Original Article

Effectiveness of Pit and Fissure Sealants in Reducing White Spot Lesions during Orthodontic Treatment

A Pilot Study

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ABSTRACT

Objective: A pilot investigation was performed to test the null hypothesis that highly filled (58%) resin sealants do not prevent white spot lesions in patients undergoing active orthodontic treatment.

Materials and Methods: A split-mouth design was applied to 60 healthy patients, with the sealant randomly allocated to either the right or the left side of each jaw. The sealant was applied to the incisors and canines from the gingival surface of the bracket to the free gingival margin. The contralateral teeth had the same type of bracket with no sealant. Sealants were placed on the experimental teeth 2 weeks to 3 months after initial bonding and were removed after 15 to 18 months. Intraoral photographs, visual assessments, and DIAGNOdent (KaVo Dental Corporation, Lake Zurich, Ill) measurements were used to assess white spot lesions after sealant removal.

Results: Six lesions on the teeth with sealants were identified visually, compared with 22 lesions on the teeth without sealants. The teeth without sealants had 3.8 times the number of white spot lesions than were noted on the sealed teeth. These sealants showed no visible signs of discoloration. The DIAGNOdent measured statistically significant differences between sealed and unsealed teeth in the maxilla ($P < .001$) and in the mandible ($P = .010$). DIAGNOdent measurements also showed a difference between sealed and unsealed teeth after the 28 teeth with visible lesions were excluded.

Conclusion: The hypothesis was rejected. Ultraseal XT Plus clear sealant (Ultradent Products, South Jordon, Utah) produced a significant reduction in enamel demineralization during fixed orthodontic treatment and should be considered for use by clinicians to minimize white spot lesions. (*Angle Orthod.* 2009;79:337–344.)

KEY WORDS: Demineralization; White spot lesions; Pit and fissure sealants; Prevention

INTRODUCTION

Orthodontic treatment with fixed appliances has been associated with white spot lesions that often occur in otherwise well-treated cases. The overall prevalence among orthodontic patients varies from 2% to 96%,[1–9] depending on the methods used to assess and score decalcification, the presence of decalcification before treatment, and the use of fluoride supplements during treatment.

White spot lesions develop in association with brackets, bands, arch wires, ligatures, and other orthodontic devices that complicate conventional oral hygiene measures, leading to prolonged plaque accumulation.[10] In the presence of fermentable carbohydrates, demineralization of the enamel around the bracket can occur in as little as 4 weeks.[3] Enamel lesions have been reported to develop on all teeth but are observed most frequently on the cervical and middle third of the buccal surface of the maxillary lateral incisors, the mandibular canines, and the first premolars.[3,4] Although demineralized enamel may remineralize partially after debonding, the white enamel lesions are often irreversible.[4,10,11] Demineralized white spot lesions on enamel have been reported 5 years

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after completion of orthodontic treatment and appear to be resistant to remineralization.[6]

Orthodontists are frustrated by the fact that these permanent scars generally are perceived to be preventable when good oral hygiene practices are followed by the patient. Because patient compliance often is lacking, various preventive measures have been employed as adjuncts to oral hygiene instruction. Fluoride agents have been shown to be effective, but their effectiveness depends on patient compliance.[12] The ideal preventive measure should be easy for the clinician to use and independent of patient cooperation. The application of resin sealants on the enamel surface surrounding the bracket, which should protect the enamel surface from acid attack, has been suggested as a method of preventing enamel demineralization.[13]

Previous in vivo studies in which sealants were used to protect enamel surfaces around orthodontic brackets have shown unfavorable outcomes because of the lack of sealant retention. Retention problems may have been due to the resins used, which did not resist mechanical abrasion from mastication and brushing.[14,15] A recent in vitro study indicates that light-cured filled resin, Pro Seal, (Reliance Orthodontic Products, Itasca, Ill) holds promise in inhibiting the demineralization process.[16]

The purpose of this study was to determine whether a highly filled (58%) resin sealant, Ultraseal XT Plus clear sealant, (Ultradent Products, South Jordon, Utah) could be used for the prevention of white spot lesions. This pit and fissure sealant is used commonly on posterior teeth and has been shown to be retentive and to resist mechanical abrasion.[17] The aim of this clinical study was to evaluate the effects of a pit and fissure sealant on white spot lesion formation in adolescents undergoing treatment with fixed orthodontic appliances. The null hypothesis was that no differences in white spot formation are evident between experimental and control teeth.

