Influence of air abrasion and etching on enamel and adaptation of a dental sealant

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ABSTRACT. Aim of this study was to evaluate the marginal microleakage of a dental sealant using different pre-treatment techniques of the enamel surface. Methods Thirty extracted human intact teeth were selected and divided into 3 groups (n = 10) (1: acid etching with 37% orthophosphoric acid – 3M ESPE, St. Paul, Minnesota, USA; 2: air abrasion; 3: air abrasion + acid etching). The sealant (Helioseal, Vivadent Ivoclar AG, Liechtenstein) was applied into occlusal pits and fissures and light cured for 40 sec. All samples were thermocycled for 300 cycles (5°C-55°C). Teeth were then immersed into a 2% methylene blue solution for 24 hrs and sectioned in a mesio-distal direction. Forty-eight sections were obtained for each group. Each section was analysed and photographed with a stereomicroscope (50x) assessing dye penetration (0: no dye penetration; 1: dye penetration restricted to the outer half of the sealant; 2: dye penetration restricted to the inner half of the sealant; 3: dye penetration into the underlying fissure). Statistics Data were statistically analysed (Mann-Whitney test). Results Specimens prepared after air abrasion combined with acid etching showed lower microleakage expression if compared with the other two groups (p<0.01). Conclusion A combination of mechanical air abrasion and chemical acid etching represents an effective pre-treatment of enamel surface that may significantly reduce the risk of microleakage.

Keywords: Dental sealants, Air-abrasion, Acid etching, Microleakage, Marginal infiltration.

Introduction
Dental caries is still one of the most common diseases affecting the oral cavity and occlusal pits and fissures are the major areas involved by the carious process [Bohannan, 1993]. The complex morphology of the occlusal surface, leading to bacterial accumulation and proliferation, is responsible for the development of 60-85% of all carious lesions in these zones [Dummer et al., 1990; Hicks and Flaitz, 1993; Kaste et al., 1996]. An effective method for preventing occlusal caries is represented by pit and fissure sealing, a conservative and pain-free procedure [Simonsen RJ, 1989; Waggoner and Siegal, 1996; Simonsen, 2002].

Dental sealants are able to isolate pits and fissures from bacteria and their acidic metabolites [Going et al., 1978]. It has been demonstrated that marginal adaptation of dental sealants gradually reduces over time and after 5 years a marginal microleakage, responsible for oral fluids infiltration at the tooth-sealant interface, can be observed in 50% of all cases [Going et al., 1978]. Since microleakage has been defined as the passage of bacteria, fluids, molecules, or ions between the cavity surface and the applied restorative material [Srinivasan et al., 2005], microleakage at the tooth-sealant interface may affect the efficacy of sealants by providing a bacterial pathway which supports the progression of the cariogenic process underneath the sealant [Going et al., 1978].

An optimal retention and adaptation of the sealant, in order to prevent marginal microleakage, is dependent on the type of enamel pre-treatment [Ansari et al., 2004]. Pre-treatment of the enamel surface is mandatory to obtain the access to the deepest areas of pits and fissures, remove stains and organic debris and increase surface roughness [Geiger et al., 2000]. Pumice prophylaxis is able to remove debris from those areas that are easily accessible but not in deep pits and fissures [Ellis et al., 1999]. Acid etching with
phosphoric acid represents the standard procedure for pre-treating hard dental tissues surface. The etching agent increases enamel surface roughness and ensures resin tag formation providing a micro-mechanical interlocking at the enamel-sealant interface [Silverstone, 1972].

Acid etching is a technique-sensitive method [Kanellis et al., 1997] and no complete cleaning of the pit and fissures before sealant placement can be sometimes achieved [Garcia-Godoy and de Araujo, 1994; Garcia-Godoy and Gwinnett, 1994], especially in deep fissures, which are more difficult to clean and etch thus affecting the ability of the sealant to isolate these fissures [Taylor and Gwinnett, 1973; Symons et al., 1996]. Results of studies on microleakage of sealants placed by the conventional method of acid etching enamel are controversial [Wright et al., 1999; Hatibovich-Kofman et al., 2001].

In order to decrease marginal microleakage, alternative enamel pre-treatment methods have been recently proposed: air-abrasion with aluminium oxide particles delivered by air pressure [Kanellis et al., 1997; Hatibovich-Kofman et al., 1998; Wright et al., 1999] or combined techniques (air-abrasion associated with acid etching) showed promising preliminary results [Ellis et al., 1999; Hatibovich-Kofman et al., 2001]. It has been postulated that air abrasion allows for complete cleaning of pits and fissures prior to sealant placement [Kanellis et al., 1997] and may be able to help detect hidden caries [Goldstein and Parkins, 1999]. Moreover air abrasion may reduce patient’s discomfort by eliminating the vibration, pressure and noise associated with rotational burs mounted on handpieces [Wright et al., 1999].

