Original Article

Effect of Pretreatment with Fluoride, Chlorhexidine, and Mixed Fluoride-Chlorhexidine Gels on Shear Bond Strength of Orthodontic Brackets: An Ex-Vivo Study

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ABSTRACT

Background and Aim: Orthodontic patients are at an increased risk of caries due to difficulty in plaque control. Antimicrobial agents, such as fluoride and chlorhexidine, can be useful in preventing tooth demineralization. The present study aimed to determine the effect of fluoride and chlorhexidine gels and their mixture on the shear bond strength (SBS) of orthodontic brackets.

Materials and Methods:In this ex-vivo study, 70 premolars were divided into seven groups. The first group was considered as the control. The second, third, and fourth groups were first etched with 37% phosphoric acid and then pretreated with chlorhexidine, fluoride, and fluoride-chlorhexidine gels, respectively. The brackets were then bonded. In the fifth, sixth, and seventh groups, the enamel surface was etched after pretreatment, and then, the brackets were bonded. After mounting the teeth, SBS was measured using the Instron machine. Data were analyzed using one-way analysis of variance (ANOVA) and Tamhane's T2 test ($\alpha \leq 0.05$).

Result: The mean SBS was 19.7 MPa in the control, 11.1±2.5 MPa in the second, 11.8±3.6 MPa in the third, 21±7.5 MPa in the fourth, 19.4±9 MPa in the sixth, and 14.1±6.7 MPa in the seventh group with no statistically significant differences. However, there was a statistically significant decrease in the mean SBS (8±5.2 MPa) of the fifth group (chlorhexidine before etching) compared to the control group (P=0.04).

Conclusion: The use of fluoride and chlorhexidine can be recommended to orthodontic patients because of antibacterial and anticaries properties and no significant decrease in the SBS of orthodontic brackets (except when chlorhexidine is used before etching).

Keywords: Dental Bonding, Orthodontic Brackets, Fluoride, Chlorhexidine

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Introduction:

Orthodontic brackets are used in fixed orthodontic treatments to align the teeth and form a more appealing appearance, an ideal occlusion, and improved social relationships. An important factor that should be considered is the bond strength of the composite by which brackets are bonded to teeth.[1] Studies have shown that, shortly after the bracket is

affected by mechanical and thermal stresses, which lead to a gradual loss of composite bond mainly during the first week.[2]

Furthermore, when bonding brackets with composite, etching may remove 5-10 microns of the enamel surface, which can lead to demineralization of this surface around brackets.[3] Moreover, the presence of brackets makes oral hygiene and plaque control more difficult. Therefore, there is a need for agents that reduce caries risk and microbial plaque and increase the resistance of teeth against decay.[4]

Fluoride is widely used to prevent dental caries. Bonding of fluoride to enamel surfaces renders them less soluble in acidic environments, thereby increasing the resistance of teeth against decay.[5] Fluoride ions prevent enamel demineralization and promote remineralization by increasing calcium deposition on the tooth surface. It has been reported that even low fluoride concentrations in saliva can change enamel demineralization into remineralization. Fluoride also reduces the caries-inducing potential of dental plaque.[6,7]

Orthodontic patients show a significant increase in the level of plaque and salivary Streptococcus mutans (S. mutans).[8] It has been reported that this increase in S. mutans levels occurs in the first weeks after orthodontic treatment and increases demineralization.[9] Therefore, the use of chlorhexidine, as an antibacterial agent to reduce the level of salivary S. mutans and plaque, can be effective in the first week. The use of fluoride (anti-caries properties) and chlorhexidine (antibacterial properties) can be beneficial for patients under orthodontic treatment.[10,11]

It is important to note that the use of fluoride, chlorhexidine, or their combination can affect the bond strength of orthodontic brackets, which can reduce the efficacy of orthodontic treatment. Since studies on this topic have yielded contradictory results,[12-14] the use of these agents in orthodontic treatments is controversial. Therefore, the present ex-vivo study aimed to determine the effect of fluoride, chlorhexidine, and fluoride-chlorhexidine combination gels on the shear bond strength (SBS) of orthodontic brackets.

