Original Article

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

Yesil Duymus Z, Fındık Aydıner S, Yanikoglu N

Department of Prosthodontics, Faculty of Dentistry, Atatürk University, Yakutiye, Erzurum, Turkey

Received: 27-Sep-2022;
Revision: 20-Nov-2022;
Accepted: 27-Dec-2022;
Published: 27-Feb-2023

Abstract

Background: The esthetic expectations of patients are increasing by the day. That is why it is important to minimize the color changes in the oral cavity in both the temporary and permanent restorations. **Aim:** This study was carried out to compare the time-dependent color changes of polished and unpolished temporary crown materials prepared by different methods in various solutions. **Materials and Methods:** Half of the two different temporary restoration materials prepared with a diameter of 10 mm and a thickness of 2 mm were polished, and half were not polished. The ΔE* values of the samples kept in various solutions were recorded. Data were statistically evaluated by using variance analysis (ANOVA) and a Tukey HSD multiple comparison test. **Results:** It was determined that the material type, the solution, the interaction between the material types and the surface treatment, and the interaction between the surface treatment and the solution were statistically significant for color change ($p < 0.001$). **Conclusion:** The most significant color change in the inter-material evaluation was observed in chemically polymerized polymethyl methacrylate. In the evaluation between beverages, the highest color change was found in sugared coffee, and the lesser color change was observed in polished samples.

Keywords: *Color stability, storage solutions, storage time, temporary crown materials*

Introduction

Temporary crowns should be made carefully to protect the dental pulp from thermal, physical, and biological factors in order to restore damaged esthetics, lost function, and phonation to to ensure the continuity of biological tissues.[1] Patients and physicians tend to prefer temporary restorations to provide almost as much function and esthetics as fixed prostheses in full arch treatments in cases where occlusion is required to be raised and in cases where long-term use is required, such as crowns over implants.[2]

It is very important that there should be no color change in materials used for temporary restorations, especially in restorations that are to be used for a long time in the anterior.[3]

Presently, materials such as chemical and light-cured, polymethylmethacrylate, polyethylene methacrylate, polymethyl methacrylate, urethane dimethacrylate, and bis-acryl resins are used as fixed temporary restorations.[4] In recent years, with the development of computer-aided software and production technology, CAD/CAM temporary restorations have been introduced.[1]

In order to prevent treatment complications, patient dissatisfactions, and additional costs in need of replacements, the quality and careful execution of temporary restorations which may be needed to be used for a period varying between a few days and 6 months is very important for the physician and patient.[5] Factors such as water absorption,[6] conversion degree,[7] diet,[8] and poor oral hygiene can change the

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_659_22

Address for correspondence: Dr. Fındık Aydıner S, Department of Prosthodontics, Faculty of Dentistry, Atatürk University, Atatürk Mh., 25240 Yakutiye/Erzurum, Turkey.
E-mail: rona13_rona@hotmail.com

How to cite this article: Duymus ZY, Aydıner SF, Yanikoglu N. The effect of different staining solutions on the color stability of temporary crown materials. Niger J Clin Pract 2023;26:234-9.

color stability of restoration materials. Other additional factors that can affect color change include surface roughness,[9] reduced mechanical properties, and poor biocompatibility. Additionally, regardless of the material type, an unpolished surface also negatively affects color stability.[5]

The visual perception of the light or phenomenon that allows the same objects to be perceived differently is called color. The observer, the light source, and the object are three factors upon which color depends. Changing one of these factors causes the perception of color to change. In dentistry, color can be determined visually as well as with an instrument.[10] The angle between the human eye, the object, and the light source can change the perception of color; also, the aging of the eye causes inconsistent color perception. As a result of metamerism, the same object may appear different in color in different light sources. In addition, color can be perceived differently as a reflection of the physiological and psychological changes of the person.[5] In order to avoid these situations, it is preferable to use electronic devices with standard illumination.[11] It has been reported that these devices are more objective and make such precise measurements that even small color changes can be detected.[3]

Colorimetric color analysis is a sensitive, quantitative method used to examine color changes in dental materials. Spectrophotometric and colorimetric color measurements give repeatable and reliable numerical values, even at color changes below the eye's detection level.[3] The CIE L * a * b * (Commission Internationale de l'Eclairage) color system is frequently used in instrumental color analysis.[11,12] The CIE L*a b* color system consists of three coordinates; the L* coordinate gives the lightness value of the color, and the a* and b* coordinates represent the positions on the red/green and yellow/blue axes. Moreover, the + a* axis represents the red intensity of the color, the –a* axis represents the green intensity of the color, the + b* axis represents the yellow intensity of the color, and the -b * axis represents the blue intensity of the color. Color difference (ΔE*) is a mathematical calculation of the direction and magnitude of the difference between two points in a three-dimensional color space.[12] Bankoğlu Güngör *et al*.[3] studied the color changes caused by coffee, tea, red wine, and cola in temporary materials, and among these beverages, the highest degree of color change was with coffee. On the other hand, distilled water, cola, and mixed fruit showed a low level of color change that was not statistically significant.

