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Effect of Staining Solutions on Color Stability of Different Temporary Crown Materials

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Abstract

Objectives: Staining effect of solutions on temporary crowns is a frequent problem. Discoloration of dental materials after long term usage is an important issue in clinical practice. Furthermore, there is limited information on staining effect of different beverages on color stability of various temporary crown materials.

Methods: A total of 80 cylindrical specimens from A2 shade self-curing bis-acryl composite and methyl methacrylate temporary crown materials were fabricated (n = 10). The initial color measurements were taken by using a digital spectrophotometer, according to CIE L*a*b* system. Then specimens were placed in staining solutions (distilled water, coffee, tea and cola). The other measurements of specimens were taken after 1 week and 4 weeks immersion time.

Results: The data were statistically analyzed using ANOVA and Tukey tests. Bis-acryl composite resin materials were more color stable than methacrylate resin materials after 1 week immersion time ($p<0.05$). However, after 4 weeks immersion time, there was no significant difference among bis-acryl coffee, bis-acryl tea, methacrylate distilled water and methacrylate cola groups. Bis-acryl-cola and bis-acryl-distilled water exhibited significantly lower color change than the other solutions after 4 weeks.

Conclusion: Results indicated that color stability is affected by both material types and beverages. The bis-acryl resin composite material was found more color stable than methyl methacrylate resin temporary crown material. After 1 week and 4 weeks immersion time, coffee and tea showed more staining than the other solutions in two temporary crown materials.

Keywords: *Composite resins; Color stability; PMMA resins; Staining solutions; Temporary crowns*

Introduction

Provisional restorations are necessary to protect vital prepared teeth from hypersensitivity and pulp irritation. Moreover, they constitute an important step to assess functional and aesthetic outcomes [1-3]. Many materials, such as polyvinyl methacrylate, urethane methacrylate, bis-acryl, and micro filled resin, auto polymerizing polymethyl methacrylate, polyethylene methacrylate can be used when performing a temporary crown [4,5]. They can be polymerized by light, chemical or both. Polymethyl methacrylate (PMMA) resins have been displayed as the most color stable materials in various studies; however, there are also different studies that demonstrate the new generation composite materials could be also color stable [1,6-9].

In the anterior region, because of esthetic reasons, provisional restorations should maintain their color stability in the long-term. A color stable provisional restoration can be easily accepted by patients [6,9]. Water absorption [10,11], chemical reactivity [12,13], diet [12-14] and inappropriate polymerization are such factors that can affect the color stability of provisional restorations.

Oral hygiene and surface toughness are also advocated in color stability of a temporary crown [15]. In fact, accumulation of dental plaque can also result in discoloration [16]. According to Ellingsen and Nordbö [17], three main factors can be responsible for staining mechanism. These are; a) production of colored components in plaque by chromogenic bacteria; b) retention of colored substances from dietary constituents passing through the oral cavity; c) formation of colored products from the chemical transformation of pellicle components [18].

Color changes of the restorations can be evaluated with color measuring devices or visually [1,19]. Spectrophotometers and colorimeters have been used to assess the color measurement of dental materials. Color differences can be demonstrated by two different systems: Munsell color system and Standard Commission International de L'E clairage Color System (CIE Lab) [1]. CIE Lab system is well suited for evaluation minimal color changes and commonly used to record the color differences and recommended by the American Dental Association (ADA). Thus, there are three main colors in nature which create all other colors by mixing each other: red, blue and green [20,21].

Spectrophotometer and colorimeter measure the color change and indicate it in three coordinates: (L*, a*, b*), which locate the object's color within the CIELAB color space. The L* coordinate refers to lightness of an object, the a* value represents the red to green chroma, and the b* is chromaticity coordinate in the yellow-blue axis. The color variation between two color positions (ΔE) can be measured for each object with the aid of formula noted below where ''i'' indicates the initial measurement while ''f'' indicates the final measurement [1]:

$$\Delta E = [(L1^* - L2^*)^2 + (a1^* - a2^*)^2 + (b1^* - b2^*)^2]^{1}/^{2}$$

There is a lack of information in recent studies reporting effect of different solutions on color degradation of bis-acryl composite and methyl methacrylate resin based provisional materials. There is still not a consensus on which color change is perceptible in clinical practice. Different studies have reported variant ΔE values ranged from 1 to 3.7. One study also reported that 6.7 ΔE values are acceptable for clinical practice [22]. The purpose of this study was to assess the color stability of PMMA resin based and bis-acryl composite based resin materials after 1 week and 4 weeks storage in different staining solutions.

