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Effect of Five Staining Solutions on the Colour Stability of Two Acrylics and Three Composite Resins Based Provisional Restorations

Şebnem Begüm Türker*, Ayşe Koçak† and Esra Aktepe†

Abstract – *The effect of coffee, tea, coca-cola, orange-juice and red wine on the colour stability of acrylic and composite based provisional materials were evaluated. Two acrylic resins and three composite resins were studied. 48 standardized specimens for each provisional material were prepared. Each group was divided into 6 subgroups. Specimens from each group were immersed in staining solutions at room temperature for 30 days. Red wine and tea caused the most significant colour changes and orange juice showed the least significant colour changes. ΔE of all of the provisional restorations materials was changed after the immersion in all of the staining solutions during the experimental process.*

KEY WORDS: Provisional materials, Colour, Staining solutions

INTRODUCTION

During the time between the preparation of the tooth and the placement of the final restoration, the tooth is protected by a provisional restoration[1]. Provisional fixed prostheses should help promote periodontal health, provide proper occlusion while protecting the tooth structure and offering esthetic restoration of the dental abutment[1,2,3].

Three types of chemically polymerized materials are commercially available for provisional coverage of single and multiple units. These include ethyl methacrylates, methyl methacrylates and bis-acryl composites resins[4]. As ethyl methacrylates have shown poor wear resistance and poor esthetics[5,6], the methyl metacrylates and bis-acryl composite resin materials possess a larger market share[2,4,7]. Bis-acryl resins have low exothermic, good fit and moderate colour retention, strength and fit. Resin materials include light-curing resins, thermal- light curing resin[2].

Provisional fixed prostheses is kept in the mouth for as short a period as possible awaiting final restoration or long-term interim fixed prostheses[3]. When long-term provisionalization is required, colour stability of the provisional restoration becomes an important consideration in the selection of a particular provisional material[8].

Colour stability of the provisional fixed prostheses relates not only to the chemichophysical properties of the resin but also, the patient's habits[3]. Tea, soy sauce, tannin, curry, licorice, cocao, coffee and clorhexidine based oral rinses, all tend to stain natural teeth and discolor the provisional fixed prostheses to an even greater extent, largely because of material porosity [5,9]. Fluid pigments from food, beverages, drugs and nicotine are deposited in the interprismatic spaces of the teeth, on conservative and prosthetic restorations, and especially on the provisional fixed prostheses acrylic resin, which are more porous than resin composite and reinforced resins[10].

Many authors used various staining solutions to observe their staining capacity of various provisional materials[3,5,7,8,11-13]. Tea and coffee were used commonly as staining agents. There were no studys in the literature which used the red wine as alcohol, cola and orange juice together as staining agents for the provisional restorations. The aim of this study was to examine the effects of five different types of staining solutions, coffee, tea, cola, orange juice and red wine on the colour stability of two acrylic-based and three composite-based provisional restorative materials after immersion of 1 day, 7 days and 30 days of daily usage.

MATERIALS AND METHODS

Five staining solutions (coffee, tea, cola, orange juice, red wine) and as a control group distilled water were used to evaluate their effects on two chemically activated methyl metachrylate resins, one light-cured composite based resin and two chemically activated composite resins (Table 1).

Preparations of Specimens

Holes 10 mm diameters were drilled in a 2 mm-thick polytetrafluoroethylene plate to form acrylic and composite based provisional resin's/specimens. The provisional resins materials were placed into the mold separately and sandwiched between 2 glass plates. In accordance with the manufacturer's directions, visible light cured composite-based resin were polymerized for 40 seconds with a wide-type prismatic light-polymerizing unit (3M, Dental Products Division, St. Paul, Min) at 420 mW. The chemically cured acrylic-based materials were mixed in a powder: liquid

