

Comparison of the Microleakage of Encapsulated and Hand-Mixed Glass Ionomer in Class V Restorations in Deciduous Teeth

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Backgrounds: The degree of microleakage is one of the main criteria in evaluating the restorative materials such as glass ionomer (GI) restoratives, which are available in two forms: loose powder and liquid form to be hand-mixed or pre-proportioned in a capsule to be mixed mechanically.

Objectives: This study was conducted to compare the microleakage of encapsulated GI restoratives with their hand-mixed equivalent.

Materials and Methods: In this interventional (field trial) study, 40 extracted caries-free deciduous teeth were selected. After preparing class V cavities, teeth were divided into two groups. Cavities in group one were restored with encapsulated self-cured GI restorative (EQUIA, Fuji IX). In the second group, hand-mixed GI restoratives (Fuji IX) were used, which were prepared in accordance with the manufacturers' recommended powder to liquid mixing ratios. After thermo cycling, the samples were immersed in 0.5% methylene blue solution for 12 hours. Then, they were sectioned for examination under light microscope. Micro leakage of each restoration was evaluated by the depth scale of the dye penetration along the tooth-restoration interface.

Results: Statistical analysis by Mann-Whitney U test showed no significant difference in micro leakage between encapsulated GI restoratives and their hand-mixed equivalents ($P < 0.05$).

Conclusions: There was no difference between micro leakage of hand-mixed and encapsulated GIs and in case of following the manufacturer's instruction and recommendations, hand-mixed GIs could be as efficient as their encapsulated equivalents.

Keywords: Glass Ionomer Cements; Dental Leakage; Deciduous Tooth

1. Background

The search for finding an ideal restorative material is still a challenge in dentistry. Thus, for each individual clinical situation, dentists must assess certain properties in order to find the most suitable material. Such properties include biocompatibility, adhesion to the tooth structure, absence of marginal leakage, wear and pressure resistance, fluoride release, setting and working time, facilities related to its manipulation, and finally the cost (1). Marginal leakage is a major drawback of filling materials, which can lead to recurrent caries (2, 3). Efficient contact between filling material and tooth structure, marginal seal, is a critical factor in reducing the micro leakage (4).

Glass ionomer restoratives have some exclusive physical and chemical properties, which make them excellent dental restorative materials in pediatric dentistry. They have cariostatic function by providing a slow release of fluoride; they are biocompatible with pulpal tissue (5), and chemically bind to enamel, dentin, and cementum, thereby reduce the need for the retentive cavity preparation, which make them suitable materials for restoring cervical lesions (5, 6). These lesions usually have little or

no enamel at the cervical margin and restorative materials come into contact with cementum or dentine (7).

GIs are presented in two ways, i.e. as a powder and liquid which are proportioned with a spoon and dropper and mixed by hand, and in capsules in which the powder and liquid are pre-proportioned and undergo mechanical mixing (8). Hand-mixing has been reported to lead to operator-induced variability due to the inaccurate dispensation of the powder and liquid constituents using scoop and dropper bottle systems. In using a scoop, the volume of the powder can vary depending on the powder packing density achieved on filling the scoop (9-11). Also dropper bottles usually dispense uncalibrated volumes of the liquid because of the variations in the angle of the bottle while holding and the pressure exerted to squeeze a drop (12). The variations in the powder to liquid mixing ratios (utilized in clinical practice) are further intensified when scoop and dropper bottle systems are not used, and the powder and liquid are mixed empirically by "eye" to the operators' desired consistency. Therefore, the functional properties normally associated with hand-mixed GIs prepared at the manufacturers' recommended pow-

der to liquid mixing ratios are rarely achieved in clinical practice (9-11). Dowling et al. reported that encapsulation produces consistent mixtures prepared to the manufacturers' recommendation as the mixing technique and times are standardized; which results in better mechanical properties (13).

2. Objectives

The present study aimed to compare the micro leakage of encapsulated GI restoratives with their hand-mixed equivalents for the range of powder to liquid mixing ratios recommended by the manufacturers.