MATERIALS AND METHODS

Sixty healthy adolescents (30 male and 30 female) were selected from the patient pool in the Orthodontic Department at Baylor College of Dentistry, in Dallas, Texas. They were selected on the basis of (1) being between 11 and 16 years of age and (2) having all of their permanent maxillary and mandibular anterior teeth. Informed consent was obtained according to the guidelines for human research subjects established by the Institutional Review Board (IRB) at Baylor College of Dentistry. All patients who had been accepted for treatment in the orthodontic clinic and who met the inclusion criteria were given the opportunity to participate in this study as soon as IRB approval was granted. Sixty patients who met the inclusion criteria were accepted for the study. A small percentage of patients declined to participate. The patient pool represented a cross section of the different appliance techniques (brackets) used by supervising faculty members.

This prospective study used a split-mouth design, with Ultraseal XT Plus clear sealant randomly allocated to either the right or the left side of the maxilla or mandible. The sides were allocated prior to the start of the study by a random number generator. For each experimental quadrant, the sealant was applied to the incisors and canines, from the gingival surface of the bracket to the free gingival margin. The contralateral control teeth had the same types of brackets bonded in the same manner, with no sealant applied. A total of 360 maxillary teeth and 258 mandibular teeth were studied. Nine maxillary teeth and 36 mandibular teeth were excluded because of gingival overgrowth up to the bracket, which obscured the tooth surface. Data were collected on 14 patients after debonding; the remaining 46 patients had brackets still in place and were undergoing active treatment. Before treatment, patients were instructed thoroughly regarding proper oral hygiene procedures while undergoing orthodontic treatment.

Several types of orthodontic brackets (traditional and self-ligating) were bonded by means of three different techniques (phosphoric acid/Transbond XT [3M Unitek, Monrovia, Calif] primer/Transbond XT adhesive; phosphoric acid/Ortho-Solo [Ormco Corporation, Orange, Calif]/Transbond XT adhesive; and Transbond Plus L-Pop Self-Etching Primer [3M Unitek]/Transbond XT adhesive). For the two phosphoric acid techniques, the teeth were cleaned with pumice and were rinsed and dried thoroughly. The area where the bracket was to be placed was etched with a 37% phosphoric acid gel (Reliance) for 15 seconds and then was rinsed with water. After rinsing, the enamel surface was dried with compressed moisture and oil-free air. A layer of Transbond XT primer or Ortho-Solo was applied to the tooth. Transbond XT paste was applied to the base of the bracket, which was pressed firmly onto the tooth. Excess adhesive was removed, and the adhesive was light-cured with the Ortholux LED curing unit (3M Unitek) for 20 seconds. The light was applied for 10 seconds at each bracket's mesial and distal aspects. For the Transbond Plus L-Pop (3M Unitek), the self-etching primer was gently rubbed onto the surface for approximately 15 seconds with a disposable applicator; a compressed moisture- and oil-free air source was used to deliver a gentle burst of air to the enamel. The bracket was bonded with Transbond XT adhesive paste, as in the two phosphoric acid groups.

