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Pits and fissures: Relative space contribution in fissures from sealants, prophylaxis pastes and organic remnants

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Abstract

Background: Previous studies by the authors have looked at the nature of the fissure system of human permanent molars and premolars, and has provided evidence for the presence of a prismless layer of enamel. It was noted during these studies that the fissure spaces were often occupied by material other than the fissure sealant. The aim of this study was to define these materials and to look at the percentage contribution of each to the sealed fissure space.

Methods: A sample of teeth, both molars and premolars, were sealed with an unfilled fissure sealant after prophylaxis with a coloured prophylaxis paste. In one group, the crown of the tooth was removed by dissolution in hydrochloric acid following placement of the sealant. This revealed a negative image of the fissure system and its contents. The second group of teeth was sectioned following sealing, and the contents of the fissure space were analyzed.

Results: The negative image of the fissure system displayed the fissure contents by colour and the sectioned teeth were able to be computer analyzed to establish the relative contribution of sealant, prophylaxis paste and organic material to the fissure space.

Conclusions: Sealant contribution was in the range of 14-96 per cent, prophylaxis paste from 0-50 per cent and organic remnants 0-55 per cent. The presence of these last two components could contribute to sealant loss.

Key words: Pits, fissures, prophylaxis paste.

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INTRODUCTION

The use of pit and fissure sealants is a valuable clinical procedure to prevent occlusal caries in molar and premolar teeth, provided they are placed with care and then routinely maintained.

One of the first recorded recommendations in the use of a preventive measure for occlusal caries was by Gabell in 1941.[1] He described a technique for use in caries-susceptible mouths:

> 'A thin mix of black copper cement should be carried to the sulci with an explorer after drying and sterilizing. The tooth should then be covered with tin foil to protect it from moisture and the patient instructed to bring the teeth together and hold this position until the cement has set. The tin foil is then stripped off, and the excess cement may be chipped off with an explorer. This protection will last from six months to a year, and should be maintained until the tooth is in occlusion.'

Thirty years later, a similar technique was used by McLean and Wilson to force glass ionomer cements into fissures.[2]

The Third National Health and Nutrition Examination Survey conducted in the USA in 1996 (NHANES III) reported that while 78 per cent of 17 year olds had experienced dental caries only 19 per cent of children ages 5-17 years had received at least one sealant.[3] A survey of paediatric dentists and paediatric dentistry departments in US Dental Schools by Primosch and Barr[4] in 2001 to determine the variation and patterns of sealant usage came to the conclusion that there was no apparent consensus as to the appropriate patient and tooth selection criteria.

The work of Fatatsuki *et al.*[5] examined the early loss of sealants, either partial or complete, and showed a 14 per cent loss in the first three months following placement, with a further 7 per cent loss in the following three months. A 1995 study of private practitioners reported a failure rate in excess of 50 per cent over a three year period.[6]

Simonsen's classic long term study of fissure sealants, using an autocured, partly filled coloured sealant, showed a retention rate after 15 years of almost 28 per cent and with a partial retention rate of 35 per cent.[7]

Sealants are most cost effective when placed in patients, and on surfaces, at high risk for decay.[8] They must be adequately maintained to be effective.[9]

Our previous studies[10,11] have examined the morphology of fissures in molars and premolars as well as the presence of organic remnants following etching.

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A more recent study[12] looked at the nature of the enamel forming the walls of fissures and showed this to be of a prismless structure. Hence, failure to achieve a satisfactory bond for fissure sealants may be due to the lack of tag formation following etching. This prismless layer of surface enamel within the fissure has now been demonstrated microscopically by Hoh *et al*.[13]

Galil and Gwinnett[14] in 1975 studied the contents of fissures to examine their post-eruptive microbial colonization. While the upper portions of fissures contained a large number of distinct cocci and bacilli, the bottom of the fissures contained an amorphous mass of material with few recognizable bacteria and strong evidence of mineralization.

Kanellis *et al*.[15] compared sealant retention rates following traditional acid etching and the use of air-abrasion without etching. While the difference in retention rates at one year between the two techniques was not significant for occlusal surfaces, there were significant differences found in retention rates on other surfaces where air-abrasion preparation had a higher failure rate.

In 1972 Gwinnett and Buonocore[16] reported that there were deposits in the pits and fissures which would adversely influence resin penetration. In 1973 Taylor and Gwinnett[17] showed that pumice still remained within the fissure system when it was used to remove surface organic debris. More recently, Asquinazi *et al*.[18] have used radioactively labelled pumice to show that some of the pumice used in the prophylaxis is retained within the fissure system even after a 60 second wash, or the combined action of etching for 30 seconds followed by a 30 second wash.

