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Pits and fissures: etch resistance in prismless enamel walls

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Abstract

Background: In a previous study to examine the nature of etching on the walls of fissures, there was a consistent result of resistance to deep etching on parts of the walls and a zone of lesser etching on part of the walls as evidenced by the uptake of stain. The staining had been used to examine the nature of the etch pattern. The aims of this study were to define the nature of this etch resistant area.

Methods: A sample of 55 teeth, both molars and premolars, were divided into three groups. In the first group the wetting of fissures by the etchant was examined; the second group tested for the effects of pellicle-cuticle-debris or air entrapment on the etching process. The final group looked at alternative mechanical treatments of the fissure prior to etching.

Results: The specimens split along the fissures showed clearly that the etch resistant zone was not due to lack of contact with the etchant or the presence of a pellicle-cuticle-debris covering, but to the presence of a prismless enamel structure. This study showed that this zone inhibited tag development on the fissure walls.

Conclusions: The mechanical removal of this prismless layer of enamel within the fissure system should result in an improved bonding of a fissure sealant through better tag development, in turn leading to a reduction in the failure rate of a sealant used to prevent caries.

Key words: Fissure morphology, prismless layer, fissure sealants.

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INTRODUCTION

The technique of sealing fissures with a polymerising resin requires, firstly, penetration of the sealant to some extent into the fissures and secondly, adhesion to the tooth structure. Fissures may have varying amounts of organic remnants[1,2,4,5,6] which can limit the penetration of etching agents and their efficacy, and hence the area available for adhesion. The area available for adhesion is that of the enamel forming the opening into the fissure and the fissure walls themselves.

The clinical observation is that there is usually one of three outcomes after the placement of a fissure sealant. First, all of the sealant is retained, any loss being usually due to wear. Second, partial loss of the occlusal portion of the sealant may occur leaving remnants of the sealant in the fissures, and this is always a provocative issue because it affects judgement of success. Thirdly, there may be total loss of the sealant. The retention in the fissure will depend in part on the degree of etching that might occur in the opening to the fissure and on the walls of the fissure.[10,11] Possible resistance to etching is then of clinical interest for retention of the sealant.

In a series of specimens an air-water slurry of sodium bicarbonate was used in experiments to remove pellicle and deposits from fissures prior to etching,[3,6,7] it was noted that a region in the deeper sections of the fissures did not appear to etch as deeply. The degree of etching had been gauged by a dye absorption technique (Aniline Blue-Orange G).[3,4,5]

In the specimens that showed complete etching of the fissure system, as evidenced by the uptake of dye following the etching, it was always on those teeth that had shallow broad fissure systems, supporting the belief that the etchant often fails to successfully wet the deeper regions of narrow fissures.[3,6,7]

The areas that typically did not etch were the entrance to the fissure and the fissure walls. Galil[9] cites Awazawa[12] as finding that fissure surfaces were mainly prismless enamel with a degree of hypomineralization.[13] Tadokoro et al[14] similarly described this area within fissures as being resistant to etching, and more recent research has demonstrated similar findings.[2,10,11,21]

Because all the specimens tested showed this resistance to etching as evidenced by the uptake of stain, the question arose whether this lack of staining might be due to air entrapment preventing the etching agent from wetting these surfaces. Alternatively, a pellicle-cuticle-debris layer could prevent or diminish etching.

The objectives of this study were to examine if the reduction in etching might be histological in nature and if this affected resin tag formation or the reduction in

