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A Comparative Study of Heat and Self-Cured Acrylic Resins on Color Stability of 5 Brands of Denture Teeth

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Abstract

Background: Denture teeth play a critical role in overall aesthetic outcomes of removable complete dentures, and long-term maintenance of these outcomes depends on the color stability of the prosthetic teeth. The characteristics of denture base resins play a significant role in prosthetic clinical performance and aesthetics.
Objectives: The purpose of this study was to assess the effect of two flasking materials on the color stability of five brands of denture teeth that were immersed in commonly consumed beverages.
Materials and Methods: In the present study 560 denture teeth (20 series) were invested with heat- and cold-cured acrylic resin. All the specimens were thermo cycled between 4°C and 60°C, with 60 Seconds dwell times for 1000 cycles. Subsequently, the specimens in each group were divided into four subgroups based on the immersion medium: coffee, tea, cola, or distilled water. Digital images of the teeth were taken before immersion and 30 days after immersion. The color samples were measured using the CIE L^* a^* b^* system, and color differences (ΔE) were calculated. The data were evaluated by 3-way ANOVA and the Tukey HSD test.
Results: There were significant differences in color change between the cold-cured acrylic resins and the heat-cured acrylic resins, with a reduced amount of discoloration in the heat-cured group ($\Delta E = 10.12 \pm 3.93$, $P = 0.001$). The solutions showed significantly different amounts of discoloration on the teeth; distilled water had the least effect ($\Delta E = 8.49 \pm 2.62$, $P = 0.001$) and coffee had the maximum discoloration ($\Delta E = 14.14 \pm 7.77$, $P = 0.001$). A Tukey test showed that there was no significant difference between each brand of denture teeth.
Conclusions: Coffee caused the most color changes in the examined resin denture teeth. Tea and cola left less staining on the teeth, and distilled water caused the least discoloration. Generally, investing by heat- and cold-cured acrylic resins can significantly affect the color stability of resin denture teeth; however, heat-cured acrylic resins had fewer color changes.

Keywords: Denture Teeth, Color Stability, Immersion Media, Heat-Cured Acrylic Resin, Self-Cured Acrylic Resin

1. Background

Denture teeth play a critical role in the overall aesthetic outcomes of removable complete dentures, and long-term maintenance of this factor depends on the color stability of the prosthetic teeth. The characteristics of denture base resins play a significant role in prosthetic clinical performance and aesthetics (1-4). Selection of color-stable and resistant dental material results in higher aesthetic value and resistance to staining (5, 6). Ceramic teeth have generally been replaced by composite teeth, and despite better mechanical properties the prostheses fabricated by these teeth will have some degree of discoloration over time (7). Some changes in denture base resin structure and different procedures for fabricating complete dentures have attempted to improve their mechanical properties. Denture base resin is often initiated by mixing the recommended proportion until a doughy mass is prepared, and the associated flask is filled, placed under pressure in a warm water bath or microwave, or the resin is allowed to be cured by chemical composition (8).

Numerous studies have investigated the effects of various factors on denture teeth discoloration, such as commercial types of denture teeth, their composition, filler, processes like polishing, mouthwashes, and colored food and drinks (9, 10).

2. Objectives

Recognizing the lack of research on the effects of flasking materials on color changes of denture teeth, this study

aimed to assess the effect of two flasking materials on the color stability of five brands of denture teeth immersed in commonly consumed beverages.

3. Materials and Methods

In this study, five sets of acrylic resin denture teeth with the shade of A1 and the largest size were prepared, from the following denture teeth brands: DCL (Ivoclar/Vivadent, Schann, Liechtenstein), Isosid TAK (Betadent, Tehran, Iran), Crystal ECL (Betadent, Tehran, Iran), Glamour (Ideal Makoo, Tehran, Iran), and Apple (Ideal Makoo, Tehran, Iran). Therefore, following patterns in previous studies, 560 denture teeth, including 5 series of each brand, were investigated. Each half set (14 teeth) was considered as a group. So for each brand of denture teeth, 8 groups consisting of 112 teeth were examined. Also, each of the 4 specific solutions included 14 teeth. For each group, a wax base with a thickness of 5 mm, width of 10 mm, and length of 10 cm was prepared, and the teeth were attached to the wax base in a straight line, at a distance of 3 mm from each other. The maxillary teeth were attached to the superior border and the mandibular teeth to the inferior border of the wax (Figure 1).