Materials and Methods:

In this ex-vivo study (ethical approval code: IR.RUMS.REC.1397.029), 70 extracted human premolar teeth were selected and examined to ensure no caries or cracks. The surfaces of the teeth were cleaned of all debris and residual soft tissues. The teeth had been kept in normal saline for a maximum of three months and at room temperature before the study was performed.[15] Based on the materials and phases of pretreatment (after or before etching), the teeth were divided into seven groups:[16-18]

The first group (control) received no pretreatment and was washed and dried after the tooth surface was etched with 37% phosphoric acid (3M ESPE, St. Paul, MN, USA) for 30 seconds according to the manufacturer's instructions. The metal bracket (Ortho Organizer Inc., CA, USA) was then placed using bracket holders at the center of the buccal surface of the tooth and was cured with Transbond XT orthodontic composite (3M Unitek, Monrovia, CA, USA) for 20 seconds (Figure 1). [16]

Figure 1: Placing the bracket on the buccal surface of the tooth

In the second group, after the enamel surface was etched similar to the control group, 2% chlorhexidine gel (Morvabon Co., Tehran, Iran) was applied to the etched surface for 20 seconds. The brackets were then bonded similar to the control group. In the third group, 1.23% fluoride gel (Maquira, Maringá, Paraná, Brazil) was applied to the etched surface for one minute.

In the fourth group, after etching, a fluoride-chlorhexidine mixture (TePe Munhygienprodukter, Malmö, Sweden) was used for one minute as pretreatment, and then, the brackets were bonded.[17]

In the fifth group, pretreatment was performed before etching. The chlorhexidine gel was first applied to the enamel surface for 20 seconds, and then, the enamel surface was etched similar to the previous groups, and finally, the bracket was bonded. In the sixth group, fluoride gel pretreatment was performed for one minute. In the seventh group, the enamel surface was etched for one minute after pretreatment with a fluoride-chlorhexidine mixture.[18]

The samples were then mounted in acrylic cylinders (Acropars, Karaj, Iran) with the dimensions of 2×2cm with the buccal surface being exposed. All samples were kept in distilled water for 72 hours at 37±1°C and were subjected to 1000 thermal cycles. (17) The SBS was measured using the Instron machine (Zwick GmbH & Co. KG, Ulm, Germany) at a speed of 0.5 mm/minute. Then, the values obtained in Newton (N) were calculated in MPa (Megapascal) by dividing the peak load by the fracture area (Figure 2).

Figure 2: Using the Instron device to measure shear bond strength (SBS)

The fracture patterns of the specimens were observed under a stereomicroscope (Olympus, Tokyo, Japan) at ×10 magnification by two trained researchers, and the adhesive remnant index (ARI) was reported (Table 1). [18]

Table 1. Adhesive remnant index (ARI)

Score	ARI
0	No adhesive on enamel
1	Less than 50% of adhesive on enamel
2	More than 50% of adhesive on enamel
3	All adhesive on enamel

Data were entered into SPSS (Version 21, SPSS Inc., Chicago, IL, USA).

Descriptive statistics [mean and standard deviation (SD)] were also reported. P-values lower than 0.05 were deliberated as statistically significant.

Since the data distribution was normal according to the Shapiro-Wilk test (P>0.05), one-way analysis of variance (ANOVA) was used to evaluate the SBS.

Since the homogeneity of variances was not confirmed by Levene's test (P<0.05), Tamhane's T2 test was used to compare the SBS of the groups.

Results:

The mean, SD, minimum, and maximum SBS of orthodontic brackets are shown in Table 2. According to this table, the highest mean SBS was related to pretreatment with a fluoride-chlorhexidine mixture after etching (21.03 MPa), and the minimum was related to pretreatment by chlorhexidine (8.04±5.2 MPa).

One-way ANOVA showed a statistically significant difference among the mean SBS of the seven groups (P=0.001).

The Tamhane›s T2 test showed that the mean SBS of the bonded brackets decreased only in the group pretreated by chlorhexidine before etching compared to the control group (P=0.04), and in the other groups, it was not statistically significant compared to the control group (P<0.05).

The statistical analysis also showed that the mean SBS was not significantly different with different pretreatments before and after etching (P<0.05; Table 2).

