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In vitro performance of ultrasound enamel preparation compared with classical bur preparation on pit and fissure sealing

ABSTRACT

Aim *Fissure sealants are effective in preventing caries. The aim of this* in vitro *study was to evaluate the effects of two different enamel surface preparation techniques for pit and fissure sealing.*

Methods *Sixty extracted sound third molars were used. For each tooth, the mesial half of the occlusal fissures was treated with ultrasound diamond tip T1 mounted on an ultrasonic handpiece, while the distal half with conventional diamond bur. The teeth were randomly divided into 2 groups (n = 30/each). Group 1 samples were stored in distilled water at 4 °C. For group 2 samples, sealing of occlusal fissures was performed according to standard procedures. Bucco-lingual cuts parallel to the long axis of the tooth were made in order to separate the two different types of preparations. The effects of the executed procedures were assessed with SEM.*

Results *Surfaces prepared with ultrasound system showed the presence of residual debris and appeared more irregular than surfaces prepared with traditional bur system. Furthermore, images showed the presence of cracks on the bottom and on the walls of the ultrasound prepared fissures.*

Conclusion *Conventional bur surface treatment showed a better performance when compared to ultrasound preparation and could probably ensure superior sealant retention.*

Keywords *Bur preparation; Dental fissure sealants, Ultrasound tips.*

Introduction

Despite the great achievements obtained about oral health in the global population, teeth decay still remains the most prevalent chronic disease, especially among underprivileged groups, both in developed and underdeveloped countries [Ferrazzano et al., 2006; Ferrazzano et al., 2016b].

Occlusal pits and fissures, representing more than 85% of caries-affected tooth surfaces, are the most susceptible areas to decay, due to their complex morphology [Hicks and Flaitz, 1993; Cehreli et al., 2006], and this condition emphasises the importance of sealants in the prevention of caries today [Topaloglu Ak and Riza Alpoz, 2010; Welbury et al., 2004].

Many studies have been focused on the optimal technique for the application of pit and fissures sealants and addressed the question of whether an invasive (enameloplasty) or non-invasive technique should be used [Beauchamp et al., 2008].

The retention of pit and fissure sealants is undoubtedly essential for the effectiveness of the procedure and the surface pretreatment regimen prior to placement is one of the most important factors affecting retention [Sungurtekin and Oztaş, 2010].

A mechanical preparation, consisting in widening fissures with rotary instrumentation, is suggested, permitting a better diagnosis of underlying decalcifications and improving sealant retention both with a deeper sealant penetration and an increase of the surface area [De Craene et al., 1988; Garcia-Godoy and Araujo, 1994]. Moreover, it facilitates the removal of plaque and debris that may interfere with the etching process [Burrow et al., 2003].

Different techniques have been proposed for enameloplasty including the use of different types of burs, air abrasion systems, and lasers [Khogli et al., 2013; Bevilacqua et al., 2007].

Many concerns have been raised regarding sealant microleakage with bur pretreatment. The sealant-enamel interface microleakage may limit the efficacy of sealants by providing a pathway for plaque and debris, which supports the progression of the cariogenic process underneath the sealant [Handelman, 1982].

The use of Er:YAG laser is another technique for cleaning or pretreating the enamel before sealant application [Olivi et al., 2011; Haznedaroglu et al., 2014; Savatier et al., 2014]. It creates cavities by thermo-mechanical ablation. Compared to burs, laser ablation does not require local anaesthesia, it is less painful and more comfortable for patients by producing less noise and vibration; on the other hand, laser ablation takes more time and requires expensive equipment; in addition, safety considerations during laser use need to be taken into account [American Academy of Pediatric Dentistry, 2013].

Another preparation method is air abrasion. Air abrasion can be used as an alternative to bur excavation due to its selectivity and high patient acceptance [Christensen, 1998], and it has also been suggested as an alternative for acid etching. It consists of striking the tooth with abrasive particles, such as alumina (Al2O3), at high air pressure [Goldstein and Parkins, 1994].

