Original Article

A Comparative Evaluation of the Color Stability of Commercially Available Provisional Restorative Materials after Immersion in Different Media

Jagruti R. Gadhvi*, Somil Mathur, Meena Shah, Akanksha Trivedi, Manan Shah, Takshil Shah
Department of Prosthodontics, Faculty of Dental Science, Dharmsinh Desai University, Nadiad, Gujarat, India.

Abstract

Aim: The purpose of this study was to evaluate and compare the color stability of commonly used three different provisional restorative materials after immersion in four different media and accelerated aging. **Materials and Methods:** In this study 3 commercially available provisional restorative materials (DPI, Cooltemp, and Protemp) were evaluated for color stability. A total of 48 disc-shaped specimens with dimensions of 10 mm diameter and 2 mm thickness were prepared. The specimens were then subjected to aging in artificial saliva. Four different staining solutions namely tea, turmeric, coca-cola, and mouthwash were prepared for evaluation of color stability of the specimens and were immersed in them for 21 days. Color measurements were recorded before and after immersion. **Results:** The results of this study showed that maximum difference of light transmittance (%T) was seen in Group D (DPI, polymethylmethacrylate [PMMA]). Hence, Group D showed the least color stability whereas Group P (Protemp and bis-acryl composite) showed the highest color stability. For staining solutions, the results reveal that maximum color change was seen after immersion in turmeric. **Conclusion:** All three provisional restorative materials exhibited statistically significant color change after exposure to staining solutions. DPI (PMMA) showed the least color stability in all immersion media.

Keywords: Color stability, Provisional restorative materials, Staining media

Introduction

Fixed prosthodontic treatment involves many treatment modalities like complete or partial coverage, natural tooth or dental implant abutments, full mouth rehabilitation, which commonly relies on indirect fabrication of definitive prosthesis in the dental laboratory. Fabrication of definitive prosthesis is a time-consuming procedure which necessitates protection of the prepared tooth during this interim period with a provisional restoration.

Provisional restorations ensure that the prepared tooth is protected from the oral environment and its relationship with the adjacent and opposite teeth are maintained. In order to preserve the prepared abutment teeth, provisional restorations are fabricated and the process is known as provisionalization. It provides pulpal protection, maintains periodontal health, occlusal relationship and tooth position of the abutment tooth and also helps in deciding the shade, shape, and contour of the final restoration, especially in cases of long-term anterior provisionalization.[1]

Provisional restorations are known to be good diagnostic tools because they are, a kind of aesthetic and functional rehearsal for permanent restoration, which helps the dentist to assess whether the prosthesis being planned will sufficiently meet the esthetic, biomechanical, and physiological needs of the patient.[2] There are different types of provisional restorative materials namely bis-acryl composite, polymethylmethacrylate (PMMA), urethane dimethacrylates, polyethylmethacrylate, etc. These materials should not only satisfy mechanical requirements such as strength and resistance to wear, but also meet biologic and esthetic needs. Bis-acryl composites and PMMA are the most commonly used provisional restorative materials.

Color stability of these provisional restorative materials is a concern, particularly when the provisional restoration is in the

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Address for correspondence: Dr. Jagruti R. Gadhvi, Department of Prosthodontics, Faculty of Dental Science, Dharmsinh Desai University, Nadiad, Gujarat, India.
Email: jagrutigadhvi6996@gmail.com

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esthetic zone and must be worn for extended periods of time. Ideally, dental resins should not change in color or appearance subsequent to fabrication.[3] Provisional materials may undergo color change as a result of the complex interaction of a number of factors, such as incomplete polymerization, water sorption, surface reactivity, patient's diet, and oral hygiene regimen. Discoloration of provisional materials for fixed prosthodontics may result in patient dissatisfaction and additional expenses for the replacement.

In vitro accelerated aging conditions simulate the effect of some of these factors on dental polymers such as the resins used for provisionalization. Water plays a key role in the chemical degradation of resins, by accelerating the processes of oxidation and hydrolysis.[4] Although these conditions are not able to replicate the complex *in vivo* conditions, they assess the response of provisional resin materials to simulated conditions which helps in considering their potential for clinical color stability.

Hence, the purpose of this study was to evaluate and compare the color stability of commonly used three different provisional restorative materials after immersion in four different media and accelerated aging.