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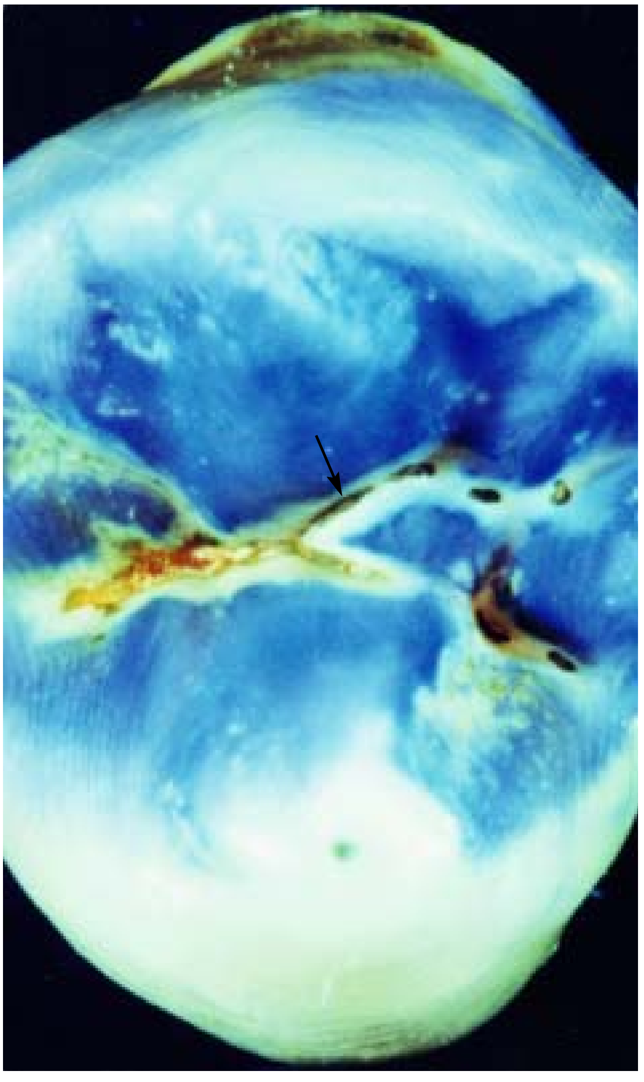

Fig 1. Specimens showing typical failure of etch to reach the base of fissures – the white central area.

etching might be due to a lack of wetting by the etching agent for either reasons stated above.

MATERIALS AND METHODS

Analysis of wetting by etchant of fissure walls

First, to show that the non dye-staining area of the fissure walls was not due to lack of wetting by the etchant or the presence of pellicle, a group of 20 teeth (9 premolars and 11 molars) which were stored in a chlorhexidene (0.05 per cent)-cetrimide (0.5 per cent) solution after extraction, was used. The roots were cut off with a diamond disc under running water, just below the cemento-enamel junction, and then a slot was cut from the CEJ towards the fissure. The slot was cut such that the teeth could be split along the fissure system at a later stage.

The teeth were then washed and cleaned on the occlusal surfaces with pumice and water on a bristle brush. All specimens were etched using 37 per cent phosphoric acid gel (Scotch Bond Etchant, 3M Dental Products, St Paul, MN, USA) for 60 seconds, followed by washing and drying.

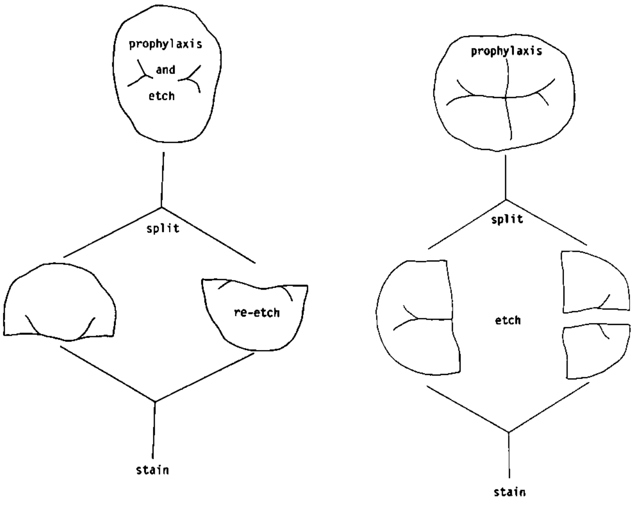

Fig 2. The scheme of treatment of the first group of 20 teeth; bicuspids (9) and molars (11) were treated in the sequence shown.

