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Effect of Brushing with Whitening Toothpaste on External Discoloration of Resin Modified Glass Ionomer Cement

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Abstract

Introduction: Resin Modified Glass Ionomer Cement (RMGIC) is a restorative material that combines the properties of Glass Ionomer Cement (GIC) and Composite Resin. RMGIC is prone to external discoloration due to exposure of dark colored beverages such as coffee, tea, and Coca-Cola. Extrinsic stains of the overlaid material can be removed using whitening toothpaste. A lot of people drink Coca-Cola, however, there has not been many studies discussing the effect of whitening toothpaste brushing on the RMGIC discolored by Coca-Cola. **Purpose:** To analyze the effect of brushing with whitening toothpaste on RMGIC discolored by Coca-Cola. **Methods:** Thirty cylindrical RMGIC (*GC Fuji II LC® Light-Cured, GC Corp, Japan*) specimens, 6 mm in diameter, 2 mm in thickness were divided into 3 groups treated with 3 toothpastes respectively. The specimens were soaked in Coca-Cola for 7 days and then brushed using various toothpastes namely Pepsodent 8 Plus Whitening Toothpaste, Pepsodent Regular Toothpaste, and no toothpaste for 4 minutes 40 seconds. **Results:** Brushing with different toothpaste groups resulted in a significantly different increase in L* values ($p<0.05$), a significantly different decrease in b* and a* values ($p<0.05$). The color change caused by brushing Pepsodent 8 Plus Whitening Toothpaste was significantly different with brushing Pepsodent Regular Toothpaste. **Conclusion:** Brushing Coca-Cola discolored RMGIC with whitening toothpaste resulted in the greatest improvement in brightness and discoloration compared to other toothpastes.

Keywords: Coca-Cola; discoloration; RMGIC; toothbrushing; whitening toothpaste

Introduction

The prevalence of cavities in Indonesia is still relatively high. Citing data from the Ministry of Health's Riskesdas in 2018, the prevalence of dental caries in Indonesia was 88.8%.[1] Cavities must be filled immediately to prevent the spread of infection to the tooth's supporting tissue. Patients with a high risk of caries and requiring restoration in areas with low pressure can use Resin Modified Glass Ionomer Cement.[2] Resin Modified Glass Ionomer Cement (RMGIC) is a restoration material produced by combining the properties of Conventional Glass Ionomer Cement (GIC) with Composite Resin.[3]

The composition of RMGIC is almost the same as GIC; the difference is in the liquid content. The liquid of GIC contains polycarboxylic acid and water, while the liquid of RMGIC has an addition of HEMA (hydoxyethylmethacrylate).[2] The addition of HEMA aims to improve

the chemical and mechanical properties of GIC. Chemically, GIC does not use dentin binders to bond with the tooth structure so that it has good adhesion strength.[2] However, the composition of the resin matrix and the addition of HEMA in GIC is hydrophilic or water sorption which can absorb more fluid so that GIC is susceptible to color changes.[4] The RMGIC has the same acid-base reaction as GIC, adding the polymerization of resin by light curing.

Color changes are the result of physical and chemical interactions in tooth tissue and can occur due to intrinsic or extrinsic factors. [4] Extrinsic stains cause dental fillings to appear yellowish-white, yellow, yellow-brown, and brown. The main products that cause extrinsic pigmentation are coffee, black tea, tobacco, red wine, and cola drinks. [4] This is because the color pigments in drinks have a different refractive index compared to the filler and resin particles, so that the color pigments can spread and then absorb light and cause increased opacity in GIC.[5]

Carbonated drinks generally contain high sugar, carbon dioxide, and carbonic acid so that they are acidic or pH <7.[6] The high sugar content in carbonated drinks can increase color changes in composite resin. [7] Based on previous studies, carbonated drinks have an acidic pH that can cause roughness of the RMGIC surface. [8] Drinks with an acidic pH will release a lot of H+ ions, H+ ions that diffuse into the glass ionomer component replace metal cations so that metal ions in the matrix decrease and cause RMGIC dissolution or the outer surface of RMGIC becomes hollow. [9]

