FINAL REPORT

Project Type:
Orthodontic Faculty Development Fellowship Award

Principle Investigator:
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Project Title:
Incidence of WSL During Orthodontic Treatment in Patients With and Without Protective Facial Sealants.

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Amount of Funding:
$20,000

Summary:
Our data collection and statistical analyses are complete. The specific goal of this project was to determine if the University's clinical practice of placing sealants on the facial surface of all anterior teeth was effective in the reduction/elimination of WSLs. The results presented below provide evidence of no significant reduction in WSL despite application of facial sealants. There were significantly more WSL on the maxillary anterior teeth in the sealant than the no-sealant group. There was no significant difference in the severity of the WSL in the maxillary arch, but the mandibular lesions were significantly less severe.

These results are not yet published but are in the process of being submitted to the AJODO. The results have also been submitted for consideration for the 2019 AAO Table Clinic Presentations. This information will lead to further study, by us and well as others, into the prevention/elimination of WSLs. We will continue this line of research until we find the ultimate solution to this devastating iatrogenic issue.

Funding of this project by AAOF is greatly appreciated and has already been used to further my career. I have recently submitted my dossier for promotion to Associate Professor, and this grant, research project, and plans for publication were included in my accomplishments. Acknowledgement of the AAOF will be included in my Table Clinic (should it be selected), as well as in any future presentations or publications.

ABSTRACT

Purpose:
To determine if the application of sealants on the facial surface of the anterior teeth reduces the number or severity of white spot lesions (WSL) in orthodontic patients. Secondarily, risk factors for WSL will be determined.

Materials:
Pre- and post-orthodontic treatment photographic images of 1727 patients were obtained from the orthodontic department of TX A&M College of Dentistry. Of these, 885 who did not have sealants were randomly chosen from pre-treatment records dated from August 2000-November 2009. Another group, comprised of 842 consecutively treated patients who did have sealants (Proseal, Reliance Orthodontic Products) applied immediately prior to bracket placement, had pre-treatment records dated from September 2012-November 2016. To be included, cases could represent any malocclusion, provided that they had adequate pre- and post-treatment digital photographs in which the cervical third was visible. Photographs were examined by a single observer, and the WSL with their relative sizes/severity were noted. Severity of each lesion was scored using a modified Gorelick scale.

Results:
Overall, there was no significant difference in the incidence of WSL between the sealant (25%) and no-sealant (21%) groups. Significantly (P=.04) more subjects in the sealant than no-sealant group developed WSL in the maxillary arch during treatment. While there was no significant difference in the severity of the WSL in the maxillary arch, the lesions in the mandibular arch were significantly (P=.047) smaller in the sealant (1.51) than the no-sealant (1.54) group. Lack of fluorosis, the male gender, poor pre-treatment oral hygiene, a decline in oral hygiene during treatment, treatment time over 36 months, and the presence of WSL pre-treatment were all statistically significant risk factors in patients who formed WSL during treatment. The highest risk factors for the development of WSL were the presence of pre-existing WSL (RR=3.15), followed by poor pretreatment oral hygiene (RR=2.18) or a decline in hygiene during treatment (RR=1.89).

Conclusions:
Placing facial sealants prior to bracket placement does not reduce WSL. Orthodontists need to be mindful of risk factors such as oral hygiene, treatment time, and pre-existing WSL prior to the initiation of orthodontic treatment, during treatment planning, as well as during treatment itself.

INTRODUCTION

White spot lesions (WSL) are the most common negative sequelae resulting from orthodontic fixed appliance treatment.[1] They gradually develop when the amount of enamel demineralization due to an acid attack is not completely offset by the natural remineralization processes. The outermost surface of the enamel typically remains intact, while demineralization of the subsurface enamel progresses.[2] Light refraction through the enamel is affected once the subsurface mineral content is altered, causing the characteristic chalky, white appearance.[2,3]

The prevalence of WSL that develop during the period of orthodontic treatment has been reported in the literature to range from 0-97%.[3-15] Methods of lesion identification, sample size, population

characteristics, and supplemental fluoride application all play a role in determination of prevalence during orthodontic treatment. In order to secure large samples, teeth are commonly examined using clinical photographs, which has been proven to be as reliable as direct visual assessment.[6] Studies utilizing clinical photographs have reported WSL prevalence in the range of 23-46%. [4-6,9, 10, 14]

