ORIGINAL ARTICLE

Medical Journal of Western Black Sea
Batı Karadeniz Tıp Dergisi

Med J West Black Sea 2023;7(2): 180-187
DOI: 10.29058/mjwbs.1265876

The Effects of Different Types of Surface Conditioning Methods on Enamel Demineralization: An In-vitro Rebonded Bracket Study

Farklı Mine Yüzey Hazırlık İşlemlerinin Mine Demineralizasyonu Gelişimine Etkisinin Değerlendirilmesi: Bir İn-vitro Rebonded Braket Çalışması

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Cite this article as: Acır KC et al. The effects of different types of surface conditioning methods on enamel demineralization: An in-vitro rebonded bracket study. Med J West Black Sea. 2023;7(2):180-187.

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Received
15.03.2023

Revision
22.05.2023

Accepted
07.06.2023

ABSTRACT

Aim: This study aimed to evaluate the effects of the conventional etching and primer (CEP) method and the self-etching primer (SEP) method on demineralization while rebonding the brackets.

Material and Methods: Sixty extracted maxillary first premolar teeth were divided into 4 groups, each containing 15 teeth. The teeth in Groups 1 and 2 were bonded using CEP, and those in Groups 3 and 4 were bonded using SEP. After the first bonding, adjacent surfaces of the brackets were measured using DIAGNOdent pen, and demineralization values were recorded (T0). The teeth were kept in a demineralization solution for 15 days in a 37°C incubator. Then, all brackets were debonded. The teeth in Groups 1 and 3 were rebonded using CEP, and those in Groups 2 and 4 were rebonded using SEP. In this way, via the enamel surface conditioning prior the first bonding and rebonding, the groups were constructed as; Group 1 (CEP-CEP), Group 2 (CEP-SEP), Group 3 (SEP-CEP) and Group 4 (SEP-SEP). The teeth were kept in the same solutions by same way (T1). The Kolmogorov-Smirnov test was used to determine whether or not the data were normally distributed, the Wilcoxon test was used for comparisons within groups, and the Mann-Whitney U and Kruskal-Wallis tests were used for comparisons between groups. $p<0.05$ was considered significant.

Results: At T1, the demineralization values in Group 1 obtained from all surfaces were found to be significantly higher than those in Groups 3 and 4 ($p<0.05$). The amount of increase in demineralization between T0 and T1 was observed to be the greatest on the gingival surfaces and the smallest on occlusal surfaces in all groups. Regardless of the enamel surface measured, the mean increase in values on all surfaces was the highest in Group 1 and the lowest in Group 4.

Conclusion: Considering the effects of orthodontic bracket rebonding on the enamel surface, the self-etching primer method produces less enamel demineralization than the conventional etching and primer method.

Keywords: Demineralization, rebonded bracket, diagnodent

ÖZ

Amaç: Bu çalışma, yeniden yapıştırılan braketlerde geleneksel asitle pürüzlendirme yöntemi ile self-etching primer yönteminin demineralizasyon üzerindeki etkilerini değerlendirmeyi amaçlamaktadır.

Gereç ve Yöntemler: 60 adet çekilmiş maksiller birinci premolar diş, her biri 15'er diş içeren 4 gruba ayrıldı. Braketler, Grup 1 ve 2'de asit ile pürüzlendirme ile, Grup 3 ve 4'te self-etching ile yapıştırıldı. İlk yapıştırma işleminden sonra braketlerin komşu yüzeyleri DIAGNOdent pen kullanılarak ölçüldü ve demineralizasyon değerleri kaydedildi (T0). Dişler 37°C inkübatörde 15 gün demineralizasyon solüsyonunda bekletildi. Daha sonra tüm braketler koparıldı. Braketler, Grup 1 ve 3'teki dişlerde asitle

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pürüzlendirme ile, Grup 2 ve 4'teki dişlerde ise self-etching primer ile tekrar yapıştırıldı. Böylece, ilk yapıştırma ve tekrar yapıştırma öncesi mine yüzey hazırlığı ile gruplar şu şekilde oluşturuldu; Grup 1 (asitle pürüzlendirme/asitle pürüzlendirme), Grup 2 (asitle pürüzlendirme/self-etching), Grup 3 (self-etching/asitle pürüzlendirme) ve Grup 4 (self-etching/self-etching). Dişler aynı solüsyonlarda aynı şekilde bekletildi (T1). Verilerin homojen dağılıp dağılmadığını belirlemek için Kolmogorov-Smirnov testi, grup içi karşılaştırmalarda Wilcoxon testi ve gruplar arası karşılaştırmalarda Mann-Whitney U ve Kruskal-Wallis testleri kullanıldı. $p<0.05$ anlamlı kabul edildi.

