Original Article

Comparison of shear bond strength of stainless-steel orthodontic brackets bonded with different adhesives and bonding agents

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Abstract

Introduction: The type of bonding agent and adhesive can play an important role in the bond strength of orthodontic brackets. This study measured and compared the shear bond strength (SBS) of brackets bonded with Z250 and Denu adhesives, as well as two different types of bonding agents (Single Bond and Denu Bond).

Methods: In this in vitro study, 80 intact premolars were randomly divided into four groups (20 teeth per group). The brackets were bonded to the teeth in the following order: group A: Single Bond + Z250 adhesive; group B: Denu Bond + Z250 adhesive; group C: Single Bond + Denu adhesive; and group D: Denu Bond + Denu adhesive. The SBS values were recorded using a universal testing machine, and Adhesive Remnant Index (ARI) scores were determined. The data were analyzed by ANOVA and Fisher's exact test at a significance level of 0.05.

Results: The mean SBS values of the A, B, C, and D groups were reported as 16.66, 17.21, 14.61, and 15.91 MPa, respectively. No significant difference was found among the groups in terms of SBS and ARI scores (P=0.06 and P=0.78, respectively).

Conclusion: The Denu adhesive can be used as a clinical alternative to commercial adhesives, such as Z250, for bonding metal orthodontic brackets. Moreover, bonding agents and adhesives from different companies can be used simultaneously. (*J Dent Mater Tech 2023;12(1): 10-15)*

Keywords: *Composites resin, orthodontics, bond strength, bonding agent*

Introduction

Bonded orthodontic brackets serve as a means of transferring force from the activated archwire to the teeth for the purpose of tooth movement. The bond strength of brackets must be sufficient to withstand mastication and archwire forces (1,2).

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When planning to develop bonding systems, three major factors should be considered; including accelerating the process, enhanced function in the wet environment, and increased resistance to demineralization. The selected adhesive system and bonding agent, play a fundamental role in the success of fixed orthodontic therapy with bonded brackets (3). The use of conventional restorative composites has been advocated by some authors for bonding brackets (4, 5), but there is no consensus on the suitability of restorative adhesives for orthodontic procedures. According to Buyuk et al. (6), the bond strength of low-shrinkage adhesives is lower than that of Transbond XT adhesive. However, Borges et al. (5) and Bilal, and Arjumand (7) established similar results when using restorative composites and standard orthodontic adhesives.

Filtek Z250 is a type of microhybrid adhesive (8), and despite its widespread application in restorative dentistry, there is still no consensus on its potential benefits for bonding orthodontic brackets (9). Furthermore, adhesives containing nanoparticles may eventually replace other forms of adhesives (7). Denu adhesive is a water-soluble and light-cured universal composite resin with a nanohybrid filler and excellent biocompatibility. Other benefits of Denu adhesive are low shrinkage and ease of application (10, 11).

Due to the lack of studies comparing Denu with other commercially available adhesives, this study aimed to compare the shear bond strength (SBS) of metal brackets attached to teeth using Z250 and Denu adhesives, as well as two different types of bonding agents (Single Bond and Denu Bond).

Materials and methods

The sample size was calculated as n=20, using an alpha=5%, power=0.8, g (groups)=4, and Δ (effect size) =0.6.

Eighty intact premolar teeth extracted for orthodontic purposes were collected from dental clinics in Zanjan, Iran. Teeth with carious lesions, any sort of restorations, severe hypocalcification, or visible cracks were discarded. After disinfecting with 0.5% chloramine T solution, samples were stored in distilled water. The samples were then observed under a stereo microscope (ST-39, Motic, Barcelona, Spain) at X 4 magnification. The root surface of each tooth, i.e. from the apex to the cementoenamel junction, was embedded in self-cure acrylic resin (Acropars Re, Marlic Medical Industries Co, Tehran, Iran). The base of the bracket, which would be bonded in the next steps, was parallel to the direction of the machine's force and perpendicular to the horizontal plane.

Bonding procedure

In this study, Z250 (3M ESPE, St. Paul, USA) and Denu (Denu, HDI, Seoul, South Korea) adhesives, as well as Single Bond (3M ESPE, St. Paul, USA) and Denu (HDI, Seoul, South Korea) bonding agents were used to bond brackets to the teeth. The samples were randomly divided into four groups (20 teeth per group) as follows:

Group A: Single Bond + Z250 adhesive.

Group B: Denu Bond + Z250 adhesive.