Some studies reported that burs led to less microleakage than conventional acid etch technique, laser or air abrasion in sealed teeth [Subramaniam et al., 2009; Geiger et al., 2000; Lupi-Pégurier et al., 2004; Agrawal and Shigli, 2012]. However, others reported opposite findings [Mazzoleni et al., 2007].

According to Lupi-Pégurier et al., when a subsequent phosphoric acid conditioning was accomplished, the dye infiltration at the enamel-sealant interface did not differ significantly regardless of the preparation of the fissures (invasive or not) [Lupi-Pégurier et al., 2007].

Furthermore, some studies have indicated that a significan increase of microleakage occurs using air abrasion alone without acid etching when compared with acid etching alone or bur preparations with acid etching [Hatibovic-Kofman et al., 1998; Haws et al., 1996].

In the opinion of Topaloglu-Ak et al. [2013], lasered vs. non-lasered fissures prior to application of a total etch adhesive system does not make a significant difference in terms of microleakage.

Despite the amount of scientific works on pit and fissure surfaces preparation techniques, very little is known about the using of ultrasound tips for this purpose [Handelman, 1982; Olivi et al., 2011; American Academy of Pediatric Dentistry, 2013; Christensen, 1998].

The most common use of ultrasound in dentistry is for professional oral hygiene, to clean dental surfaces from plaque and calculus or in endodontic root canal treatment [Walmsley et al., 1992]. For this intention, high intensity and low frequency (kHz) ultrasound are used. High power ultrasound is also used for oral and craniofacial surgical applications, in particular for cutting bone [Stübinger et al., 2008].

The aim of the present study was to evaluate *in vitro* the effects on sealant's retention of the preparation of dental surfaces by means of ultrasonic tips, compared to the traditional bur preparation.

Materials and Methods

Teeth sample cleaning

Sixty third molars, extracted for orthodontic purpose, were selected for the study. The teeth were free of cracks, caries and restorations.

After manual removal of soft tissue remnants and calculus, the occlusal surfaces of all teeth were cleaned with pumice powder, applied with nylon bristle brushes (Hawe Neos Dental miniature, 831 RA, Switzerland) mounted on a dental handpiece (Kavo Intramatic Lux 3 20 LH, D481631, Germany) at slow speed to remove salivary pellicles and any remaining plaque. After cleaning, residual pumice on the teeth was removed by washing in distilled water.

Afterward the samples were placed in distilled water at 4 °C.

Sample preparation

For each tooth, the mesial half of the fissures was treated with T1 ultrasound tip mounted on a handpiece activated by DentSurgTMPiezo (Intra-Lock®, Germany), while the distal half was slightly opened using a fissurotomy diamond bur (D1 Intensiv, Dental Trey, Italy) on a high-speed handpiece.

Then, the teeth were randomly assigned to 2 groups (n = 30/each).

Group 1 samples were stored in distilled water at 4 °C.

Group 2 samples were etched with a 37% phosphoric acid gel (3M ESPE Scotchbond Universal etchant, St. Paul, MN, USA) for 30s, rinsed for 20s with water and dried until the surface was chalky white. A layer of bond (Adper™ Scotchbond™ 1 XT, 3M ESPE, St. Paul, MN, USA) was placed on occlusal surfaces and photo-polymerised. The next step consisted of applying a resin-based sealant (Clinpro, 3M ESPE, St. Paul, MN, USA). The material was carefully placed in the pits and fissures, manipulated with an explorer in order to prevent voids, air entrapment or bubbles and cured for 30s with LED curing light. Subsequently the samples were stored in distilled water at 4 °C.

Subsequently, roots were cut off 2 mm below the cementoenamel junction with a diamond disk (Horico - Hopf, Ringleb and Co. GmbH and Cie.™ – mod. Diaflex® H347), mounted on a microtome, so as to facilitate hydration of the samples.

Bucco-lingual cuts parallel to the long axis of the tooth were made in order to separate the different types of preparations.

The samples obtained were divided into 4 subgroups according to their preparation (Table 1) and were placed in distilled water at 4 °C.

