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Orginal reseach article

Effects of adhesive systems applied under fissure sealants to microleakage and shear bond strength

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Abstract

Objective: The aim of this study was to examine the effect of bonding agents under fissure sealants on bond strength and microleakage.

Materials and Method: A total of 210 freshly extracted non-carious human third molar teeth were used (105 teeth for shear bond strength and 105 teeth for microleakage assessment). The teeth were randomly assigned to 14 groups, with 15 teeth in each group. Fissurit FX was applied to the etched enamel in the control groups. In the experimental groups, the self-etch adhesives: Clearfil SE Bond, G Bond, Clearfil DC Bond and the total-etch adhesives: Prelude, Adper Single Bond and Optibond S were applied and light-cured followed by the subsequent application and light-curing of Fissurit FX. Shear bond strength was tested to failure in a universal testing machine with a 1 mm/min crosshead speed. The shear bond strength data was analyzed by using One Way ANOVA and Tukey HSD tests. Microleakage was evaluated by using a dye penetration method after mechanical loading and thermocycling. The microleakage data was analyzed by using the Kruskal-Wallis and Tamhane tests.

Results: The microleakage of the Adper Single Bond Plus group was significantly less than that of the control group ($p<0.05$). However, the shear bond strength value of the Adper Single Bond Plus group was significantly less than that of the control group, again. The shear bond strength value of Clearfil SE Bond was significantly greater than that of the control group ($p<0.05$).

Conclusion: Clearfil SE Bond improved the shear bond strength, and Adper Single Bond Plus decreased the microleakage of the fissure sealant. An inverse relationship was found between the microleakage and the shear bond strength performances of Adper Single Bond Plus.

Keywords: Dental bonding; dental leakage; pit and fissure sealants; shear strength

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Introduction

The application of pit and fissure sealants is a non-invasive technique that plays a fundamental role in the prevention of occlusal caries in both primary and permanent teeth.[1] Occlusal caries are often associated with the pit and fissure morphology [2] Retention of food on occlusal surfaces, lack of saliva flow to the fissures and insufficient intake of fluoride are the culprit for the high incidence of occlusal caries.[3,4] The application of pit and fissure sealants is a widely accepted preventive technique. This conservative technique caring with tackling pit and fissure caries is a minimal invasive approach that is even acceptable to most children.[5] The clinical success of fissure sealants is highly related to their appropriate application.[6] A dry enamel surface is mandatory to achieve good adhesion.[7]

Adhesive agents have been used as mediating agents between the enamel surface and the filling. Adhesive systems can be classified into 2 groups in terms of clinical procedures: etch and rinse and self-etch adhesives. The first system includes phosphoric acid etching and primer/adhesive resin in 1 bottle, and the second system includes etching and priming solution in 1 bottle and an adhesive resin or an etch-prime-adhesive as an all-in-one procedure.[8] The published literature indicates that the use of dentin bonding agents before sealant application can be helpful for reducing

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microleakage and increasing the bond strength.[7] In contrast, administration of a bonding agent before the application of pit and fissure sealants did not increase the bond strength.[9] An easy, rapid and realistic method of evaluating these applications is necessary. Similar results obtained under *in vivo* conditions may be obtained under *in vitro* conditions by simulating the oral cavity conditions (thermal changes and chewing forces) in a laboratory environment to mimic the natural aging process. Studies investigating the use of adhesive systems prior to fissure sealant placement are still few in the literature, and the existing works have shown controversial results.[10-14] Because of these different findings, it is necessary to investigate the effect of different bonding agents under fissure sealants on bond strength and microleakage. In the present study, the hypotheses tested was that: (1) the use of a bonding agent under fissure sealants affect the microleakage and shear bond strength, (2) the effect of bonding agents on shear bond strength and microleakage are consistent.

Materials and Method

Microleakage assessment

A total of 105 freshly extracted non-carious human third molar teeth were selected and stored in saline solution. After removing soft tissue residues and calculus, the teeth were cleaned with no-fluoride pumice. The teeth were washed under running water to eliminate pumice residues prior to use, etched with 37% phosphoric acid for 20 sec, and the teeth were randomly assigned to 7 groups, with 15 teeth in each group.

Group 1 (Control group): the fissure sealant 'Fissurit FX' (VOCO GmbH, Cuxhaven, Germany) was applied to the etched and air-dried enamel.

Group 2: Clearfil SE Bond (Kuraray Medical Inc., Okayama, Japan) dentin bonding agent was applied to the etched enamel, followed by the application of Fissurit FX.

Group 3: G Bond (GC Corporation, Tokyo, Japan) dentin bonding agent was applied to the etched enamel, followed by the application of Fissurit FX.

Group 4: Clearfil DC Bond (Kuraray Medical Inc., Okayama, Japan) dentin bonding agent was applied to the etched enamel, followed by the application of Fissurit FX.