A metal muffle with the dimensions of 20 × 20 cm and a thickness of 6 cm was prepared. Flasking of the specimens was performed in a conventional manner and also with silicon, so that only the labial surface of the teeth contacted the gypsum (Figure 2). Half of the specimens were invested with heat-cured acrylic resins (Meliodent, Bayer Co., Germany) and half of them with auto polymerized acrylic resins (Meliodent, Bayer Co., Germany), according to the manufacturer's recommendations. After deflasking, the specimens were thermo cycled for 1000 cycles between 0 and 60°C with a 60 seconds dwell time. Then, the specimens from each investment were divided into 4 subgroups and immersed into one of the selected beverages at 37°C for one month (16, 18).

3.1. Preparation of Beverages

1. Tea: Fourteen tea bags (Lipton Yellow Label tea, London, England) were immersed in 2,800 mL of boiling water for 3 minutes. After cooling to room temperature the contents were filtered with filter paper.

2. Coffee: Fifty six gram of coffee (Nescafe, Classic Nestle, Swiss) was immersed in 2800 mL boiling water and allowed to cool to 25°C, and the contents were filtered with filter paper.

3. Cola: 2,800 mL of cola (Zamzam Co., Tehran, Iran) was kept at 25°C.

4. Distilled water: 2,800 mL of distilled water (Faraz Dentin Co., Isfahan, Iran) was kept at 25°C.

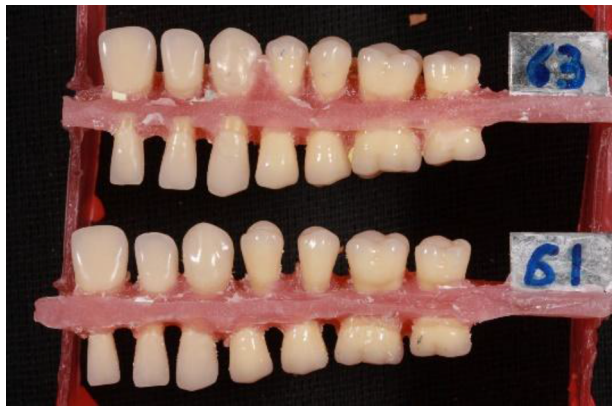

Figure 1. Denture Teeth Attachment Into The Wax

Figure 2. Investment of The Specimens With Silicon

The solutions were poured into the teeth container, and incubated at 37°C for one month. Solutions were stirred once a day to prevent precipitation of pigments. Also, they were changed every other day. Before immersing the teeth into the colored solutions, they were immersed in distilled water at 37°C for 24 hours. Then the specimens were removed from the water and digital images were taken after drying. After one month, another digital photograph was taken under the same conditions as the baseline image.

3.2. Digital Photography

Photos were taken at a shutter speed of 1.60 seconds, F: 20, ISO = 100, with a 100 macro lens, using a digital camera (Canon EOS40, Canon, Japan) at a distance of 40 cm from each specimen. Photos were saved in TIFF format. In order to standardize the photo conditions, two halogen 60W flashlights in a dark box (80 × 40 × 40 cm) were used.

The angle between the lens and the light source was 45° to reduce reflection from the tooth surface (Figure 3). Standard white photographic paper was placed adjacent to the specimens to calibrate the photos and eliminate the camera and environmental conditions.

Figure 3. Dark Box, Placement of The Camera Lens and of The Light Source

3.3. Color Assessment

The CIE L^* a^* b^* color system is a 3D color space with 3 axes: L, a, and b. The advantages of the CIE L^* a^* b^* system is that color differences can be expressed in units that can be related to visual perception and clinical significance. The middle one-third of each tooth was selected with a freestyle drawing instrument in Photoshop software (CS4 Adobe Systems, San Jose, CA) to determine the average a^* b^* and L^* (Figure 4).

The color difference (ΔE) before and after immersion in the solution was calculated for each specimen using the following formula:

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

The data was analyzed by 3 way ANOVA followed by the Tukey HSD post hoc tests ($\alpha = 0.05$), using SPSS software version 11 (SPSS Inc., Chicago, IL, USA).

4. Results

There were significant differences in color change between cold-cured acrylic resins and heat-cured acrylic resins, and results demonstrated a reduced amount of discoloration in heat-cured group ($\Delta E = 10.12 \pm 3.93$, $P = 0.001$) (Table 1). The solutions showed significant differences of discoloration on the teeth; distilled water had the least effect ($\Delta E = 8.49 \pm 2.62$, $P = 0.001$), and coffee had the maximum discoloration ($\Delta E = 14.14 \pm 7.77$, $P = 0.001$) (Table 2). There was no significant difference between each brand of denture teeth (Table 3). In addition, the results from comparing different denture teeth derived from the Tukey test are shown in Table 4.

