ADHESION OF A SEALANT WITH PRE-REACTED GLASS IONOMER PARTICLES UNDER SALIVARY CONTAMINATION: AN IN VITRO STUDY

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Palavras-chave: Selantes de Fossas e Fissuras. Giômer. Resistência ao Cisalhamento. Cimentos de Ionômero de Vidro.

RESUMO

Objetivo: este estudo in vitro comparou as forças adesivas do selante resinoso com o selante da tecnologia Giomer sob contaminação salivar. **Materiais e Métodos**: cinquenta e dois incisivos bovinos foram divididos aleatoriamente em quatro grupos (n=13): GI, um selante resinoso (Fluroshield®) sem contaminação salivar (controle do GII); GII, selante Fluroshield + contaminação salivar; GIII, um selante com tecnologia Giomer (BeautiSealant®) sem contaminação salivar (controle do GIV); e GIV, selante BeautiSealant® + contaminação salivar. Nos grupos de contaminação salivar, a saliva artificial foi utilizada por meio de uma pipeta e, após 20 s, foi seca ao ar e aplicado o selante. Os testes de resistência ao cisalhamento foram realizados usando uma máquina de teste universal. A variância ANOVA de uma via e o teste de Tukey foram usados para comparações múltiplas. Os tipos de fratura foram analisados em estereomicroscópio com aumento de 40X. **Resultados**: as médias e desvios padrão (DP) de adesão para Fluroshield® e BeautiSealant® no grupo sem contaminação salivar foram 15,27 (±0,96) e 11,90 (±0,94), e após contaminação salivar foram 13,14 (±1,03) e 8,95 (±1,33), respectivamente, indicando haver diferença estatisticamente significante entre GI e GII p=0.020, GIII e GIV p=0.041. Falhas mistas foram detectadas em GI (38%), GII (44%), GIII (38%) e GIV (62%). **Conclusão**: houve diminuição estatisticamente significativa dos valores de resistência adesiva nos grupos com contaminação salivar para ambos os selantes estudados. No entanto, não foi observada diferença significativa entre os dois selantes quando comparados os materiais utilizados.

Keywords: Pit and Fissure Sealants. Giomer. Shear Strength. Glass Ionomer Cements.

ABSTRACT

Objective: this in vitro study compared the adhesive strengths of the resin sealant with the Giomer technology sealant under salivary contamination. **Materials and Methods:** fifty-two bovine incisors were randomly divided into four groups (n=13): GI, a resin sealant (Fluroshield®) without salivary contamination (control of GII); GII, Fluroshield sealant + salivary contamination; GIII, a Giomer technology sealant (BeautiSealant®) without salivary contamination (control of GIV); and GIV, BeautiSealant® sealant + salivary contamination. In the salivary contamination groups, artificial saliva was used through a pipette, and after 20 s, it was air-dried and the sealant was applied. Shear strength tests were performed using a universal testing machine. One-way ANOVA variance and Tukey's test were used for multiple comparisons. The fracture types were analyzed using a stereomicroscope with 40X magnification. **Results:** the means and standard deviations (SD) of adhesion for Fluroshield® and BeautiSealant® in the group without salivary contamination were 15.27 (±0.96) and 11.90 (±0.94), and for the group with salivary contamination, 13.14 (±1.03) and 8.95 (±1.33), respectively, indicating a statistically significant difference between GI and GII p=0.020, GIII and GIV p=0.041. Mixed failures were detected in GI (38%), GII (44%), GIII (38%), and GIV (62%). **Conclusion:** there was a statistically significant decrease in the adhesive strength values in the groups with salivary contamination for both the sealants studied. However, no significant difference was observed between the two sealants when the materials used were compared.

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INTRODUCTION

Pit and fissure sealants are widely used in the prevention of caries. The selection of the sealant depends on the patient's age, behavior, and time since the teeth erupted.[1] The use of resin-based sealants is a simple but moisture-sensitive procedure that should be performed in a controlled environment.[2,3] The most appropriate time for the application of occlusal sealants is immediately after the eruption of permanent molars or in the first 18 months after their eruption.[4] Newly erupted teeth are less mineralized and may be more susceptible to caries.[1,5-7] However, some studies have shown that the rate of failure increases when the resin-based sealant is applied soon after tooth eruption with the distal marginal ridge not fully erupted, due to the risk of contamination by moisture and saliva during sealant application.[4,8] Thus, in newly erupted teeth, the control of salivary contamination is a decisive factor for treatment success.[1,9-11] As resin sealants are sensitive to moisture, ionomeric sealants have been indicated as an alternative when absolute isolation is not possible.[12-14] However, a systematic review with meta-analysis by Kühnisch *et al*.[15] on the longevity of pit and fissure sealants reported that ionomeric sealants are often inferior to other materials. The ideal pit and fissure sealant should have adequate bond strength, wear and abrasion resistance, good marginal integrity, and a good cost-benefit ratio.[3,16] Sealant retention is often evaluated by shear bond strength tests, and the results are considered reliable and effective in comparative studies determining the adhesion of materials to the dental structure.[17]

