Predicting improvement of postorthodontic white spot lesions

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Introduction: Patients undergoing orthodontic treatment are at greater risk for developing white spot lesions (WSLs). Although prevention is always the goal, WSLs continue to be a common sequela. For this reason, understanding the patterns of WSL improvement, if any, has great importance. Previous studies have shown that some lesions exhibit significant improvement, whereas others have limited or no improvement. Our aim was to identify specific patient-related and tooth-related factors that are most predictive of improvement with treatment. **Methods:** Patients aged 12 to 20 years with at least 1 WSL that developed during orthodontic treatment were recruited from private dental and orthodontic offices. They had their fixed appliances removed 2 months or less before enrollment. Photographs were taken at enrollment and 8 weeks later. Paired photographs of the maxillary incisors, taken at each time point, were blindly assessed for changes in surface area and appearance at the individual tooth level using visual inspection. **Results:** One hundred one subjects were included in this study. Patient age, brushing frequency, and greater percentage of surface area affected were associated with increased improvement. Central incisors exhibited greater improvements than lateral incisors. Longer time since appliance removal and longer length of orthodontic treatment were associated with decreased levels of improvement. Sex, oral hygiene status, retainer type, location of the lesion (gingival, middle, incisal), staining, and lesion diffuseness were not found to be predictive of improvement. **Conclusions:** Of the various patient-related and tooth-related factors examined, age, time since appliance removal, length of orthodontic treatment, tooth type (central or lateral incisor), WSL surface area, and brushing frequency had significant associations with WSL improvement. (Am J Orthod Dentofacial Orthop 2016;149:625-33)

Orthodontic treatment has long served as a means for providing patients with improved esthetic, functional, and psychological benefits. Unfortunately, white spot lesions (WSLs) are a common and undesirable side effect that can diminish the satisfaction that a patient experiences after orthodontic treatment. Some studies have shown that the prevalence of WSLs is as high as 97% among orthodontic populations.[1]

WSLs are characterized by their greater opacity than healthy enamel. They have a whiter appearance as a result of mineral loss in the surface layers; this alters the refractory index and increases the scattering of light in the affected area because of damaged surface roughness.[2] The appearance of the lesion can vary from minor surface change to cavitation.[3] In some instances, stains can be incorporated into a lesion and lead to the formation of brown spots during the remineralization process, worsening the esthetic problem.[4] Prevention and treatment of WSLs are important for the integrity of the teeth, as well as for esthetics, since they often affect the maxillary incisors.

Several options have been proposed to address these lesions, depending on their nature and severity. The recommended treatments range from as simple as improved home care with fluoride toothpaste to more invasive options involving composite restorations. There is still a lack of strong evidence in the literature, however, regarding the most effective treatment protocol and the ideal timing for maximizing improvement.[5]

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In addition to the abundance of available treatment options, the unpredictable patterns and degrees of improvement add to the complexity of WSL treatment. There is a wide range of improvement in lesions from one patient to the next. Lesions can vary in size, shape, and location and are as unique as the oral environment of the patients in whom they are found. Results from a previous randomized control trial by Huang et al[6] found no significant differences in subjective or objective improvement in the appearance of the WSLs among those who received MI Paste Plus, PreviDent fluoride varnish, or normal home care during an 8-week period. Although some WSLs exhibited little or no improvement, some did show considerable improvement. Since the treatment arm did not appear to have a large role in the improvement of WSLs, investigation of other possible factors associated with WSL improvement seemed warranted.

The first aim of this study was to determine whether the following patient factors are predictive of the overall improvement of WSLs: age, sex, time since appliance removal, length of orthodontic treatment, self-reported tooth brushing, oral hygiene, or retainer type. Each patient factor was analyzed with the null hypothesis of no difference in WSL improvement for both subjective and objective measures.

The second aim was to compare the following tooth-related factors with the amount of WSL improvement: proportion of tooth surface area affected, tooth type (central or lateral incisor), staining, location (gingival, middle, incisal), and lesion diffuseness. The null hypothesis was that there would be no difference in WSL improvement associated with the tooth-related factors.

