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Full Length Research Paper

In vitro study of staining agents effects on optical properties of esthetic restorative materials

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The authors have studied the effect of four staining agents on the optical properties of esthetic restorative materials through translucency tests. Two commercial brands of composite resins were used: Point 4 (Kerr) and Charisma (Heraeus-Kulzer). The liquids tested were: wine, cola, chlorhexidine solution and nicotine solution. The translucency was measured at different periods of time: P_0 – before immersion (baseline), P_1 - 1 h after immersion, P_2 - 2 h after immersion and successively, P_3 – 24 h after immersion up to a period of 7 weeks. ANOVA statistical analysis was applied to the data ($p < 0.05$). The results lead to the following conclusions: (1) Composite resins submitted to the tested immersion mediums were stained, (2) the lower percentage of translucency was observed for nicotine containing solution, (3) The percentage of translucency decreased with the period of immersion.

Key words: Composite resin, dental materials, translucence.

INTRODUCTION

Clinical relevance

Staining may compromise the required esthetic results of resin composite restorations and thereby interfere with the longevity of the restorations.

In recent days, composite resins associated with adhesive systems are commonly used on a day-to-day practice in esthetic restorative dentistry. According to Dinelli et al. (1994), a restorative material for anterior teeth should be considered, not only for its biological properties, but for its esthetical properties as well. These properties are configured as decisive elements in the context of selective criteria for restorations in which this type of material is used. Regarding this opinion, Khokhar et al. (1991) emphasized that patients considered esthetics as a major factor for personal appearance. Whereas the need for a material which matches the natural appearance of teeth has become extremely important Powers et al. (1980).

Composite resins have been frequently modified in their composition in the past years, because of technological improvements. These improvements lead to advances in the esthetic and optical properties, surface texture and integrity, lower sorption of dye solutions and higher resistance to staining of composite resins.

Literature has mentioned a great number of immersion mediums in laboratory tests, aiming to assess resistance to staining of esthetic materials (Asmussen, 1981; Dinelli et al., 1996; Khokhar et al., 1991). Some products, such as tea, coffee, nicotine solution, cola, soy sauce, wine,

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Table 1. Analysis of variance (ANOVA) of the composite resin translucency percentage.

Variation source	DF	Sum of squares	Mean square	F	Significance
Groups	7	2,198.10	314.01	130.34*	<0.001
	10	4,787.16	478.71	198.71*	<0.001
Periods	70	1,439.45	20.56	8.53*	<0.001
Groups x Periods	352	848.00	2.41		
Residue	439	9,272.71			
Total					

*Significant values ($p < 0.05$).

artificial saliva, distilled water; medicines and cigarette smoke were proven to stain teeth and materials (Asmussen, 1981; Dinelli et al., 1996; Khokhar et al., 1991).

Based on this scientific information, the authors decided to study the effect of staining agents on two commercial brands of composite resins, indicated for both anterior and posterior teeth.

MATERIALS AND METHODS

In order to perform this study, two commercial brands of composite resins were used: Point 4 (Kerr Corp., Orange, CA) and Charisma (Heraeus Kulzer, Inc, South Bend, IN).

The composite resins were carefully inserted into a circumferential stainless steel mold with 10 mm of internal diameter and 1 mm of height positioned onto a 0.051 mm thick transparent polyester film strip (Mylar, DuPont, Wilmington, Del.) over a glass slide. Another 0.051 mm thick transparent polyester film strip was applied on top of the metal matrix filled with the composite resin. An additional glass slide was placed over the previously positioned polyester film strip, and a 1 kg weight applied during 1 min. Afterward the weight was removed and the composite resin light-cured for 40 seconds each side (Optilux 501, Kerr Corp, Orange, CA), through the polyester film strip. The output light intensity was continuously monitored with a radiometer (SDS Demetron, Orange, CA) to ensure a constant value of 600 mW/cm^2.

After curing, the specimens were removed from the mold and randomly divided into eight treatment groups (n = 5):

G1 – Point 4 stained with red wine
G2 – Point 4 stained with cola
G3 – Point 4 stained with chlorhexidine
G4 – Point 4 stained with nicotine
G5 – Charisma stained with red wine
G6 – Charisma stained with cola
G7 – Charisma stained with chlorhexidine
G8 **–** Charisma stained with nicotine

The immersion was done 24 h after curing and the observation times were set as follows:

P_0 (baseline) – before immersion (no contact with the solution)
P_1 – 1 h soaked in the solution
P_2 – 2 h soaked in the solution
P_3 **–** 24 h soaked in the solution

After P_4 (1 week), the measurements were made one time for week until periods of 7 weeks were completed. The percentage values of translucency were measured by means Jouan electrophoresis apparatus (series 021A/No. 10, Jouan, Paris, France) (Dinelli et al., 1994, 1996). Specimens were kept into the immersion medium at all times, except during the evaluation. Data were analyzed by two-way analysis of variance (ANOVA) and Tukey's HSD test to identify the significant groups at a p value of 0.05.

RESULTS

The following results correspond to 440 values of the translucency percentage. It was considered two commercial brands of composite resins, four immersion solutions, five replicas for each experimental condition, and the periods of time programmed. The results obtained in the tests are shown in Table 1 for analysis of variance. Observing Table 1, it can be noted that the Group (type of resin composite) was significant, indicating that, regardless the periods considered, at least one of the groups showed an average translucency different from the others.