Materials and Methods

Four different solutions (distilled water, coffee, tea and cola) were evaluated and their staining effects on auto-polymerized bis-acryl composite (Structure 3, Voco GmbH, Germany) and polymethyl methacrylate (Imident, Imicryl, Turkey) temporary crown materials. Forty cylindrical specimens were prepared for each group, a total of 80 specimens, using two different temporary crown materials (Shade A2) measuring 15 ± 0.1 mm in diameter and 2 ± 0.1 mm in thickness were placed into a special teflon mold. All materials were mixed, manipulated, and polymerized according to the manufacturers' instructions. Specimens were kept dry at room temperature until all specimens were fabricated. The specimens were wet-ground with 1000-grit silicon carbide abrasive paper for 10 s for the purpose of surface standardization. Specimens were then stored in distilled water at 37°C for 24 h and blotted dry with tissue paper before color measurement. The first day of service for provisional restorations in the oral environment was simulated by this rehydration process. Study groups with restorative materials and staining agents used in this study are shown in Table 1.

Forty specimens were randomly divided into 4 groups (n = 10) for 3 staining solutions. Distilled water was considered as control group. Color differences of each specimen were measured with a spectrophotometer (Vita Easyshade Compact, DEASYCS220, VITA Zahnfabrik H. Rauter GmbH & Co.KG, Säckingen Germany) at baseline (T0), after one week (T1) and four weeks (T2) of immersion in various treatment solutions. Results were determined using the CIELAB system.

CIELAB system is based on three parameters; L*, a*, and b* for defining color. L* refers to the lightness coordinate, and its value ranges from zero (black) to 100 (white). The a* and b* are chromaticity coordinates in the red-green axis and the yellow-blue axis, respectively. Positive a* values indicate a shift to red, and negative values indicate a shift to green. Similarly, positive b* values indicate the

yellow color range, and negative values indicate the blue color range. Measurements were repeated three times for each specimen, and the mean values of the L*, a*, and b* data were calculated [1].

Groups	Materials and Solutions	Manufacturers
G1	Bis-acryl-coffee	Structur 3, Voco GmbH, Germany
G2	Bis-acryl-coke	Structur 3, Voco GmbH, Germany
G3	Bis-acryl-tea	Structur 3, Voco GmbH, Germany
G4	Bis-acryl-distilled water	Structur 3, Voco GmbH, Germany
G5	Methyl-methacrylate-coffee	Imident, Imicryl Ltd, Turkey
G6	Methyl-methacrylate-coke	Imident, Imicryl Ltd, Turkey
G7	Methyl-methacrylate-tea	Imident, Imicryl Ltd, Turkey
G8	Methyl-methacrylate-distilled water	Imident, Imicryl Ltd, Turkey

Table 1: *Material types and beverages used in the present study.*

Before each measurement session, the spectrophotometer was calibrated according to the manufacturer's recommendations by using the supplied white calibration standard. The mean values of ΔL*, Δa*, Δb* were automatically calculated and recorded by the spectrophotometer. Color difference ΔE was calculated from the mean ΔL*, Δa*, Δb* values for each specimen with the formula mentioned above [1].

Results

According to ANOVA and Tukey results, statistically significant differences were found between the material groups and staining solutions. Means and standard deviations were illustrated in Table 2. After 1 week immersion period, the highest color change was observed in G7-polymethyl methacrylate-tea, while the lowest color change was observed in G2-bis-acryl-cola ($p<0.05$). However, there was no significant difference among staining solutions in two types of temporary crown materials.

