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Shear Bond Strength of Orthodontic Brackets Bonded with a Self-Adhering Composite in Dry and Saliva-Contaminated Conditions

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ABSTRACT

Objectives: The purpose of this study was to evaluate the effect of saliva contamination on shear bond strength (SBS) of orthodontic brackets bonded by a self-adhering composite compared with a conventional adhesive.

Materials and Methods: This in vitro, experimental study investigated 40 human premolars. The teeth were randomly divided into four groups based on the adhesive type and bonding condition: (I) Vertise Flow composite without saliva contamination (VF), (II) Vertise Flow composite with saliva contamination (VF/S), (III) Transbond XT composite without saliva contamination (TXT), and (IV) Transbond XT composite with saliva contamination (TXT/S). After the preparation step, brackets were bonded to the buccal surface of the teeth, and samples were mounted in acrylic blocks, incubated at 37°C for 24 hours, and underwent thermocycling between 5- 55°C. Next, the SBS was measured by a universal testing machine. Data were analyzed by ANOVA and Tukey's test. $P<0.05$ was considered statistically significant.

Results: ANOVA showed a significant difference in SBS among the groups ($P<0.001$). The highest SBS was achieved in the TXT group (26.63±9.09 MPa), followed by TXT/S (13.69±4.23 MPa), VF/S (3.68±1.49 MPa), and VF (3.04±1.73 MPa).

Conclusion: Saliva contamination did not have a significant effect on SBS of brackets bonded with Vertise Flow. However, it did not provide acceptable bond strength for orthodontic bracket bonding in the clinical setting.

Keywords: Dental Bonding; Orthodontic Brackets; Saliva

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INTRODUCTION

The bonding process is an inseparable part of orthodontic treatment, which is mediated by phosphoric acid etching introduced by Bonocore in 1955. Maintaining isolation is a significant factor associated with successful bonding, which is especially challenging in the posterior region and hard-to-reach areas. In order to solve this problem and improve bonding quality, several techniques and agents, such as hydrophilic substances, have been introduced [1].

A group of self-adhering composites was recently introduced to the market. The special feature of these composites is elimination of the need for etching of enamel and bonding

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agent application on the tooth surface. Therefore, application of these composites decreases the possibility of enamel surface contamination during the bonding process. In addition, they are more cost-effective [2,3]. Shear bond strength (SBS) is the main factor in evaluation of clinical applicability of a bonding system in orthodontics. Several studies estimated that the bond strength must be at least 6-8 MPa to withstand the forces that are routinely applied to the brackets during the course of treatment [4-6].
Contamination of the enamel surface during the bonding process results in reduction of enamel surface energy, which has been increased by the etching process, and decreases the bond strength by disturbing resin tag formation in terms of quantity and length [7-9].
Self-adhering composites such as Vertise Flow are reported to have a proper marginal seal and bond strength [10]. They also have the same hardness as packable composites [11]. However, there should be more investigation regarding their water sorption, hygroscopic expansion, and mass reduction [12,13].
Glycerol-phosphate dimethacrylate, which is a functional monomer that exists in self-adhering composites, is an acidic substance that etches the enamel and bonds to the calcium present in tooth structure [14].
Vertise Flow is a flowable self-adhering versatile composite with adequately high bond strength and appropriate marginal seal, applicable for various dental procedures [15,16].
Regarding the advantages of self-adhering composites for bonding of orthodontic brackets in areas with difficult isolation, and taking into account the brilliant features of Vertise Flow, the purpose of this study was to evaluate the SBS of orthodontic brackets bonded with Vertise Flow compared with Transbond XT composite in presence and absence of saliva contamination.

MATERIALS AND METHODS

This study was approved by the ethical committee of Qazvin University of Medical Sciences with the following ethical code: IR.QUMS.REC.1394.639

Preparation of specimens:

In this in vitro, experimental study, 40 premolar teeth were randomly evaluated in four groups. Sound human premolars extracted for orthodontic treatment within 3 months prior to the study onset were used in this study. In visual inspection, no caries, restoration, crack, or fracture were observed in the specimens.
The tissue resides were removed by a manual curette (McCall; Hu-freidy, USA), the teeth were thoroughly rinsed, and stored in a closed-lid container containing chloramine T for 72 hours for disinfection. Afterwards, the specimens were rinsed again and stored in distilled water at room temperature.
The enamel surface of the samples was cleaned by a rubber cup and pumice paste for 15 seconds, washed with distilled water, and dried with oil-free air. Finally, the specimens were divided into four random groups, each including 10 samples:

1. VF: Vertise Flow composite without saliva contamination.
2. VF/S: Vertise Flow composite with saliva contamination.
3. TXT: Transbond XT composite without saliva contamination.
4. TXT/S: Transbond XT composite with saliva contamination.