MATERIAL AND METHODS

This study is a further investigation of data from a previous project regarding WSLs. The photographs that formed the sample data were originally collected from a randomized (1:1:1), single-blind, active-controlled, parallel-group trial evaluating the improvement of WSLs in 3 treatment arms.[6] The treatment arms were MI Paste Plus (GC America, Allsip, Ill), containing casein phosphopeptide-amorphous calcium phosphate and 900 ppm of fluoride; PreviDent fluoride varnish (22,600 ppm of fluoride; Colgate Oral Pharmaceuticals, New York, NY); and a home-care control group with oral hygiene instructions and over-the-counter toothpaste (1100 ppm of fluoride; Colgate Oral Pharmaceuticals). In the original study, photographs of the WSLs were taken at 2 times: the start of the study (T1) and 8 weeks later (T2). Data were collected from private orthodontic and general dentistry offices belonging to the Practice-based Research Collaborative in Evidence-based Dentistry network in the Northwestern United States (Northwest PRECEDENT). The network was co-operated by the University of Washington and the Oregon Health and Science University, and it comprised Washington, Oregon, Montana, Idaho, and Utah.

Eligibility criteria for this study included the fulfillment of the following conditions: completion of fixed appliance orthodontic therapy within the past 2 months, at least 1 WSL on the facial surface of a maxillary incisor that was not present before starting orthodontic treatment, and age between 12 and 20 years. Subjects excluded from this study were those who were unwilling to be randomly assigned to 1 of the 3 treatment groups; had any abnormal oral, medical, or mental conditions; received therapy for WSLs after orthodontic treatment; displayed frank cavitations associated with the maxillary incisors; or were unable to speak or read English. Patients (and parents, for those under 18 years of age) consented to participate before the study.

Throughout treatment, oral hygiene was reinforced by staff members. Clinicians provided patient information, including age, sex, length of orthodontic treatment, and retainer type. All subjects also completed a questionnaire, which gave us information regarding their average daily brushing frequency.

Two types of evaluations (subjective and objective improvement) were performed for the 4 maxillary incisors, for each pair of photographs (initial and 8 weeks). For subjective improvement, a blinded panel of 5 dental professionals (expert panel) assessed improvement using a visual analog scale from 0 to 100 mm (0 mm, no improvement or worsened, to 100 mm, complete resolution). These evaluations were performed as part of the original study, and the mean ratings of the panel were used for overall improvement of the 4 maxillary incisors.

For objective improvement, 2 examiners (a dental student and a general dentist) performed the assessments for improvement by measuring changes in WSL surface area at each time point. WSL surface area was divided by total tooth surface area to calculate the pretreatment and posttreatment percentages of affected surface areas. The change in percentage of affected surface area was obtained by subtracting the T2 surface area from the T1 surface area. These assessments were also performed as part of the original study for all 4 incisors.

For this current study, we considered improvement of a lesion to be a visible decrease in the affected surface area, minimized contrast between the WSL and surrounding healthy tooth structure, or any combination of changes resulting in an overall improved esthetic appearance. In the previous study, all 4 incisors were

evaluated as a unit, rather than each tooth individually (Table I). To perform evaluations at the single-tooth level, we cropped the images of the 4 maxillary incisors into individual teeth (n = 404) and then further cropped them into horizontal thirds, evaluating only the portions affected (n = 728) (Fig 1). To maintain a uniform size and a similar level of magnification, a grid of a fixed dimension was used to show only the tooth or portion of the tooth being evaluated. This method allowed us to mask all other teeth or parts of teeth, minimizing any undesired influence from the surrounding teeth on the evaluation scores. Once all images were cropped to the proper dimensions, the lesions were then categorized according to the different characteristics that were of interest to this study.

At the single-tooth level, each lesion was categorized by the presence or absence of staining. Most WSLs are uniformly white throughout (unstained), but occasionally some have a yellowish or brownish area of discoloration (Fig 2). A primary and a secondary evaluator (an orthodontic resident [S.K.] and a general dentist [M.K.]) categorized the staining before blinding for the time points to ensure that the staining was present at the start of the study. After categorization, the time points were obscured for all images to reduce any expectation bias for improvement because one might naturally expect improvement over time even when no improvement had occurred. Of the 404 incisors, 105 exhibited staining (26%). Categorization for staining had an agreement of 87% between the evaluators.