Since air abrasion increases enamel surface roughness, some authors have suggested that it may substitute acid etching when applying pit and fissure sealants [Kanellis et al., 1997; Wright et al., 1999], while other studies indicated that significantly more microleakage occurs using air abrasion alone when compared to acid etching only [Olsen et al., 1997; Hatibovich-Kofman et al, 1998; Vawerenn Hogervorst et al., 2000]. It has been suggested that a combination of mechanical air abrasion and chemical acid etching may be more effective than acid etching alone in preventing microleakage [Ellis et al., 1999; Hatibovich-Kofman et al., 2001].

Aim of this study was the evaluation of the effect of acid etching, air abrasion and air abrasion combined with acid etching of occlusal pits and fissures on marginal microleakage of a dental sealant. The null hypothesis tested was that there is no difference in treatment of enamel surface prior to sealant placement.

Materials and methods

Thirty recently extracted non-carious human third molars were selected for the study (patients 18-50 years old). Teeth were collected after informed signed consent was obtained by donors under a protocol approved by the University of Trieste. Teeth were stored in a 0.5% chloramine solution up to 2 weeks at 4°C. Occlusal surfaces were cleaned with a prophy brush mounted on a slow-speed handpiece with a water-based slurry of pumice for 10 sec and then thoroughly rinsed for 30 sec with water and air dried. Teeth were then randomly divided into 3 groups (n = 10) associated with different enamel treatment techniques: group I was acid etched with 37% orthophosphoric acid (3M Espe, St. Paul, Minnesota, USA) for 30 sec; in group II air abrasion was performed using 50 μm alumina particles (sandblaster Danville Micromecet) at 2 atm for 30 sec and a distance from enamel surface of 4.5 mm; group 3 was prepared with air abrasion followed by water rinsing for 30 sec and air drying and then acid etching. Both treatments were performed with the same procedures described above. All teeth were finally rinsed with water for 30 sec and air dried. An opaque dental sealant (Helioseal, Ivoclar Vivadent AG, Liechtenstein) was then applied into occlusal pits and fissures using a disposable tip. In order to prevent the air bubble formation the resin was adapted into fissures using a small dental probe (diameter 0.5 mm). The sealant was light cured for 40 sec with a halogen curing unit (Heliolux DLX, Ivoclar Vivadent AG, Liechtenstein). All samples were thermocycled for 500 cycles between 5°C and 55°C at 0.5 cycle/min (Thermocycler WIllytec, 5D Mechatronic GmbH, Feldkirchen-Westernham, Germany).

Teeth apical foramen was sealed with sticky wax to prevent penetration of the dye. Root external surface was completely coated with a double layer of nail varnish. Once the nail varnish was dry, each tooth was placed in a 2% aqueous solution of methylene blue, buffered to pH 7 for 24 hrs at 37°C. The teeth were then rinsed thoroughly in tap water and roots were sectioned at the cementum-enamel junction with a diamond bur mounted on a high-speed handpiece. Crowns were embedded into a low viscosity epoxy resin (Buehler Epo-thin) and sectioned in a mesiodistal plane using a 0.4 mm diamond blade in a microtome (Accutom Struers). Sections were placed approximately at 1 mm distance from each other. In this way 48 sections were obtained for each group.

Each section was examined under a stereomicroscope (50x) and photographed with a digital camera. The sealant/tooth interface was
completely imaged. The photographed images were scored by a blind trained examiner. A microleakage score from 0 to 3 was given to each section based on dye penetration and tooth-sealant interface. According to Överbö and Raadal (1990) a score of 0 on the scale represented no dye penetration. A score of 1 represented dye penetration restricted to the outer half of the sealant; a score of 2 represented dye penetration restricted to the inner half of the sealant; a score of 3 represented dye penetration into the underlying fissure. Mean dye penetration was calculated for each group. Data were analysed with Mann-Whitney test with a global significance level of 0.05.

In order to evaluate the morphological aspect of enamel surface after the different pre-treatments, three additional third molars, each prepared with one of the three treatment protocols, were observed with SEM (3000x).

Results
An example of sections from each group is shown in figures 1-3. Results of dye penetration are summarised in figure 4. Statistical analysis revealed no difference between group 1 and 2 (p>0.05); while the combined technique (group 3) determined a significantly lower infiltration degree (p<0.01) compared to acid etching alone and air abrasion alone (groups 1 and 2). Score 3 was not found in any of the tested specimens.