Groups	1 week	4 week	p
G1	2.72 ± 0.48^{a}	5.63 ± 2.72^{a}	,009**
G2	2.21 ± 0.55^{a}	2.13 ± 0.46^{b}	,721
G3	3.09 ± 0.58^{a}	5.16 ± 2.84^{a}	,007**
G4	2.70 ± 0.50^{a}	2.12 ± 0.32^{b}	,069
G5	8.09 ± 1.13^{b}	8.70 ± 1.40^{c}	,359
G6	8.07 ± 1.01^{b}	7.93 ± 1.08^{ac}	,723
G7	8.29 ± 1.24^{b}	8.30 ± 1.27^{c}	,986
G8	7.45 ± 1.25^{b}	7.76 ± 1.37^{ac}	,649

Table 2: *Means and standard deviations.*

Note: *Means with the same superscripted lowercase letters in the same column are not significantly different ($p>0.05$).*

*** indicates significant difference in the same line, according to paired t test results ($p<0.05$).*

After immersion for 2 weeks, no significant difference was found among polymethyl methacrylate groups (G5, G6, G7 and G8). The highest color difference was observed in G5-polymethyl methacrylate-coffee, while the lowest color difference was observed in G4-bis-acryl-distilled. However, no significant difference was found between G2-bis-acryl-distilled and G4-bis-acryl-cola ($p>0.05$).

According to paired T comparison test results, statistically significant differences were found between 1 week and 4 weeks immersion period for only G1-bis-acryl-coffee and G3-bis-acryl-tea ($p<0.05$).

Discussion

Thickness is a main factor in color measurement; therefore, specimens were prepared as 2 mm in the present study. In the current literature, it is assumed that darker materials are more color stable than the lighter ones [1,23-25]. Therefore, A2 shade was chosen as a main color in fabrication of specimens. Furthermore, A2 is mostly preferred in the researchers' clinic. Recently, several studies investigated the color change values which are acceptable in clinical practice [22,26-28]. Um and Ruyter [29] reported that ΔE value of 1 unit is visually acceptable. This value could be higher for the clinical acceptance of temporary crown materials [1].

Johnston and Kao [28] reported that ΔE value of 3.7 or less is clinically acceptable in dental practice. In the present study, bis-acryl specimen groups (G1,G2,G3 and G4) showed less color change than 3.7 ΔE value which is considered to be acceptable, while methacrylate groups (G5,G6,G7, and G8) exhibited higher ΔE values than 3.7 ΔE. After 4 weeks immersion period, G5-methacrylate-coffee and G7-methacrylate-tea showed noticeable color change (>3.7). Furthermore, between 1 week and 4 weeks immersion periods, G1 and G3 showed statistically significant color change ($p<0.05$). These findings are in accordance with past studies which also consider coffee and tea as staining substances [30,31]. It is considered as composite-based resins tend to absorb water in high rate in comparison to methacrylate resins [30]. This property of bis-acryl composite-based resin could explain the reason of continuous absorption of composite resins during 4 weeks immersion period in coffee and tea groups.

Coffee and tea groups showed more staining than the other solutions in two materials. The reason for this may be that coffee and tea are possible absorbable solutions which also have different chemical and physical properties behind it. Furthermore, yellow colorants of coffee and tea are much more than the other solution types [30-33].

In the current study, cola did not produce as much discoloration as tea and coffee, although it is assumed that cola is degradable due to its low pH. It could be defined as due to its lack of yellow colorant [29] and high acid rate, cola did not exhibit more color change than tea and coffee groups.

In the present study, for all solution types, bis-acryl specimen groups exhibited less color change ($p < 0.05$) than methacrylate specimens during 1 week immersion time. These findings are not in accordance with Bayindir., *et al*. [1]. Due to its hydrophilic nature [34], triethyl eneglycol-dimethacrylate (TEGDMA) may be responsible for discoloration of composite resins [35]; however, nano-hybrid composite resin used in the present study contains BIS-GMA (bisphenol A glycidyl methacrylate), instead of TEGDMA. Cross-linking agents and fillers are used in order to avoid from discoloration in acrylic and composite resin matrix [35]. According to Imamura., et al. [36], discoloration of composite resins occurs in composite matrix, filler and at the interface. Moreover, self-cured acrylic materials consist of polyethyl methacrylate powder and methacrylate liquid. However, composite based resins consist of resin matrix and fillers. In the present study, bis-acryl composite resin consists of dimethacrylates, silicate fillers, catalysts, stabilizers. In this study, filler types may be considered as a main factor that provides color stability in bis-acryl composite resin. Furthermore, surface toughness may affect the color stability of materials over time.

