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Colour Stability of Denture Base Resin and Soft Liners Following Exposure to Staining Agents and Denture Cleanser.

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KEYWORDS

Colour Stability, Denture base resin, Soft liners, Cleansers, Staining agents, CIELab values.

ABSTRACT:

Introduction: Denture base resin must match the colour and appearance of the oral tissues to achieve aesthetic results. Long-term colour stability in denture base resins starts with the resin maintaining colour and translucency during processing. In dentistry, colour is one of the most important dimensions of aesthetics. Soft denture liners are commonly used to enhance the comfort and fit of dentures. Colour stability of denture materials is affected by the type of material, staining agent, and cleansing regimen used.

Aim: Study to evaluate the colour stability of hard-cure resin and soft liners when exposed to staining agents such as coffee and aerated drinks (Coca-Cola), with distilled water as a control. Additionally, to study the effect of sodium hypochlorite as a cleansing agent on these materials.

Materials and Methods: Thirty disks (10mm diameter, 2mm thick) were prepared from heat-cure (PMMA denture base resin -DPI heat-cure denture base resin) and soft liners (GC soft liner and Mollosil soft liner). After taking baseline colorimetry measurements, the specimens were immersed for 8 hours in staining agents: coffee, Coca-Cola, and distilled water. After 8 hours, the specimens were rinsed with water. Subsequently, the specimens were immersed in 0.5% sodium hypochlorite as a cleanser. The procedure was repeated for 30 days. In between this, on the first day as a baseline line with the help of a colorimeter (spectrophotometer), the colour stability of the specimens after 7 days, 15 days, and 30 days was studied.

Results: Heat-cure base resin showed a highly significant colour change (ΔE) at 30 days. Significant interaction was found between resin, liners, and cleansers. For the staining agent coffee, Coca-Cola allowed more dissociation than water.

Conclusions: Colour stability of denture base resin and soft lining against coffee and Coca-Cola was not significantly different. The effect of staining solutions on the colour of test material in each session, however, was perceivable by the human eye (ΔE>1). The colour shifts of all test material were clinically acceptable (ΔE<3.7). Sodium hypochlorite solution in low concentration (0.5%) acts as an effective cleanser for protecting the prosthesis from microbial colonization and maintaining overall and dental health.

Introduction:

The aesthetic longevity of removable dentures is a pivotal concern in Prosthodontics, with colour stability being a critical factor influencing patient satisfaction and prosthesis acceptance. Denture base materials and soft liners are susceptible to discoloration over time due to various factors, including dietary habits, such as consumption of staining beverages like tea, coffee, and aerated drinks such as Coca-Cola, Pepsi, etc., which have been shown to significantly affect the colour stability of acrylic denture base resin as well as soft liners[1].

Colour stability is the ability of any denture material to retain its original colour[2]. Colour stability of denture base resin and soft liners has been evaluated in the literature[3, 4]. It is one of the clinical properties for all

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dental materials [5- 9] ,and colour changes are indicators of aging or damage to the dental materials [10]. Previous studies have indicated that the colour stability of denture material is influenced by the type of material, the staining agent, and the cleansing regimen employed. However, there is a paucity of comprehensive studies evaluating the combined effects of common dietary staining agents and chemical cleansers on both denture base materials and soft liners.

Denture base resin must match the colour and appearance of the oral tissues to provide satisfying aesthetic results [11]. Long-term colour stability in denture resins starts with the resin maintaining its colour and translucency, processing [12]. Overheating or insufficient pressure during polymerization can cause porosity, excessive residual monomers [13, 14], and unfavorable surface characteristics [15, 16]. Porosity in hard denture base resins has been associated with colour changes during the consumption of coffee, Coca-Cola, and wine [13, 18-22]. Acidity of consumed drinks causes decolouration of denture base resins[16, 23, 24].