The objectives of this investigation were to gain a better understanding of the morphology of the fissure space using replicas and to understand the contribution to the fissure space by organic and other remnants, prophylaxis pastes and sealant.

MATERIALS AND METHODS

A sample of 20 posterior permanent teeth, previously stored in formosaline, was used. The roots were cut off and the crowns temporarily mounted on a glass slide with an adhesive for ease of handling.

A prophylaxis of the occlusal surface was carried out with either a junior cup bristle brush or a Porte tapered bristle brush. A colouring agent was added to each of the prophylaxis materials to allow differentiation between sealant resin and organic matter.

In a pilot study several materials were tested for their suitability as a colouring agent. These included graphite, black Indian ink, silicon carbide, precipitated copper and aniline blue and, of these, the last was the best.

Ten of the teeth were cleaned with a pumice and water slurry, half with each type of brush, using a slow speed handpiece for a period of 30 seconds. The remaining 10 teeth were cleaned with a Zircate and water prophylaxis paste (Zirconium Silicate, Tin Oxide

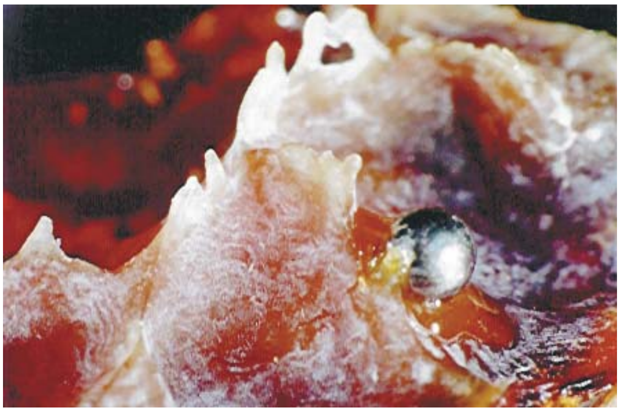


Fig 1. A 1mm diameter ball bearing was adhered to the point of entry to the fissure system of a molar as a measurement scale.

and Sodium Saccharine, Dentsply, York, Pennsylvania, USA), five teeth being cleaned with each type of brush for a period of 30 seconds.

After prophylaxis the teeth were washed with a water spray for 60 seconds, dried then etched and sealed with a red tinted fissure sealant (Teethmate F1, Kuraray Co Ltd, Osaka, Japan), following the manufacturer's instructions. This is an unfilled sealant with a low viscosity, for better penetration into the fissure system.

The sealed teeth were then embedded in epoxy resin, and the tooth structure removed by immersion in 20 per cent hydrochloric acid for three days. After the removal of enamel and dentine the specimens were washed in distilled water, dried and mounted on a glass slide for examination and photographing.

To indicate scale, a 1mm diameter ball bearing was adhered to the resin negative of the fissure system at the point of entrance to the fissure (Fig 1).

A second group of 25 teeth, 20 molars and five premolars, after the removal of the roots, were subjected to prophylaxis with aniline blue coloured Zircate powder and water prophylaxis paste. Excess prophylaxis paste was then removed with a 60 second water spray, the teeth were dried, etched and sealed with Teethmate-F1, following the manufacturer's instructions.

To define the point of entry to the fissure as outlined by Juhl,[19] a piece of soft orthodontic ligature wire 200µm in diameter was adapted to the fissure system entrance under a stereo microscope and then the fissure sealant was placed under vacuum. Figures 2 and 3 are examples of this.

All measurements for determining the area of each participant of the fissure space were made from this point.

Using an Isomet slow speed diamond saw (Buehler Ltd, Lake Bluff, Illinois, USA) these sealed teeth were cut in 1mm slices in a bucco-lingual direction (Fig 4). This produced, on average, seven slices for a molar and four slices for a premolar. To ensure the integrity of the slices, they were mounted on a glass slide.

Fig 2. Photograph of the occlusal surface of a molar tooth, overlaid with 200μm diameter wire to define the fissure entrance.

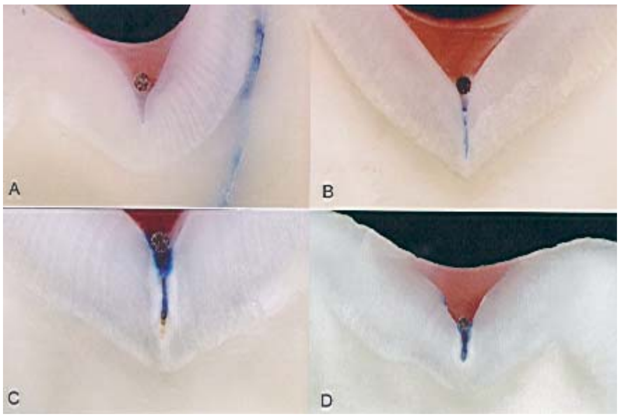


Fig 3. Sectioned molar and premolar teeth showing 200μm wire in place following the placement of the sealant and defining fissure depth.

