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Effect of Different Denture Cleansers on Color Stability of Acrylic Resin Teeth – An In Vitro Study

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Abstract

Introduction: The durability of denture teeth to colour change is critical in selecting denture teeth, especially in terms of aesthetic demands and patient expectations. It is critical that the artificial teeth color remains constant over time when exposed to various cleaning solutions. The objective of the study is to assess the influence of three different commercially available denture cleansers on the color of acrylic resin teeth using the digital photography method and the Commission Internationale de l'Eclairage (CIE) L*a*b* standard. **Methodology:** Sixty acrylic maxillary central incisor teeth were divided to three groups of 20 samples each. The samples were left immersed in three different denture cleansers (DENSIVE, SECURE and CLINSODENT) for one month, simulating one month of usage by the patient. Digital photography was used to obtain baseline and final color readouts of the teeth on the basis of CIE L*a*b* standard, using image analysis software (Adobe Photoshop Inc System) and the color alteration (ΔE) of the samples was computed. **Results:** Maximum color change was found in teeth treated with DENSIVE denture cleanser, followed by CLINSODENT and SECURE, respectively. And this was found to be statistically significant (p-value ≥ 0.05). **Conclusion:** It is possible to deduce that the color stability of acrylic resin teeth is influenced by the use of denture cleansing solutions, and a marked color change was noted with the digital photography method.

Keywords: Acrylic Resin Teeth, Denture Cleansers, Digital Photography Method, Staining

1. Introduction

Edentulism is commonly recognized as a poor health outcome since it can diminish a person's quality of life[1]. The World Health Organization[2] assessed edentulism prevalence in India to be 19% among 65–74 years old. Peltzer *et al.*[3] reported "edentulism prevalence in India to be 16.3% (95% CI 14.3–18.4)"[3], Acrylic resins and porcelains have both been utilized to fabricate artificial teeth.

Acrylic acid and also its metabolites became acknowledged even during the 1890s. It wasn't till 1901 that this field of study got its start when Dr. Otto Röhm created solid, clear polymers of acrylic acid. Acrylic monomer derivatives, methyl and ethyl acrylate and completely clear solid polymers were developed. Peyton FA4 points out, "The first successful alternative to vulcanite as a denture base material was introduced in 1936 and is called Vernonite. It is a Polymethyl Methacrylate (PMMA) heat-processed product. PMMA was used for crowns, inlays and permanent partial dentures by the year 1940"[4].

Increased surface irregularity produced by brushing, encourages the build up of biofilm. It may also be connected to a greater deposition of beverage-derived pigments, resulting in tooth discoloration and aesthetic harm. Pero AC *et al.*[5], "Synthetic teeth with double cross-linked polymers, Interpenetrating Polymer Network type (IPN) acrylic resin teeth and conventional acrylic resin teeth with inorganic compounds were all introduced to address the shortcomings of acrylic resin, such as low wear resistance and low color stability"[5].

Several studies have linked poor denture cleanliness to systemic infections such as endocarditis and pneumonia. Many patients in long-term care facilities cannot brush their dentures properly due to sickness, dementia and poor

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physical dexterity. Inadequate cleaning might encourage the growth of Candida and bacterial species, which could function as reservoirs for infections to spread. Chemical denture cleaning solutions have the benefit of being easy to use.Various studies have demonstrated that they are effective in minimizing biofilm development in vitro and in vivo[6].

The peroxide cleanser work by lowering surface tension and liberates oxygen. Because the liberated oxygen might cause effervescence, the cleanser may be able to remove debris mechanically. Hypochlorites are considered to interact directly on plaque's organic matrix. Hypochlorites bleach light stains and food debris by destroying the organic matrix with hypochlorite ions (ClO) and chlorine molecules (Cl2)[7].

In contemporary aesthetic dentistry, it is becoming increasingly vital to analyze tooth color for rehabilitation and bleaching procedures. The traditional visual approach uses shade tabs that are often teeth-shaped. The instrumental method uses color-measuring instruments. Borse S *et al.*[8] stated the two basic ways for shade analysis, "Vita Lumina, Vita classical-three-dimensional (3D) master (Vita) and Portrait IPN shade guide (Dentsply) are the currently available teeth shade tabs. Spectroshade (spectrophotometer, MHT Optic Research AG, Niederhasli, Switzerland), Vita easy shade (spectrophotometer, Vident, Brea, CA, USA) and ShadeScan (digital camera with a colorimeter, Cynovad, Montreal, Canada) are some of the devices used to determine tooth color"[8].