Table 1. Comparison of Heat and Cold-Cured Acrylic Resins in Discoloration of Denture Teeth

Study Groups	ΔE [a]	P value
Heat-cured acrylic resin	10.12 ± 3.93	0.001
Cold-cured acrylic resin	11.76 ± 6.36	0.001

[a] values are expressed as mean ± SD.

Table 2. Average Color Stability of Different Denture Teeth After Immersion in Different Beverages

Study Groups	ΔE [a]	P value
Preparation of Beverages		0.001
Distilled water	8.49 ± 2.62	
Cola	10.34 ± 4.35	
Tea	10.79 ± 3.48	
Coffee	14.14 ± 7.77	

[a] values are expressed as mean ± SD.

Table 3. Average Color Stability of Different Denture Teeth Before and After Processing

Study Groups	ΔE [a]	P value
Brands		0.001
Ivoclar Vivadent DCL	10.98 ± 4.26	
BD Isosid TAK	9.18 ± 2.94	
BD Crystal EC	11.83 ± 6.73	
Apple	10.92 ± 6.88	
Glamour	11.78 ± 4.46	

[a] values are expressed as mean ± SD.

5. Discussion

Denture teeth play a significant role in the final aesthetics of removable prostheses. The survival of this aesthetic greatly depends on the color stability of the teeth. Many patients complain about their prostheses being discolored by food pigments (2).

PMMA acrylic resin is the most common material used in dentistry, and is divided into heat-cured, chemical, light-cured, and microwave groups according to their chemical

