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Research Article

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Effects of Orange Juice and Tea on Color Stability of Polyetheretherketone, Polymethyl Methacrylate, and A Composite Resin

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Abstract

Objectives: *This study aimed to assess the effects of orange juice and tea on color stability of polyetheretherketone (PEEK), polymethyl methacrylate (PMMA), and a composite resin.*

Materials and Methods: *In this in vitro, experimental study, 45 disc-shaped specimens with 1 mm thickness and 15 mm dimeter were fabricated from PEEK, PMMA and Crea.lign composite resin (n=15 from each). The baseline color parameters of the specimens were measured by a spectrophotometer according to the CIE L*a*b* color space. The specimens were then immersed in orange juice, distilled water and tea at 37°C for 2 h/day for 30 days, and their color parameters were measured again. The color change (ΔE) of specimens was calculated and analyzed using one-way and repeated measures ANOVA and Tukey's test.*

Results: *According to one-way ANOVA, type of restorative material had no significant effect on ΔE (P=0.113) but type of coloring solution significantly affected the ΔE (P<0.001). The interaction effect of type of restorative material and type of solution on ΔE was not significant (P=0.731). Color change of specimens in distilled water and orange juice was < 2.7 and not clinically perceivable; however, ΔE of specimens in tea solution was > 5, and clinically detectable.*

Conclusion: *Within the limitations of this in vitro study, it appears that type of coloring solution has a more prominent effect on color stability than the type of material since the three tested materials showed comparable color stability. Tea can cause clinically detectable color change in all tested materials.*

Keywords: Composite Resins, Color, Polyetheretherketone, Polymethyl Methacrylate, Tea

Introduction

Color change of restorative materials is a common concern particularly in the esthetic zone [1]. Physical and chemical properties of resin, and the nutritional regimen are the main factors that affect the color stability of dental restorative materials [2-4]. The color stability of restorative materials in the oral environment may change following exposure to saliva, and colored foods and drinks, or due to interactions between them [5].

Discoloration of intraoral restorations leads to patient dissatisfaction and can result in treatment failure in the long-term [6]. Despite the recent advances in the formulations of dental restorative materials, their color change still remains a problem [7]. Any color mismatch between intraoral restorations and natural teeth is important and would lead to patient dissatisfaction [8].

Composite resins are increasingly used for tooth-colored restoration of teeth due to their improved physical and chemical properties and excellent esthetics [9]. However, long-term success of composite restorations depends on their color stability [10].

Polymethyl methacrylate (PMMA) is a highly popular polymer in dentistry. It has favorable properties such as optimal biocompatibility, reliability, easy use, low toxicity, light conduction, and adequate hardness [11].

Polyetheretherketone (PEEK) has been suggested as an alternative to composite resins [12]. This polymer has favorable properties such as higher strength and hardness, better polishability, higher color stability, and lower water sorption than composite resins [13].

PMMA, PEEK and composite resins are commonly used for intraoral restorations [14]. Many studies have assessed the color stability of dental restorative materials [15-25]. However, information regarding the color stability of the abovementioned three restorative materials is limited and controversial. Considering the significance of this topic, this study aimed to assess the effect of colored drinks on color stability of PEEK, PMMA, and Crea.lign composite resin.

Materials and Methods

This in vitro, experimental study evaluated 45 disc-shaped specimens with 1 mm thickness and 15 mm dimeter fabricated from PEEK (BrecAM. BiOHPP-98 mm 20 mm AG; A2-Bredent Co., Senden, Germany), PMMA (Ceramill TEMP-A2-71L 20 mm, Amann Girrbach AG, Germany) and Crea.lign composite resin paste (Dentin A2; Bredent GmbH Co., Senden, Germany) (n=15 from each) [19,21,22,24,26].

According to ISO4049, a minimum of 3 specimens should be fabricated from each material [26]. The minimum sample size was calculated to be 4 according to a previous study assuming $\alpha = 0.05$, $\beta = 0.2$, color change (ΔE) = 1.1, and effect size of 0.83 using one-way ANOVA Power Analysis feature of PASS 11 software [21]. To increase the study power, 5 specimens were fabricated for each group (a total of 15 from each material).

