Original Article

Do total or partial etching procedures effect the rate of white spot lesion formation?

A single-center, randomized, controlled clinical trial

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ABSTRACT

Objective: To determine whether total or partial etching procedures influence the appearance of white spot lesions (WSLs).

Materials and Methods: This split-mouth, double-blind, controlled, randomized study included 20 patients (mean age 16.75 years), who had class I malocclusion, mild crowding, and satisfactory oral hygiene. A total of 40 maxillary quadrants were randomly allocated to be treated using a total etching (TE) or partial etching (PE) protocol. Quantitative light fluorescence images were captured at the beginning and at 3 (T1) and 6 (T2) months after beginning orthodontic treatmen, as well as when the debonding phase of orthodontic treatment was complete (T3). The presence of pre- and posttreatment WSLs was assessed with quantitative light fluorescence software and analyzed with Student's *t*-test.

Results: The analyses showed that, at T2, the total etching group had significantly higher ΔQ and A scores than the partial etching group ($P < .05$). The ΔF scores increased significantly at all timepoints in the TE group, but only at T1 and T3 in the PE group. However, no differences were noted at T3 between the TE and PE groups ($P > .05$). The inclusion of only right-handed people may have limited the generalizability of the findings. The absence of analyses of the plaque and gingivitis scores of patients was another limitation of this study.

Conclusions: WSL formation was observed mostly in maxillary lateral incisor teeth irrespective of the etching technique. Although PE seems to be more successful in the first 6 months, no difference was observed between PE and TE in the long term for WSL formation. (*Angle Orthod.* 2019;89:16–24.)

KEY WORDS: White spot lesions; Total etch; Partial etch; Quantitative light fluorescence

INTRODUCTION

White spot lesions (WSLs) are one of the possible adverse effects resulting from the use of fixed orthodontic appliances[1] and remain a considerable clinical problem.[2] Formation of WSLs is caused by acid production due to long-term bacterial plaque accumulation on enamel surfaces close to fixed appliances and the loss of calcified tooth material on the enamel surface.[3]

Some methods, such as antimicrobial dentifrices, fluoride, mouth rinses, casein phosphopeptides-amorphous calcium phosphate, sealants, laser and antimicrobial modifications of orthodontic biomaterials can be effective for the prevention of WSLs in orthodontics.[4,5] However, the type of bonding agents used may influence WSL formation on the tooth surface.[6]

The detection of WSLs is important because the process can lead to cavitation if not arrested.[7] In a previous study, WSLs were observed on enamel surfaces within 4 weeks after beginning orthodontic treatment.[8]

The quantitative light fluorescence (QLF) technique is based on the property of tooth enamel to auto-

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fluoresce when flashed with visible light.[9] During demineralization, minerals are displaced by water, resulting in a reduced fluorescence luminosity when compared with healthy enamel.[10] QLF has been used in many studies to detect WSL formation during orthodontic treatment in vivo.[10,11] Numerous factors can influence the bond strength of brackets bonded to enamel, such as the acid etching technique, enamel surface, type of bonding agents, and dental bleaching.[12]

No published studies have investigated whether etching procedures are linked to WSL formation, although there have been studies evaluating specific effects related to bonding materials.[6] The objective of this study was to determine whether total vs partial etching procedures affect the formation of WSLs and bracket breakage in orthodontic treatment.

MATERIALS AND METHODS

The Erciyes University (Kayseri, Turkey) local ethics committee approved the experimental protocols. Signed informed consent was obtained from all patients before participation in the present study. The patients were recruited from a pool of untreated orthodontic patients at Erciyes University, Faculty of Dentistry, Department of Orthodontics, during a 15-month period.

The study was designed as a split-mouth, double-blinded, randomized, controlled trial with a 1:1 allocation ratio. A total of 20 patients (12 girls, 8 boys), with a mean age of 16.75 $\pm$ 2.83 years were included in the study.

The inclusion criteria were as follows: (1) permanent dentition, (2) skeletal and dental class I malocclusion, (3) mild crowding, (4) patients required treatment with fixed appliances without extractions, (5) patients with adequate oral hygiene, (6) the absence of any serious defects on the enamel surface, (7) right-handed patients, (8) patients without any genetic and congenital abnormalities or mouth breathing, (9) patients residing in the same region. No alterations were made to the methods after the start of the trial.

All patients' upper dental arches were separated into two quadrants: the upper left and upper right. A split-mouth method was used with random allocation of the etching methods to either the left or the right sides. Randomization of quadrants was performed using a computer-generated allocation and total etching (TE) and partial etching (PE) groups were established.