Squeezing opposing cervical areas together across the cervical slot caused the crown to fracture through the fissure[4] (Fig 2). Half of each specimen was then re-etched and all pieces were stained by the Aniline Blue-Orange G technique.[5]

To check/ensure that air entrapment was not a factor in the tests, the re-etched half of the split specimen was carefully examined for any evidence of changes in staining. Similarly, the presence, or absence, of pellicle was checked microscopically.

Analysis for pellicle-cuticle-debris or air entrapment effects

A second group of five teeth was cleaned and etched as before, and then fissure sealed (Oralin Tinted, SS White Manufacturing, Lakewood, NJ, USA). If acid etch resistance was present on the walls of fissures, then this could be assessed by the length of resin tag formation of the sealant.

After embedding the sealed teeth in epoxy resin, the tooth structure was removed by placing the teeth in 22 per cent hydrochloric acid for three days, and the remaining sealant replicas of the fissures were prepared by sputter coating with gold-palladium for scanning electron microscopy to examine the tag structure of the resin. Montages were made to compare tag morphology from the occlusal surface to the base of the fissures.

Analysis of alternative pre-chemical treatment of tissues prior to etching and sealing

A third group of 30 teeth, the fissures were modified prior to etching and staining (5 teeth with a small round tungsten carbide bur [Jet Carbide burs (ISO 007. 7B 556), Beavers, Canada], 10 teeth with a fine diamond [Komet (8859-010), Komet Co, West Germany], 5 teeth with a diamond coated broach in an ultrasonic-endodontic tip [Endosonic Diamond No 35, Caulk Dentsply Co., USA], 5 teeth with a micro-

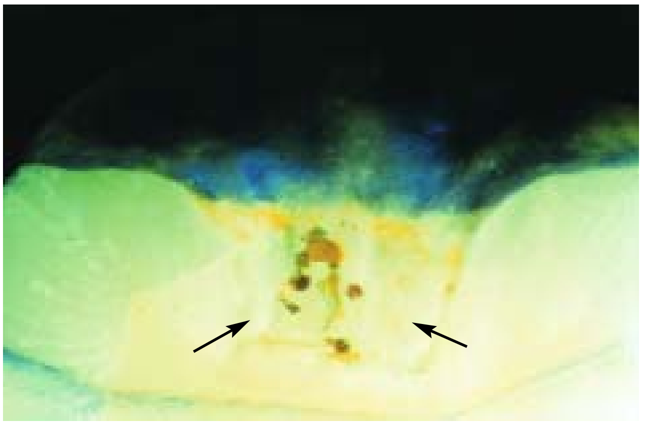

Fig 3. A fissure wall in a split tooth illustrating the etch resistant zone which did not take up the stain.

abrasion machine [KCF 1000 Whisperjet, American Dental Technologies, Michigan, USA], and 5 teeth with an air/water micro-abrasion machine [EMS Air Flow, PrepK, Nyon, Switzerland]).

The subsurface enamel in the fissure walls was then stained with the Aniline Blue-Orange G solution to indicate the degree of etchability or resistance following these treatments.

RESULTS

Reduced etching is shown in Figure 1, as evidenced by the lack of dye uptake, at the entrance to fissures. This typical picture was present in all specimens that were etched and stained prior to splitting.

In the first group of 20 teeth those halves which were only etched once showed a common zone which did not take up dye. This zone is illustrated in Figure 3. The other halves of this first group of molar teeth after splitting along the fissures and re-etching also showed this etch resistant zone which did not take up stain. Where microscopically there was no pellicle apparent after splitting and re-etching then this etch resistant zone was again evident.

The second group of five teeth prepared for SEM examination supported the results from the first group. The montage in Figure 4 illustrates the typical decrease in etch pattern and resin tags in the upper two thirds of the fissure wall. Over this area, at this relatively low magnification, the sealant acts like an impression material to show etch patterns of the enamel prism ends where present; higher magnifications allow determination of tag lengths. At the base of the pit as seen in Figure 4 there is some evidence of perikymata rings.

