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RESEARCH AND EDUCATION

Effect of liquid polishing materials on the stainability of bis-acryl interim restorative material in vitro

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ABSTRACT

Statement of problem. The discoloration of interim restorations may negatively affect a patient's perception of treatment.

Purpose. The purpose of this study was to investigate the effect of liquid polishing materials on the color stability of bis-acryl interim restorative material.

Material and methods. One hundred twenty specimens (10×2 mm) of a bis-acryl interim restorative material were divided into 3 groups. Group CO (control) was not subjected to any liquid polishing material. Groups GC and BC were polished with 2 liquid polishing materials. The specimens were then divided into 4 subgroups (n=10) and stored for 24 hours at 37°C in different staining solutions: coffee, coffee with sugar, cola, and distilled water. The color of the specimens was measured at baseline and after immersion with a spectrophotometer by using the CIE L*a*b* system, and color changes (ΔE) were calculated. The means of color change for each specimen were analyzed by 2-way and 1-way ANOVA tests. Post hoc comparisons were made with the Tukey HSD and Tamhane T2 tests.

Results. The application of liquid polishing materials significantly decreased the staining of auto-polymerized bis-acryl interim restorative material ($P<.01$). Coffee with sugar resulted in higher ΔE values than coffee without sugar or cola.

Conclusions. The use of liquid polishing materials significantly decreased staining when compared with bis-acryl specimens without liquid polish. The presence of sugar in coffee increased color change compared with coffee without sugar for all groups evaluated. (J Prosthet Dent 2015;113:475-479)

An interim restoration must provide stabilization and function and restore esthetics by covering the prepared tooth structure during the fabrication period of a definitive prosthesis.[1] Ideally, an interim restoration may also help to determine the therapeutic outcome of a treatment plan and definitive restorations, particularly in multidisciplinary esthetic reconstructions.[1-3] For longer periods of use, the color stability of an interim restoration in the esthetic zone is a major concern since interim restorations that undergo rapid and significant discoloration subsequent to fabrication may negatively affect a patient's perception of treatment.[4,5]

Because of their improved mechanical properties and ease of manipulation, bis-acryl resins are widely used to fabricate interim restorations with a direct technique.[6,7] Regardless of composition and polymerization method, these materials tend to undergo color changes over time due to the use of medicaments such as chlorhexidine or whitening agents and the consumption of various staining beverages.[8,9] Studies have demonstrated that adequate finishing and polishing are key factors for the resistance of a restoration to plaque accumulation and staining.[9-14] Liquid polishing materials are low viscosity, light-polymerized resin formulations with a low amount of filler particles that provide a sealed and smooth polished surface for interim and composite resin restorations.[14-18]

The CIELab Color System represents a uniform color scale covering all the colors visible to the human eye and is commonly accepted as a suitable system for most perceptual studies of color differences (ΔE) in dental materials.[19,20] Different threshold values of color change that produce visually perceptible differences have been reported in a number of studies. In general, a ΔE value of

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Clinical Implications

Liquid polishing materials may be a useful alternative to conventional polishing procedures and reduce the stainability of bis-acryl interim restorations.

3.7 or more is considered as a threshold value for a clinically unacceptable and visually perceptible color difference.[21-24]

The purpose of this in vitro study was to evaluate the effect of 2 liquid polishing materials on the stainability of an autopolymerized bis-acryl interim restorative material upon exposure to different staining agents. The null hypothesis was that liquid polishing materials and staining agents do not affect the stainability of an autopolymerized bis-acryl interim restorative material.

