Research Article

Effect of a novel coating material on the microleakage of glass hybrid restoration in primary teeth – An in vitro study

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Abstract: Background: Glass ionomer restorations are widely employed in the field of pediatric dentistry. There is a constant demand for a durable restoration that remains functional until exfoliation. This study aimed to measure and compare the effect of a novel coating material (EQUIA Forte Coat) on the microleakage of glass hybrid restoration (EQUIA Forte HT) in primary teeth. Material and method: Thirty cavitated (class-II) primary molars were allocated randomly into two groups based on the coat application; uncoated (control) and coated group (experimental). Cavities were prepared by the use of a ceramic bur (CeraBur) and restored with EQUIA Forte HT with or without applying a protective coat (EQUIA Forte Coat). Samples went through the thermocycling process and dipped in 2% methylene blue dye before being sectioned through the center of the restoration. Microleakage was evaluated digitally using software and a camera connected to a stereomicroscope (30 x magnification) to assess dye penetration of the sectioned samples at both the occlusal and gingival marginal levels. Results: There was a significant difference between the coated and uncoated groups at both occlusal (p=.029) and gingival margin sites (p=.001). Conclusion: Higher microleakage values were associated with the uncoated group compared to the coated one. The application of a protective coating to the restorations is an efficient approach to decrease the microleakage of the restorations that can be usefully adopted in clinical practice.

Keywords: CeraBur, EQUIA Forte coat, Glass hybrid restorative system, Microleakage, Nano Coat.

Introduction

Dental caries is the oral disease with the highest incidence and prevalence worldwide, which constitutes an oral public health problem [(1)]. The prevalence of dental caries is high in children across the globe. Because primary teeth serve as the foundation for permanent teeth and are highly susceptible to decay, these teeth are considered of utmost significance, and preserving their health is a major health priority [(2)]. The prerequisites for the treatment of decayed primary teeth are conservative tooth preparation and durable restorative materials that remain in function until exfoliation time [(3)]. For the conservative preparation, manufacturers have developed new burs composed of ceramic (CeraBur, Komet, Germany) with the benefits of better tactile feeling and greater excavation capabilities on softened carious dentin while maintaining as much sound dental structure as feasible [(4)].

There is a critical demand to find restorative materials that need fewer steps, less time, and less expense in pediatric dentistry. Glass ionomer restorations have been widely employed in this field since they fulfill those requirements [(5)]. Glass ionomer-based restorative materials have the advantages of chemically adhering to the tooth structure, anti-cariogenic properties through the release of fluoride, biocompatibility, and minimal thermal expansion [(6,7)]. However, these materials also have shortcomings

compromising restoration durability, such as being moisture sensitive, desiccation intolerant, non-stress-bearing, wear-prone, crack-prone, and excessive porosity [8]. To improve the previously existing shortcomings, a glass hybrid-based restoration (EQUIA Forte HT) was introduced in 2019. The new hybrid chemical structure and protective coating system (EQUIA Forte coat) confer the restoration improvement in physicomechanical properties [9]. It is generally accepted that one of the most important factors that determine how long dental restorations will last is marginal leakage at the tooth/restoration interface [10]. A restoration with a satisfactory, marginal seal minimizes marginal deterioration, preventing further leakages and secondary caries [11].

To compare the effect of EQUIA Forte coat on the marginal seal (microleakage), the generated hypothesis was that the applied coating would not influence the microleakage, and the coated group would not significantly differ from the uncoated group. The null hypothesis was compared against the alternative hypothesis. This study aimed to measure and compare the effect of a novel coating material (EQUIA Forte coat) on the microleakage of glass hybrid restoration (EQUIA Forte HT) in primary teeth.

Materials and Methods

Preparation of the sample

The Research Ethics Committee of the University of Baghdad/College of dentistry approved the study (Reference number: 333/333321). This study included thirty cavitated (class-II) primary molar teeth. Over-retentive, serially extracted (Orthodonticlly), and naturally exfoliated teeth were used for this study. Teeth were preserved in a 0.1 solution of thymol after proper prophylactic cleaning until usage [12]. Any tooth having breaks or malformations was eliminated throughout the sample collecting procedure [13].

