chemical cleansing
8	Nicotine Solution	Nil
9	Nicotine Solution	Mechanical Cleansing
10	Nicotine Solution	Mechanical Cleansing + Chemical cleansing
11	Ayurvedic Tonic	Nil
12	Ayurvedic Tonic	Mechanical Cleansing
13	Ayurvedic Tonic	Mechanical Cleansing +Chemical cleansing

Table 2: Mean (\pm SD) of baseline cielab colour measurements for specimen stained with tea

	L	A	B
Control ©	31.29 \pm 2.34	7.92 \pm 1.87	4.04 \pm 2.03
Tea (1)	37.97 \pm 1.55	7.52 \pm 2.01	5.53 \pm 1.87
Tea +Mech. Cleansing (2)	35.15 \pm 1.21	5.46 \pm 1.64	3.79 \pm 1.67
Tea +Chem. Cleansing (3)	31.55 \pm 1.88	6.89 \pm 1.84	3.24 \pm 1.62

Colour measurements of specimen in the control group ©, stained by black tea (1), stained by tea and cleansed by mechanical method (2), and stained by tea and cleansed by mechanical and chemical methods (3).

Table 3: Mean (\pm SD) of baseline cielab colour measurements for specimen stained with ayurvedic tonic

	L	A	B
Control ©	31.29 \pm 2.34	7.92 \pm 1.87	4.04 \pm 2.03
Draksharishtam (1)	37.49 \pm 1.88	7.21 \pm 1.57	4.16 \pm 1.23
Draksharishtam +Mech. Cleansing (2)	33.38 \pm 1.46	5.31 \pm 1.06	2.26 \pm 1.33
Draksharishtam +Chem. Cleansing (3)	32.83 \pm 1.79	7.46 \pm 1.62	3.84 \pm 1.03

Colour measurements of specimen in the control group ©, stained by ayurvedic tonic (1), stained by ayurvedic tonic and cleansed by mechanical method (2), and stained by ayurvedic tonic and cleansed by mechanical and chemical methods (3).

Table 4: Mean (\pm SD) of baseline cielab colour measurements for specimen stained with betel nut mixture

	L	A	B
Control ©	31.29 \pm 2.34	7.92 \pm 1.87	4.04 \pm 2.03
Betel Mixture (1)	36.94 \pm 1.35	7.00 \pm 1.93	4.40 \pm 1.73
Betel Mixture +Mech.Cleansing (2)	33.76 \pm 1.59	6.73 \pm 1.48	3.85 \pm 1.18
Betel Mixture +Chem.Cleansing (3)	31.76 \pm 2.02	6.23 \pm 1.85	2.7 \pm 1.05

Colour measurements of specimen in the control group ©, stained by betel nut mixture (1), stained by betel nut mixture and cleansed by mechanical method (2), and stained by betel nut mixture and cleansed by mechanical and chemical methods (3).

Table 5: Mean (\pm SD) of baseline cielab colour measurements for specimen stained with nicotine solution

	L	A	B
Control ©	31.29 \pm 2.34	7.92 \pm 1.87	4.04 \pm 2.03
Nicotine (1)	36.46 \pm 1.54	7.26 \pm 1.38	3.76 \pm 1.29
Nicotine +Mech.Cleansing (2)	34.24 \pm 1.97	5.3 \pm 1.06	2.08 \pm 1.06
Nicotine +Chem.Cleansing (3)	34.99 \pm 1.63	6.14 \pm 1.39	3.17 \pm 1.19

Colour measurements of specimen in the control group ©, stained by nicotine solution (1), stained by nicotine solution and cleansed by mechanical method (2), and stained by nicotine solution and cleansed by mechanical and chemical methods (3).

Table 6: Means (\pm SD) of colour changes (Δ E) from baseline based on staining solutions.

Test Group	Δ E After Staining
Tea	6.85 \pm 0.92
Draksharishtam	6.24 \pm 1.01
Betel Mixture	5.73 \pm 0.91
Cigarette	5.22 \pm 0.94

Table 7: Means (\pm SD) of colour changes (Δ E) from baseline based on the cleansing regimen

	Tea	Draksharishtam	Betel Mixture	Cigarette
Without Cleansing (1)	6.85 \pm 0.92	6.24 \pm 1.01	5.73 \pm 0.91	5.22 \pm 0.94
Mech. Cleansing (2)	4.58 \pm 0.82	3.78 \pm 1.03	2.75 \pm 0.75	4.4 \pm 1.04
Chem. Cleansing (3)	1.33 \pm 0.67	1.62 \pm 1.13	2.2 \pm 0.47	4.2 \pm 0.65
P Value (Anova Test)- Within Group	0.0001*	0.0001*	0.0001*	0.03*
Post Hoc Test 1 Vs 2	0.0001*	0.0001*	0.0001*	0.10
(Tukey's Hsd 1 Vs 3	0.0001*	0.0001*	0.0001*	0.03*
Test) 2 Vs 3	0.0001*	0.0002*	0.23	0.86

*P<0.05 is statistically significant