Table 1: Properties of the three materials used in this study

Material	Abbrev.	Type	Manufacturer	Composition	Ref	Lot	Filler %
Biohpp A2	PEEK	Blank	Bredent, Senden, Germany	Ceramic fillers-partially crystalline	54002121	463034	20
Ceramill A2	PMMA	Blank	GmbH- Germany-Amann Girrbach	Polymethyl methacrylate Cross link	760323	50915	-
Crea.lign A2	COMP	PASTE	Bredent, Senden, Germany	Nano filled ceramic -bis-GMA	CLFNDA30	N173893	60

PEEK and PMMA blanks were obtained and sectioned into disc-shaped specimens by a computer-aided design/computer-aided manufacturing (CAD/CAM) machine (Ceramill MAP 400; Amann Girrbach AG, Germany). Next, the specimens were polished with 1000- and 2000-grit abrasive papers and cleaned with compressed air [22]. The dimensions of the specimens were then measured by a digital caliper with 0.01 mm accuracy (MAX150; Hogetex, Netherlands) [26]. According to ISO4049, the diameter of specimens should not be smaller than 14.8 mm.

For the fabrication of composite specimens, disc-shaped silicone molds measuring 15 mm in diameter and 1 mm in depth were obtained [26]. Composite resin was applied into the molds. Pressure was applied in order for the excess material to leak out and to eliminate voids [24]. It was then light-cured with a curing unit (Labo Light LV-III, GC, Japan) with 120 W power, 440 to 480 nm wavelength, and 1500 mW/cm^2 light intensity for 40 s [21]. The specimens were then removed from the molds and polished with 2000-grit abrasive paper [25]. The specimens were cleaned with compressed air, and their dimensions were measured by a digital caliper with 0.01 mm accuracy [26].

Next, the baseline color parameters of the specimens were measured by a spectrophotometer (CI6XNB380; X-Rite Incorporated, USA) in D65 lighting condition at 380-780 nm wavelength. The CIE L*a*b* color parameters were measured and recorded [19,21,22,24,26].

To prepare the tea solution, one tea bag (Doghazal, Iran) was placed in 200 mL of distilled water at boiling temperature (100°C) for 1 min. After removing the tea bag, the volume of the solution was reached to 200 mL and it was cooled down to 37°C [24]. Also, 200 mL of orange juice (San Itch, Iran) and 200 mL of pure distilled water (Teb Shimi, Iran) were used [21,23].

Of 15 PMMA specimens, 5 were immersed in distilled water, 5 were immersed in tea, and 5 were immersed in orange juice at 37°C for 2 h/day for 1 month. Each day, the specimens were removed from the solutions after 2 h of immersion, rinsed under running water for 10 s, and were then stored in distilled water at room temperature until the next day. The solutions were refreshed daily [21,23,24]. The same was performed for composite resin and PEEK specimens.

After the completion of 1-month period, the specimens were removed from the coloring solutions, rinsed under running water for 10 s, and dried. Their color parameters were measured again by the same spectrophotometer, and ΔE was calculated using the formula below:

$$\Delta E = \sqrt{(\Delta l)^2 + (\Delta a)^2 \ (\Delta b)^2}$$

Data were analyzed using one-way ANOVA, repeated measures ANOVA, and Tukey's test at 0.05 level of significance.

Results

Table 2 shows the mean ΔE of PEEK, PMMA, and composite resin following immersion in the three solutions. According to one-way ANOVA, type of restorative material had no significant effect on

ΔE (P=0.113) but type of coloring solution significantly affected the ΔE (P<0.001). The interaction effect of type of restorative material and type of solution on ΔE was not significant (P=0.731).

According to Tukey's test (Table 3), distilled water and orange juice had no significant difference regarding ΔE of specimens (P=0.140). However, orange juice and tea (P<0.001), and distilled water and tea (P<0.001) were significantly different in this respect, and tea caused significantly greater ΔE. Overall, the ΔE was 0.75 in distilled water, 1.4 in orange juice, and 6.4 in tea.

