*International Journal of Paediatric Dentistry* 2005; **15:** 51–60

# *In-vitro* microleakage of repaired fissure sealants: a randomized, controlled trial

V. SRINIVASAN[1], C. DEERY[1] & Z. NUGENT[1,2]
[1]*Department of Paediatric Dentistry, Edinburgh Dental Institute, Edinburgh, and*
[2]*Dental Health Services Research Unit, University of Dundee, Dundee, UK*

**Summary.** The aim of this study was to investigate whether differences in surface treatment prior to repair influenced the seal of a resin fissure sealant placed on the occlusal surfaces of permanent molar teeth.
*Setting. In-vitro* study.
*Sample and methods.* One hundred and twenty-eight extracted human first and second molars were randomly allocated to one of four groups of 32 teeth each. A light cured, unfilled, opaque resin fissure sealant (Delton) was placed on their occlusal surface following cleaning by prophylaxis and acid etching. Following storage in artificial saliva (Saliva Orthana) for a week, duplication of sealant failure was carried out. The teeth were then subjected to one of four different surface treatments: Group 1: with a slow-speed prophylaxis brush followed by acid etching (control method); Group 2: a slow-speed bur and acid etching; Group 3: air abrasion and acid etching; and Group 4: acid etching and application of a bonding agent. Following a further week of storage in artificial saliva two layers of impermeable varnish were applied to the nonocclusal surfaces of the teeth; their apices were then sealed with wax and the teeth were immersed in 1% methylene blue for 48 h. The teeth were then sectioned (ISOMET 1000) to achieve three cuts resulting in a maximum of four blocks, i.e. six surfaces per tooth. A total of 715 sections from 126 teeth were scored for microleakage on the intact and repaired side of the fissure sealant.
*Results.* Statistical analysis did not demonstrate any one single method of repair to be superior to the control method for reapplication of the sealant.
*Conclusion.* All four techniques compared in this study seem to be acceptable for replacing or repairing lost or fractured fissure sealants. As prophylaxis with a brush rotating at slow speed followed by acid etching, which probably represents current practice, is also the simplest technique that can be practised on children, it is therefore recommended.

## Introduction

Fissure sealants (sealants) are materials that are applied to the surfaces of teeth in order to obliterate the fissures and remove the sheltered environment in which caries may thrive. This conservative intervention of tackling pit and fissure caries involves a minimum of treatment which most children have no difficulty in accepting [1]. Resin sealants are the most widely used and also have the greatest evidence of effectiveness in their favour [2]. The effectiveness of fissure sealants carried out in fluoridated and nonfluoridated areas, as part of public health measures and in private clinics, have been proved beyond doubt [3,4]. Sealants should be repaired if they are to be effective and inadequately sealed surfaces are more likely to decay than completely sealed surfaces [5–7]. Policy documents and clinical guidelines

Correspondence: C. Deery, Consultant in Paediatric Dentistry, Edinburgh Dental Institute, Lauriston Building, Lauriston Place, Edinburgh, EH3 9YW, UK. E-mail: chris.deery@LPCT.scot.nhs.uk

strongly advise monitoring and repair or re-treatment of lost or fractured sealants in order to ensure longevity and caries protection [8,9].

It has been suggested that sealants may fail owing to one or more of the following reasons: inadequate surface preparation prior to etching, moisture contamination, nature of enamel surface changes following acid etching, depending on the presence or absence of prismless enamel, handling properties of the material and low resistance of the materials to wear [10,11]. Any repair or replacement of a fissure sealant should be carried out in the most effective way possible to resist microleakage and prevent dental caries. Microleakage may be defined as the passage of bacteria, fluids, molecules or ions between a prepared tooth surface and the restorative material applied [12]. As the primary mode of sealant failure is owing to the introduction of contaminants, repair could be effected after subjecting the surface to a treatment that would remove the contamination present and prevent further contamination, thus effecting optimum bonding. In such instances all of the methods of repairing fractured composite resin restorations could be applied to the repair or resealing, as the basic components of both the materials are similar. Currently there exists no literature on the most effective method of surface treatment of a deficient/failed sealant prior to resealing. Therefore the aim of this study was to investigate whether different surface treatments during repair influenced the seal of a lightly cured opaque resin sealant placed on occlusal surfaces of permanent molar teeth *in-vitro*.

## Method

One hundred and twenty-eight human, uncavitated first and second molars which had been extracted for orthodontic purposes were stored in 0·2% thymol following extraction. A power calculation carried out before the commencement of the study determined the appropriate sample size of 128 teeth would have sufficient power to detect a 10% difference in microleakage at the $P = 0{\cdot}05$ level of significance [13]. After gross debridement of the teeth, the occlusal surfaces were cleaned with a prophylaxis brush rotating under slow speed for 10 s. The teeth were rinsed with air-water spray for 30 s, dried with compressed air for 10 s and one proximal half of the occlusal surface etched with 38% ortho phosphoric acid for 60 s, as

