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Original Research Article

Effect of Toothbrushing on Color Changes of Esthetic Restorative Materials

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Abstract

Purpose: The aim of this study was to evaluate the effects of various drinks and toothbrushing on the color changes of esthetic restorative materials used in dentistry. ***Materials and Methods:*** Forty specimens were prepared from each of four restorative materials (nano-hybrid composite [IPS EMPRESS Direct ivoclar] composite resin [Tetric N-Ceram Bulk Fill,ivoclar], glass ionomer cement [Vivaglass CEM PL ivoclar], composite resin [Tetric N-Ceram cavifil,ivoclar]). Specimens were divided into four groups for immersion in five different staining solutions (cola, chocolate milk, coffee, 7up and cherry juice). Each group was subdivided into brushing and non-brushing groups. The specimens in the brushing subgroups were brushed with toothpaste once a day using toothbrush. Color was measured using a Digital Shade Matching System DSMS, and color changes were calculated between baseline and 21 days, 1, 2, 3, 4, 5, 6 months. ***Results:*** All the solutions evaluated yielded color changes after 21 days, and these changes were significantly greater for glass ionomer cement than IPSS EMPRESS, composite bulkfill and composite resin ($p < 0.006$). Brushing no significantly difference for the color changes of restorative materials ($p > 0.004$). ***Conclusion:*** Chance for staining the esthetic restorative materials in a short period is low except GIC, and the brushing has no significant effect to prevent any discoloration for the esthetic restorations in a short period approximate one month.

Keywords: toothbrushing, Restorative Materials, IPSS EMPRESS.

CLINICAL SIGNIFICANCE

The color stability values after brushing may better reflect the discoloration of the esthetic restorative materials. Any color stability study model should consider the effects of toothbrushing that can remove the adsorbed colorants. The results of this study until now (after 21 days) also showed that IPSS EMPRESS, composite bulkfill and composite resin can be used in anterior restorations with their higher color stability than GIC restoration.

INTRODUCTION

In today's society, both adults and children are conscious of appearances, particularly smiles, and many patients now choose esthetic restoration of the anterior segment of the dental arch [1]. A variety of esthetic materials are available in esthetic dentistry, including nano-hybrid composite, glass ionomer cements (GICs), and composite resins. Composite resins were first introduced around 1970 and since then have been used principally for direct esthetic restorations in both anterior and posterior regions [2]. Glass ionomer restorations have recently become very popular in clinical dentistry due to favorable properties such as fluoride release and adhesion to tooth structure; however, GICs are technique sensitive in their application and sensitive to degradation by organic acids from dental plaque and food intake [3-6]. Nano-hybrid composite came to provide restorations that fulfill the highest esthetic demands.

Staining is a problem common to all these materials after long-term use [7, 9]. Both intrinsic and extrinsic factors may be implicated in the discoloration of restorative materials [8, 9]. Intrinsic factors include discoloration of the resin material itself caused by alterations in the resin matrix and the interface between matrix and filler [8, 10].

Extrinsic factors of discoloration include staining by adsorption or absorption of colorants as a result of contamination from exogenous sources such as

colored drinks [8, 9, 11]. The oral environment is daily exposed to a variety of media that have the potential to stain or otherwise alter the surfaces of dental restorations, thereby causing esthetic degradation. For this reason, it is important to understand how long-term daily exposure to common beverages can alter the color of restorative material and whether or not this change is perceptible to the human eye [1-6]. To evaluate color changes of tooth-colored restorative materials A Digital Dental Shade Guide Machine(DDSGM) can be used, DDSGM can take the measurements using the Commission International de I'Eclairage (CIE) L*a*b* system, that will helps to gets the color change (ΔE), even its lower than 1.5; however, this rate cannot be detected by the human eye. Researchers considered that ΔE values below 3.3 is not perceptible to the human eye and can be accepted clinically [26]. Color changes (ΔE) defined by The Glossary of Prosthodontic Terms; total color difference computed by use of a color difference equation.[13]

Studies performed on enamel showed that some extrinsic stains can be removed partially or totally by means of toothbrushing with dentifrice [12]. Therefore, this study aimed to assess over a 6 months' period the effects of several common beverages and toothbrushing on the surface staining of esthetic dental restorative materials used in dentistry.

