Shear Bond Strength of Pit-and-Fissure Sealants to Saliva-contaminated and Noncontaminated Enamel

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ABSTRACT

Purpose: The purpose of this study was to investigate the shear bond strength of 2 resin-based pit-and-fissure sealants—Clinpro and Fluroshield—to saliva-contaminated and noncontaminated enamel.
Methods: Forty buccal halves of permanent molar crowns were individually embedded in polyester resin and ground with wet silicone carbide papers to obtain flat enamel surfaces. The specimens were randomly assigned to 2 groups: (A) without contamination; and (B) contaminated with 0.01 ml of fresh human saliva. Each group was divided into 2 subgroups (N=10), according to the sealant applied: (1) Clinpro; and (2) Fluroshield. Shear bond strength was tested at a crosshead speed of 0.5 mm/min. Failure mode was assessed.
Results: Means (MPa) were: (1) A1=7.66±3.12; A2=12.39±4.34; (2) B1=5.05±1.44; B2=10.44±2.35. Data were submitted to analysis of variance and Scheffé's statistical test ($P<.05$). There was a statistically significant difference ($P<.05$) between both the sealants and the experimental conditions analyzed. Fluroshield provided higher bond strength and was different from Clinpro ($P<.05$) in the absence of contamination. Within the saliva-contaminated group, however, no statistically significant difference ($P>.05$) was observed between the tested materials.
Conclusions: It may be concluded that, under dry conditions, the filled pit-and-fissure sealant (Fluroshield) yielded better bonding performance. Salivary contamination undermined the adhesion of both materials to enamel and resulted in lower bond strengths. (J Dent Child 2005;72:95-99)

KEYWORDS: BOND STRENGTH, SEALANT, SALIVARY CONTAMINATION

Since the 1920s, several attempts have been made to reduce the occurrence of caries on the occlusal surfaces, including measures targeted toward elimination of pits and fissures with the aim of enhancing the mechanical cleaning of these areas. Nevertheless, these efforts only succeeded after 1955, when Buonocore[1] published his classic study documenting a pioneer method for mechanical bonding of acrylic resin to the dental enamel previously etched with phosphoric acid. Buonocore's outcomes widened the scope in dental research and further prompted the development of materials with improved adhesion to tooth substrates.

On this basis, over the last few decades dentistry has experienced remarkable scientific and technologic advances. This is true not only in terms of notable improvement of restorative materials and techniques, but also (and perhaps more importantly) considering the review of ancient concepts. This resulted in more efficient oral health management, with emphasis on a preventive overview.

In this context, treating caries-susceptible pits and fissures with sealants has been considered an outstanding adjunctive tool to oral health care strategies and fluoride therapy to de-

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crease occlusal caries. The sealing material is mechanically bonded to the tooth surface and acts as a physical barrier to plaque retention, thus minimizing the harmful action of cariogenic microorganisms on enamel.[2-5] Sealants have been claimed to promote adequate protection of occlusal surfaces, provided they are able to thoroughly fill pits, fissures, and/or anatomical defects and remain completely intact and bonded to the enamel surface for a lifetime.[6]

The preventive benefits of such treatment rely directly upon their retention, resistance to wear, and ability to yield optimal sealing along the enamel-sealant interface and prevent marginal microleakage.[7] Therefore, the long-term clinical success of pit-and-fissure sealants is closely related to the accomplishment of an accurate placement technique.[5]

The findings of former studies[4,8,9] have highlighted the role played by salivary contamination as the main factor related to sealant loss. Retention of pit-and-fissure sealants is considerably decreased when proper salivary control and dry field isolation is not achieved, as is commonly experienced with young children, patients with special needs, and newly erupted teeth. In these cases, even when stringent moisture control procedures are attempted during sealant application, contamination of etched enamel can occur. Saliva and moisture contamination of the etched surface before sealant placement have been cited as the most common reasons for unsuccessful sealing. This is because the microporosities produced by the acid etchant on enamel become partially occluded, thereby preventing optimal resin tag formation and undermining bonding of the sealant.[10] Indeed, pit-and-fissure sealants should ideally be chemically bonded to the enamel surface, which would minimize the influence of acid etching (and its related features) on the bonding protocol.

Newer brands of pit-and-fissure sealants continue to be developed, despite the lack of scientifically based information addressing the bonding performance of these materials. With this in mind, this study aimed to investigate the shear bond strength of 2 resin-based pit-and-fissure sealants applied to the saliva-contaminated and noncontaminated enamel of permanent teeth. One of these products is a recently introduced unfilled material with fluoride release (Clinpro, 3M/ESPE, St. Paul, Minn), and the other is a widely utilized fluoride-releasing, filled sealant (Fluroshield, Dentsply/Caulk, Milford, Del).

METHODS

Forty sound human third molars, extracted within a 6-month period, were selected, cleaned with water/pumice slurry in dental prophylactic cups, and stored in 0.9% saline solution with 0.4% sodium azide at 4°C.