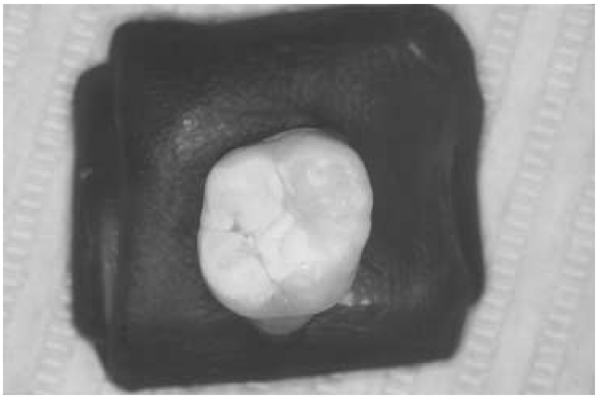

**Fig. 1.** Acid etching one proximal half of occlusal surface.

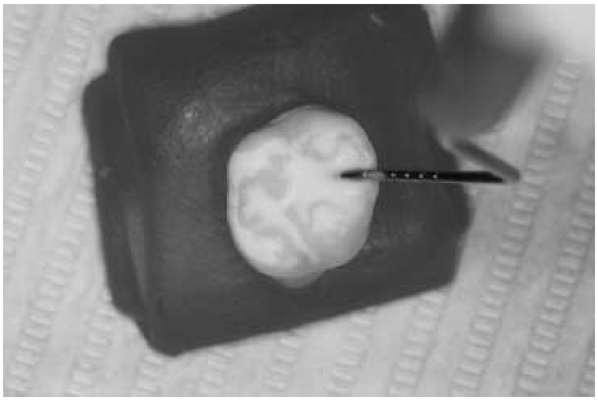

**Fig. 2.** Creating point of application during placement of fissure sealant.

recommended by the manufacturer [Fig. 1]. The Delton fissure sealant (Dentsply Preventive Care, Weybridge, UK) was applied on the whole of the occlusal surface of the teeth using a small spoon excavator. A blunt periodontal probe was placed on the untreated proximal half of the occlusal surface to create a point of application and the material cured for 30 s (200–500 nm) [Fig. 2]. The periodontal probe was removed after light curing, and the polymerized sealant broken by placing the probe in the point of application and removing half of the sealant [Fig. 3]. All the teeth had one half of the occlusal surface covered by the sealant and one half devoid of the sealant and ready to be resealed [Fig. 4] after being subjected to one of the control or test surface treatments described later. The teeth were randomly assigned to a group; 32 teeth in each group. The teeth were then stored as allocated in artificial saliva (Saliva Orthana, AS Pharma, Polegate, UK) for 1 week, after which the teeth were removed

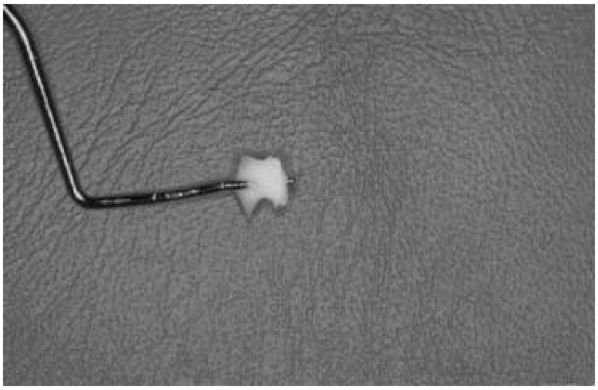

**Fig. 3.** Duplication of sealant fracture/failure.

**Fig. 4.** Partially sealed occlusal surface of molar tooth.

from the artificial saliva and washed with air-water spray. The teeth were then subjected to one of the following surface treatments prior to resealing.

*Group I: prophylaxis brush and acid etching (control)*

Traditional prophylaxis with a brush rotating at slow speed was used as a control surface treatment without pumice or prophylaxis paste. Following the prophylaxis the occlusal surfaces were rinsed with air-water spray for 30 s and dried for 15 s with compressed air followed by etching with 38% orthophosphoric acid for 30 s. The etchant was washed off with the water spray for 30 s and dried with compressed air for 15 s.

*Group II: 1/4 round stainless bur and acid etching (test)*

Enameloplasty with a 1/4 round stainless steel bur (RND PC 2 RA, Ash, London, UK) was carried out with a slow-speed handpiece using a light 'sweeping' motion for 10 s to open the pits and fissures and also to remove contaminants from the resin surface. The teeth were then rinsed with water spray, dried and etched with 38% ortho phosphoric acid for 30 s. The etchant was washed with the air-water spray for 30 s and dried with compressed air for 15 s.

*Group III: air abrasion with 50 μ alumina and acid etching*

The occlusal surfaces of all the teeth in this group were subjected to air abrasion. The nozzle of the microetcher was held 5 mm away from the tooth surface and moved in a slow, even motion over the whole occlusal tooth surface for 15 s or until an even, dull 'etched' appeared. The tooth was then cleaned with compressed air for 15 s followed by etching with 38% orthophosphoric acid for 30 s and rinsing with water spray for 30 s and 15 s air drying.