Materials and Methods

Three commercially available provisional restorative materials (DPI, Cooltemp, and Protemp) were used for the evaluation and comparison of color stability. For the standardization of all specimens, a customized stainless-steel mold (Figure 1) was prepared with an aim of creating specimens of uniform thickness. The dimensions of the mold were selected in accordance with International Organization for Standardization - ISO no: 7491.

Disc-shaped specimens with dimensions of 10 mm diameter and 2 mm thickness (ISO no: 7491) were prepared from each material with the help of the three-layered stainless-steel mold (Figures 2-4). A total of 48 specimens were fabricated, out of which 16 specimens were fabricated for Group C (Cooltemp, bis-acryl composite resin), 16 specimens were fabricated for Group D (DPI, PMMA), and 16 specimens were fabricated for Group P (Protemp, bis-acryl composite resin). After all the specimens were fabricated, the specimens were checked and analyzed for surface defects. After all the specimens were prepared, they were stored in artificial saliva at room temperature.

Figure 1: Stainless steel mold

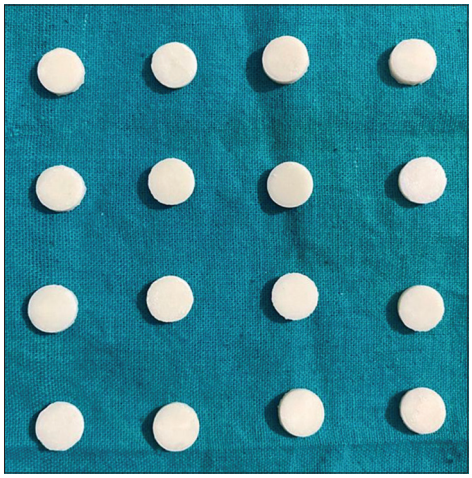


Figure 2: Polymethylmethacrylate - DPI

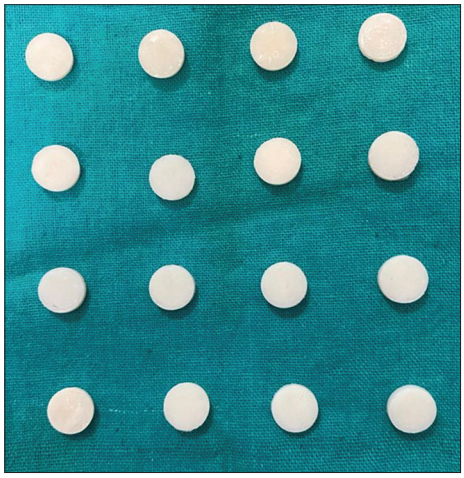


Figure 3: Bisacryl composite resin – Cooltemp

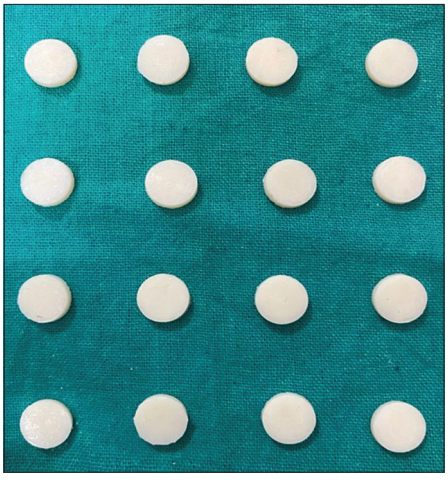


Figure 4: Bisacryl composite resin - Protemp

The specimens were then subjected to aging in artificial saliva for 10,000 cycles replicating three months of intraoral use. Aging was done at 5°C and 55°C temperature (Figure 5). Color measurements of all specimens were taken before immersion in different staining solutions using a spectrophotometer (Cary 5000, Agilent Corporation, United States). The specimens were then divided into four subgroups for immersion in four different solutions. Each subgroup consisted of twelve samples containing four specimens of each material.

Preparation of Staining Solutions for Immersion

Four different staining solutions (Figure 6) namely tea, turmeric, coca-cola, and mouthwash were prepared for the evaluation of color stability of the specimens. The staining solutions were prepared in the following concentrations (Table 1):

- Subgroup 1: Tea (Taj Mahal, Hindustan Unilever Ltd.,) solution was prepared by adding 2 g of tea in 150 ml of water. This tea was mixed with artificial saliva in 2:1 ratio
- Subgroup 2: Turmeric (Ramdev Food Products Pvt. Ltd.,) solution was prepared by adding 0.5 g of turmeric in 150 ml of water. This turmeric was mixed with artificial saliva in 2:1 ratio
- Subgroup 3: Coca-Cola (Hindustan Coca-Cola Beverages Pvt. Ltd.,) mixed with artificial saliva in 2:1 ratio
- Subgroup 4: Mouthwash (Listerine, Johnson and Johnson) mixed with artificial saliva in 2:1 ratio.