Borse S *et al.*[8] reported "the most common shade of maxillary and mandibular incisors in males is A2 for Vita Lumina, 2R2.5 for Vita 3D master and 140 for Chromascopshade guide and for females is A1 for Vita Lumina, 1M2 for Vita 3D master, and 120 for Chromascop shade guide. Males have darker teeth than females"[8].

The CIE L*a*b* color space is one of the most extensively used and popular colorspaces today, used to measure the color attributes of dental materials. Joiner A9 in his review, "Color is defined using a three-dimensional mathematical framework based on an equal distance in the color space, directly connected to equal perceived gradations. Color is divided into three variables in this approach. L* is a metric for brightness or whiteness. For bright or white samples, high L values are obtained. a* measures hue-chroma in the red-green order, where positive a* indicates redness and negative a* indicates greenness. b* measures hue-chroma in the yellow-blue order, where positive b* indicates yellowness and negative b* indicates blueness. The CIE L*a*b* system has the benefit of being well-suited to measuring minor color variations. It has the ability to represent color differences in units that are connected to visual perception and clinical relevance".[9]

Considering that artificial teeth undergo color alteration over the course of time and this alteration may be related to the cleaning methods, the null hypothesis examined was that none of the denture cleansers promoted significant alteration of color in the teeth. The aim of the study was to assess and compare the staining capabilities of three different commercially available denture cleansers on acrylic resin teeth.

2. Material and Methods

Sixty acrylic (PREMADENT, Super Dental Products, India) maxillary central incisor teeth in the shade M1-22 was used in the investigation. Digital photography was used to obtain baseline color readouts of the teeth according to the CIE L*a*b* standard. The image processing in accordance with the procedurestated by Bengel[10]. Ethical clearance was obtained from the institutional ethics board [IEC/TDCH/106/2021].

The study employed a Canon 500D series single-lens reflex digital camera (SLR) (Canon Inc., Tokyo, Japan). The digital camera was attached to an Asus vivo book laptop (Asustek Computer Inc., Taiwan) with image analysis software installed (Adobe Photoshop version 21, Adobe Inc System, California). They generate a dimensionally precise picture[10]. A digital photo of the teeth was taken and saved as a JPEG file with the similar level of compression. The camera settings were 100 mm macro lens with autofocus, f20 aperture and 1/125 second shutter speed"[10].

- In the Adobe Photoshop software, the levels dialog, which had a histogram chart and three color dropper tools, was opened.
- The dropper tool is moved over the gray card in the picture and the red, blue, and green values were obtained. To change these to L*a*b* values, 'image'was clicked in the main toolbar followed by 'mode' and then L*a*b* color. The L*a* b* values of the gray card were obtained".
- "The known L*a*b* values of the gray card were 54, 0 and 0, respectively. The L*a*b* values obtained were

adjusted/calibrated to these values. This was done by clicking on 'image', then 'adjustments', and then 'hue/saturation'. Similarly, the a* and b* values were calibrated. The photograph was standardized using the gray card as a reference".

- "The 'Magnetic Lasso Tool' in the software was used to delineate the area on the maxillary right central incisor. The 'Magic Wand' tool next to it was used to eliminate the reflection on the tooth surface. The right central incisor was ready for determination of its L*a*b* values, which was done using the depiction in the histogram toward the right-hand side of the screen"[10]. (Figure 1).

For the analysis, only well-exposed digital photos were taken. Photographs that were under or overexposed were rejected and new images were taken[11]. Because the range of these values differs in both systems, the Photoshop L*a*b* values were converted to the Commission Internationale de l'Eclairage (CIE) L*a*b* values. In Photoshop, the range of the mean L* value L (PM) is 0 to 255. The CIE L* value ranges from 0 to 100.