All etching and bonding (including rebonding of bracket failures) were performed by one researcher. Blue High Viscosity Gel Etchant (Reliance Orthodontic Products, Inc., Itasca, Ill), which contains 37% phosphoric acid, was used as the etching agent. In the TE group, the vestibular surface of all teeth, up to the gingiva, was etched for 15 seconds. In the PE group, for all teeth, only an area slightly wider than the brackets' base area was etched for 15 seconds (Figure 1). After etching, the tooth surfaces were thoroughly rinsed for 15 seconds and dried with air. All etched enamel surfaces were bonded with Transbond XT Light Cure Adhesive primer (3M Unitek, Monrovia, Calif). Master/Mini Master Series brackets (American Orthodontics, Sheboygan, Wis) and molar tubes were bonded using the direct bonding technique. Each tooth was polymerized using a VALO Ortho LED (Ultradent Products, South Jordan, Utah) at 3200 mW/cm^2 for 3 seconds.

Figure 1. (A) Total etching (TE) or partial etching (PE) procedures: the right quadrant of the patient was totally etched and the left one was partially etched; (B) opaque enamel surface after etching.

At the beginning of treatment, each patient received written and verbal oral hygiene information. Oral hygiene instructions were repeated once every appointment by one researcher. All patients were advised to use same toothbrush and toothpaste (1450 ppm fluoride). Each patient was seen once every month by the same researchers (EDS, KKD). During treatment, no fluoride products (except toothpaste) such as mouth rinses or tablets were applied. At each appointment, the patients brushed their teeth under supervision before capturing QLF images.

A QLF-D Biluminator 2-camera system (Inspektor Research Systems, Amsterdam, The Netherlands) was used to detect the presence of WSLs. The following settings were applied: International Standard

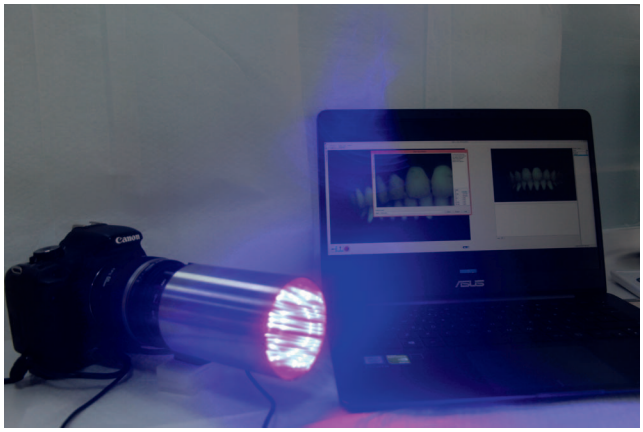

Figure 2. The QLF-D Biluminator 2 camera (Inspektor Research Systems, Amsterdam, The Netherlands) and image-capturing software (C3 v1.20, Inspektor Research Systems).

Organization speed of 1600; aperture of 5.6, and a shutter speed of 1/30 second (Figure 2). The QLF-D images were captured in a controlled darkroom by the same investigator (EDS) and at an equivalent distance (10 cm), which was achieved by standardizing the camera position and angle through the software's video-repositioning technique.

The primary outcome measure in this study was calculation of mean WSL scores using computer-assisted analysis. Measurements were performed at the following timepoints: immediately before the treatment (T0), at 3 months after beginning the treatment (T1), 6 months after beginning the treatment (T2), and at the end of the orthodontic treatment (T3). The secondary outcome measures were the assessment of all treated teeth to determine the severity of WSLs on each tooth and to determine the bracket failure incidence resulting in association with the etching procedure used.

The patients were not informed about which quadrants were chosen for TE or PE. Therefore, the patients were blinded to the treatment applied. Similarly, the investigator (EDS) who measured WSL scores and analyzed the data was also blinded as to the origin of the data and to the etching groups. Blinding was achieved using letter codes that disguised patient and group names during measurement of WSL scores.

The same investigator (EDS) evaluated the buccal surfaces of all of the patients' maxillary incisors, canines, premolars, and first molars for WSLs using analysis software (QA2 v1.20; Inspektor Research Systems; Figure 3). WSL analysis of the QA2 software was used to measure four parameters, which included ΔF (lesion depth), ΔFmax (the greatest depth of the lesion), ΔQ (lesion volume), and A (lesion area with a ΔF threshold $\leq -5\%$).

Intraobserver errors were evaluated using the formula described by Dahlberg.[13] QLF images of 10 randomly selected patients were reassessed after 1 month to determine method errors. Method error was found to be small (PE group value, 0.17; TE group value, 0.34) and clinically insignificant.

In this study, bracket breakage was recorded during orthodontic treatment and evaluated for failure rate. When brackets failed, rebonding was performed using the same etching protocol.

Sample Size Calculation

G*Power software (version 3.0.10; Franz Faul Universitat, Kiel, Germany) was used to calculate sample size and a sample size of 20 quadrants in each group was calculated to give $>$ 85% power to identify significant differences with an effect size of 0.90 at a significance level of $\alpha = 0.05$.