MATERIAL AND METHODS

The materials used in this study are presented in Table 1. One hundred twenty bis-acryl specimens were prepared from a custom-made polyether mold (10-mm diameter, 2-mm thick). The size approximated the maximum facial or occlusal thickness of an interim crown.[5] No additional finishing or polishing procedures were performed on the specimens in order to simulate the clinical steps of a direct fabrication technique of interim restorations. A power analysis was performed to determine the number of specimens required in each test group in order to determine if statistical differences exist between groups. For the accepted effect size f parameter, a 1.0 power and .05 alpha error probability, the number of specimens required in each group was determined to be 40. Specimens were divided into 1 control and 2 test groups according to different liquid polishing systems, then further divided into 4 subgroups of 10 specimens each according to 3 different staining agents and water. In Group CO, specimens served as the control group, with no liquid polishing material applied. In Groups GC and BC, the liquid polishing materials were applied to both sides of the specimens, according to the manufacturer's recommendations. The specimens were then stored in distilled water at 37°C for 24 hours, simulating the first day of service for interim restorations in the oral environment.

Quantitative baseline color (ΔE) measurements were made with a spectrophotometer (VITA Easyshade; VITA Zahnfabrik). Three measurements were made for each specimen. The instrument was recalibrated after measuring each group. After baseline color measurements, each subgroup was stored in staining agents and distilled water for 24 hours. The average time for consumption of 1 cup of coffee is 15 minutes, and the average consumption of coffee is calculated as 3.2 cups per day.[16] Therefore, 24 hours' storage time simulated the consumption of the drink over 1 month.

Specimens in the subgroups were stored in 37°C coffee; 3.6 g of coffee (Nescafe Gold; Nestle) was dissolved in 300 mL of boiling distilled water, according to the manufacturer's suggested concentration. In the coffee with sugar subgroups, specimens were stored in 37°C coffee with sugar, where coffee was prepared as previously described, and then 10 g of white sugar was added for every 300 mL. In the cola subgroups, specimens were stored in 37°C cola (Coca-Cola; Coca-Cola Co).

After 24 hours in the solutions, the specimens were rinsed with distilled water for 5 minutes and blotted dry with tissue paper before color measurement by the same operator. The total color difference between the 2 positions (after 24 hours' storage in staining agents and baseline) in the 3-dimensional (3D) L*a*b* color space was calculated as a single number, ΔE.

The color change was quantified by the National Bureau of Standards (NBS), which rates the way that the human eye evaluates a color change (Table 2). The formula used for this conversion is NBS unit=ΔE×0.92. The mean ΔE values of all specimens were converted to NBS units to reveal whether the color changes of the studied groups were clinically detectable.

Software (SPSS for Windows v15.0; Statistical Package for Social Sciences) was used for statistical analysis. Conformity of the parameters to a normal distribution was assessed by the Shapiro-Wilk test, and the parameters conformed to a normal distribution. Two-way ANOVA and 1-way ANOVA tests were used for the intergroup comparisons of parameters without normal distribution. A test of the homogeneity of variances revealed both homogeneous and nonhomogeneous variances. Therefore, the Tukey HSD test was used for post hoc evaluation of groups with homogeneous variances, and the Tamhane T2 test was used for post hoc evaluation of groups with nonhomogeneous variances (α=.05).

Table 1. Materials used

Group Name	Brand Name	Material Type	Manufacturer	Batch No.
Group BC (BisCover LV)	BisCover LV	Low-viscosity liquid polish	Bisco	1200004969
Group GC (G-Coat Plus)	G-Coat Plus	Nanofilled self-adhesive, photopolymerized protective coating	GC	1112121
	Acrytemp	Autopolymerized bis-acryl interim restorative material	Zhermack	C700200

Table 2. National Bureau of Standards (NBS) system of expressing color differences

NBS Units	Critical Remarks of Color Differences
0.0-0.5	Excessively mere change
0.5-1.5	Mere: Mere change
1.5-3	Noticeable: Perceivable change
3-6	Appreciable: Prominent change
6-12	Much: Excessively marked change
12 or more	Very much: Change to other color

Table 3. Effects of liquid polish materials and staining agent on color change (ΔE)

Source	F	P
Liquid polish	679.89	.001**
Staining agent	346.34	.001**
Liquid polish×Staining agent	129.40	.001**

Two-way ANOVA test; **P<.01.