3. Materials and Methods

This study was conducted during winter of 2013-14. In this interventional (field trial) study, 40 extracted caries-free deciduous teeth were selected. Residual tissues were removed gently by soft brush with particular attention to cervical portion of the teeth, to avoid removing of the cervical cementum. The teeth were stored in distilled water for one month. The cavities were prepared on the buccal side of each tooth with 3 mm width, 2 mm height, and 1.5 mm depth. No mechanical retention or bevels were placed. The occlusal margins of the cavities were placed in the enamel and the cervical margin was located in the cementum.

The depth of the cavities was controlled by a Michigan O periodontal probe with Williams markings, which has circumferential lines at 1, 2, and 3 mm. The teeth were randomly divided into two groups. In group one; cavities were restored with encapsulated self-cured glass ionomer (EQUIA, Fuji IX). The capsules were tapped to loosen the powder, activated for 2 seconds to rupture the membrane separating the powder and liquid constituents, then placed into the capsule holder of amalgam mechanical mixing machine (Shahid Faghihi amalgamator) centrifuging for 10 seconds at 4000 rpm, in accordance with manufacturers' instructions. The capsules were placed into a metal GC capsule applicator and click to facilitate the extrusion of the GI restorative plastic mass. GI was inserted in the cavities while still shiny. As soon as the cement began to lose its shiny appearance, pressure was applied with an amalgam packer.

In group two, cavities were restored with hand-mixed equivalents of the encapsulated GI restoratives (Fuji IX) which were prepared in accordance with the manufacturers' recommendation; the powder to liquid ratio was 3.6 g/1.0 g (1 level scoop of powder to 1 drop of liquid). The appropriate amount of GI liquid and powder was placed onto the glass-slab. The powder was separated into two equal parts; half was hand-mixed with the liquid for 10 seconds, using a plastic spatula; the remainder added and hand-mixed for a further 20 s in accordance with the manufacturers' instructions. Glass-slab, spatula and liquid bottle were kept at room temperature. GI was inserted in the cavities exactly the same manner as group

one. In some recent studies, the effect of using coating in reducing the micro leakage was evaluated and concluded that application of unfilled resin as coating material reduces the micro leakage by filling surface porosities and cracks in addition to filling the gap between material and tooth structure (which is caused by setting shrinkage). Coating is also effective in protection of GIs against moisture or desiccation (14-16).

Therefore, for better comparison between two forms of GIs and mainly evaluating the effects of mixing method, we refused to use unfilled resin, which is presented only in encapsulated GI package. During the GIs set, the teeth were stored in artificial saliva for one week at 37°C (17) and then thermo cycled 600 times between water baths held at 5°C and 55°C with a dwelling time of 30 seconds in each bath. Then, the root apices were sealed with wax in all teeth in order to prevent dye penetration through the pulp chamber. All samples were coated with two layers of nail varnish up to 1 mm border around the margin of the cavity. The teeth were immersed in 0.5% methylene blue solution for 12 hours at room temperature. After that, the samples were washed under tap water and embedded in acrylic resin.

They were sectioned longitudinally in a buccolingual direction by using a micro motor straight handpiece mounted with a rotating and water cooled diamond disc. The sections were examined under the light microscope (Zeiss) at $\times 30$ magnification. The depth of penetration was recorded according to Table 1 (18). Data were analyzed statistically using the Mann-Whitney U tests. The level of significance was set at 0.05.

4. Results

Data collected from occlusal and gingival margin of each group were summarized and presented in Tables 2 and 3. The majority of samples exhibited dye penetration along the tooth-restoration interface. Hand-mixed Fuji IX GIC showed a higher value of mean score of dye penetration (1.6 ± 0.25 in occlusal margins, and 1.8 ± 0.23 in the gingival margin) than encapsulated Fuji IX GIC (1.1 ± 0.21 in occlusal margin, and 1.6 ± 0.24 in the gingival margin). However, statistical analysis by Mann-Whitney U test revealed no significant difference in microleakage between two groups, in occlusal margin ($P = 0.137$) and in gingival margin ($P = 0.663$), Table 2.