Statistical Analysis

The mean WSL scores (ΔF, ΔFmax, ΔQ, A) and standard deviations were calculated for etching groups and for each maxillary tooth. The mean WSL scores of each maxillary tooth were compared to evaluate whether a specific tooth was more likely to develop WSLs. Intra- and intergroup comparisons were performed to determine whether the etching process affected WSL formation at the T0, T1, T2, and T3 timepoints. The normality of data distributions was assessed using the Shapiro–Wilk normality test. Comparisons between the two groups and maxillary teeth at T0, T1, T2, and T3 were performed using Student's *t*-test. The results were considered significant at $P < .05$ (SPSS version 15.0; SPSS Inc., Chicago, Ill).

RESULTS

The mean treatment time was 10.33 $\pm$ 2.41 months, and no patients were lost to follow-up. Patients' orthodontic treatments started in April 2014 and ended in May 2015. A Consolidated Standards of Reporting Trials (CONSORT) flow chart showing the flow of patients during the trial is shown in Figure 4. For the primary outcome measures, a total of 240 buccal surfaces of the 20 patients were evaluated. During orthodontic treatment, no significant problems were observed other than WSL formation and gingivitis related to dental plaque.

Table 1 provides the means of the ΔF, ΔFmax, ΔQ, and A scores as well as the *P* values of the TE and PE groups. At T0, T1, and T3, no differences were observed between the TE and PE groups with regard to the WSL parameters. At T2, the ΔQ and A scores of