Bulgular: T1 döneminde Grup 1'de tüm yüzeylerden elde edilen demineralizasyon değerleri Grup 3 ve 4'e göre anlamlı şekilde yüksek bulundu ($p<0.05$). Tüm gruplarda T0 ve T1 arasındaki demineralizasyon artış miktarının en fazla gingival yüzeylerde, en az oklüzal yüzeylerde olduğu görüldü. Ölçülen mine yüzeyinden bağımsız olarak, tüm yüzeylerdeki değerlerin artış ortalaması Grup 1'de en yüksek, Grup 4'te en düşüktü.

Sonuç: Ortodontik braketlerin yeniden yapıştırılmasının mine yüzeyine etkileri göz önüne alındığında, self-etching primer yöntemi geleneksel asitle pürüzlendirme yöntemine göre daha az mine demineralizasyonu oluşturur.

Anahtar Sözcükler: Demineralizasyon, rebonded braket, diagnodent

INTRODUCTION

The detachment of brackets due to breaks or misposition during orthodontic treatment is common and undesirable. The breaking of the brackets is usually caused by excessive chewing forces generated by the patient, but they may also be due to an improper bonding method or contamination during bonding (1,2). Bracket failure is more common especially in molars and second premolars (3,4). Mandibular teeth are also more affected by bracket breaks than maxillary teeth because there is a higher probability of contamination with saliva during bracket positioning (5,6).

Two main techniques are used for the direct bonding of brackets. These are the conventional etching and primer (CEP) method and the self-etching primer (SEP) method (7). SEP combines etching, rinsing, and priming in a single step, simplifying the clinical usage of adhesive systems and saving time (8).

It is accepted that etching the enamel surface with orthophosphoric acid before the application of the adhesive system is the most important step in bonding the brackets to the enamel surface (9). However, it is reported that shallow depressions and pits formed by acid etching of the enamel are still present on the enamel surface after debonding the brackets and removing all visible adhesive remnants (10). CEP causes the inorganic structure of the enamel to change and leads to the formation of a weak enamel surface against acid attacks. As a consequence, the formation of demineralized areas can be observed, especially in patients who cannot follow ideal oral hygiene habits (9,11).

Debonded brackets are mostly adhered to the tooth using the same protocols. However, since these processes require enamel surface re-conditioning, they may cause more mineral loss in the enamel (12). This causes increased demineralization and the development of white spot lesions when it is not balanced by remineralization (13).

Most studies so far have focused on the bond strength or adhesive remnant values of rebonded brackets. Unlike this, in our study, it is aimed to compare and evaluate developments in enamel demineralization on the occlusal, gingival, and proximal surfaces of brackets rebonded to extracted human maxillary first premolars, which were subjected to CEP or SEP methods before rebonding, by measuring them with the laser fluorescence device called DIAGNOdent pen.

The null hypothesis was that no difference exists between demineralization around brackets rebounded with different enamel surface conditioning methods in the pH cycle.

MATERIAL and METHODS

Ethical Approval and Preparation of Samples

Ethics committee approval was obtained for the study from Zonguldak Bulent Ecevit University Non-Invasive Clinical Research Ethics Committee (Decision No: 2020/22, Date: 18/11/2020). Sixty maxillary first premolars were used for orthodontic treatment. Care was taken to ensure that the teeth were free of cavities, fillings, restorations, cracks, fractures, and fluorosis on the enamel (14). The teeth were stored in a 0.1% thymol solution, which was renewed once a month, in the dark and at room temperature. The buccal enamel surfaces of the teeth were cleaned with a pumice-water mixture with rubber bands. Afterwards, all surfaces of the samples, except the crown parts, were coated with an acid-resistant nail varnish to imitate the oral environment. The buccal enamel surfaces of the teeth to be included in the study were checked for demineralization by measurements made with a DIAGNOdent pen. Teeth with values between 0 and 3, which were considered healthy, were included in the study.