One or two seconds after the intake of sucrose (sugar), an acidic environment occurs, which will damage the dentine. The pH drops from 7.0 to 5.5 because of this unfavorable environment. When sucrose goes into a chemical reaction, it gives more energy than other carbohydrates and causes an increase in bacteria that causes decay.[13] Although it is known today that sucrose is a caries-causing agent, it has not been investigated as to whether it has an effect on the color change in temporary crown materials; furthermore, the difference in color change between polished and unpolished surfaces has not been studied.

In this study, the color changes of chemically polymerized temporary crown materials and temporary restorative materials prepared with CAD/CAM in polished and unpolished materials and changes with the addition of sugar and also the effect on the color stability of antiseptic mouthwash were studied. In this study, the aim was to explore this study's hypothesis that defends that less color change will be observed on polished surfaces, and there will be more color change in beverages with added sugar than those without added sugar regardless of the temporary restorative material.

Materials and Methods

In the study, chemically polymerized, cadmium-free, A2-colored polymethylmethacrylate (IMICRYL Imident, Konya, Turkey) and a polymethylmethacrylate block prepared with CAD/CAM (Tempo Cad, On-Dent Ltd., Izmir, Turkey) were used. In order to prepare chemically polymerized, cadmium-free polymethylmethacrylate samples, a metal sheet on which there was a hole with a 10 mm diameter and 2 mm thickness was prepared. The powder and liquid were mixed at the rate recommended by the manufacturer and placed in the gaps in the metal mold (10 mm diameter, 2 mm thick), and a smooth surface was obtained by covering it with glass. Standardization was achieved by sanding for 10 seconds with 600 grit silicon carbide paper. Half of the samples were not treated in any way, and half of the samples were polished with a rubber brush.

To prepare samples with CAD/CAM, 112 samples were prepared from the block (Tempo Cad., On-Dent Ltd., Izmir, Turkey); then the sample 10 mm in diameter and 2 mm thick was digitally designed. Half of the chemically polymerized samples prepared with CAD/CAM (56 samples) were polished in line with the manufacturer's recommendations, and half of the samples (56 samples) were not polished.

All samples were kept in distilled water for 24 hours.[14] Polished and unpolished samples were randomly divided into seven groups (n = 8) and dried with blotting paper. Each group was numbered inside.

The initial colors (CIELab) of the samples were measured using a dental spectrophotometer (Vita Easy Shade). Measurements were performed by calibrating as recommended by the manufacturer under D65 standard lighting conditions. Measurements were repeated three times on each sample surface, and the average L, a, and b values were recorded.

The samples, which were cola (Coca-Cola Company, Turkey), distilled water, tea with/without sugar (Lipton Yellow Label, Corlu, Turkey), Turkish coffee with/without sugar (Kurukahveci Mehmet Efendi, the TS 3117, Y. Dudullu, Istanbul), and mouthwash (Listerine® Cool Mint, Johnson & Johnson Plumbing Supplies, San. ve Tic. Ltd. Sti., Turkey), were kept in 100 ml plastic containers first for 24 hours and then 1 week and after 3 weeks time. After each period, the color changes were measured. Afterward, the roughness and microhardness values were measured again. The tea solution was prepared by immersing five prefabricated doses of tea in 500 ml boiling water for 10 minutes; the Turkish coffee was prepared by boiling 5–7 g powder in 65 ml cold distilled water for a few minutes. Tea or coffee with sugar was prepared by measurement of 10 g sugar to 300 ml beverage.[15] Distilled water was used as a control group. During this study, all solutions were refreshed once a week.[16]

Following this process, the color values were measured three times: after 24 hours, then 1 week after, and finally 3 weeks later. It was measured by one investigator. The measurement was taken at the mid-way level, and the averages were taken and recorded. The color differences were calculated using the formula below:[1]

$$\Delta E^* = [(L1^*-L0^*)\ 2+(a1^*-a0^*)\ 2+(b1^*-b0^*)\ 2]\ ½$$

L1, a1, and b1 values represented the CIE L * a * b * values in beverages of samples after holding; L0, a0, and b0 values represented the initially measured CIE L * a * b * values.[17]

Data were evaluated statistically by analysis of variance (ANOVA) using statistical analysis software (SPSS 18.0 for Windows, IBM Corp, SPSS Inc, Chicago, IL, USA). Tukey's HSD post hoc test was used to determine the differences between the groups ($\alpha = 0.05$).

