Original Article

Retention of sealants during orthodontic treatment: *An in vitro comparison of two etching protocols*

Christopher Chau[a]; Phillip M. Campbell[b]; Nima Deljavan[c]; Reginald W. Taylor[d]; Peter H. Buschang[e]

ABSTRACT

Objective: To test the retention of smooth-surface sealants bonded with different etching protocols against toothbrushing and, secondarily, to characterize the type and location of sealant loss.

Materials and Methods: Eighty-nine extracted human teeth were randomly assigned one of two etching protocols: 37% phosphoric acid etch (ETCH) or self-etching primer (SEP). Six specimens at a time were placed in a toothbrushing machine to simulate 4, 8, 12, and 24 months of toothbrush abrasion. Using black-light photographs of each specimen taken before and after brushing, four blinded coinvestigators determined new sealant loss, loss along the edge of an initial defect, and the location of sealant loss.

Results: Overall, there were significantly ($P < .05$) more teeth with sealant loss in the SEP group (38.6%) than in the ETCH group (15.5%). New loss of sealant was significantly ($P < .05$) more likely in the SEP group (27.2%) than in the ETCH group (2.2%). Of the teeth with new loss of sealant, all (100%) had loss at the edge, and 23% had progressive loss. There was no significant group difference in sealant loss from initial defects. Of the teeth that showed enlargement of initial defects, 91% had loss at the edge and 91% had progressive loss.

Conclusions: Using SEP to apply facial sealants results in lower retention rates than using ETCH. The vast majority of sealant loss occurs at the edges. Loss of sealant due to enlargement of an initial defect is highly progressive over time. (*Angle Orthod.* 2015;85:750–756.)

KEY WORDS: Etching; Sealant retention; Self-etching primer; 37% Phosphoric acid; Sealant loss

INTRODUCTION

Enamel decalcification and white spot lesions (WSL) are common problems associated with orthodontic treatment, caused by plaque accumulation and bacterial attack on the enamel surface. The prevalence of WSL among orthodontic patients ranges from 2% to 96%, depending on the method of assessment.[1–4] A recent large-scale study found that 23.4% of patients develop at least one clinically visible white spot lesion during their course of treatment.[5] Prolonged treatment time, poor initial oral hygiene, changes in oral hygiene, and preexisting WSL are significant risk factors for the development of posttreatment WSL. These discolorations can cause dissatisfaction for both patients and orthodontists in otherwise successful treatment.

WSL are problematic for orthodontists because appliances increase plaque retention and patients are often not compliant. Several strategies have been suggested to prevent the development of WSL during treatment, including fluoride mouth rinses, fluoride gels,[6–8] and casein phosphopeptide amorphous calcium phosphate pastes.[9] Their success in preventing WSL again depends on patient compliance. In-office application of fluoride varnish is an effective, noncompliant, method of decreasing demineralization,[10–12] but the effects have only a limited duration. Filled resin sealants, which do provide a physical barrier to plaque, have been shown to decrease the number and severity

[a] Private Practice, Temecula, Calif.

[b] Associate Professor and Chairman, Department of Orthodontics, Texas A&M University Baylor College of Dentistry, Dallas, Tex.

[c] AEGD Resident, Texas A&M University Baylor College of Dentistry, Dallas, Tex.

[d] Associate Professor, Department of Orthodontics, Texas A&M University Baylor College of Dentistry, Dallas, Tex.

[e] Regents Professor and Director of Orthodontic Research, Department of Orthodontics, Texas A&M University Baylor College of Dentistry, Dallas, Tex.