*Group IV: acid etching and application of bonding agent*

The tooth surface was etched with 38% ortho phosphoric acid for 30 s and rinsed with water spray for 30 s and dried with compressed air for 15 s. Prime and Bond *NT* (Dentsply, Weybridge, UK) was applied on the whole of the occlusal surface of the tooth with a disposable brush. The solvent was removed by compressed air from the dental syringe as recommended by the manufacturer and light cured for 10 s.

Delton sealant was reapplied with an excavator on the proximal half of the teeth which was being resealed and allowed to flow over the other proximal half with the intact sealant and cured for 60 s. After 1 week of storage in artificial saliva the teeth were rinsed with air-water spray and dried with compressed air. The apices of the teeth were sealed with sticky wax to prevent ingress of the dye. The teeth were then coated with two layers of nail varnish (Max Factor Diamond Hard, Weybridge, Procter and Gamble, UK) to within 1 mm of the fissure sealant. Two different colours of nail varnish were used to differentiate the repaired and nonrepaired proximal halves of the occlusal surfaces of the teeth and ensure complete coverage of both layers.

Once the nail varnish was dry, each tooth was placed in a 1% aqueous solution of methylene blue, buffered to pH 7·00 for 48 h at 37 °C. The teeth were then rinsed thoroughly in tap water. Each tooth was mounted in individual blocks of clear acrylic (chemical cure poly methyl metha acrylate) to facilitate their mounting in the sectioning machine. Each tooth was sectioned longitudinally in a mesio-distal plane to achieve three cuts with a water-cooled diamond disc on a microtome (Isomet 1000, Buehler, Coventry, UK). This resulted in four sections, each approximately 1·5–2 mm in thickness, with six surfaces to score per tooth.

Each surface was examined under ×15 magnification with a light microscope (Olympus SZ60, Tokyo, Japan) and photographed with a digital camera (Olympus SZ-ILA/C-4040ZOOM, Tokyo, Japan). The photographed images were independently scored for microleakage by two trained examiners, using a modified version of the scoring of Ovrebo and Raadal [14]. The scoring system is described in Table 1. One of the examiners was the operator and was therefore potentially aware of the groupings of the teeth. Re-examination and agreement reconciled differences between the examiners. The worst score for each tooth was the principal unit for statistical analysis because the sections drawn from one tooth are not independent but represent a cluster.

Nineteen teeth (15%; $n = 114$ sections) were selected using computer-generated random numbering to enable the determination of interexaminer reproducibility. All teeth were scored twice by each examiner to assess intraexaminer reproducibility. Intra-examiner reproducibility was carried out midway through the scoring stage on these 19 teeth by both the examiners and the reproducibility for each examiner statistically analyzed to arrive at a Cohen's kappa value. The examinations were carried out over a number of days therefore it is unlikely that an examiner would remember a previous score. Further the examiners were blinded by not having access to previous scores.

**Table 1.** Microleakage scoring system [modification of Ovrebo and Raadal 1990 (14)].

| Score | Depth of 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 to the underlying fissure |
| 1c, 2c, 3c | Dye penetration owing to caries |
| c | Caries elsewhere, not contributing to dye penetration |
| s | Dye penetration through the surface of the teeth |

## Results

There was evidence of dye penetration, and therefore microleakage, to a greater or lesser extent, in teeth from the control group and each of the test groups ($n = 58$, 46%). Out of a total of 128, 126 teeth yielded 715 sections in total. Two teeth were damaged in the sectioning process and hence lost from the study sample; one belonging to group 1 (control group of prophylaxis and acid etch) and one belonging to group 3 (air abrasion and acid etch).

Table 2 shows the microleakage scores according to the section level analysis with a maximum of six surfaces per tooth totalling 715 scores. No leakage (score = 0) was found on 588 surfaces out of a total of 715 surfaces (82·2%). Statistical analysis using the nonparametric Pearson chi-squared tests indicated no significant difference ($P = 0{\cdot}10$).

Table 3 and Fig. 5 show the distribution of tooth-level microleakage scores for all 126 teeth using the worst microleakage score for each tooth. Air abrasion followed by acid etching group had the most sealants exhibiting no leakage (score = 0) at 64·5% [20/31] as well as the least number of sealants displaying maximum leakage (score = 3) at 29·0% [9/31]. The enameloplasty group had the least number of teeth with no leakage at 46·9% (15/32) and the etch followed by bonding agent group had the most number of sealants with maximum leakage at 46·9% (15/32). Statistical analysis using the Pearson chi-squared test indicated no difference ($P = 0{\cdot}55$) between all four methods of surface treatment.

**Table 2.** Microleakage scores on the repair side of the fissure sealants (sections).

| Group | *n* | % Score 0 | % Score 1 | % Score 2 | % Score 3 | % Score 1, 2, 3 |
|---|---|---|---|---|---|---|
| Group 1 | 178 | 84 | 4 | 1 | 11 | 16 |
| Group 2 | 180 | 76 | 7 | 3 | 14 | 24 |
| Group 3 | 168 | 85 | 2 | 3 | 10 | 15 |
| Group 4 | 189 | 85 | 3 | 1 | 11 | 15 |
| Total | 715 | 83·25 | 4 | 2 | 11·5 | 17·5 |

No statistically significant differences, $P = 0{\cdot}10$.

