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MICROSHEAR BOND STRENGTH OF SELF-ADHESIVE COMPOSITE VERSUS CONVENTIONAL RESIN-BASED FISSURE SEALANT USING DIFFERENT ENAMEL PRETREATMENT PROTOCOLS

Mayada S. Sultan* *and* Sarah M. S. Khalil **

ABSTRACT

Objective: To evaluate the microshear bond strength of self-adhesive composite versus conventional resin-based fissure sealant using different enamel pretreatment protocols.

Methods: A total of 50 sound human premolars extracted for orthodontic reasons were used for the current study. Teeth roots were sectioned and crowns were mounted in self-cured acrylic resin blocks. The teeth were randomly divided into five equal groups according to the tested materials and enamel pre-treatment protocols as follow; **Group I:** self-adhesive flowable composite (Constic) without enamel pre-treatment, **Group II:** Constic composite with prior enamel etching, **Group III:** Constic composite with prior enamel etching and adhesive resin application, **Group IV:** conventional resin-based fissure sealant (Ultraseal XT plus) with prior enamel etching, **Group V:** Ultraseal XT plus fissure sealant with prior enamel etching and adhesive resin application. Microshear bond strength (μSBS) was tested using a universal testing machine. Data were tabulated and statistically analyzed using One-way ANOVA followed by Tukey's post hoc test.

Results: There was a statistically significant difference between microshear bond strength of the five tested groups. **Group III** showed the highest microshear bond strength value followed by **Group V,** then **Group II** and **Group IV** while **Group I** showed the lowest microshear bond strength value.

Conclusions: Self-adhesive composites have superior performance than conventional resin-based fissure sealants when using enamel pretreatment protocols. The use of enamel etching and adhesive resin before the application of self-adhesive composite and conventional resin-based fissure sealants was beneficial in improving the microshear bond strength.

KEY WORDS: Self-adhesive composite, Resin-based fissure sealant, Enamel etching, Adhesive resin, Microshear bond strength.

* Associate Professor, Operative Dentistry Department, Faculty of Dentistry, Fayoum University, Egypt.
** Lecturer, Pediatric Dentistry and Dental Public Health Department, Faculty of Dentistry, Beni-Suef University, Egypt.

INTRODUCTION

Dental caries is one of the most common oral diseases affecting individual patients and public in terms of medical, social, and economic concerns[1]. It is a multifactorial disease that results from the interaction between specific acidogenic bacteria in the dental plaque biofilm, fermentable carbohydrates, and the tooth surface [2]. The biofilm bacteria produce organic acids that cause demineralization (mineral loss) of hard tooth tissues [3]. In favorable conditions, caries lesions can be reversed by remineralization (mineral gain), as caries development is a dynamic process [4].

Although dental caries can occur at any tooth surface, pit and fissure caries account for approximately 90% of permanent posterior teeth caries and 44% of the primary teeth caries in children [5]. The occlusal surfaces are the most susceptible surfaces to caries because of the characteristic morphology that tends to retain food and bacteria, providing suitable sites for the development of dental caries [6]. The use of caries preventive measures such as topical fluoride application, plaque control, and dietary sugar control has effective results in declining caries prevalence with greater effect on smooth surface carious lesions [7]. However, these preventive measures are less effective when applied to prevent occlusal caries due to the retentive nature of pits and fissures, which makes them difficult to be protected by fluoride administration [6,7].

Pit and fissure sealant is one of the preventive approaches that are applied to occlusal carious lesions to create a physical barrier that facilitates cleaning and prevents plaque accumulation and subsequent demineralization of the deep occlusal pits and fissures [3]. The two predominant types of fissure sealant materials available worldwide are resin-based sealants and glass ionomer-based sealants [7]. Resin-based sealants are most commonly used in clinical practice. They were composed of urethane dimethacrylate (UDMA) or bisphenol A-glycidyl mathacrylate (bis-GMA) monomers [1,8]. They exhibited promising retention rates and good durability because of their better stability under occlusal forces [6].

Sealant retention is dependent on micro-mechanical bonding between resin and enamel, so the resin sealants are applied to the occlusal surface of the tooth using acid-etch technology [9]. The most commonly used phosphoric acid concentrations are 35% and 37% [7]. Achieving adequate adhesion at the interface between hard tooth tissues and restorative materials is crucial. Therefore, the use of adhesive systems prior to fissure sealant application had a positive effect on the sealant, improving sealant penetration and retention [10]. However, reducing the steps of fissure sealant application eliminates the possibility of saliva contamination and improves the marginal adaptation [10].