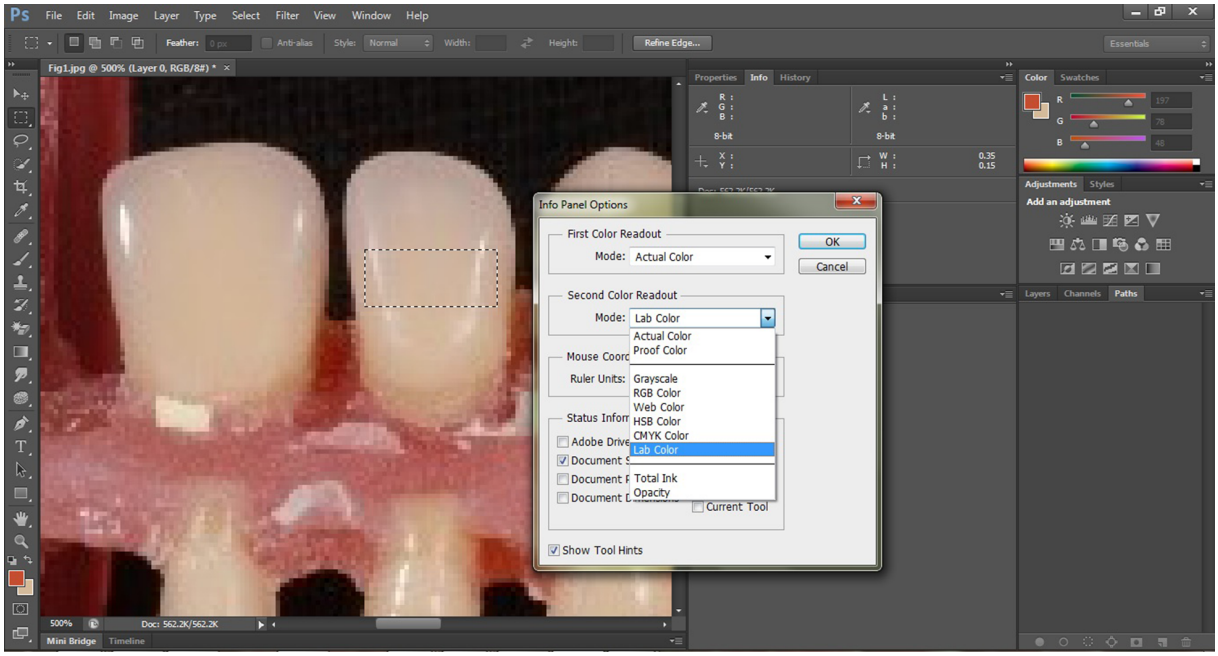

Figure 4. Photoshop Software (CS4) Used to Determine The Average a* b* and L*

reactions (free radicals). The presence of Amine facilitators in cold-cured acrylic resins can be problematic in the color stability of the teeth. They produce color products by oxidation; thus, the color stability of chemically cured types is not as good as heat-cured types (11). Assuncao et al. (12) reported no difference between two polymerization procedures, heat cure and microwave, in the discoloration of denture teeth. Imirzalioglu et al. (13) found significant discoloration in heat polymerization, but discoloration was not significant in the auto polymerization process (e > 3.7). Hong et al. (14) investigated five acrylic resins and considered the auto polymerized acrylic resin the least susceptible to discoloration.

In the current study, an overall comparison of heat- and cold-cured acrylic resins in the discoloration of denture teeth, cold-cured acrylic resins showed the maximum discoloration with an ΔE value of 11.76 ± 6.36 ($P = 0.001$) (Table 1). The reason for this difference may be due to the residual monomers acting as plasticizers (11). In Rosentritt et al. (10) study's, spectrophotometric analysis reported discoloration between 1 - 2.5 (ΔE), less than the results of the current study, which could be due to procedural differences.

According to the results of the current study, considering the mean color changes of denture teeth influenced by cola, tea, coffee, and distilled water, the coffee solution had the maximum ($\Delta E = 14.14 \pm 7.77$, $P = 0.001$) discoloration and distilled water had the minimum discoloration ($\Delta E = 8.49 \pm 2.62$, $P = 0.001$) (Tables 2 and 3). Mutlu-sagesen also showed that a coffee solution was more choromogenous than other solutions, which was in line with our study. However, less than 3.3 of ΔE may be justified due to the non-thermo cycled samples (15). In a 2006 study of, Ertas evaluated distilled water as causing the least discoloration, with cola, tea, and coffee respectively higher, also in line with the current study (16). In 2011, Silva et al. found that denture teeth could be discolored after immersion cycling in distilled water, which may be due to the internal composition of the resin constructor of artificial teeth, the water sorption phenomenon, and micro cracks caused by this sorption (17). Discoloration of denture teeth depends on the hydrophilic nature of choromogenous solutions as well as their material properties (18).

Ghahramanlou et al. (19) evaluated the color stability of reinforced composite teeth in comparison with porcelain denture teeth by spectrophotometric analysis. The samples were immersed in distilled water, orange juice, cola, and tea for 1 month. The results showed color changes (ΔE) of more than 3 for the composite specimens. In this study, tea had the maximum discoloration ($\Delta E = 6.09$) which was less than current study; this could be due to the non-thermo cycling procedure.

Based on these results, it is concluded that coffee caused the most color changes in the examined resin denture teeth. Tea and cola had less staining on the teeth, and

Table 4. Tukey Test For Comparing Average Color Stability Between Different Denture Teeth

Denture Teeth	ΔE [a]	Sig.
Ivoclar vivadent DCL		
BD isosid TAK	1.85 ± 2.9	0.968
BD crystal EC	-0.55 ± 2.9	1
Apple	-1.19 ± 2.9	0.994
Glamour	-0.77 ± 2.9	0.999
BD Isosid TAK		
Ivoclar vivadnt DCL	-1.85 ± 2.9	0.968
BD crystal EC	-2.41 ± 2.9	0.92
Apple	-3.04 ± 2.9	0.831
Glamour	-2.63 ± 2.9	0.892
Ivoclar vivadnt DCL	0.55 ± 2.9	1
BD Crystal EC		
BD isosid TAK	2.4 ± 2.9	0.92
Apple	-0.63 ± 2.9	0.999
Glamour	-0.22 ± 2.9	1
Apple		
Ivoclar vivadnt DCL	1.19 ± 2.9	0.994
BD isosid TAK	3.04 ± 2.9	0.831
BD crystal EC	0.63 ± 2.9	0.999
Glamour	0.41 ± 2.9	1
Ivoclar vivadnt DCL	0.77 ± 2.9	0.999
Glamour		
BD isosid TAK	2.63 ± 2.9	0.892
BD crystal EC	0.22 ± 2.9	1
Apple	-0.41 ± 2.9	1

[a] values are expressed as mean ± SD.

distilled water caused the least discoloration. Generally, investing by heat and cold-cured acrylic resins can significantly affect the color stability of resin denture teeth, but heat-cured acrylic resins had fewer color changes.

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