Corresponding author: Dr Peter H. Buschang, Department of Orthodontics, Texas A&M University Baylor College of Dentistry, 3302 Gaston Ave, Dallas, TX 75246 (e-mail: phbuschang@bcd.tamhsc)

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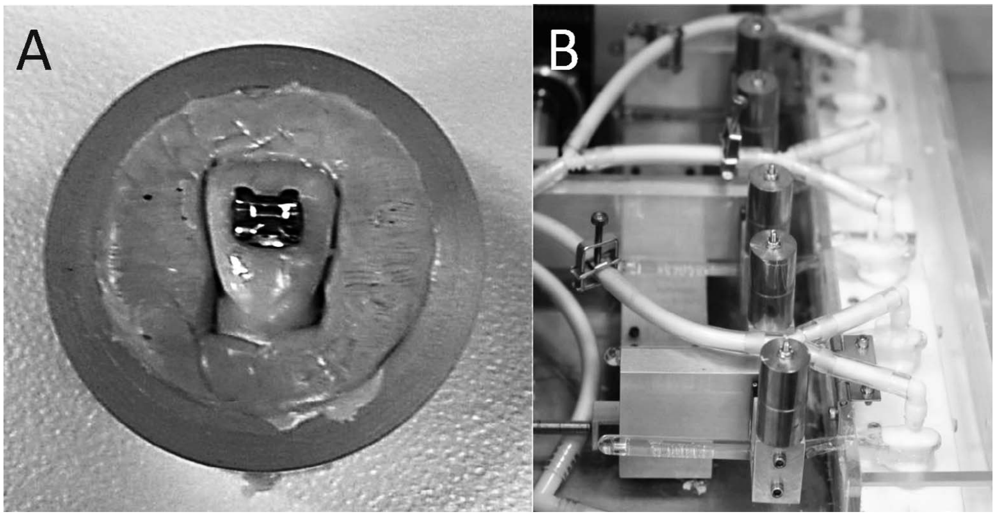

Figure 1. (A) Example of a specimen mounted in an acrylic ring; (B) toothbrushing machine, with six specimens at a time placed in machine to simulate toothbrush abrasion.

of WSL on enamel facial surfaces.[10,13–15] A key factor of a sealant's effectiveness is its retention on the enamel surface throughout treatment. Occlusal sealant retention ranges between 81% and 95% over 1 year and 77% and 92% over 2 years.[16–21] While studies have examined sealant retention on occlusal surfaces, little is known about sealant retention on smooth surfaces. Knowing where and when facial sealant loss occurs during treatment would be valuable in determining which areas to focus on when checking for retention and how often it needs to be reapplied.

The most commonly used protocol for smooth surface sealant application involves etching enamel with 37% phosphoric acid for 15 seconds (ETCH). However, etching requires a dry field, which is difficult to maintain during sealant application, and saliva contamination reduces bond strength of sealants.[22] Self-etching primers (SEPs) could simplify the steps of sealant application by eliminating the need for rinsing. The SEPs are rubbed on the enamel surface for 5 seconds and thinned out with air before applying sealant. Since there are no separate etch and rinse steps, this may save time during the procedure, thereby minimizing potential moisture contamination. Since there is no difference in the bond strength of orthodontic brackets between traditional etching and SEP,[23,24] it is reasonable to assume that SEP could be used effectively with facial sealants placed before bonding brackets. While lower retention of occlusal sealants has been reported for SEP than for ETCH,[25,26] a 24-month clinical trial found no difference in retention between the two etching protocols.[27] It has also been shown that SEP provides less resistance to decalcification than does traditional etching.[28] In order to advocate the use of SEP for the placement of facial sealants in orthodontics, more information is needed.

The aim of the present in vitro study was to evaluate the retention of sealants placed on the labial surface and subjected to simulated toothbrushing. The primary purpose was to compare the retention of smooth-surface sealants bonded with different etching protocols against toothbrushing; the secondary purpose was to characterize the type and location of sealant loss.

MATERIALS AND METHODS

Eighty-nine extracted human teeth, with unrestored, noncarious buccal surfaces were cleaned, disinfected, autoclaved, and then stored in a 0.05% sodium hypochlorite solution. The sample included 32 incisors, 12 canines, and 45 premolars; the teeth were randomly assigned within each group to one of two groups: ETCH or SEP.

To prepare the teeth for a toothbrushing simulation machine (Proto-tech Oral Wear Simulator, Portland, Ore), the roots were sectioned from the crowns with a diamond disc, retention grooves were placed on the lingual of the crowns, and the crowns were mounted in acrylic rings using Exaflex Putty (GC America, Alsip, Ill). The crowns were centered and pressed into the putty so that only the buccal surface was exposed (Figure 1A).