Previous studies reported that the self-adhesive resin-based sealants achieved lower bond strength compared to the traditional flowable composites that were used with bonding agents [11,12]. Combining an all-in-one bonding system with a flowable composite holds great potential with respect to saving chair time and minimizing handling issues [12]. According to the manufacturer, Constic is a self-etching and self-adhesive flowable composite that combines an etching gel, bonding agent, and flowable composite for a faster, easier, and more efficient treatment process. The manufacturer's claims that Constic has high bond strength and one of its indications is pits and fissures sealing. Microshear bond strength tests determine the material's ability to bond with the tooth structure that in consequence determines its clinical effectiveness [9]. Therefore, this study was conducted to evaluate the microshear bond strength of self-adhesive composite versus conventional resin-based fissure sealant using different enamel pretreatment protocols.

MATERIALS AND METHODS

Specimens' Preparation and Grouping

A total of fifty sound human premolars extracted for orthodontic reasons were used in the current study. The study was approved by Faculty of Dentistry Beni-Suef University Research Ethical Committee for Scientific Studies and Research (FDBSU- REC) with approval number (# REC-FDBSU / 01092022-01/SM). The teeth were washed under running water, scaled from adhering soft tissue and plaque. They were stored in saline at 4°C for not more than one month. Roots of the premolars were horizontally sectioned below the cemento-enamel-junction by 2 mm. Crowns were mounted in self-cured acrylic resin using metal molds (2 cm x 3 cm) with the labial surface facing upward. Enamel was wet ground using 80 grit sandpaper discs to achieve flat enamel surfaces.

Finally, the specimens were rinsed with deionised water and randomly divided into five equal groups (n=10) according to the tested materials and enamel pre-treatment protocols as follow; **Group I:** self-adhesive flowable composite (Constic, DMG, Hamburg, Germany) without enamel pre-treatment according to the manufacturer's instructions. **Group II:** Constic self-adhesive flowable composite with prior enamel etching (35% phosphoric acid, Select HV® Etch w/BAC, Bisco, Schaumburg, U.S.A.), **Group III:** self-adhesive flowable composite Constic with prior enamel etching and adhesive resin application (Single Bond Universal adhesive, 3M ESPE, St.Paul, MN, USA), **Group IV:** conventional resin-based sealant (Ultraseal XT plus, Ultradent, USA) with prior enamel etching, **Group V:** Ultraseal XT plus sealant with prior enamel etching and adhesive resin application.

Enamel pre-treatment procedures:

Group I: (Constic + No enamel pretreatment)

Rubber microtubes of 0.8 mm diameter and 1 mm height (Harvard tubing, USA) were placed on the enamel surface of the specimens receive no enamel pre-treatment and stabilized by sticky wax. The microtubes were filled with Constic flowable composite and were covered with celluloid strips (Stripmat, POLYDENTIA, CH-6805 Mezzovico, Switzerland) then light cured using LED light curing unit (Elipar S10 free light 3M ESPE) with light intensity 1200 mW/cm^2 for 20 sec according to the manufacturer's instructions. After curing, the rubber microtubes were sectioned longitudinally using sharp scalpel and removed. Samples which were debonded during removal of rubber microtubes were excluded. The specimens were then stored in distilled water for 24 h before testing.

Etching groups

Groups II, III, IV, and **V** the specimens were etched for 15 sec using 35% high viscosity phosphoric acid etchant, rinsed for 10 sec under running water and gently dried with air spray for 10 sec until a frosty appearance was seen.

In **Group II**: (Constic + enamel etching) and **Group IV**: (Ultraseal XT plus + enamel etching) the specimens were prepared using the same procedures mentioned in **Group I**. Regarding, **Group IV**: the microtubes were filled with Ultraseal XT plus pits and fissure sealant then light cured for 20 sec according to the manufacturer's.

Bonding Procedures

Group III; (Constic + enamel etching + adhesive resin) and **Group V**; (Ultraseal XT plus + enamel etching + adhesive resin) the bonding was achieved using Single Bond Universal adhesive in etch and rinse mode. Two coats of the adhesive resin were applied on etched enamel surfaces using disposable microbrushs. Rubber microtubes placed on the etched enamel surfaces before light curing of the adhesive resin then the adhesive was light cured for 10 sec according to the manufacturer's instructions. The microtubes in **Group III** and **Group V** were filled with Constic flowable composite and Ultraseal XT plus pits and fissure sealant respectively following the same procedures as mentioned before.