The null hypothesis tested in this study was that there are no differences among three different solutions on color stability of three different tooth colored materials and that toothbrushing would not affect the stainability of these restorative materials.

MATERIALS AND METHODS

This study was conducted using four restorative materials (nano-hybrid composite shade Enamel A1 [IPS EMPRESS Direct ivoclar] composite resin [Tetric N-Ceram Bulk Fill,ivoclar], glass ionomer cement [Vivaglass CEM PL ivoclar], composite resin [Tetric N-Ceram cavifil,ivoclar]) (Table-1) and five solutions (cola [C], chocolate milk [N], coffee [F],7up [U] and cherry juice [CJ]) (Table-2).

Table-1: Restorative materials used in the study

Product	Material type	Mixing	Curing	Manufacture
IPS EMPRESS Direct	Nano-hybrid composite	N/A	Light-cure for 20 seconds	Ivoclar Vivadent AG FL-9494 Schaan/ Liechtenstein
Tetric N-Ceram Bulk Fill	Composite resin	N/A	Light-cure for 20 seconds	Ivoclar Vivadent AG FL-9494 Schaan/ Liechtenstein
Vivaglass CEM PL	Glass ionomer cement	30 seconds with a mixer	Working and curing time 6-8 minutes	Ivoclar Vivadent AG FL-9494 Schaan/ Liechtenstein
[Tetric N-Ceram cavifil	Composite resin	N/A	Light-cure for 20 seconds	Ivoclar Vivadent AG FL-9494 Schaan/ Liechtenstein

Table-2: Media used in the study

Product	Material type	Manufacture	PH
Cola	Soft drink	The Coca-Cola Co, KSA	2.4
Chocolate milk	Milk	Nesquik, Nestle, Bursa,Türkiye	
Coffee	Solvents coffee	Nescafe,Nestle,Araras,Brazil	
7up	Soft drink	7up,The Jomaih Drinks Factory,Riyadh,KSA	
Cherry juice	Fruit juice	Tono,Arrow juice Co,Jeddah,KSA	6.4

According to the manufacturer's instructions for all the tested materials; the GIC was allowed to set for 8 minutes at room temperature, while the other restorative materials were polymerized using a LED unit (Freelight 2 Elipar, 1,200 mw/cm2, 3M ESPE, Ireland) for 20 seconds. Specimens were polished with a polishing kit (Astrobol, Ivoclar Vivadent AG FL-9494 Schaan/ Liechtenstein) with an electric handpiece at 15,000 rpm for each unit (small flame, large flame, cup and disk). All specimens were hydrated in 37°C distilled water for 24 hours.

Baseline color data were obtained after the specimens preparation, and the specimens were distributed into five groups (N = 8) for immersion in one of the five solutions. Each group was also subdivided into brushing and non-brushing subgroups (N = 4). Specimens were immersed in solutions for 3 hours per day at room temperature over a 6 -months test period and replaced in distilled water following immersion with controlled temperature (37°C) using A Water path machine.

The specimens in the brushing subgroups were also brushed with toothpaste (Colgate optic white, Dazzling mint, Fabrique Group, Poland) once a day using a manual toothbrush (Braun Oral-B Plak Control Ultra) for 5 seconds to each surface. Prior to color measurement, specimens were drained of liquid, lightly rinsed with distilled water, and dried with paper tissue.

Color was measured using A Digital dental shade guide machine (Vita Easushade Advance 4.0, North America) Color changes (ΔE) were calculated between baseline color measurements and measurements made after 21 days, 1st , 2nd , 3rd , 4th , 5th and 6th months.