Preparation of Groups and Bonding Methods

The sample size of the study, in which the effect size was calculated using the means of the groups and standard deviation was performed by the G*Power program (version 3.1.9.7; Franz Faul, Universität Kiel, Kiel, Germany). With the α error = 0.05 and the power (1 - α error prob) set to 0.85, the actual power of the study calculated as 87%, and total sample size should have been 56. Sixty maxillary first premolar teeth were randomly divided into 4 groups of 15 samples in each group. Gemini metal brackets (3M Unitek, Monrovia, CA) were used to bond the teeth.

The bonding agents that were used in the CEP method in Groups 1 and 2 were as follows: 35% phosphoric acid (3M Unitek Etching Gel System, Monrovia, CA), Transbond XT Primer (3M Unitek, Monrovia, CA), Transbond XT Light Cure Adhesive Paste (3M Unitek, Monrovia, CA).

The bonding agents that were used in the SEP method in Groups 3 and 4 were as follows: Transbond Plus Self Etching Primer (3M Unitek, Monrovia, CA), Transbond XT Light Cure Adhesive Paste (3M Unitek, Monrovia, CA).

3M ESPE Elipar S10 (3M ESPE Dental Products, Monrovia, CA) curing light source with a light intensity of 1200 mW/cm^2 and wavelength of 430-480 nm used for adhesive paste polymerization. During the polymerization, a total of 20 s of light was applied from the mesial and distal sides of brackets for 10 s.

First Bonding

The teeth in Group 1 and Group 2 were bonded with the CEP method. The enamel surface was etched with 35% phosphoric acid for 30 s. It was then washed and dried for 15 s, respectively. Transbond XT Primer was applied as a thin layer. Then, brackets loaded with sufficient adhesive paste were placed on the teeth in the correct position. The excess adhesive was removed with a thin probe, and a total of 20 s of curing light was applied from the mesial and distal for 10 s each for polymerization.

The teeth in Group 3 and Group 4 were bonded with the SEP method. Transbond Plus Self Etching Primer was applied as a thin layer on the clean enamel surfaces without plaque on which the brackets would be positioned. Then, the brackets loaded with sufficient adhesive paste were carefully placed on the teeth in the correct position. The excess adhesive was removed with a thin probe and a total of 20 s of curing light was applied from the mesial and distal for 10 s each for polymerization.

Initial Measurement of Samples with DIAGNOdent (T0)

Demineralization values on the gingival, occlusal, and proximal enamel surfaces adjacent to the bracket in the groups were measured using the tip number 2 of the DIAGNOdent pen (KaVo, Biberach, Germany). A single proximal demineralization value was recorded for each tooth by averaging the measurement performed on the mesial and distal proximal surfaces. Measurements were repeated three times, and all measurements were made by the same researcher (KC. A.) without knowing which bonding methods the groups belong to. The values were recorded as T0 values.

pH Cycle

A demineralization-remineralization cycle was applied to create demineralized areas on all enamel surfaces of the samples except the acid-fast nail polish area and imitate the oral environment. The demineralization solution used in the study contained 2.0 mmol/L calcium, 2.0 mmol/L phosphate, and 50 mmol/L acetate, at a pH value of 4.3, and an environment simulating the acidic environment created by plaque bacteria was created (15). The remineralization solution, on the other hand, contained 1.5 mmol/L calcium, 0.9 mmol/L phosphate, and 150 mmol/L potassium chloride, at a pH value of 7.0, and an environment in which the buffering effect of saliva was simulated in the oral environment against acids (15). The applied pH cycle consisted of a 6-hour demineralization cycle and then a 17-hour remineralization cycle. For the demineralization to take place, the samples were first kept in the demineralization solution in a 37°C oven for 6 hours to imitate body temperature, and the teeth in each group were kept in separate containers. Afterwards, the teeth that were removed from the demineralization solution were washed with deionized water, dried slightly, and then, kept in the remineralization solution for the next 17 hours. The samples were then removed from this solution, washed with deionized water, dried slightly, and again placed in the demineralization solution. The solutions were changed daily. The pH cycle was continued for 15 days.

Debonding and Cleaning of Debonded Brackets

After the 15 days pH cycle, the samples were removed from the experimental containers and the brackets were carefully debonded mechanically using an orthodontic bracket remover plier (Dentaurum, Ispringen, Germany). Adhesive residues remaining on the enamel surface were removed with conical tungsten carbide burs (American Orthodontics, Wisconsin, USA). A new tungsten carbide bur was used after every 5 enamel surface cleaning procedures to avoid any procedural errors. For the brackets to be rebonded, the adhesive residues on the bracket base were removed by sandblasting. 50 µm Al2O3 particles were used for the sandblasting process.