One of the easiest ways to restore extrinsic stains is to use whitening toothpaste.[10] Toothpaste with whitening content is widely available in the community, such as Pepsodent Whitening, Pepsodent White Now, Zact, and others. Based on previous studies, whitening toothpaste generally contains bleach such as pearlite 7%, speedy whitening agent, hydrated silica, sodium bicarbonate, microcleansing crystal which are effective against extrinsic tooth discoloration due to coffee. [11] However, there have not been many studies that have tested the effect of whitening toothpaste on discoloration of GIC due to exposure to Coca-Cola, because Coca-Cola is a dark-colored drink and is popular with the public and can cause significant discoloration like coffee. [5] This study was conducted with the aim of determining the effect of whitening toothpaste on GIC that has experienced discoloration due to carbonated drinks, namely Coca-Cola.

Methods

A total of 30 specimens of RMGIC (GC Fuji II LC® Light-Cured, GC Corp, Japan) were divided into 3 groups of 10 specimens (2 mm height × 6 mm diameter cylindrical mold, light-cured for 20 s). The specimens were prepared according to manufacturer's instructions. The groups are Group A, brushed using toothpaste containing Pepsodent Complete 8 Plus Whitening; Group B, brushed using Pepsodent Regular toothpaste; and Group C, the control group brushed without toothpaste.

The specimens were immersed in 200 ml distilled water for 24 hours and stored in an incubator at 37°C. After 24 hours, the specimens of each group A, B, and C (n = 10) were tested for initial color with a colorimeter (brand?). The specimens were then immersed in Coca-Cola solution in an incubator at 37°C, and the solution was replaced every day for 7 days, then were cleaned with an ultrasonic cleaner for 1 minute and dried using a tissue paper. Specimens of each group A, B, and C (n = 10) were re-tested of surface color using a colorimeter. To decolorized, the specimens were brushed using toothpaste dissolved in water with a ratio of 1: 1 (1 g toothpaste mixed with 1 ml of water). Brushing the specimens were done by an Oral B Vitality Clean Electric Toothbrush rotating at 7600 rpm, load of 200 grams for 4 minutes 40 seconds. Group A was brushed using Pepsodent Complete 8 Plus Whitening toothpaste, Group B with Pepsodent Regular toothpaste, and Group C was brushed without toothpaste.

The data obtained were then analyzed using SPSS software. The Shapiro-Wilk normality test was carried out, then using the One-Way ANOVA test for changes in Δb * and ΔE * values, while changes in values ΔL* and Δa* values were analyzed using the Kruskal Wallis test because the data were not normally distributed. Color parameters were evaluated based on the CIE L*a*b* color system, as illustrated in Figure 1. The Bonferroni post-hoc test was then used to analyze the significancy between groups.

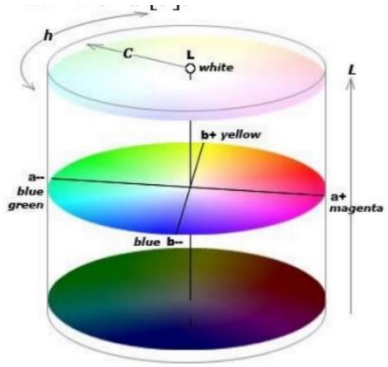

Figure 1. CIE L*a*b*system.[19]

Results

The results of the L* and ΔL* values are presented in Table 1. Table 1 shows the mean L* values of RMGIC before and after brushing with different types of toothpaste, which reflect changes in brightness. A comparison of the percentage differences in L* values among the groups indicates variations in brightness following the brushing procedure with each toothpaste formulation.