Measurements were taken using the Commission International de I'Eclairage (CIE) L*a*b*system. ΔE was calculated using the following equation:

$$\Delta E^*_{ab} = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2}$$

1,2

Data were analyzed using the statistical software SPSS for Windows, Version 12.0.1 (SPSS Inc., Chicago, IL, USA). Thus, data did not meet the preconditions for variance analysis, nonparametric tests were used to analyze the data. When there are two groups to compare, Mann–Whitney *U* or Wilcoxon tests were used. The dependent two groups were analyzed using Wilcoxon Signed Rank test. When groups were more than two, Kruskal–Wallis test was used. To determine which group differences accounted for significant differences, multiple comparisons with Bonferroni's correction were performed. A value of $p < 0.008$ was considered statistically significant in identifying differences in staining capacity of the test solutions (according to the Bonferroni correction), whereas a value of $p < 0.004$ was considered significant in identifying the effects of brushing on specimen color, and a value of $p < 0.006$ was considered significant in identifying differences in the amount of color change according to the restorative materials tested.

RESULTS

Now in this paper we will present the current result of our research that contributed by the 1st reading which came after 21 days of starting this research.

For all groups, the mean color differences (ΔE) and standard deviations are represented for differences between the restorative materials in Table 3 & 4, for differences between brushing or non-brushing groups in Table-5, for differences between solutions in Table-6. The data with the superscript symbol (*) in the table demonstrated statistically significant differences.

Table-3: The mean ΔE values and standard deviations for the restorative material (Anova test)

Restorative Material	Mean	Std. Deviation	
IPSS	8.5089	±3.93260	0.024*
Comp Hybrid	8.3186	±3.67633	
Comp Bulkfi	10.0300	±7.54583	
GICs	16.7098	±9.48751	

Table-4: The mean ΔE values and standard deviations between the restorative material (Turkey post Hoc)

(I) Restorative Material	(J) Restorative Material	Sig.
IPSS	Comp Hybrid	1.000
	Comp Bulkfi	0.955
	GICs	0.042*
Comp Hybrid	IPSS	1.000
	Comp Bulkfi	0.938
	GICs	0.036*
Comp Bulkfi	IPSS	0.955
	Comp Hybrid	0.938
	GICs	0.129
GICs	IPSS	0.042*
	Comp Hybrid	0.036*
	Comp Bulkfi	0.129

Table-3 shows the data processed with Anova test, with no significant difference between the restorative material. Table-4 shows the data processed with Turkey post Hoc with significant difference between the GICs when compare with the IPSS and the Composite hybrid materials.

Table-5: The mean ΔE values and standard for differences between brushing or non-brushing groups (indep t-test)

Brushing	Mean	Std. Deviation	
No	11.8551	±6.53695	0.408
Yes	9.9286	±7.95809	

Table-5 shows the data of the brushing and non-brushing groups processed with indep t-test with no significant difference between the two compared groups.

Table-6: The mean ΔE values and standard deviations for diff erences between solutions (Anova test)

Immersion media	Mean	Std. Deviation	Std. Error
Cola	8.5538	±5.90243	0.147
7up	14.5334	±10.35500	
Cherry	12.5083	±7.84321	
Coffea	12.4829	±5.01187	
Nesquik	6.3809	±3.73505	

Table-6 shows the data when compare the solutions by Anova test with no significant difference between the whole groups.

DISCUSSION

The results of this study showed the null hypothesis that different solutions and toothbrushing would not affect the stain susceptibility of tooth-colored restorative materials were accepted until now.

A Digital dental shade guide machine has been used to measure color change in dental materials. For this study, the CIE L*a*b* system was chosen because of its ability to detect small differences in color [5, 14], although color changes of less than 3.3 are considered clinically insignificant [4, 5].

In contrast to previous studies [9, 10, 15], the specimens in the present study did not remain in continuous contact with the staining solutions tested, but similar to Nasim and colleagues [16] the specimens were immersed in either of the beverages for 3 hours per day, and then immersed in distilled water for the rest of the day in order to more closely replicate the actual clinical situations.