Heat-cure acrylic resins, commonly used for denture bases, are a plastic material that hardens under heat. They typically consist of powder (polymer) and liquid (monomer) that are mixed to form a dough-like consistency, which is cured with heat. The most common type of heat-cure resin is polymethyl-methacrylate (PMMA). It has been successfully used for various applications in dentistry for many years. It has many advantages, particularly its appearance and ease of manipulation [11]. It is a preferred material for removing denture bases and implant-supported restorations. Pure PMMA is a clear thermoplastic material that provides the opportunity of colour matching with the tissue by adding plasticizers and cadmium. These materials are supplied in the form of powder and liquid [25]. It is most commonly used denture base resin as they have low cost, easy construction method, and ease of repair compared to other materials available for fabrication of denture [26].

Soft denture base reliners are materials that form a cushioned layer between the hard denture base and the oral mucosa. The liners help in distributing, more evenly, the forces of mastication to underlying tissues by absorbing some of the masticatory forces [27]. They have the potential of improving the comfort of denture patients with ridge atrophy, thin and non-resilient mucosa, bony undercuts, and bruxomania [28]. Resilient lining materials can be categorized as plasticized acrylic resins or silicon polymers. One major indication for soft liner is to reduce the problems arising from the effects of age changes in denture-bearing tissues. The use of soft liner can improve both masticatory efficiency and oral comfort for patients presenting reduced thickness of the oral mucoperiosteum [29]. Denture soft liner has a considerable role in removable prosthodontics because of its cushioning effect and its ability to redistribute masticatory forces transmitted to the denture bearing area [30].

The use of soft liners for relining removable dentures is usually advantageous for patients with atrophic ridges, bony undercuts, denture opposing natural teeth, and non-resilient mucosa [31, 32]. Lining material allows the mucosa to heat by distributing functional loads across denture-bearing tissues [31, 33,34].

To measure the colour stability of heat-cure resins and soft liners, a common procedure involves fabricating test specimens, immersing them in different staining solutions, and then using a spectrophotometer to assess the colour changes. Staining of polymeric (heat-cure resin) materials by coloured solutions such as coffee, tea, nicotine, and beverages has been reported by many researchers [35-40].

It is well known that beverages such as tea, coffee, wine, and some artificial dyes used in food may increase the discoloration of both denture base resin and soft liners. Consumption of certain beverages, such as tea and coffee, may affect the esthetic and physical properties of resins during restoration. The consumption of aerated drinks, being acidic, may be detrimental to the properties of restorative resins. It has been observed that low pH media, such as Coca-Cola (pH 2.7), affect the surface integrity of materials, including resin, by softening the matrix. Coffee has been found to have a stronger chromatogram than tea or Coca-Cola [41].

The choice of denture cleanser for different denture base resins is based on the chemistry of resin and cleanser, denture cleanser concentration, and duration of immersion. Denture cleanser solutions used were 0.5% sodium hypochlorite.

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Davi LR et al[42] found that hypochlorite solution in low concentration is also effective in eliminating all microorganisms. Similar findings were reported by many workers [43, 44].

Aim and Objectives

Aim:

The aim of this in vitro study is to measure the colour stability of heat-cure denture base resin and soft liners subjected to staining agents and cleaned with denture cleanser.

The null hypothesis was that no colour change would be found in denture base resin and soft liners after staining when cleaned with a common chemical cleanser.

Objectives:

- To determine the baseline colorimetric values of specimens prepared using a spectrophotometer.
- To measure colour changes (ΔE values) of specimens after staining and post-cleaning phases using spectrometric analysis.

Materials and Methods

This in vitro study was carried out at Dr Rajesh Ramdasji Kambe Dental College and Hospital, in the Department of Prosthodontics and Crown & Bridge, Kanheri-Sarap, Tq-Barshitakli, Dist-Akola, Maharashtra, India. Spectrophotometric measurements were carried out at the Department of Chemistry, Sant Gadge Baba Amaravati University, Amaravati, using a UV-VIS Spectrophotometer Carry 60 (Agilent Tech.).

Commonly used heat-cure resin (PMMA) is chosen for this study; GC and Mollosil soft liners were also used. Sodium hypochlorite is used as a cleanser. The material information is summarized in Table 1.

Table 1: denture base resin and soft liners tested.