New restorative and preventive materials with combined chemical properties of glass ionomer cements and composite resins have been introduced in the market, called the Giomers. These materials were idealized based on the incorporation of glass ionomer particles with a pre-activated surface (S-PRG-Surface Pre-Reacted – Glass Ionomer – Shofu), and with the capacity to release and recharge fluoride, silicon, boron, strontium, and other ions.[18-21] In vitro studies have shown that the micromechanical properties and biocompatibility of Giomers are similar to those of the conventional composite resins, in addition to showing excellent clinical performance.[18-23] S-PRG technology is used in several dental materials for being highly aesthetic and multifunctional.[1,3,20,21,23,24] BeautiSealant®, a pit and fissure sealant containing S-PRG particles, consists of a fluid material, easy to apply with uniform tonality, and is packed in a syringe for direct filling to avoid the formation of bubbles. Before using the paste, a layer of self-conditioning primer is applied to the enamel surface as a pre-treatment material, without the need to wash the surface after applying the primer.[24,25]

Due to the lack of research evaluating the adhesion of the new sealant, Giomer, the objective of this study was to compare the adhesive strength of this material with that of a conventional resin sealant, with and without salivary contamination. Therefore, the null hypothesis is that there is no significant difference in relation to the materials used.

MATERIALS AND METHODS

This study used fifty-two bovine incisors that were randomly divided into four groups (n=13): Group I, resin sealant (Fluroshield®) without salivary contamination (control); Group II, Fluroshield sealant + salivary contamination; Group III, Giomer technology sealant (BeautiSealant®) without salivary contamination (control); and Group IV, BeautiSealant® sealant + salivary contamination. The teeth were sectioned 2 mm below the cementoenamel junction using a cutting machine (Miniton, Struers A/S, Copenhagen, Denmark). The root portion was discarded and only the crowns were used, which were placed inside ¾ inch polyvinyl rings, measuring 2 centimeters (cm) in height and 2.5 cm in diameter, with the buccal face downwards. Subsequently, the chemically activated acrylic resin (JET, Clássico, Campo Claro Paulista, Brazil) was poured. After resin polymerization, the buccal surfaces of the specimens were flattened in a polisher (Politriz, Struers A/S, Copenhagen, DK-2610, Denmark) with water sandpaper (decreasing granulation from 180 to 600), and then subjected to prophylaxis with pumice and water using Robinson brushes mounted on a micromotor for 15 s, washed and dried for the same time, and then stored at 37°C for 24h.

Preparation and treatment of specimens

The study sample was obtained from a single operator. Groups I and II were conditioned with 37% phosphoric acid for 30 s, washed, and air-dried for 15 s. The specimens were fixed on a metal table developed at the Houstoun Biomaterial Research Center that allowed the enamel surface to be pressed against a bipartite Teflon matrix. The matrix had a central hole in the form of a cylinder, 4 mm high and 3 mm in diameter, corresponding to the area where the material adhered to the surface. Subsequently, the Fluroshield® sealant (3M/ESPE, Maplewood, Minnesota, USA) was inserted into the central hole of the matrix with the applicator tip, and polymerization was performed with halogen light (Ultralux Photopolymerizer, Dabi Atlante S/A Ind. Dental Doctor, Ribeirão Preto, SP, Brazil) at a wavelength of 480 mW/cm^2 for 20 s.

To carry out the salivary contamination of Group II, after acid etching, the enamel surfaces were contaminated with 0.02 mL of artificial saliva (KH_2PO_4, K_2HPO_4, KCl, NaCl,

$MgCl_{2.6}H_2O$, $CaCl_{2.2}H_2O$, NaF, sorbitol, nipagin, nipasol, carboxymethylcellulose (CMC), water, Laboratory of Pharmaceutical Sciences, School of Pharmaceutical Sciences of Ribeirão Preto, University of São Paulo, Ribeirão Preto, SP, Brazil) using a pipette, and after 20 s it was air-dried for the same time, with subsequent placement on the metal table and matrix for the application of sealant.