We used Vertise Flow composite (Kerr Corporation, Orange, CA, USA) in VF and VF/S groups and Transbond XT composite (3M, Unitek Co., Minneapolis, USA) in TXT and TXT/S groups to bond the brackets (Standard Edgewise 0.018-inch; American Orthodontics, Sheboygan, WI, USA).
VF group: Firstly, we applied and lightly rubbed one layer of Vertise Flow composite on the enamel surface of the samples for 15 seconds (without any previous etching). Then, a new layer of composite was applied and the brackets were placed on the mid-facial surface of the teeth.
VF/S group: The samples were prepared using the same method as the VF group, with the difference that we applied fresh saliva on the enamel surfaces for 15 seconds before bonding. Unstimulated saliva was collected from a donor.
TXT group: The enamel surface of the

samples was etched with 37% phosphoric acid (Condac; FGM, Joinville, SC, Brazil) for 20 seconds. It was then rinsed with water and air-dried. Afterwards, a thin and uniform layer of Transbond XT primer (3M Unitek, Monrovia, CA, USA) was applied on the enamel surface and light-cured for 15 seconds. Then, we bonded the brackets to the mid-facial surface of the teeth using Transbond XT adhesive paste.
TXT/S group: The samples were prepared as in the TXT group with the difference that the samples were contaminated with saliva after etching.
After the bonding process, the samples were mounted in acrylic blocks with a rectangular 0.016×0.022-inch straight wire (Fig. 1).

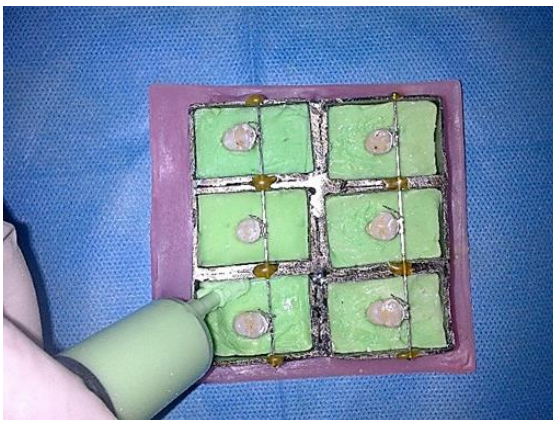

Fig. 1: Fixing the teeth in a metal mold in an appropriate direction using a 0.016×0.022-inch wire

Then, the blocks were incubated in distilled water (37°C) for 24 hours and subjected to thermocycling for 5000 thermal cycles (between 5-55°C).
SBS test:
A universal testing machine (Zwick Roell Z020; Zwick GmH & co.KG, Ulm, Germany) was used to measure the SBS. To debond the brackets, shear force was applied to the samples parallel to the facial surface of the teeth with a crosshead speed of 1mm/minute (Fig. 2). The maximum force needed to remove the brackets was measured and noted by a computer connected to the machine and reported in Newtons (N).

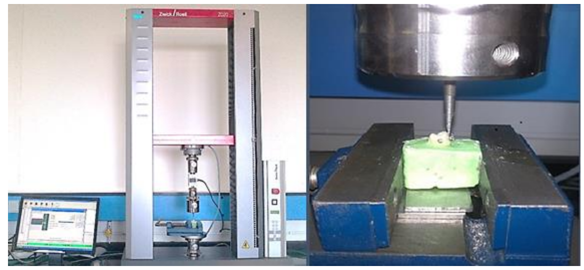

Fig. 2: Performing the shear bond strength test using a universal testing machine

To convert the values to megapascals (MPs), they were divided by the cross-sectional area of the brackets (12.45mm^2).
Statistical analysis:
The data were analyzed by ANOVA, and the Tukey's test was used to compare the groups pairwise. P<0.05 was considered statistically significant.

RESULTS

Descriptive data including the mean, standard deviation, maximum and minimum SBS values in the four groups are presented in Table 1.

Table 1: Mean and standard deviation (SD) of shear bond strength (MPa) in the four study groups

Groups	Minimum-Maximum	Mean	SD
VF	0.99-7.24	3.04	1.73
VF/S	2.15-6.13	3.68	1.49
TXT	13.65-43.1	26.63	9.09
TXT/S	6.65-17.68	13.69	4.23

VF: Vertise Flow composite without saliva contamination; VF/S: Vertise Flow composite with saliva contamination; TXT: Transbond XT composite without saliva contamination; TXT/S: Transbond XT composite with saliva contamination

The TXT group showed the highest SBS (26.63±9.09 MPa) followed by the TXT/S (13.69±4.23 MPa). The VF/S (3.68±1.49 MPa), and VF (3.04±1.73 MPa) groups showed lower SBS values. ANOVA showed a significant difference in SBS of the groups (P<0.001). Table 2 shows pairwise comparisons of the groups regarding the SBS by the Tukey's test.

DISCUSSION

In this study, we compared the SBS of orthodontic brackets bonded with a self-adhering composite (Vertise Flow) and

Transbond XT composite in presence and absence of saliva contamination.