*DDS, PhD
†DDS

Table 1. *Materials Tested*

Materials	Chemistry	Manifacturers
Structure 2 Dominant	Chemically polymerized uretan di-methyacrylate Composite-resin	Voco GbmH, Cuxhaven, Germany
GC Unifast LC	Light polymerized uretan di-methylacrylate Composite resin	GC Corporation, Tokyo, Japan
Systemp c&b	Chemically polymerized uretan polymethyacrilate Composite resin	Ivoclar Vivadent, Fürstentum, Liechtenstein
Dentalon Plus	Chemically polymerized polymethyl methacrylate	Heraeus Kulzer, Inc
Temdent	Chemically polymerized polymethylmetacrylate	Schütz-Dental Co., Germany
Tea	Lipton	Gayrettepe,İstanbul,Türkiye
Coffee	Nescafe-Classic	Karacabey, Bursa, Türkiye
Coca-cola	Coca-cola	Yenibosna,İstanbul, Türkiye
Orange juice	Cappy	Yenibosna,İstanbul, Türkiye
Wine	Red Yakut Wine	Kavaklıdere-Ankara, Türkiye

ratio of 2g: 1 up to 1.2 ml was mixed in a mixing cup for 40 s with a glass spatula to a homogenous mix according to the manufacturer's directions and the resin was inserted into the polytetrafluoroethylene mould. The specimens were removed from the mould after they were completely set. The excess provisional materials were ground by hand lapping with a 600 grift silicon carbide paper.

To prepare the coffee solution 15 g of coffee (Nescafe Classic, Karacabey, İstanbul) was poured into 500 ml of boiling distilled water. The tea solution was prepared by immersing 5 prefabricating doses of tea (Lipton, Gayrettepe, İstanbul) into 500 ml of boiling distilled water and used after 10 minutes of waiting periods. Fresh solutions were used for each treatment session.

All the specimens were placed into desiccator (Normax, Fabrica de Vidros Cientificos, Lda, Marinha Grande, Portugal) containing silica gel at 37°C ±1°C until a constant weight was attained. Specimens were then stored in distilled water at 37°C ±1°C for 24 h. Eight randomly selected specimens from each material were immersed in each of the six staining solutions for an average of 3 h per day. The staining procedure was performed over a period of 30 days. The distilled water was used as a control group. At the end of the staining procedure all of the specimens were kept in fresh distilled water until the next daily application. Minolta Spectrophotometer CM-3600 d (Minolta Co.; Ltd., Osaka, Japan) was used to evaluate the colour and colour difference of each specimen.

The baseline measurements, T1, were obtained after whole specimens were saturated; T2 was measured after the rehyradation period. T3, T4, T5 were obtained after 1, 7 and 30 days of the staining solution's immersion respectively.

To evaluate colour differences, the CIELAB calorimetric system was used[11]. Before each measurement session, the colorimeter was calibrated according to the manufacturer's recommendations by using the supplied white calibration standard. Each specimen was measured 3 times by placing each specimen on the measuring head and covering with the black cover. The mean ΔE* value of three measurements were automatically calculated by the colorimeter and recorded.

Anova analysis of variance was used to evaluate colour measurements. Significant results were evaluated again with Scheffe-F test ($p<0.0001$). Repeated measure test was used to evaluate the colour differences to find the relation between time and staining procedure. ($p=0.0001$)

RESULTS

Values of mean colour difference ΔE* and standard deviations for each combination of staining solutions and provisional material groups are given in Table 2 and in Table 3. The three way Anova test results are given in Table 4. Results of the repeated measure Anova and three way Anova indicated that the effects of all 3 factors, and all possible interactions among them, were statistically significant ($p=.0001$).

The first significant colour difference was shown at the first daily usage with Systemp c&b provisional materials after coffee and wine immersion. At the 7th day and 30th day of the experimental process Systemp c&b provisional materials was the least colour stable material with wine solution. The most staining solution was the red wine. Tea and coffee were the second and third staining solutions which affect all the provisional materials (Table 2, 3 and 6). All the provisional materials, except Systemp c&b, were approximately the same discoloration effects (Table5). The mean ΔE* values increased significantly with time for all staining solutions of each provisional restorative material (Table 2, 3 and 7).

DISCUSSION

The value of ΔE*represents relative colour changes that on observer might report for the materials after treatment or between time periods. Thus ΔE* is more meaningful than the individual L*, a* and b* values[7].

Seghi et al[12], Um and Ruyter[13] and Liberman et al[14] reported that ΔE* value equal to L* is considered visually detectable 50% of the time, whereas a ΔE* value greater than 2 is detectable 100% of the time. Johnston and Kao[15] reported that the average colour difference between compared teeth rated as a 'match' in the oral environment was 3.7 (ΔE*). Seghi et al[12] presumed that on acceptable colour difference can after be 2 or 3 times greater than the detectable limits. Doray et al[16] considered visually perceptible colour change (ΔE*) greater than or equal to 3.3 as well Yannikakis et al[7] referred discoloration below or above the value ΔE* 3.7 as 'acceptable' or 'unaccepted', respectively. In the present study, as Yannikakis et al[7], the ΔE* value=3.7 or >3.7 was accepted as clinically acceptable and below this value was considered as clinically unacceptable.