Table 1. Mean L Value of RMGIC Before and After brushed with Different Toothpastes

Toothpaste Type	L*± SD			
	Before Immersion	After Immersion	After Brushing	Percentage (%) of Color Change After immersion-After Brushing
Group A: Pepsodent Complete 8 Plus Whitening Toothpaste	59.22 ± 0.88	59.31 ± 0.99	63.84 ± 1.31	7.63 %
Group B: Regular Pepsodent Variant Toothpaste	57.06 ± 0.73	58.63 ± 1.51	61.29 ± 0.29	4.53 %
Group C: Without Toothpaste (Control)	56 ± 0.52	55.79 ± 1.35	57.53 ± 1.61	3.11 %

The statistical analysis of the ΔL* values between toothpaste groups is summarized in Table 2. The Kruskal–Wallis test was used to evaluate the significance of brightness changes among the different toothpaste types. The results demonstrate whether there were statistically significant differences in ΔL* values between the groups after the brushing intervention.

Table 2. Significancy of ΔL* between Toothpaste Types with Kruskal-Wallis Test

Group of Toothpaste Type	ΔL* Value
Group A: Pepsodent Complete 8 Plus Whitening Toothpaste	4.53 ± 1.56^{b}
Group B: Regular Pepsodent Variant Toothpaste	2.66 ± 1.41^{a}
Group C: Without Toothpaste (Control)	1.74 ± 1.15^{a}

*Different superscript means significant differences post hoc test (*p<0,05)*

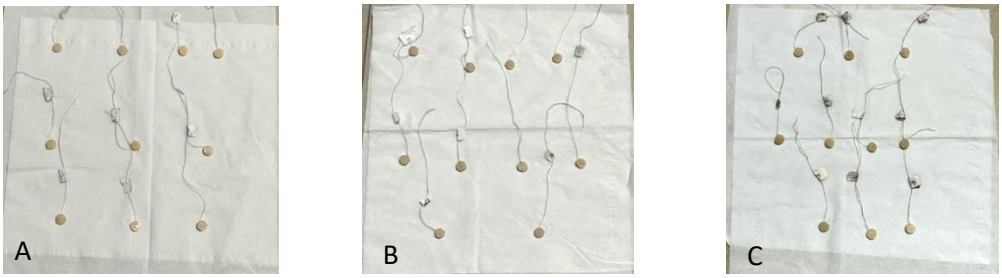

Figure 2. (A) Brushed specimens with whitening toothpaste, (B) Brushed specimens with regular toothpaste, (C) Brushed specimens without toothpaste.

Based on Figure 2, there were color changes in the three groups of specimens. Group A, brushed with Pepsodent Complete 8 Plus Whitening Toothpaste showed the brightest specimen appearance. In group B, the specimens brushed with Pepsodent Regular Toothpaste showed lighter change in color. Group C, specimens brushed without toothpaste showed a change in color, but not as bright as the other brushing groups.

Changes in the a* values of RMGIC before immersion, after immersion, and after brushing with different toothpaste types are presented in Table 3. The Pepsodent Complete 8 Plus Whitening toothpaste group showed a markedly lower percentage change in a* value after brushing (2.6%) compared to the Pepsodent Regular toothpaste group (46.6%), indicating a smaller shift toward the red–green axis. Statistical analysis using the Kruskal–Wallis test demonstrated a significant difference in Δa* values between toothpaste types, as shown in Table 4.

Table 3. Mean of a* Value of RMGIC Before Brushed and After Brushed Using Toothpaste Types

Toothpaste Type	a*± SD			Percentage (%) of color change After Immersion – After Brushing
	Before Immersion	After Immersion	After Brushing	
Group A: Pepsodent Complete 8 Plus Whitening Toothpaste	0.15 ± 0.13	1.51 ± 0.25	1.47 ± 0.24	2.6 %
Group B: Regular Pepsodent Toothpaste	0.48 ± 0.19	1.48 ± 0.52	0.79 ± 0.25	46.6 %
Group C: Without Toothpaste (Control)	0.3 ± 0.	1.79 ± 0.37	1.12 ± 0.38	37.4 %

Table 4. Significance of ΔL* Value between Toothpaste Types with Kruskal Wallis Test

