In vitro comparison of the bond strength to the enamel of conventional and self-etching dental fissure sealants

**ABSTRACT**

**Aim** Dental caries in pits and fissures of molars is still very common in young people, despite a gradual reduction in their incidence and prevalence. Prevention with the aid of dental fissure sealants can help to reduce the onset of decay. In vitro tests were conducted to compare the bond strength to enamel of self-etching sealants versus those applied using the conventional procedure.

**Methods** The lingual surface of 40 extracted, caries-free, mandibular third molars was milled to make them flat. The prepared teeth were randomly divided into two groups of 20 teeth each: those in Group A were treated with Clinpro (3M ESPE, St. Paul, MN, USA); those in Group B with Quick Seal (BJM Laboratories Ltd, Or-Yehuda, Israel). Cylinders of sealant were attached to the enamel of the flat surfaces of the samples using a polymerisation process treating the surfaces involved according to the type of material. All samples underwent load testing by means of a universal test machine.

**Results** The results of the load testing, measured in MPa, were analysed using the Student’s t-test for independent samples and the differences proved significant, indicating that the traditionally-applied sealant (mean strength 21.06 MPa) assured a significantly stronger bond (p < .05) than the self-etching sealant (mean strength 10.43 MPa) under our experimental conditions.

**Conclusion** Conventional sealants generally provide a considerably higher bond strength than self-etching sealants.

**Keywords** Bond strength; Self-etching sealant; Shear test.

**Introduction**

Changes occurring in the epidemiology of dental decay, such as the decline of caries and the different patterns of clinical progression of the disease, have had a major fallout on the diagnosis and treatment of incipient lesions, which have increasingly aimed at preventing caries and preserving the tooth structure [Brunelle et al., 1997; Brown et al., 1995]. Despite the considerable reduction in the prevalence of dental caries, this condition continues to be one of the main public health problems and, in absolute terms, it is the most prevalent condition among the paediatric and adolescent populations of the Western world [Ferro et al., 2007a; Mazzoleni et al., 2008]. In these age groups dental decay mainly affects the enamel surface of the tooth, particularly the pits and fissures on the occlusal surfaces of the first and second permanent molars, whereas the smooth surfaces of the teeth are almost entirely unaffected because they are easier to clean and the enamel layer is thicker and better protected by fluoride prophylaxis.

Taking action on the related risk factors (the bacterial flora causing dental caries, a diet rich in fermenting carbohydrates, low host defenses, socioeconomic factors) and adopting increasingly effective prevention protocols have led to a drastic reduction in the onset of dental decay in young patients [Ferro et al., 2007b; 2012]. Sealing the pits and fissures in the permanent molars has proved a valuable aid in preventing the initial start of any dental decay [Albani et al., 2005].

Dental fissure sealing consists in applying a fluid resin over the occlusal surface of the molars (pretreated to facilitate the retention of the resin on the surface of the tooth), then the resin is polymerised with a halogen lamp. This procedure is painless and minimally invasive [Bromo et al., 2011] and ultimately facilitates oral hygiene. Fissure sealing is an effective and advisable procedure for the prevention of dental decay on the occlusal surface of the permanent molars [Ahovuo-Saloranta et al., 2004].

The method is also safe and, within certain limits, prevents the progression of any incipient dental caries [Mertz-Fairhurst et al., 1986]. The validity of sealants in preventing dental decay [Swift, 1988] is based on the physical barrier that prevents any metabolic exchanges between the microorganisms in the fissures and the oral cavity [Handelmann et al., 1976; Mertz-Fairhurst, 1984].