Based on recommendations on uniform color spaces[11], a transformation was done by using the following formula: L* = L (PM) x 100/255. The a* and b* values were transformed in the same manner. The Photoshop values range from 0 to 255 and the CIE a*, and b* values from +120 to +120. The transformation formulae were as follows: a* = [a(PM) - 128] X 240/255; b* = [b(PM) - 128] X 240/255, where L(PM), a(PM), and b(PM) are the Photoshop mean values of L*, a*, and b*, respectively"[11].

The 60 PREMADENT maxillary central incisor teeth, a two-layered crosslinked acrylic in shade M1-22 were divided into three groups, each with 20 samples, Group A-DENSIVE, Group B-SECURE and Group C-CLINSODENT (Figures 2A, 2B). The samples were

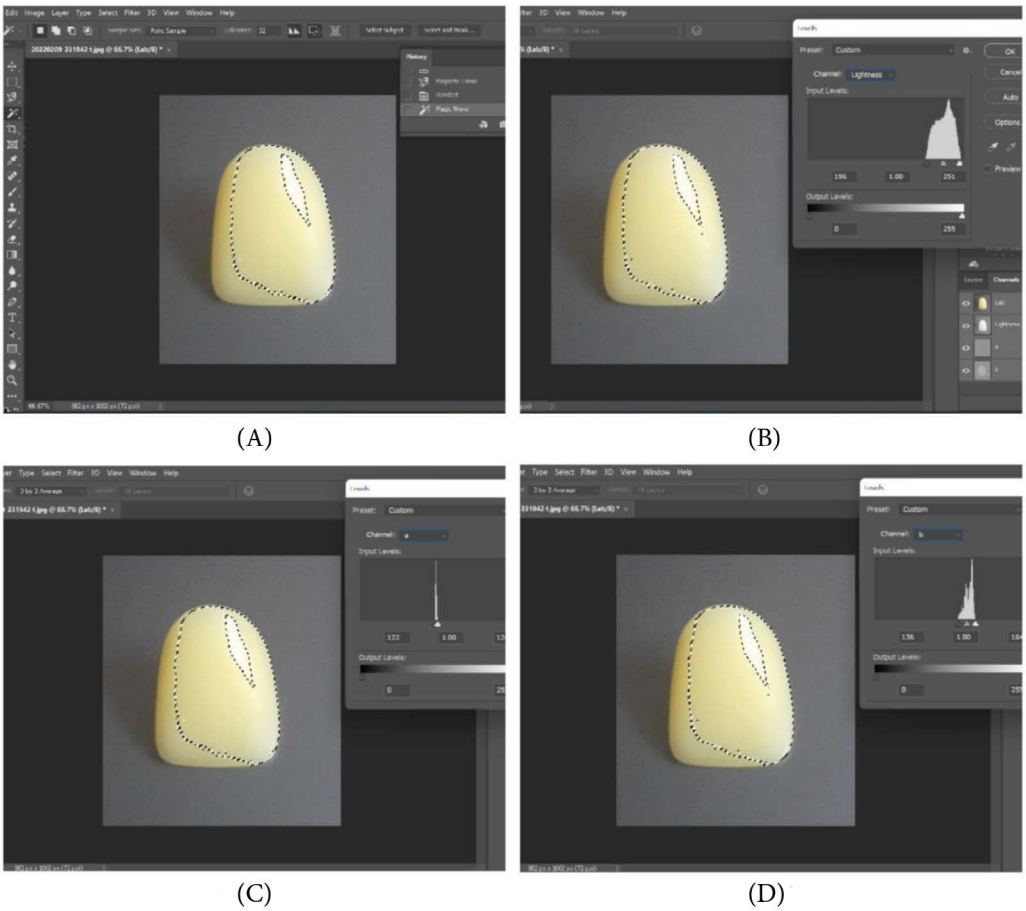


Figure 1. After Gray card standardization, the "Magnetic Lasso Tool" and "Magic Wand tool" are used to delineate and eliminate the reflection on the tooth surface, respectively **(A).** The histogram toward the right-hand side of the screen was used to determine L* **(B)** a* **(C)** b* **(D)** values.