Materials	**Type**	**Composition**	**Manufacturer**
Heat-cure resin	Heat activated	Polymethylmethacrylate	
GC Reline™ soft	Commercial RTV material	Polyvinyl dimethyl siloxane with 50-55% silica.	GC Dental Products Corp, Tokyo, Japan.
Mollosil® soft liner	Silicon Soft relining material Cold-cure silicon-based, permanently soft	Alkyl silicon resin in an organic solvent.	KG Kostner and Co. Karlsrube, West Germany.
Sodium hypochlorite	Cleanser	Sodium hypochlorite	AB Enterprises, Ghatkopar East, Mumbai.
Distilled water	Control	Distilled water	WALDENT Water Distillation unit

Thirty disks (10mm diameter, 2 mm thick) were fabricated from heat-cure resin (PMMA). Specimens fabricated from PMMA were processed with a conventional heat activation technique after dimensionally accurate wax disks were invested in a denture flask. Following the manufacturer's instructions, the powder and liquid were combined. Following the dough stage, the mixture was kneaded, filled into the mold, and finally closed using a bench press. The flasks were first allowed to undergo a brief polymerization process in a water bath at 72°C for 1.5 hours, and then they were boiled for 30 minutes in water at 100°C in a dental acrylizer. Following the curing procedure, the flasks were allowed to cool on a bench until they reached room temperature. The flash was cut, and the specimens were recovered. The resin disks were polished and modified on one side after

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processing. Dimensions of disks were verified by using a digital caliper.

The soft liner materials (GC and Mollosil soft liner) were prepared following the manufacturer's guidelines. Both the soft liners were then carefully applied to the prepared intaglio surface of the 15 denture base disks separately. The denture, now coated with the soft liner, was re-flasked to ensure proper adhesion and complete curing of the liner. Any excess material is trimmed, and the denture disks are finished. Glazing the junction between the denture base disk and the soft liner may further improve the bond. Specimens were stored in water for 24 hours at 37 °C to stimulate body temperature.

Initial colorimetry values for each specimen were recorded using a spectrophotometer (specification). Ten specimens from each group were immersed in two staining solutions-coffee and Coca-Cola (specification)—for 8 hours. After immersion, the specimens were rinsed with distilled water and then placed in a cleansing solution containing sodium hypochlorite (0.5%) for 12 hours at room temperature. Distilled water was used as the control. The staining and cleansing solutions were replenished after each immersion. This cycle was repeated every 24 hours for a total duration of 30 days. Colorimetry measurements were taken using a spectrophotometer on days 1 (baseline), 7, 15, and 30.

The spectrophotometer was calibrated with white and black calibration plates before each measurement. Each specimen was rinsed with distilled water and dried before colour measurement. Mean and standard deviation for colour change (Δ E) values were determined using the CIELab colorimetric system. Colour change was calculated for each specimen from changes (Δ) as follows:

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

Where L*, a*, and b* are differences in colour parameters for two specimens measured for comparison. The L* coordinate represents the brightness of the object, a* value represents red or green chroma, and b* represents blue or yellow chroma [45].

To determine the colour change in 1week, 2weeks, and 4weeks, the mean ΔE values of specimens in each staining solution were evaluated with a Two-Way ANOVA test. The significant differences were analysed with the Tukey test to find out which group differed from the other.

Results

The effect of duration and different staining solutions on the colour shift of acrylic resin and soft liners was observed in the present study Δ. The results were calculated between specimens of each test material in the controlled group and specimens of the same material in different staining solutions.

Denture base resin specimens staining studied in this work is shown in Fig. 1. Baseline CIELab values (means ±standard deviations) for the baseline measurements are shown in Table 2. Means ± standard deviation of colour changes from baseline measurements (ΔE) after 1, 2, and 4 weeks of staining and cleansing cycles are shown in Table 3.