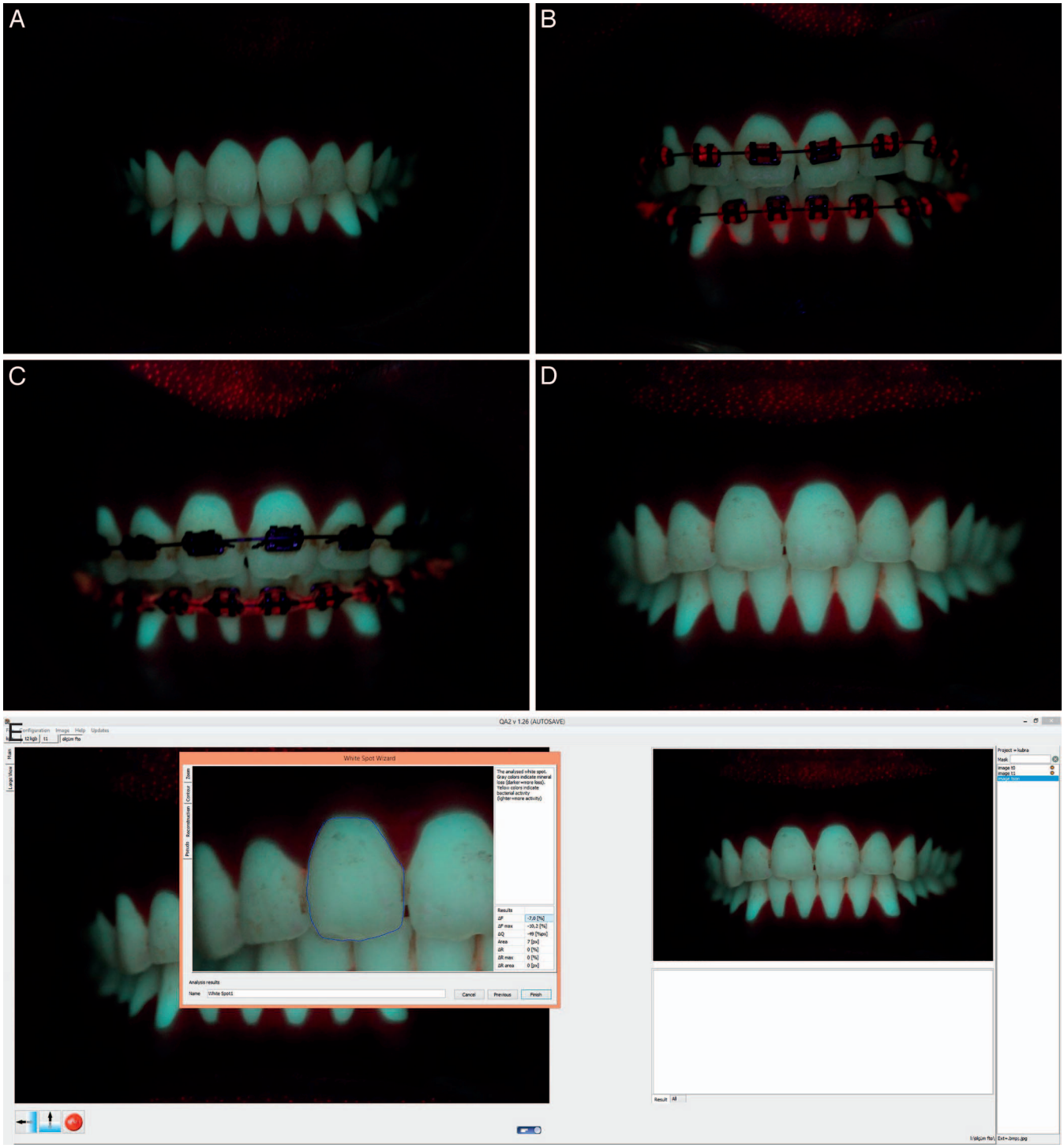

Figure 3. (A) Pretreatment (T0), (B) 3 months after beginning the treatment (T1), (C) 6 months after beginning the treatment (T2), (D) posttreatment (T3), and (E) analyzing software (QA2 v1.20; Inspektor Research Systems) used for the measurements.

the TE group were significantly higher than those of the PE group ($P < .05$), indicating an increase in lesion volume in the TE group at T2.

A comparison between the TE and PE groups with regard to ΔF, ΔFmax, ΔQ, and A scores at the various timepoints is presented in Table 1. Statistically significant increases were observed in the ΔF and ΔFmax values from T0 to T2 in both groups. In the TE and PE groups, variations in ΔF, ΔFmax, ΔQ, and A scores from T0 to T3 were also demonstrated (Table 2). Moreover, in the TE group, ΔQ and A scores

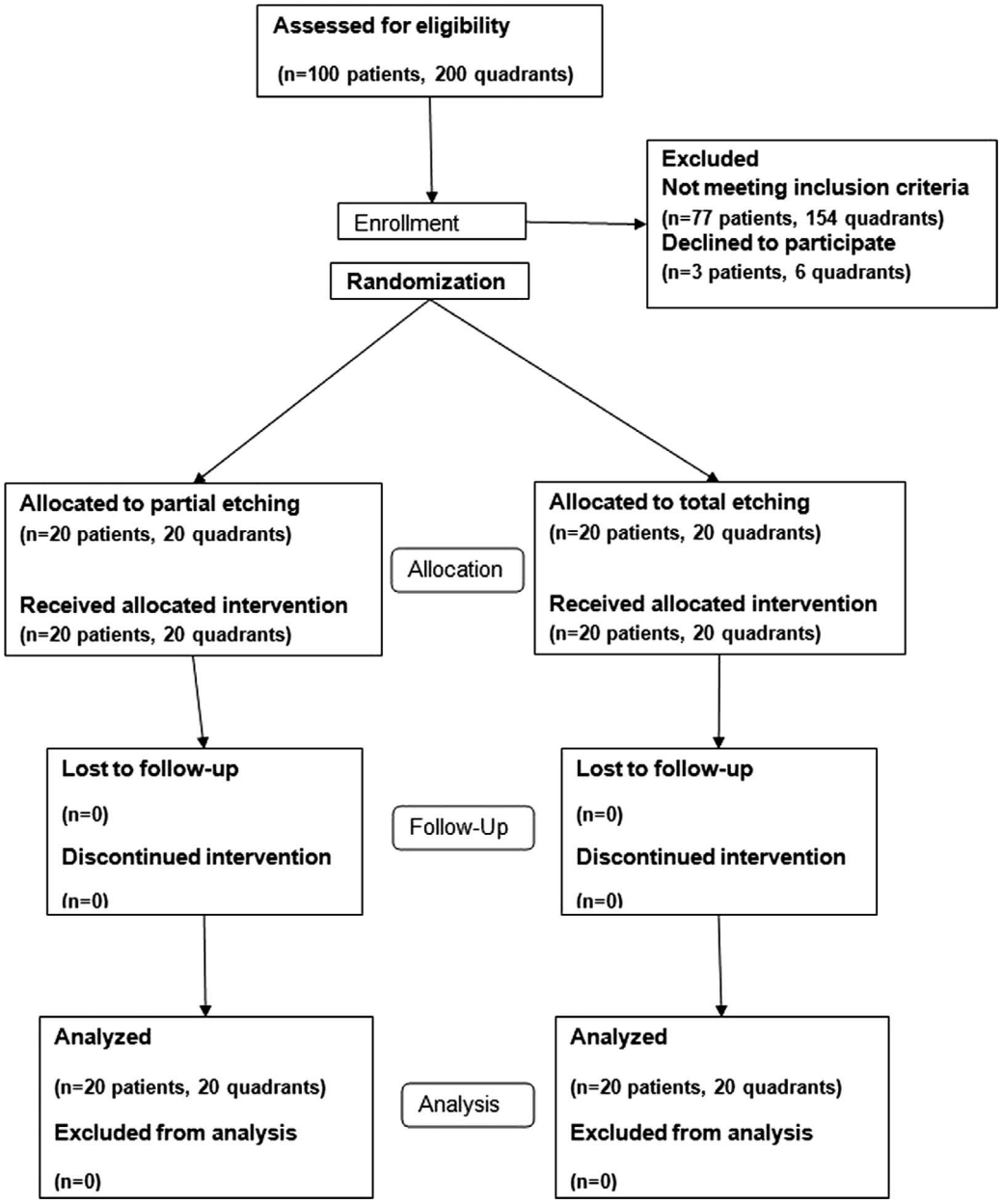

Figure 4. Consolidated Standards of Reporting Trials (CONSORT) diagram showing the flow of participants through each stage of the trial.

decreased during the period from T2 to T3 when compared with the PE group.