Roots were sectioned 2 mm below the cemento-enamel junction. Crowns were bisected longitudinally in a mesiodistal direction with a water-cooled diamond saw (Minitom, Struers A/S, Copenhagen, DK-2610, Denmark). The lingual halves were discarded. The buccal halves (N=40) were individually embedded in polyester resin (Milflex Indústria Química Ltda, São Bernardo do Campo-SP, 09844-150, Brazil) using PVC rings (2.1 cm diameter; 1.1 cm high), with the enamel surfaces facing up. After resin polymerization, the rings were removed and the resin/tooth blocks were ground with wet no. 180-grit to no. 400-grit silicon carbide (SiC) papers (Buehler Ltd, Lake Bluff, Ill) in a polishing machine (Politriz DP-9U2, Struers, A/S, Copenhagen, DK-2610, Denmark) to expose, flatten, and smooth the enamel surface. Afterward, polishing with wet no. 600-grit SiC paper was accomplished for 30 seconds to produce a standardized smear layer.

To demarcate the enamel-bonding site, a piece of insulating tape with a 3-mm diameter central hole, made via a modified Ainsworth rubber-dam punch, was attached to the specimens' surface. Demarcation of the bonding site aimed to define a fixed test surface, so that the bond strength recorded would solely be related to the predefined area.

The 40 specimens were randomly assigned to 2 groups of equal size: (A) noncontaminated enamel; and (B) saliva-contaminated enamel. Each group was then divided into 2 subgroups (N=10), according to the resin-based pit-and-fissure sealant utilized: (1) Clinpro; and (2) Fluroshield. The materials' compositions, specifications, and manufacturers are displayed in Table 1.

The demarcated enamel sites were etched with 37% phosphoric acid (Etching Gel, 3M/ESPE, St Paul, Minn) for 30 seconds, rinsed thoroughly for 20 seconds, and dried with a mild, oil-free air stream to obtain a uniformly whitish, dull, chalk-like appearance. For group B specimens, the etched surface was contaminated for 20 seconds with 0.01 mL of fresh human saliva[10] collected from the same donor and dropped with a micropipette. Next, the contaminated enamel was gently air dried for 5 seconds.

Table 1. Materials Tested

Material	Clinpro	Fluroshield
Type	Unfilled resin-based pit-and-fissure sealant	Filled resin-based pit-and-fissure sealant
Principal ingredients	Tri-ethylene glycol dimethacrylate, bisphenol A diglycidyl methacrylate, tetrabutylammonium tetrafluoroborate, dichloride methylsilane, silica and dye	Urethane modified, Bis-GMA dimethacrylate, barium aluminoborosilicate glass, Bis-GMA, sodium fluoride, dipentaerythritol pentaacrylate phosphate, titanium dioxide, silica amorphou
Manufacturer	3M ESPE	Dentsply
Batch number	2AW	40509

For both noncontaminated and saliva-contaminated groups, a polytetrafluoroethylene jig (3 mm in diameter, 2 mm high) was placed over the demarcated enamel site and carefully attached with an adhesive system. The jig was completely filled with the sealant, using a syringe with a disposable 30×7 gauge needle to avoid the inclusion of air bubbles. The material was light-cured for 20 seconds with a visible light-curing unit (XL 3000, 3M/ESPE, St Paul, Minn) with a 450-mW/cm^2 output.

Once the bonding procedure was completed, the polytetrafluoroethylene jig was sectioned longitudinally with a scalpel blade, opened, and carefully removed together with the insulating tape used to demarcate the bonding site. This created a sealant cylinder-shaped specimen (3×2 mm) adhered to enamel surface. After a 24-hour storage in distilled water at 37°C, the specimens were air dried and shear bond strength was tested using a knife-edge blade in a universal testing machine (Mod. MEM 2000, EMIC Ltda, São José dos Pinhais, Brazil) running at a crosshead speed of 0.5 mm/min. Bond strengths were recorded in Kgf and converted into MPa. Means and standard deviation were calculated, and data were analyzed by 2-way analysis of variance (ANOVA) using a factorial design with saliva contamination and pit-and-fissure sealant as independent variables. Multiple comparisons were done using Scheffé's statistical test at a 0.05 significance level. Fractured specimens were examined with a ×40 stereomicroscope to assess the failure modes, which were classified as adhesive, cohesive, or mixed.

RESULTS

Shear bond strength means and standard deviations for noncontaminated and saliva-contaminated groups are displayed in Table 2.

Overall, data analysis showed a statistically significant difference ($P<.05$) between the tested pit-and-fissure sealants, with higher bond strength means for Fluroshield. Regarding salivary contamination, it was observed that bond strengths to saliva-contaminated enamel were lower ($P<.05$) than those recorded for noncontaminated enamel.

Considering the interaction between sealant and salivary contamination, no statistically significant difference ($P>.05$) was observed between the sealants under contaminated conditions. On the other hand, in the absence of contamination, Clinpro yielded statistically lower bond strength means than Fluroshield.

The examination of the bonding sites after the shear strength test revealed that an adhesive-failure mode predominantly occurred in both groups. Cohesive and mixed failures were also observed, mainly in the group without salivary contamination.