Toothpaste Types	Δa*
Group A: Pepsodent Complete 8 Plus Whitening toothpaste	-0.03 ± 0.28[b]
Group B: Regular Pepsodent Varian Toothpaste	-0.69 ± 0.39[a]
Group C: Without Toothpaste (Control)	-0.67 ± 0.41[a]

*Different superscript means significant differences with post hoc test (*p<0,05)*

The mean b* values of RMGIC before brushing and after brushing with different toothpaste types, representing changes along the yellow–blue axis, are shown in Table 5. Furthermore, the comparison of Δb* values among groups revealed significant differences, as analyzed using the one-way ANOVA test. The statistical significance of these differences is summarized in Table 6, indicating that the type of toothpaste influenced the degree of yellowish–bluish color change after brushing.

Table 5. Means of b* Value of RMGIC Before Brushing and After Brushing Using Toothpaste Types

Toothpaste Types	b*± SD			
	Before Immersion	After Immersion	After Brushing	Percentage (%) of Color Change After Immersion – After Brushing
Group A: Pepsodent Complete 8 Plus Whitening Toothpaste	5.84 ± 0.58	7.38 ± 0.67	6.89 ± 0.69	6.63 %
Group B: Regular Pepsodent Toothpaste	6.13 ± 0.25	7.61 ± 0.86	5.98 ± 0.58	21.4 %
Group C: Without Toothpaste (Control)	5.82 ± 0.12	7.2 ± 0.61	6.37 ± 0.63	15.2 %

Table 6. Significance of Δb* Value between Toothpaste Types with One-way Anova Test

Toothpaste Types	Δb*
Group A: Pepsodent Complete 8 Plus Whitening Toothpaste	-0.49 ± 1.05[ab]
Group B: Regular Pepsodent Toothpaste	-1.63 ± 0.89[ac]
Group C: Without Toothpaste (Control)	-1.14 ± 0.61[a]

*Different superscript means significant differences with post hoc Bonferoni test (*p<0,05)*

The difference in the average percentage and significance of ΔE* values (color change) for each group can be seen in Table 7. and Table 8.

Table 7. Means of ΔE* Value of RMGIC Before Brushing and After Brushing Using Toothpaste Groups

Toothpaste Types	ΔE* ± SD		
	Before Immersion	After Immersion	Percentage (%) of Color Change After Immersion – After Brushing
Group A: Pepsodent Complete 8 Plus Whitening Toothpaste	2.75 ± 0.91	4.7 ± 1.45	70.9 %
Group B: Regular Pepsodent Toothpaste	2.82 ± 0.81	3.2 ± 1.69	13.47 %
Group C: Without Toothpaste (Control)	2.74 ± 0.8	2.32 ± 1.1	15.32 %

Table 8. Significance of ΔE* Value between Toothpaste Types with One-way ANOVA Test

Toothpaste Types	ΔE*
Group A: Pepsodent Complete 8 Plus Whitening Toothpaste	1.95 ± 0.54^{b}
Group B: Regular Pepsodent Toothpaste	0.37 ± 1.65^{a}
Group C: Without Toothpaste (Control)	-0.41 ± 1.11^{a}

*Different superscript means significant differences with post hoc Bonferoni test (*p<0,05)*

Discussion

In this study, the after brushing with several toothpaste types showed an increase in the ΔL* value, a decrease in the Δa* value, and in the Δb* value. Based on Table 7, the percentage of color change (ΔE*) of specimens brushed with Pepsodent 8 Plus Whitening Toothpaste was 70.9%, while the percentage of color change (ΔE*) of specimens brushed with Pepsodent Regular Toothpaste was 13.47%. The color change that occurred when brushed with whitening toothpaste were greater than those with regular toothpaste. This color change occurs due to the abrasive content in toothpaste which is an insoluble component in toothpaste. During brushing,

these abrasive particles can be trapped between the toothbrush bristles and the stained extrinsic surface can be removed.[20] In addition, Pepsodent 8 Plus Whitening Toothpaste contains an active whitening ingredient, namely CI 77891 (Titanium Dioxide) which is usually used as a whitening agent in toothpaste products. Titanium Dioxide acts as a mild abrasive that helps remove surface stains on teeth but does not affect deeper discoloration or intrinsic stains.[21]