A Tukey's test was applied to compare averages aiming to identify where the significant differences occurred ($p = 0.91$). Thus, applying the value of the significant minimum difference to the averages in Table 2, it can be evidenced that: For Point 4 (Kerr), the staining capacity of red wine staining was lesser than the staining capacities of cola and nicotine, and similar to that of chlorhexidine. It was evidenced that this resin featured a higher susceptibility to discoloration by nicotine than that shown with cola.

For Charisma (Heraeus Kulzer) composite resin, the staining capacity of red wine staining was higher than the staining capacity of cola and chlorhexidine. Cola and chlorhexidine have shown similar staining effects. For this composite resin, nicotine was the most contaminating agent.

Table 3 showed that the period of staining was also significant. In order to identify which periods showed differences among the averages, Tukey's test was also applied. According to Table 3, the more time of contact the composite resin had with the staining solutions, the lesser translucent it becomes.

Table 2. Tukey's test for translucency averages among groups (%).

Resin	Vinho	Coca-cola	Clorex	Nicotuina
Point 4	61.40b	59.67a	60.54ab	58.14a
Charisma	62.27b	63.58c	63.69c	57.20a

Standard deviation: 1.55, equal letters indicate no difference averages.

Table 3. Translucence averages for different periods of staining (%).

P_0 (Baseline)	P_1 1 h	P_2 2 h	P_3 24 h	P_4 1 w	P_5 2 w	P_6 3 w	P_7 4 w	P_8 5 w	P_9 6 w	P_{10} 7 w
65.30f	65.3 f	64.22fe	63.25e	61.50d	60.62cd	59.95cd	59.95cd	57.90b	56.70ab	55.15a

Standard deviation: 1.55, h = hour, w = week, equal letters indicate no difference averages.

DISCUSSION

Many factors may have an impact on the alteration of optical and esthetic properties of resin composite restorations (Dinelli et al., 1996). Composite resins are susceptible to color alteration under ultraviolet rays, staining agents from food, and mainly due to bad hygiene habits (Asmussen, 1981, 1983; Bagheri et al., 2005; Santos, 2008).

It was evidenced that after 24 h all observation times showed differences in translucency, except for 2, 3 and 4 week which featured similar translucency averages. Translucency percentage decreased during the observation periods in which discoloration occurred. The transmission of light through the composite was probably reduced because of the action of dyes (Chan et al., 1980; Cooley et al., 1987; Powers et al., 1980; Settembrini et al. (1995). Therefore regardless of the experimental groups, both composite resins had a similar behavior (Table 1).

Several authors emphasized the deleterious action of the chemical agents present in cigarettes and in other substances containing dyes (Chan et al., 1980; Cooley et al., 1987; Ertas et al., 2006; Guler et al., 2005; Powers et al., 1980; Settembrini et al., 1995). Cigarette smoke was able to cause staining over esthetic restorative materials (Dinelli et al., 1996). The results of this study are consistent with the above authors.

The resin matrix has been shown to play an important role in staining susceptibility (Bagheri et al., 2005; Ertas et al., 2006). Alcohol facilitated staining by softening the resin matrix (Abu-Bakr et al., 2000; Ferracane, 1994). The quantity of alcohol in red wine played a substantial role in the staining of composite resin (Patel et al., 2004).

The wear resistance of composite resin-based materials may be reduced by immersion in low pH solutions, such as cola (Chadwick et al., 1990). According to um and Ruyter (1991), cola has low pH and it might damage the surface integrity of resin composite materials. Consequently the composite resin surface became vulnerable to staining (Table 1). Chlorhexidine gluconate also had a staining effect over composite resin (Mutlu-Sagesen et al., 2005). Some authors believe that the contact of a composite resin with chlorhexidine and organic substances, such as mucin or serum, did not produce significantly higher color changes (Lee and Powers, 2005). However, this study found that chlorhexidine displayed the higher staining of the composite, regardless the composite resin composition (groups G3 and G7).

A significant amount of residual monomer or short chain polymers may remain unbound in the set composite resin material (Ferracane and Marker, 1992). Staining molecules may diffuse through the resin matrix. Changes in translucency were influenced by resin matrix composition and also the filler size (Kim et al., 2005). Composite with larger filler size tended to uptake more staining molecules.

The results of this study can be extrapolated to the clinical scenario because the consumption of red wine and cola is common. chlorhexidine is also frequently use in mouthwashes. With respect to nicotine, is also common that smokers have composite resin restorations. It is interesting in future work to test the staining in nanopaticulate resins.

Conclusion

1. Composite resins submitted to the tested immersion mediums were stained,
2. Translucency percentage decreased along the periods with dye solution,
3. For Point 4 (Kerr) composite resin, the staining capacity of red wine staining was lesser than the staining capacities of cola and nicotine, and similar to that of chlorhexidine,
4. For Charisma (Heraeus Kulzer) composite resin, the staining capacity of red wine staining was higher than the staining capacity of cola and chlorhexidine. Cola and chlorhexidine have shown similar staining effects,

5. The lower percentage of translucency was observed for nicotine containing dyes.

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