According to Ertas., *et al*. [34], nano-hybrid composite resins are more color stable than micro hybrid composite resins when subjected to staining solutions. Furthermore, staining results in liquid absorption of the superficial layer of the composite resin over time [37]. Staining of composite resins increase with surface roughness [38]; surface morphology and absorption mechanism [39,40]. Therefore, additional studies evaluating the surface morphology, roughness; in addition, studies evaluating color stability of materials in the presence of dental plaque are essential.

Conclusion

A limitation of the current study was that the color stability of temporary crown materials was evaluated without testing the effect of thermal cycling and surface roughness on materials. Within the limitations of this study, the following conclusions could be drawn:

A. Nano-hybrid bis-acryl composite material exhibited more color stability than polymethyl methacrylate resin during immersion periods.

B. After immersion for 1 week, the tea solution showed more color change than other solutions; however, after immersion for 4 weeks, the coffee solution exhibited more color change than other solutions in two types of temporary crown materials.

C. After immersion for 1 week and 4 weeks, coffee and tea solutions exhibited more staining effect than other solutions in two materials.

Bibliography

1. Bayindir F., *et al*. "The effect of staining solutions on the color stability of provisional prosthodontic materials". *Journal of Dentistry* 40 Suppl 2 (2012): e41-e46.
2. Academy of Prosthodontics. "Glossary of prosthodontic terms". 7th Edn. Chicago: Elsevier (1999): 78.
3. Guler AU., *et al*. "Effects of different drinks on stainability of resin composite provisional restorative materials". *Journal of Prosthetic Dentistry* 94.2 (2005): 118-124.
4. Christensen GJ. "The fastest and best provisional restorations". *The Journal of The American Dental Association* 134.5 (2003): 637-639.
5. Gough M. "A review of temporary crowns and bridges". *Dental Update* 21.5 (1994): 203-207.
6. Doray PG., *et al*. "Color stability of provisional restorative materials after accelerated aging". *Journal of Prosthodontics* 10.4 (2001): 212-216.
7. Khokhar ZA., *et al*. "Color stability of restorative resins". *Quintessence International* 22.9 (1991): 733-737.
8. Crispin BJ and Caputo AA. "Color stability of temporary restorative materials". *Journal of Prosthetic Dentistry* 42.1 (1979): 27-33.
9. Kilinc E., *et al*. "Resin cement color stability and its influence on the final shade of all-ceramics". *Journal of Dentistry* 39.Suppl 3 (2011): e65-e71.
10. Fusayama T., *et al*. "Discoloration test of acrylic resin fillings by an organic dye". *Journal of Prosthetic Dentistry* 25.5 (1971): 532-539.
11. Satou N., *et al.* "*In vitro* color change of composite-based resins". *Dental Materials* 5.6 (1989): 384-387.
12. Waerhaug J. "Temporary restorations: advantages and disadvantages". *Dental Clinics of North America* 24.2 (1980): 305-316.
13. Pipko DJ and el-Sadeek M. "An *in vitro* investigation of abrasion and staining of dental resins". *Journal of Dental Research* 51.3 (1972): 689-705.
14. Nordbö H., *et al*. "Iron discoloration of acrylic resin exposed to chlorhexidine or tannic acid: a model study". *Journal of Prosthetic Dentistry* 49.1 (1983): 126-129.
15. Asmussen E and Hansen EK. "Surface discoloration of restorative resins in relation to surface softening and oral hygiene". *Scandinavian Journal of Dental Research* 94.2 (1986): 174-177.
16. Vogel RI. "Intrinsic and extrinsic discoloration of the dentition: A literature review". *Journal of Oral Pathology & Medicine* 30.4 (1975): 99-104.
17. Eriksen HM and Nordbö H. "Extrinsic discoloration of teeth". *Journal of Clinical Periodontology* 5.4 (1978): 229-236.
18. Omata Y., *et al.* "Staining of Hybrid Composites with Coffee, Oolong Tea, or Red Wine". *Dental Materials* 25.1 (2006): 125-131.
19. Turgut S and Bagis B. "Colour stability of laminate veneers: an in vitro study". *Journal of Dentistry* 39.Suppl 3 (2011): e57-e64.
20. Seghi RR., *et al*. "Colorimetric changes in composites resulting from visible-light-initiated polymerization". *Dental Materials* 6.2 (1990): 133-137.
21. Okubo SR., *et al*. "Evaluation of visual and instrument shade matching". *Journal of Prosthetic Dentistry* 80.6 (1998): 642-648.
22. Gross MD and Moser JB. "A colorimetric study of coffee and tea staining of four composite resins". *Journal of Oral Rehabilitation* 4.4 (1977): 311-322.
23. Uchida H., *et al.* "Color stability of dental composites as a function of shade". *Journal of Prosthetic Dentistry* 79.4 (1998): 372-377.
24. Eldiwany M., *et al*. "Color stability of lightcured and post-cured composites". *American Journal of Dentistry* 8.4 (1995): 179-181.
25. Mutlu-Sagesen L., *et al.* "Color stability of a dental composite after immersion in various media". *Dental Materials Journal* 24.3 (2005): 382-390.