WSL are the early manifestation of caries.[2] Defensive strategies are focused on prevention, interception, and modification of preventable risk factors. Specific preventive measures include: education (hygiene, diet), dental sealant application, fluoridated agents (toothpaste/gel, rinse, varnish), and non-fluoridated agents (xylitol, chlorohexidine, casein phosphopeptide-amorphous calcium phosphate).[16] Many of these strategies are compliance-based, which is why the application of sealants and long-lasting fluoride varnishes are popular preventive methods for orthodontic patients. A Cochrane review of sealant and fluoride varnish application in 2010 revealed some evidence of the superiority of sealants in occlusal caries applications.[17] A 2012 randomized clinical trial with 500 subjects in parallel groups found that both fluoride varnish applied every 6 months and a single application of sealant were equally effective in preventing pit and fissure caries.[18]

While numerous studies have been conducted in regard to pit and fissure sealants, literature regarding smooth surface sealant application is relatively scarce. A 2003 *in vitro* evaluation of 50 enamel specimens showed a significant difference in microhardness between samples that were sealed with Proseal (Reliance Orthodontic Products) filled sealant compared to those that were either unsealed, sealed with unfilled sealants, or treated only with fluoride varnish.[19] An *in vivo* study showed a 3.8 times decrease in the number of teeth with visible WSL when the teeth were sealed with Ultradent XT Plus (Ultradent, South Jordan, UT). The same study reported a decrease in WSL size between the sealed and unsealed teeth, but statistical probabilities were not reported in regard to lesion severity.[20] An *in vivo* study in 2013 evaluated 62 patients whose maxillary anterior teeth were sealed with Biscover (Bisco, Schaumburg, Ill) filled sealant. They found a clinically small, but statistically significant decrease in the number of WSL, but no difference in the severity of lesions.[21] Another sealant by Ultradent, Opal Seal, was found to provide no reduction in WSL formation or severity during 8 weeks of treatment.[22] Hammond et. al. found oral hygiene to be much more important in reduction of WSL than an antimicrobial, selenium leeching sealant (SeLECT Defense) (Table 1).[23]

Table 1. Prevalence and Severity of WSL Reported in Studies Using Smooth Surface Sealants Based Upon Sealant, Design, Identification Method, Supplemental Fluoride Use, Sample Size, Treatment Duration, and Control Group.[a]

Study	Design	Sealant	Method of Identification	Fluoride	Sample Size	Duration	Controls	Decrease In # WSL	WSL Severity
Hu et al.[19]	In Vitro	ProSeal	Microhardness	None	50	14 days	**CG**	**<.001**	NA
Benham et al. [20]	In Vivo	Ultradent XT Plus	P, DVA, Diagnodent	None	60	15-18 months	**I**	**<.001** Mx **.046** Md	Not reported
O'Reilly et al.[21]	In Vivo	Biscover	DVA	None	62	Duration of tx	**CG**	**.024**	.082
Tufekci et al.[22]	In Vivo	OpalSeal	DVA, Microhardness	Fl releasing sealant	22	8 weeks	**I**	.106	.08
Hammad et al. [23]	In Vivo	SeLECT Defense	P	Selenium releasing sealant	50	Duration of tx	**CG**	.215	NA

[a] CG = used control group for comparisons, I = used individual posttreatment status compared to pretreatment status, P = photographic evaluation, DVA = direct visual assessment, Fl = fluoride.

Because of the limited number of in vivo studies, small sample sizes, and inconsistency in duration, controls, and reported outcomes, the effect that smooth surface sealants have on white spot lesions remains unclear. The aim of this study was to determine if the application of a filled sealant (Proseal, Reliance Orthodontic Products) onto the anterior teeth will result in a reduction in the number or severity of WSL in orthodontic patients. Risk factors will be evaluated to determine predictors for WSL prior to and during treatment.

MATERIALS AND METHODS

Pre- and post-orthodontic treatment photographic images of 1727 patients were obtained from the orthodontic department of TX A&M College of Dentistry, whose institutional review board approved the study. All cases were completed by orthodontic residents and supervised by various clinical faculty. To be included, cases had to have adequate pre- and post-treatment digital photographs. All patients were in the late-mixed or permanent dentition. No malocclusion was excluded, provided that the gingival third of the anterior teeth was visible in the photographs. No subjects were involved in a formal supplemental fluoride rinse/gel/varnish program. However, standard tooth brushing instructions were given, and patients were encouraged to continue regular dental visits, which could include fluoride treatment as recommended by the treating dentist.