**Table 3.** Microleakage scores on the repair side of fissure sealants (teeth).

| Group | *n* | % Score 0 | % Score 1 | % Score 2 | % Score 3 | % Score 1, 2, 3 |
|---|---|---|---|---|---|---|
| Group 1 | 31 | 52 | 10 | 3 | 35 | 48 |
| Group 2 | 32 | 47 | 9 | 6 | 38 | 53 |
| Group 3 | 31 | 65 | 0 | 6 | 29 | 35 |
| Group 4 | 32 | 53 | 0 | 0 | 47 | 47 |
| Total | 126 | 54·0 | 4·8 | 4·0 | 37·3 | 46·0 |

No statistically significant differences, $P = 0{\cdot}55$.

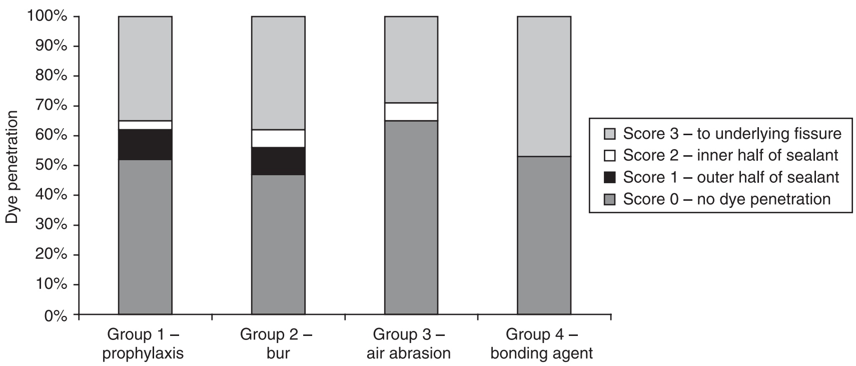


**Fig. 5.** Microleakage scores [%] on the repair side of the fissure sealants (teeth), $n = 126$.

Microleakage was also observed on the intact side of the sections. Out of the total of 715, 81·4% ($n = 586$) did not display any microleakage, with a score of 0. Eighty-eight sections (12·3%) showed severe microleakage with a score of 3 and minimal (score 1) microleakage was seen in 34 of the samples (4·8%). Out of a total of 126 teeth, 68 (54%) showed no microleakage (score 0).

The kappa values were interpreted using Landis and Koch's six-point scale [15]. The intraexaminer Kappa values for examiner I (VS) were 0·58 (moderate agreement) for the 19 teeth and 0·50 (moderate agreement) for the 114 sections. The second examiner (CD) had kappa values of 0·75 (substantial agreement) for the 19 teeth and 0·63 (substantial agreement) for the 114 sections. Inter-examiner agreement had a kappa value of 0·60 (moderate agreement) at the tooth level ($n = 126$) and kappa of 0·54 (moderate agreement) at the section level ($n = 715$). As previously stated differences between the examiners were reconciled by both examiners looking at the images together and giving a microleakage score that was agreed upon by both.

## Discussion

The clinical significance of a microleakage test is always viewed with uncertainty. Within it's own limitations, it should be viewed as a theoretical level of leakage that may occur *in-vivo* and can be accepted as an aid for developmental purposes and this is how it has been used in this study [16]. The penetration of a dye, although not an absolute measure, can indicate the lack of a perfect seal. However, there is no evidence in the literature to demonstrate that sealants penetration by dye as a measure of leakage correlates with clinical failure. All the groups in this study, including the nonrepaired side demonstrated dye penetration to some degree.

It is difficult to mimic sealant failure *in-vitro*, particularly as the sealant may fail for a number of reasons [10,11]. Aprismatic enamel would be evenly distributed across the sample but may not be identified clinically. However, this may not be an issue as an *in-vivo* study concluded that an ideal etch pattern is not essential in order to produce a strong bond [17]. Further the predominate cause of sealant failure at least in the short term is salivary contamination of the etched surface [11,18]. It was therefore felt more appropriate to mimic failure on enamel, which did not have any previous roughening, thereby duplicating the effect of salivary contamination, during etching. The alternative approach would have been to contaminate the etched surface with either artificial or human saliva; however, this was rejected because of difficulty with standardization. The point of application created by the periodontal probe facilitated easy removal of the sealant from the unetched half of the occlusal surface on all 126 teeth samples.

This study did not incorporate a thermocycling stage in it, as thermocycling has no statistically significant effect on microleakage [19]. Simulation of the oral environment in this study was carried out by storing the teeth prior to the beginning of the study in 0·12% thymol; the sealed teeth in artificial saliva and storing the samples immersed in the dye at 37 °C.