Table 2: Pairwise comparisons of shear bond strength between the groups

Groups	Mean difference between groups	P
VF & VF/S	0.64	0.992
VF & TXT	23.59	<0.001
VF/S & TXT/S	10.65	<0.001
VF/S & TXT	22.95	<0.001
VF/S & TXT/S	10.01	0.001
TXT & TXT/S	12.93	<0.001

VF: Vertise Flow composite without saliva contamination;
VF/S: Vertise Flow composite with saliva contamination;
TXT: Transbond XT composite without saliva contamination;
TXT/S: Transbond XT composite with saliva contamination

The obtained data showed a SBS of 3.04±1.73 MPa for the self-adhering composite in absence of saliva and 3.68±1.49 MPa in presence of saliva. The results indicated that saliva contamination did not significantly change the SBS of Vertise Flow to orthodontic brackets. Nevertheless, both Vertise Flow groups had a significantly lower SBS than the Transbond XT groups.

Self-adhering materials can reduce the number of aerosols, as the clinician skips the etching and rinsing process. Furthermore, they lower the risk of infection since they expedite the process [17].

Clinically, saliva contamination of tooth surfaces can occur in two steps in the bracket bonding process: after etching and after the primer application, and can adversely affect the bond strength [18]. For this reason, we applied the saliva in VF/S and TXT/S groups to evaluate the effect of saliva contamination on SBS.

In a study by Khanehmasjedi et al, [19] the SBS of metal brackets to the enamel surface was not significantly different between the use of Single Bond and Universal Bond resin. However, they found a significant difference when bonding in wet condition, such that in presence of saliva contamination, the bond strength was higher in the Single Bond group.

According to the current results, the SBS of Vertise Flow composite in presence and absence of saliva was the same. This finding suggests that saliva contamination has an insignificant effect on SBS of this particular composite. However, the SBS in both conditions was far below the acceptable threshold of 6-8 MPa implying that it is not acceptable for clinical application. Since we did not find the Vertise Flow acceptable in terms of SBS, the adhesive remnant index was not evaluated.

Fallahzadeh et al. [20] evaluated the effect of light-cure and self-etched adhesive resins on bond strength of orthodontic brackets in presence of saliva. They reported that light curing is a more important factor in bond strength than saliva contamination. Since, light curing improves the mechanical features of resin tags and causes a higher bond strength, it is especially important for the final layer of self-etch primers, that bonds to brackets. This study also indicated that saliva contamination after applying the self-etch primer did not affect the bond strength. In this study, the bond strength improved when light-curing was performed (for 10 seconds) after application of self-etch primer. It also suggested to light-cure the self-etch primer after saliva contamination [20].

Reolofs et al. [21] evaluated the effect of premedication for saliva reduction on the bond failure of orthodontic brackets. They concluded that premedication for saliva reduction did not affect the SBS. Hafez and Nassar [22] studied the effect of blood and saliva contamination on SBS of metal brackets bonded with light-cure cyanoacrylate adhesive. They found that blood contamination of the enamel surface significantly decreased the SBS. However, there was no significant difference between the SBS of the control group and the saliva contaminated group. Similarly, Retamoso et al. [23] reported that saliva contamination did not cause a significant change in SBS of orthodontic brackets bonded by Transbond XT. On the contrary, in the current study, application of Transbond XT in the absence of enamel contamination resulted in maximum SBS (26.63±.09 MPa), suggesting that saliva contamination significantly reduces the SBS in brackets bonded by Transbond XT composite. Different studies have reported contradictory results regarding the effect of saliva contamination on the bond strength when using this system.

Cacciafesta et al. [24] indicated that saliva contamination adversely affected the SBS of orthodontic brackets, bonded by Transbond XT. The findings of their study were consistent with our results. In the present study, the samples were subjected to 5000 thermal cycles between 5-55°C. The results are controversial regarding the use of thermocycling. One study suggested that thermocycling decreased the bond strength, while another study rejected this claim [25,26]. However, we performed thermocycling to simulate the oral clinical setting. In the present study, the SBS of both Vertise Flow groups -with and without saliva contamination- was lower than the minimum acceptable threshold for clinical use. However, considering the results of other studies, the SBS of some self-adhering composites is reported to be adequate for bonding purposes in orthodontic treatments [3,10,24]. Further studies on various self-adhering composites are required to find the adhesives with appropriate features for clinical orthodontic use.

CONCLUSION

Vertise Flow self-adhering composite cannot provide clinically acceptable SBS for orthodontic brackets. However, saliva contamination of enamel surfaces does not have a significant effect on SBS of orthodontic brackets bonded with Vertise Flow. When using Transbond XT composite, saliva contamination significantly reduces the SBS of orthodontic brackets. Nevertheless, it provides a clinically acceptable SBS even in presence of saliva contamination.

CONFLICT OF INTEREST STATEMENT

None declared.

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