Group 5: Prelude (Danville Materials, San Ramon, CA, USA) dentin bonding agent was applied onto the etched enamel, followed by the application of Fissurit FX.

Group 6: Adper Single Bond Plus (3M ESPE Dental Products, St. Paul, MN, USA) dentin bonding agent was applied to the etched enamel, followed by the application of Fissurit FX.

Group 7: Optibond S (Kerr, Orange, CA, USA) dentin bonding agent was applied to the etched enamel, followed by the application of Fissurit FX.

Dentin bonding agents and sealing material were polymerized by using a halogen high intensity light curing unit (Optilux 501, Kerr, Danbury, CT, USA). Washing, air drying, application of the bonding agents and the polymerization procedures were conducted according to the manufacturers` instructions.

Specimens were thermocycled 500 times in an electronic thermal cycling machine (Nova Tic., Konya, Turkey) in water baths at 5±2 °C at room temperature and at 55±2 °C with a dwell time of 30 s in each bath. Specimens were fixed on a chewing simulator (Vega Chewing Simulator, Nova Tic, Konya, Turkey) and each tooth was occluded against a stainless steel antagonist with a rounded end in its center (5 mm diameter). Fifty Newtons (N) of mechanical load was applied 10,000 times at a frequency of 0.5 Hz and then the apical foramens of the teeth were subsequently covered with a sticky wax. All specimens were soaked in a 5% basic fuchsin dye solution for 24 h. The excess solution was removed from the teeth by washing under running tap water. Next, the specimens were sectioned buccolingually and parallel to the long axis with a low-speed handpiece into 3 fragments for microleakage evaluation. After performing the procedures described above, the depth of dye penetration in each section was examined under a steromicroscope with 40× magnification.

Microleakage was graded according to the following criteria:[15] 0: no dye penetration, 1: dye penetration in the occlusal third of the enamel-sealant interface, 2: dye penetration through the middle third of the interface, 3: dye penetration through the apical third of the interface (Figure 1). The data were analyzed by using the Kruskal-Wallis and Tamhane tests.

Shear bond strength assessment

A total of 105 freshly extracted non-carious human third molar teeth were selected and stored in saline solution. After removing soft tissue residues and calculus, the teeth were cleaned with non-fluoridated pumice. The roots were sectioned 1 mm below the cemento-enamel junction and the crowns were embedded into acrylic blocks so that the buccal surfaces faced upward. The buccal surfaces of all specimens were hand-polished with 600 grid silicone carbide paper to provide standard surfaces. Care was taken not to expose the dentin. Subsequently, the specimens were randomly assigned to 7 groups with 15 teeth in each group, and the applications described previously for the microleakage assessment were performed for these 7 groups. A plastic cylinder (height: 2 mm, diameter: 2.38 mm) was placed over the etched and

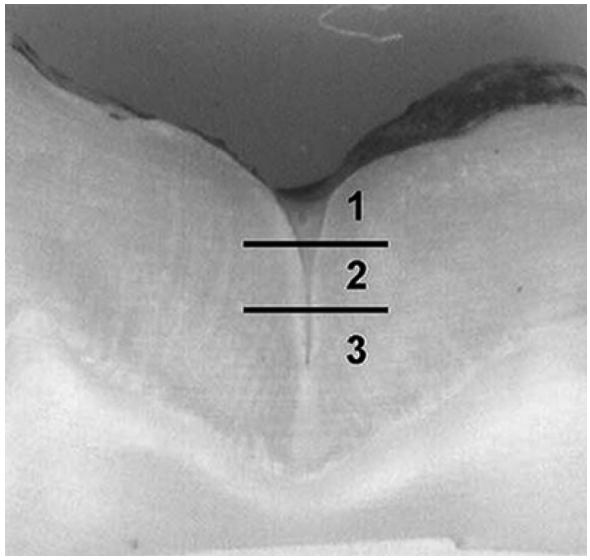

Figure 1. *The scoring system used in the microleakage evaluation. 0: no dye penetration, 1: dye penetration in the occlusal third of the enamel-sealant interface, 2: dye penetration through the middle third of the interface, 3: dye penetration through the apical third of the interface*

bonded enamel surface and the sealant was placed inside the cylinder ring and light-cured from the upperside of the cylinder for 20 sec. The samples were stored in distilled water for 24 h at 37 °C, and the shear bond strength was tested to failure by using a knife-edge blade in a universal testing machine (Testometric, Lancashire, UK) with a 1 mm/min crosshead speed. The data were analyzed by using the One Way ANOVA and Tukey HSD tests.