The buccal surface of each mounted tooth was cleaned using a slurry of nonfluoridated flour of pumice and water for 5 seconds with a slow-speed prophy angle brush and then rinsed. A specially designed vinyl sticker was then applied across the tooth and mounting ring to delimit the tooth surface to be sealed and create defined incisal/occlusal and gingival borders. The

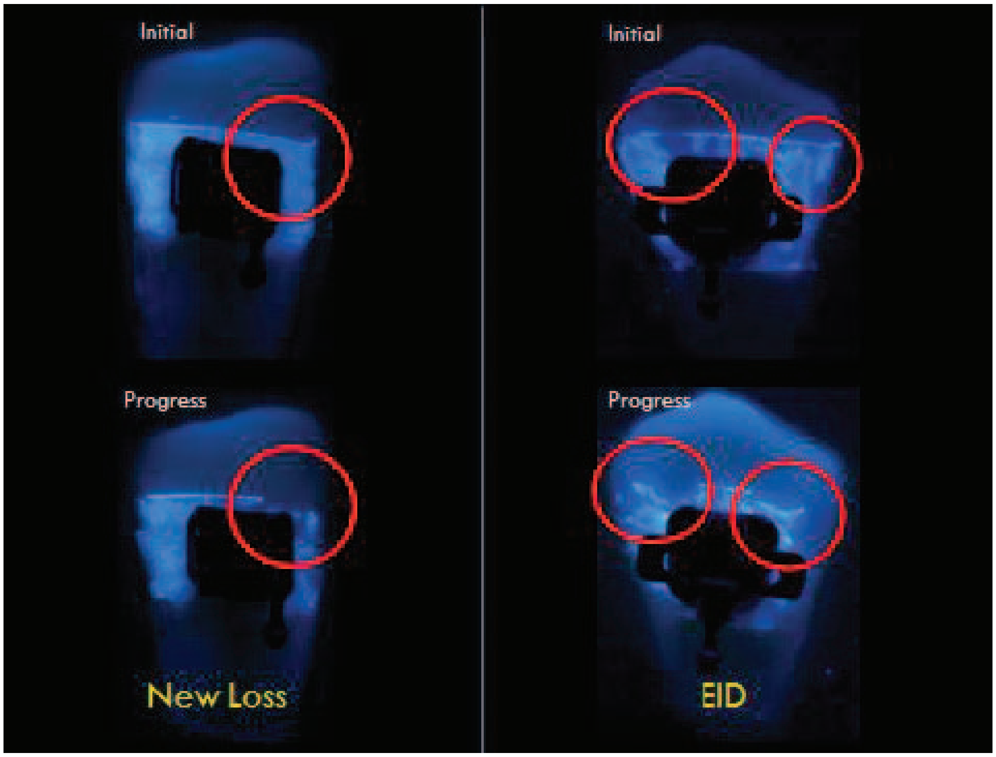

Figure 2. Types of sealant loss, with new loss (loss from a fully sealed area) and enlargement of an initial defect or loss associated with an incompletely sealed area at initial placement.

buccal surfaces of the ETCH group were etched with 37% phosphoric acid etchant gel (Reliance Orthodontic Products, Itasca, Ill) for 15 seconds, completely rinsed under running water, and then thoroughly dried. For the SEP group, Transbond Plus Self Etching Primer (L-Pop, 3M Unitek, Monrovia, Calif) was applied to the buccal surfaces of the teeth for 5 seconds with a microbrush and then dried and thinned out for 2 seconds with a triplex air-water syringe, as per manufacturer instructions. Both groups then underwent application of a thin coat of 38%-filled Opal Seal orthodontic sealant (Ultradent, South Jordan, Utah) to their buccal surfaces with a microbrush, followed by a 2-second single burst of air from a triplex air-water syringe held 2 inches above the specimens and directed from gingival to incisal. Both groups of teeth were light cured for 3 seconds with an Ortholux Luminous Curing Light (3M Unitek). Precoated Miniature Twin metal brackets (3M Unitek) specific to each tooth type were then bonded to the center of the buccal surfaces and light cured for 12 seconds.