Second Bonding (Rebonding)

The enamel surface conditioning processes in each group prior to the rebonding of the brackets to the cleaned tooth surfaces are shown in Table 1.

In this way, via the enamel surface conditioning prior the first bonding and rebonding, the groups were constructed as; Group 1 (CEP-CEP), Group 2 (CEP-SEP), Group 3 (SEP-CEP) and Group 4 (SEP-SEP).

End of pH Cycle and Final Measurement of Samples (T1)

The samples to which the brackets were rebonded were again subjected to the pH cycle described above. With the second 15 days pH cycle, the total duration of the pH cycle was 30 days. The samples that completed the 30 days pH cycle were removed from the solutions. Then, enamel demineralization results on the occlusal, gingival, and proximal surfaces of the brackets were measured with the DIAGNOdent pen and recorded as T1 values.

Statistical Analysis

The SPSS (Statistical Package for the Social Sciences) 28.0 (IBM SPSS, Chicago, USA) program was used for the statistical analyses of the data obtained in the study. Mean, standard deviation, median, minimum, maximum, frequency, and percentage values were used as descriptive statistics. Whether the data were normally distributed or not was evaluated using the Kolmogorov-Smirnov test. The Wilcoxon test was used for the intragroup comparisons, whereas the Mann-Whitney U and Kruskal-Wallis tests were used for the intergroup comparisons. The level of statistical significance was taken as $p<0.05$.

Table 1: Enamel surface conditioning prior to bonding applied according to the groups in the study.

Groups	Enamel surface conditioning	
	Prior the first bonding	Prior the second bonding (rebonding)
Group 1 (n=15)	CEP	CEP
Group 2 (n=15)	CEP	SEP
Group 3 (n=15)	SEP	CEP
Group 4 (n=15)	SEP	SEP

CEP: Conventional etching and primer, **SEP:** Self-etching primer.

RESULTS

T0 and T1 Measurement Values

The DIAGNOdent measurement values at T0 and T1 are shown in Table 2. At T0, no significantly difference was found among the demineralization values obtained from the occlusal, gingival, and proximal surfaces of the samples belonging to the groups. However, at T1, there was a significantly difference among the demineralization values obtained from the occlusal and proximal surfaces of the samples in the groups, but no significantly difference was found among the values obtained from the gingival surface. Moreover, a significantly difference was found in the demineralization values obtained from all surfaces of the samples in all groups between the T0 and T1 measurements.

At the T1, there was no significantly difference between the demineralization values obtained from all surfaces of the samples in Group 1 and Group 2, while the values of the samples in Group 1 were found to be significantly higher than those of the samples in Groups 3 and 4. At T1, there was no significantly difference between the demineralization values obtained from the gingival and proximal surfaces of the samples in Group 2 and Group 3, while the values of the samples in Group 2 on the occlusal surface were found to be significantly higher than those of the samples in Group 3. Again, at T1, there was no significantly difference between the demineralization values of the samples in Group 2 and Group 4 obtained from the gingival surface, while the values obtained from the occlusal and proximal surfaces of the samples in Group 2 were significantly higher than those of the samples in Group 4. Furthermore, at T1, no significantly difference was found between the demineralization values obtained from all surfaces of the samples in Groups 3 and 4 (Table 2).

Table 2: T0 and T1 demineralization results obtained from the occlusal, gingival, and proximal surfaces of the groups.

Surfaces		Groups				
		Group 1 (n=15)	Group 2 (n=15)	Group 3 (n=15)	Group 4 (n=15)	p
Occlusal	T0	2.27±0.46	2.33±0.62	2.27±0.70	2.00±0.93	0.962
	T1	4.93±1.49	4.60±1.06	3.53±1.24[1,2]	3.67±0.97[1,2]	**0.008**
	p	**0.001**	**0.002**	**0.002**	**0.004**	
Gingival	T0	2.93±0.88	3.00±1.07	2.87±0.99	2.93±1.03	0.998
	T1	7.87±2.67	7.13±0.88	6.53±1.41[1]	5.67±1.05[1]	0.051
	p	**0.001**	**0.001**	**0.001**	**0.001**	
Proximal	T0	2.66±0.19	2.73±0.17	2.66±0.18	2.63±0.17	0.969
	T1	7.23±0.48	6.33±0.35	5.63±0.32[1]	4.86±0.20[1,2]	**0.001**
	p	**0.001**	**0.001**	**0.001**	**0.002**	

Measurement values are given as mean ± standard deviation. [1] Difference with Group 1 *p*<0.05 / [2] Difference with Group 2 *p*<0.05.