Table 4. Effect of liquid polishing materials on color change (ΔE)

Liquid polish	ΔE (mean ±SD)	P
Control	10.66 ±6.36	.001*
G-Coat Plus	2.98 ±1.63	
BisCover LV	2 ±1.03	
Control/G-Coat Plus		.001**
Control/BisCover LV		.001**
G-Coat Plus/BisCover LV		.585**

*One-way ANOVA test, **Tamhane T2 test, P<.01.

Table 5. Color changes (ΔE) in different staining agents after 24 hours of immersion

	Liquid Polish (mean ±SD)			
Staining Agent	Control	G-Coat Plus	BisCover LV	P*
Coffee with sugar[1]	16.2 ±1.4[a]	4.94 ±0.72[b]	2.9 ±0.96[c]	.001**
Coffee[1]	13.58 ±2.16[d]	2.81 ±0.22[e]	2.11 ±0.5[e]	.001**
Cola[2]	2.19 ±0.46[f]	1.19 ±0.3[g]	0.99 ±0.43[g]	.001**
Distilled water[2]	1.1 ±0.1[h]	0.87 ±0.12[i]	0.76 ±0.13[i]	.001**

*One-way ANOVA test, **P<.01. Post hoc tests: [1]Tamhane T2 test, [2]Tukey HSD test. The same superscript letters statistically insignificant difference.

RESULTS

The effects of liquid polishing materials and staining agents on color change are summarized in Table 3. According to the 2-way ANOVA, these factors and their interactions exerted a statistically significant (P<.01) influence on color stability. The difference between the mean ΔE values of 2 liquid polishing materials was statistically significant (P<.01) (Table 4). In Group CO, statistically higher ΔE values were obtained when compared with Groups GC and BC (P<.01). The difference between the ΔE values of Groups GC and BC was statistically insignificant (P>.05). The mean values and SDs of color changes are presented in Table 5. After a 24-hour immersion period in staining agents and distilled water, higher ΔE values were observed for coffee with sugar than for coffee, cola, and distilled water (Fig. 1). For the specimens subjected to coffee with sugar, the difference between the mean ΔE values of Group CO, Group GC, and Group BC was statistically significant (P<.01) (Table 5). In Group CO, statistically higher ΔE values were obtained when compared with Groups GC and BC (P<.01). In Group GC, statistically higher ΔE values were obtained when compared with Group BC (P<.01).

Regarding coffee, cola, and distilled water application, the difference between the mean ΔE values of Group CO and Groups GC and BC was statistically significant (P<.01) (Table 5). In Group CO, statistically higher ΔE values were obtained when compared with Groups GC and BC (P<.01). The difference between ΔE values of Groups GC and BC was not statistically significant (P>.05).

The conversion of the mean ΔE values to NBS units (Table 2) revealed clinically "noticeable" to "appreciable" (1.94 to 4.54 NBS units) color changes for both liquid polishing materials, whereas their effect on color change

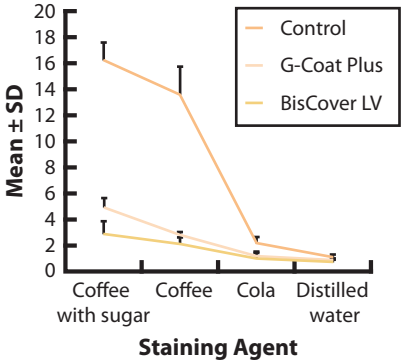

Figure 1. Mean (SD) values of color changes (ΔE).

was "very much" (12.49 to 14.9 NBS units) for specimens without any liquid polishing applied. The effect of cola on the color change of liquid polishing applied specimens was clinically "mere" to "noticeable" (0.91 to 1.09 NBS units), whereas its effect on color change of the control group was "noticeable" (2.01 NBS units). The effect of distilled water on the color change of liquid polishing applied specimens was clinically "mere" (0.69 to 1.01 NBS units).

DISCUSSION

The hypothesis that liquid polishing materials and staining agents do affect the stainability of autopolymerized bis-acryl interim restorative material was accepted. According to statistical analysis, the liquid polishing material was the most significant factor for color change (F=679.89), followed by the staining agent (F=346.34) (Table 3).