The percentage change in brightness (ΔL*) of specimens brushed using Pepsodent Complete 8 Plus Whitening Toothpaste was 7.63% while the group using Pepsodent Regular Toothpaste it was 4.53%. The greatest increase in L* brightness was obtained in the Pepsodent Complete 8 Plus Whitening Toothpaste group specimens. Abrasive particles content is the most commonly found in toothpaste. The combination of calcium carbonate, hydrated silica, silica, and alumina have been shown to produce the highest increase in brightness. Alumina is an abrasive material with the highest level of abrasiveness according to the Moh scale. The results of the ΔL* significance analysis also showed significant differences between the Pepsodent 8 Plus Whitening Toothpaste and Pepsodent Regular Toothpaste brushing groups. These significant differences indicated that brushing with whitening toothpaste produced a higher level of brightness compared to brushing with regular toothpaste.

The percentage of redness-greenness (Δa*) decreased in the brushing group using Pepsodent Complete 8 Plus Whitening Toothpaste (2.6%) while in the brushing group using Pepsodent Toothpaste Regular Variant, the percentage is 46.6%. In this case, the greatest degree of redness was obtained in the specimen brushed with Pepsodent Regular Toothpaste group. The decrease in the degree of redness-greenness (a*) in both groups indicates a decrease in the concentration of redness in each specimen.

The percentage yellowness-bluishness (Δb*) decreases in the brushing group of Pepsodent Complete 8 Plus Whitening Toothpaste (6.63%), while in the brushing group using Pepsodent Toothpaste Regular Variant it was 21.4%. Meanwhile the greatest decrease in yellowness was obtained in the specimen of the Pepsodent Regular Toothpaste group. The decrease in the degree of yellowish-blue (b*) in both groups indicates a decrease in the concentration of yellow color in each specimen.

Abrasive materials in toothpaste will work mechanically to clean extrinsic stains on the surface of the RMGIC. Abrasive particles are insoluble components in toothpaste and will be trapped between the toothbrush bristles so that extrinsic stains can be cleaned.[33]

In this study, brushing using an electric toothbrush with micropulse technology or soft bristles, or oscillating and rotating movements that rotate back and forth at a constant of 7600 rotations per minute is given a load of 200 g for 4 minutes 40 seconds or equivalent to 1 month of brushing. According to David (2016), a rougher composite resin surface will appear brighter than a smoother surface.[22] This is because the filler particles of the composite resin are released from the matrix bond. So, the rougher the surface, the less chromatic the chroma will be.[22]

According to Zairani (2016), there are several factors that can affect the roughness of the RMGIC. Surface roughness is influenced by brushing technique, brushing strength, duration and frequency of brushing, thickness and stiffness of the bristles, and abrasive materials in the toothpaste used.[16]

From the results of this study, the combination of calcium carbonate and silica have been shown to remove extrinsic stains due to the color of Coca-Cola pigments. However, it is not higher than the combination of calcium carbonate, silica, hydrated silica, and alumina. This explains the different effectiveness of brushing Without Toothpaste (control) and Pepsodent Toothpaste Regular Variant which are still below Pepsodent 8 Plus Whitening Toothpaste to remove extrinsic stains mechanically on RMGIC.

The limitation of this study is the short duration applied in Coca-Cola immersion that may influence the outcomes of the external discoloration of RMGIC. Longer immersion duration should be done in further studies.

Conclusion

It can be concluded that brushing the discolored surface of RMGIC previously stained by Coca Cola with whitening toothpaste led to an increase in brightness, a reduction in redness and yellowness values. Furthermore, brushing with various toothpastes formulation produced an enhancement in the brightness of RMGIC, with the whitening toothpaste yielding the greatest color change.

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