Microshear Bond Strength Testing (μSBS)

The specimens for each group were subjected to microshear bond strength test after 24 h using a universal testing machine (Lloyd LR 5K, Lloyd Instruments Ltd, Hampshire, UK) with a cross head speed of 0.5mm/min. A thin metal wire (0.2 mm diameter) was looped around each restoration cylinder and gently held flushing with the interface. The metal wire was secured in the upper compartment of the universal testing machine. Each specimen cylinder was loaded to failure, and the force required for debonding was divided by the bonded area of the specimens to express the bond strength values in MPa.

Statistical analysis:

Numerical data were tested for normality and variance homogeneity using Shapiro-Wilk and Levene's tests respectively. Data showed parametric distribution and variance homogeneity, so they were presented as mean and standard deviation values and were analyzed using one-way ANOVA followed by Tukey's post hoc test. The significance level was set at $p<0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows*.

RESULTS

Results recorded a statistically significant difference between microshear bond strength of the five tested groups. **Group III; (**Constic + enamel etching + adhesive resin) showed the highest microshear bond strength value (33.59±1.90) followed by **Group V;** Ultraseal XT plus + enamel etching + adhesive resin (25.01±1.32), then **Group II;** Constic + enamel etching (23.93±1.29), and **Group IV;** Ultraseal XT plus + enamel etching (22.40±1.93), while the lowest microshear bond strength value was found in **Group I;** Constic + No enamel pretreatment (8.79±0.64).

Post hoc pairwise comparisons between the groups revealed that there was a statistically significant difference between the different groups. **Group III** showed the highest mean microshear bond strength value ($p<0.001$). In addition, **Group V** showed a statistically significant higher value in comparison to **Group II** and **Group IV** ($p<0.001$). Both groups showed a statistically significant higher values than **Group I,** which showed the lowest mean microshear bond strength value. Mean, standard deviation values and results for intergroup comparisons for micro-shear bond strength values are presented in table (1) and in figure (1).

TABLE (1): Mean, standard deviation values and intergroup comparisons for micro-shear bond strength (MPa) of the five tested groups

Micro-shear bond strength (MPa) (Mean±SD)					f-value	p-value
Group I	Group II	Group III	Group IV	Group V		
8.79± 0.64^{D}	23.93± 1.29^{BC}	33.59± 1.90^{A}	22.40± 1.93^{C}	25.01± 1.32^{B}	357.84	<0.001*

Means with different superscript letters within the same horizontal row are significantly different; *significant (p<0.05).

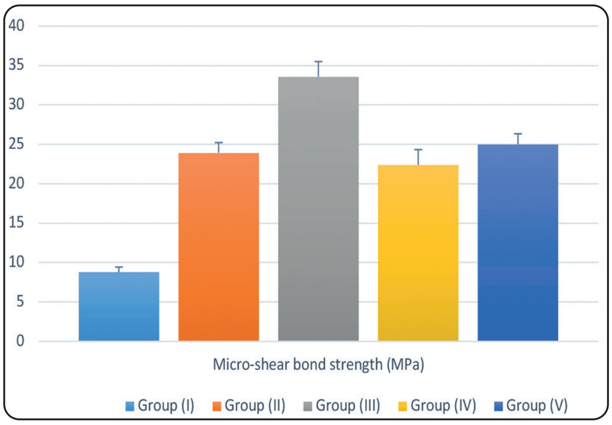

Fig. (1): Bar chart showing the mean and standard deviation values for micro-shear bond strength (MPa) of the five tested groups

* R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

DISCUSSION

Preservation of sound tooth structure and reducing patients' risk for caries have become important concerns for minimally invasive treatment approaches [(13)]. The occlusal surfaces are the most susceptible sites to caries in permanent teeth due to their retentive feature that retain food and bacteria, which become inaccessible to mechanical oral hygiene measures [(6)]. Pit and fissure sealants are widely accepted preventive measures that protect pits and fissures from caries through depriving bacteria from their habitat and forming a barrier to protect the tooth against food accumulation and subsequent further demineralization [(14)]. The effectiveness of sealants is dependent on sealant retention as long as their clinical survival can be predicted by assessing the microshear bond strength [(15)].