The clinical success of fissure sealing relies on how well the resin bonds to the enamel and remains intact, and the durability of the procedure varies in relation to the
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anatomy of the tooth’s surface and its retentive capacity, which is strongly influenced by accurate cleaning before the resin is applied [Mc Lean et al., 1979]. Orthophosphoric acid is often used to treat the cleaned enamel surface of the tooth [Jeronimus et al., 1975]: during this step, it is important to keep the operative field dry by isolating it from the saliva since this moisture could limit the resin’s functional stability and durability [Going et al., 1976]. It is consequently advisable to apply the sealant only after isolating the tooth with a rubber dam to avoid saliva contamination of the etched surface of the enamel or the resin [Duangthip et al., 2003; Mazzoleni et al., 2007].

The primary goal of fissure sealing is thus to reduce the risk of dental decay by protecting the dental tissue against any external source of damage [Herrera M et al., 2009]. Sealants play an important part in the prevention of dental decay and children whose molars are not sealed are at higher risk of full-blown caries [Tapias Ledesma et al., 2002].

The aim of our study was to compare the strength of the bond between two different types of fissure sealant and the enamel surface of the tooth by testing the mechanical load required to detach the sealant from the tooth. In assessing our results the different modes of application of the two sealants and the number of steps involved were also taken into account.

Materials and methods

Forty caries-free, impacted third molars were extracted, cleaned to remove any periodontal residue and debris and stored in saline solution for 30 days before processing [Wadenya et al., 2009].

The teeth were randomly divided into two groups of 20 teeth each, Group A and B, which were sealed with conventional Clinpro sealant (3M ESPE, St. Paul, MN, USA) and Quick Seal self-etching sealant (BJM Laboratories Ltd, Or-Yehuda, Israel), respectively.

The roots of all the teeth were removed using a Resista abrasive separator disc 0.6 mm thick and with diameter of 13 mm (Metaldent, Rome, Italy). The crowns were mounted in square (10x10 mm) copper rings and fixed with Vertex self-curing resin (Dentimex BV, Zeist, Netherlands), leaving only the lingual surfaces exposed. The lingual surfaces were milled on a Fresart 83 Artiglio parallelometer (Metaldent, Rome, Italy) with an 837F diamond bur (Meisinger, Neuss, Germany) to remove a 0.3 mm layer of enamel and flatten the surface. Each tooth then underwent digital radiography to check for the complete removal of the enamel or invasion of the dentine layer during milling on the parallelometer.

Cylinders of fissure sealant, obtained using transparent hollow plastic cylindrical containers 0.275 mm in diameter and 10 mm high as a mold, were bonded to the enamel of the lingual surfaces of each prepared sample (Fig. 1).

The cylinders of sealant were obtained with Clinpro for Group A and Quick Seal for Group B according to the manufacturers’ instructions.

- Group A - Clinpro (3M ESPE, St. Paul, MN, USA). This resinous fluoride-releasing fissure sealant is suitable for photopolymerisation and is applied after etching the surface of the tooth with 37% orthophosphoric acid for 20 s, followed by rinsing with water for 1 minute. The cylinder of sealant was then polymerised for 60 s with a LED-technology Easylight photopolymeriser (R&S, Paris, France).

- Group B - Quick Seal (BJM Laboratories Ltd, Or-Yehuda, Israel). This is a light-activated, fluoride-releasing, self-etching fissure sealant that is applied to the enamel in a single step, with no need for any preparatory acid etching and rinsing. The cylinders of sealant were polymerised using the same LED-technology Easylight photopolymerizer (R&S, Paris, France), again for 60 s.

The samples were wrapped in cotton wool and stored for one month in an environment with a relative humidity of 100% to prevent any dehydration before the bond strength tests [Wadenya et al., 2009].

Each sample then underwent shear testing in an all-purpose Model 3366 machine (Instron, Milan, Italy), using the machine’s punch to load the sealant cylinders at the cylinder-tooth interface up to failure [Wadenya et
al., 2009] (Fig. 2, 3). For each tooth, the ultimate bond strength was recorded in MPa resulting from the ratio of the force applied to the surface area of the sealant. Based on the machine settings, a standard loading rate of 1 mm/min was used during the tests.

