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Effect of air abrasion treatment on microleakage of a pit and fissure sealant (in vitro study)

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Abstract

The aim of this study was to compare in vitro the microleakage of a pit and fissure sealant after different enamel surface treatments: (1) acid etching only, (2) air abrasion only, and (3) air abrasion followed by acid etching.

Thirty sound human upper premolars were used in this study. The teeth were divided into three groups according to the type of treatment prior to sealant application: Group 1 (in which the occlusal surface was etched with 37% phosphoric acid gel for 30 seconds), Group 2 (in which the occlusal surface was air-abraded for 10 seconds with sodium hydrogen carbonate powder), and Group 3 (in which the occlusal surface was air-abraded as in group 2 and then acid etched as in group 1). Then a light-cured pit and fissure sealant (Fisseal, Promedica, Germany) was applied to the central fissure in the occlusal surface of each tooth and light cured for 20 seconds. Then the teeth were thermocycled between 5°C and 55°C for 10 cycles, immersed in 0.5% basic fuchsin dye for 24 hours at room temperature, embedded in auto-polymerizing acrylic resin, sectioned longitudinally bucco-lingually, and examined under a stereomicroscope for dye penetration.

The results of this study showed that the highest mean of microleakage scores was in group 2 (air abrasion group), while the lowest mean of microleakage scores was in group 3 (air abrasion + acid etching), with statistically highly significant difference ($p < 0.01$) between group 1 and group 2, and between group 2 and group 3, with statistically non-significant difference between group 1 and group 3 ($p > 0.05$).

Air abrasion treatment prior to sealant application was not effective in reducing microleakage and should be followed by acid etching.

Key words: Air abrasion, pit and fissure sealant, microleakage.

Introduction

Pits and fissures are recognized as being highly susceptible to caries. This high susceptibility may be attributed to the complex morphology of the pits and fissures which are considered to be an ideal site for the pretension of bacteria and food remnants rendering mechanical means of debridement inaccessible⁽¹⁾. Debris and pellicle may remain in the fissures even after cleaning with a dental explorer and

etching the pits and fissures with a suitable acid⁽²⁾.

Other factors responsible for the high incidence of the occlusal caries include the lack of salivary access to the fissures as a result of surface tension effectively preventing remineralization and reducing the effectiveness of fluoride⁽¹⁾.

Pit and fissure sealants are effective caries preventive agents as long as they remain bonded to the teeth⁽³⁾. However, the preventive benefit of this

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treatment relies upon the ability of the material to promote an appropriate sealing of the pits, fissures, or eventual anatomic defects and remain completely intact and bonded to enamel surface, thus preventing microleakage and the consequent progression of a carious process underneath the sealant⁽⁴⁾.

For adequate retention of the sealant, it is necessary to maximize the surface area for bonding and ensure that the enamel be clean, free of salivary contamination, and dry at the time of sealant placement. Micromechanical adaptation of the sealant is achieved through the porosities created by conditioning the enamel, conventionally by acid etching, before the application of the sealant. However, acid etching is a technique-sensitive process involving several time consuming steps⁽³⁾.

Recently, newer methods for preparing dental substrates have been developed such as air abrasion⁽⁴⁾. Air abrasion technology was introduced as an alternative to rotary cutting equipment for minimal cavity preparation. This technique, also called kinetic cavity preparation, uses kinetic energy to remove tooth structure⁽⁵⁾ by blowing the tooth with a high speed stream of purified aluminum oxide particles using compressed air through very fine tips⁽⁶⁾.

Air abrasion procedure is virtually painless, which in most cases eliminates the need for an anesthetic solution, and produces no vibration and no heat, making it a good option for children who may be afraid of the needle, and noise and vibration of a regular dental drill⁽⁷⁾.

Studies on air abrasion have reported improvements in sealing as ranging from no improvement to complete⁽³⁾.

Aim of the study: The aim of this study was to compare in vitro the

microleakage of a pit and fissure sealant after different enamel surface treatments: (1) acid etching only, (2) air abrasion only, and (3) air abrasion followed by acid etching.