The specimens from Groups III and IV had the BeautiSealant® primer (#PN 1799; Giomer, Shofu Inc., Kyoto, Japan) applied to the surfaces of each specimen for 5 s and dried for the same time, according to the manufacturer's instructions. The specimens were attached to the same metallic table and Teflon matrix in the same manner as described above, and the BeautiSealant® sealant (Giomer, Shofu Inc., Kyoto, Japan, #PN 1799) was applied to the central hole of the matrix using the applicator tip, and then polymerized with halogen light (Ultralux Photopolymerizer, Dabi Atlante S/A Ind. Médico Odontológica, Ribeirão Preto, SP. Brazil) at a wavelength of 480 mW/cm^2 for 20 s. For Group IV, after application of the primer, the enamel surfaces were contaminated with 0.02 mL of artificial saliva by means of a pipette, and after 20 s it was air-dried for the same time, with subsequent placement on the table and matrix for sealant application. The specimens of the four groups were kept for 24 h and immersed in distilled water at 37°C after application of the sealant.

Shear test

The specimens were coupled to a universal testing machine (MEM-EMIC, São José dos Pinhais, Paraná) for shear tests at the Integrated Laboratory for Research in Biocompatibility of Materials (LIPEM) of the Ribeirão Preto School of Dentistry. The adhesive force values are expressed and recorded in MPa.

Fractures modes

The fracture patterns of the specimens were analyzed using a stereomicroscope at a magnification of 40x to evaluate the failure modes, which were classified as: adhesive fracture (adhesive fracture at the enamel/material interface), cohesive enamel fracture (rupture of the tooth structure), cohesive fracture in the material (breakage of the material structure), and mixed fracture (fracture of both the interface and the material used in the same specimen).

Statistical analysis

The obtained data were statistically analyzed to verify the distribution. One-way ANOVA and Tukey's test were used for multiple comparisons. All the analyses were performed using the GraphPad Prism 4.0 software (Graph Pad Software Inc., San Diego, CA, USA) with a significance level of 5%.

RESULTS

The normality analysis of the data showed a sample number greater than 50 (df=52); therefore, the Kolmogorov–Smirnov test was used as the normality test, with a p-value= 0.200.

The average of the values obtained from the shear test of the resin sealant without contamination by saliva was 15.27 (±0.96), and the average of the values of the Giomer sealant was 11.90 (±0.94). After salivary contamination, the averages were 13.14 (±1.03) for the resin sealant, and 8.95 (±1.33) for the Giomer sealant.

There was a statistically significant decrease in the adhesive strength values in the groups with salivary contamination for both the sealants. However, no significant difference was observed between the two sealants when the materials used were compared. The data are presented in Table 1.

Analysis of the fracture patterns of the adhesion sites of the specimens after the shear strength test showed adhesive failures of 38%, 44%, 24%, and 15% in the Groups I, II, III, and IV, respectively. Cohesive failures included GI (24%), GII (12%), GIII (38%), and GIV (23%). Mixed failures were detected in GI (38%), GII (44%), GIII (38%), and GIV (62%).

***Table 1**: Means and standard deviation of the shear test of the groups with and without salivary contamination.*

	Fluroshield®	BeautiSealant®	*p* values
Without salivary contamination	15.27±0.96 Aa	13.13±1.03 Aa	0.450
With salivary contamination	11.89±0.94 Ba	8.95±1.33 Ba	0.229
p values	0.020	0.041	

*Note: * Different capital letters indicate statistically significant differences between lines.* Equal lowercase letters indicate statistical similarities between columns.*

DISCUSSION

In this study, null hypotheses were accepted. There was no statistically significant difference between the adhesive strength of the resin sealant and Giomer sealant under both the conditions analyzed. The results of this study can be compared with those of similar studies.[11,12] Although the two sealants had decreased adhesive values, there was no significant difference between the groups under salivary contamination.