The images of the horizontal thirds were labeled as the gingival, middle, and incisal thirds. Only portions of the tooth affected by a WSL were evaluated. Portions of the tooth containing no lesions were not included. The same 2 evaluators independently examined each third and categorized each lesion by its diffuseness (Fig 3). Any lesion with a discrete linear shape with areas of healthy, unaffected tooth structure adjacent to both sides of the lesion was considered to be a discrete lesion. Any lesion with a nonlinear, amorphous, or ill-defined appearance was categorized as diffuse. Any lesion containing both types of these lesions on the same tooth third was classified as a mixed lesion. Time points were also obscured for each third before evaluation.

For the blinded evaluation of single teeth and tooth thirds, the evaluators rated each image on a WSL improvement scale of 1 to 5: 1, significantly worse; 2, slightly worse; 3, the same; 4, slightly better; or 5, significantly better than its corresponding image taken at the other time point (Table I). The average scores of the raters were used. Twenty images were evaluated a second time, at least 1 month apart, to calculate the reliability of the raters' average scores.

Statistical analysis

Analyses were conducted using SAS software (version 9.2; SAS Institute, Cary, NC).

Descriptive data were summarized with frequency tables (Table II). Regression models were run using generalized estimating equations, which allowed accounting for clustering by site and subject. Intraclass correlation coefficient (ICC) values for both factors were negligible.

We performed univariate analyses to identify potential factors of interest and then selected the covariates for our multivariate analyses based on our univariate results. Models were adjusted for age, sex, time since appliance removal, length of orthodontic treatment, and brushing frequency. Although the previous study found no difference in improvement among the 3 original treatment arm groups, we performed a sensitivity analysis for treatment arm to verify that there were no differences among groups when adjusting our model for our particular choice of covariates.

RESULTS

A total of 115 subjects were eligible for evaluation in our study. Subjects were removed due to poor-quality images (n = 5) or missing lateral incisors (n = 2). One subject's records were not obtainable from the previous study. Six additional subjects were dropped from the study because they had multiple retainer types. A total of 101 subjects (49 boys, 52 girls; mean age, 14.4 ± 1.5 years) were included in the final analyses. The subjects dropped from our study did not vary with respect to demographic data and initial WSL severity compared with the subjects included in this study. Although there was no difference in improvement among the 3 treatment groups in the original randomized controlled trial, patient compliance was factored in for the MI Paste Plus group as part of the multivariate analysis, and it was not significant.

Duplicate measurements of 20 sets of images showed good repeat reliability. The ICC was 0.92. The ICC values were 0.72 and 0.85 between the subjective and objective evaluators in the previous study, respectively.

For the analyses of all 4 incisors, the mean subjective improvement from the original study for the 4 incisors over the 8-week period (T1-T2) was 26%. Using these subjective ratings from the original study, we found no patient-related factors associated with improvement (Table III). The total percentage of surface area initially affecting all 4 incisors was also not significant for improvement (data not shown). The objective surface area measurements from the original study showed an

Table I. Description of evaluations

Evaluation level	*Evaluation type*	*Outcome measure*	*Factors evaluated*
4 maxillary incisors	Subjective improvement Objective improvement	Visual improvement (%) Reduction of surface area (%)	Age Sex Time since deband Treatment time Brushing frequency Oral hygiene Retainer type Initial WSL surface area
Single tooth	Improvement scale	1: Significantly worse 2: Slightly worse 3: Same 4: Slightly better 5: Significantly better	Age Sex Time since deband Treatment time Brushing frequency Oral hygiene Retainer type Initial WSL surface area Tooth type Staining
Tooth thirds	Improvement scale	1: Significantly worse 2: Slightly worse 3: Same 4: Slightly better 5: Significantly better	Age Sex Time since deband Treatment time Brushing frequency Oral hygiene Retainer type Initial WSL surface area Lesion location Diffuseness

average improvement of 19% for the 4 maxillary incisors. In the multivariate analyses, we found greater improvement in WSL appearance with each additional year of patient age. With each additional month of orthodontic treatment or time since appliance removal, less improvement was observed (Table IV).