A single, well-trained operator prepared all the samples. After establishing appropriate access to the carious cavitation by removing carious and undermined enamel using a diamond bur (Henry Schein, USA)[14], cavities were prepared by ceramic bur (CeraBur, Komet, Germany) mounted on slow speed hand-piece to remove carious tissue selectively. Then cavities were washed with water spray, air dried, and a suitable matrix band was applied, preparing them for the restorative procedure.

Restoration of the samples

Glass hybrid restoration (EQUIA Forte HT) was applied with or without a coat (EQUIA Forte coat) according to each group as follows: Before the restoration procedure, the cavities were conditioned for 10 seconds with a cavity conditioner acid (GC, Japan) containing 20% polyacrylic acid, followed by washing and drying.

EQUIA Forte HT (GC, Japan) capsule was mixed in an amalgam mixer according to the manufacturer's instructions (GC, 2019), and immediately injected via the nozzle into the cavities using the Riva applicator (SDI Limited, Australia). The filling was then contoured, and any excess material was removed using a proper instrument.

A water-cooled, superfine diamond bur (Henry Schein, USA) was utilized to finish the restoration. Then, teeth were allocated in a random manner using a simple randomization technique according to the presence of coating into two groups: Uncoated (control) and coated group. The restorations in the coated group were then coated with a thin layer of EQUIA Forte Coat (GC, Japan) using a micro brush applicator and light-cured for twenty seconds as per the manufacturer's instructions (GC, 2019).

Microleakage test

Samples were maintained for 24 hours in a container with distilled water at 37° C. Thermal cycling was performed at 5°C and 55°C water baths for 500 cycles with a 30-second dwell time [15]. To avoid Methylene blue penetration via unfavorable areas, a flowable composite was used to seal the root apices [16], and two coats of nail varnish were applied to the entire tooth except for the restoration and 1 millimeter beyond the margins [17]. At 37°C, samples were immersed in a 2% Methylene blue dye solution for 24 hours, followed by washing with distilled water and drying [18,19]. Samples were embedded in acrylic resin blocks and subjected to longitudinal sectioning through the center of the restoration by XP Precision Sectioning Saw (Ted Pella, USA) in a mesiodistal direction [20]. All the generated sections received digital examination using a stereomicroscope (30 x magnification) with a software (Optika Vision lite 2.1 software) to assess the dye penetration in millimeters at both the occlusal and gingival marginal levels.

Dye penetration assessment was carried out by two trained examiners with 99% intra and interexaminer agreement (intraclass correlation coefficient), who were blinded to the tested groups. Image of each section was obtained using a camera connected to the stereomicroscope, then imported to the software, and the length of Methylene blue dye penetration was measured in millimeters. Each tooth was represented by the section that recorded the highest dye penetration value [21].

Statistical analysis

The analyses of data were performed with SPSS version 26.0 software (SPSS Inc., Chicago, USA). To determine the level of significance at $p < 0.05$, groups were compared using the Mann-Whitney U test.

Results

Effect of the coating on the microleakage

Marginal microleakage values in mm were recorded and analyzed (for both the coated and uncoated groups) at both the occlusal and gingival margin levels, (Table 1).

The occlusal margin site

At the occlusal margin, the Mann Whitney U test revealed a statistically significant difference between the coated and uncoated groups (p=.029), (Figure 1). All of the samples in the coated group exhibited no microleakage (zero values) at the occlusal margin, whereas only 50% of the uncoated group showed no microleakage.

The gingival margin site

At the gingival margin, the results of the Mann Whitney U test showed a statistically significant difference between the coated and uncoated groups (p=.001), (Figure 1). Whereas 60% of the coated group's samples recorded zero value (no microleakage) at the gingival margin, the entire uncoated group showed microleakage.

Effect of coating on the surface of the filling material

It was noticed that the surface appearance of EQUIA Forte HT under the microscope showed cracks in the uncoated samples while smooth crackles surface presented in the coated groups.

