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White spot formation associated with sealants used in orthodontics

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Abstract

Oxygen inhibition of sealant polymerization occurs when substantial thicknesses of low viscosity resins are applied to smooth tooth surfaces. Measurements have shown a range of sealant thickness from 0 to 228 micrometers. The objective of this study was to test whether or not the polymerized film present on the tooth was sufficient to provide protection against enamel dissolution. Metal brackets were bonded to thirty caries-free teeth using five different commercially available resins. The six teeth in each group were exposed for 96 hours to an aritifical caries environment of lactic acid in hydroxy-ethyl cellulose at pH 4.5. The teeth were then embedded and serially sectioned longitudinally. The sections were examined by polarization microscopy, scanning electron microscopy, and contact microradiography. Results showed that with the exception of Nuva Seal, all other resins frequently failed to prevent the formation of subsurface lesions in enamel where sealant was initially applied.

Introduction

The use of small, resin-bonded brackets in orthodontics is a routine procedure in many practices. It has been heralded as a more physiologic approach than the circumferential banding of teeth in which gingival irritation and white spot formation are well-known.

Using ultraviolet photographic and clinical techniques Gwinnett and Ceen[1] established that extensive areas of plaque can develop in association with resin-bonded brackets. Other investigators have demonstrated that the rough surface of conventionally filled resins predispose to the rapid attachment and growth of oral micro-organisms.[2]

Gorelick, Geiger and Gwinnett[3] have studied the frequency of occurrence of white spot lesions associated with directly bonded orthodontic brackets. These occur at the cervical junction of the resin and enamel, and frequently appear to extend beneath the bonding resin. Placement of a resin sealant on the labial enamel surface prior to bracket bonding has been suggested as a method of providing protection against such demineralization.[4] The duration of this protection however, is predicated upon polymerization of the resin sealant, its thickness and distribution. Recent studies by Ceen and Gwinnett,[5] have shown significant variations in the thickness of resin sealant films applied during the direct placement of bonded orthodontic brackets. Measurements of film thickness of five commercially available products ranged from 228 microns to amounts so small as to be immeasurable by light-optical techniques. This was confirmed by scanning electron microscopy. A relation between viscosity and polymerized film thickness was noted in which the more viscous resins produced thicker films. While the labial enamel was clinically covered with resin initially, oxygen inhibition of polymerization in some products involved almost the full thickness of the resin film present. Subsequent washing will remove this inhibited film.

It has been suggested by Gwinnett and Matsui,[6] and by Silverstone,[7] that the presence of a clinically undetected subsurface accumulation of resin may afford protection against enamel demineralization. The objective of this study was to test whether any protection was afforded to the enamel peripheral to bonded orthodontic brackets when sealants were applied.

Methods and Materials

Thirty freshly-extracted, caries-free, permanent maxillary anterior and bicuspid teeth were bonded with metal brackets using five commercially available resins.[a] Prior to bonding, the teeth were stored in 70% alcohol. Five groups were established for identifica-

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tion. Four groups were bonded using an intermediate sealant and composite resin. One group was bonded using a so-called wet film composite resin without an intermediate sealant as a control. The bonding procedures involved the following steps:

1) The enamel surface was cleaned using flour of pumice on a soft rubber cup, applied for 15 seconds with a slow speed handpiece.
2) The entire labial surface was conditioned for 60 seconds using orthophosphoric acid supplied by the manufacturer.
3) The sealant was applied to the entire labial surface on four of the five groups.
4) Bonding resin was applied to the bracket base and the bracket was bonded to the tooth surface.
5) Excess composite resin was carefully removed from the periphery of the bracket.

After bonding, the crowns of the teeth were covered with nail varnish to within 1mm of the bonding resin. This exposed the area adjacent to the bonding resin in which white spots were encountered clinically. The roots of the teeth were covered with wax and each tooth suspended from a glass rod in a rubber-stoppered bottle containing a medium for producing white spots.

The medium consisted of a sodium lactate buffer in hydroxy-ethyl cellulose at pH 4.5. The specimens were suspended in the medium for 96 hours and washed thoroughly with water upon removal. The specimens were dried and embedded in Epon for sectioning. Longitudinal sections were cut with a water-cooled, rotating, diamond wheel to include the bracket, its bonding resin and the adjacent tissue. The sections were reduced to approximately 100 microns using a graded series of wet and dry abrasive papers.[b] A minimum of two sections were prepared from each tooth.