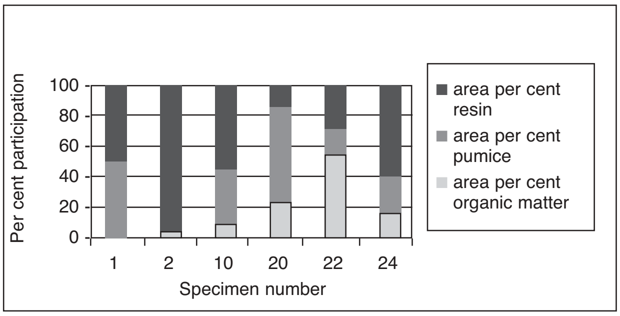
Unfortunately, this resulted in only one side of the slices being available for examination.

This produced 160 slices of sealed teeth, and these were photographed at 20x magnification using a Wild-Leitz M400 microscope.

Fifty of the photographic images were selected for digitizing to allow computer analysis using SPOT software (Diagnostic Instrument Inc, Silicon Valley, California, USA). It was relatively simple to identify the red of the sealant, the blue of the coloured prophylaxis paste and the yellowish colour of the organic remnants, allowing the areas of the fissure space to be measured.

Table 1. Relative contributions of organic material, prophylaxis paste and sealant to the fissure space

Specimen	Area per cent		
	Organic matter	Pumice	Resin
1	0	50	50
2	3.5	0	96.5
10	5	41.5	53.5
20	23	63	14
22	55	14	31
24	16	24	60



Using the cursor, it was possible to outline each of the three areas of interest, while the SPOT programme measured the area of each.

RESULTS

Area measurements of the fissure contents provided relative values for each of the three components, sealant, prophylaxis paste and organic remnants. Table 1 gives the results for a selection of the specimens. The data for the group of 32 specimens gave the following results:

organic remnants range 0-55 per cent, Mean 9.4 S.D. +/- 11.2

prophylaxis paste range 0-50 per cent, Mean 21.8 S.D. +/- 16.5

sealant resin range 14-96 per cent, Mean 68.8 S.D. +/- 19.2

Figure 5 is a montage of four of the specimens, showing a selection of the sections from the sealed teeth

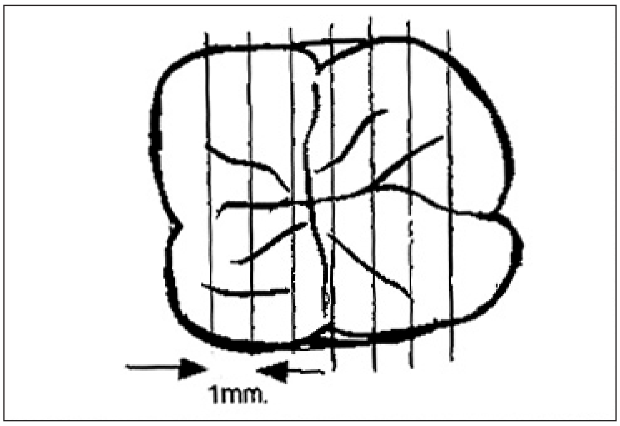


Fig 4. Demonstrates the sectioning of a molar tooth.

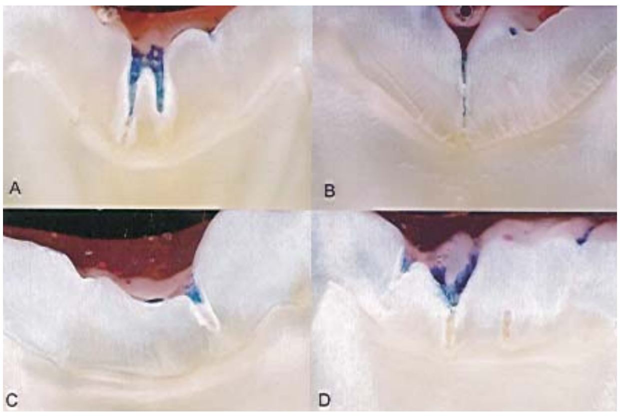


Fig 5. Montage of four slices through fissure sealed molar teeth which were digitized for computer analysis.