Table 2: Mean ΔE of PEEK, PMMA, and composite resin following immersion in the three solutions (n=5)

Media	Material	Minimum	Maximum	Mean	Std. Deviation
Water	Composite	0.85	1.50	1.1400	0.27185
	PEEK	0.59	1.05	0.8320	0.19728
	PMMA	0.18	0.46	0.2900	0.10909
Tea	Composite	5.34	7.28	6.2300	0.78093
	PEEK	5.33	11.16	6.9240	2.44395
	PMMA	5.04	7.16	6.1920	0.80992
Juice	Composite	1.44	2.01	1.7160	0.24234
	PEEK	1.35	2.02	1.6040	0.27135
	PMMA	0.80	0.97	0.8900	0.08276

Table 3: Pairwise comparisons of coloring solutions regarding ΔE by the Tukey's test

					95% Confidence Interval	
(I) media		Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
Water	Tea	-5.6947*	0.33339	0.000	-6.5096	-4.8798
	Juice	-0.6493	0.33339	0.140	-1.4642	0.1656
Tea	Water	5.6947*	0.33339	0.000	4.8798	6.5096
	Juice	5.0453*	0.33339	0.000	4.2304	5.8602
Juice	Water	0.6493	0.33339	0.140	-0.1656	1.4642
	Tea	-5.0453*	0.33339	0.000	-5.8602	-4.2304

Discussion

This study assessed the effect of colored drinks on color stability of PEEK, PMMA, and a composite resin. The results showed that the mean ΔE of the three restorative materials was not significantly different (P=0.113). However, the three media had a significant difference with regard to ΔE (P<0.001). Orange juice and distilled water were not significantly different in this respect but tea caused significantly greater color change than the other two solutions. ΔE was < 5 in distilled water and orange juice, and was not clinically perceivable. However, immersion in tea caused a ΔE > 5 which was clinically detectable.

Gujjari, et al. evaluated the color stability of PMMA and acrylic-based composite exposed to tea, coffee, and cola [24]. They showed significantly higher color stability of PMMA than acrylic-based composite. The maximum color change of resins occurred in artificial saliva + coffee followed by tea + artificial saliva. After 7 days of immersion in artificial saliva + tea solution, ΔE was 3.99 for PMMA and 4.56 for composite resin. In the present study, the three tested materials were not significantly different regarding ΔE, which is different from the results of Gujjari, et al [24]. This difference in the results can be due to different immersion times of specimens in the solutions and type of materials. Also, in the present study, the specimens were evaluated after 1 month while they assessed the specimens after 3 and 7 days. The mean ΔE of materials after 1 month ranged from 6.19 to 6.92 in the present study while it was in the range of 3.99 to 4.56 after 7 days in their study.

Color change following exposure to tea is probably due to the absorption of stains present in tea solution into the surface of resin materials [27,28]. Mazaro, et al. assessed the color stability of temporary restorative materials (acrylic resin and acrylic-based resin) in artificial saliva, artificial saliva + cola, and artificial saliva + coffee [22]. Acrylic resin samples experienced greater color change than acrylic-based resins. Coffee caused maximum discoloration. As the immersion time increased, the color change of all temporary restorative materials increased as well. Previous studies have reported relatively high discoloration potential of acrylic-based resins following exposure to pigmented compounds [29,30]. Haselton, et al. [1] demonstrated that PMMA-based materials had lower capacity of liquid sorption due to their more uniform structure. However, coloring solutions can penetrate in-between tiny particles due to non-homogenous structure of acrylic-based resins and cause their faster and greater discoloration. In the present study, the minimum color change in all solutions occurred in PMMA (although not significant), which is in line with previous results [1]. Arregui, et al. evaluated the ΔE and water sorption of 9 different flowable composite resins after 6 months of storage [20]. Red wine caused maximum color change. They also showed that water sorption was related to color change of composite resins. They reported a ΔE in the range of 7.9 to 40 after 4 weeks of immersion in tea solution; this value was 6.23 for composite resin in the present study. The ΔE after 4 weeks of immersion in orange juice was 3.42 to 11.5 in their study while this value was 1.71 in the present study. These values highlight the considerable difference in stainability of flowable and conventional composite resins. However, both studies demonstrated higher color change due to immersion in tea compared with orange juice. The ΔE>3.3 is considered clinically unacceptable; all specimens immersed in distilled water and orange juice in the present study showed a ΔE < 3.3, which was clinically acceptable while all specimens immersed in tea showed a ΔE > 5 which was clinically unacceptable. Thus, irrespective of the type of material, exposure of restorations to tea for 2 h/day for 1 month can cause severe discoloration [20]. Poggio, et al. evaluated the color change of four types of composite resins in coffee, red wine and cola and found no significant difference between different composite types [31]. However, they showed that coffee caused significant color change of all four types of composite resins. Their results were in agreement with our findings. Evidence indicates that composite resins absorb water and other pigmented fluids, causing their discoloration. Water can serve as a carrier for pigments, delivering them into the resin matrix [32].