The results of this study revealed a statistically significant result obtained in the groups and between groups

Table 2. *Mean ΔE values for tested resin composite provisional materials and solutions*

Provisional Restorations	Staining Solutions	Distilled water		1thday		7thday		30thday	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Structure 2 Dominant	Tea	0.3	0.1	0.7	0.4	2.9	0.7	2.2	0.3
	Coffee	0.3	0.2	1.6	0.6	3.9	3.2	4.5	1.2
	Coca-cola	0.2	0.1	0.7	0.3	1.1	0.3	2.2	0.3
	Orange Juice	0.4	0.4	0.4	0.3	0.9	0.4	0.9	0.3
	Red Wine	0.5	0.2	0.7	0.3	1.8	0.8	4.5	1.2
	Distilled water	0.3	0.3	0.4	0.2	0.5	0.3	0.8	0.6
GC Unifast LC	Tea	0.4	0.2	0.4	0.2	3.4	0.7	7.9	1.3
	Coffee	0.6	0.3	0.7	0.3	1.6	0.8	2.5	1.0
	Coca-cola	0.5	0.4	0.5	0.3	3.1	3.2	3.5	2.4
	Orange Juice	0.4	0.3	0.5	0.3	1.7	1.5	2.1	1.2
	Red Wine	0.8	0.7	0.9	0.7	3.2	2.2	5.6	3.5
	Distilled water	0.6	0.2	0.6	0.2	1.0	0.4	1.2	0.5
Systemp c&b	Tea	0.8	0.6	0.6	0.3	2.6	1.0	5.4	1.2
	Coffee	0.4	0.2	2.3	1.2	3.8	2.3	7.3	2.9
	Coca-cola	0.6	0.4	0.9	0.2	1.5	0.3	2.0	0.9
	Orange juice	0.5	0.2	1.1	0.7	2.8	1.0	2.6	1.2
	Red Wine	0.8	0.5	2.1	0.6	11.0	2.5	12.1	2.3
	Distilled water	0.5	0.3	0.4	0.3	1.3	0.9	1.3	0.5

*Mean ΔE value

Table 3. *Mean ΔE values for tested acrylic provisional materials and solutions*

Provisional Restorations	Staining Solutions	Distilled water		1thday		7thday		30thday	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Dentalon Plus	Tea	0.4	0.2	0.4	0.1	2.3	0.6	7.9	2.0
	Coffee	0.3	0.2	0.6	0.3	0.9	0.3	3.6	1.5
	Coca-cola	0.4	0.5	0.3	0.2	0.7	0.2	2.2	0.7
	Orange juice	0.5	0.3	0.4	0.3	1.1	0.7	2.9	1.2
	Red Wine	0.7	0.5	0.5	0.2	1.2	0.4	6.4	1.8
	Distilled water	0.3	0.1	0.6	0.6	0.9	0.7	2.2	0.5
Temdent	Tea	0.3	0.3	0.4	0.3	3.5	0.7	8.3	0.5
	Coffee	0.2	0.2	0.5	0.2	1.7	0.7	3.6	3.9
	Coca-cola	0.3	0.3	0.7	0.8	1.4	0.4	2.6	1.3
	Orange juice	0.4	0.1	0.4	0.3	0.3	0.1	2.3	1.3
	Red Wine	0.2	0.1	0.6	0.3	1.4	0.3	7.0	3.4
	Distilled water	0.2	0.2	0.6	1.2	0.5	0.3	1.0	0.6

*Mean ΔE value

Table 4. *Three-way Anova results*

	df	Sum of square	Mean square	F ratio	Probability
Staining solutions (A)	5	714.5	142.9	101.2	0.0001
Provisional Restorations (B)	4	197.4	49.4	35	0.0001
AB	20	449.9	22.5	15.9	0.0001
Times (C)	3	2062.7	687.6	487	0.0001
AC	15	905.4	60.4	42.8	0.0001
BC	12	126.8	10.6	7.5	0.0001
ABC	60	429.6	7.2	5.1	0.0001