Table 1. Dye Penetration Scale

Score	Scale
0	No dye penetration
1	Dye penetration to enamel/cementum margin of the cavity
2	Dye penetration to dentin wall of the cavity
3	Dye penetration up to the floor of the cavity

Table 2. Micro Leakage Score Frequency for Encapsulated and Hand-Mixed GIC in Occlusal Margin ^{a,b}

GIC groups	0 ^c	1	2	3
Capsulated GIC	30	40	20	10
Hand-mixed GIC	20	25	30	25

^a Abbreviation: GIC, glass ionomer cement.^b Data are presented as %.^c Scale of dye penetration according to Table 1.**Table 3.** Microleakage Score Frequency for Encapsulated and Hand-Mixed GIs in Gingival Margin ^{a,b}

GIC groups	0 ^c	1	2	3
Capsulated GIC	20	20	35	25
Hand-mixed GIC	15	20	35	30

^a Abbreviation: GIC, glass ionomer cement.^b Data are presented as %.^c Scale of dye penetration according to Table 1.**Table 4.** Comparison of Mean Score of Dye Penetration Between Encapsulated Glass Ionomer Cement and Hand-Mixed Glass Ionomer Cement ^{a,b}

	Hand-mixed GIC	Capsulated GIC	P value
Dye penetration in occlusal margin	1.6 ± 0.25	1.1 ± 0.21	0.137
Dye penetration in gingival margin	1.8 ± 0.23	1.6 ± 0.24	0.663

^a Abbreviation: GIC, glass ionomer cement.^b Data are presented as mean ± SD.

5. Discussion

In this study, 40 class V cavities were restored in two groups by encapsulated and hand-mixed GI restoratives and compared in terms of their microleakage. Encapsulated GI, in which preportioned powder and liquid are mixed mechanically, are not better than their hand-mixed equivalents, in which powder and liquid are proportioned with spoon and dropper and are mixed by spatula on glass-slab. The result of a number of studies indicated that hand-mixed GIs rarely lead to a satisfying outcome, because of empirical mixing the powder and liquid by 'eye' to the operators' desired consistency instead of using the manufacturer's recommended powder to liquid ratios (9-12). Therefore, hand-mixed cements prepared in clinical settings, have not shown acceptable properties in comparison with encapsulated GI, which might be the result of not following the manufacturer's recommendation during mixing powder and liquid by hand.

The method of mixing is an important factor in achieving an effective contact between powder and liquid and finally a set material with low porosity. In more fluid material, vigorous mechanical mixing results in more air

inclusion, while hand-mixing leads to better mechanical properties and less porosity. Therefore, in material with less viscosity (luting GIs), slow hand-mixing is recommended. In materials with higher viscosity (restorative GIs), method of mixing is not an important factor and in both methods, inclusion of large voids is not significant (19). In the hand-mixing procedures, some errors are unavoidable; errors such as using uncalibrated volume of liquid because of variation in the angle of bottle when it is hold and the pressure exerted to squeeze a drop, the powder packing density achieved on filling the scoop (9, 12) and glass-slab temperature. In the present study, it was concluded that by following the manufacturer's general structures, these errors are negligible but considering the fact that clinicians mostly have a tendency toward using less powder/liquid ratio in order to achieve a less viscous material because of easier mixing and handling, encapsulated GI might have some advantages at least for beginners.

In this study, hand-mixed GI was prepared and used within the first day after liquid bottle opening, but in clinical setting, the liquid in the bottle is used during a period of few months in which case the solvent is evaporated and as a result, the properties of material could be altered. Encapsulation of GI might be a solution to this problem. Because, all factors were not evaluated in our survey, future studies are recommended to compare different brands of GI and in different viscosities. Also, gradual evaporation of solvent in liquid bottle of hand-mixed GIs needs future investigation. It is also suggested that the effect of light-cured coating on microleakage be evaluated. There was no difference between microleakage of hand-mixed and encapsulated GIs and in case of following the manufacturer's instruction and recommendations, hand-mixed GIs could be as efficient as their encapsulated equivalents; however, using encapsulated GIs are more user-friendly in clinical settings.

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Authors' Contributions

Study concept and design: Hamid Moradian and Shiva Jafarian; acquisition of data: Shiva Jafarian; analysis and interpretation of data: Shiva Jafarian.

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