The efficacy of the sealants as a preventive method against caries effectively depends on the adequate adhesion and retention of the material to the enamel surface.[26] In resin sealants, the retention occurs through a micromechanical process established by the infiltration and subsequent polymerization of the sealant in the microporosity network, previously created by the acid on the enamel surface.[25] High resin sealant retention values are reported in literature.[1,9-12,27]

Salivary contamination or the presence of moisture in the operative field is frequent when adequate isolation is not achieved, thereby, reducing the bond strength between the sealant and contaminated surface and causing a partial or total loss of the material in a short time.[1,9,10,27]

The choice of both the sealants for this analysis is somewhat assertive, as both Fluroshield® and BeautiSealant® are light-cured materials. In addition, the Giomer sealant brings a new perspective to dental materials with the Giomer technology, which is a material containing glass ionomer particles with a pre-activated surface (S-PRG: Surface-Pre-Reacted-Glass-Ionomer, Shofu).[19,20,28,29] The Fluroshield® resin sealant, in turn, is a well-established sealant in the literature; therefore, the comparison between these two materials is of great value. It is necessary to emphasize that the use of an ionomeric sealant could make the comparison between the materials studied unfeasible, considering that the ionomeric material, in addition to not being photoactivated, has its adhesion and composition different from both the sealants studied.[26,30]

The literature shows that there are no superiorities in relation to the classification of materials used as sealants for pits and fissures; therefore, their employability should be chosen according to the specificity of each patient.[26,31] However, resin sealants, when well indicated, offer physical and mechanical properties superior to those of other classifications of sealants, which corroborates the results of this study.[26,31]

The BeautiSealant® is an easy-to-use material that does not require acid conditioning, thus avoiding surface washing and drying. The reduction of technical steps is extremely interesting in pediatric dentistry, as procedures must be conducted more quickly, especially in young children or those with behavioral problems. As a pre-treatment, the Giomer sealant only requires the use of a self-conditioning primer, which must be applied for 5 s on the clean enamel surface, before the sealant is applied.[1,7,25] In this study, the results obtained for the Giomer sealant were similar to those obtained for the resin sealant, showing that it is a promising material, being faster and easier to apply, requires fewer steps, and can be indicated for use under non-ideal sealant application conditions, such as cases in which salivary contamination occurs inadvertently.

Some clinical studies have been performed, and Ntaoutidou *et al.*[7] observed that the retention rate of the Giomer sealant (BeautiSealant, Shofu) was 16.5%, and that of the resin sealant (Seal it, Spident) was 82.2% after 18 months, when applied to the first permanent molars of children between six and 12 years. In a recent clinical study, Topal and Kirzioglu[1] investigated three types of sealants applied at different stages of tooth eruption in children aged 5–8 years. The first permanent molars were considered for the study in the following stages of tooth eruption: stage 3 (more than half of the buccal surface covered by gum, visible occlusal surface), and stage 4 (less than half of the buccal surface covered by gum, visible occlusal surface). After 18 months, the retention rate of the Giomer sealant was lower than that of other resin sealants evaluated in both the stages. In this study, despite being an in vitro assay, salivary contamination negatively affected both the Giomer and resin sealants. Thus, although the manufacturer believes that the Giomer sealant is an alternative for newly erupted teeth, in which absolute isolation is difficult due to the practicality of the technique, further in vivo and in vitro studies are necessary to verify the effectiveness of Giomer sealants.

In the analysis of fracture patterns in conditions of salivary contamination, adhesive fracture is more frequent.[32] However, our study shows that despite salivary contamination influencing a decrease in the shear strength values, both the materials showed a higher percentage of mixed fractures, in which fracture occurs on both the adhesive face and the material.

This study had some limitations inherent to the methodology used. As previously mentioned, both the sealants were applied to smooth surfaces. This parameter was adopted to standardize the adhesion surface of the materials on the enamel surface. In addition, it is believed that the strength of the sealants studied may play a role in their adhesion. In this regard, the microhardness analysis could be a suggestion for future studies on this topic.

Based on the results of this in vitro study, the salivary contamination remains a challenge in clinical practice. Despite the development of new multifunctional materials, such as the Giomer sealants, which represent a new class of hybrid materials that combine the chemical properties of composite resins with glass ionomer cements to work as fluoride reservoirs, and are faster and easier to apply, and possibly an excellent material for caries prevention, more studies should be conducted to evaluate the marginal micro-infiltration, adhesion, and wear resistance, as well as longitudinal clinical studies.

CONCLUSION

Based on the results of this study, it can be concluded that the control groups did not show statistically significant differences between the resin and Giomer sealants, and in the groups with salivary contamination; the adhesion values of the two sealants decreased.

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