Table 5. *Mean ΔE values for the provisional material tested (values with the same letter were significant statistically)*

	Mean*	SD
Structure 2	1.6[a]	2.0
GC Unifast LC	1.8[b]	2.2
Dentalon Plus	1.6[c]	2.0
Temdent	1.6[d]	2.4
Systemp c&b	2.8[a b c d]	3.3

* Mean ΔE value

Table 6. *Mean ΔE values for the staining solution (values with the same letter were significant statistically)*

	Mean*	SD
Tea	2.8[a c d]	3.0
Coffee	2.1[b e f]	2.3
Coca-cola	1.4[d g]	1.5
Orange Juice	1.1[c f h]	1.1
Red Wine	3.1[b g h ı]	3.7
Distilled Water	0.8[a e ı]	0.7

* Mean ΔE value

Table7. *Mean ΔE values for the immersion time (values with the same letter were significant statistically)*

	Mean*	SD
Distilled water	0.4[a b]	0.4
1 day	0.8[b c d]	0.9
1 week	2.2[c e]	2.3
1 month	4.2[a d e]	3.2

* Mean ΔE value

(=0.0001). The ΔE* values of all tested provisional material, except Systemp c&b, were at the same level. The mean ΔE* value of the Structure2 Dominant and GC-Unifast chemically cured composite based resin restorative material was nearly similar to the mean ΔE* value of the chemically cured acrylic-based resin restorative materials. Systemp c&b, composite-based resin provisional restorative materials showed the most severe colour changes. The findings of this study are in agreement with Doray et al's study[16]. Further investigation is needed to evaluate the relationship between the staining solution and provisional restorative material with respect to the chemical properties of the provisional restorative material, the surface roughness of the specimen and the concentration of the staining solution.

The least colour stable staining solution was the wine (ΔE*=3.1). The staining capacity of tea (ΔE*=2.8), coffee (ΔE*=2.1), coca-cola (ΔE*=1.4) and orange juice (ΔE*=1.1) were less than the red wine. Crispin and Caputo[5] reported that the tea-coffee solution caused the greatest amount of darkening over a 1-month period. Scotti et al[3] stated that the solution of synthetic saliva and coffee produced the greatest darkening. Yannikakis et al[7] reported that the coffee solution exhibited more staining capacity than the tea solution. The results of this study agreed with Crispin and Caputo's study. The quality and the concentration of the tea and coffee products selected could affect the results of the present study. Wang et al[17] found that the acrylic resins showed better resistance to coffee stain than did the composite resins, however in the present study the staining capacity of all the tested materials, except Systemp c&b, were nearly the same. There are no studies in the literature which used red wine, coca-cola and orange juice as a staining solution for provisional restorative material. Coca-cola and orange juice solution's ΔE* values are equal to 1 or nearly over 1, so, we can conclude that it is visually detectable 50% of time. Even if the ΔE* value of wine is 3.1, being the highest value of the study, is still within the limitations of the clinically acceptable levels. When long-term esthetics provisionalization is required, the drinking habits of the patients must be considered while choosing the type of provisional restorations material.

The staining capacity of all provisional restorative material tested had seen after one week of immersion, except Systemp c&b, and one month of immersion revealed serious colour changes. In agreement with other studies[3-5-7], we concluded that with greater longevity of immersion time, colour changes become more intense.

Koumajian et al[18] reported in their in vivo study that all material tested showed same degree of stain at the 9 week evaluation and no colour change was detected until after 5 week observation. The findings of the present study are different from these of Koumajian et al[18]. The complexity of the oral environment and variation in individual dietary and oral hygiene habits may affect the results. This in vitro study provides information about different types of fabricating provisional restorations with respect to colour changes caused by various solutions. The results may be useful to clinicians when selecting the material to be used for provisional restorations.

CONCLUSION

The combination of provisional materials, staining solutions and immersion are significant factors affecting colour stability. When long-term esthetics provisionalization is required, the drinking habits of the patients must be considered while choosing the type of provisional restorations material

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ADDRESS FOR CORRESPONDENSE

Dr. Ş. Begüm Türker, Marmara University, Dept. of Prosthodontics, Faculty of Dentistry, Büyük Çiftlik Sok No:6, 34365 Nişantaşı, İstanbul-TÜRKİYE.
E-mail: begumturker@hotmail.com

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