T0: Initial Measurement of Samples with DIAGNOdent pen, **T1:** Final Measurement of Samples with DIAGNOdent pen.

Demineralization Increases in DIAGNOdent Measurements

The degrees of increase in the DIAGNOdent values obtained for each group (the difference between the T0 and T1 values) are seen in Table 3 and Figure 1. While there was no significantly difference among the amounts of increase in the values obtained from the gingival surfaces of the samples in the groups, between the T0 and T1 measurement, there were a significantly differences among the amounts of increase in the values obtained from the occlusal and proximal surfaces. While the degrees of increase in the values obtained from the occlusal surfaces of the samples in Group 3 between the T0 and T1 measurements were significantly lower than those in Groups 1 and 2, no significantly differences were found among the other groups. While the degrees of increase in the values obtained from the proximal surfaces of the samples in Group 4 between the T0 and T1 measurements were significantly lower than those in Groups 1 and 2, no significantly difference was found among the other groups (Table 3).

Table 3: Results on the degrees of increase in the demineralization values between T0 and T1 obtained from the occlusal, gingival, and proximal surfaces of the groups.

Groups	Surfaces		
	Occlusal	Gingival	Proximal
Group 1 (n=15)	2.67±1.45	4.93±3.08	4.56±0.57
Group 2 (n=15)	2.27±1.39	4.13±2.07	3.60±0.43
Group 3 (n=15)	1.27±0.88[12]	3.67±1.68	2.96±0.38
Group 4 (n=15)	1.67±1.45	2.73±1.67	2.23±0.25[12]
p	**0.025**	0.114	**0.009**

Measurement values are given as mean ± standard deviation. [1]Difference with Group 1 $p<0.05$ / [2]Difference with Group 2 $p<0.05$

Between T0 and T1, the degrees of increase in the values obtained from the occlusal, gingival, and proximal surfaces were the highest in Group 1, the lowest in Group 3 on the occlusal surface, and the lowest in Group 4 on the gingival and proximal surfaces. Between T0 and T1, the degrees of increase in the values of all groups were observed to be the highest on the gingival surfaces and the lowest on the occlusal surfaces (Figure 1).

The mean degree of increase in demineralization values obtained from three different surfaces, independent of the enamel surfaces measured, is shown in Figure 2. Between T0 and T1, the lowest increase in demineralization values

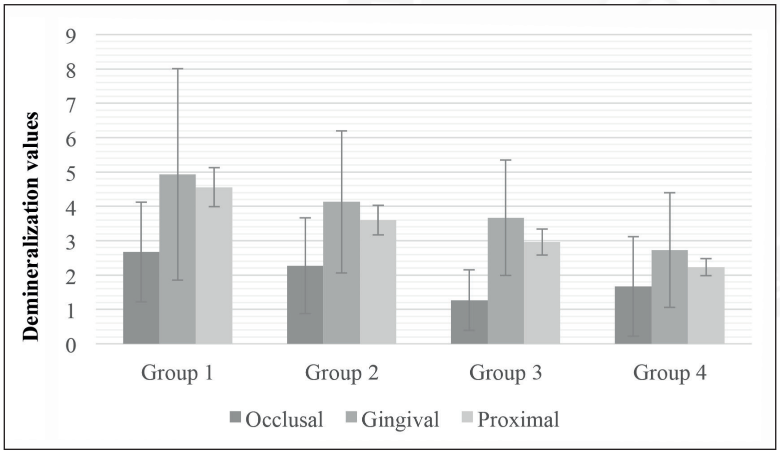

Figure 1: Plot of the degree of increase in the demineralization values between T0 and T1 obtained from the occlusal, gingival, and proximal surfaces of the groups.