Sealants were placed on the experimental teeth 2

weeks to 3 months after initial bonding. The teeth were visually inspected for decalcifications prior to sealant placement. The teeth were cleaned with pumice and were rinsed and dried thoroughly. The area where the sealant was to be placed was etched with a 37% phosphoric acid gel (Reliance) for 15 seconds and then rinsed with water. After rinsing, the enamel surface was dried completely with compressed oil-free air. UltraSeal XT Plus sealant was applied gingival to the brackets, light-cured with the Ortholux LED curing unit for 20 seconds, and then checked with an explorer for retention. The UltraSeal XT Plus clear sealant is a filled resin (58% by weight) with an average particle size of 1.5 microns and a density of 1.73 g/mL.

Initial intraoral photographs were taken before bracket placement and after initial sealant placement with a Canon EOS Digital Rebel XT camera (Canon USA Inc, Lake Success, NY), using a 105 mm macro lens and macro flash at a distance of approximately 18 inches. The photographs, which included right and left facial views of sealed and control teeth, were used to assess the presence of white spot lesions. After 15 to 18 months, the sealants were carefully removed with a 30-fluted bur (Brassler, Savannah, Ga), final photographs were taken, and direct visual assessments of the photographs were made to record any visible decalcification on the experimental and control teeth. The lesions were recorded by direct visual assessment with the use of Øgaard's[6] modification of the scoring systems proposed by Gorelick et al.[3] Lesions were scored as follows: 1—no white spot lesion; 2—slight white spot lesion covering less than one third of the surface; 3—severe white spot lesion covering more than one third of the surface; 4—white spot lesion with cavitation.

The DIAGNOdent (KaVo Dental Corporation, Lake Zurich, Ill) was used after sealant removal to quantify objectively white lesions according to fluorescence. The DIAGNOdent operates at a wavelength of 655 nm. At this wavelength, clean healthy teeth exhibit little or no fluorescence. In contrast, demineralized teeth exhibit fluorescence proportionate to the degree of demineralization, resulting in elevated scale readings on the display of the DIAGNOdent. DIAGNOdent recordings were taken on the buccal surface of control and experimental teeth. Measurements with the DIAGNOdent were performed with a conical tip that was used to measure the area of the lesion close to the gingival margin of the bracket base. The DIAGNOdent was calibrated for each patient with a sound site (incisal one third of the central incisor, as recommended by the manufacturer). Control and experimental teeth were scanned carefully with the probe, with the tip held in contact with the tooth surface and tilted around the measuring site so that fluorescence could be collected from all directions. Maximum readings for the evaluations were recorded.

Statistical Analyses

Because data from DIAGNOdent were not distributed normally, medians, interquartile ranges, minimums, and maximums were used for descriptive purposes. Wilcoxon tests were performed to determine statistical differences (using $P < .05$) between experimental and control sides. To determine whether DIAGNOdent was sensitive enough to identify nonvisible decalcifications, an additional analysis was performed that excluded the teeth with visible lesions.

RESULTS

During this study, only 6 of 60 evaluated patients showed visual signs of white spot lesions (Figures 1 and 2). Four of these patients developed white spots in only one arch (Figure 1). Two patients developed white spots in both arches (Figure 2). Patients #11 (Figure 1) and #25 (Figure 2) showed visible signs of white spots on both sealed and nonsealed teeth. However, the lesions on the nonsealed teeth were much larger than those on the sealed teeth. Patients #6, #8, #18, and #23 (Figures 1 and 2) developed white spots only on the nonsealed teeth.

Six lesions were identified on the teeth with sealants and 22 lesions on the teeth without sealants (Table 1). The teeth without sealants had a 3.8 times greater number of white spot lesions than did the teeth with sealants. Nineteen (68%) of the teeth identified with white spots were in the maxillary arch, and nine (32%) were in the mandibular arch. The maxillary laterals and canines without sealants showed the highest incidences of white spots. Five of the six patients had white spot lesions on the maxillary laterals and canines. The mandibular laterals and canines with sealants showed the lowest incidences of white spots. Five of the six patients with white spot lesions were male.

