

The effect of sealant application and sealant loss on caries-like lesion formation *in vitro*

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Abstract

The effect of sealant placement and sealant loss on caries-like lesion formation was studied using an artificial caries technique and polarized light microscopy. The results indicate that lesion formation does not occur subjacent to an intact sealant. Even enamel which had lost its sealant was found to be caries-free. It is concluded that resin tags may be responsible for the ability of sealants to resist a caries-like attack.

With the introduction of the acid-etch technique, it became possible to reduce greatly the occurrence of pit and fissure caries¹⁻³ and to improve the marginal integrity of composite resin restorations.^{4,6} Retention of resin materials is due to penetration of resin tags into the porosities created by acid-etching sound enamel.^{7,9} These tags may penetrate the enamel to a depth of 50 to 60 micrometers.^{7,9}

Although the caries reduction potential of sealants and sealant retention rates have been shown, many practitioners still express concern regarding the effect sealant placement has on the caries susceptibility of both unsealed etched enamel and enamel which has lost its sealant.¹⁰ The placement of sealant or a bonding agent dramatically reduces the solubility of enamel in organic acids.^{8,11,12} The solubility rate of sealed enamel has been shown to be reduced greatly when compared with solubility rates for sound enamel. Acid-etched enamel has a higher solubility rate than sound enamel. However, following an exposure period of one to four days to whole saliva, the solubility rate for acid-etched enamel was found to be similar to that for sound enamel. The effect of sealant loss on enamel solubility has been studied *in vitro* by abrading away the sealant until no material is detected by visual and tactile examination.^{11,12} The solubility rate of the enamel which has "lost" its sealant was shown to be less than that for sound enamel. It was suggested that sealant tags were retained in the abraded enamel and these tags were

responsible for the increased resistance to acid dissolution when compared with sound enamel. Furthermore, it has been postulated that resin tags may provide protection against carious lesion formation.^{8,11,12}

The purpose of this study is to evaluate the effect of sealant placement and sealant loss on the formation of caries-like lesions *in vitro*.

Methods and Materials

A total of 20 extracted, caries-free molar and premolar teeth were used in this study. The specimens were cleaned thoroughly with fluoride-free prophylaxis paste using a slowspeed handpiece. Mesiodistal cavities were prepared on buccal and lingual surfaces of the teeth using cross-cut fissure burs in a highspeed handpiece. The buccal cavities were the test sites, the lingual cavities serving as controls. The cavities were rectangular shaped with rounded internal line angles. The cavity depths were 1.0 mm or less with the cavity walls and floors placed in enamel. An acid-resistant varnish was applied to each tooth leaving the cavity and a 1 mm rim of sound enamel surrounding the cavity exposed. The cavity and the exposed sound enamel were treated with the etching solution provided by the manufacturer for 60 seconds. The specimens were washed with water for 30 seconds and air dried for 30 seconds. Sealant^a was then placed in the cavity preparation. The cavity margins were sealed, resulting in featheredged margins.

In order to determine the effects of sealant loss on caries-like lesion formation, the sealant was removed from five sealed cavities using a cross-cut fissure bur in a highspeed handpiece. Following sealant removal, the cavities were examined using a dental explorer and a stereo-zoom binocular microscope to make certain that no sealant was pres-

^aDelton-Johnson and Johnson Co., East Windsor, NJ.

ent. The specimens were then placed in an acidified gelatin gel brought to pH 4.0 by the addition of lactic acid. This artificial caries system creates caries-like lesions in enamel which are indistinguishable from naturally occurring carious lesions.¹³ After an appropriate exposure period, the specimens were sectioned through the test regions and ground sections were prepared for polarized light examination.

Ground sections were examined by polarized light microscopy following imbibition in water. Two zones of enamel caries may be seen in water, the negatively birefringent surface zone and the positively birefringent body of the lesion. Each cavity provided two test sites, the cervical cavity margin and the occlusal cavity margin. If the sealant was ineffective at preventing lesion formation, lesions would be present beneath the sealant along the enamel surface, the cavity wall and the cavity floor.