Results

When the analysis of variance of ΔE data was examined, the interaction between material–surface treatment–solution retention time was found to be extremely significant ($p < 0.001$). The interaction between the material and the surface treatment and the interaction between the material and the solution were significant ($p < 0.05$). The average and standard deviation results of the ΔE values are shown in Tables 1 and 2.

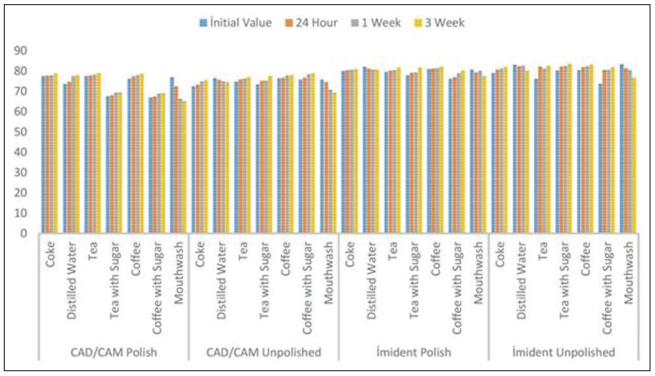

Figure 1: Graph of average results of ΔE values

Table 1: The Means and standard deviation results of the data CAD/CAM materials (ΔE)

	Beginning time (the means)	Beginning time (Sd)	24 hours (the means)	24 hours (Sd)	1 week (the means)	1 week (Sd)	3 weeks (the means)	3 weeks (Sd)
CAD/CAM Polished								
Coke	77.6	1.49	77.7	1.11	77.9	1.05	78.8	0.80
Distilled water	73.7	1.28	74.7	1.72	77.5	0.67	77.9	1.36
Tea	77.6	1.02	77.8	0.74	78.2	0.42	79.2	0.84
Tea with sugar	67.5	1.68	68.1	1.79	69.2	2.02	69.3	1.90
Coffee	76.1	2.19	77.3	0.64	78.1	1.08	78.7	0.71
Coffee with sugar	66.9	2.06	67.2	1.75	68.6	2.19	68.9	1.22
Mouthwash	76.9	1.68	72.3	2.62	66.2	1.00	65.0	3.41
CAD/CAM Unpolished								
Coke	72.5	4.75	73.0	4.38	74.9	3.74	75.4	4.39
Distilled water	76.6	4.25	75.5	3.84	75.0	3.05	74.3	4.38
Tea	74.8	4.46	75.8	3.60	76.3	3.26	76.9	3.30
Tea with sugar	73.3	3.87	75.3	3.04	75.3	2.71	77.6	3.40
Coffee	76.5	3.91	76.7	4.74	77.8	2.52	78.1	2.97
Coffee with sugar	75.7	3.89	76.8	4.00	78.4	3.06	78.9	3.24
Mouthwash	75.8	4.59	74.4	4.13	70.6	5.37	69.2	5.28

Table 2: The Means and standard deviation results of the data imident materials (ΔE)

	Beginning time (the means)	Beginning time (Sd)	24 hours (the means)	24 hours (Sd)	1 week (the means)	1 week (Sd)	3 weeks (the means)	3 weeks (Sd)
IMIDENT Polished								
Coke	79.9	1.83	80.3	1.63	80.7	1.04	81.0	1.48
Distilled water	82.2	2.89	81.1	2.93	80.8	2.44	80.8	2.45
Tea	79.6	1.17	80.2	1.02	80.5	0.83	81.8	1.22
Tea with sugar	78.0	3.64	79.2	2.32	79.3	1.99	81.6	2.51
Coffee	81.0	2.70	81.2	1.38	81.3	1.41	82.2	1.71
Coffee with sugar	76.1	4.78	77.0	3.95	79.0	2.37	80.1	1.91
Mouthwash	80.8	1.47	79.3	1.62	80.1	1.43	77.5	2.38
IMIDENT Unpolished								
Coke	79.2	2.24	80.7	2.16	81.2	1.77	82.0	2.14
Distilled water	83.0	2.35	82.4	3.07	82.7	2.52	80.2	2.20
Tea	76.0	3.45	82.1	3.01	81.2	3.05	82.5	3.14
Tea with sugar	80.1	1.84	82.2	2.03	82.6	2.15	83.3	2.05
Coffee	80.4	2.04	81.9	2.83	82.4	2.80	83.0	3.07
Coffee with sugar	73.8	9.57	80.5	5.20	80.7	6.33	82.0	5.92
Mouthwash	83.3	2.70	81.3	3.02	80.5	2.62	76.8	6.27