Initial photographs of each specimen were taken to obtain the baseline sealant coverage of the buccal surfaces. Each specimen was positioned 12 inches from the camera lens and directly under two black lights mounted 6 inches apart. Standardized photographs (exposure time, 1/125 second; film speed, 100; F-stop, f/8) were taken in a darkened room using a Canon Rebel T2i digital camera with a Canon EF-S 60-mm macro lens (Canon, Melville, NY).

Six specimens at a time were then placed in the toothbrushing simulator (Figure 1B). A medium-bristled toothbrush (Deluxe Denta-Brite, Eagle Home Products, Huntington, NY) was centered over the sealed portion of each specimen's buccal surface and oriented to brush in a mesiodistal direction. A new toothbrush was used for each specimen. A constant force of 280 g of pressure was applied to the surface by the brush.[29,30] After 2500, 5000, 7500, and 15,000 brushstrokes, the specimens were removed from the toothbrushing machine, and black light photographs were taken. These brushstrokes represented 20 strokes per day over a period of 4, 8, 12, and 24 months, respectively.[29] A slurry of 1:3 toothpaste and neutral sodium bicarbonate solution was constantly cycled through the machine during the toothbrushing process. The solution was drained and changed for each subsample of 6 specimens after 15,000 brushstrokes.

Analysis

The initial, 4-month, 8-month, 12-month, and 24-month photographs of each specimen were placed side-by-side in chronologic order on a presentation slide and projected in a dimly lit room. Four coinves-

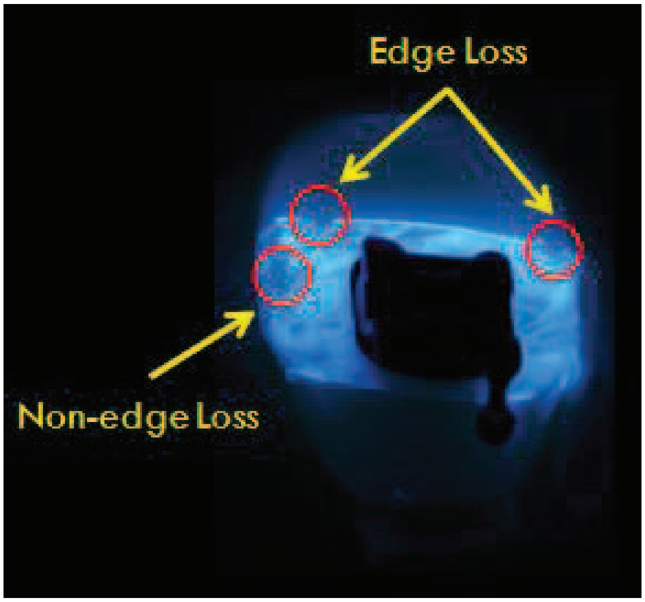

Figure 3. Locations of sealant loss, including edge loss (ie, loss at the outer border of sealant) and nonedge loss (ie, loss located away from the outer border of sealant and surrounded by intact sealant).

tigators, blinded as to group affiliation, rated each specimen to determine whether (1) there was new sealant loss over time, (2) there was sealant loss due to an initial defect, (3) sealant loss occurred at the edge of the sealant, and (4) sealant loss occurred away from the edge. Progressive loss (ie, further sealant loss between time points) for each of the four types was also evaluated. New loss was defined as loss from a fully sealed area of tooth surface, whereas loss due to an initial defect was associated with an incompletely sealed area at the time of placement (Figure 2). Edges were defined as the outer borders of sealant (Figure 3). Dichotomous yes or no scores were used for all the evaluations. Rating differences among investigators were discussed until consensus was reached.

Statistics

SPSS version 19 (SPSS Inc, Chicago, Ill) was used to analyze the data. Chi-square tests were performed to determine whether there were statistically significant ($P < .05$) differences in orthodontic sealant retention between the ETCH group and the SELF group.