Heimer, et al. evaluated the color change of PEEK, PMMA and a composite resin in distilled water, curry solution, red wine and chlorhexidine. The minimum ΔE was recorded for specimens immersed in distilled water and chlorhexidine while the maximum ΔE was recorded following exposure to curry solution. PEEK experienced significantly lower color change while composite showed maximum color change. Color change of materials was significantly different in their study while this difference was not significant in the present study [19]. This controversy between the results of the two studies can be due to the duration of immersion of specimens in solutions, and different types of coloring solutions. Gawriołek, et al. compared the color change of six types of composite resins and dental compomers following exposure to coloring solutions [16]. The maximum color change in the majority of specimens occurred in tea and coffee, especially in combination with sugar. Their results regarding the high staining potential of tea were in agreement with our findings. Assaf, et al. compared the color stability of three resin-based restorative materials following immersion in coloring solutions for 0, 3, 30, 45, 60 and 75 days [17]. The results revealed a significant difference in color change of composite resins after 75 days. Coffee caused the maximum color change. Their results highlighted the susceptibility of composite resins to discoloration, which was in accordance with our findings. Liebermann, et al. evaluated the effect of coloring solutions, duration of storage, and temperature on color stability of three CAD/CAM restorative materials [18]. They showed higher discoloration following 7 days of storage compared with 1 day. Higher ΔE values were recorded following storage in curry solution, followed by red wine, and distilled water. Lava Ultimate composite resin showed higher ΔE than Vita Enamic resin ceramic and IPS Empress CAD leucite ceramic. Specimens immersed in solutions at 37°C showed significantly lower color change than those stored at 55°C. The restorative materials, coloring solutions, and duration of storage in their study were different from ours; however, they showed greater discoloration following an increase in exposure time.

This study had an in vitro design. Thus, the results should be generalized to the clinical setting with caution. Future studies are required to compare the effects of other colored drinks such as cola, coffee and energy drinks on color stability of different types of commonly used dental restorative materials. The effect of time on discoloration should also be assessed in studies with longer follow-ups. Moreover, clinical trials are required to confirm the results of in vitro studies.

Conclusion

Within the limitations of this in vitro study, it appears that type of coloring solution has a more prominent effect on color stability than the type of material since the three tested materials showed comparable color stability. Tea can cause clinically detectable color change in all tested materials.

References

1. Haselton DR, Diaz-Arnold AM, Dawson DV (2005) Color stability of provisional crown and fixed partial denture resins. The Journal of prosthetic dentistry 93: 70-75.
2. Hachiya Y, Iwaku M, Hosoda H, Fusayama T (1984) Relation of finish to discoloration of composite resins. The Journal of prosthetic dentistry 52: 811-814.
3. Şen D, Göller G, İşsever H (2002) The effect of two polishing pastes on the surface roughness of bis-acryl composite and methacrylate-based resins. The Journal of prosthetic dentistry 88: 527-532.
4. Maalhagh-Fard A, Wagner WC, Pink FE, Neme AM (2003) Evaluation of surface finish and polish of eight provisional restorative materials using acrylic bur and abrasive disk with and without pumice. Operative dentistry 28: 734-739.
5. Nejatidanesh F, Momeni G, Savabi O (2009) Flexural strength of interim resin materials for fixed prosthodontics. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry 18: 507-511.
6. Ghavam M, Pourhaghighi M, Mohammadi M (2001) Color stability of IDM composite resin. Journal of Dental Medicine 13: 5-11.
7. Hasani-Tabatabaei M, Yassini E, Moradian S, Elmamooz N (2009) Color stability of dental composite materials after exposure to staining solutions: a spectrophotometer analysis. Majallah i Dandanpizishki (Journal of Islamic Dental Associ-