Group C: Single Bond + Denu adhesive.

Group D: Denu Bond + Denu adhesive.

The buccal surface of each tooth was polished, rinsed, and dried. The tooth was etched with 37% phosphoric acid gel (Morva bone, Tehran, Iran) for 30 seconds, and then rinsed for 10 seconds, followed by drying with gentle air until a frosty appearance was observed on the surface. Subsequently, the designated bonding agent for each group was applied to enamel, thinned with a gentle air pressure, and cured for 20 seconds by a light cure device (LED D, Woodpecker, China), with an intensity of 1400 mW/cm^2. The stainless-steel brackets (Jade, TSHdental, Tehran, Iran) were held by bracket tweezers, and the adhesive was placed on the bracket base with the same thickness. Afterwards, the bracket was positioned at the middlen of the buccal surface alongside the longitudinal axis of the tooth by applying force with a scaler. The excess adhesive was removed from around the bracket with the scaler, followed by light curing the adhesive for 40 seconds (10 seconds from each side). The prepared samples were kept in distilled water at room temperature for the next steps.

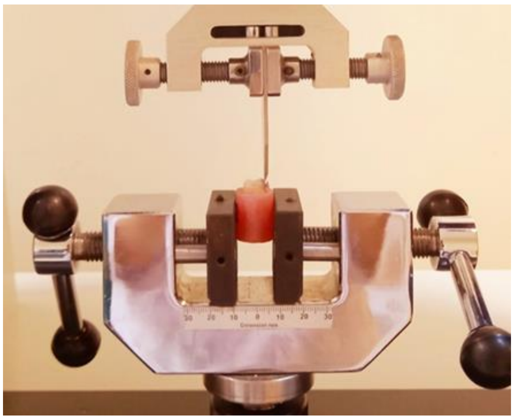

Figure 1. Bracket debonding by the universal testing machine

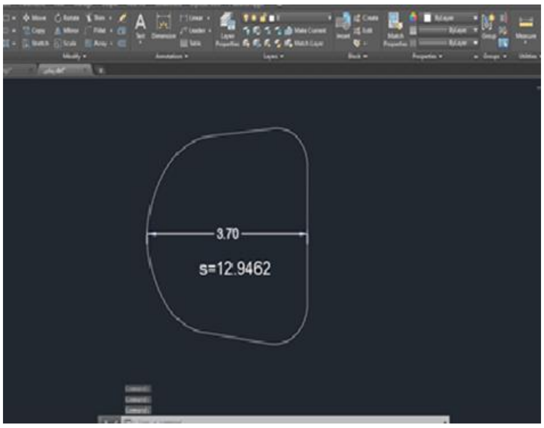

Figure 2. Calculation of the bracket base area using AutoCAD 2019

Shear bond strength assessment

The shear bond strength (SBS) of brackets was measured by a universal testing machine (STM-20, Santam, Tehran Iran) with a cross-head speed of 0.5 mm/min. An occluso-gingival load was applied to the tooth-bracket interface until failure (Figure 1). The shear force was recorded in newton (N), and the SBS was calculated in megapascal (MPa) by dividing the force by the bracket base area.

The scanned image of the bracket was imported into AutoCAD 2019 software to measure the base area. The area around the image of the bracket was determined, and the bracket base area was calculated as 12.95 mm^2 by the software (Figure 2).

Adhesive remnant index assessment

Following the debonding procedure, the samples were examined under ×10 magnification with a stereo microscope and scored from 0 to 3 based on the adhesive remnant index (ARI) scores (12).

Statistical analysis

One-way ANOVA was run to compare the SBS values among the experimental groups. Fisher's exact test was used to analyze the ARI data. The statistical analysis was performed by R-4.0.2 software with a significance level of 0.05.

Results

There was no significant difference in SBS and ARI scores among the four groups (P=0.06 and P=0.78, respectively) (Tables 1 and 2). The highest SBS was found in group B (Denu Bond + Z250 adhesive) and the lowest in group C (Single Bond + Denu adhesive). Regarding ARI, scores 2 and 3 were the most and least frequently observed scores, respectively.

Discussion

The present study revealed no significant difference in SBS of the brackets bonded with various adhesives and bonding agents. The recorded mean SBS values of the four groups ranged from 14 to 17 MPa, which is accepable for orthodontic purposes (9).