Initially, 1000 randomly selected cases who did not have sealants were chosen from pre-treatment records obtained between August 2000-November 2009. Cases were excluded, mostly due to incomplete records or poor photographs, and a final sample of 885 (378 males, 14.7 $\pm$ 4.9 years old; and 507 females, 14.8 $\pm$ 5.8 years old) remained. Another group comprised of 842 (353 males, 15.1 $\pm$ 8.0 years old; and 507 females, 15.6 $\pm$ 7.5 years old) patients who had pre-treatment records taken between September 2012-November 2016, was selected from a group of 1022 consecutively treated cases who did have sealants (Proseal by Reliance Orthodontic Products) applied immediately prior to bracket placement. Sealants were placed per manufacturer instructions on all anterior teeth immediately prior to bracket placement. The teeth were pumiced, etched with 37% phosphoric acid etching solution for 15 seconds, rinsed and dried. Proseal sealant was applied to all anterior teeth in the treatment group, thinned lightly with air, and light-cured for 10 seconds. Bracket placement then proceeded using Transbond XT (3M Unitek), and each bracket was light-cured for 30 seconds.

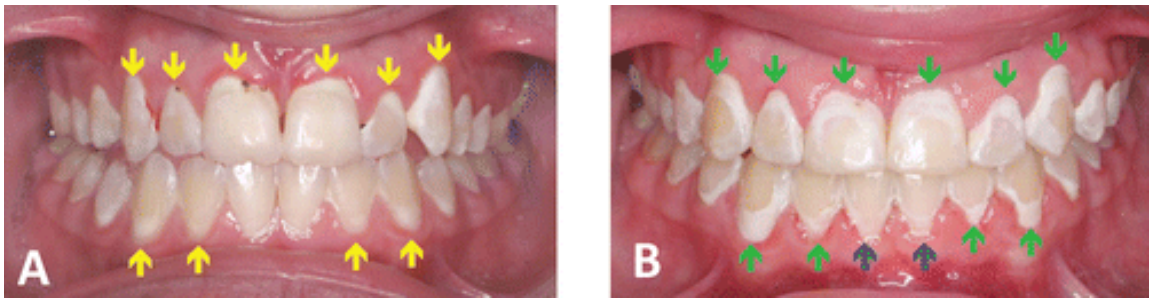
Chart data collected included the patient's age at initial records, gender, birth date, banding date, and debanding date. Photographs were examined by a single blinded observer. Pre- and post-treatment images were retrieved from Dolphin Imaging, placed side-by-side on a computer monitor, and evaluated in a darkened room. The presence of new or worsened WSL with their relative sizes/severity were noted.

Each tooth was evaluated for any obvious WSL. If the side–by-side comparison showed an identical white spot in both the pre-and posttreatment photographs it was considered to be a developmental or fluoridic white spot and was not counted as a WSL (Figure 1). A white spot that was noted in the

pretreatment photograph but worsened (enlarged or became more severe), was recorded as a WSL (Figure 2). All new WSLs were also counted.

Figure 1. (A) Pretreatment photo showing WSL that did not change during treatment and thus not counted (yellow arrows). (B) Posttreatment photo showing unchanged WSL (yellow arrows) and WSL that developed during treatment (blue arrows) and thus were counted.

Figure 2. Pretreatment photo demonstrating pre-existing WSL (yellow arrows). (B) Posttreatment photo demonstrating pre-existing WSL that worsened and thus were counted (green arrows), as well as new WSL (blue arrows).



Severity of each lesion was scored using a variation of the Gorelick scale (0=no lesion, 1=thin line in cervical third, 1.5=thin line in > cervical third, 2=wide, diffuse band in cervical third, 2.5=wide, diffuse band in > cervical third, or 3=cavitation) (Figure 3).

Figure 3. Posttreatment photo demonstrating WSL severity ranking. 0=no lesion, 1=thin line in cervical third, 1.5=thin line in > cervical third, 2=wide, diffuse band in cervical third, 2.5=wide, diffuse band in > cervical third, or 3=cavitation.

Oral hygiene was evaluated in both pre- and posttreatment photographs. Because the final photographs were taken immediately upon debanding and composite removal, different criteria were applied for the pretreatment and posttreatment photographs (Table 2). The posttreatment evaluation was primarily based on the positive or negative gingival changes that were evident and were assumed to have taken at least several months to occur.