### Results

Descriptive statistical analyses were initially conducted on the results (Table 1) to identify the trend of the variables considered and assess the normality of their distribution (Fig. 4, 5). The mean value in Group A was 21.06 MPa, with a standard deviation (SD) of 3.19891, maximum and minimum values of 26.7 and 15.4 MPa, respectively, and a median of 21.25 MPa. For Group B, the mean value was 10.43 MPa, SD 3.44568, the maximum and minimum values 16.3 and 3.5 MPa, and the median 10.4 Mpa (Fig. 6). Having ascertained the normality of the distribution of the variables, for the statistical analysis Student’s t-test was used to compare the means of independent samples: the results were found statistically significant. Since the result of the Leven test was >0.05, it was assumed that the variances were the same so a p value of <0.05 in the t-test indicated that the bond strength obtained in Group A was statistically higher than the bond strength obtained in Group B (F=0.114; p=0.00).

### Discussion

This study compared the bond strength to the enamel achieved using two different methods for applying
fissure sealants. Some differences emerged, both in the procedure of application and in the results obtained in terms of strength of the bond between the tooth and the sealant.

As reported by Wadenya et al. [2009], in agreement with our study, the bond achieved with the self-etching sealant was clearly much weaker than the bond obtained with the classic sealant applied after the enamel etching process [Wadenya et al., 2009]. The bond strength values recorded for the self-etching sealant (mean 10.43 MPa) was far from negligible, however, and higher than the strength range needed to ensure the clinical efficacy of the fissure sealing treatment, given that sealants used for this purpose are not generally subject to excessive loading [Borsatto et al., 2008]. In fact, Borsatto et al. [2008] calculated that 12.28 (± 4.29) MPa is an adequate bond strength for fissure sealants. The bond strengths achieved in our tests with the self-etching sealant falls within this range, which would therefore ensure adequate results in clinical practice.

Apart from their bonding strength, there is no other substantial physical or mechanical difference between one-step sealants and conventional sealants, but the former have the advantage of reducing the time taken to complete the fissure sealing procedure because there is no need for any preparatory etching and rinsing steps. This is an important, highly positive feature in clinical practice when it comes to applying the product in young patients (as is often the case), who are frequently unwilling to submit to dental treatments. Being able to speed up the process solves or contains a number of problems such as: children’s difficulty in submitting to lengthy treatment sessions; saliva contamination of the surface being treated; unfeasibility of using rubber dams; and poor patient compliance [Deery et al., 2005].

The clinical success of fissure sealing depends on the ability of the material to bond firmly to the surface of the enamel and reliably isolate pits and fissures of molars from the oral cavity; these characteristics are directly influenced by all the above-mentioned factors.

In some clinical settings, therefore, self-etching sealants compensate for their weaker bond strength with the advantage of being quicker and easier to apply [Pithon et al., 2007].

In the light of our findings, we can confirm that the conventional fissure sealing method still assures more reliable results, but self-etching sealants can nonetheless perform sufficiently well for clinical purposes.

It would probably be advisable to adopt the latter in less cooperative patients at high risk of dental decay in order to enable early fissure sealing, as soon as the first molars erupt; then further action can be taken with a traditional fissure sealant and a multi-step process later on, when the child is older [Herrera et al., 2009].

The micro-infiltration of self-etching sealants appears to be comparable with that of sealants applied after using etching procedures [Wadenya et al., 2009].

Conclusion

Based on the findings obtained in our in vitro tests, and within the limits of our approach, the following conclusions can be drawn.

1) Fissure sealing with a self-etching sealant is an easier procedure because there are fewer steps involved, making it preferable in some cases.

2) Conventional sealants generally assure a considerably higher bond strength than self-etching sealants.

3) Despite the weaker bond of self-etching sealants to enamel, they demonstrated a far from negligible bond strength, sufficient to guarantee the clinical efficacy of the treatment.

References