The following complementary methods of section examination were chosen.

The first method was polarization microscopy. Each section was prepared for mounting using routine histological methods. The sections, mounted in eukit, were examined with a microscope equipped with polarized light attachments and strain-free optical components. Observations were recorded on Kodak Type A film with a quartz plate inserted to provide a first order Newton interference color at 550 nanometers. This red color was used as a basis for comparing the birefringent qualities of enamel.

The second method was scanning electron microscopy. One of the sections from each tooth was mounted on an aluminum stub using silver conductive paint. Each section was then briefly exposed to 50% phosphoric acid to bring into relief that portion of the lesion into which embedding resin had infiltrated. The sections were then coated with gold in a sputtering device equipped with a water-cooled anode. The samples were examined in a scanning electron microscope[c] operating at 10 Kv - 20 Kv. Observations were recorded on Polaroid type 52 film.

The third method of examination was contact microradiography. Each section was mounted on a Kodak 649-0 photographic plate housed in a microradiographic camera developed and reported by Gwinnett and Frazier.[8] The radiographs were taken on an x-ray diffraction generator[d] equipped with a fine focus copper target. The plates were developed in D19 and subsequently mounted on microscope slides for examination and photomicrography.

Results

Those teeth to which chemically catalyzed sealants were applied failed consistently to prevent the formation of white spots adjacent to the bracket and its bonding resin.

An examination of sections using polarized light microscopy showed a narrow, continuous, sub-surface zone of positive birefringence contrasting with the intrinsic negative birefringence of enamel (Figure 1). This photomicrograph is a typical example of the findings of this study and it shows an altered zone of enamel extending cervically from the edge of the bonding resin and the bracket. In a number of instances, the lesion appeared to extend slightly below the bonding resin (Figure 2).

Scanning electron microscopy provided confirmation of the existence of sub-surface lesions in enamel

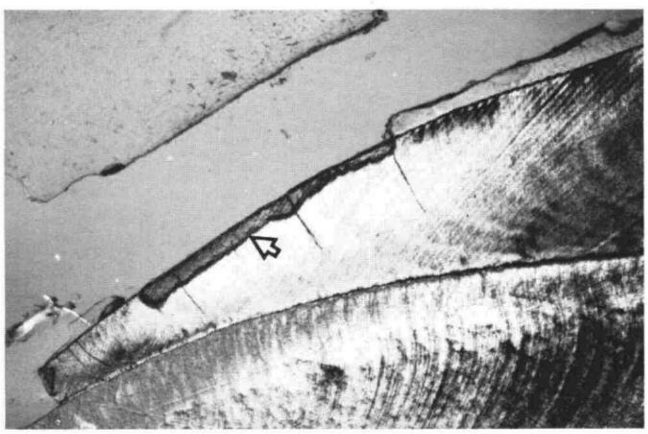

Figure 1. Photomicrograph taken in polarized light in which a zone of demineralization (arrow) can be seen in an area to which sealant was applied. Original magnification x 25.

a1. Nuva Tach — Caulk Corp.
2. Endur — Ormco Corp.
3. Concise — 3M Corp.
4. Interlock — Rocky Mountain/Orthodontics.
5. Solo Tach — Caulk Corp.

b3M Corporation, St. Paul, Minnesota.

cAMR, Bedford, Massachusetts.

dPhillips, Bridgeport, Connecticut.

adjacent to, and occasionally below, the bonding resin. The spaces created during white spot formation were infiltrated with the embedding resin. In Figure 3, the resin is shown in relief following partial demineralization of the enamel during specimen preparation.

In this particular specimen (Figure 4) the lesion can be seen to extend beneath the bonding resin.

Contact microradiographs (Figure 5), provided additional confirmation for the existence of a zone of sub-surface demineralization at sites where sealant was placed during the bonding of the brackets. Beneath a zone of relatively intact outer enamel is a zone of radiolucency due to mineral loss.

No differences were noted between the controls and teeth to which autopolymerized sealants were added.

Discussion

Sealants are recommended on the basis of fulfilling three primary functions: 1) to enhance bond strength, 2) to enhance marginal adaptation and eliminate interfacial permeability, and 3) to protect enamel from dissolution. While results from laboratory and clinical studies have formed the basis for these recommendations[9] much equivocation exists on the subject. Pits and fissures sealed with resins have shown significant reductions in the caries attack rate for the occlusal site.[10] However, the application of some of these same sealants has failed to provide consistent protection against white spot formation on smooth tooth surfaces immediately adjacent to bonded orthodontic brackets (Figure 6).