Table 2. Shear Bond Strength Means (MPa) and Standard Deviation of the Experimental Groups

	1=Clinpro	2=Fluroshield
A=without contamination	7.66± 3.12	12.39±4.34
B=with contamination	5.05± 1.44	10.44± 2.3

DISCUSSION

Pit-and-fissure sealants can be either resin-based or glass ionomer-based materials and provide sealing of occlusal pits and fissures. These materials:

1. obliterate the preferred habitat of *Streptococcus mutans*;
2. enhance self-cleaning;
3. avoid accumulation of cariogenic microorganisms;
4. prevent the occurrence of carious lesions on these sites.[5,12]

The retention of resin sealants is a micromechanical process established by the infiltration and further polymerization of the sealant into the microporosity network created by the acid etchant on enamel surface. Some factors, however, may undermine the bonding of occlusal sealants and, hence, compromise their long-term clinical success. One such factor is contamination of enamel after acid etching.[8] Because of the high enamel reactivity induced by the acid etching, even minute exposures to saliva or oral moisture, as brief as 1 second, may be enough to create a pellicle that occludes many of the micropores and leads to an ultrastructural alteration of etched enamel morphology.

The surface debris left on the etched enamel after salivary contamination considerably impairs penetration of the sealant into the microporosities created by etchant. This interferes with the formation of the resin tags responsible for mechanical adhesion, reducing their number and length, and directly affects the bonding of the sealing material.[13,14] Moreover, it has been demonstrated that rinsing of the contaminated etched surface with water is not enough to remove the organic debris and protein left by saliva.[14] Therefore, when resin tag formation is disturbed by inadvertent contact with moisture and/or saliva during the sealing procedures, poor adhesion and sealant failure should be expected.

These outcomes agree with those of the current investigation, in which the overall bond strength to saliva-contaminated enamel was markedly lower than that recorded under dry, noncontaminated conditions.

In the present study, salivary contamination was induced for 20 seconds, which complies with the methodology proposed by Vargas et al.[11] Different times of contamination—5 seconds,[9] 10 seconds,[8] and 60 seconds[15]—have been suggested in the literature. Tandon et al[16] have compared the tensile bond strengths of a sealant after 1, 5, 10, 30, and 60 seconds of salivary contamination and did not observe a statistically significant difference among the periods tested. Nevertheless, when the conditions (contaminated or not) were compared, the group without salivary contamination showed better bonding performance. The finding that salivary contamination reduces bond strength is not a new finding.[8,9,17-21] It is good for dentists to be reminded of this, however, and to see that this remains true for new sealant materials as well.

Concerning the sealant retention, the need for accomplishment of dental prophylaxis before enamel etching is a controversial subject. Some authors[22,23] support that prophylaxis is an unnecessary step and assign the quality of removal of the acquired pellicle only to acid etching. On the other hand, there are those[24,25] who consider that dental prophylaxis is essential to obtain optimal bonding between the sealant and the enamel surface. For purposes of standardization, in the present study, prophylaxis was performed for all specimens before acid etching.

In this study, Clinpro yielded significantly lower bond strength than Fluroshield. These outcomes would possibly be ascribed to the presence of fillers in Fluroshield, since such particles increase the resistance of the material to abrasion[26] and also probably increase the mechanical resistance of the material. The main difference between the tested sealants relies on the presence or absence of fillers, since both materials are resin-based and contain fluoride in their composition.

A noteworthy point to be highlighted is that, unlike the unfilled sealants, the sealing materials with inorganic fillers in their composition have higher viscosity. This may impair the ability of these sealants to flow into the pits and fissures. The closer to the bottom of the pits and fissures, however, the shorter are the resin tags.[25] Furthermore, the presence of fillers in the sealant formulation may increase the resistance of the resin tags produced.

This study's findings revealed that, despite the expected bonding ability and advertised benefits, recently introduced 3M/ESPE Clinpro unfilled sealant did not perform as well as a widely known, fluoride-releasing, filled sealant (Fluroshield), particularly under dry conditions. Although the results of in vitro investigations cannot be directly extrapolated to clinical conditions, the results of this study may add some helpful information to clinical practice. These results suggest that new materials should not be readily incorporated into daily practice right after they are released into the market.

Clinpro has impressive expected bonding abilities and other advertised benefits, such as the color change feature, ease of application, and absence of filler content. Clinpro, however, did not yield higher bond strength than Fluroshield—a resin-based sealant extensively tested in in vitro and in vivo studies. Further studies and clinical evaluations are required to confront or corroborate these outcomes. Further studies should also assess the ultimate influence of saliva contamination on the long-term bonding performance of newer pit-and-fissure sealants and, thus, predict with some degree of reliability, the quality of the adhesion obtained.

CONCLUSIONS

Based on the methodology employed and results obtained, the following conclusions can be drawn:

1. Clinpro sealant yielded significantly lower bond strength than Fluroshield.
2. Salivary contamination interfered with the shear bond strength of both sealants.

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