During orthodontic treatment (T0–T3), WSL formation was detected in each maxillary tooth, without distinction of etching procedures. Table 3 shows the mean values of the 12 maxillary teeth and *P* values for each timeperiod (T0–T3) for ΔF, ΔFmax, ΔQ, and A. The differences between T0 and T1 were significant for ΔFmax values of all teeth except the right first molar and right second premolar. In addition, significant differences in ΔF values were evident between T0 and T2.

Table 4 shows the bracket failure rate of the PE and TE groups. Brackets that were accidentally debonded or needed to be rebonded for any patients during treatment were not included. The bracket failure rate in the TE group was higher than the PE group, and most bracket failures occurred on the left second premolars. All of the bracket breakage was observed between timepoints T1 and T2.

DISCUSSION

The presence of WSLs is of considerable importance given that demineralization is associated with orthodontic treatment. WSLs have been reported to

Table 1. Comparison of the ΔF, ΔFmax, ΔQ, and A Values Between T0 (Pretreatment), T1 (3 Months After Beginning the Treatment), T2 (6 Months After Beginning the Treatment), and T3 (Posttreatment) for the Total and Partial Etch Groups

QLF	Intergroup Comparison				Intragroup Comparison, *P* Value					
Parameters[a]	T0	T1	T2	T3	T1–T0	T2–T0	T3–T0	T3–T2	T3–T1	T2–T1
ΔF										
Partial	−1.41 ± 4.2	−3.485 ± 5.1	−10.474 ± 56.6	−-3.344 ± 5.5	<.001***	<.001***	.003***	.171	.839	.179
Total	−0.992 ± 2.6	−3.922 ± 5.1	−5.533 ± 9.6	−3.225 ± 5.7	<.001***	<.001***	<.001***	.061	.323	.109
P value	.358	.511	.347	.871						
ΔFmax										
Partial	−2.517 ± 8.3	−4.817 ± 8	−6.875 ± 10.6	−4.992 ± 10.5	.031*	<.001***	.046*	.171	.885	.093
Total	−1.408 ± 4.1	−5.85 ± 8.4	−8.117 ± 12.6	−5.283 ± 13	<.001***	<.001***	.002***	.089	.69	.105
P value	.194	.333	.413	.849						
ΔQ										
Partial	−99.292 ± 611.8	−118.142 ± 393.5	−128.775 ± 429	−296.85 ± 1236.9	.777	.666	.118	.161	.133	.842
Total	−80.342 ± 489.8	−271.408 ± 1084.5	−433.55 ± 1489.6	−134.158 ± 839.8	.08	.014*	.545	.056	.274	.336
P value	.791	.147	.032*	.234						
A										
Partial	8.558 ± 55.8	12.825 ± 40.2	13.008 ± 34.5	25.067 ± 93.5	.498	.459	.098	.187	.97	.97
Total	8.717 ± 51.7	29.075 ± 104.6	33.675 ± 101.4	10.5 ± 51.3	.057	.017*	.789	.077	.082	.73
P value	.982	.114	.036*	.136						

[a] ΔF, lesion depth; ΔFmax, the greatest depth of the lesion; ΔQ, lesion volume; A, lesion area with a ΔF threshold ≤ −5%.
* $P < .05$, ** $P < .01$, *** $P < .001$.

occur in 2% to 96% of orthodontic patients who undergo multibracket appliance treatment.[3,14] Shi et al.[15] reported that QLF is more reliable for quantification of smooth-surface caries. In the present study, the intent was to investigate the effect of TE and PE on the development of WSLs during multibracket appliance orthodontic therapy.

At the beginning of treatment, TE and PE quadrants were randomly selected in all patients to eliminate differential brushing effects. Patients who resided in the same region were chosen because of differences in the fluoride content of water in different regions, thus the preventive effect of fluoride on WSL formation was similar for all patients enrolled. Multiple studies concerning WSL formation have been conducted in vitro.[7,16–18] However, in vitro conditions cannot directly simulate the intraoral environment. In this study, a split-mouth design was used to minimize differential effects (such as salivary properties, fluoride intake through water, dietary habits, tooth brushing).