Significant differences were noted between DIAGNOdent measurements of experimental and control teeth (Table 2). The maxillary laterals ($P = .002$), canines ($P < .001$), and total maxillary sealed teeth ($P < .001$) showed significantly less decalcification when compared with the corresponding teeth on the opposite side without sealants. The mandibular canines with sealant also showed significantly ($P = .020$) less decalcification than was seen with the mandibular canines without sealant. The DIAGNOdent measurements showed similar patterns of differences between experimental and control teeth after the 28 teeth with visible white spots were excluded. Significant differences were noted between maxillary laterals ($P = .007$), maxillary canines ($P = .005$), total maxillary

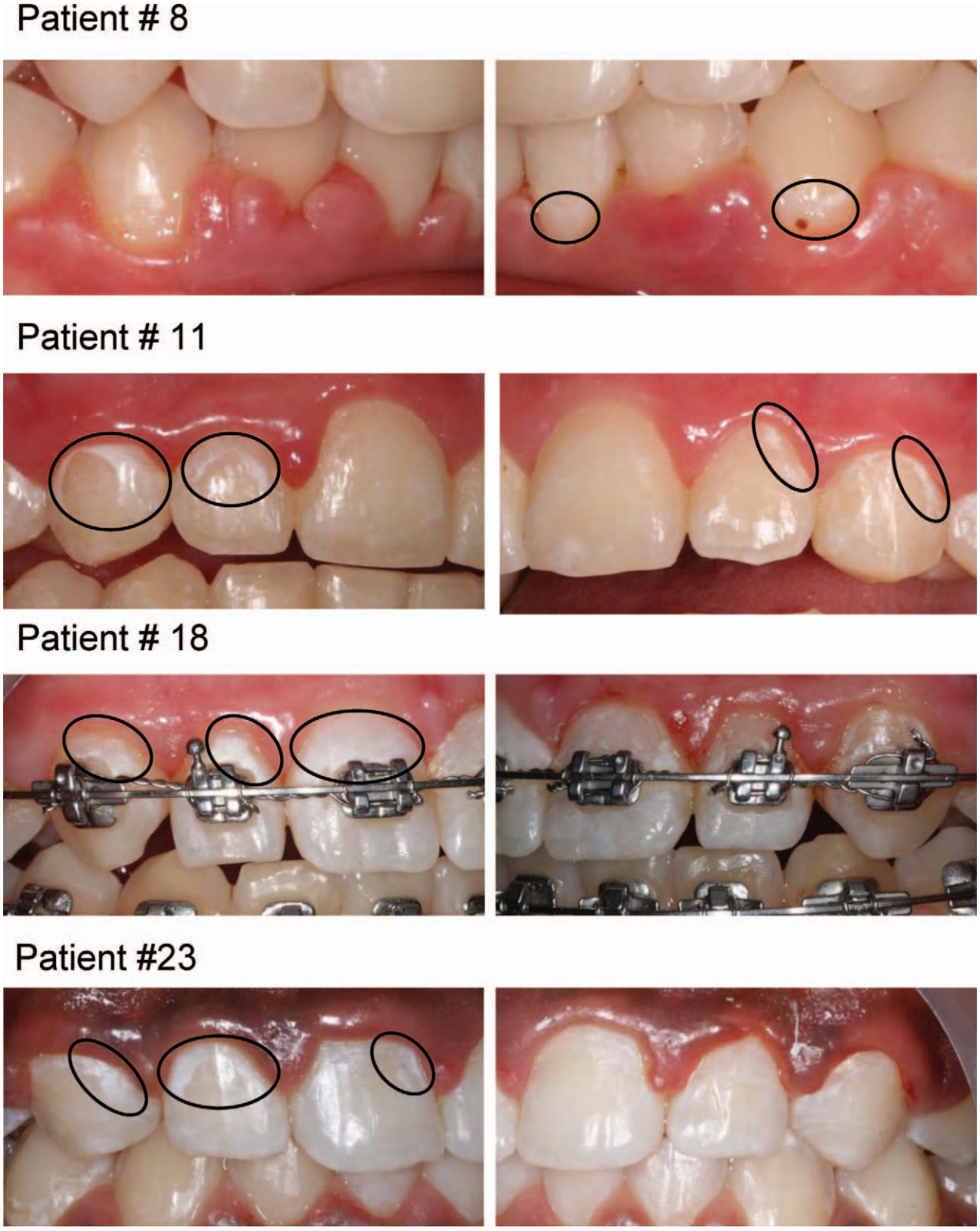

Figure 1. White spot lesions in one arch with circles indicating size and location.