Achieving a proper bond and an adequate marginal seal between the enamel surface and the fissure sealant is extremely important to avoid marginal leakage and subsequent passage of bacteria and debris through the tooth-restoration interface, which may result in recurrent caries[(16)]. Therefore, the present study was conducted to evaluate the microshear bond strength of self-adhesive composite versus conventional resin-based fissure sealant using different enamel pretreatment protocols.

The results of the present study showed that all the tested groups revealed a statistically significant effect on microshear bond strength of enamel. **Group III; (**Constic + enamel etching + adhesive resin) showed the highest mean microshear bond strength followed by **Group V; (**Ultraseal XT plus + enamel etching + adhesive resin). Regarding the etched groups; **Group II; (**Constic + enamel etching) showed statistical significant higher microshear bond strength followed by **Group IV;** (Ultraseal XT plus + enamel etching) while **Group I; (**Constic + No enamel pretreatment) showed the lowest microshear bond strength value.

In the present study, **Group I (**Constic + No enamel pretreatment) showed the lowest statistically significant microshear bond strength. According to the manufacturer, Constic is a self-etching, self-adhesive flowable composite which combines an etching gel, bonding agent, and flowable composite in one syringe. It is dependent on the presence of the adhesive monomer glycerol phosphate dimethacrylate (GPDM), which bonds to the calcium ions in tooth tissues, providing a micromechanical and chemical bond [(10)]. This result was in agreement with **Panse et al., 2018** [(8)] who found that shear and tensile bond strength of conventional sealant (Fissurit F) was better than that of Constic.

The results of the etched groups (**Group II and Group V)** showed statistical significant high microshear bond strength. This is attributed to the increase in enamel surface energy by removing the smear layer thus increase the surface wettability [(12)]. Acid etching is possible with the self-adhering composites in **Group II** due to the presence of the phosphate group of the monomer glycerol phosphate dimethacrylate (GPDM) [(7)].

The results of this study showed that **Group II: (**Constic + enamel etching) has statistical significant higher microshear bond strength in comparison to **Group IV: (**Ultraseal XT plus + enamel etching). The explanation for the increase in bond strength in **Group II** is the presence of 10-methacryloyloxydecyl dihydrogen phosphate (MDP) monomer in Constic, which forms stable 10-MDP-Ca salts with the hydroxyapatite, resulting in a strong chemical bond with tooth tissues [(17)].

This result was in accordance with **Korporowicz et al., 2019** [(9)] who reported that self-adhesive flowable composite after enamel etchant was statistically significantly higher than that of the conventional pits and fissures sealant. Also, a previous study reported that acid etching was still mandatory with a self-adhering flowable resin composite to improve retention and obtain better sealing ability compared to resin based sealant [(18)].

The results of the bonded groups with Single Bond Universal adhesive (**Group III and Group V)** showed the highest microshear bond strength values. This might be explained by the presence of 10- methacryloyloxydecyl dihydrogen phosphate (10 MDP) in the adhesive resin constituents that is able to form an ionic interaction with hydroxy-apatite [19]. In addition to acid etch in these groups prior to adhesive resin application increases the wettability of the enamel surface, thus allowing more resin penetration and increasing the depth and number of resin tags [12].

In the present study **Group III;** (Constic + enamel etching + adhesive resin) showed the highest mean microshear bond strength followed by **Group V;** (Ultraseal XT plus + enamel etching + adhesive resin). This may attribute to the composition of Constic, which is a flowable composite with numerous advantageous characteristics, including low viscosity, low elastic modulus, and ease of handling. The higher filler content in Constic composite lowers the porosity and offers better retention than traditional resin based pit and fissure sealants [20].

The findings of this study corroborated those of **Almahdy et al., 2020** [21] who claimed that using a bonding agent prior to fissure sealant application increased the microtensile bond strength. **Mezquita-Rodrigo et al., 2022** [22] found that the best shear bond strength was observed when bonding agents containing 10-methacryloyloxydecyl dihydrogen phosphate in their chemical composition were applied before the application of pit and fissure sealant.

On the other hand, this result was in contradiction with a previous study [23] reported that the use of bonding agents prior to the application of pit and fissure sealant was not necessary to improve sealant retention. This might be explained by the difference in the type of bonging agent and fissure sealant used.

CONCLUSIONS

Within the limitations of the current study, it could be concluded that self-adhesive composites have superior performance than conventional resin-based fissure sealants when using enamel pretreatment protocols. The use of enamel etching and adhesive resin before the application of self-adhesive composite and conventional resin-based fissure sealants was beneficial in improving the microshear bond strength.

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