In the third group where fissure widening under water spray was undertaken with a tungsten carbide or diamond bur, the fissure showed complete uptake of stain after etching compared with little or no staining if there is no pretreatment, i.e., pretreatment removes the relatively etch resistant enamel. This also occurred with the broach in the ultrasonic handpiece, but here the removal of the prismless enamel was to a lesser extent

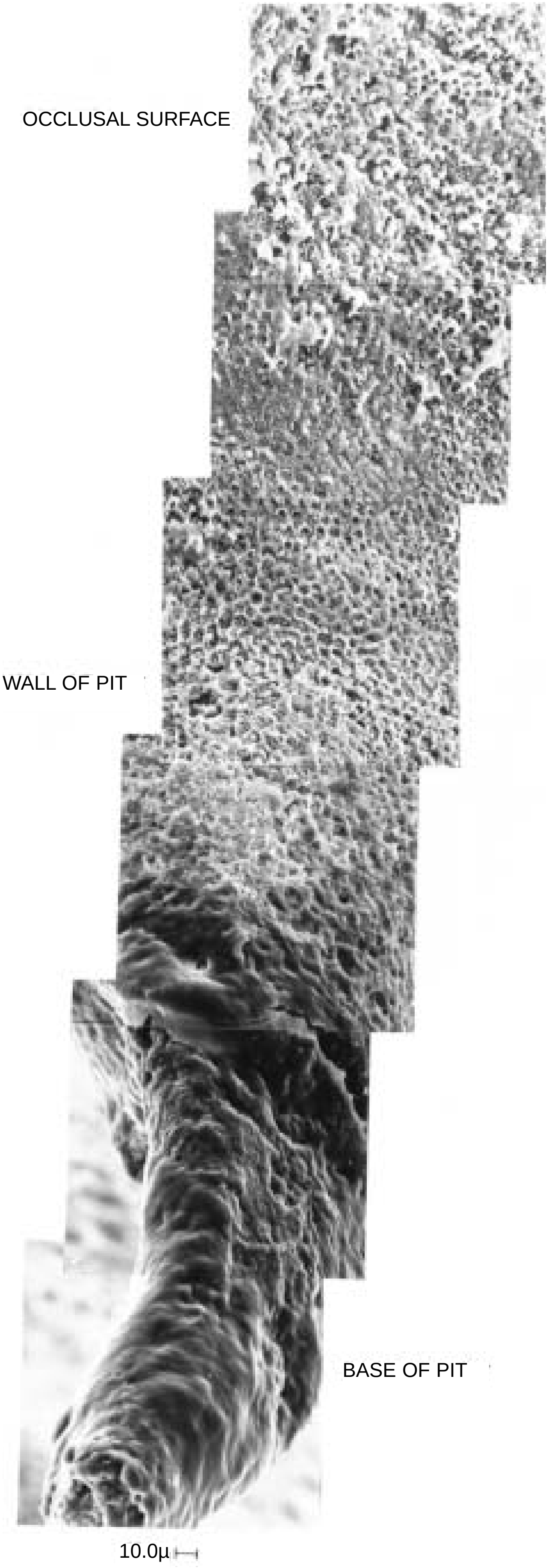

Fig 4. A montage from the SEM study showing the decrease in resin tag length of sealant with increasing depth into a fissure. (Magnification ×400).

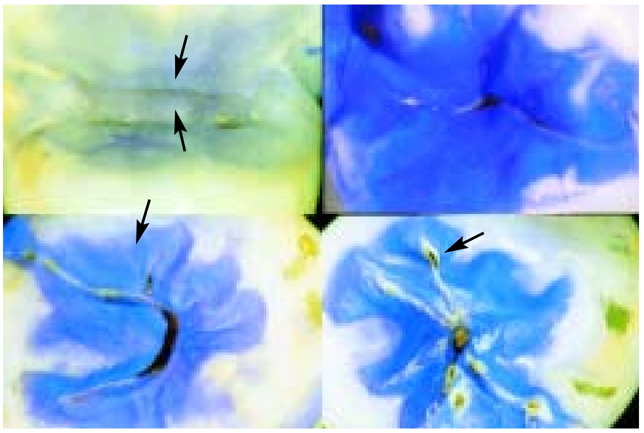

Fig 5. Typical results after using a bur (top left), a diamond (bottom left), air-abrasion (top right) and a broach ultrasonically (bottom right).