Results

Unfilled Cavity Preparations

The unfilled cavity preparations which were exposed to the acidified gelatin gel possessed two distinct types of lesions, an outer surface lesion and a cavity wall lesion (Figure 1). The cavity walls and floors were more extensively involved by the caries-like lesion than the surface enamel. This observation was based on the depth of enamel involved by the body of the wall lesion as compared with the depth of penetration of the body of the outer lesion. Well-defined surface zones were noticeably absent in the majority of specimens with cavity wall lesions. The outer surface lesions generally had distinct, negatively birefringent surface zones.

Cavities With Sealant Loss

The cavities which had their sealant removed did not develop cavity wall lesions (Figure 2). Outer surface lesions were present and appeared to terminate near the location occupied by the sealant featheredge prior to its removal. A small quantity of retained sealant could be seen adjacent to the cavity wall in a few specimens. Since no cavity wall lesions developed, resin tags present in the porosities of the cavity walls and surface enamel were thought to provide protection against the caries-like process.

Cavities With Featheredge Sealant

Featheredging of sealant material over the cavity margin resulted in an interesting effect on caries-like lesion formation (Figures 3 and 4). Outer surface lesions appeared adjacent to the point at which the sealant featheredge commenced. However, no lesion formation developed beneath the sealed enamel surface and no cavity wall lesions were observed. A few specimens (Figure 4) had featheredges of minimal

thickness, but no lesion formation occurred subjacent to these areas. This emphasizes the fact that the mere presence of resin tags is sufficient to prevent caries-like lesion formation, irrespective of the quantity of material present.

Contamination of the surface enamel was thought to have occurred prior to sealant placement with two specimens (Figure 5). The sealant did not adhere to the surface enamel at the periphery of the featheredge. However, the sealant was in close contact with the cavity wall and the surface enamel adjacent to the cavity wall. Development of a caries-like lesion occurred subjacent to the peripheral sealant where no bond formed. The boundary of the lesion was located at the point where the sealant and etched enamel were in intimate contact.

Discussion

The ability of sealants to prevent the formation and progression of caries-like lesions has been demonstrated in this study. Previously, tags of resin have been shown to be responsible for the retention of sealants and composite resin restorations.^{1,3} In addition, it has been suggested that the presence of clinically undetected subsurface resin tags may provide protection against demineralization of enamel.^{7,8} The lack of lesion formation subjacent to the sealant materials supports this suggestion. Even after the sealant was mechanically abraded away, the cavity preparation and surface enamel which had been sealed were protected from the caries-like attack. However, the adjacent sound enamel was not protected and lesion formation occurred.

The artificial caries method¹³ used in this study produces lesions in enamel which are indistinguishable from naturally occurring enamel caries. This results in a caries-like attack upon sound enamel which is comparable to the *in vivo* caries attack, but occurs at a more rapid rate. Information gained from the present study has demonstrated the effect of a diffusion controlled caries-like attack upon sound enamel, whereas enamel solubility studies can only test the effect of exposing sound enamel to acid solutions. The results obtained with the artificial caries method used in this study should correlate well with *in vivo* development of caries adjacent to sealants and composite resin restorations.

Cariostasis following *in vivo* loss of pit and fissure sealants has been reported.¹⁴ Caries reduction for teeth which have lost their sealants was found to be 83% when compared with their contralateral control teeth. The histopathologic sequelae of caries-like attack upon enamel which had sealant abraded away was demonstrated in the present study. Even though the sealant could not be detected tactilely and macroscopically, the sealed abraded enamel was

Figure 1. Longitudinal ground section of an unfilled cavity preparation exposed to the acidified gelatin gel. The section was imbibed with water and viewed with a polarized light microscope. The cavity wall lesion (W.L.) shows a greater depth of penetration into sound enamel (S.E.) than the caries-like outer surface lesion (C.L.). The wall lesion involves the entire cavity preparation (C) including the floor of the cavity. (80x)

