Effect of whitening toothpaste on the discoloration level of stained conventional glass ionomer cement

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Abstract. Staining is not unique to natural enamel and may also occur on the restorative material, such as conventional glass ionomer cement (GIC). This study identified the effect of whitening toothpaste on the discoloration level of conventional GIC. In total, 24 GIC specimens were immersed in coffee and then brushed with one of the four commercially available. The specimens were brushed for various durations (1, 2, and 4 weeks), and changes in discoloration were assessed using a digital colorimeter (VITA Easy Shade). Significant changes (p<0.05) in brightness were observed after the first and fourth week of brushing. However, not all toothpaste caused significant color changes. This study provides evidence that some whitening toothpaste can decrease the discoloration level of stained conventional GIC.

1. Introduction
Oral and dental diseases are highly prevalent in the modern Indonesian society. According to a 2007 health survey, 75% of the Indonesian population suffers dental caries at an average severity level (DMF-T index) of five teeth per person [1]. According to the Indonesian Health Profile released in 2011, 120,000 cases of permanent tooth restoration have been reported across Indonesia, and such a need for dental restorative procedures is continually increasing in developing countries, including Indonesia [2].

The World Health Organization introduced the atraumatic restorative treatment (ART), a procedure that uses only manual excavation techniques to eliminate dental caries without the use of burs or advanced equipment. After the removal of the caries, the cavity is restored with conventional glass ionomer cement (GIC) [3]. Currently, conventional GIC, a tooth-colored filling material that chemically binds dentin, is one of the most widely-used restorative materials [4]. Moreover, it can mediate fluoride release, which can prevent the further demineralization and enhance the remineralization of enamel and dentin and inhibit the growth of caries-causing bacteria [5].

Although conventional GIC ensures good esthetic results, it may still become discolored over time. Extrinsic factors, such as smoking and the consumption of beverages with coloring agents (tea or coffee) or cationic agents (chlorhexidine), may cause conventional GIC to appear yellowish-white, yellow, brownish-yellow, or brown [6].

Coffee, in particular, is known to cause GIC discoloration. Coffee is one of the most consumed beverages in the world and the second largest traded commodity after petroleum [7]. According to the Indonesian Coffee Exporter Association, coffee consumption in Indonesia was estimated to be 240,000–270,000 tons in 2011 and is increasing at a rate of 6%–8% per year [8]. Consequently, many people experience the discoloration of their teeth or restoratives due to the consumption of coffee; thus, stain-removing and whitening toothpaste are demanded by consumers.
Currently, whitening toothpaste are readily available, and several brands such as Pepsodent Whitening, Pepsodent White Now, dan Zact: Tooth Stain Fighter, Darlie All Shiny White, Formula Sparkling White, and other toothpaste, are commercially available in Indonesia. Many studies across various countries have evaluated the effectiveness of whitening toothpaste in reducing extrinsic stains on teeth either in vitro or in vivo [9,10]. However, the effect of whitening toothpaste on restoratives remains to be experimentally tested.

Currently, esthetics is a crucial part of dentistry, and restoration and prostheses performed in order to meet good aesthetic. Thus, esthetic failure is one of the most common reasons for the replacement of restoratives [11]. Among various esthetic values, color stability is an important aspect of restoration, and extrinsic agents causing discoloration negatively affect the color stability of restoratives [6]. Considering the scarcity of research regarding the effectiveness whitening toothpaste in removing extrinsic stains from restorative materials, this study was conducted to evaluate the effect of four types of whitening toothpaste on the discoloration of stained conventional GIC.

2. Materials and Methods
This study was experimental laboratory study using 24 specimens of conventional GIC (GC FUJI IX) shaped in cylinder with a diameter of 6 mm and a height of 3 mm. All specimens were produced using the same method in accordance with manufacturer’s instructions to ensure uniform shape and density (powder:liquid ratio of 1:1). After manipulation, conventional GIC was filled into a cylindrical mold, covered with celluloid matrix, and compressed with 200-g weight.

All specimens were immersed in coffee for 6 days for discoloration [12]. Coffee solution was prepared by dissolving Nescafe Classic coffee powder in boiled water at a 1 g:75 ml ratio, according to manufacturer’s instruction. Water was boiled until reaching boiling point and mixed with coffee powder; the mixture was allowed to cool to 40°C. After immersion, the color of stained samples was measured using a digital colorimeter to evaluate lightness (L0), green-red (a0), and blue-yellow (b0) scores before brushing. VITA Easy Shade was used as a reference to estimate color.