The use of a prophylaxis brush followed by acid etching was chosen as the control group, as this is the practice adopted by most dentists for application of sealants; although no statistically significant difference has been reported in retention rates of sealants between a group wherein the teeth were cleaned by a slurry of pumice and a group where the teeth received no prophylaxis prior to acid etching [20]. The use of pumice or any prophylaxis paste was decided against because it has been reported that remaining debris comprising pellicle and pumice can still remain in the depth of the deep fissures after prophylaxis and etching [21,22]. Therefore the presence of the pumice or prophylaxis paste can prevent the penetration of the etchant into the depth of the fissure, thereby reducing the available etched substrate to be infiltrated by the sealant resin.

The three experimental study methods were chosen for their potential advantages. Enameloplasty and air abrasion increase the surface area for bonding. These techniques will also remove the relatively nonreactive surface of the residual resin. Enameloplasty also removes aprismatic enamel; whether air abrasion does this has not been documented. The use of bonding agents is noninvasive and may be more acceptable for use in children than the former techniques. It may also help combat the influence of salivary contamination but assessment of this is outwith the aims of this study [11]. The generation of heat and noise associated with enameloplasty by a slow-speed bur is minimized in air abrasion; however, air abrasion requires the use of high-volume suction and a rubber dam, which may not be an acceptable practice in some children.

Air abrasion and etching were tested by studies comparing the *in-vitro* microleakage after the first application of a fissure sealant following pumice prophylaxis, bur and air abrasion in combination with acid etching [13,23–25]; however, parallels can be drawn between these studies and the current one to a certain extent only, as they are single applications and not repairs. In a similar single-application *in-vitro* study, Zyskind *et al.* [23] compared the microleakage of pit and fissure sealants applied to air-abraded enamel with and without etching. They concluded acid etching after air abrasion of the surface enamel decreased leakage compared with air abrasion alone. The group prepared by air abrasion followed by acid etching fared better than the other groups but this was not statistically different. This result is similar to those obtained by Ovrebo and Raadal [14], and Blackwood *et al.* [24].

One possible advantage of air abrasion is it simplifies the problem of distinguishing the boundary between composite restoration and tooth structure. Similarly the boundary between old sealant and tooth structure is more easily identified following air abrasion.

Even though the use of air abrasion has gained considerable popularity in recent years, it has emerged from the above-mentioned studies that the role of etching is critical and more important than the method of surface preparation prior to it. These studies also convincingly prove that air abrasion does not eliminate the need for etching; although, air abrasion has been reported to minimize heat changes, vibration, and noise and possibly the need for anaesthesia in restorative dentistry [26]. Hatibovic-Kofman *et al.* [25] have reported limitations to this technique, which include the significant expense of the air abrasion units, risk of particle inhalation and formation of alumina particles layer on the surfaces in the clinic. The noninvasive nature of the sealant procedure does become unacceptable to some children when air abrasion is used. Considerable acclimatization of the patient may be necessary prior to the use of air abrasion, as it requires the use of high-volume evacuation suction and rubber dam during use to minimize risks of particle inhalation. Adequate operator practice and training is required before clinical use. So the practice of air abrasion may not be as easy as one would expect of a procedure appropriate for children.

For the enameloplasty group in this study a ‘sweeping motion’ along the fissure patterns of the occlusal surfaces of the repair half of the sample and the intact fissure sealant surface was carried out. Sufficient removal of enamel was carried out to effect removal of most of the surface stain in this study. The bur used in this study was found to be slightly better than a fissure bur, as evidenced by the lower degree of microleakage found by Zervou *et al.* [27] when they compared the two burs. Halterman *et al.* [28] reported a broad range of enameloplasty preparation depths reported by dentists in a 1995 survey of Northern California paediatric dentists, reinforcing the observation that clinicians are not consistent with the technique. Their study reported that 50% of paediatric dentists always use a light 'sweep' of the grooves (0·5 mm) without necessarily removing all stains or 'chalkiness' in the grooves. The use of burs also varied, as four types of burs, namely 1/4, 1/2, 330 and flame/pointed diamond, predominated among 17 different types of burs used.

Comparing enameloplasty with etch to pumice and etch, Xalabarde *et al.* [19] demonstrated no significant difference in microleakage when comparing enameloplasty and etch to pumice and etch. They evaluated two different types of burs, the Sorensen diamond (tapering fissure) and 1/4 round carbide, but neither reduced the marginal leakage significantly, nor was there any difference in the microleakage between thermocycled and nonthermocycled specimens; however, a study comparing pumice and acid etching, bur preparation and acid etching, and microabrasion alone found less microleakage for the bur preparation group [25]. The percentage of sections showing no leakage for all the arms of the present trial were similar to the bur preparation arm of this previous trial at approximately 80%. As with air abrasion, enameloplasty may be unacceptable to anxious children, as it involves the use of rotary instruments.

*In-vitro* studies using bovine enamel [11] and human teeth [18,29] reported significant reductions in microleakage of single application sealants following salivary contamination, when a layer of bonding agent was applied. The use of an intermediary layer of bonding agent between two layers of the same material (Delton) resulted in microleakage similar to microleakage resulting in samples repaired by other means in this study. The promising results shown by the studies of bonding agents mentioned earlier were not achieved by this study. But the studies that have shown promising results have reported the use of bonding agent under sealant on wet contamination enamel. Therefore the absence of salivary contamination which could not be incorporated into an *in-vitro* study protocol could have contributed to the contradictory results.