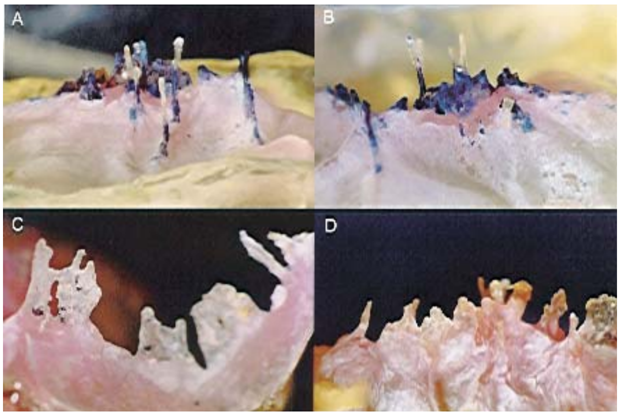


Fig 6. Montage of four molars showing the negative images of the fissure systems. The pink of the sealant, the blue of the prophylaxis material and the clear layer of the organic material are all clearly visible. Specimen C is the occlusal-palatal groove on an upper molar.

that had been subjected to a prophylaxis with aniline blue coloured prophylaxis paste. It was from this group of photographs that digitized images were made for subsequent computer analysis. Six cursor tracings of each section were made in order to reduce any operator error, with the average measurement being used for the analysis of the fissure contents.

In all the specimens, except those with a broad, shallow fissure system, there was prophylaxis material within the fissure. Two specimens showed over 50 per cent prophylaxis paste occupancy of the fissure space as assayed by the area method. The presence of organic material also represented a significant proportion of the fissure space in many of the specimens. It was surprising to find significant amounts of organic material present in some of the broad, shallow fissure systems where no prophylaxis paste had been retained.

The negative reproductions of the fissure systems obtained from the teeth of group A, as shown in Fig 6, revealed the different layers of resin, prophylaxis paste and organic remnants.

Microscopic examination of these specimens did not indicate acid dissolution of the prophylaxis paste or other fissure contents. The possibility of the formation of a hybrid 'resin-fixed' component of prophylaxis paste and organic remnants was not observed in these specimens.

DISCUSSION

Surface

Previous studies[12] have investigated the presence of prismless layer of enamel at the fissure entrance as well as part of the walls of the fissure itself, which result in a reduced etching pattern. The presence of organic material within the fissure system has also been demonstrated.[10]

Cleaning

This present study shows the difficulty of achieving clean surface enamel at the fissure entrance without

Fig 7. Scanning electron microscope photograph illustrating debris and pellicle on the cuspal slopes of a molar tooth.

filling the fissure space with the prophylaxis material. This can result in poor etching and therefore poor bonding of the sealant. This is illustrated in Fig 7 which is a scanning electron microscope (SEM) photo of the surface of a molar, showing the debris and pellicle present on the slopes of the cusps at the entrance to the fissure system. From this it is quite evident that there is a need to clean the enamel surface before etching and the placement of a sealant.

Spatial nature

The spatial nature of fissures by negative imaging has been demonstrated by Juhl.[20] Similar specimens used in the present study (Fig 6) demonstrate the complexity and variety of fissure systems which are not just troughs easily occluded by sealants.

In clinical practice, air bubbles trapped in the fissure will greatly decrease sealant penetration in many instances leading probably to early loss.

Contents

Analysis of the negative reproductions such as illustrated in Fig 6, while showing colour differentiations for the fissure contents, did not allow for computer analysis of relative contributions by sealant, prophylaxis and organic material.

Assessment of sections of sealed teeth indicated that the large contribution of prophylaxis paste and organic remnants to the fissure space may be expected to predispose to sealant loss. It is important to note that for these specimens the sealants were placed with vacuum and thus show no air bubble spaces that might be expected clinically.

While the data for contents of the fissures show a large variation in the fissure space occupied by the different components, reflecting some of the variations in fissure morphology, the surprising result was that the organic remnants and the prophylaxis paste may each occupy much of the fissure space. It is not surprising that some fissure sealants are lost early after placement and this must lead to a clinical review of technique and careful recall for examination and replacement programme of all sealants.

Clinical technique

One clinical protocol to improve the retention rate for fissure sealants would appear to be the opening of the fissure system by using air abrasion, the Fissurotomy System developed by the SS White Company (Lakewood, New Jersey, USA) or a very fine tapered diamond bur such as a 957 UF 007 from Komet (Lemgo, Germany) would be an appropriate alternative to take.[21-24]

This will remove the prismless layer lining the fissure and enhance the development of tags to ensure better bonding of the sealant and opening the entrance to the fissure will allow better flow of the sealant into the fissure space, with the hope that it will reach the base of the fissure system. Both of these procedures should have a favourable impact on the bonding of the sealant, with the expectation of a reduction in sealant loss.

In a study by Hosoya and Johnston[25] in which the cleaning and polishing effects of various agents on primary enamel were evaluated they made the statement 'If you want to etch ground enamel, for effective etching you must first use a handpiece to grind the enamel that is to be etched'.

An alternative clinical viewpoint is to retain the prismless enamel lining on the fissure wall as an acid resisting barrier to caries.

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