The specimens were divided into four groups, and each group was treated with one of four toothpaste: Pepsodent (Pencegah Gigi Berlubang, PT. Unilever Indonesia Tbk) as control toothpaste; Zact: Stain Fighter (PT. Lion Wings); Pepsodent White Now (PT. Unilever Indonesia Tbk); and Formula Sparkling White (PT. Ultra Prima Abadi). The toothpaste was mixed with water at a 1:1 ratio. Presumably, a posterior filling would be brushed for 10 s when normally brushing the teeth. Thus, to simulate 1 week of brushing, the specimen was brushed for 2 min 20 s. To simulate an additional week of brushing, the specimens were brushed for an additional 2 min 20 s. To simulate an additional 2 weeks of brushing (i.e., four weeks of brushing in total), the specimens were brushed for an additional 4 min 40 s. Pressure, particle speed, and the type of toothbrush used were controlled among the groups. After each round of brushing, color was assessed using the digital colorimeter to evaluate the lightness (L*), green-red (a*), and blue-yellow (b*) scores.

3. Results
Color change was also calculated from ∆E using the following formula: \( \Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2] \). The L*, a*, b*, and ∆E scores are presented in Figure 1 – 4.

There was a significant change in L* (\( \Delta L^* \)) after 4 weeks of brushing (one-way ANOVA). In addition, a significant change in \( \Delta L^* \) was observed between 1 week and 4 weeks of brushing with Pepsodent White Now toothpaste (repeated measures ANOVA). However, \( \Delta L^* \) did not significantly differ between 1 week and 2 weeks of brushing.

A significant change in a* (\( \Delta a^* \)) was noted between 1 week and 4 weeks of brushing but not between 2 and 4 weeks using the control toothpaste (Friedman test). No significant differences in \( \Delta a^* \) were observed for the other three toothpaste as well as between brushing for 1, 2, or 4 weeks (Kruskal–Wallis test).
Figure 1. L* scores before and after brushing with whitening toothpaste

Figure 2. a* scores before and after brushing with whitening toothpaste

Figure 3. b* scores before and after brushing with whitening toothpaste
A significant change in $b^*$ ($\Delta b^*$) was observed between 1 week and 4 weeks of brushing with $Zact$ toothpaste (repeated measures ANOVA). No significant changes in $\Delta b^*$ were observed over time for the other three toothpaste. Regarding the duration of brushing, a significant change in $\Delta b^*$ was observed after 1 week of brushing but not after 2 weeks and 4 weeks (one-way ANOVA).

Regarding $\Delta E$, a significant change was observed only between 1 week and 4 weeks of brushing with the control toothpaste (repeated measured ANOVA). Regarding the duration of brushing, a significant change in $E$ ($\Delta E$) was observed after 4 weeks of brushing but not after 1 or 2 weeks of brushing.

4. Discussion
The measurements and statistical analyses in this study demonstrated that not all toothpaste groups and brushing durations significantly changed the color of the stained GIC specimens. The effectiveness of a whitening toothpaste may relate to its abrasiveness. Factors that influence abrasiveness include the hardness of abrasive material, particle shape, particle size, pressure, particle speed, and the type of toothbrush used [13,14]. Because pressure, particle speed, and the type of toothbrush used were controlled among the groups, the abrasive capability of toothpaste used in this study was assessed in terms of their hardness, particle shape, and particle size.

As shown on the packaging, the toothpaste differed in their abrasive material content. Both $Pepsodent$ and $Zact$ contained calcium carbonate, silica, and aluminium oxide; $Pepsodent White Now$ contained silica alone; and $Formula Sparkling White$ contained calcium carbonate and silica plus a chemical abrasive phtalimido peroxycaproic acid. Materials that are harder and larger and have sharp edges and irregular shapes are expected to be more effective at removing extrinsic stains from restorative material [13].

According to the Mohs scale of mineral hardness, aluminium oxide has a hardness value of 9.25 compared to silica and calcium carbonate with values ranging from 2.5–5.0 [15]. Particle shape and size silica crystals are cylindrical with a 5–5.5-nm diameter and 44–67-nm length [16]. Calcium carbonate exhibits variable shapes and sizes, but generally measures approximately 0.7–10-µm diameter.

Based on the CIE $L^*$, $a^*$, and $b^*$ measurements, significant changes in $\Delta E$ were observed after 1, 2, and 4 weeks of brushing with $Zact$. Indeed, given its calcium carbonate, silica, and aluminium oxide composition and the properties of these substances, $Zact$ is expected to be the most abrasive among the used toothpaste. In contrast, the smallest change in $\Delta E$ occurred in specimens brushed with $Pepsodent White Now$, which contained only one type of abrasive. The pattern of increased lightness after 1 and 2
weeks of brushing followed a reduction in lightness after 4 weeks of brushing may have occurred because the *Pepsodent White Now* toothpaste was not adequately abrasive to remove stains absorbed into the structure of the restorative material.

5. Conclusion
This study demonstrated that brushing with whitening toothpaste for between 1 and 4 weeks can increase the lightness of stained conventional GIC. Lightness continually increased with brushing duration, and the greatest increase in lightness occurred for specimens brushed with the most abrasive toothpaste.

6. References
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