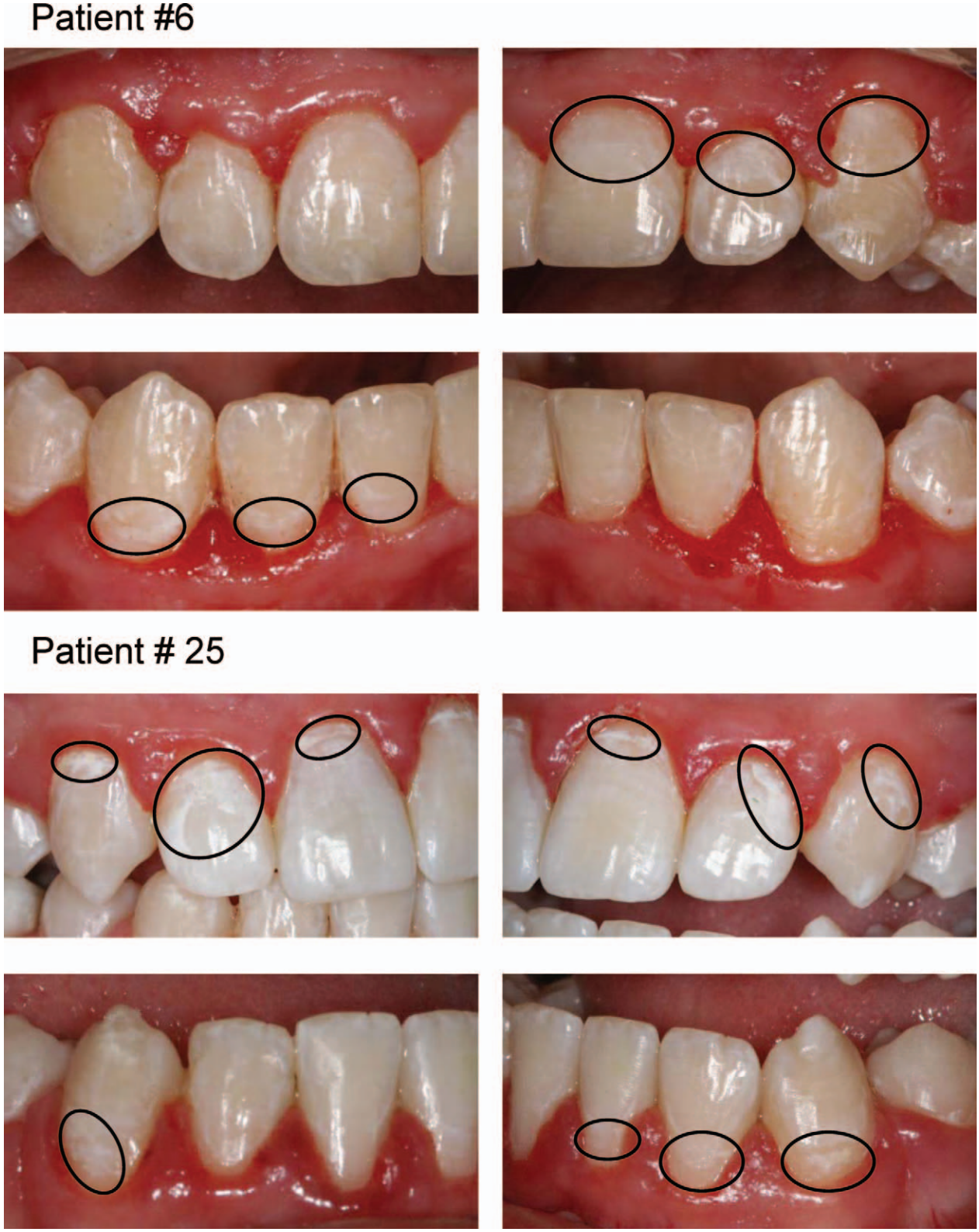

Figure 2. White spot lesions in both arches with circles indicating size and location.

Table 1. Visual Assessment Scores for Patients Identified As Having White Spot Lesions[a,b]

		w/ Sealants							w/o Sealants						
ID	Sex	U1	U2	U3	L1	L2	L3	Total	U1	U2	U3	L1	L2	L3	Total
6	M	1	1	1	1	1	1	0	3	3	3	2	2	3	6
8	M	1	1	1	1	1	1	0	1	1	1	2	1	2	2
11	M	1	2	2	NA	NA	NA	2	1	3	3	NA	NA	NA	2
18	M	1	1	1	1	1	1	0	3	3	3	1	1	1	3
23	M	1	1	1	NA	NA	NA	0	3	3	3	NA	NA	NA	3
25	F	2	2	2	2	1	1	4	2	3	3	2	2	2	6
Total		1	2	2	1	0	0	6	4	5	5	3	2	3	22

[a] NA indicates not available.
[b] Total indicate the numbers of teeth with one or more lesions.

Table 2. Descriptive Statistics (medians, interquartile ranges, minimums, and maximums) of DIAGNOdent measurements (with Wilocoxon comparisons of experimental and control teeth)[a]

	w/ Sealants				w/o Sealants				Side Differences	
	Median	25%	75%	Max	Median	25%	75%	Max	w/Visual WSL[b]	w/o Visual WSL
U1	0.0	0.0	1.0	3.0	0.0	0.0	1.0	4.0	.168	.637