It was found that the initial ΔE values of the samples prepared with CAD/CAM and chemically polymerized polymethylmethacrylate (Imident), both polished and graded, increased in the cola, the tea, the sugared tea, the coffee, and the sugared coffee 3 weeks later and decreased in the mouthwash. As for samples kept in distilled water, it was found that the values increased in the CAD/CAM polished samples and decreased in the other groups [Figure 1].

Discussion

The hypothesis of the study was accepted because it was established in this study that the surface treatment was significant for color change. The liquid absorption, the amount of polymerization, the surface roughness, and the material thickness were among the factors affecting the color change in the temporary restoration materials used in dentistry.[18] In this study, samples were prepared in 2 mm thickness, in accordance to previous studies.[5,18,19] Mutlu-Sagesen *et al*.[14] carried out studies on color; it was reported that there is a connection between the color of temporary crown materials, composites, and the color change, and the light materials change more in color. Considering this situation, all materials were prepared in the A2 color. Because the roughness of the surface of dental materials exposed to the oral environment will affect the color change, it was desired that the surface be as smooth and shiny as possible.[20] In this study, while half of the samples were not treated by any process, half of the samples were smoothed by standard polishing processes, and they were kept in distilled water at 37°C for 24 hours before being put into solutions in order to remove the residual monomer.[14]

It is very important to evaluate the color change that occurs in dental materials. In this study, a color measurement device was used to eliminate subjective differences in the evaluation of color change and to assess with quantitative measurements. CIE Lab is a recommended system in dental procedures. In this system, color is characterized on the basis of human perception and measured in three spatial coordinates. In the system, the L* value represents lightness–darkness, the a* value represents the coordinate of color between red–green, and the b* value represents the position between blue–green. Color difference (ΔE*) is a mathematical calculation of the direction and magnitude of the difference between two points in a three-dimensional color space.[21] When the calculated ΔE value for the two colors measured is 0, the color difference is defined as "excellent"; when the color difference is between 0.5 and 1.5, it is defined as "very good"; when the color difference is between 1 and 2, it is defined as "good"; when the color difference is between 2 and 3.5, it is defined as clinically "acceptable"; and color differences greater than 3.5 are defined as clinically "unacceptable".[22]

The ΔE* value is used to evaluate the perception of the color change that occurs as a result of a certain process or after a certain period of time in materials. Therefore, it is more significant to use the ΔE* value in evaluating the color change displayed by the materials than considering the L, a, and b values one by one.[18] When the ΔE values of the beverages kept in this study were compared, it was seen that the maximum color change was in the Imident samples kept in sugared coffee for 3 weeks, and the least color change was in the

samples kept in distilled water. In all materials tested, ΔE values were listed in descending order as sugared coffee > coffee > sugared tea > tea > coke > distilled water.

Frequently consumed beverages such as tea, coffee, cola, and red wine are generally used in studies examining the color stability of restorative dental materials.[23] Therefore, in order to evaluate color stability, the effects of tea, coffee, cola, and mouthwash as well as sugared tea and sugared coffee because they are consumed a lot in Turkish society were investigated. As a result of the research, it was found that the average consumption time of a cup of tea or coffee is 15 minutes. Assuming that individuals who drink tea or coffee consume an average of three glasses of these beverages per day, the 3-week holding period seems to be equivalent to more than a year in real life.[23] In this study, the samples were kept in beverages for 3 weeks in order to simulate long-term consumption. Mutlu-Sagesen *et al*.[14] reported in their study that the preparation and concentration of coffee and tea affected the degree of color change. Therefore, the solutions used in the study were prepared in accordance with daily use.[24]

Yeşil Duymuş *et al*.[25] found in their study that the samples they prepared from the seromer were colored much more in Turkish coffee than tea, cola, or fruit juice.