Table 1: *Mann Whitney U test compares the microleakage between the coated and uncoated CeraBur groups at the occlusal and gingival margin sites.*

Site	Group	N	Mean Rank	U value	p-value	Significance
Occlusal	**Coated**	15	12	165.0	0.029	S.
	Uncoated	15	19			
Gingival	**Coated**	15	10.33	190.0	0.001	S.
	Uncoated	15	20.67			

S=significant at $p<0.05$

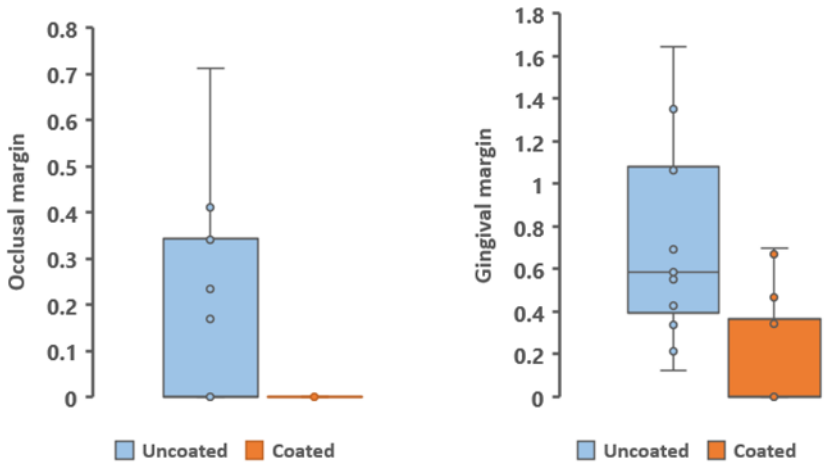

Figure 1: Microleakage in millimeters of coated and uncoated groups represented by box and whisker plot.

Discussion

Primary teeth restoration varies from that of the permanent teeth. The capacity of primary teeth to appropriately support and hold intra-coronal restorations is impaired by the shorter clinical crown heights of these teeth. Additionally, the bigger pulp chambers, pulp horns that are nearer to the surface and the wide contact areas are factors that need consideration concerning the restorative procedures [22].

Glass ionomer (GI) restorations have been used widely in the treatment of primary teeth due to their capacity to chemically adhere to the tooth structure and release fluoride [23]. However, the traditional GI materials possess limitations resulting in marginal disintegration, microleakage, and subsequent restoration failure [3].

One of the essential requirements for the longevity of restoration is an adequate seal between the tooth and the restoration. A weak marginal seal with subsequent microleakage permits the entrance of bacteria and oral fluids, which might contribute to the formation of secondary caries, hypersensitivity, and pulpal pathology [20,24]. Various modifications and formulae have been developed in an attempt to improve the traditional GI restorations [3].

The success of the GI-based EQUIA and EQUIA Forte (GC, Japan) restorations led to the development of EQUIA Forte HT in 2019. It is a novel, capsulated form, glass hybrid substance with a higher viscosity than the previous generations. These glass hybrid materials were created by mixing glass particles of varied sizes with the conventional filler-like, highly reactive, microscopic particles. This property enhances reactivity and physicomechanical properties, making it suitable for long-lasting fillings and allowing an easy bulk placement for stress-bearing class I and II cavities [9,25].

A light-cured nano-filled resin covering EQUIA Forte Coat is another modification of EQUIA Forte HT. According to manufacturers (GC, 2019), this new coat contains nano-fillers that boost mechanical properties and marginal sealing. It also offers protection of the restoration throughout the initial phase of the setting when it is most vulnerable to water absorption or dehydration. Over time, the nano-coating is supposed to wear off as the manufacturer (GC, 2019) designed to allow for the second phase of restoration maturation [26]. In addition, the coat confers a shiny, smooth finish to the final restoration, which adds to its advantage [19,27].

In this study, microleakage was measured and compared in two groups (Equia Forte HT without and with nano-coating) to assess the effectiveness of the EQUIA Forte coat. Since EQUIA Forte HT is a novel material, no available research was found in the widely distributed literature that specifically measured and compared the microleakage values of Equia Forte HT with the use of Equia Forte coat. However, research on previous generations of EQUIA Fil and EQUIA Forte Fil were used to compare the result of this study.