Materials and Method

Materials and Equipment

The main materials and instruments used in the study are shown in Figure 1, which included: Fisseal light-cured pit and fissure sealant (Promedica, Germany), 37% phosphoric acid gel (Gel Etchant, Kerr Corporation, USA), TDP-II air abrasion handpiece (Beijingtiandong medical equipment company LTD, China), and cleaning powder supplied by the manufacturer of the air abrasion handpiece, which is composed of sodium hydrogen carbonate and food spice.

Methods

Sample Selection

Thirty sound human upper premolars, extracted for the purpose of orthodontic treatment, were collected for use in this study. The teeth were cleaned with pumice and carefully rinsed with water to remove the residual debris from the pits and fissures. Then the teeth were examined with a magnifying lens and light from a light curing unit for the presence of cracks. Only intact teeth free of defects and of comparable size were selected and stored in distilled water at room temperature.

Sample Grouping

The teeth were divided into three groups of ten teeth each according to the type of treatment performed prior to sealant application as follows:

Group 1: The occlusal surface of each tooth was etched with 37% phosphoric acid gel (Gel Etchant, Kerr Corporation, USA) for 30 seconds, rinsed with air/water spray for 20 seconds, and air-dried gently. This is

accomplished according to the manufacturer's instructions.

Group 2: The occlusal surface of each tooth was air-abraded for 10 seconds⁽³⁾ with the cleaning powder composed of sodium hydrogen carbonate and food spice supplied by the manufacturer of the air abrasion handpiece (TDP-II, Beijingtiandong medical equipment company LTD, China) attached to the dental unit. The nozzle tip of the air abrasion handpiece was held at a distance of approximately 2 mm and at an angle of 45°C with the occlusal surface⁽⁴⁾ (Figure 2). Following air abrasion treatment, the teeth were rinsed well to remove any residual aluminum oxide particles and dried.

Group 3: The occlusal surface of each tooth was air-abraded as in group 2 and then acid etched as in group 1.

Sealant Application

A light-cured pit and fissure sealant (Fisseal, Promedica, Germany) was applied to the central fissure in the occlusal surface of each tooth using the needle applicator provided by the manufacturer. A dental probe was passed through the sealant after its application to ensure proper penetration of the sealant into the fissure area. This is according to the manufacturer's instructions. After application, the sealant was light cured for 20 seconds using a light curing machine (Coltolux, Coltene Whaladent, France).

After curing, the teeth of each group were stored in distilled water for 24 hours at room temperature.

Thermocycling

Thermocycling was done to simulate temperature changes in the oral cavity that might result in changes in the microspace between the tooth and the sealant. This was done by cycling the teeth between two water baths: one of the water baths

maintained at 5°C and the other at 55°C, with a dwell time of 30 seconds. The number of cycles was 10 cycles.

Dye Penetration Test

After thermocycling, the teeth were dried and their apices were blocked with auto-polymerizing acrylic resin to prevent dye penetration through the apical foramen. Then the teeth were coated with two layers of nail varnish to within approximately 2 mm of the sealant-tooth interface to prevent dye penetration from anywhere except via the sealant-tooth interface. The teeth were then immersed in 0.5% basic fuchsine dye for 24 hours at room temperature.

Sectioning

After dye penetration, the teeth were rinsed well under running water, dried, and embedded in blocks of auto-polymerizing acrylic resin. Then the teeth were sectioned longitudinally bucco-lingually through the cusps' tips using a diamond wheel mounted in a sectioning machine (Accutom) with water cooling.

Microleakage Measurement

Microleakage was evaluated by assessing the dye penetration at the tooth-sealant interface according to the method described by *Overbo and Raadal (1990)*⁽⁸⁾ by examining the sections of the teeth under a stereomicroscope with reflected light under a magnification of x4 as follows:

-**Score 0** = no dye penetration.

-**Score 1** = dye penetration restricted to the outer half of the sealant.