Regardless of the cavity class and location, polishing of tooth-colored restorations, which enhance both esthetics and longevity of restorations, is an essential step in restorative dentistry [17]. In this study, to mimic clinical situations, polishing was done with a polishing kit (Astrobol, Ivoclar Vivadent AG FL-9494 Schaan/ Liechtenstein), The surface texture of a tooth-colored restoration influences the stain resistance of the restoration which can be affected by polishing [18, 19]. In a recent study, Erdemir and colleagues [20] showed that composite produced the smoothest surface after being polished with Sof-Lex whereas GIC produced the roughest surface. This study did not investigate surface roughness, however, after standard polishing procedure for all materials tested; GIC, which may have a rough surface, showed higher staining than the other materials.

The staining potential of liquids varies according to their composition, pH, and other characteristics [6, 21, 22]. In the present study until now, all materials were not discolored by all staining agents tested except the GICs, unlike the other previous researches. A study by Bagheri and colleagues [6] found the cola, despite its low pH, have less staining capacity than other agents. However, a study by Tunç and colleagues [23] examining the staining potential of Nesquik, grape juice and cola found cola to cause greater staining of esthetic restorative materials than Nesquik and grape juice.

A study by Bezgin colleagues [24] found that distilled water chosen for negative control group produced color differences perceptible to the human eye on the first and 60-day examinations which did not differ from other solutions used. Several studies have been performed to assess the effect of water on color change of esthetic restorative materials [25-29]. Similar to this study, these studies have demonstrated statistically significant differences between baseline and post-immersion color values. Color changes at 24 hours could be attributed to the post-irradiation polymerization reaction that lasts for up to 24 hours [28, 29]; whereas changes after long-term immersion could be attributed to hygroscopic absorption of water in the material [25, 26, 28]. Buchalla and colleagues [28] stated that changes in optical properties of the material due to water absorption could have been responsible for the different values of ΔE.

Previous studies have shown that fluoride-releasing materials have a greater ion release when submitted to pH variations that could lead to lower color stability when compared to composite resins [30, 31]. In the present study, the acidic media used (cola and cherry juice) caused greater staining of GIC when compared to the other used restorative materials.

Differences in color stability among restorative materials can be ascribed to the constituents (water and amount of fillers) and water sorption [4, 5, 14]. Restorative materials capable of absorbing water may also be capable of absorbing other fluids that can result in discoloration [6, 10]. It has previously been suggested that conventional GICs are less susceptible to staining because their high water content allows them to absorb less water [6]. Conversely, it has also been suggested that hydrophilic materials such as GIC are more susceptible to staining than hydrophobic materials such as composite resin [1, 11, 15]. In the present study, GIC showed the greatest susceptibility to staining, whereas the difference in the susceptibility of IPSS and composite resines was not statistically significant.

Surface conditions of the restorative materials are another determining factor in color stability. Fine colorant particles may be deposited into the pits of restorative materials. This discoloration caused by

surface adsorption may be prevented by toothbrushing [4, 5, 14]. In this study, it was assumed that brushing the specimens inhibited the adsorption of colorants onto the surface of the restorative materials and decreased the amount of color change over time. For example, composite resin showed the most color change after 1 day and the least color change after 60 days in the brushing group, whereas in the non-brushing group, it showed the least color change after 1 day and the most color change after 60 days. Short-term discoloration caused by toothbrushing can be attributed to surface irregularities caused by toothbrush which was decreased over time [32].

Studies performed on enamel showed that some extrinsic stains can be removed partially or totally by means of toothbrushing with dentifrice [12]. Bagheri and colleagues [6] have suggested that unlike in vitro conditions, actual staining in the oral cavity would be influenced by the intermittent nature of stain exposure, the dilution of staining media by saliva and other fluids and the polishing of restorations through toothbrushing. In line with this suggestion, Um and Ruyter [26] concluded that regular brushing can reduce or even prevent coffee and tea from staining resin-based veneering materials. In the present study no significant difference until now either between brushing and non-brushing groups, or between the immersion media groups, justify that may be the materials with its good quality which needs a long time to be stained, where our current result (21 days) consider a short time, and our research supposed to be continued for a six month.

CONCLUSION

Chance for staining the esthetic restorative materials in a short period is low except GIC, and the brushing has no significant effect to prevent any discoloration for the esthetic restorations in a short period approximate one month.

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