For the analyses at the single-tooth level, the mean WSL improvement scale rating was 3.77, indicating that most lesions stayed the same or improved slightly over the 8-week period. Assessment at this level also showed that lateral incisors had less improvement than central incisors (Table V). Subjects with a self-reported brushing frequency of twice or more per day were 0.42 points higher on the improvement scale than those who brushed less frequently (Table V). When we examined each tooth, WSLs with a greater surface area showed slightly more improvement. Longer time since appliance removal was associated with less improvement (Table V). Staining of WSLs showed no relationship with improvement (Table V).

In the analyses of tooth thirds, we found no significant difference in improvement between the gingival, middle, and incisal thirds. Lesion diffuseness was also not related to improvement (Table VI).

DISCUSSION

We identified several factors that were associated with a significant effect on improvement in the appearance of WSLs. Overall, we observed a tendency for WSLs to improve during the 8-week period, according to all 3 evaluation methods. However, different patient-related and tooth-related factors were significant for improvement, depending on the type of assessment.

With each additional year of age, there was a 3.1% greater reduction in WSL surface area over the 8-week period (Table IV). With greater age, there may be some improved dexterity and effectiveness at brushing. Also, a study comparing the salivary contents of children (6-12 years) and adults (19-44 years) found that calcium concentrations were lower in children.[7] Perhaps the difference in mineral concentrations of saliva could play a contributing role in WSL improvement. In examining sex, previous studies have shown conflicting findings regarding the effect of sex on the prevalence of WSL development. Male subjects are often believed to have lower compliance and may be less concerned with their dental appearance, but we found no difference in improvement between the sexes.[8]

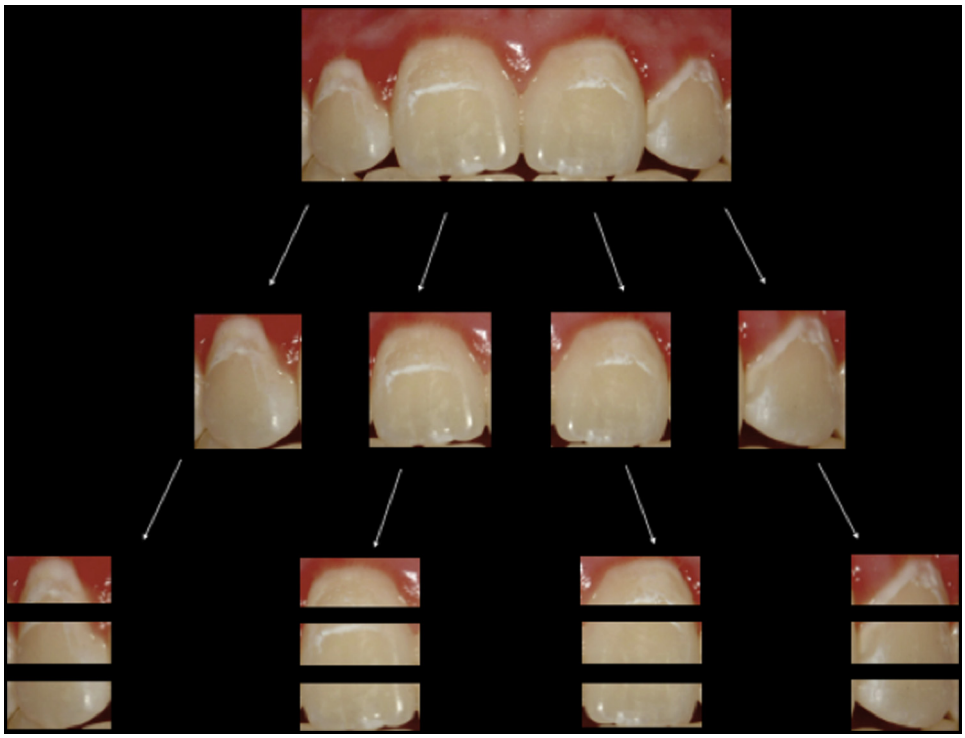

Fig 1. Images of 4 incisors, single teeth, and tooth thirds.

Fig 2. Example of WSLs displaying staining.