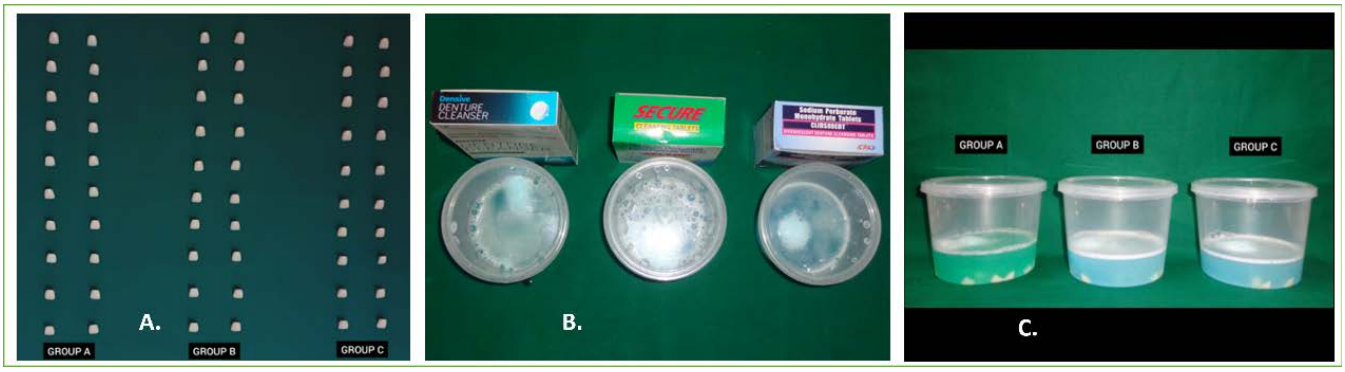


Figure 2. **A)** Three groups (20 each) of acrylic maxillary central incisors; **B)** Three different denture cleansers.Group A-DENSIVE, Group B-SECURE and Group C-CLINSODENT; **C)** Samples immersed in respective denture cleansers, 8 hours/day for one month.

left immersed in the denture cleansers for one month in plastic containers at room temperature, simulating one month of usage by the patient (Figure 2C). Generally, patients remove the dentures for 8 hours at night and to simulate that the teeth were immersed for eight hours per day. The cleansers were replaced daily throughout the month[12]. After rinsing the samples under running water, they were immersed in artificial saliva (ICPA Wet mouth) for the rest of the day, this is to simulate the patient wearing the dentures for the remainder of the day.

After one month, the teeth were rinsed, and photographs were taken. Standardized photos were used to find L*a*b* values. The obtained values of the teeth after soaking in denture cleansers were compared with the previous reading. The final color readouts were measured after the process and the change in color (ΔE) of the samples was computed with the formula[13] and the difference was noted.

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

where: $\Delta L^* = L^*_{final} - L^*_{initial}$,

$\Delta a^* = a^*_{final} - a^*_{initial}$ and

$\Delta b^* = b^*_{final} - b^*_{initial}$"[13]

Statistical Analysis

The Shapiro Wilk and Kolmogorov Smirnov tests were used to determine whether the data had a normal distribution. After the colour readout, the values were presented to statistical analysis (One way ANOVA, Tukeys' HSD Post hoc test at the level of significance at 95%) with software SPSS version 21.

3. Results

The mean color alteration ΔE value was found to be higher in Group A (23.79 ± 0.742) (DENSIVE), followed by Group C (22.97 ± 1.166) (CLINSODENT) and Group B (16.25 ± 2.318) (SECURE) after one month, respectively. Results of this study show, maximum color change in teeth treated with DENSIVE denture cleanser, followed by CLINSODENT and SECURE, respectively. And it was determined that this was statistically significant (p-value ≥ 0.05). Hence, the null hypothesis is rejected. (Refer to Table 1). The groups were compared using Tukey's HSD Post hoc analysis.

- Group A vs. Group B, Group A (DENSIVE) showed marked color alteration.
- Group B vs. Group C, Group C (CLINSODENT) showed marked color alteration. This was found to be statistically significant (p-value ≥ 0.05).
- Group A vs. Group C, Group A (DENSIVE) showed marked color alteration. However, this difference was not found to be statistically significant (p-value ≥0.05) (Table 2).