Table 1. Sealant Loss by Group and by Type of Loss

	ETCH[a] (%)	SEP[b] (%)	Both (%)
New loss[c]	1 (2.2)*	12 (27.2)*	13 (14.6)
Enlargement of initial defect[d]	6 (13.3)	5 (11.4)	11 (12.4)
No change	38 (84.5)*	27 (61.4)*	65 (73.0)
Total teeth in group	45 (100.0)	44 (100.0)	89 (100.0)

[a] ETCH indicates 37% Phosphoric acid etch.
[b] SEP indicates self-etching primer.
[c] New loss indicates loss from a fully sealed area.
[d] Enlargement of initial defect indicates loss associated with an incompletely sealed area at initial placement.
* Significant ($P < .05$) difference between ETCH and SEP groups.

Table 2. Sealant Loss of the Two Groups by Location

	ETCH[a] (%)	SEP[b] (%)	Both (%)
Edge[c]	6 (85.7)	17 (100.0)	23 (95.8)
Nonedge[d]	1 (14.2)	1 (5.9)	2 (4.2)
Total teeth in group showing loss	7 (100.0)	17 (100.0)	24 (100.0)

[a] ETCH indicates 37% phosphoric acid etch group.
[b] SEP indicates self-etching primer group.
[c] Edge indicates loss at the outer border of sealant.
[d] Nonedge indicates loss located away from the outer border of sealant and surrounded by intact sealant.

RESULTS

Of the 89 teeth, 13 (14.6%) showed new loss of sealant, which was significantly ($P < .05$) greater for the SEP than for the ETCH group (Table 1). Of the 13 teeth that showed new loss, 12 (92.3%) were from the SEP group, representing 27.2% of the teeth in that group. The remaining teeth (7.7%) showing new loss were from the ETCH group, representing 2.2% of the teeth in that group. Of the teeth showing new sealant loss, all (100%) had loss at the edge, while only one (7.7%) had nonedge loss (Table 2). Three (23%) of the teeth that had new loss showed progressive loss over the duration of the experiment (Table 3).

Eleven (12.4%) of the 89 teeth had initial sealant defects that enlarged over time (Table 1). Six (55%) were from the ETCH group and five (45%) were from the SEP group, representing 13.3% and 11.4% of teeth, respectively, from each group. There was no statistically significant group difference in sealant loss when there were initial defects. Of the 11 teeth that showed enlargement of initial defects, 10 (90.9%) had loss at the edges and 1 (9.1%) had nonedge loss (Table 2). Ten out of the 11 (90.9%) teeth with enlarged initial defects showed progressive loss over time (Table 3). Enlargement of initial defects was significantly more progressive than was new loss of sealants.

None of the teeth showed both new sealant loss and increased sealant loss from an initial defect. By combining both types of loss, seven (15.5%) of the

Table 3. Progression of Sealant Loss Showing New Loss vs Enlargement of Initial Defect

	New Loss[a] (%)	EID[b] (%)
Progressive loss	3 (23.1)*	10 (90.9)*
Total teeth in group showing loss	13 (100.0)	11 (100.0)

[a] New Loss indicates sealant loss of fully sealed areas.
[b] EID indicates enlargement of an initial defect.
* Significant ($P < .05$).