There was dye penetration and hence microleakage observed on the intact side of the samples in this study. Out of a total of 715 sections scored 582 (81·4%) sections did not show any dye penetration. The side of the samples where the sealant was intact was prepared prior to sealing by slow-speed prophylaxis earlier on in the sample collection stage and acid-etched prior to sealing. This is comparable to the control group (Group 1) where the prophylaxis with the brush and acid etching were carried out just prior to the first application of the sealant. The distribution of microleakage on the intact side is relevant, as it emphasizes the point that sealants leak *in vitro* to a certain extent irrespective of the type of surface treatment carried out prior to application and also irrespective of whether it is the first application or a repair or resealing over a fractured sealant. A total of 582 sections exhibited no microleakage on the intact side compared with 588 on the repair side. Therefore there was no difference between the repaired (Groups 2, 3 and 4) and the intact (non-repaired) sides; however, the effectiveness of the sealants in preventing dental caries has been confirmed beyond doubt by the highest levels of evidence (evidence obtained from meta-analysis of randomized, controlled trials) [9].

The values for intraexaminer reproducibility were lower than in other studies [24]. There was also a difference between the two examiners in their kappa values for intraexaminer reproducibility. Examiner I (VS), who was also the operator and hence not blind to the surface treatment carried out in the samples, was able to achieve a moderate agreement ($\kappa = 0{\cdot}58$). Examiner II (CD), who was blind to the surface treatment and calibrated for caries scoring, achieved a substantial agreement ($\kappa = 0{\cdot}63$). Blackwood *et al.* [23] reported an intraexaminer reproducibility of almost perfect agreement ($\kappa = 0{\cdot}90$) when scoring microleakage of fissure sealants applied after three different surface treatments (pumice prophylaxis, fissure enameloplasty and air abrasion). Although the reproducibility is lower than hoped, it still represents acceptable levels. Further, the examiners looked at the sections independently and then reconciled differences maintaining the validity of the validating criterion. The intraexaminer reproducibility could possibly have been improved with additional training in the early stages of the study.

One criticism of the study is that the operator who applied the sealants also examined and scored the sections and therefore was potentially not blind.

Given the coding of the sections it is unlikely that this examiner would remember the allocation of any individual section and therefore have biased the results. Similarly the need for the examiners to agree on the results would also act against any bias.

All methods in this study were equally effective, but *in-vitro* studies cannot incorporate all factors. Further research in the area of resealing or repair of failed fissure sealants is necessary as part of clinical studies with the highest level of evidence (randomized, controlled trials). These are needed to identify the most effective and efficient method of resealing acceptable to children with a high caries risk.

## Conclusion

This *in-vitro* investigation did not demonstrate any one single method of repair to be superior to the control method, which was the use of slow-speed prophylaxis with a brush without any medium, followed by acid etching with 38% orthophosphoric acid for 30 s, before repair of the failed sealant. The control method seems to be the most appropriate, as this method is also likely to be agreeable to most children because of its noninvasive nature.

**Résumé.** *Objectifs.* Cette étude a eu pour objectif d'évaluer si les différences de traitement initial de surface influençaient le lien de scellements de sillons placés sur les surfaces occlusales de molaires permanentes.
*Mise en oeuvre.* Etude in vitro.
*Echantillon et Méthodes.* Cent vingt huit premières et secondes molaires humaines extraites ont été distribuées au hasard dans l'un des quatre groupes de trente deux dents. Un scellant photopolymérisable opaque non foulé (Delton) a été placé sur les surfaces occlusales après nettoyage et mordançage acide. Après conservation dans de la salive artificielle (Saliva Orthana) pendant une semaine, une simulation de scellement a été effectuée. Les dents ont ensuite été soumises à l'un des quatre traitements de surface. Groupe 1: à l'aide d'une brosse de prophylaxie à vitesse lente suivie d'un mordançage acide (méthode témoin), Groupe 2: fraise à vitesse lente et mordançage acide, Groupe 3: abrasion à l'air et mordançage acide, Groupe 4: mordançage acide et application d'agent de liaison. Après une semaine supplémentaire de stockage en salive artificielle, deux couches de vernis imperméable sur les surfaces non occlusales des dents. Leurs apex ont été scellés à la cire et les dents ont été immergées dans du bleu de méthylène à 1% pendant 48 heures. Les dents ont ensuite été sectionnées (ISOMET 1000) pour réaliser 3 découpes, soit un maximum de 4 blocs i.e. six surfaces par dents. Au total, 715 sections issues de 126 dents ont été notées pour les micro-percolations du côté intact et du côté réparé du scellant.
*Résultats.* L'analyse statistique n'a pas montré la supériorité d'aucune méthode de réparation par rapport à la méthode témoin pour réappliquer le scellant. Statistical analysis did not demonstrate any one single method of repair to be superior to the control method for reapplication of the sealant.
*Conclusion.* Les quatre techniques compares dans cette étude semblent acceptables pour remplacer ou réparer des scellants perdus ou détériorés. Comme la prophylaxie par brosse rotative à faible vitesse suivie par mordançage acide, qui représente probablement la pratique courante, est également la méthode la plus simple chez l'enfant, celle-ci est par conséquent recommandée.