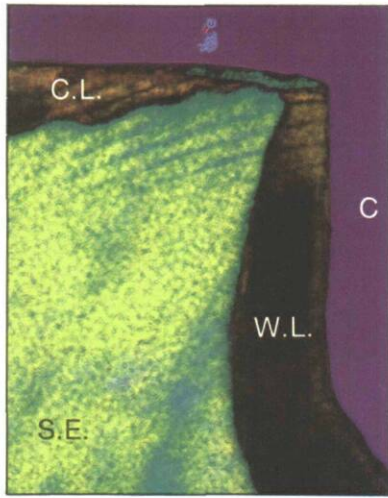


Figure 2. Longitudinal ground section of a cavity with sealant loss (sealant mechanically abraded away) exposed to the acidified gelatin gel. The section was imbibed with water and viewed with a polarized light microscope. Although the sealant was not detected tactilely or macroscopically, no cavity wall lesion developed and the caries-like outer surface lesion (C.L.) did not involve the area that was occupied by the featheredged sealant prior to removal. A remnant of sealant (S) may still be seen in the cavity preparation (C). S.E. = sound enamel. (80x)

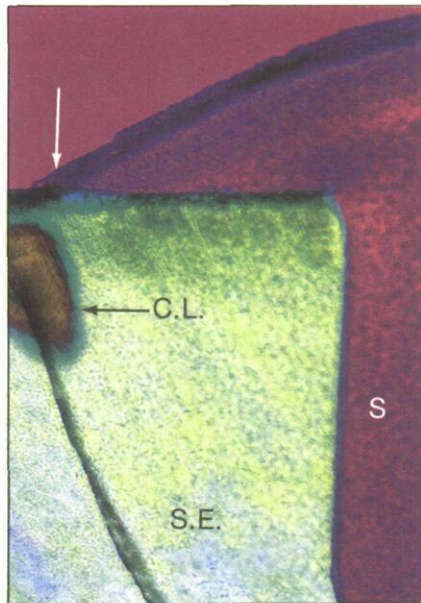
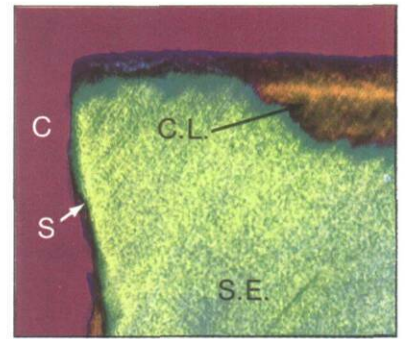


Figure 3. Longitudinal ground section of cavity filled with sealant (S) featheredged (arrow) over cavity margin. Ground section imbibed in water and viewed with a polarized light microscope. The caries-like outer surface lesion (C.L.) has not involved the cavity wall or the sealed surface enamel. The boundary of the caries-like lesion (C.L.) terminates at the point (arrow) where bonding has occurred between the sealant (S) and the etched enamel. S.E. = sound enamel. (80x)

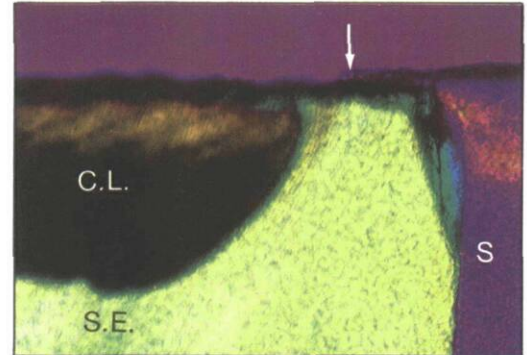
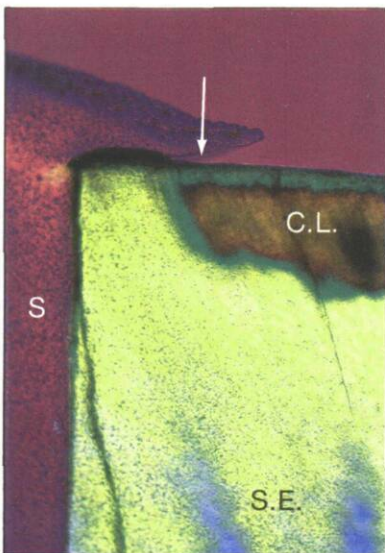


Figure 4. Longitudinal ground section of cavity filled with sealant (S) featheredged (arrow) over cavity margin. Ground section imbibed in water and viewed with a polarized light microscope. This specimen has a featheredged margin of sealant (arrow) which is of minimal thickness. However, the caries-like outer surface lesion (C.L.) does not involve the sealed enamel, but terminates near the area where the featheredged margin (arrow) commences. S.E. = sound enamel. (80x)

Figure 5. Longitudinal ground section of cavity filled with sealant (S) featheredged over the margin. Ground section imbibed with water and viewed with a polarized light microscope. With this specimen it is likely that contamination of the surface enamel has occurred resulting in a failure of the sealant to bond to a portion of the etched enamel surface. The caries-like outer surface lesion (C.L.) is located subjacent to the area where bonding did not occur. However, the lesion (C.L.) does not involve the cavity wall or the surface enamel which is bonded to the sealant (arrow). S.E. = sound enamel. (80x)



caries-free. Undoubtedly, the presence of residual resin tags provided protection against caries-like lesion formation.