Based on before- and after-treatment QLF images, this study revealed the development of new WSLs in patients treated with fixed orthodontic appliances. Published studies confirm that orthodontic appliances

Table 2. Comparison of the Changes From T0 (Pretreatment) to T3 (Posttreatment) for the Total and Partial Etch Groups

QLF Parameters[a]	ΔF	*P* Value	ΔFmax	*P* Value	ΔQ	*P* Value	A	*P* Value
T1–T0								
Total	−2.93 ± 5.6	.27	−4.4 ± 4.3	.13	−191 ± 444.9	.069	20.3 ± 42.09	.073
Partial	−2.04 ± 6.3		−2.3 ± 4.8		−18.8 ± 186.1		4.2 ± 17.09	
T2–T0								
Total	−4.54 ± 9.9	.38	−6.7 ± 7.8	.32	−353.2 ± 684	.045*	24.9 ± 46.71	.078
Partial	−9.06 ± 56.9		−4.35 ± 5.9		−29.5 ± 96.8		4.4 ± 17.63	
T3–T0								
Total	−2.23 ± 6.2	.85	−3.8 ± 8.9	.63	−53.8 ± 420.1	.414	1.7 ± 28.65	.295
Partial	−1.93 ± 7.4		−2.4 ± 7.2		−197.5 ± 658		16.5 ± 54.53	
T3–T2								
Total	2.30 ± 8.44	.35	2.8 ± 6.1	.55	299.3 ± 465.7	.013*	−23.1 ± 34.3	.011*
Partial	7.13 ± 56.47		1.8 ± 7.9		−168 ± 649.9		12 ± 47.7	
T3–T1								
Total	0.69 ± 6.59	.45	0.5 ± 7	.82	137.2 ± 524.5	.108	−18.5 ± 41.9	.053
Partial	0.14 ± 6.44		−0.1 ± 4.7		−178.7 ± 679.7		12.2 ± 53.9	
T2–T1								
Total	−1.61 ± 9.31	.28	−2.2 ± 4.9	.34	−162.1 ± 218.7	.401	3.9 ± 36.6	.828
Partial	−6.98 ± 55.53		−2. ± 3.9		−10.6 ± 155		0.1 ± 14.7	

[a] ΔF, lesion depth; ΔFmax, the greatest depth of the lesion; ΔQ, lesion volume; A, lesion area with a ΔF threshold ≤ −5%.
* $P < .05$, ** $P < .01$, *** $P < .001$.

Table 3. Comparison of ΔF, ΔFmax, ΔQ, and A Values[a] for Maxillary Teeth in the T0 (Pretreatment), T1 (3 Months After Beginning the Treatment), T2 (6 Months After Beginning the Treatment), and T3 (Posttreatment)