**Zusammenfassung.** *Ziele.* Ziel der Studie war es zu untersuchen, wie Oberflächenbearbeitung von Reparatur einer Versiegelung sich auf die Reparatur einer Fissurenversiegelung bei bleibenden Molaren auswirkt.
*Setting.* In-vitro-Studie.
*Material und Methoden.* einhundertachtundzwanzig extrahierte menschliche erste und zweite bleibende Molaren wurden zufällig einer von vier Gruppen zugeordnet. Ein lichthärtender, ungefüllter opaker Versiegeler (Delton) wurde nach vorheriger Zahnreinigung und Säurekonditionierung appliziert. Nach einwöchiger Lagerung in künstlichem Speichel (Saliva Orthana) wurde nachversiegelt. Dazu wurden vier verschiedenen Vorgehensweisen der Oberflächenbearbeitung durchgeführt: Gruppe 1: langsam laufendes Winkelstück mit Zahnreinigungsbürste, danach Säureätzung; Gruppe 2: langsam laufendes rotierendes Instrument und Säureätzung; Gruppe 3: Partikelstrahlabrasion und Säureätzung; Gruppe 4: Säureätzung und Applikation von Bonding.

Nach einer weiteren Woche Lagerung in künstlichem Speichel wurden die Zähne bis auf die Okklusalfläche mit einer doppelten Lackschicht überzogen, die Apices wurden mit Wachs verschlossen und die Zähne dann für 48 h in 1% Methylenblaulösung eingelegt. Danach wurden die Zähne durch drei Schnitte aufgetrennt (Isomet 1000) so dass sechs zu untersuchende Oberflächen je Zahn resultierten. In

die abschließende auswertung hinsichtlich Farbstoffpenetration wurden 715 Schnitt von 126 Zähnen einbezogen.
*Ergebnisse.* Keine der benutzten Methoden zeigte statistisch signifikante Unterschiede zu den anderen Methoden der Nachversiegelung.
*Schlussfolgerung.* Alle vier in dieser Studie untersuchten Techniken erschienen akzeptabel für die Nachversiegelung von verlorenen oder frakturierten Versiegelungen. Da die Verwendung der Zahnreinigungsbürste mit nachfolgender Ätzung die derzeit wohl geläufigste und für die Anwendung am Kind praktikabelste Methode ist, kann diese auch für die Nachversiegelung empfohlen werden.

**Resumen.** *Objetivos.* El objetivo de este estudio fue investigar si diferencias en el tratamiento de la superficie antes de reparar influía en el sellado de la resina de un sellador de fisuras colocado en las superficies oclusales de molares permanentes.
*Realización.* estudio in vitro.
*Muestra y métodos.* Se distribuyeron aleatoriamente, 128 primeros y segundos molares en cuatro grupos de 32 dientes cada uno. Se colocó en cada superficie oclusal, tras la limpieza por profilaxis y grabado ácido, un sellador de fisuras opaco sin relleno fotopolimerizable (Delton). Después de su almacenamiento en saliva artificial (Saliva Orthana) durante una semana, se consiguió simular un fallo del sellador. Los dientes se sometieron entonces a uno de los cuatro tratamientos de la superficie:

Grupo 1. con cepillo de profilaxis a baja velocidad seguido de grabado ácido (método control), grupo 2: fresa a baja velocidad y grabado ácido, Grupo 3: abrasión por aire y grabado ácido, Grupo 4: grabado ácido y aplicación de un agente de adhesión. Después de otra semana de almacenamiento en saliva artificial se aplicaron a las superficies no oclusales de los dientes, dos capas de barniz impermeable; sus ápices luego se sellaron con cera y los dientes se sumergieron en azul de metileno al 1% durante 48 horas. Seguidamente los dientes se seccionaron (ISOMET 1000) realizando tres cortes que dieron lugar a un máximo de cuatro bloques ej: seis superficies por diente. Se valoraron un total de 715 cortes de 126 dientes, en busca de microfiltrado en el lado intacto y en el lado reparado del sellador de fisuras.
*Resultados.* El análisis estadístico demostró que ninguno de los métodos de reparación es superior al método control para la reaplicación del sellador.
*Conclusión.* Las cuatro técnicas comparadas en este estudio parecen ser aceptables para reeemplazar o reparar selladores de fisuras perdidos o fracturados. Como la profilaxis con un cepillo rotatorio a baja velocidad seguido de grabado ácido probablemente es la más representativa de la práctica corriente, es también la técnica más sencilla que puede practicarse en los niños, es por tanto la recomendada.