As a result of the study, it was determined that different beverages affect the color stability of the temporary restoration materials and that the most significant color change was in imicryl samples. The greater color change in samples prepared from a temporary material containing polymethyl methacrylate may be because of the higher resin content and higher porosity resulting from manual manipulation.[26] Türker *et al*.[27] stated that pigments obtained from foods and beverages cause higher color change in more porous acrylic resins.

In a study examining the color stability of seven different methyl methacrylate resins at the end of 9 weeks, it was found that the auto-polymerizing resin changes color much more than the heat-polymerized resin.[28]

In another study evaluating the color change in acrylic resins with Turkish coffee, tea, and mouthwash, it was stated that the finishing-polishing processes and polymerization method applied to the surface in addition to the holding times had an important effect on the color change, and Turkish coffee was the most staining of the solutions used. In the same study, it was determined that auto-polymerizing acrylics show much more significant color change in coffee solutions, and materials without finishing and polishing are also stained more than those that are polished. Similar to the control group, the least color change was seen in samples which were polymerized with heat, to which finishing and polishing processes were applied and were kept in mouthwash for 24 hours.[16]

In this study, the color changes of the chemically polymerized temporary crown material and the temporary restorative materials prepared with CAD/CAM increased with the addition of sugar. Mouthwash also affected the color stability; however, it had a lightening rather than a darkening effect.

Bayındır *et al*.,[18] when evaluating the color stability of methyl methacrylate resins used in the production of temporary crowns, found that Nescafe created an over-dyeing effect, and there was less color change in bis-acrylic-based resins cured by auto-polymerization.

As the surface becomes smoother with the finishing and polishing processes, early period color change is prevented. The roughness of the surface makes it easy to hold the stain mechanically.[19] It was reported that mechanical properties are positively influenced by the increase in the conversion density of the monomer to polymer.[29]

Time is critical in the color stability of temporary restorative materials. It was reported that as the dipping time increased, the color differences were much greater.[30] In this study, an increase in color with an increase in time was detected in all solutions except mouthwash and distilled water.

The color change varies from person to person and depends on factors such as saliva and enzymes in the mouth, consumed food and drinks, temperature changes, smoking, and poor oral hygiene. These are the limitations of the study. It is one of the limitations of the study that all these factors could not be replicated in ideal experimental conditions in this and similar studies. Samples prepared for the study were kept in an artificial solution that did not contain saliva, unlike in clinical conditions. Moreover, although polishing is applied to the samples, the anatomical grooves and fossa in the teeth do not reflect clinical conditions. Nevertheless, the large number of samples used in our study, the diversity of the groups, and the use of the drinks consumed by the society in daily life are the advantages of this study. In order for temporary materials to meet the longer clinical usage period, it is necessary to perform the anamnesis taken by the physicians and, according to the clinical conditions, to increase the success and life of the temporary restorations.