Table 2. Criteria Used for Evaluating Pre- and Posttreatment Oral Hygiene Status

Oral Hygiene	Pretreatment Status	Posttreatment Status
Good	No visible plaque, no gingivitis	No visible plaque, no hypertrophy, gingival bleeding only due to composite removal
Fair	Some visible plaque, isolated areas of gingivitis	Some visible plaque, isolated gingivitis or hypertrophy, gingival bleeding only due to composite removal
Poor	Thick and/or generalized plaque, with gingivitis	Multiple areas of visible plaque and/or generalized hypertrophy, gingivitis and gingival bleeding

Fluorosis was evaluated based on the initial photographs due to composite removal and subsequent enamel desiccation in the posttreatment photographs. Only fluorosis on the anterior teeth was considered. It was deemed fluorosis rather than a WSL if it appeared on more than one tooth and extended beyond the incisal edges.

Statistics

Comparisons of frequencies were performed using x^2 analyses. Statistical significance was set at $P<.05$.

The risk ratio (RR) is defined by the formula RR=%with WSL/% without WSL. The RR compares the risk of a group's possessing a certain characteristic (such as fluorosis) with the risk for those without that characteristic. It describes the likelihood of a WSL forming within the group.

RESULTS

The percentage of patients presenting with pre-existing WSL were nearly identical in the sealant and no-sealant groups. In both groups, 9% had at least one WSL in the maxillary arch prior to treatment (74 individuls in the sealed group and 78 individuals in the unsealed group). The mandibular arch was similar, with pre-existing WSL identified in 3% (24 individuals) and 4% (36 individuals) of the sealant and no-sealant groups, respectively (Table 3).

Overall, there was no significant difference in the incidence of WSL between the sealant (25%) and no-sealant (21%) groups over the course of orthodontic treatment. 213 individuals who had sealants developed at least one WSL during orthodontic treatment, compared to 183 individuals whose teeth were not sealed, a non-significant difference. There was no significant difference the number of subjects who formed WSL in the mandibular arch, 126 (15%) and 130 (15%) in the sealant and no-sealant groups respectively. Significantly (P=.04) more subjects in the sealant (N=185) than no-sealant group (N=160) developed WSL in the maxillary arch during treatment (Table 3).

Table 3. Number and percentage of individuals with WSL before, after, and during treatment within the maxillary, mandibular, and combined arches.

	Maxillary					Mandibular					Total				
	Sealant		No Sealant			Sealant		No Sealant			Sealant		No Sealant		
	Number	%	Number	%	Prob	Number	%	Number	%	Prob	Number	%	Number	%	Prob
Before Treatment	74	9	78	9	NS	24	3	36	4	NS	78	10	87	10	NS
After Treatment	239	31	238	27	**0.04***	150	18	166	19	NS	291	35	270	31	NS
During Treatment	185	22	160	18	**0.04***	126	15	130	15	NS	213	25	183	21	NS

NS = not statistically significant, * = statistically significant

There was no significant difference in the severity of the WSL in the maxillary arch, with the average severity of the lesions in the sealant group being 1.51, and the no-sealant group 1.40. The mandibular arch showed lesions that were significantly (P=.047) smaller in the sealant (1.39) than the no-sealant (1.54) group. Table 4.

Table 4. Severity of WSL which formed within the maxillary and mandibular arches during orthodontic treatment.

Maxillary			Mandibular		
Sealant	**No Sealant**	**Prob**	**Sealant**	**No Sealant**	**Prob**
1.51	1.40	NS	1.39	1.54	**.047***

NS = not statistically significant, * = statistically significant

Lack of fluorosis (P=.004), the male gender (P<.001), poor pre-treatment oral hygiene (P<.001), a decline in oral hygiene during treatment (P<.001), treatment time greater than 36 months (P<.001), and the presence of WSL pre-treatment (P<.001) were all statistically significant risk factors in patients who formed WSL during treatment. The highest risk factor for the development of WSL was the presence of a pre-existing WSL (RR=3.15). This indicates that individuals with WSL prior to treatment were 3.15 times more likely to form a new WSL over the course of their orthodontic treatment than those without that risk factor (Table 5). Other factors that placed patients at higher risk were poor pretreatment oral hygiene (RR=2.18), a decline in hygiene during treatment (RR=1.89), treatment time in excess of 36 months (RR=1.44), lack of fluorosis (RR=1.42), and the male gender (RR=1.28).

Table 5. Comparison of individuals, and Risk Ratios for individuls with and without certain traits who developed WSL during orthodontic treatment.