## References

1 Gordon PH, Nunn JH. Fissure sealants. In: Murray JJ (ed.) *The prevention of oral disease*, 3rd edn. New York: Oxford University Press, 1996: 78–94.
2 Feigal RJ. The use of pit and fissure sealants. *Pediatric Dentistry* 2002; **24**: 415–422.
3 Weintraub JA. The effectiveness of pit and fissure sealants. *Journal of Public Health Dentistry* 1989; **49**: 317–330.
4 Ripa W. Sealants revisited: An update of the effectiveness of pit and fissure sealants. *Caries Research* 1993; **27**: 77–82.
5 Chestnutt IG, Schafer F, Jacobson APM, Stephen KW. The prevalence and effectiveness of fissure sealants in Scottish adolescents. *British Dental Journal* 1994; **177**: 125–129.
6 Deery C, Fyffe HE, Nugent Z, Nuttall NM, Pitts NB. Integrity, maintenance and caries susceptibility of sealed surfaces in adolescents receiving regular care from general dental practitioners in Scotland. *International Journal of Paediatric Dentistry* 1997; **7**: 75–80.
7 Ismail AI, Gagnon P. A longitudinal evaluation of fissure sealants applied in dental practices. *Journal of Dental Research* 1995; **74**: 1583–1590.
8 British Society of Paediatric Dentistry: a policy document on fissure sealants in paediatric dentistry. *International Journal of Paediatric Dentistry* 2000; **10**: 174–177.
9 Scottish Intercollegiate Guidelines Network National Guideline 47. *Preventing Dental Caries in Children at High Caries Risk*. Edinburgh: Royal College of Physicians, 2000.
10 Gwinnett AJ, Caputo L, Ripa LW, Disney JA. Micromorphology of the fitting surface of failed sealants. *Paediatric Dentistry* 1982; **4**: 237–239.
11 Hitt JC, Feigal RJ. Use of bonding agent to reduce sealant sensitivity to moisture contamination: an *in vitro* study. *Pediatric Dentistry* 1992; **14**: 41–46.
12 Kidd EAM. Microleakage: a review. *Journal of Dentistry* 1976; **4**: 199–206.
13 Hatibovic-Kofman S, Butler SA, Sadek H. Microleakage of 3 sealants following conventional, bur and air-abrasion preparation of pits and fissures. *International Journal of Paediatric Dentistry* 2001; **11**: 409–416.
14 Ovrebo RC, Raadal M. Microleakage in fissures sealed with resin or glass ionomer cement. *Scandinavian Journal of Dental Research* 1990; **98**: 66–69.
15 Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977; **33**: 159–174.
16 Pashley DH, Clinical considerations of microleakage. *Journal of Endodontics* 1990; **16**: 70–77.
17 Hobson RS, McCabe JF. Relationship between enamel etch characteristics and resin-enamel bond strength. *British Dental Journal* 2002; **192**: 463–468.
18 Borem LM, Feigal RJ. Reducing microleakage of sealants under salivary contamination: Digital-image analysis evaluation. *Quintessence International* 1994; **25**: 283–289.
19 Xalabarde A, Garcia-Godoy F, Boj JR, Canalda C. Microleakage of fissure sealants after occlusal enameloplasty and

thermocycling. *Journal of Clinical Pediatric Dentistry* 1998; **22**: 231–235.
20 Donnan MF, Ball IA. A double blind clinical trial to determine the importance of pumice prophylaxis on fissure sealant retention. *British Dental Journal* 1975; **165**: 283–286.
21 Burrow MF, Makinson OF. Pits and fissures: remnant organic debris after acid etching. *ASDC Journal of Dentistry for Children* 1990; **57**: 348–351.
22 Garcia-Godoy F, Gwinnet AJ. Penetration of acid solution and gel in occlusal fissures. *Journal of the American Dental Association* 1987; **114**: 809–810.
23 Zyskind D, Zyskind K, Hirschfeld Z, Fuks A. Effect of etching on leakage of sealants placed after air abrasion. *Pediatric Dentistry* 1998; **20**: 25–27.
24 Blackwood J, Dilley DC, Roberts MW, Swift EJ. Evaluation of pumice, fissure enameloplasty and air abrasion on sealant microleakage. *Pediatric Dentistry* 2002; **24**: 199–203.
25 Hatibovic-Kofman S, Wright GZ, Braverman I. Micrleakage of sealants after conventional, bur, and air-abrasion preparation of pits and fissures. *Pediatric Dentistry* 1998; **20**: 173–176.
26 Goldstein RE, Parkins FM. Using air-abrasive technology to diagnose and restore pit and fissure caries. *Journal of the American Dental Association* 1995; **126**: 761–766.
27 Zervou C, Kugel G, Leone C, Zavras A, Doherty E, White GE. Enameloplasty effects on microleakage of pit and fissure sealants: an in vitro study. *Journal of Clinical Pediatric Dentistry* 1998; **20**: 25–27.
28 Halterman CW, Rayman M, Rabbach V. Survey of pediatric dentists concerning dental sealants. *Pediatric Dentistry* 1995; **17**: 455–456.
29 Hebling J, Feigal RJ. Use of adhesive as an intermediate bonding layer to reduce sealant microleakage on saliva-contaminated enamel. *American Journal of Dentistry* 2000; **13**: 187–191.