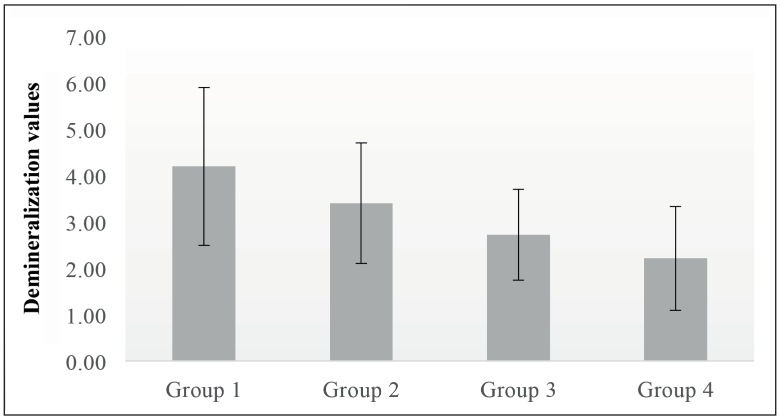

Figure 2: Plot of the mean increase in demineralization values in the groups independent of the enamel surfaces measured.

was observed in Group 4, while the highest increase was observed in Group 1 (Figure 2).

DISCUSSION

In fixed orthodontic treatments, the incidence of white spot lesions increases as a consequence of insufficient oral hygiene, the formation of retentive areas for bacterial colonization by orthodontic attachments, and the release of acid that predisposes the enamel to demineralization and bacterial plaque, especially around the brackets (16-18). Increasing acidic activity, especially during orthodontic treatment, due to the inability to clean the bacterial plaque effectively, causes rapid initial caries formation in the enamel that is etched with acid before bonding (19). It was reported that the incidence of at least one white spot lesion was 50% in patients treated with fixed orthodontic appliances, and only 24% in untreated controls (16). Additionally, it was reported that 72.9% of patients receiving orthodontic treatment developed at least one white spot lesion during treatment, and 2.3% of them showed cavitation (20).

Bracket failure during orthodontic treatment is undesirable and increases the duration and cost of the treatment. Although these bracket failures can be caused by the patient, they can also be caused by an improper bonding method and contamination during bonding (1,2). Lovius et al. (21) stated that bracket failures can occur in 16% to 23% of patients.

In the literature review, it is seen that most of the studies on rebonded brackets focus on bond strength and adhesive remnant values (1,10,12,22). This study focused on the effect of different types of surface conditioning methods on enamel demineralization while rebonded the brackets.

Researchers have performed various pH cycle models to simulate demineralization and remineralization events in the oral environment (22-26). In this study, the content of the demineralization solution used was the same as that used by several researchers. The demineralization solution used for the demineralization phase of the samples had a low pH of 4.4, imitating clinical conditions similar to the acidic environment produced by plaque bacteria. Many researchers used similar remineralization solution contents (25-27). The remineralization solution was prepared in such a way to preserve the levels of calcium and phosphate found in natural saliva. Under laboratory conditions, it was aimed to imitate demineralization with bacterial plaque and remineralization with saliva by using this pH cycle model.

In their study in which the demineralization around brackets bonded to cattle teeth was investigated, Baysal et al. (28) formed and compared groups as Transbond XT adhesive primer used on acid etched surfaces, Pro Seal adhesive primer, Opal Seal adhesive primer, and Transbond Plus SEP used on the non-etched surface. They reported that no significant difference was observed between the Transbond XT group and the Opal Seal group in terms of demineralization after the acidic solution they applied, and more demineralization was observed in the Pro Seal and Transbond Plus SEP groups compared to the Transbond XT group. They stated that the highest calcium ion release was in the self-etching group. Ghiz et al. (29) observed in their study that evaluated the effects of CEP and SEP on enamel demineralization under in-vivo conditions that, patients with moderate or poor oral hygiene in the SEP group had higher demineralization scores and more white spot lesions. They explained this situation with the low pH in the SEP group, and therefore, the continuous exposure of the enamel surface to the acidic environment. In this study, the highest degree of demineralization around the brackets belonging to Group 1, which was applied CEP during rebonding, and the lowest degree of demineralization around the brackets in Group 4, which was applied SEP during rebonding, contradicted the results of these studies in the literature. Based on these findings, the null hypothesis was rejected.