With each additional month since appliance removal, there was 14.9% less improvement in surface area (Table IV). This suggests that most improvement occurs shortly after appliance removal. Other studies investigating remineralization patterns of WSLs have supported these findings and have described an exponential pattern of remineralization, with all improvement occurring within the first month.[9] Studies of WSLs that developed over a longer period of time, involving subsurface layers of enamel, showed the greatest amount of remineralization during the first few months and then continuing at a slower rate thereafter.[10] Since the average treatment time for our subjects was 25.7 months, the lesions were likely to have formed over a period of months rather than weeks. With that in mind, we would have expected a more gradual improvement, but instead our findings were more consistent with that of an exponential pattern. Length of orthodontic treatment showed only a 0.29% decreased improvement of WSLs with each additional month in treatment according to objective measurements. Although it is statistically significant, a difference of 0.29% per month is not clinically significant. Even with an additional year of treatment, this amounts to only a 3.5% decrease in improvement. One study found that teeth bonded for a relatively short treatment time (12-16 months) had the same incidence of WSLs as those with longer treatment times (up to 36 months).[11] Another study found that the greatest formation of WSLs occurs in the first 6 months of treatment, with a gradual slowing by 12 months.[12] Therefore, if lesion severity and formation are relatively established by the first year of orthodontic treatment, it was not surprising to see minimal differences in improvement among our subjects, who were in treatment for longer than 12 months.

Retainer type was not shown to be significant for WSL improvement. In terms of distribution, 55% received Hawley retainers and 45% received vacuum-formed (Essix) retainers. Since it is believed that the free flow of saliva may be a major factor in preventing WSLs, it would be reasonable to believe that the full

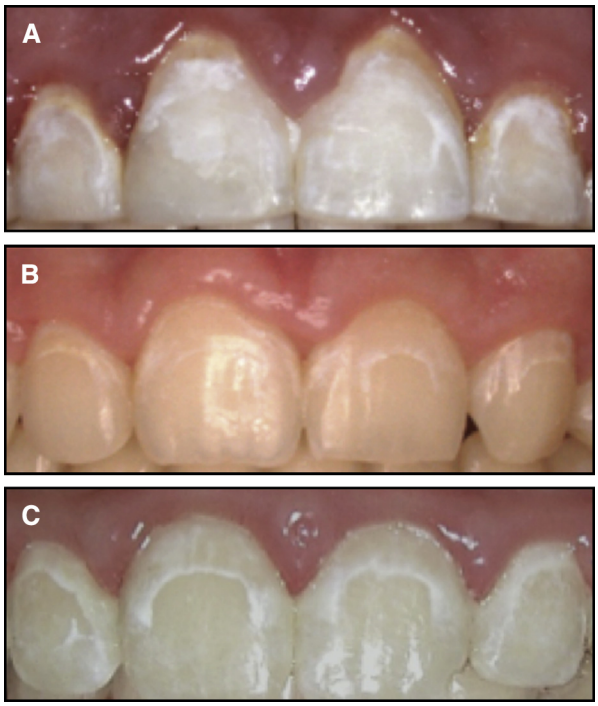

Fig 3. Examples of **A,** diffuse lesion; **B,** discrete lesion; and **C,** mixed lesion.

coverage design of an Essix retainer might inhibit some of the remineralization process.[11] Although we do not know the compliance level of retainer wear among these subjects during the 8-week period, we can assume that compliance for Essix retainer use was generally as good, if not better, than that of the Hawley retainer group.[13] However, improvement of WSLs was found to be comparable between the groups. Therefore, when selecting a retainer type for patients, WSL improvement does not need to be a primary concern for our choice of retainer.

Brushing frequency of 2 times or more per day was associated with an increase of 0.42 on the WSL improvement scale, when compared with those who brushed less frequently (Table V). This is not surprising, since more frequent clearing of food and plaque from the tooth surfaces would decrease exposure of the enamel to the acidogenic bacteria and their products. Surprisingly, oral hygiene during treatment did not have a significant relationship with improvement. Most patients had poor (47%) or fair (43%) oral hygiene throughout their orthodontic treatment. Despite having good oral hygiene, the 10% of subjects in the good hygiene group were still susceptible to WSL formation during treatment and did not exhibit greater improvements in the weeks after appliance removal. This may be due to patient factors other than oral hygiene that were not accounted for: eg, composition of biofilm, diet, and variations in salivary flow rate, pH, and buffer capacity.[14]

Table II. Summary of descriptive data (n = 101)