Such lesions are located in areas where new and often extensive plaque accumulations occur[1] (Figure 7). Sealants are applied in the normal course of the bonding protocol to such areas in anticipation of enamel protection.

An examination of surfaces to which sealant has been applied shows areas of enamel microscopically devoid of sealant (Figure 8). This can be observed clinically and such an observation has also been reported by Zachrisson and his co-workers.[11]

Gravity significantly influences the distribution of sealant on the tooth. It is often clinically difficult to position the patient and the teeth to minimize its effect, particularly in the lower arch. Low viscosity seal-

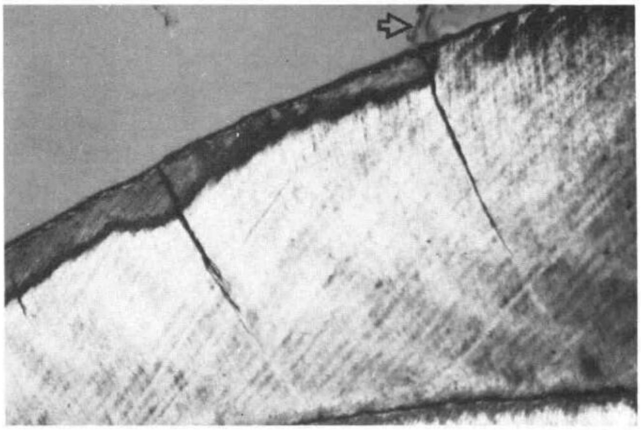

Figure 2. Photomicrograph showing extension of lesion below bonding resin (arrow). Original magnifcation x 67.

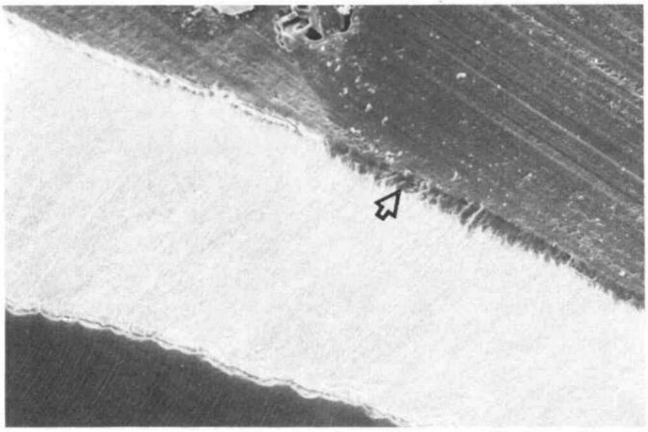

Figure 3. Scanning electron micrograph showing lesion infiltrated with embedding resin (arrow). Original magification x 80.

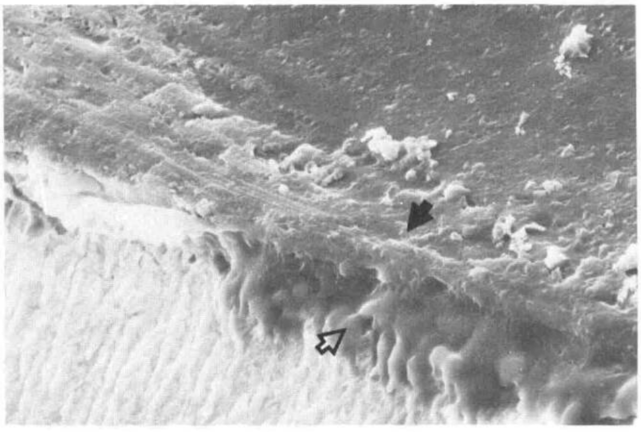

Figure 4. Scanning electron micrograph showing infiltrated lesion (open arrow) extending below the bonding resin (closed arrow). Original magnification x 800.