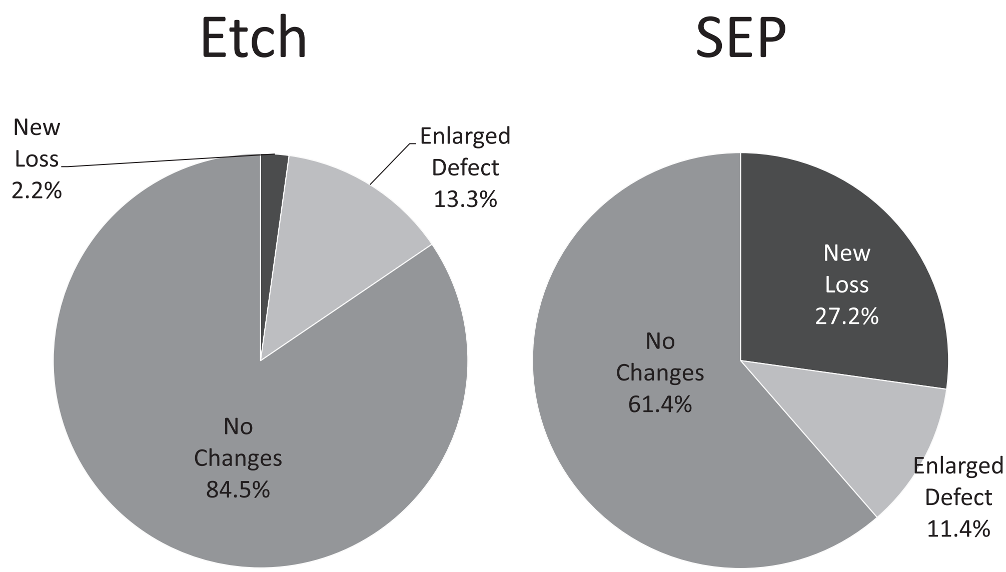

Figure 4. Sealant changes using 37% phosphoric acid etch (ETCH) or self-etching primer (SEP).

teeth in the ETCH group and 17 (38.6%) of the SEP group experienced sealant loss (Figure 4). There was significantly ($P < .05$) more sealant loss when using SEP to apply sealant vs ETCH. The progression of sealant loss was not different between groups.

DISCUSSION

Approximately 85% of the ETCH group and 61% of the SEP group exhibited complete sealant retention. Retention of the ETCH group approximates the 90%–97% retention rate reported by Van Bebber et al.,[31] who also used a phosphoric acid etch preparation. The small difference in retention rate may be due to the use of a different sealant (ProSeal) and different filler contents.

New loss of facial sealant was greater in teeth prepared with SEP than with ETCH. This confirms previous 12-month clinical studies evaluating occlusal sealant retention.[25,26] Because occlusal sealants that fill pits and fissures are thicker than facial sealants, more surface resin can be lost without losing coverage of the tooth. While thickness may explain why retention is lower in facial sealants, viscosity and oxygen inhibition must also be considered in order to explain the differences between the ETCH and SEP groups. It is also possible that group differences in the enamel surfaces before application of the sealant could have played a role. In the ETCH group, the sealant was applied to dried etched enamel; in the SEP group, the sealant was applied to a layer of etch primer.

Because studies have shown no differences in bond strength when compared with etch preparations,[23,24] it was originally thought that SEP might be effectively used with occlusal sealants. However, composites used to bond brackets are 70% filled, while the facial sealants used in the present study were only 38% filled. Increasing the filler content of a sealant increases its viscosity.[32] When SEP is used to prepare the tooth surface, even though most of the primer is removed, a thin layer remains after air drying. When a bracket having a 70%-filled composite is applied to this primer layer, the resin might be viscous enough to maintain its integrity. However, when we placed Opal Seal on a SEP-prepared surface, the sealant became noticeably miscible with the thin primer layer, which was not the case on the dry, etched surfaces. After the sealant was cured, sealant coverage could be verified with black light. The miscibility with the SEP might have decreased the relative thickness and viscosity of the sealant. Dental resins with lower viscosity or lower filler content exhibit less polymerization on the surface, possibly because increased mobility of the molecules within a material increases exposure to oxygen, which inhibits polymerization.[33] Low viscosity, unfilled sealants fail to produce films of necessary thickness for adequate retention during orthodontic treatment.[34] Oxygen inhibition of polymerization results in sealant loss over time, the uncured resin being more susceptible to wear. The thinner the sealant layer, the greater the oxygen-inhibited proportion present and the greater the chance of sealant loss.

When there was sealant loss, it occurred mostly at the edges. These are the areas that clinicians should focus on when evaluating whether teeth need to be resealed. Sealant loss was particularly progressive in areas where there was an initial defect, suggesting that incomplete sealant coverage at the time of placement greatly increases the likelihood of continued loss over time. Since there was no difference in the amount of initial defect enlargements between the ETCH and SEP groups, the presence of an initial defect may be more important for sealant retention than the etching protocol. Initial coverage is important to ensure better retention during treatment and to prevent the formation of caries or WSL. Incompletely sealed teeth are more susceptible to caries than are unsealed teeth.[35]

CONCLUSIONS

- Using self-etching primer to apply facial sealants resulted in lower retention rates than using 37% phosphoric acid etch.
- The vast majority of sealant loss occurred at the edges.
- Loss of sealant due to an enlargement of an initial defect was highly progressive over time.

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