ation of Iran) 21: Pe69-78.
8. Browning WD (2003) Use of shade guides for color measurement in tooth-bleaching studies. Journal of Esthetic and Restorative Dentistry 15: S13-20.
9. Fontes ST, Fernández MR, Moura CM, Meireles SS (2009) Color stability of a nanofill composite: effect of different immersion media. Journal of Applied Oral Science 17: 388-391.
10. Villalta P, Lu H, Okte Z, Garcia-Godoy F, Powers JM (2006) Effects of staining and bleaching on color change of dental composite resins. The Journal of prosthetic dentistry 95: 137-142.
11. Frazer RQ, Byron RT, Osborne PB, West KP (2005) PMMA: an essential material in medicine and dentistry. Journal of long-term effects of medical implants 15: 629-639.
12. Najeeb S, Zafar MS, Khurshid Z, Siddiqui F (2016) Applications of polyetheretherketone (PEEK) in oral implantology and prosthodontics. Journal of prosthodontic research 60: 12-19.
13. Rothmund L, Shehata M, Van Landuyt KL, Schweikl H, Carell T, et al. (2015) Release and protein binding of components from resin based composites in native saliva and other extraction media. Dental Materials 31: 496-504.
14. Maldonado-Naranjo AL, Healy AT, Kalfas IH (2015) Polyetheretherketone (PEEK) intervertebral cage as a cause of chronic systemic allergy: a case report. The Spine Journal 15: e1-3.
15. Available from: https://www.ARAdPolymer.com/ PEEK.
16. Gawriołek M, Gawriołek K, Eliasz W, Czarnecka B, Paszynska E, et al. (2020) How Does the Color of Restorative Material Change during Exposure to Dietary Liquids Due to the Acquisition of a Discolored Layer?. Coatings 10: 866.
17. Assaf C, Abou Samra P, Nahas P (2020) Discoloration of Resin Composites Induced by Coffee and Tomato Sauce and Subjected to Surface Polishing: An In Vitro Study. Medical Science Monitor Basic Research 26: e923279-1.
18. Liebermann A, Vehling D, Eichberger M, Stawarczyk B (2019) Impact of storage media and temperature on color stability of tooth-colored CAD/CAM materials for final restorations. Journal of applied biomaterials & functional materials 17: 2280800019836832.
19. Heimer S, Schmidlin PR, Stawarczyk B (2017) Discoloration of PMMA, composite, and PEEK. Clinical oral investigations 21: 1191-200.
20. Arregui M, Giner L, Ferrari M, Valles M, Mercadé M (2016) Six-month color change and water sorption of 9 new-generation flowable composites in 6 staining solutions. Brazilian oral research 30: e123.
21. HashemiKamangar SS, Yazdanpanah F, Dehaky MG, Kharazifard MJ (2015) The Color Stability of Silorane-based Versus Methacrylate-based Composites after Immersion in 100% Orange Juice and Nonalcoholic Beer 6: 2.
22. Mazaro JV, Minani LM, Zavanelli AC, Mello CC, Lemos CA (2015) Evaluation of color stability of different temporary restorative materials. Revista de Odontologia da UNESP 44: 262-267.
23. Sagsoz NP, Yanıkoglu N, Ulu H, Bayındır F (2014) Color changes of polyamid and polymetyhl methacrylate denture base materials. Open Journal of Stomatology 4: 489-496.
24. Gujjari AK, Bhatnagar VM, Basavaraju RM (2013) Color stability and flexural strength of poly (methyl methacrylate) and bis-acrylic composite based provisional crown and bridge auto-polymerizing resins exposed to beverages and food dye: an in vitro study. Indian Journal of Dental Research 24: 172-177.
25. Guler AU, Yilmaz F, Kulunk T, Guler E, Kurt S (2005) Effects of different drinks on stainability of resin composite provisional restorative materials. The Journal of prosthetic dentistry 94: 118-124.
26. Available from: https://www.iso.org/standard/67596.html.
27. Ergün G, Mutlu-Sagesen L, ÖZKAN Y, Demirel E (2005) In vitro color stability of provisional crown and bridge restoration materials. Dental materials journal 24: 342-350.
28. Um CM, Ruyter IE (1991) Staining of resin-based veneering materials with coffee and tea. Quintessence Int 22: 377-386.
29. Rutkunas V, Sabaliauskas V, Mizutani H (2010) Effects of different food colorants and polishing techniques on color stability of provisional prosthetic materials. Dental materials journal 29: 167-176.
30. Nejatidanesh F, Lotfi HR, Savabi O (2006) Marginal accuracy of interim restorations fabricated from four interim autopolymerizing resins. The Journal of prosthetic dentistry 95: 364-367.
31. Poggio C, Ceci M, Beltrami R, Mirando M, Wassim J, et al. (2016) Color stability of esthetic restorative materials: a spectrophotometric analysis. Acta biomaterialia odontologica Scandinavica 2: 95-101.
32. Satou N, Khan AM, Matsumae I, Satou J, Shintani H (1989) In vitro color change of composite-based resins. Dental Materials 5: 384-387.