U2	**1.0**	**0.0**	**1.0**	**9.0**	**1.0**	**1.0**	**2.0**	**13.0**	**.002**	**.007**
U3	**1.0**	**1.0**	**2.0**	**5.0**	**2.0**	**1.0**	**2.0**	**15.0**	**<.001**	**.005**
U-Total	**2.0**	**1.0**	**5.0**	**16.0**	**3.0**	**2.0**	**5.0**	**28.0**	**<.001**	**<.001**
L1	1.0	0.0	2.0	3.0	1.0	0.0	2.0	6.0	.334	.739
L2	1.0	1.0	2.0	3.0	1.0	1.0	2.0	7.0	.790	.822
L3	**1.0**	**1.0**	**2.0**	**4.0**	**2.0**	**1.0**	**2.0**	**13.0**	**.010**	**.046**
L-Total	4.0	2.0	5.0	8.0	3.0	2.0	5.5	8.0	.095	.409

[a] Bold indicates significant ($P < .05$) side differences.
[b] WSL indicates white spot lesions.

Table 3. Incidences of White Spot Lesions on Anterior Teeth

	Control Population		Orthodontic Population	
Reference	Sample Size	Anterior Teeth	Sample Size	Anterior Teeth
Gorelick et al (1982)[2]	50	3%	121	11.5%
Mizrahi (1982)[7]	426	7.6%	—	–
Mizrahi (1983)[8]	—	—	269	8.5%
Zachrisson & Zachrisson (1971)[1]	50	4.4%	124	12.7%
Ingervall (1962)[9]	60	13.8%	60	23.5%
Artun & Brobakken (1986)[4]	60	9%	60	44%

sealed teeth ($P < .001$), and mandibular canines ($P = .046$).