Table 1. Descriptive statistics of the SBS in the study groups

Group	Definition	Mean	SD	P-Value
A	Single Bond + Z250 adhesive	16.66	2.7	0.06
B	Denu Bond + Z250 adhesive	17.21	2.9	
C	Single Bond + Denu adhesive	14.61	2.6	
D	Denu Bond + Denu adhesive	15.91	3.9	

Table 2. Frequency and percentage distribution of the ARI scores in the study groups

Group	Definition	Score 0	Score 1	Score 2	Score 3	P-Value
A	Single Bond + Z250 adhesive	3 (15%)	8 (40%)	9 (45%)	0 (0%)	0.78
B	Denu Bond + Z250 adhesive	1 (5%)	7 (35%)	12 (60%)	0 (0%)	
C	Single Bond + Denu adhesive	1 (5%)	7 (35%)	11 (55%)	1 (5%)	
D	Denu Bond + Denu adhesive	1 (7.5%)	5 (33.7%)	12 (55%)	2 (3.8%)	

Denu is a nanocomposite and Z250 is a microhybrid composite. Microhybrid adhesives have good mechanical properties and are desirable for applications under stress (13). A study by Minaei et al. (9) showed no significant difference between the bond strength of Z250 and Transbond XT, suggesting that it can be used for bonding orthodontic brackets. Investigations have shown that SBS enhances by increasing the concentration of the adhesive filler (14). In this regard, nanohybrid adhesives such as Denu have recently been introduced to provide superior bio-mechanical properties, such as increased bond strength, reduced dimensional changes, and better initial polishability. Nanohybrid adhesives adopt a combinational approach of nanomeric and conventional fillers (15) and can show comparable or better properties, compared to microhybrid materials (16). However, the findings of this study revealed no significant benefit of nanohybrid adhesive over the conventional microhybrid composite.

A bonding agent is one of the influential factors for bracket bonding to the tooth. The results of a study conducted by Sharma et al. (17) showed that the SBS of brackets bonded without a primer is lower than that of the brackets bonded whit a primer. Bilal (18) demonstrated that the SBS of brackets bonded with an acid-etching primer is significantly higher than that of the self-etching primer.

According to the dental material manufacturers, it is better for the dentist to use bonding agents and adhesives from the same brand in order to obtain better results (19). Mahmoud et al. (20) used one manufacturer's adhesive system with another manufacturer's brackets. According to the obtained results, the SBS increased when brackets and adhesive systems from the same manufacturer were used. In this study, there was no statistical difference among the groups in terms of SBS, which showed that the concurrent use of bonding agents and adhesives from different companies results in a bond strength close to that obtained when using bonding agents and adhesives from the same company.

In the present study, the highest failure rate was within the adhesive, which is similar to the results of studies by Bilal et al. (7), and Minaei et al (9). Bond failure can occur within the adhesive, at the bracket-adhesive interface, or at the adhesive-enamel interface. Bond failure progresses toward the adhesive-enamel interface as the bond strength increases (21). Although no statistically significant difference was observed regarding ARI scores among the groups, the Z250 adhesive included a greater number of samples with an ARI score of 0 and a higher SBS than the Denu adhesive, which yields the failure area closer to the adhesive-enamel interface. The lower ARI score shows that less adhesive remains on the enamel during debonding. On the other hand, bond failure at the bracket-adhesive interface is more acceptable to orthodontists because the possibility of damage to the enamel is reduced during debonding (22).

Previous studies have shown that the structure of nanocomposites is more compact than other adhesives. Due to the fact that nanocomposites pose a higher viscosity than other adhesives, they are not able to easily penetrate on the bracket's base; however, they are still recommended for bonding of orthodontic brackets because of their sufficient bond strength (23, 24). The use of Denu adhesive may be recommended because of the higher number of samples with an ARI score of 3 in this group. Despite the extensive research that has been conducted concerning this issue, the literature is still contradictory regarding which ARI score is more clinically advantageous (21).

As bracket debonding in clinical conditions is different from the force applied by the device in the laboratory process, different bond strength values can be expected in the oral environment (25). Further studies are suggested to assess bond strength of different adhesives and bonding agents in the clinical setting. Other physical, chemical, and clinical properties of nanocomposites should also be assessed in future investigations.

Conclusion

According to the findings of this study, bonding agents and adhesives from different companies can be used simultaneously, and provide sufficient bond strength. Furthermore, Denu adhesive can be used as a clinical alternative to conventional restorative adhesives, such as Z250, for bonding metal orthodontic brackets.

Conflict of Interests

The authors declare no conflict of interest.

Acknowledgment

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