26. Seghi RR., *et al*. "Visual and instrumental colorimetric assessments of small color differences on translucent dental porcelain". *Journal of Dental Research* 68.12 (1989): 1760-1764.
27. Ruyter IE., *et al*. "Color stability of dental composite resin materials for crown and bridge veneers". *Dental Materials* 3.5 (1987): 246-251.
28. Johnston WM and Kao EC. "Assessment of appearance match by visual observation and clinical colorimetry". *Journal of Dental Research* 68.5 (1989): 819-822.
29. Um CM and Ruyter IE. "Staining of resin-based veneering materials with coffee and tea". *Quintessence International* 22.5 (1991): 377-386.
30. Koksal T and Dikbas I. "Color stability of different denture teeth materials against various staining agents". *Dental Materials Journal* 27.1 (2008): 139-144.
31. Canay S., *et al*. "Evaluation of colour and hardness changes of soft lining materials in food colorant solutions". *Journal of Oral Rehabilitation* 26.10 (1999): 821-829.
32. Azer SS., *et al*. "Effect of bleaching on tooth discolouration from food colourant in vitro". *Journal of Dentistry* 39. Suppl 3 (2011): e52-e56.
33. Rutkunas V., *et al*. "Effects of different food colorants and polishing techniques on color stability of provisional prosthetic materials". *Dental Materials Journal* 29.2 (2010): 167-176.
34. Ertas E., *et al*. "Color stability of resin composites after immersion in different drinks". *Dental Materials Journal* 25.2 (2006): 371-376.
35. Gregorius WC., *et al*. "Effects of ageing and staining on color of acrylic resin denture teeth". *Journal of Dentistry* 40 Suppl 2 (2012): e47-e54.
36. Imamura S., *et al*. "Effect of filler type and polishing on the discoloration of composite resin artificial teeth". *Dental Materials* 27.6 (2008): 802-808.
37. Minami H., *et al*. "Effects of thermal cycling on surface texture of restorative composite materials". *Dental Materials* 26.3 (2007): 316-322.
38. Mutlu-Sagesen L., *et al*. "Color stability of different denture teeth materials: an in vitro study". *Journal of Oral Science* 43.3 (2001): 193-205.
39. Joiner A. "Tooth colour: a review of the literature". *Journal of Dentistry* 32. Suppl 1 (2004): 3-12.
40. Assunção WG., *et al*. "Effect of polymerization methods and thermal cycling on color stability of acrylic resin denture teeth". *Journal of Prosthetic Dentistry* 102.6 (2009): 385-392.

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