					P Values					
Tooth[b]	T0	T1	T2	T3	T1–T0	T2–T0	T3–T0	T3–T2	T3–T1	T2–T1
ΔF										
16	−2.825 ± 7.4	−0.36 ± 1.6	−2.59 ± 3.6	0	.084	.907	.108	.005***	.33	.029*
15	−0.67 ± 2.9	−2.75 ± 4.7	−3.16 ± 4.9	−2.335 ± 4.8	.136	.086	.114	.328	.736	.707
14	0	−2.74 ± 4.2	−4.035 ± 5.2	−1.745 ± 3.1	.01*	.003**	.022*	.054	.309	.291
13	−0.91 ± 2.2	−6.025 ± 6.5	−7.77 ± 8.4	−4.49 ± 6.9	.03*	.001***	.042*	.084	.493	.458
12	−0.625 ± 1.9	−4.5 ± 5.4	−7.42 ± 6.3	−4.62 ± 5.7	.006**	<.001*	.006***	.011*	.006***	.068
11	−1.62 ± 3.5	−5.765 ± 5.7	−6.465 ± 5.5	−3.42 ± 3.7	.01*	.002***	.208	.029*	.138	.534
21	−2.595 ± 4.3	−6.09 ± 4.5	−6.265 ± 6	−3.835 ± 4.6	.01*	.036*	.445	.034*	.074	.872
22	−0.31 ± 1.3	−4.49 ± 5.2	−7.975 ± 8.3	−5.125 ± 4.8	.002***	<.001***	<.001***	.095	.628	.036*
23	−1.17 ± 4.3	−4.575 ± 5.6	−5.715 ± 7.5	−4.24 ± 9.3	.05	.022*	.21	.401	.859	.312
24	1.445 ± 2.9	−3.395 ± 5.7	−34.74 ± 136.9	−4.175 ± 8.5	.18	.292	.18	.33	.701	.31
25	−0.91 ± 2.2	−3.755 ± 4.7	−10.735 ± 26.7	−3.09 ± 4	.03	.122	.079	.196	.602	.243
26	−1.89 ± 3.4	0	−1.17 ± 3.7	−2.34 ± 5.1	.023*	.515	.75	.28	.058	.184
ΔFmax										
16	−5.65 ± 16.4	−0.4 ± 1.7	−1.7 ± 7.6	0	.129	.357	.142	.33	.33	.471
15	−1.5 ± 6.7	−3.8 ± 7	−4.6 ± 7.5	−3.15 ± 7.7	.333	.215	.498	.231	.729	.603
14	0	−4.25 ± 7.9	−5.8 ± 9.07	−2.6 ± 5.6	.026*	.01*	.053	.119	.397	.469
13	−1 ± 2.4	−8.85 ± 10.6	−13.8 ± 11.9	−6.1 ± 9.5	.002***	<.001***	.036*	.009***	.362	.021*
12	−0.65 ± 2	−6.4 ± 8.8	−10.6 ± 11.9	−6.95 ± 9.3	.01*	.001***	.006***	.028*	.822	.103
11	−2.4 ± 5.8	−9.3 ± 9.6	−9.6 ± 9.6	−4.6 ± 5.8	.01*	.006***	.316	.047*	.09	.884
21	−3.05 ± 5.4	−7.8 ± 6.2	−8.65 ± 9.6	−5.45 ± 7.9	.017*	.038*	.333	.097	.231	.596
22	−0.45 ± 2	−5.3 ± 7.3	−12.8 ± 17.6	−6.1 ± 6.4	.007***	.007***	.002***	.083	.714	.036*
23	−2.7 ± 7.4	−7.2 ± 10.2	−8.95 ± 18.2	−10.25 ± 26.1	.007***	.165	.242	.795	.548	.497
24	−5.15 ± 4.2	−2 ± 9.4	−6.8 ± 11.3	−8.1 ± 21.9	.007***	.093	.225	.741	.503	.529
25	−1 ± 2.5	−6.35 ± 8.1	−5.05 ± 8.4	−5.1 ± 7.5	.007***	.07	.046*	.978	.591	.496
26	−3.15 ± 6.8	0	−1.6 ± 5	−3.25 ± 7.1	.007***	.393	.96	.291	.057	.176
ΔQ										
16	−337.8 ± 1053.2	−1.8 ± 8.05	−67.9 ± 303.6	0	.167	.294	.168	.33	.33	.343
15	−18.05 ± 80.7	−114.9 ± 462.6	−108.65 ± 283.5	−316.5 ± 1321.6	.373	.195	.328	.466	.526	.908
14	0	−148.4 ± 349.7	−147.5 ± 393.5	−9.4 ± 27.7	.073	.111	.147	.122	.091	.989
13	−2.6 ± 8.1	−218.9 ± 523	−220.7 ± 417.7	−87.25 ± 242.5	.08	.031*	.136	.018*	.148	.977
12	−1.2 ± 4.03	−109.15 ± 323.9	−332.15 ± 1074	−137.3 ± 313.3	.153	.184	.066	.367	.741	.216
11	−194.65 ± 844.8	−424 ± 984.4	−473.4 ± 1345.3	−137.95 ± 440.3	.142	.049*	.799	.317	.272	.762
21	−6.5 ± 17.5	−156.4 ± 307.2	−77.25 ± 128.1	−106.95 ± 328.06	.044*	.024*	.19	.67	.625	.303
22	−4.65 ± 20.7	−182.5 ± 431.02	−588 ± 1326.4	−37 ± 56.7	.078	.064	.034	.077	.158	.172
23	−59.15 ± 213.6	−704.2 ± 2391.6	−961.4 ± 2823.8	−960 ± 2884.7	.241	.17	.183	.998	.754	.515
24	−32.5 ± 114.2	−142.5 ± 399.5	−314.85 ± 1101	−525.9 ± 1508.7	.263	.271	.164	.597	.297	.48
25	−2.05 ± 6.07	−134.55 ± 366.9	−69.2 ± 128.04	−157.3 ± 456.6	.124	.032*	.145	.36	.824	.402
26	−418.6 ± 1308.1	0	−13.4 ± 43.3	−110.5 ± 434.1	.169	.172	.244	.335	.269	.183
A										
16	20.55 ± 57.6	0.25 ± 1.1	4.9 ± 21.9	0	.129	.283	.128	.33	.33	.356
15	1.35 ± 6.03	11.4 ± 43.3	13.05 ± 33.6	28.4 ± 111.2	.321	.149	.293	.51	.516	.691
14	0	15.1 ± 34.5	16.8 ± 42.8	1.15 ± 3.01	.065	.095	.104	.108	.087	.857
13	0.4 ± 1.18	22.4 ± 48.2	27.45 ± 51.04	8.6 ± 18.6	.056	.029*	.065	.029*	.161	.551
12	0.2 ± 0.6	10.1 ± 25.2	21.6 ± 56.1	13.8 ± 37.2	.096	.104	.118	.472	.683	.172
11	19.85 ± 85.9	49.75 ± 109.3	45.25 ± 110.9	13.95 ± 39.3	.1	.022*	.79	.264	.204	.716
21	0.8 ± 1.7	23.75 ± 47.1	8.5 ± 12.04	12.8 ± 39.09	.043*	.009*	.189	.596	.427	.179
22	0.8 ± 3.5	21.3 ± 49.1	46.8 ± 102.5	5 ± 7.4	.074	.06	.046*	.079	.166	.298
23	7.75 ± 26.6	69.15 ± 223.3	61.3 ± 176.3	61.25 ± 181.5	.23	.19	.214	.999	.9	.763
24	4.25 ± 14.7	13.2 ± 31.5	24.8 ± 75.3	41.1 ± 118.4	.283	.252	.189	.576	.334	.461
25	0.3 ± 0.9	15 ± 38.4	8.2 ± 15.4	15.45 ± 41.1	.104	.036*	.117	.426	.961	.408
26	47.4 ± 149.1	0	1.4 ± 5.03	11.9 ± 48.3	.172	.173	.247	.349	.285	.228