Conclusions

The color change of temporary restorative materials showed alteration according to the material used and the type of drink. In this study, the most significant color change in the inter-material evaluation was observed in polymethyl methacrylate-based imicryl. In the evaluation between beverages, the highest color change was found in sugared coffee, followed by coffee, and a lesser color change was observed in polished samples.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Rayyan MM, Aboushelib M, Sayed NM, Ibrahim A, Jimbo R. Comparison of interim restorations fabricated by CAD/CAM with those fabricated manually. J Prosthet Dent 2015; 114:414-9.
2. Al Jabbari YS, Al-Rasheed A, Smith JW, Iacopino AM. An indirect technique for assuring simplicity and marginal integrity of provisional restorations during full mouth rehabilitation. Saudi Dent J 2013;25:39-42.
3. Güngör MB, Nemli SK, Bal BT, Doğan A. Farklı içeceklerde bekletilen geçici restorasyon materyallerinin renk stabilitelerinin karşılaştırılması. Acta Odontol Turc 2016;33:80-5.
4. Doray PG, Wang X, Powers JM, Burgess JO. Accelerated aging affects color stability of provisional restorative materials. J Prosthodont 1997;6:183-8.
5. Rutkunas V, Sabaliauskas V, Mizutani H. Effects of different food colorants and polishing techniques on color stability of provisional prosthetic materials. Dent Mater J 2010;29:167-76.
6. Satou N, Khan AM, Matsumae I, Satou J, Shintani H. *In vitro* color change of composite-based resins. Dent Mater 1989;5:384-7.
7. Ferracane JL. Correlation between hardness and degree of conversion during the setting reaction of unfilled dental restorative resins. Dent Mater 1985;1:11-4.
8. Nordbo H, Attramadal A, Eriksen HM. Iron discoloration of acrylic resin exposed to chlorhexidine or tannic acid: A model study. J Prosthet Dent 1983;49:126-9.
9. Sen D, Goller G, Issever H. The effect of two polishing pastes on the surface roughness of bis-acryl composite and methacrylate-based resins. J Prosthet Dent 2002;88:527-32.
10. Keyf F, Uzun G, Altunsoy S. Diş hekimliğinde renk seçimi. Hacettepe Diş Hek Fak Derg 2009;33:52-8.
11. Dozic A, Kleverlaan CJ, El-Zohairy A, Feilzer AJ, Khashayar G. Performance of five commercially available tooth color-measuring devices. J Prosthodont 2007;16:93-100.
12. Haselton DR, Diaz-Arnold AM, Dawson DV. Color stability of provisional crown and fixed partial denture resins. J Prosthet Dent 2005;93:70-5.
13. https://beslenmevediyetdergisi.org/index.php/bdd/article/view/1013/919 [Last accessed on 2023 Jan 11].
14. Mutlu-Sagesen L, Ergün G, Özkan Y, Bek B. Color stability of different denture teeth materials: An *in vitro* study. J Oral Sci 2001;43:193-205.
15. Berber A, Cakir FY, Baseren M, Gurgan S. Effect of different polishing systems and drinks on the color stability of resin composite. J Contemp Dent Pract 2013;14:662-7.
16. Yeşil Duymuş Z, Yanıkoğlu N, Arık M. Evaluated of colour changed of acrylic resin materials in the different solutions by using 500 nm monochromatic light. Asian J Chem 2010;22:6669-76.
17. İşcan Yapar M, Gül P. Farklı içeceklerde bekletilen siloran ve dimetakrilat esaslı kompozitlerin renk stabilitelerinin karşılaştırılması. Acta Odontol Turc 2015;32:51-6.
18. Bayindir F, Kurklu D, Yanikoglu ND. The effect of staining solutions on the color stability of provisional prosthodontic materials. J Dent 2012;40:41-6.
19. Turgut S, Bagis B, Ayaz EA, Ulusoy KU, Altintas SH, Korkmaz FM. Discoloration of provisional restorations after oral rinses. Int J Med Sci 2013;10:1503-9.
20. Atabay C, Tunçdemir MT. Geleneksel Türk içeceklerinde bekletilen laminate geçici restorasyon materyallerinin renk stabilitelerinin karşılaştırılması. Yeditepe Dent J 2019;15:166-70.
21. Mohammadi-Bassir M, Babasafari M, Rezvani MB, Jamshidian M. Effect of coarse grinding, overglazing, and 2 polishing systems on the flexural strength, surface roughness, and phase transformation of yttrium-stabilized tetragonal zirconia. J Prosthet Dent 2017;118:658-65.
22. Bagheri R, Burrow MF, Tyas M. Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials. J Dent 2005;33:389-98.
23. Noie F, O'Keefe KL, Powers JM. Color stability of resin cements after accelerated aging. Int J Prosthodont 1995;8:51-5.
24. Park JK, Kim TH, Ko CC, García-Godoy F, Kim HI, Kwon YH. Effect of staining solutions on discoloration of resin nanocomposites. Am J Dent 2010;23:39-42.
25. Duymuş Z, Sağsöz N, Sağsöz Ö, Bayindir F. Seromerlerin farklı solusyonlardaki renk değişimlerinin incelenmesi. Atatürk Üniv Diş Hek Fak Derg 2011;24:81-4.
26. Arima T, Murata H, Hamanda T. The effects of crosslinking agents on the water sorption and solubility characteristics of denture base resins. J Oral Rehabil 1996;23:476-80.
27. Turker SB, Kocak A, Aktepe E. Effect of five staining solutions on the colour stability of two acrylics and three composite resins based provisional restorations. Eur J Prosthodont Restor Dent 2006;14:121-5.
28. Koumjian JH, Firtell DN, Nimmo A. Color stability of provisional materials in vivo. J Prosthet Dent 1991;65:740-2.
29. Lee SY, Lai YL, Hsu TS. Influence of polymerization conditions on monomer elution and microhardness of autopolymerized polymethyl methacrylate resin. Eur J Oral Sciences 2002;110:179-83.
30. Scotti R, Mascellani SC, Forniti F. The *in vitro* color stability of acrylic resins for provisional restorations. Int J Prosthodont 1997;10:164-8.