	% of Patients With Trait Who Developed WSL	% of Patients Without Trait Who Developed WSL	Probability	Risk Ratio
No Fluorosis	37	26	**.004***	1.42
Male Gender	37	29	**<.001***	1.28
Poor Pre-treatment Oral Hygiene	61	28	**<.001***	2.18
Oral Hygiene Decline	58	28	**<.001***	1.89
Treatment Time > 36 months	36	25	**<.001***	1.44
Pre-Existing WSL	85	27	**<.001***	3.15

NS = not statistically significant, * = statistically significant

DISCUSSION

Pre-existing WSL were found in 10% of the current sample, which corresponds with previously published results ranging from 10-15%.[9-11, 20]. A much higher percentage was reported by Enaia et al (32%), but overall WSL were higher in that population (40%), so there may have been dietary or other factors which affected the number of WSL in both pre- and post-treatment groups.[7]

In this study we found that 25% of individuals with sealants, and 21% of patients without sealants developed WSLs during orthodontic treatment. These incidences are similar to that of Lovrov et al, who reported an incidence of 26%, using a similar methodology in a university setting.[10] Chapman et al[6] and Akin et al[4] reported higher results (36% and 32% respectively). Chapman et al, however, evaluated only the maxillary anterior teeth which are more likely to have WSL[3,9], and Akin et al evaluated all of the teeth including the molars which have been shown to have a high occurrence of WSL[3]. Other studies have found higher incidences of WSL, but the lesions were identified by direct observation which may have resulted in a higher detection rate.[13-15] The largest reported incidence of WSL during orthodontic treatment was reported by Boersma et al who reported a prevalence of 97%.[5] However, they identified WSL using QLF (quantitative light-induced fluorescence) which is highly sensitive and reports lesions before they are clinically visible.

This study found a significantly higher percentage of subjects developing WSL in the sealed (22%) versus unsealed (18%) maxillary anterior teeth. This is in contrast to findings by Benham, who found the incidence of maxillary WSL to be 8% in sealed subjects and 28% in unsealed subjects.[20] The lower incidence in that study could have been due to small sample size (N=60), short treatment duration (12-15 months), or due to the fact that brackets were not removed on many of the patients examined.

Although not statistically significant, the overall percentage of WSL in our sealant group (25%) compared to the no-sealant group (21%) was increased. This may be explained by the reported increase in bacterial colonization of composite resin and sealant materials.[24-26] It is also possible that the patients had a false sense of security since the sealants were knowingly placed. This is supported by the fact that there was a significant difference in the decline of oral hygiene between the two groups, with 25% and 11% declining in the sealant and no sealant groups, respectively.

The severity of white spot lesions in the maxillary arch was not statistically significant between these groups. However, there was a statistically significant ($p=.047$) difference in the severity of mandibular WSL. O'Reilly et al reported small, but statistically insignificant, differences in severity in both arches between their sealant vs. no sealant groups.[21] Their sample size was small, however, and WSL were scored by both direct visual and photographic methods. Benham et al [20] reported smaller WSL in their visually assessed sealant group, although statistical tests were not performed. They also evaluated lesions with a DIAGNOdent fluorescence device which revealed significant severity differences in the maxillary ($P<.001$) but not the mandibular arch. The DIAGNOdent measures demineralization that is quantifiable, but may not be able to be seen clinically. As discussed previously, the Benham et al study was a pilot program with small sample sizes and inconsistent methodology.

Risk factors for the development of WSL (Table 3) were found to be consistent with findings in other studies with slight differences. In the current sample, 26% of individuals with fluorosis developed WSL compared to 37% without. There is not extensive literature describing this risk factor, but Julien et al [9] showed significant differences in WSL between groups with (16%) and without (26%) fluorosis. Caries in general is has been shown to be less frequent in groups with significant fluorosis.[27]

Studies which have explored gender differences in WSL formation have either shown a greater tendency[1,8-11]or significantly more WSL in male patients.[5,6,14] Our sample revealed similar significant differences, with 37% of males and only 29% of females being affected. It is doubtful that true gender-based differences exist. More likely would be differences in compliance with oral hygiene between the genders as reported by Ostberg. [28]

Poor hygiene would be expected to be a risk factor in the development of WSL. In the present study, 61% of those individuals with poor, compared with 28% if those with good initial oral hygiene, developed at least one WSL during treatment. This is similar to findings by Chapman who found WSL in 57% of those with poor hygiene.[6] It is a higher percentage than found in a previous sample of unsealed teeth which showed WSL in 35% of poor brushers.[9] It is possible that the placement of sealants resulted in the attraction of even more bacterial plaque in poor brushers, similar to *in vitro* studies showing attraction of plaque to composite resins.[24,25]

The relationship between WSL and changes in oral hygiene during the course of treatment has not been widely explored in the literature. However, in a 2012 study, it was a reported that a decline in oral hygiene resulted in WSL in 59% of individuals. The current study showed very similar results, with 58% of patients developing WSL when oral hygiene declined.