SEM observation showed that the combined use of aluminium oxide and orthophosphoric acid determined the higher surface irregularities than the single techniques (fig. 5). Comparing air abrasion (i.e. group 2) (fig. 6) versus with acid etching (i.e. group 1) (fig. 7), a less homogeneous surface with deeper
irregularities were observed with enamel sandblasting. No alumina particles were observed in sections from group 2 and 3.

Discussion
Optimal adaptation of dental sealants depends essentially on an adequate enamel treatment [Chan et al., 1999] and sealant penetration to the bottom of the fissures is affected by fissure depth and morphology. Proper infiltration is crucial in deep fissures which are more susceptible to caries development. An accurate pre-conditioning of enamel surface in deep fissures may be compromised by the inability to remove debris, to drive the etching gel into the deepest areas, and to properly dry the surface [Taylor and Gwinnett, 1973; Symons et al., 1996].

Phosphoric acid etching is the most used enamel conditioning procedure in adhesive dentistry, also for sealants application. Etching removes superficial contaminants and enhances surface roughness, but it does not ensure complete cleaning of the deepest occlusal pits and fissures before sealant placement [Garcia-Godoy and de Araujo, 1994; Garcia-Godoy and Gwinnett, 1994].

Mechanical removal of debris from the enamel surface is considered as an important prerequisite in sealant application [Ansari et al., 2004]. Some investigators have observed that mechanical pit and fissure preparation increases sealant penetration, probably through an extended surface area for retention and an increase in the bulk of sealant which improves wear resistance [Geiger et al., 2000] thus providing lower microleakage [Wright et al., 1999]. Mechanical preparation of pits and fissures has also the advantage to reach deep and narrow zones that could be affected by hidden caries. Both air abrasion and bur preparations may be used for this objective [Hatibovic-Kofman et al., 2001]. Previous studies observed no significant difference between conventional acid etch only and bur preparation associated with acid etching of pit and fissures [Xalabarade et al., 1996; Hatibovic-Kofman et al., 2001].

Enamel pre-treatment, such as air abrasion alone [Kanellis et al., 1997; Hatibovic-Kofman et al., 1998; Wright et al., 1999] and air abrasion followed by acid etching have been recently investigated [Zyskind et al., 1998; Ellis et al., 1999; Hatibovic-Kofman et al., 2001; Blackwood et al., 2002]. Some investigators described better result when preparing tooth surfaces with air abrasion than the conventional etching technique [Wright et al., 1999], while other studies
consider air abrasion inadequate, due to the observation that poor surface roughness and more microleakage occur with air abrasion alone if compared with acid etching alone [Olsen et al., 1997; Hatibovich-Kofman et al., 1998; Ellis et al., 1999; Waveren Hogervorst et al., 2000].

Our study demonstrated that aluminium oxide alone determined a higher incidence of marginal microleakage (23% of sections) compared to conventional acid etching (14.5%), even though the score of infiltration was higher in etched samples. In fact 37% orthophosphoric acid yielded a greater dye penetration (score 2 = 10.5%) in the deepest areas of pits and fissures if compared with air abrasion (6.2%). This result may be related with the incomplete removal of debris from the bottom of fissures obtained with acid etching, responsible of an inadequate adaptation of the sealant on enamel surface.

In the third group (air abrasion followed by acid etching) only one section (2.1%) out of the examined 48 presented marginal microleakage: penetration and adaptation of sealant were higher, especially in the innermost and irregular fissures (fig. 1). Moreover, the SEM evaluation indicated that the combined use of aluminium oxide and 37% orthophosphoric acid is able to create a more irregular surface than single techniques tested separately (fig. 5, 6, 7).

In accordance with previous studies the results of this investigation indicate a synergistic effect of air abrasion and acid etching in the pre-treatment of occlusal surfaces prior to sealants application [Zyskind et al., 1998; Ellis et al., 1999; Hatibovic-Kofman et al., 2001; Blackwood et al., 2002] thus reducing marginal leakage.

The inconsistency observed comparing the results of sealant studies may be explained by the diversity of methods used to study microleakage: different testing dyes are used and the type of sealant also affects the results [Wright et al., 1999; Hatibovic-Kofman, et al., 2001]. Since no concordance between study results exists, a standardised protocol to compare microleakage studies in a more reliable way should be proposed.

**Conclusion**

Microleakage in teeth treated with air abrasion was not significantly different if compared with etched samples, even though SEM analysis showed that air abrasion creates a more irregular enamel surface and probably a better adaptation at the tooth-sealant interface. The null hypothesis was rejected because the results of this study seem to support the observation that a combination of mechanical air abrasion and chemical acid etching represents an effective pre-treatment of enamel surface and may significantly reduce the risk of microleakage. In order to introduce this technique in operative practice as a substitute of phosphoric acid further studies are required.

**References**