Concerning microleakage, the results of this study revealed that the Equia Forte coat was able to inhibit dye penetration at the occlusal margin of all the samples (100%) and showed significantly less leakage at the gingival margin (60%). This might be due to the protective effect of the nano-coating against water absorption and dehydration in the initial setting and the ability of the coat's nanoparticles to tightly seal any surface imperfections resulting in a better marginal seal. These results agreed with Gopinath, 2017[28]; Gaintantzopoulou et al., 2017[3]; Ali et al., 2019[5]; Habib et al., 2021[19]; Alwan and Athraa, 2021[29], who concluded that less microleakage was associated with the EQUIA and EQUIA Forte restorations with coat application.

Regarding surface texture, coat application resulted in a smooth, lustrous surface, indicating that the coat filled all the possibly formed cracks. The resulted smooth surface is more durable since crack is the future leading to stress points and facilitating future fracture, microleakage, secondary caries, and subsequent failure of restoration, which emphasizes the use of the coating.

Further in vitro studies considering mechanical loading (chewing simulator) are recommended. The study result must be confirmed in vivo with follow-up evaluation after a while to assess the duration of coat wear and the restoration status (Clinical performance) after the coat wearing.

Conclusion

Higher microleakage values were associated with the uncoated group compared to the coated one. The application of a protective coating to the restorations is an efficient approach to decrease the micro-

leakage of the restorations that can be usefully adopted in clinical practice. In addition, the coat imparts a highly glossy texture to the structure of the teeth.

Conflict of interest: None.

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العنوان: تأثير مادة واقية جديدة على التسرب الدقيق لحشوة Glass المهجنة في الأسنان اللبنية - دراسة مختبرية

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المستخلص:

الخلفية: تستخدم حشوات ال**glass ionomer** على نطاق واسع في مجال طب أسنان الأطفال. هنالك طلب مستمر للحصول على حشوات تبقى فعالة حتى موعد سقوط هذه الأسنان واستبدالها بالأسنان الدائمية. هدفت هذه الدراسة إلى قياس ومقارنة تأثير مادة واقية جديدة (**EQUIA Forte Coat**) على التسرب الدقيق لحشوة **glass** المهجنة (**EQUIA Forte HT**) في الأسنان اللبنية.

المواد وطرق العمل: تم استخدام ثلاثين من الأسنان اللبنية ذات التجاويف المتسوسة (الفئة الثانية) وتقسيمها بطريقة عشوائية إلى مجموعتين بناءً على تطبيق الطبقة الواقية ؛ المجموعة غير المطلية (المجموعة الضابطة) والمطلية (المجموعة التجريبية). تم تحضير التجاويف بواسطة سنبلة مصنوعة من السيراميك (**CeraBur**) وتم حشوتها باستخدام **EQUIA Forte HT** مع أو بدون الطبقة واقية (**EQUIA Forte Coat**). مرت العينات بعملية التدوير الحراري وتم غمسها في صبغة الميثيلين الزرقاء بتركيز 2٪ قبل أن يتم قطعها من منتصف الحشوة. تم تقييم التسرب الدقيق رقميًا باستخدام برنامج وكاميرا متصلة بمجهر مجسم (تكبير 30 ×) لتقييم تغلغل الصبغة في العينات المقطوعة على المستويين الهامشي الإطباقي واللثوي.

النتائج: تم العثور على فرق معنوي كبير بين المجموعتين المطلية وغير المطلية في كل من المستويين الهامشي الإطباقي (**p = .029**) واللثوي (**p = .001**).

الاستنتاج: ارتبطت القيم العالية للتسرب الدقيق بالمجموعة غير المطلية مقارنة بالمجموعة المطلية. يعد تطبيق الطبقة الواقية على الحشوات طريقة فعالة لتقليل التسرب الدقيق للحشوات و التي يمكن اعتمادها بشكل مفيد في الممارسة السريرية.