The literature has been divided over the topic of treatment time and its relationship to WSL. The current study found that patients in treatment for more than 36 months had significantly more WSL (36%) in comparison to those treatment in less than 36 months (25%). Lovrov et al[10] found no correlation between WSL and treatment time, however, others have reported significant differences.[6,9] The sample size many play and important role in this measurement. Lovrov et al had a small sample (n=53) compared to the studies who have reported significant differences.

The most important risk predictor found in this study was the presence of a pre-existing WSL, with 85% of patients with a pre-existing WSL developed new WSL, compared to only 27% of those without them. Lovrov et al[10] and Julien el al[9] reported that 47% and 87% of their samples, respectively, with pre-existing WSL developed new lesions during orthodontic treatment. The Lovrov et al study showed a lower percentage, however compared to this study, the sample was much smaller in size, they were on a formal program of Fluoride rinse treatment, and they were professionally treated with fluoride every 6 months.

The present study confirms risk factors and provides guidelines for clinical practice. Although protective sealants were placed in a large number of patients, they did not reduce the number or severity of WSL during orthodontic treatment. As a result, risk factors present in patients prior to and during their treatment must be evaluated to better protect them from harm. For example, if patients have pre-existing WSL (the highest risk predictor), it may be better to postpone initiation of treatment unless they are able to maintain good oral hygiene. The treatment plan should be efficient, so that the patients' treatment is kept as short as possible.

EDUCATIONAL, TEACHING, AND CLINICAL OBJECTIVES

Looking back at my objectives for education, teaching, and clinical skills, it is interesting to see the changes that occur in our professional lives. The clear, straight path that is planned often gives way to curves and detours, but somehow we still get to the same place.

Educational Plan:
My plan was to focus on managerial education related to my position as Clinic Director. Reality set in when our clinic manager, who had been in the position for 20 years, retired. There was a sudden void in leadership that I had to fill immediately. Gone was the luxury of learning to lead and manage. Instead I had to hire, train, mentor, and manage a replacement immediately. It was a forced "education by fire".

Instead of using the time and resources as planned, I used them to take an intensive aligner course. This became important as it has related to new teaching/clinical responsibilities that will be discussed below.

Teaching Plan:
My responsibilities in the area of teaching have expanded over the past year. We have had two faculty members retire and they have not been replaced. As a result, I have added additional courses to help fill that void. I have an increased number of clinical and didactic introductory courses for which I am responsible, spending nearly all day with new residents during their first month. We have added intra-oral scanning/3D printing into our clinic and I am responsible for instruction in that regard. I continue to teach the didactic principles of aligner therapy, but I am also developing a series of courses in 3D printing and advanced appliance fabrication.

Clinical/Clinical Teaching Plan:

I have been elected to serve on the dental curriculum revision committee for our university. As part of this comprehensive didactic and clinical revision, our department has been called upon to add significantly more aligner therapy into the pre-doctoral curriculum as well as creating an "aligner clinic" that will include both graduate and pre-doctoral students. Once the curriculum changes are approved,

I will be responsible for implementing these changes. As mentioned earlier, it was fortuitous that I found myself involved with more education in regard to aligner therapy.
I still believe that the most effective teachers are those who maintain a private practice. There is no substitute for the experience of treating your own patients, maintaining the growth of a practice, and managing a staff. Residents can feel confident that you are experiencing the same pressures and market issues that they are soon entering into. I currently work three days in academics (75% FTE) and maintain a private office three days per week.

CONCLUSIONS

- Placement of filled sealants to the facial surfaces of the teeth prior to bracket placement did not reduce WSL.
- The severity of WSL that formed during orthodontic treatment was not significantly less in the maxillary arch, but lesions were significantly less severe in the mandibular arch in the sealant group.
- Six statistically significant risk factors for developing WSL during treatment were identified: Male gender (RR=1.28), lack of fluorosis (RR-1.42), treatment time in excess of 36 months (RR=1.44), a decline in oral hygiene during treatment (RR=1.89), poor pre-treatment oral hygiene (R=2.18), and the existence of pre-treatment WSL (RR=3.15).

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