Parameter	*Value*
Age in years (SD)	14.4 (1.5)
Female (n)	52 (51.5%)
Initial surface area affected (SD)	10.7% (7.7%)
Oral hygiene (n)	
Good	10 (9.9%)
Fair	43 (42.6%)
Poor	48 (47.5%)
Months since appliance removal (SD)	
Mean (SD)	0.26 (0.44)
≤1 week	73 (72.3%)
Months in orthodontic treatment (SD)	25.7 (9.7)
Brushing frequency (n)	
≤1 time per day	37 (36.6%)
≥2 times per day	64 (63.4%)
Retainer style (n)	
Hawley	56 (55.5%)
Essix	45 (44.6%)

Table III. Visual improvement of 4 incisors (multivariate analysis)

Parameter	*Improvement (%)*	*95% CI*		P *value*
Age	0.5	−2.5	3.6	0.72
Sex				
Female	−0.6	−9.3	8.1	0.90
Male	–	–	–	–
Removal time (mo)	−4.3	−10.9	2.3	0.20
Treatment time (mo)	−0.01	−0.3	0.3	0.97
Brushing frequency				
≤1 time per day	–	–	–	–
≥2 times per day	6.6	−5.6	18.8	0.29

Lateral incisors showed less improvement than did central incisors; they were 0.18 points lower on the improvement scale (Table V). Previous studies have shown that lateral incisors are more frequently affected with WSLs than are central incisors.[15,16] Lateral incisors were also found to be the most severely affected teeth.[15] Compared with central incisors, lateral incisors are smaller and also have less distance from the bracket to the free gingival margin, which is more conducive to accumulating plaque and debris.[11] Although we do not know the exact cause, the diminished improvement of the lateral incisors might be related to the relatively larger proportion of affected surface areas and lesions that are generally more severe. The gingival and middle thirds made up the greatest proportion of affected sites, at 44% and 45%, respectively. In comparing all potential sites, the gingival and middle thirds were affected 26% and 27% of the time, respectively. This was expected,

Table IV. Surface area improvement of 4 incisors (multivariate analysis)

Parameter	Improvement (%)	95% CI		P value
Age	3.1	0.5	5.8	0.02
Sex				
Female	0.8	−6.6	8.3	0.83
Male	–	–	–	–
Removal time (mo)	−14.9	−20.6	−9.2	<0.0001
Treatment time (mo)	−0.3	−0.6	−0.02	0.04
Brushing frequency				
≤1 time per day	–	–	–	–
≥2 times per day	7.5	−2.8	17.8	0.15

Table V. Improvement scores of single teeth (multivariate analysis)

Parameter	Improvement (1-5 scale)	95% CI		P value
Age	0.01	−0.08	0.1	0.84
Sex				
Female	−0.09	−0.3	0.1	0.44
Male	–	–	–	–
Removal time (mo)	−0.64	−0.9	−0.4	<0.0001
Treatment time (mo)	−0.002	−0.02	0.01	0.81
Brushing frequency				
≤1 time per day	–	–	–	–
≥2 times per day	0.42	0.03	0.81	0.03
Tooth type				
Central incisor	–	–	–	–
Lateral incisor	−0.18	−0.3	−0.02	0.03
WSL surface area	0.01	0.003	0.03	0.02
Staining	0.2	−0.1	0.4	0.17

Table VI. Improvement scores of tooth thirds (multivariate analysis)

Parameter	Improvement (1-5 scale)	95% CI		P value
Age	−0.01	−0.1	0.1	0.72
Sex				
Female	−0.05	−0.2	0.1	0.62
Male	–	–	–	–
Removal time (mo)	−0.2	−0.5	0.03	0.08
Treatment time (mo)	−0.004	−0.01	0.005	0.39
Brushing frequency				
≤1 time per day	–	–	–	–
≥2 times per day	0.3	0.1	0.5	0.02
Location				
Gingival	−0.03	−0.2	0.1	0.69
Middle	–	–	–	–
Incisal	−0.2	−0.5	0.05	0.10
Diffuseness				
Diffuse	−0.01	−0.3	0.3	0.97
Discrete	–	–	–	–
Mixed	0.02	−0.3	0.4	0.9

because the areas with the greatest difficulty to clean are directly adjacent to and gingival to the brackets. The incisal third of the tooth comprised only 11% of the affected sites. Although there were differences in WSL formation rates for each region of the tooth, there were no differences in their improvement.