A two-way ANOVA Test was carried out, which is the most appropriate statistical test to analyze the colour stability of one denture base resin, two strainers, two soft liners, and one cleanser. This test allows for the examination of the effects of two independent variables, i.e., stainers and soft liners, on the dependent variable, i.e., colour stability, while controlling for the effects of the other. Two categorical factors (strainers and soft liners) influence colour stability. This test reveals that the interaction effect of one factor (stainer) on the colour stability depends on the level of the other factor, i.e., soft liner. It also assesses the individual effect of each factor on colour stability, regardless of other factors.

Two-way ANOVA testing between cleanser and staining solution indicated a significant difference (ρ= 0.059). The Tukey test indicated that after 4 weeks, cleansed resin had more colour change (Mean ΔE=15.9)than those with cleanser. Two-way ANOVA interaction between cleanser nd denture base resin indicated a significant difference (ρ =0.32). The two-way ANOVA interaction between denture base resin and staining agents indicated a significant difference. The Tukey Test showed that after 4vweeks coffee produces more colour change (Mean ΔE= 13.23) than coca cola (Mean ΔE =15.43)

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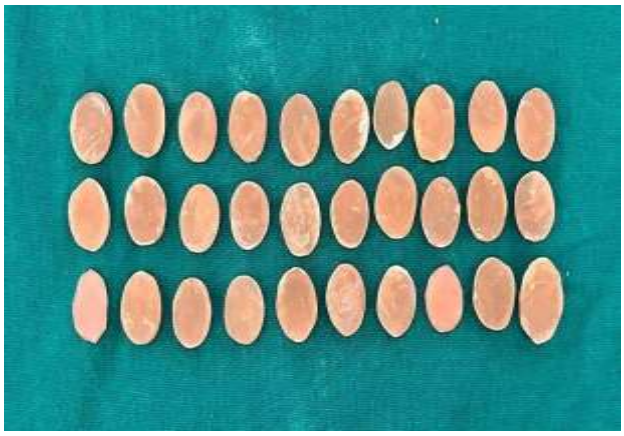

Figure 1: Colour changes in denture base resin and soft liner specimens during 4 weeks of staining in coffee and cleansing with water or sodium hypochlorite.

Figure 2: UV-VIS Spectrophotometer Carry 60 (Agilent Tech.).

Table 2: Mean (±SD) of baseline CIELab colour measurements for each denture base resin and soft liner before treatment.

Resin	L*	a*	b*
PMMA	57.6(±0.3)	22.2(±0.42)	14.4(±0.22)
GC soft liner™	47.44(±1.77)	19.31(±1.18)	10.00(±0.70)
Mollosil®	51.04(±0.58)	23.3(±1.37)	14.37(±1.26)

a* and b* -chromatic scale, L*-light and dark on a scale 0 (black) to 100 (white), SD -standard deviation, CIE – International Commission on Illumination.

Table 3: Means (ΔSD) of colour changes (ΔE) from baseline at various time intervals for one denture base resin, two soft liners, two staining agents, and one denture cleanser(SD- Standard Deviation)

Resin	Soft liner	Staining agent	Cleanser	ΔE from baseline		
				Week 1	Weeks 2	Weeks 4
PMMA	-	Coffee	Sodium hypochlorite	13.39 (±0.79)	14.16 (±1.08)	14.22 (±0.84)
PMMA	-	Coca Cola	Sodium hypochlorite	14.7 (±0.26)	13.83 (±0.25)	14.2 (±0.66)
-	GC Soft liner™	Coffee	Sodium hypochlorite	15.12 (±0.97)	15.13 (±0.99)	16.06 (±0.89)
-	GC Soft liner™	Coca Cola	Sodium hypochlorite	15.02 (±0.78)	15.05 (±0.8)	14.87 (±0.93)
-	Mollosil®	Coffee	Sodium hypochlorite	11.88 (±0.74)	12.58 (±0.83)	12.83 (±0.81)
	Mollosil®	Coca Cola	Sodium hypochlorite	12.40 (±0.79)	12.30 (±0.81)	12.53 (±0.84)

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Discussion

The study results indicate that staining intensity over time with the colour change value (ΔE) increases up to 30 days. Water sorption initially softens the polymer resin components by swelling the network, reducing functional forces between polymer chains. Acrylic resins tend to absorb solvent or water owing to the polarity of PMMA molecules. The absorbed solvent diffuses into the polymer network, disrupting polymer linkages and causing hydrolytic degradation, resulting in a colour change of acrylic resin [46]. Water sorption saturation in polymeric materials leads to stabilizing colour changes.