Figure 5: Aging machine

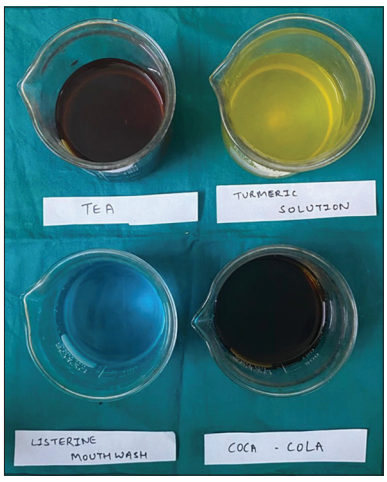


Figure 6: Staining solutions

Immersion

Twelve specimens were immersed in all four staining solutions for 21 days. For each day specimens were immersed in the solution for 2 h and then removed and rinsed. All specimens were rinsed under running water for 30 s and the final measurements for color change were recorded using a spectrophotometer (Figure 7).

Results

Based on the observations, data were analyzed using Statistical Package for the Social Science version 23. A one-way analysis of variance (ANOVA) was carried out for comparison of the means of color change observed in all the three groups tested after immersion in four different staining solutions followed by *post-hoc* Tukey test.

Table 2 depicts the mean values of color change of specimens of Group C after immersion in all four staining media (tea, turmeric, mouthwash, and coca-cola). The one-way ANOVA revealed that there is a statistically significant difference present in the %T values after immersion in various media, with maximum change in turmeric and minimum change in coca-cola (Graph 1). It indicates that after immersion in turmeric the color stability is drastically decreased than others in specimens of Group C. Order of color stability- Baseline ≥ Coco-Cola > Mouth Wash >Tea ≥ Turmeric.

Table 3 depicts the mean values of color change of specimens of Group D after immersion in all four staining media (tea, turmeric, mouthwash, coca-cola). The one-way ANOVA revealed that there is a statistically significant difference present in the %T values after immersion in various media, with maximum change in turmeric and minimum change in mouthwash (Graph 2). It indicates that after immersion in turmeric media the color stability is drastically decreased than others in specimens of

Table 1: Different immersion media and number of specimens

Sub-group	Immersion media	Solution	Total specimens	DPI	Cooltemp	Protemp
1.	Tea and artificial saliva (2:1)	150ml	12	4	4	4
2.	Turmeric and artificial saliva (2:1)	150ml	12	4	4	4
3.	Cola and artificial saliva (2:1)	150ml	12	4	4	4
4.	Mouthwash and artificial saliva (2:1)	150ml	12	4	4	4

Group D. Order of color stability- Baseline > Mouth wash ≥ Coco-Cola >Tea ≥ Turmeric.

Table 4 depicts the mean values of color change of specimens of Group P after immersion in all four staining media (tea, turmeric, mouthwash, coca-cola). The one-way ANOVA revealed that there is a statistically significant difference present in the %T values after immersion in various media, with maximum change in turmeric and minimum change in mouthwash (Graph 3). It indicates that after immersion in turmeric media the color stability is drastically decreased than others in specimens of Group P. Order of color stability- Baseline ≥ Mouthwash ≥ Coco-Cola > Tea > Turmeric.

Figure 7: Cary ultraviolet-visible near-infrared spectrophotometer

Table 5 depicts the mean values of color change of specimens of all three group of specimens after immersion in four staining media (tea, turmeric, mouthwash, coca-cola). There is a statistically significant difference in various materials in all immersion media, Group D has least color stability in all immersion media. Maximum color change is observed after immersion in turmeric followed by tea and least change is observed in mouthwash and coca-cola (Graph 4).

Overall order of color stability- Baseline P > Baseline C > Baseline D > Mouth wash P > Coco-Cola C ≥ Coco-Cola P ≥ Mouth wash C > Tea P ≥ Mouthwash D ≥ Tea > Coco-Cola D ≥ Turmeric C ≥ Turmeric P > Tea D ≥ Turmeric D.