Group	Preparation	Sealant
1A	Ultrasound	No
1B	Turbine Handpiece	No
2A	Ultrasound	Yes
2B	Turbine Handpiece	Yes

TABLE 1 The samples were divided into 4 subgroups according to their preparation.

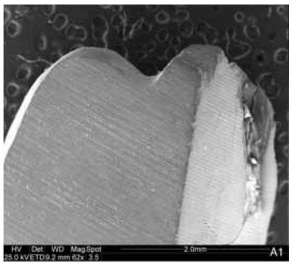

FIG. 1 Group 1a (62x).

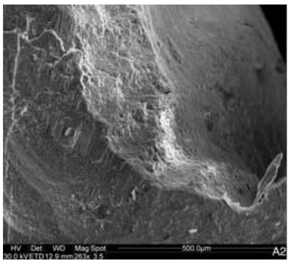

FIG. 2 Group 1a (263x).

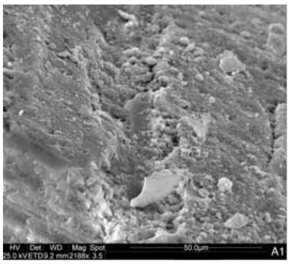

FIG. 3 Group 1a (2188x).

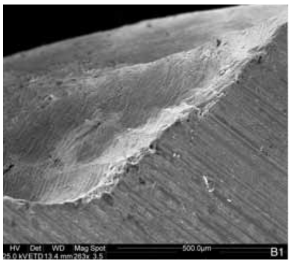

FIG. 4 Group 1b (263x).

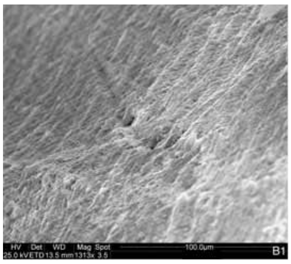

FIG. 5 Group 1b (1313x).

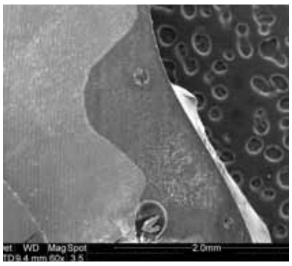

FIG. 6 Group 2a (60x).

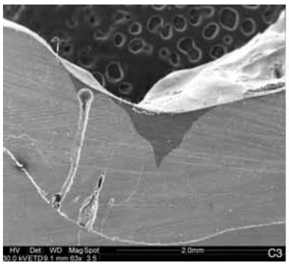

FIG. 7 Group 2a (63x).

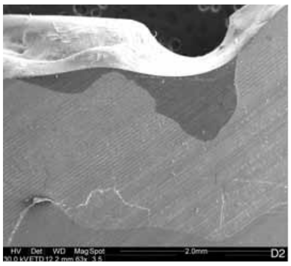

FIG. 8 Group 2b (63x).

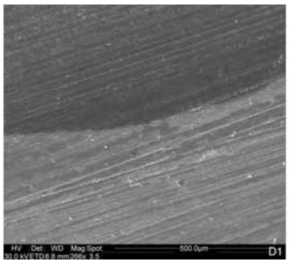

FIG. 9 Group 2b (266x).

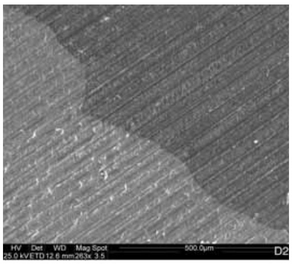

FIG. 10 Group 2b (263x).

SEM Analysis

At the end of the experimental procedures, all specimens were mounted on aluminium stubs, sputter-coated with gold (E 306, Edwards, UK) and then examined under scanning electron microscope (SEM) (FEI QUANTA 200).

Results

Group 1a

Observed through the electron microscope (SEM), group 1a samples revealed an irregular/sandblasted surface after the mechanical preparation with ultrasound tips. Furthermore, especially at a higher resolution, the SEM showed the presence of many post-preparation debris on the surface of the fissures (Fig. 1, 2, 3).