[a] ΔF, lesion depth; ΔFmax, the greatest depth of the lesion; ΔQ, lesion volume; A, lesion area with a ΔF threshold ≤ −5%.
[b] World Dental Federation (FDI) system of notation.
* $P < .05$, ** $P < .01$, *** $P < .001$.

Table 4. Bond Failure Rates for Etching Protocol and Teeth

Variable	Number of Teeth	Failure	Failure Rate, %
Etching protocol			
Partial etch	120	2	1.66
Total etch	120	5	4.16
Side			
Left	120	4	3.33
Right	120	3	2.50
Teeth			
Incisor	80	2	2.50
Canine	40	0	0
Premolar	80	3	3.75
Molar	40	2	5

and brackets impair proper hygiene, resulting in significant dental plaque accumulation and gingival inflammation, thereby increasing WSL formation.[18–20] The QLF device was used because it has been shown to be a relevant, efficient, and sensitive technique for detecting and monitoring longitudinally demineralization and WSLs both in vivo and in vitro.[10,11,21]

WSL scores were evaluated separately for each tooth in this study, and the maxillary lateral incisor was the tooth most often affected by WSLs, similar to the findings of Chapman et al.[2] According to the current results, 6 months after beginning treatment, the ΔQ and A scores were significantly higher in the TE group than in the PE group ($P < .05$). The ΔFmax score increased significantly for all timeperiods in both the TE and PE groups, and this increase was greater in the TE group. Acid etching increases enamel decalcification[22]; hence for patients with a high caries index, the etching protocol should be limited to etching of the bracket base area, and protective measures should be taken. On the other hand, ΔQ and A values showed a greater decrease for TE than PE teeth from T0 to T3. At T3, no significant difference was observed between the groups. Total etching increased the demineralization during the first 6-month period of the treatment, and after 6 months there was no difference in WSL formation in total etching compared to partial etching.

Bracket failure occurred in 7/120 teeth (Table 4). Various factors may affect bracket failures during treatment, for instance, oral hygiene, eating habits, etching protocol, and self-etching primers used at the beginning of treatment.[23] There was an attempt to eliminate these factors with oral hygiene motivation and dietary advice.

This study had some potential limitations. First, patient cooperation was a limitation. Although oral hygiene instructions were provided, controlling for individual behavior has been shown to be very difficult.[24] Another limitation was that only right-handed patients were accepted for the study because handedness may influence brushing efficiency. In addition, the absence of analyses of patients' plaque and gingivitis scores was another limitation of the study.

According to the results of this study, it can be concluded that PE is more successful than TE in inhibiting WSL formation during orthodontic treatment. WSL formation was lower in the PE group than in the TE group over all timeperiods except T2 to T3. A significant decrease in lesion area was observed in the period from T3 to T2 in the TE group. One possible explanation for this observation may be the fact that controlled clinical studies on formation of WSLs are quite difficult to perform because of the numerous factors involved, such as differences in individual behavior. Therefore, although differences of WSL scores between different etching procedures were mostly found to be statistically significant in this study, this may not be clinically important because many factors that play a part in WSL formation, such as individual differences in oral hygiene, eating habits, cooperation, and fluoride levels, should be well controlled for conclusive evidence in WSL studies. These factors can limit the generalizability of the results. As a result, further studies with large patient populations are necessary to determine the clinical importance of these findings.

CONCLUSIONS

- WSL formation was observed mostly in maxillary lateral teeth irrespective of the etching technique used.
- An increase in WSL formation was observed in both etching groups from T0 to T3. However, comparison of WSL scores showed that it was higher in the TE group.
- In the TE group, bracket failure caused by the patients was more frequently observed than in the PE group.
- Although PE seems to be more favorable in the first 6-month period, no difference was observed between PE and TE in the long term for WSL formation.

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