Results

The control group microleakage value was significantly greater than the Adper Single Bond Plus group ($p<0.05$). There were no statistically significant differences between the Adper Single Bond Plus, G Bond, Clearfil DC Bond, Clearfil SE Bond, Prelude, and Optibond S groups ($p>0.05$; Figure 2).

The shear bond strength values of the groups are presented in Figure 3. A comparison between the groups, revealed that the Adper Single Bond Plus group showed significantly lower shear bond strength values than the control group ($p<0.05$). Clearfil SE Bond group showed higher shear bond strength values than the control group ($p<0.05$). There were no statistically differences among the Clearfil DC Bond, G Bond, Prelude, Optibond S and control groups

Discussion

The pits and fissures of teeth are considered as being highly prone to caries. The application of fissure sealants has been accepted as a reliable method for preventing fissure caries when the sealants are correctly applied. Sealant placement is a painless and non-invasive technique that does not require unnecessary preparation of the tooth structure.[16,17]

Dental materials in the oral cavity are steadily exposed to heat and functional stress.[18] Therefore, in the present study we evaluated the microleakage after mechanical loading and thermocycling as the aging methods.

Previous studies reported conflicting results. Pınar *et al.*[19] and Boksman *et al.*[20] reported that the administration of a bonding agent under fissure sealants did not affect the clinical effectiveness of the fissure sealants. However in a study by Koyuturk *et al.*[21] it was found that bonding application under fissure sealant yielded favorable results in terms of microleakage.

Pits and fissure sealants are applied on the fissures of teeth, where enamel is considered resistant to etching. The sound enamel surface is without prisms, hypermineralized and contains more inorganic material compared with the inner enamel layer.[22] Acid etching of this structure results in the formation of limited porosity

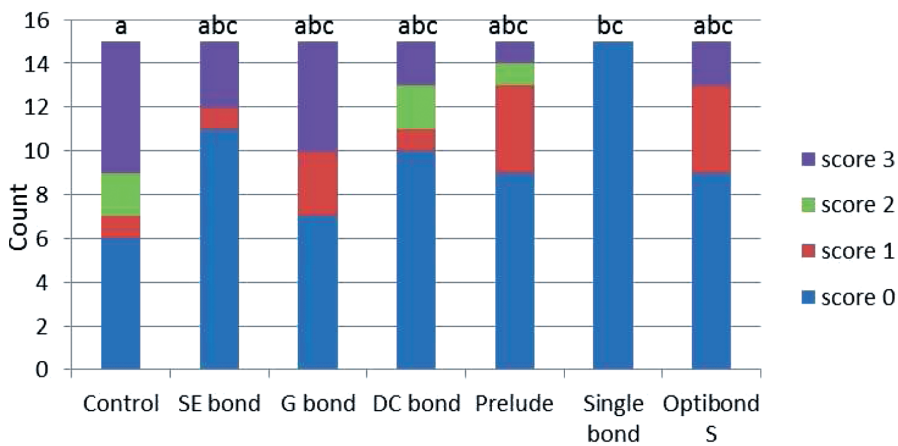

Figure 2. *Distribution of the microleakage scores according to the groups (n=15). Groups with different letters are significantly different (p<0.05)*

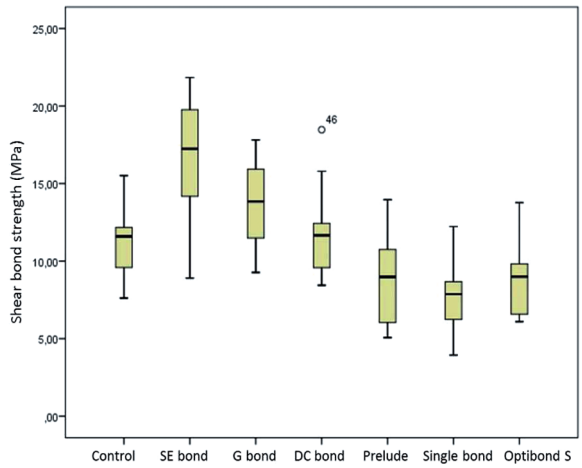

Figure 3. *The shear bond strength values (median, maximum, minimum, 25th percentile, 75th percentile and outlier) of the groups (n=15)*

and resin penetration, revealed by short resinous tags.[23] However, the effect of a self-etching primer system on the aprismatic structure of enamel is weaker than that of an etch and rinse adhesive system.[24] In our study, it was confirmed that the extent of microleakage under sealants bonded with the etch and rinse adhesive (Single Bond Plus) was less than those achieved with the self-etch adhesives.