Discussion

Color changes can lead to aesthetic problems when provisional restorations are intended to be used for a longer period. Provisional materials undergo color changes when exposed to various environmental conditions. Haselton *et al*. stated that though one of the requirements of provisional restorations is to have good color stability, current provisional materials undergo color

Table 2: Comparison of light transmittance between baseline and immersion media in Group C

Material	Immersion media	*n*	Mean	Std. Deviation	Mean Difference From baseline	% Difference From baseline	F-value	*P*-value
C	Baseline	16	25.441	2.1955			62.973	<0.001**
	Tea	4	13.568	0.5502	11.87	46.67		
	Turmeric	4	11.398	1.7980	14.04	55.20		
	Mouth wash	4	21.098	0.4768	4.34	17.07		
	Coca-Cola	4	22.448	2.1666	2.99	11.77		

**Highly significant (*P*<0.001)

Table 3: Comparison of light transmittance between baseline and immersion media in Group D

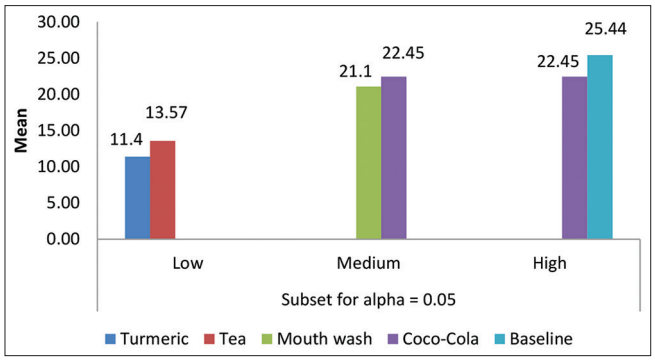
Material	Immersion media	*n*	Mean	Std. Deviation	Mean Difference From baseline	% Difference From baseline	F-value	*P*-value
D	Baseline	16	24.32	2.8106			91.372	<0.001**
	Tea	4	7.40	1.8356	16.92	69.57		
	Turmeric	4	6.15	1.3509	18.17	74.73		
	Mouth wash	4	13.62	0.7007	10.70	43.98		
	Coca-Cola	4	11.82	0.6085	12.50	51.41		

**Highly significant (*P*<0.001)

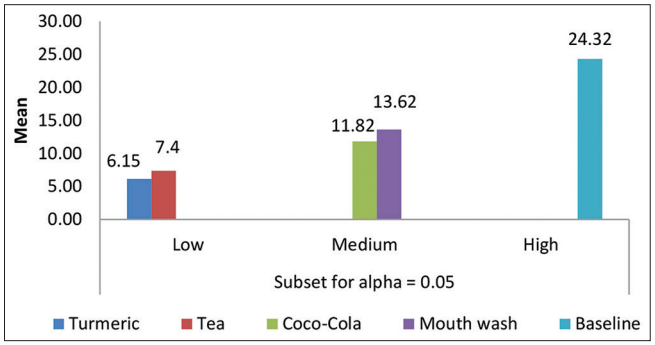
Table 4: Comparison of light transmittance between baseline and immersion media in Group P

Material	Immersion media	*n*	Mean	Std. Deviation	Mean Difference From baseline	% Difference From baseline	F-value	*P*-value
P	Baseline	16	31.95	2.9211			62.998	<0.001**
	Tea	4	18.57	1.3512	13.39	41.90		
	Turmeric	4	13.50	0.9380	18.46	57.77		
	Mouth wash	4	30.68	1.1062	1.27	3.97		
	Coca-Cola	4	27.32	2.3519	4.63	14.50		

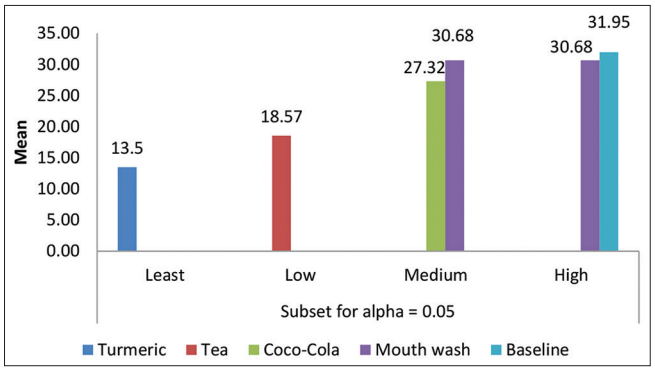
**Highly significant (*P*<0.001)