4. Discussion

This study was conducted with afford to assess the association between exposures to different denture cleansers and colour stability of acrylic resin teeth.

The cleaning processes utilized in the lab were designed to mimic the procedures used by denture wearers over a month. The methodology employed in this study is similar to that used in prior studies that used spectrophotometry and the CIE L*a*b* standard[14].

Previous studies conducted by Lars Schropp *et al.*[15] and Dhruv Anand *et al.*[16] to evaluate the efficacy of digital photographs and graphic computer software for color matching compared to conventional visual matching and

Table 1. Showing mean color alteration ΔE values of acrylic teeth treated with different denture cleansers over a month.

	N	Mean	Std. Deviation	95% Confidence Interval for Mean		p-value
				Lower Bound	Upper Bound	
Group A	20	23.7933	.74249	23.4458	24.1408	0.0000
Group B	20	16.2589	2.31877	15.1737	17.3441	
Group C	20	22.9743	1.16665	22.4283	23.5203	
Total	60	21.0088	3.73272	20.0446	21.9731	

Table 2. Showing the comparison of ΔE between each study group usingone way ANOVA test and Post Hoc - Tukey's HSD test

(I) GROUP		Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval	
					Upper Bound	Lower Bound
Group A	**Group B**	7.53439*	.49292	.000	6.3185	8.7503
	Group C	.81896	.49292	.306	-.3969	2.0348
Group B	**Group A**	-7.53439*	.49292	.000	-8.7503	-6.3185
	Group C	-6.71543*	.49292	.000	-7.9313	-5.4996
Group C	**Group A**	-.81896	.49292	.306	-2.0348	.3969
	Group B	6.71543*	.49292	.000	5.4996	7.9313
*. Mean difference at ≥0.05 level is considered as significant.						

spectrophotometer, respectively. They claimed that shade matching with the aid of digital pictures and computer software was far more accurate than traditional visual approaches and could be used as a substitute for the spectrophotometer.

When compared to electrical devices like spectrophotometers and colorimeters, digital photography has the added benefit of allowing numeric data to be analyzed with the image-editing software when assessing tooth color and the effect of bleaching methods. This is crucial for obtaining a precise clinical impression. "There is no photographic method that is free of disadvantages and inaccuracies. Even when standardizing the procedure as much as possible, there are certain variations of a technical nature that cannot be avoided"[10].

It is clear from this experiment that teeth treated with the three different denture cleansers changed color, explaining the marked changes in ΔE values after one month of immersion in the cleansers and artificial saliva. These results were consistent with findings from Saraç *et al.*[17] and Purnaveja *et al.*[18], who reported that "denture cleansers could cause whitening or bleaching, loss of soluble components or water absorption in acrylic resin materials"[17,18].

The denture cleaners utilized in this research were alkaline peroxide type (DENSIVE, SECURE, CLINSODENT) denture cleansers. Studies conducted by Ayaz EA *et al.*[19] state that sodium bicarbonate or sodium perborate, an effervescent component in the denture cleansers, decomposes into alkaline peroxide when dissolved in water. Following that, the peroxide solution releases oxygen and wears down the material mechanically[20]. These denture cleansers may cause the acrylic resin to hydrolyze and decompose. This might explain their impact on acrylic tooth color stability.

Although all the three denture cleansers used contains sodium perborate, this study does not explain the marked color change within them. This attributes to further research about the molecular aspects of the effects of denture cleansers over acrylic resin teeth.

On the other hand, exposure to denture cleaners may alter the surface characteristics, as well as the mechanical and physical attributes of acrylic teeth, thereby compromising the dentures. Therefore subsequent studies are required to evaluate other effects of denture cleansers on acrylic teeth.

5. Conclusion

Within the limitations of the study, it can be concluded that the color stability of acrylic resin teeth is influenced by the use of denture cleansing solutions and a marked color change noted with digital photography method. Sodium perborate-containing denture cleansers hydrolyze and decompose acrylic resin resulting in leaching out of color pigments leading to the color change.

Future Scope

Research on other effects of denture cleansers like roughness, stain dehydration, chemical and aging deterioration on the denture teeth, as well as over the denture base resin is needed.

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