and quite slow (Fig 5). Both the micro-abrasion techniques used 50μm alpha aluminium oxide particles, resulting in the rapid removal of the etch resistant layer of enamel. A diamond coated broach was also tried in an ultrasonic handpiece. This tip was similar to the rotary diamond in its action, but at a slower rate.

DISCUSSION

The technique of splitting teeth before applying the etch directly to the fissure walls, as used in this study, eliminated any air entrapment factor as a cause for reduced etching. The lack of etching, as evidenced by reduced dye uptake, confirms the supposition of Awazawa[12,13] that this zone is prismless in the permanent dentition. This is similar to the findings of Gwinnett[15] for smooth surfaces of deciduous teeth.

The presence of pellicle in a fissure system, which will result in a diminished etching, is demonstrated in Figure 6. It is often difficult to detect the presence of pellicle prior to etching and sealing the fissures of a tooth, although the use of loupes in association with the placement of rubber dam aids in this detection markedly.

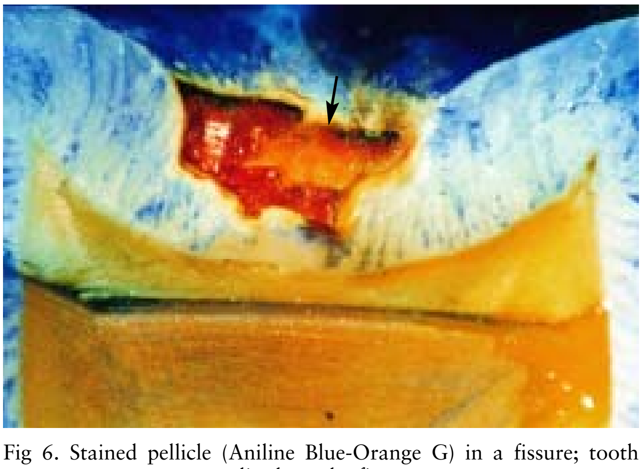

Fig 6. Stained pellicle (Aniline Blue-Orange G) in a fissure; tooth split along the fissure.

Fig 7. Surgically removed unerupted third molar etched and stained with Aniline Blue-Orange G.

The montage of the fissure system shown in Figure 4 results from the sealant acting as an impression of the enamel walls to show the etch patterns of the enamel prism ends where present. All the specimens in this study prepared for examination with the SEM showed etching patterns of Types 1, 2 and 3, as described by Silverstone, in and around the entrance to the fissure system, with numerous tags being evidenced on the cuspal slopes.

It can be seen that the depth of the etch pattern varies with depth into the fissure. This etch resistance in the middle part of the fissure wall may account for the general microscopic observation of decalcification and caries initiation being more prevalent in the deepest one third of the fissure.[22]

It has been suggested that the etch resistant ring around the entrance to the fissures system might be due to decalcification during, or after, eruption followed by remineralization with a more acid resistant apatite (E Kidd, personal communication).

To test this 18 unerupted third molars, which had been surgically removed, were etched and stained following prophylaxis with pumice and water. These unerupted teeth exhibited the same ring of etch resistant enamel at the fissure entrances (Fig 7). It would seem that this feature is a developmental one and not by remineralization after demineralization during the eruption phase from emergence to occlusal function.

In conclusion, the region just below the entrance to the fissure seems relatively resistant to etching, as hypothesised by Awazawa.[12,13] This appears to be due to a layer of prismless enamel at the surface of the walls and can be readily removed. Importantly for the retention of sealants, the etch pattern for tags decreases with depth on the walls of fissures and pits. There was also evidence that at the very base of pits and fissures an etch pattern was usually observed at a greater depth to the prismless section of the fissure wall.

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