Graph 1: Graphical representation of colour stability of Group C



Graph 2: Graphical representation of colour stability of Group D



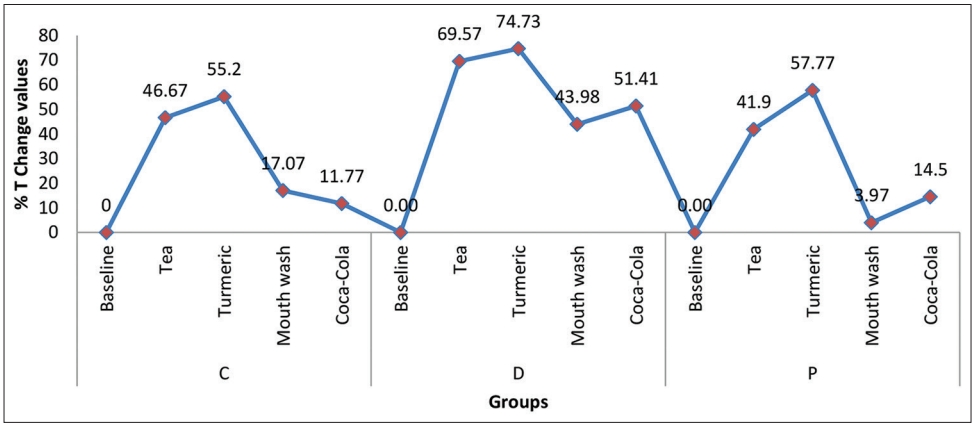
Graph 3: Graphical representation of colour stability of Group P

changes when exposed to various environmental conditions.[5] Studies by Koumjian *et al*.,[4] Yannikakis *et al*.,[6] Scotti *et al*.[7] on color stability of provisional restorative materials have suggested that color stability of these resins is unpredictable over a long period of time with most of the resins showing unacceptable color changes over time.[4,6,7] This study evaluated the color change of three provisional resins (one polymethylmethacylate -DPI and two bis-acryl composite- Cooltemp and Protemp). A total of 48 specimens were prepared and subjected to aging. After aging they were immersed in four staining solutions, tea, turmeric, coca-cola and mouthwash. Color measurements were made at baseline and 21 days after immersion.

Tea and turmeric are identified as some of the staining substances and hence, these staining solutions were used in this study. The main reason for discoloration in tea solutions is tannic acid. Major constituents of turmeric (*Curcuma*) are curcuminoids that cause the yellow stain. The smaller molecular size of curcumin and the water absorption properties have contributed to stronger staining. It appears that the colorant of turmeric is more polar making it more hydrophilic and hence staining.[8] The present research showed a significantly high color change in turmeric for all the three provisional restorative materials.

The specific wavelength (λ) at which there was a drop in the % light transmittance was observed and recorded. Measurements were taken before and after immersion in staining solutions. From the results, we can see that the mean value for % light transmittance in Group C (Cooltemp, bis-acryl composite) was 25.44 before immersion whereas after immersion there was a decrease in the percentage transmittance value in all staining medium. The values decreased to 13.56 for tea, 11.39 for turmeric, 21.09 for mouthwash and 22.44 for coca-cola.

In Group D (DPI, PMMA), light transmittance was 24.32 before immersion whereas after immersion there was a decrease in the percentage transmittance value in all staining medium. The values decreased to 7.40 for tea, 6.15 for turmeric, 13.62 for mouthwash and 11.82 for coca-cola. In Group P (Protemp, bis-acryl composite), light transmittance