Paschos et al. (30) reported that Transbond Plus SEP can release fluorine that may affect demineralization in their study, in which they compared the effects of different enamel surface conditioning methods on demineralization around brackets. Visel et al. (31) compared the enamel demineralization effects of two different methods, namely SEP and CEP, around brackets using the quantitative laser-effect fluorescence in their in-vivo study. They stated that the lowest degree of fluorescence loss was in the SEP groups, and the SEP group with in Transbond Plus, which can release fluorine, exhibited the highest degree of remineralization in the enamel. In their in-vitro study, Hess et al. (32) exposed teeth to the threat of caries for 42 days to evaluate the effects of acid etching. They used the DIAGNOdent laser fluorescence device to examine decalcified areas and reported that acid etched teeth showed 34% more decalcification than unroughened teeth. Hosein et al. (33) reported that the CEP method caused more enamel loss than Transbond Plus SEP application, and the loss on the acid etched enamel surface was between 1.11 and 4.57 micrometers, while this loss was between 0.03 and 0.74 micrometers after the application of self-etching primer. In this study, lower demineralization values were observed in the groups in which the SEP method was applied, which was in line with many studies such as the studies mentioned above.

Tan and Çokakoğlu (34) reported that the highest degree of demineralization on enamel surfaces adjacent to brackets occurred on the gingival surface adjacent to brackets. Pakshir and Ajami (35) compared microleakage values around brackets created by SEP and CEP and stated that the highest degree of microleakage occurred on the gingival surface adjacent to brackets, regardless of what bonding system was used. In this study, the amount of increase in demineralization values between the T0 and T1 measurements was observed to be the highest on the gingival surface adjacent to the bracket in all groups, regardless of the enamel surface conditioning method that was applied. This is thought to be due to the irregularity of the enamel prisms on the gingival surface, the anatomical variations of the cemento-enamel junction, the lower hard tissue capacity compared to other surfaces adjacent to the bracket, and the more porous structure of the gingival enamel surface.

In their in-vitro study with rebounded brackets, Zhang et al. (12) compared the CEP and SEP methods. They reported that CEP caused more enamel damage than SEP. In their in-vitro study, Alavi and Ehteshami (36) examined changes on the enamel surface during the rebonding of brackets and stated that CEP and SEP showed clear differences on the enamel surface, and CEP caused more enamel damage than SEP. They thought that the SEP method may be a suitable option, considering the decrease in the time spent at the patient's bedside, the technical sensitivity of the method, and the risk of enamel damage during the removal of adhesive residues after bonding or debonding.

In this study, higher demineralization values were observed in the CEP groups compared to the SEP groups in the processes of rebonding brackets, which supported the results of the afore mentioned studies. Higher demineralization values were observed in the group in which CEP was used in first bonding, and SEP was used in rebonding compared to the group in which SEP was used in first bonding, and CEP was used in rebonding. However, the difference between these groups was not statistically significant.

The limitations of this study are the use of one type of bracket, the use of only two enamel conditioning methods and the inability of demineralization-remineralization solutions to fullu simulate the oral environment. However, in our study shows that orthodontic brackets can be rebonded with the self-etching primer in order to reduce enamel loss in patients with poor oral hygiene. In order to eliminate the inadequacy of clinical trials about this topic, it would be beneficial to conduct further studies by considering the limitations of this study.

According to the results of this in-vitro study: The highest degree of demineralization occurred around the brackets in which the CEP method was used for bonding and rebonding, and the lowest degree of demineralization occurred around the brackets in which SEP was used. More demineralization occurred on the gingival enamel surfaces adjacent to the brackets in all groups. In this in-vitro study, it was seen that the SEP method protects the enamel surface to a higher extent in rebonding of orthodontic brackets, and orthodontic bracketing can be applied with SEP in patients with insufficient oral hygiene.

Acknowledgment

This study constitutes a specialty dissertation thesis by Kemal Can ACIR; Zonguldak Bulent Ecevit University, Department of Orthodontics, Türkiye. This study was presented as an oral presentation at the 2nd International Erciyes University Dentistry Congress (ERDİŞ 2023) on February 23-26, 2023, Türkiye.

Author Contributions

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Conflicts of Interest

The authors declare no conflicts of interest.

Financial Support

This research received no external funding.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki. Ethics committee approval for the study was given by the Non-Invasive Clinical Research Ethics Committee at Zonguldak Bulent Ecevit University (No: 18/11/2020:2020/22).

Data Availability Statement

All data supporting the results of this study are included within the article.

Review Process

Extremely peer-reviewed and accepted.

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