Table 2: Mean, standard deviation (SD), maximum, and minimum shear bond strength (SBS; MPa) in the study groups (n=10)

	Group	SBS	
		Mean±SD	Min-Max
1	Control	19.73±8.37	7.88-35.76
2	Chlorhexidine after etching	11.05±2.58	7.68-17.17
3	Fluoride after etching	11.81±3.69	6.67-19.39
4	Mixture after etching	21.03±7.53	12.53-36.16
5	Chlorhexidine before etching	8.04±5.19	2.83-20.20
6	Fluoride before etching	19.35±9	8.48-32.12
7	Mixture before etching	14.06±6.73	5.25-23.84

Table 3: Frequency distribution of composite fracture pattern in the seven study groups

Fracture pattern / Group (N=10)	0	1	2	3
Control	0	2 (20%)	5 (50%)	3(30%)
Chlorhexidine after etching	2 (20%)	4 (40%)	3 (30%)	1 (10%)
Fluoride after etching	3 (30%)	5 (50%)	2 (20%)	0
Mixture after etching	3 (30%)	5 (50%)	2 (20%)	0
Chlorhexidine before etching	5 (50%)	4 (40%)	1 (10%)	0
Fluoride before etching	0	4 (40%)	4 (40%)	2 (20%)
Mixture before etching	4 (40%)	5 (50%)	1 (10%)	0

Discussion:

The use of orthodontic brackets can increase the risk of dental caries and demineralization due to complicating the oral hygiene process and loss of enamel surfaces after the etching process.[3,4] Therefore, the anticaries and antibacterial properties of agents such as fluoride and chlorhexidine can be useful to prevent tooth demineralization. However, the use of these agents in orthodontic treatments is still a matter of controversy because of their side effects on SBS.[12,13,19] Therefore, the present study aimed to determine the effect of pretreatment with these agents on the SBS of brackets.

Pretreatment with a fluoride-chlorhexidine mixture was a new approach; no similar study was found in the literature using this substance. Since pretreatment with a fluoride-chlorhexidine mixture before and after etching did not significantly affect the SBS of orthodontic brackets compared to the control group, its use is recommended because of the anticaries properties of fluoride and antimicrobial properties of chlorhexidine. Since there is little information on the efficacy of the fluoride-chlorhexidine mixture, further clinical research is needed on its benefits.

Some studies have reported that pretreatment with different concentrations of chlorhexidine before etching did not affect the SBS of brackets.[20-22] However, the results of our study showed that pretreatment with a 2% chlorhexidine gel before etching significantly reduced the bond strength. This inconsistency in the results may be due to different testing conditions. For instance, in the mentioned studies, 1% chlorhexidine was used, and the SBS test was performed after 24 hours, while in the present study, 2% chlorhexidine was used, and the SBS test was performed after 72 hours. Dionysopoulos evaluated the effect of a chlorhexidine varnish incorporated into the primer solution and reported no significant differences in SBS compared to the control group, which was consistent with the present study.[23,24] Therefore, the use of chlorhexidine can be suggested after etching to exploit its antibacterial properties.

Some studies have suggested that the use of fluoride after etching has no negative effect on SBS and it can prevent primary dental caries.[16,19,20] The present study also showed that pretreatment with fluoride after etching did not significantly affect the SBS of orthodontic brackets. On the other hand, the present research showed that the use of fluoride before etching, compared to its use after etching, did not have a statistically significant effect on SBS; therefore, fluoride can also be suggested before etching. Tabrizi and Cakirer reported that the use of fluoride before bracket bonding reduced the SBS of the bracket compared to the control group that received no fluoride.[22] This result is inconsistent with the result of the present study; this may be due to different testing conditions, such as the use of 5% fluoride varnish in the study by Tabrizi and Cakirer and 23% fluoride gel in our study.[22] In addition, the SBS measurement time was 24 hours after bracket bonding in the cited study, whereas in the present study, the SBS was measured after 72 hours.

The results of the present study presented that in the case groups (fluoride, chlorhexidine, and fluoride-chlorhexidine mixture), there was no significant difference in SBS before and after etching, indicating that these antibacterial agents can be used at any stage of work.

The adhesive failure pattern that is best for enamel is intracomposite debonding or composite/bracket debonding as the composite remains on the tooth and less stress is applied to the enamel. Composites can be removed completely because of their color difference from natural teeth.

Conclusion:

The use of fluoride and chlorhexidine can be recommended to orthodontic patients because of antibacterial and anticaries properties and no significant decrease in the SBS of orthodontic brackets (except when chlorhexidine is used before etching). However, further studies are needed in this regard.

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