Group 1b

The surface of the fissures of group 1b samples, prepared with the turbine handpiece, appeared regular (Fig. 4). Moreover, the presence of debris due to this preparation was low (Fig. 5).

Group 2a

The preparation of group 2a samples was performed by means of ultrasonic tip and after that the sealant was applied. In Figure 6 it was possible to observe air bubbles at the bottom of the fissure and debris incorporated into air bubbles.

Furthermore, imperfect adhesion of the sealant to the enamel surface was observed. In fact, at higher magnifications the SEM showed the presence of areas of cracking at the bottom and on the walls of the fissure, probably due to polymerisation shrinkage (Fig. 7).

Group 2b

The preparation of group 2b samples was made by a turbine handpiece and the sealant was applied. Figures 8, 9 and 10 showed a better penetration of the sealant through the enamel surface. Moreover, no air bubbles were detected.

Discussion

Even though the last decades saw a global improvement in dental caries thanks to the use of conventional preventive systems (fluoride prophylaxis, fluoride toothpastes, oral hygiene) [Ferrazzano et al., 2008], it still is one of the most common chronic conditions both in healthy childrean and childrean affected by systemic diseases [Ferrazzano et al., 2006; Ferrazzano et al., 2009; Ferrazzano et al., 2016b]. Teeth with deep pits and fissures are more vulnerable to caries. On the other hand, fissure sealant application has beeen proven effective in preventing occlusal caries [Ferrazzano et al., 2016a; Koh et al., 1998; Ripa, 1993].

Several preparatory methods were introduced prior to the placement of the fissure sealant, with varying degrees of efficacy on the adhesiveness of material to the prepared surfaces [Blackwood et al., 2002; Francescut and Lussi, 2006; Xalabarde et al., 1998].

In the present study it was observed that the performance of ultrasound tips is lower than that of the high-speed rotating tools, relatively to the time employed.

Furthermore, SEM analysis showed that the mechanical preparation of pits and fissures with an ultrasonic tip determines an irregular surface, which worsens the micro-adhesion of the sealant. In particular, the higher presence of debris on occlusal fissures, widened with ultrasonic tip and sealed, prevents a complete distribution of the sealant and lowers the adhesion of the material to the enamel surface.

Regrettably, in literature there are no accurate studies on the validity of ultrasonic instruments for this scope.

Ultrasonic instrumentation was first introduced in dentistry for cavity preparations, using an abrasive slurry [Postle, 1958]. More recently, the concept of minimally invasive dentistry has stimulated new approaches in cavity design and tooth-cutting concepts, including ultrasound for cavity preparation [Sheets and Paquette, 2002]. Although the technique received favourable comments, it never became popular, because it had to compete with much more effective and fast instruments, i.e. the burs mounted on high-speed hand-pieces [Street, 1959].

In the present study the surface of the fissures prepared with the turbine handpiece appeared more regular, compared to samples prepared with ultrasound tips. Therefore, the lower presence of post-preparation debris in these samples does not affect the formation of a bond between enamel and sealant. These results are in agreement with the study of Wicht et al. [2002], showing that the rotating instruments have a superior cutting capacity. Furthermore, mechanical preparation has been suggested to provide better access to the deeper fissure areas, thus enabling removal of debris, deeper sealant penetration, and improved retention [Feldens et al., 1994; Garcia-Godoy and Araujo, 1994; Salama and Al-Hammad, 2002].

Conclusions

In conclusion, this *in vitro* comparative study demonstrated that fissure preparations should be carried out using diamond bur. This process may provide more surface area to retain the sealant, decrease marginal leakage and, consequently, reduce the risk of secondary caries development.

The use of ultrasound tips does not allow a preparation focused, precise and conservative of pits and fissures, such as rotary instruments do. Moreover, the preparation of the cavity with ultrasound is four times longer and requires a change of insert every five instrumented teeth.

The performance of the high-speed hand-piece has proved to be better than the oscillatory system, both in terms of time spent for preparation and of the presence of microleakage.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

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