Finishing and polishing procedures may influence surface smoothness because resin materials with rougher

surfaces are much more prone to discoloration as a result of mechanical retention.[13,24] With surface glazing, liquid polishing material reduces the surface porosity and thereby may eliminate the need for manual polishing.[18,22] In accordance with Rutkunas et al,[22] liquid polishing materials with a low amount of filler particles created a glazed surface coating, which resulted in resistance to staining by reducing the porosity of the bis-acryl resin surfaces in the present study. BisCover LV tended to render the surface more resistant to discoloration compared with G-Coat Plus, where their difference was statistically insignificant. In contrast, Lambrechts and Vanherle[18] stated that the creation of superficial pores due to the loss of a glazed surface over time may compromise stain resistance, and the existence of positive correlation between surface roughness and staining was not a true statement.

In this study, the highest color difference was observed for the coffee with sugar. The presence of sugar in coffee increased stainability compared with coffee without sugar. This may be attributed to the sticky effect of sugar, which is in accordance with the findings of Güler et al.[16] The lowest color changes were observed when cola and distilled water were used. The interaction between the liquid polishing material and staining agent has clinical significance because the color change may be noticed by the patient. For G-Coat Plus, after immersion in coffee with sugar (4.94 ΔE unit=4.54 NBS unit), an "appreciable" color change occurred, whereas other liquid polishing applied specimens presented a color change lower than the 3.7 ΔE unit threshold value for a clinically unacceptable and visually perceptible color difference.[20,21] In this study, the autopolymerized bis-acryl interim restorative material exhibited significant color change from staining agents, which might be related to multiple factors. Chemical intrinsic factors, such as polymethyl methacrylate (PMMA) particle distribution, stability of pigments, and the initiator system of interim restorative materials may also affect the curing mechanism, water absorption capacity, and consequently color stability.

Also, the more polar nature of bis-acryl polymers compared with PMMA polymers results in a greater affinity toward water, and because colorants are soluble in water, electrostatic charges on their molecules may stain surfaces.[5,22] Controversy exists in the literature about the effect of water absorption on the color stability of bis-acryl interim restorative materials. In their in vitro study, Sham et al[4] described bis-acryl resins as more color stable compared with methyl/ethyl methacrylate resins as a result of lower water absorption when interim restorations were used for extended periods. Even though additional research had been recommended to validate this result, the water-absorption capacity of acrylic resins increases in the presence of unreacted monomers in air inclusion. Because a bis-acryl interim restorative material was automixed instead of being mixed by hand spatulation, the entrapment of air or unreacted monomer during mixing might have been reduced. Therefore, it could be that the minimized amount of such entrapment defects and porosities also diminishes the amount of water sorption and makes the material more color stable.

In the present study, the application of liquid polishing materials on the surface may have acted as a barrier and limited the water absorption capacity of the bis-acryl interim restorative material, thus decreasing stainability. However, this assumption must be validated by further investigations.

Surface irregularities provide a suitable niche for bacterial adhesion, and bacteria form a biofilm matrix composed of proteins and other cellular components on a restorative material surface.[11,12] Davidi et al[13] evaluated the effect of liquid polish coating on in vitro biofilm accumulation on interim restorations and concluded that BisCover LV liquid polishing material inhibits biofilm formation by preventing salivary protein adsorption to the coated PMMA surface.

This study has a number of limitations. The experimental specimens had flat surfaces, whereas in clinical situations, the surface morphology of the interim restorations makes adequate polishing and plaque control harder to accomplish. In addition, interim restorations in the oral environment are subjected to saliva containing various proteins and enzymes, extremes of temperature for food and drink, and perhaps smoking. These factors may also contribute to color changes. Therefore, a comprehensive evaluation of these factors should be considered for future research.

Within the limitations of this study, the following conclusions were drawn:

1. The tested bis-acryl interim restorative material exhibited statistically significant color change after exposure to staining agents.
2. The presence of sugar in coffee increased color change compared with coffee without sugar for all groups evaluated.
3. The use of liquid polishing materials significantly decreased staining when compared with bis-acrylic specimens without liquid polish.

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