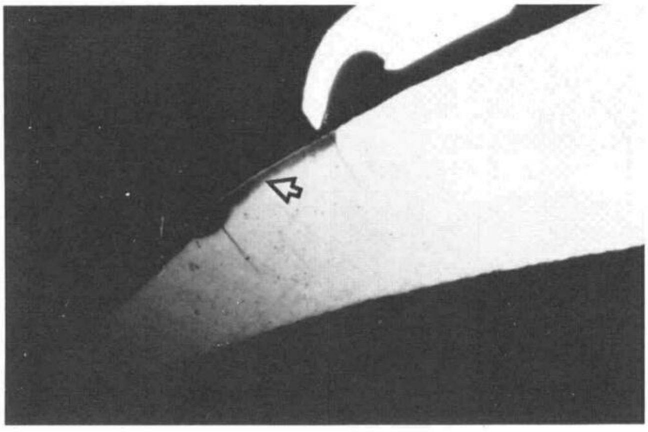

Figure 5. Contact microradiograph showing a surface area of radiolucency in enamel (arrow) adjacent to a bonded bracket indicating tissue loss. Original magnification x 25.

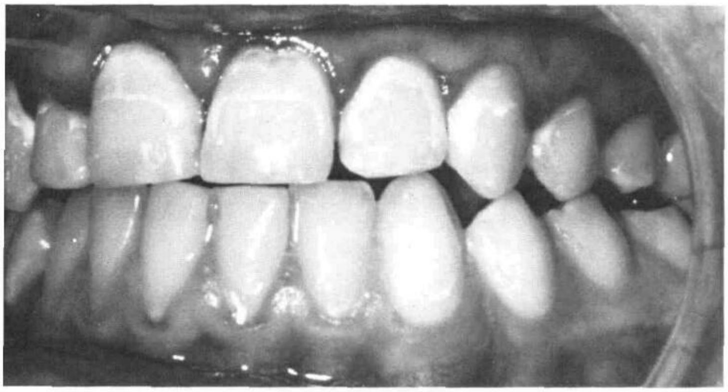

Figure 6. Upper anterior segment showing typical arc-shaped lesions of *enamel demineralization associated with bonded brackets.*

ants with relatively high spreading pressures produce thin sealant films whose thickness is often totally unpolymerized because of oxygen inhibition of polymerization. This unpolymerized resin is removed by washing to expose the etched enamel surface below.

Some sealant may be present within the enamel though it is often sparsely distributed and, as is apparent from this study, affords no protection for the enamel (Figure 9). It is also evident that demineralization of enamel may spread below the bonding resin, producing lesions greater than those clinically visible. This is consistent with clinical observations following bracket-debonding.

Contrary to popular belief, repeated applications of some sealants does not result in any accrual of resin to produce thicker layers. Figure 10 is an example of five repeated applications failing to produce any significant thickness of resin, leaving areas of exposed enamel as islands among the sealant.

The trend toward low viscosity sealant products to maximize resin penetration into the enamel micropores has posed problems in providing sealant coverage on smooth enamel surfaces.

Conclusions

Many sealants used today fail to provide enamel protection for smooth surfaces adjacent to bonded brackets. The thrust should be to maximize sealant film thickness by minimizing or eliminating the effect of oxygen inhibition of polymerization. Relatively higher viscosity resins should be examined together with the addition of fillers to improve the abrasion resistance of currently formulated products.

Acknowledgment

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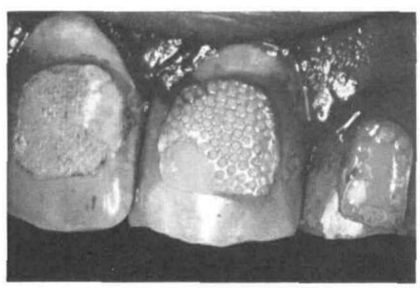
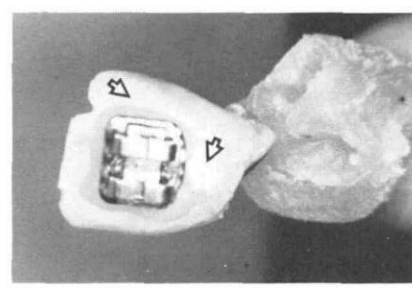
Figure 7. Photograph taken in ultraviolet light showing dark areas of plaque extending from the cervical portion of the bonding resin into the embrasures (left).

Figure 8. Denuded areas of enamel (arrows) can be seen where sealant was applied during the bonding of the bracket (right).