In most studies, the investigators used enamel surfaces flattened by silicone carbide paper before the application of adhesive resins for the bonding test.[25,26] Because of the technical difficulties of measuring the bond strength to intact enamel, in the current study, flattened enamel surfaces were prepared for the shear bond strength test. The study by Kanemura *et al.*[27] indicated that the self-etch adhesive primer produced less enamel demineralization than did the phosphoric acid; nevertheless, the self-etch adhesive system had a high bond strength to flattened enamel surfaces. Al-Sarheed[28] and Dhillon & Pathak[29] reported that the shear bond strength of pit and fissure sealants was higher with self-etching primer as compared to that achieved with conventional etching. These results are in agreement with our findings in that Clearfil SE Bond (a self-etch system) showed the highest shear bond strength in the present study. Probably, the self-etching primer is acidic enough to provide adequate retention of the resin to the flattened enamel.

Several studies reported that the administration of a bonding agent is favorable for the reduction of microleakage, and can also increase sealant retention.[30,31] These studies were performed in saliva-contaminated environments, whereas the present study was conducted under isolated conditions. The results of the study by Tulunoğlu *et al.*[7] revealed that the use of a bonding agent under fissure sealants in primary teeth increases the success of the application in both contaminated and non-contaminated conditions. Moisture-contaminated specimens gave better results than administering the sealant on non-contaminated enamel.

In the present study, for the microleakage assessment, mechanical loading and thermocycling were applied to the specimens and these aging protocols may have affected the mechanical properties of the bonding agents. Most available dental adhesives show good immediate retention and adhesive interface sealing. But after aging, some changes may occur such as contraction and expansion stress combined with an increase in chemical degradation and increased resin/tooth gap.[32,33] Adper Single Bond Plus showed the best performance in the microleakage assessment, whereas this was not the case in the shear bond strength assessment. A reduction in the microleakage performance was observed also in the Clearfil SE Bond case. These findings may be related to the aging protocols. It was reported previously that there was no relationship between marginal gap formation and bond strength[34] which is in agreement with our study.

Conclusion

Clearfil SE Bond increased the shear bond strength and Adper Single Bond Plus decreased the microleakage of the fissure sealant, and for that reason, the first tested hypothesis was accepted. The shear bond strength and microlekage of different bonding applications were different, so the second hypothesis was rejected. An inverse relationship was found between the microleakage and SBS performances of Adper Single Bond Plus.

Conflict of interest disclosure: The authors declare no conflict of interest related to this study.

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Fissür örtücünün altına uygulanan adezivlerin makaslama bağlanma kuvveti ve mikrosızıntıya etkisi

Özet

Amaç: Bu çalışmanın amacı fissür örtücünün altına adeziv uygulamanın makaslama bağlanma kuvveti ve mikrosızıntıya olan etksinin incelenmesidir.

Gereç ve Yöntem: Çalışmada 210 adet yeni çekilmiş çürüksüz insan üçüncü molar dişi kullanıldı (105 adet diş bağlanma dayanım testi için ve 105 adet diş mikrosızıntı için). Dişler rastgele 14 gruba ayrıldı (n=15). Kontrol gruplarında asitlenmiş mine yüzeylerine Fissurit FX uygulandı. Diğer gruplarda asitlenmiş mine yüzeylerine kendinden pürüzlendirmeli (self-etch) adezivler Clearfil SE Bond, G Bond ve Clearfil DC Bond ve tam pürüzlendirme (total-etch) ardından uygulanan Prelude, Adper Single Bond ve Optibond S adezivleri uygulandı. Daha sonra Fissurit FX uygulanarak polimerize edildi. Bağlanma dayanım kuvvetinin değerlendirilmesinde üniversal test cihazı kullanıldı. İstatistiksel değerlendirmede tek yönlü varyans analizi ve Tukey çoklu karşılaştırma testi kullanıldı. Mekanik ve termal yaşlandırmadan sonra mikrosızıntı değerlendirmesi için boya penetrasyon yöntemi kullanıldı. Veriler, Kruskal-Wallis ve Tamhane testleri ile istatistiksel analize tabi tutuldu.

Bulgular: Adper Single Bond Plus grubunun mikrosızıntı değeri istatistiksel olarak kontrol grubundan düşük bulundu ($p<0.05$). Adper Single Bond grubunun makaslama bağlanma değeri kontrol grubundan istatistiksel olarak, yine düşük bulundu. Buna karşın, Clearfil SE bond grubunun makaslama bağlanma dayanım değeri kontrol grubundan istatistiksel olarak daha yüksek bulundu ($p<0.05$).

Sonuç: Clearfil SE Bond, fissür örtücünün makaslama bağlanma dayanımını arttırdı; Adper Single Bond Plus, fissür örtücünün mikrosızıntısını azalttı. Adper Single Bond Plus için bağlanma dayanım kuvveti ve mikrosızıntı arasında ters bir ilişki olduğu görüldü.

Anahtar Kelimeler: Çukur ve fissür örtücüler; dental sızıntı; diş yapıştırma; kayma mukavemeti