Featheredging of composite resin restorations is a clinically accepted procedure when used in conjunction with the acid-etch technique. Microleakage studies have shown that this type of restoration significantly reduces marginal leakage at the enamel-resin interface^{4,6} With composite resin restorations, unfilled bonding agents are responsible for the formation of resin tags. Therefore, retention of the restoration is dependent upon a resin material which is identical to that used for sealing pits and fissures. In addition, the unfilled bonding agent along with the cavity wall and surface enamel forms the enamel-resin interface (Figure 6). The integrity of this

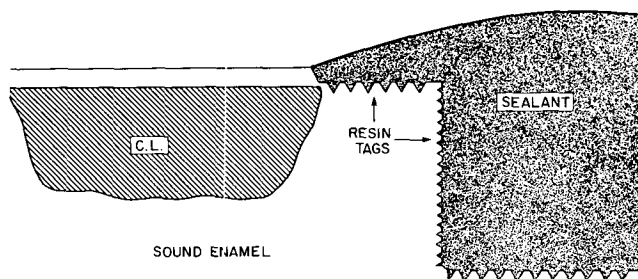


Figure 6. Schematic representation of the role of resin tags in the formation of caries-like lesions. Acid-etching of enamel produces a 10 to 15 micrometer loss of surface enamel and porosities in the enamel of 40 to 60 micrometers in depth. Sealants penetrate these pores and result in the formation of resin tags. Resin tags are responsible for retention of sealants and composite resin restorations. In addition, these resin tags decrease enamel solubility in acid and prevent the formation and progression of caries-like lesions subjacent to sealed enamel.

enamel-resin interface is quite important since this is where marginal leakage may occur and result in recurrent caries.

The featheredging part of the study demonstrated clearly that the presence of sealant determined whether or not caries would develop. Caries-like lesions were present subjacent to enamel which was not sealed. Although these lesions extended toward the featheredged sealant, the boundary of the lesion terminated at the location of the enamel-resin bond. It was also shown that contamination of the enamel surface plays an important role in determining if bonding will occur between the sealant and etched enamel. Contamination may be due to organic debris, plaque, saliva, or even oils present in the air syringe used to dry the enamel surface. Contamination could result in failure to produce an adequate bond between the resin material and the etched enamel with the possibility of subsequent recurrent caries.

The mechanism by which resin tags prevent lesion formation or progression is not known. Presumably it is because a resin surface is presented to the attacking agent rather than an enamel surface. Since the resin material is unaffected by acid, and since acid is not able to penetrate the resin layer to reach enamel, the tissue remains relatively unaffected. The results of this study tend to indicate that the presence of resin tags definitely affects the formation of caries-like lesions. When a tooth which has been sealed or restored using the acid-etch technique is subjected to a carious attack, an outer surface lesion may form adjacent to the sealant or composite resin restoration (Figure 6). However, no cavity wall lesion or lesion subjacent to the sealed surface enamel will develop if the enamel-resin interface is intact. When a sealant is lost, the presence of residual tags still provides protection against the formation of caries. Perhaps with the use of the acid-etch technique and supplementary fluoride rinses, the occur-

rence of enamel caries around pit and fissure sealants, composite resin restorations, and resin-bonded orthodontic brackets may be reduced.

Conclusions

The results from this study indicate that:

1. Sealants or unfilled bonding agents provide a protective barrier against caries-like lesion formation,
2. Loss of sealant material does not result in enamel which is more susceptible to caries, but may provide protection against the caries-like process due to the presence of resin tags in the enamel, and
3. Resin tags may be responsible for the ability of sealants to resist a caries-like attack.

Funding for the color separations in this article provided through the courtesy of Johnson & Johnson Dental Products Company, East Windsor, NJ.

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