Graph 4: Graphical representation of overall colour stability

Figure 8: After immersion in turmeric

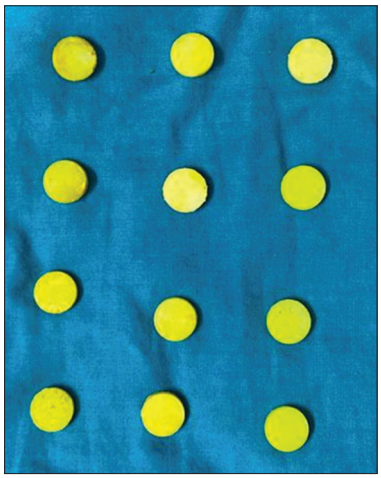


Figure 9: After immersion in tea

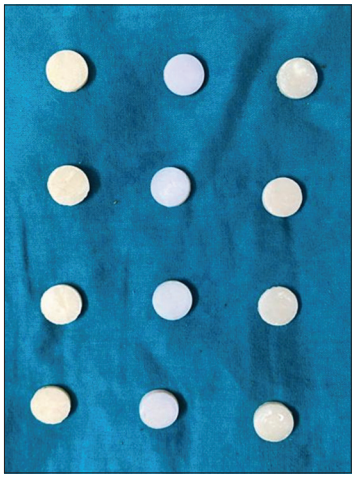


Figure 10: After immersion in mouthwash

was 31.95 before immersion whereas after immersion there was a decrease in the percentage transmittance value in all staining medium. The values decreased to 18.57 for tea, 13.5 for turmeric, 30.68 for mouthwash and 27.32 for coca-cola.

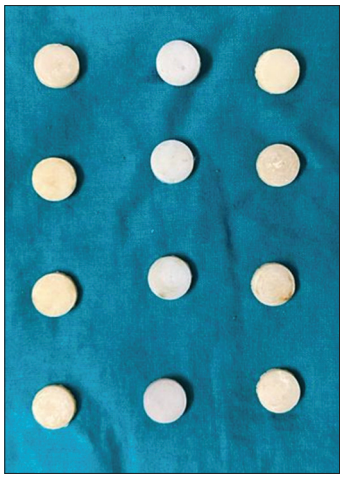


Figure 11: After immersion in Coca Cola

Table 5: Comparison of light transmittance between three groups (Group C, Group D, and Group P) in different immersion media

Immersion media	Material	*n*	Mean	Std. Deviation	F-value	*P*-value
Tea	C	4	13.57	0.55	118.545	<0.001**
	D	4	7.40	1.84		
	P	4	18.57	1.35		
Turmeric	C	4	11.40	1.80	15.378	<0.001**
	D	4	6.15	1.35		
	P	4	13.50	0.94		
Mouth Wash	C	4	21.10	0.48	451.879	<0.001**
	D	4	13.62	0.70		
	P	4	30.68	1.11		
Coco-Cola	C	4	22.45	2.17	71.99	<0.001**
	D	4	11.82	0.61		
	P	4	27.32	2.35		

**Highly significant (P<0.001)

The results of this study showed that there is a statistically significant difference in the value of light transmittance (% T) in all three groups of materials tested before and after immersion. Maximum difference of light transmittance (% T) is seen in Group D (DPI, PMMA). Hence, Group D showed the least color stability whereas Group P (Protemp, bis-acryl composite) showed highest color stability. As far as the staining solutions are concerned, the results reveal that maximum color change was seen after immersion in turmeric followed by tea whereas immersion in coca-cola and mouthwash did not show a significant difference in the color stability (Figures 8-11).

Findings of this study are in agreement with previous reports by some researchers, Doray *et al*., Sham *et al*., Sevimay *et al*., Cevik *et al*., Kotnarin *et al*. have concluded that composite resins have better color stability.[9-13] Following in vitro accelerated aging conditions, Doray *et al*. (1997) and Doray *et al*. (2001) found some resin-based composites (Integrity, Luxatemp, and Protemp Garant) to be as color stable as the acrylic resins tested.[9,14]

The observations from this study and previous research by Crispin and Caputo, Doray *et al*., Yannikakis *et al*., Doray *et al*., Gulera *et al*. showed that the type of staining agent or exposure conditions are major factors that affect color stability of provisional restorative materials.[9,6,14,15] The present study also shows that turmeric tends to stain the specimens more in comparison with tea followed by coca-cola and mouthwash. However, Doray *et al*. (1997, 2001) and Sham *et al* stated that on accelerated aging, exposure to ultraviolet radiation, or immersion in water the composites are more color stable compared to the acrylic resins.[9,10,14] This finding is similar to the findings of the present study.

Conclusion

Color stability of three provisional restorative materials was evaluated after 21 days of immersion in tea, turmeric, coca-cola, and mouthwash. Under the conditions of this study, the following conclusions were drawn:

1. All three provisional restorative materials exhibited statistically significant color change after exposure to staining solutions
2. DPI (PMMA) showed the least color stability in all immersion media followed by Cooltemp and Protemp (bis-acryl composite)
3. With respect to the staining solutions, maximum color change was observed after immersion in turmeric followed by tea, and least change was observed in mouthwash and coca-cola.

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