DISCUSSION

The incidence of white spot lesions on the anterior teeth in the present study was 10%, which is at the low end of incidences previously reported (Table 3). This lower incidence may have been due to the short duration of the study; sealants were removed 15 to 18 months after they had been applied; a greater number of white spots might have been expected over a longer period. However, it has been reported that white spots can form in as little as 4 weeks in the presence of fermentable carbohydrates.[10] It is also possible that some white spots adjacent to the brackets were not identified on patients who were not debonded because treatment was not complete.

Nineteen (~68%) of the white spot lesions identified were on maxillary anterior teeth, and nine (~32%) were on mandibular anterior teeth. This supports previous studies which showed that maxillary anterior teeth are affected more often.[2,3] This difference could be explained by the remineralizing capacity of saliva.[1] Saliva that bathes exposed tooth surfaces diminishes plaque acidity and washes away sugary substrates.[4] The mandibular dentition may be more susceptible to this cleansing action because of its close proximity to salivary glands and to saliva that is pooling around the teeth.

Results showed that Ultraseal XT Plus sealant pro-

vides significant protection against the formation of white spot lesions during fixed orthodontic treatment. Sealed teeth were almost four times less likely to form white spots than were control teeth. Moreover, white spot lesions on the sealed teeth were smaller and less severe than those on the control teeth. This indicates that the highly filled sealant used was resistant to mechanical abrasion and remained attached to the enamel surfaces throughout the duration of the study.

Previous studies have shown that some lightly filled chemically cured sealants do not completely polymerize because of oxygen inhibition of the curing reaction.[5,6,10] Such sealants are not likely to provide protection against demineralization. Light-cured sealants solve the problem of uneven polymerization; in vitro studies have shown that these materials are able to seal large areas of smooth enamel surfaces successfully and to significantly reduce enamel demineralization.[8–10] However, clinical trials have shown that light-cured sealants fail and do not provide more protection than is given by chemically cured sealants.[8,11] This may be so because the sealants tested in these clinical trials were unfilled or were lightly filled, with lower abrasion resistance and greater potential to wear than are seen with more highly filled sealants.[13] Results of the present study support the work of Hu and Featherstone,[16] who showed in a laboratory study that filled resin provides resistance to mechanical abrasion and complete enamel protection from demineralization.

Because the measures obtained showed the same pattern of susceptibility and differences between sides after the teeth with visible white spots had been removed, it appears that the DIAGNOdent may be more discriminating than visual assessment for sample data. Although the DIAGNOdent was reliable for confirming clinically visible white spot lesions, it was difficult to detect nonvisible decalcification on an individual basis because of the small differences and the limited variability. Only when statistical analysis was performed on sample data was it possible for investigators to identify differences in enamel demineralization with the use of the DIAGNOdent readings. Clinically, the DIAGNOdent may be used more appropriately to assess the severity, progression, and depth of white spot lesions. Additional studies are needed to determine the applicability of the DIAGNOdent for assessment of white spots in individual patients.

The results reported here indicate that the sealant failed to protect the entire enamel surface in two patients; this can be explained by failure of the sealant to completely bond to the enamel surface. Several patients reported that small pieces of sealant chipped away from the gingival margins of their teeth, which was probably due to the fact that sealants were placed after bracket placement and subsequent gingival hypertrophy. Future studies should consider placing the sealant at the time of the bonding appointment before gingival irritation occurs, to minimize bond failure of the sealant. Because of uncontrolled sources of potential variation, this pilot study should be considered preliminary, requiring substantiation by other, better controlled studies.

CONCLUSIONS

- Ultraseal XT Plus sealant provided a significant reduction in enamel demineralization during fixed orthodontic treatment and should be considered for use by clinicians to minimize white spot lesions.
- This highly filled light-cured sealant effectively sealed the enamel surfaces adjacent to orthodontic brackets, resisted mechanical abrasion, and remained well-attached.
- The DIAGNOdent may be useful for assessing the severity, progression, and depth of white spot lesions during orthodontic treatment.

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