-**Score 2** = dye penetration to the inner half of the sealant.

-**Score 3** = dye penetration into the fissure.

The mean of microleakage scores was calculated for each group, and the results were analyzed.

Results

Figure 3 shows the distribution of dye penetration scores in terms of number of teeth in each group.

The descriptive statistics (mean, standard deviation, minimum and maximum) of dye penetration scores at the enamel-sealant interface of the different experimental groups are shown in (Table 1). From this table, it can be seen that the highest mean of microleakage scores was in group 2 (air abrasion group), while the lowest mean of microleakage scores was in group 3 (air abrasion + acid etching).

Paired t-test comparison between each two groups (Table 2) showed a statistically highly significant difference ($p < 0.01$) between group 1 and group 2, and between group 2 and group 3, with statistically non-significant difference between group 1 and group 3 ($p > 0.05$).

Discussion

Acid etching of the enamel is a routine procedure for preparing fissures prior to sealant placement, but studies have shown that such a procedure does not remove all debris and pellicle from the base of the fissure⁽⁹⁾. Moreover, acid etching is a technique-sensitive process involving several time consuming steps⁽³⁾. On the other hand, it has been reported that sealant loss was a common problem when acid etching alone was used prior to sealant placement averaging 5-10% each year⁽¹⁰⁾. Therefore, several alternative methods have been used in an attempt to improve the longevity of the sealants but with controversial results. Air abrasion has been reported for tooth preparation, and depending on the air stream pressure and aluminum oxide particle size, creates a roughened enamel surface⁽¹¹⁾. Therefore, in this study air abrasion

treatment of the enamel (with and without a subsequent acid etching step) had been tested for microleakage through dye penetration test. It is worth to mention here that the cleaning powder used in this study differs from that used in other studies which is composed of sodium hydrogen carbonate and food spice, while in most of the other studies 25 μm aluminum oxide particles were used. However, there is no available article which mentioned the effect of such difference in particle composition on the treated enamel surface.

The results of this study showed that the highest mean of microleakage scores occurred when the enamel was treated with air abrasion only (Group 2). This could be attributed to that air abrasion treatment resulted in an irreversible removal of both the organic and inorganic components of the enamel matrix, as reported by *Laurell and Hess (1995)*⁽¹¹⁾, producing a smoother, and hence a less retentive surface, resulting in high microleakage scores, while acid etching of the enamel causes a selective dissolution of just the inorganic component of the enamel matrix creating a more retentive surface and hence resulting in less microleakage, and this was seen in Group 1. Another possible cause for the high microleakage scores in the air abrasion group might be the incomplete penetration of the sealant into the fissure as a result of the residual sodium hydrogen carbonate particles that might remain in the fissure after treatment in spite of rinsing, as these particles are finer than the aluminum oxide particles used in other studies. This finding is in agreement with the findings of *Eakle et al. (1995)*⁽¹²⁾ who reported that air abrasion produced a roughened surface but lacked the seal obtained with acid etching, and with the findings of *Davis et al. (1996)*⁽¹³⁾ and *Mentes and*

Gescoglu (2000)⁽³⁾ who found that air abrasion alone inadequately conditioned the teeth prior to sealing, resulting in significant marginal leakage. This finding is also in agreement with the results of Brown and Barkmeier (1996)⁽¹⁴⁾, Ferdianakis (1998)⁽¹⁵⁾, Ellis et al. (1999)⁽¹⁶⁾, and Guirguis et al. (1999)⁽¹⁷⁾ who all found that the use of air abrasion alone does not provide adequate sealability of preventive restorations. However, this finding disagrees with findings of Keen et al. (1995)⁽¹⁸⁾ and Wright et al. [(1996)⁽¹⁹⁾ and (1999)⁽²⁰⁾] who found no statistically significant difference in microleakage between acid etched and air abraded teeth prior to sealant or composite placement. Such disagreement might be due to the difference in the parameters of air abrasion treatment such as air pressure, particles type and size, distance and angulations of the nozzle tip from the tooth surface.