It is believed that more severe WSLs can change color from their characteristic white to a brown-black color.[14] We examined staining to determine whether these discolored WSLs would exhibit a different pattern of improvement. Of the 404 single teeth examined, 105 incisors (26%) had staining associated with their WSLs. We found that staining was not related to WSL improvement. Lesion diffuseness was also not predictive of improvement. Eighty-eight percent of lesions were categorized as diffuse, and only 7% were discrete. The remaining portion had some combination of both a diffuse and a discrete appearance. Our goal for categorizing lesions by diffuseness and discreteness was to try to identify a lesion characteristic that can be simply evaluated by visual inspection. Although we did not find a relationship between lesion diffuseness and improvement, it would be beneficial for future studies to attempt to identify a reliable trait that can be used for predicting WSL improvement.

One strength of our study is the multiple methods of evaluation that were used: we used a panel and multiple measures of improvement for observing all 4 incisors, each tooth, and tooth thirds. The visual assessment of improvement, performed by an expert panel and 2 evaluators, was an important part of the evaluation process, since it demonstrated changes that a clinician is likely to perceive. Our objective measure of improvement assessed the changes in the percentage of tooth surface affected (proportional change), which has been used in many previous studies,[15,17-20] rather than absolute measurements of luminance or size.[21,22] The comparison of proportional change also allowed us to account for any differences in magnification and angulations of teeth when using photographed images. We also pointed out a difference in the relationship between initial WSL surface area and improvement when the assessments were carried out at the level of all 4 incisors (collectively), compared with the level of each incisor. It is possible that the collective assessments clouded the actual improvement of each tooth, resulting in the insignificant findings in those analyses.

A limitation of our study design was that we combined patients who underwent 3 different treatment regimens for WSLs. However, the patients in each arm showed, on average, the same amount of improvement;

thus, the treatment arm was thought not to be the primary factor related to the degree of improvement. We also adjusted for the treatment arms in our multivariate analyses. Additionally, a common limitation of this study is that improvement may be related to lesion depth, which is difficult to measure accurately and consistently in vivo. This issue is also a clinically relevant challenge, since orthodontists cannot predict the volume (depth of demineralization) of the WSL using visual cues; they can see only the surface area, as was carried out in this study. With the limited information that is currently available to us about an in-vivo WSL, it is difficult to reliably inform a concerned patient about the future outcome of his or her WSLs.[14]

Methods to accurately report lesion depth and volume, in addition to photographic images, would be ideal for future studies to measure improvement. Some studies have used laser fluorescence, such as DIAGNOdent (KaVo, Biberach, Germany) or quantitative light-induced fluorescence (Inspektor Research Systems, Amsterdam, The Netherlands), to evaluate WSLs. Although these technologies can quantitatively assess WSLs, each method has its limitations. With laser fluorescence technology, because the readings measure the bacterial metabolites that have penetrated into the surface deposits and porosities, they do not directly detect changes within the enamel structure and are not necessarily a measure of lesion size or depth.[23] Quantitative light-induced fluorescence is known to have a close correlation with changes in enamel structure and mineral content[24] and has been validated against a number of other methods for quantification of demineralization in in-vitro studies.[25] Although quantitative light-induced fluorescence has been shown to be highly sensitive, it may not be practical for diagnosis of WSLs.[2] The authors of a recent systematic review on the various detection methods concluded that for both cost and practicality considerations, visual methods should still be the standard for clinical assessment.[26]

Additional considerations for future studies should involve collection of saliva samples to test for differences in oral bacteria composition and activity, stimulated and unstimulated salivary flow rate, pH, and calcium, phosphate, and bicarbonate concentrations. Lastly, details of patient diet, including snacking frequency and consumption of sugary or acidic drinks, could also be evaluated.

CONCLUSIONS

Of the various patient-related and tooth-related factors examined, age, time since appliance removal, length of orthodontic treatment, tooth type (central or lateral incisor), WSL surface area, and brushing frequency had significant associations with WSL improvement over an 8-week period. Sex, oral hygiene status, retainer type, location of the lesion (gingival, middle, incisal), staining, and lesion diffuseness were not predictive of improvement.

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