Significant colour shift occurred in each test group, in each staining solution over time. When the colour of heat polymerized acrylic resin was evaluated, it was observed that the colour differences between specimens in the control group and each staining solution were all perceivable by the human eye; however, only coffee significantly affected the colour of the specimen over time.

Coffee causes more staining than Coca-Cola because coffee staining involves both adsorption and absorption of colorants. The discoloration is due to the absorption of pigments from these beverages into the porous structure of acrylic resin and soft liners. Holis et al [1] have evaluated colour stability using beverages such as Coca-Cola, grape juice, and coffee. Coffee contains tannic acid (pH 6-6.4), which causes a yellow brown colour and is the primary staining agent. Coffee is often used as a staining agent in studies. Lai et al [22] reported that although coffee is considered hygroscopic, it caused significant colour changes in hydrophilic acrylic resins. Coffee stains resin by absorption and adsorption because of the different polarities of yellow colorants [20].

There is evidence that beverages like tea and coffee significantly increase the development of stains on dental materials. Cooly et al[47]reported that resin restorative materials exhibited staining after immersion in coffee solution for 7 days. A similar finding was observed in the present study.

Both cola and coffee can cause discoloration in acrylic resin and soft liners used in dentures. The discoloration is due to the absorption of pigments from these beverages into the porous structure of acrylic resin and soft liners.

It has been observed that low pH media, such as Coca-Cola (pH 2.7), affect the surface integrity of materials, including resin, by softening the matrix. Coffee has been found to have a stronger chromatogram than tea or Coca-Cola [41].

Sodium hypochlorite cleanser can affect the colour stability of acrylic resin and soft liner, potentially causing discolouration or whitening. While some studies indicate that low concentrations of sodium hypochlorite have a minimal impact on colour change, prolonged exposure or higher concentrations can lead to noticeable discoloration. Soft liners are susceptible to staining from coffee and Coca-Cola.

The study " The effect of 5.25% sodium hypochlorite on colour stability of acrylic resin and silicon-based soft liners by Sollum AM[48] investigated how common denture disinfectant solution affects the colour of different types of soft denture liners.

Coffee in particular tends to cause more pronounced discolouration in both heat-cured acrylic resin and silicon soft liners. The duration of exposure to staining solutions and cleansers significantly impacts the degree of discolouration. Coffee possesses a significant staining challenge for both heat-cure resin and soft liners. Silicon material shows better colour stability. Longer immersion in the staining solution leads to more pronounced colour changes.

The available search results do not offer specific information on the colour stability of GC soft liners. Silicon-based soft liners are generally considered to have better colour stability compared to acrylic base liners. Mollosil is shown to be more resistant to discolouration from staining agents compared to acrylic resins. The GC soft liner has better bonding properties and less water absorption as compared to Mollosil, which could affect colour stability.

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In studies assessing the colour stability of heat-cured resin and silicon soft liners, particularly when exposed to coffee and Coca-Cola as staining agents and sodium hypochlorite as a cleanser, several conclusions emerge. Coffee generally causes more significant discoloration than Coca-Cola. Both heat-cured acrylic resin and soft liners can be affected by these staining solutions, but silicon liners exhibit better colour stability, particularly when subjected to cleansers like sodium hypochlorite.

Conclusions

1. Colour change caused by coffee and cola was not significantly different.
2. Colour stability of PMMA resin and both soft liners, and that of cleansing agent, shows significant colour changes when exposed to coffee and cola. Staining intensity increased over time with colour change values (ΔE) up to 30 days.
3. The effect of the staining solution on the colour of each test material was perceivable by the human eye (ΔE >1).
4. The colour of soft liners was affected more by coffee than by cola.
5. Colour change of denture base resin and soft liners used in this study was within the clinically accepted range of colour difference.

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