On the other hand, the results of this study showed that the lowest mean of microleakage scores occurred when air abrasion was followed by a subsequent acid etching step, which could be attributed to the macroscopical superficial alterations (produced by air abrasion) and microscopical irregularities (created by acid etching) as reported by *Eakle et al. (1995)⁽¹²⁾*. This finding is in agreement with the findings of Fu and Hanniq (1999)⁽²¹⁾ who reported that air abrasion should be combined with acid etching to reduce microleakage of preventive Class I resin restorations, and with the findings of Menten and Gescoglu (2000)⁽³⁾ who found that air abrasion treatment of the enamel followed by acid etching produced the lowest microleakage scores, which however were not significantly lower than those produced by the conventional method of acid etching.

Conclusion

Air abrasion treatment prior to sealant application was not effective in reducing the microleakage of pit and fissure sealants, and should be followed by acid etching.

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Table 1: Descriptive statistics of dye penetration scores at the enamel-sealant interface of the different experimental groups.

Groups	N	Mean	S.D	Minimum	Maximum
<i>Group 1</i>	10	0.3	0.48305	0.00	1.00
<i>Group 2</i>	10	2.6	0.51640	2.00	3.00
<i>Group 3</i>	10	0.2	0.42164	0.00	1.00

Table 2: Paired t-test comparison of significance between each two groups.

Groups	T	df	Significance (2-tailed)
<i>Group 1 * Group 2</i>	-15.057	9	0.000 (HS)*
<i>Group 1 * Group 3</i>	1.000	9	0.343 (NS)**
<i>Group 2 * Group 3</i>	14.697	9	0.000 (HS)*

*(HS): Highly significant ($p \leq 0.01$)

** (NS): Non-significant ($p \geq 0.05$)



Figure 1: The main materials and instruments used in the study.



Figure 2: The nozzle tip of the TDP-II air abrasion handpiece in relation to the occlusal surface of the tooth.

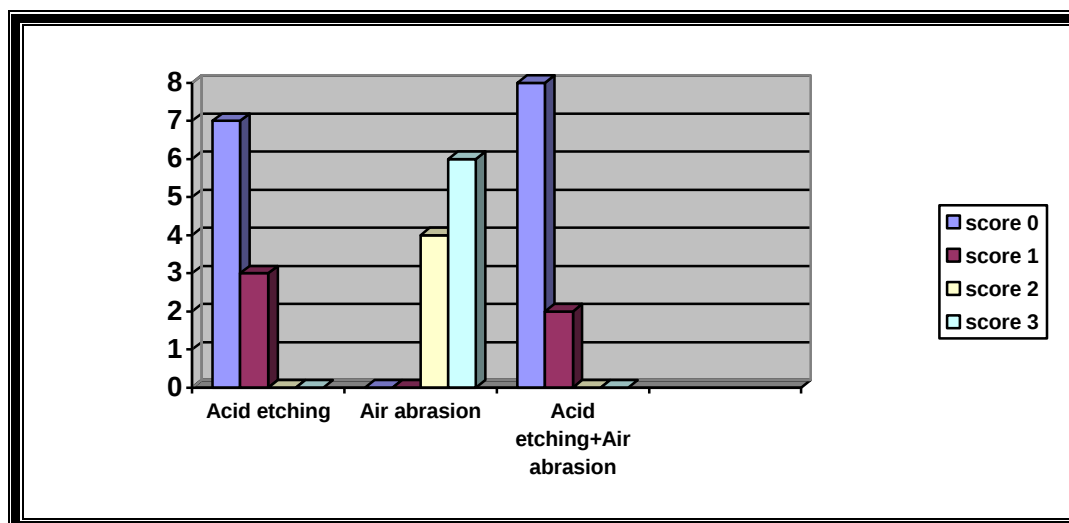


Figure 3: Bar chart graph showing the distribution of dye penetration scores in terms of number of teeth in each group.