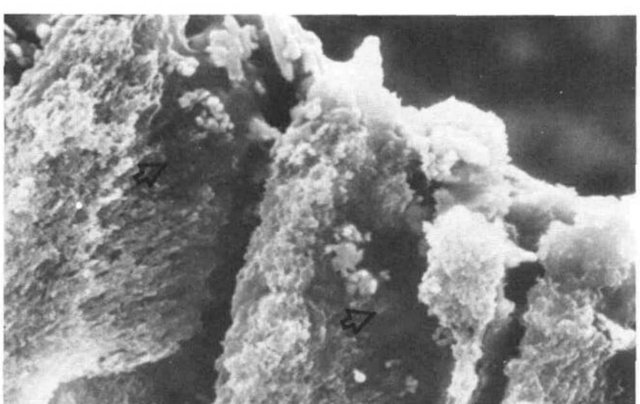


Figure 9. Scanning electron micrograph showing resin within the enamel rod structure (arrows) while appearing absent clinically. Original magnification x 5,500.

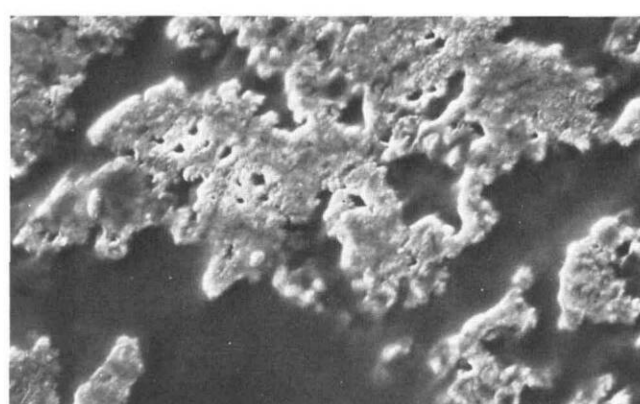


Figure 10. Scanning electron micrograph showing result of five repeated applications of a sealant. Islands of exposed enamel are present. Original magnification x 1,100.

York at Stony Brook, Stony Brook, New York 11794. Requests for reprints should be sent to Dr. Ceen.

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Quotable Quotes

Can a Tony the Tiger nutrition poster really teach schoolchildren the elements of good eating habits? After all, the Kellogg Company manufactures cereals that contain more than 50% sugar . . .

It is estimated that more than half of all classroom teachers in America are currently using industry-produced teaching aids. They come from the government, corporations, and trade associations. They are attractive and expertly produced; they are promoted at teacher conventions and heavily advertised in educational publications. And the reason they are so appealing to teachers is that they are free.

According to a recent study by Sheila Harty of the Center for Study of Responsive Law, *Hucksters in the Classroom,* more than half of the nation's 500 top industrials are supplying material to the classroom . . .

Corporations claim public interest motives for the production and distribution of their instructional materials. But the resultant educational deductions on corporate taxes must be attractive incentives . . .

Particularly disturbing about these industry-produced teaching materials is the lessons they are teaching. On July 1 of (1980), a new federal regulation was enacted that prohibits the sale of snack foods on school premises during lunch hours, to ensure better nutritional habits among school children. Yet these efforts may be undermined by the classroom wall poster from Kellogg's called "Breakfast with Froot Loops," a cereal that contains nearly 50% sugar; or the booklets for home economics classes prepared by the National Confectioners Association that claim, "To reduce, eat candy before and/or after each meal. We can promise you; It works!" — a peculiar endorsement for an educational institution to sponsor . . .

In addition to providing commercial messages touted as educational materials, some corporations are offering premiums. General Foods Corporation, America's second largest advertiser, (has run) a full page ad . . . for "Post Cereals 'Fun'n Fitness' Program"; it carrie(s) a banner headline exhorting teachers to "help your school get free athletic equipment." How? By enlisting students as surrogate salesmen who are "encouraged to participate in the program by collecting . . . Proof-of-Purchase Seals," which can be exchanged for "valuable equipment . . . absolutely free." But "collecting" Proof-of-Purchase seals really means buying Post Cereals, Log Cabin Syrups and Mixes, Awake and Orange Plus Beverages — all products that are clearly identified in the ad . . .

Action for Children's Television thinks that the problem of privately sponsored educational materials in the public schools is one that . . . warrants the public's attention. An alert citizenry can work to eliminate the practice of industry-sponsored curriculum materials by determining what, if any, regulations exist in their school district and helping to develop appropriate guidelines where none exist . . . Tony the Tiger's presence in the school cafeteria poster indicates that America's schools have become another advertising medium.

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