





Comparative Evaluation of Shear Bond Strength of New Generation Bonding Agents: An Invitro Study

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ABSTRACT

Introduction: This in-vitro study aimed to compare the shear bond strength (SBS) of stainless steel (SS) orthodontic brackets bonded with three different generations of bonding agents.

Materials and Methods: Ninety extracted maxillary 1st premolars were bonded with stainless steel brackets using three different generations of bonding agents: a) GROUP 1: Transbond XT (fifth generation, light cure adhesive, 3M Unitek, USA), b) GROUP 2: Shofu bond II (sixth generation, self-etching primer), c) GROUP 3: Adper single bond 2 (seventh generation, 3M ESPE, USA) according to their manufacturer's instructions & tested for shear bond strength with an Instron universal testing machine & results were obtained.

Results: The SBS values for group 1 was 12.3MPa, group 2 was 11.9MPa, and group 3 was 13.2MPa. The ANOVA and Tuckey's post hoc analysis revealed statistically significant differences among groups 1 & group 3 ($p \leq 0.05$).

Conclusion: All the bonding agents yielded adequate SBS values (within a range of 8-14 MPa), among which the seventh generation showed the highest shear bond strength values.

Keywords: Instron universal testing machine, Orthodontic stainless-steel brackets, Self-etching primers, Shear bond strength

INTRODUCTION

Shear bond strength (SBS) is crucial for successful orthodontic bonding. Over time, numerous bonding agents have been developed, each with its advantages and disadvantages. Currently, the 5th generation bonding agent is the most commonly used.

The success of Shear Bond Strength (SBS) in orthodontic treatment is dependent on various factors such as the size and design of the bracket base, the type of adhesive used, and the preparation of the tooth surface.^{1,2} Among these factors, the adhesive system's capacity to withstand forces directed toward the bracket-adhesive-enamel junction is of particular

importance.^{3,4}

Bond failure occurs at the adhesive-enamel interface, adhesive-bracket interphase, and cohesive failure. Bond failures of brackets at the adhesive-bracket interface are better because they cause the least damage to the enamel.

Orthodontic adhesives must ensure that the bracket remains bonded to the enamel surface throughout the treatment and allow for the brackets' easy removal without damaging the enamel. In addition to providing sufficient bond strength, the adhesive system should be easy to apply and cure.

The purpose of this study was to compare the shear bond strength of orthodontic brackets bonded with 3 different generations of bonding agents.

MATERIALS AND METHOD

Ninety maxillary 1st premolars were extracted and then stored in a solution containing 0.1% (wt/vol) thymol for a period of 1 week. The teeth were then cleansed for 10 seconds, washed with water, and air-dried. After that, all the teeth were mounted in acrylic resin and then divided into three different groups with 30 premolars each. Each of these groups was color-coded as follows:

Group 1: TRANSBOND XT {5th generation} – yellow
 Group 2: SHOFU BOND II {6th generation} – blue
 Group 3: ADPER SINGLE BOND 2 {7th generation} – green.

Bonding procedure for each generation of bonding agent:

In this study, three different sample groups were bonded using three different bonding agents: 5th generation, 6th generation, and 7th generation bonding agents.

For the 5th generation bonding agent, the teeth were etched with 37% phosphoric acid for 15 seconds, washed with water, and air-dried until they appeared white and chalky. Then, a primer was applied to the etched surface and light-cured for 10 seconds. A bracket was placed on the centre of the tooth, bonded with Transbond XT adhesive, and light-cured for 10 seconds.

For the 6th generation bonding agent, the teeth were conditioned with primer for 15 seconds, lightly dried with compressed air for 1-2 seconds, and then brackets were bonded with a bonding agent and light-cured for 10 seconds.

The 7th generation bonding agent was applied in two layers, photopolymerized for 15 seconds, followed by a light application of an air jet. Finally, brackets were bonded and light-cured for 10 seconds.

All three sample groups were bonded according to the manufacturer's protocol.



Fig. 1: Teeth samples mounted in acrylic resin

Shear bond strength was tested 24 hours after bonding. An occlusal-gingival load was applied to produce a shear force at the bracket tooth interface. Shear bond

strength is tested with the flattened end of a steel rod attached to the crosshead of a universal testing machine. A mounting jig was used to align the facial surface of the tooth to be parallel to the force during the SBS test. The bond strengths were measured at a crosshead speed of 1 mm/min, and the load applied at the time of fracture was recorded.

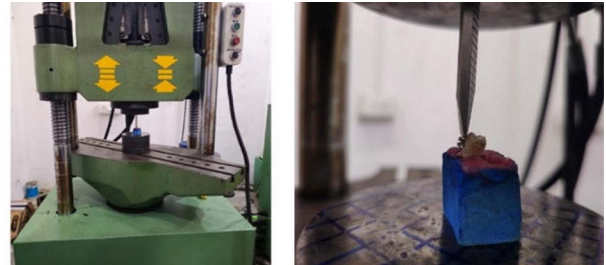


Fig. 2: Instron universal testing machine, debonding of the sample under machine

RESULTS

The study evaluated the shear bond strength of three bonding agent generations. The 7th generation bonding agent demonstrated the highest mean shear bond strength of 13.2 MPa, which was statistically superior to both the 5th and 6th generations. The 6th generation bonding agent demonstrated the lowest mean shear bond strength 11.9 MPa, though it was not statistically different from the 5th generation bonding agent. A one-way ANOVA revealed a significant difference between the groups ($P < 0.05$), with Tuckey's post hoc analysis confirming the 7th generation as the strongest, while no significant difference was revealed among groups 1 & group 3 ($p \leq 0.05$).

Table 1: Mean comparison of shear bond strength between groups

Groups	N	Mean	SD
5 th generation	10	12.3	0.18274
6 th generation	10	11.9	0.36978
7 th generation	10	13.2	0.56170

One-way ANOVA; $p \leq 0.05$ is considered statistically significant. The mean results obtained for group 1 was 12.3MPa, group 2 was 11.9MPa & and group 3 was 13.2MPa.

Table 2: Post Hoc analysis-Tukey's test

Comparison between	P value	
5 th generation	6 th generation	0.266
	7 th generation	0.012*
6 th generation	7 th generation	0.000*

$P \leq 0.05$ is considered statistically significant. The statistical results show that there is no statistically significant difference between group 1 and group 3, group 2 and group 3.

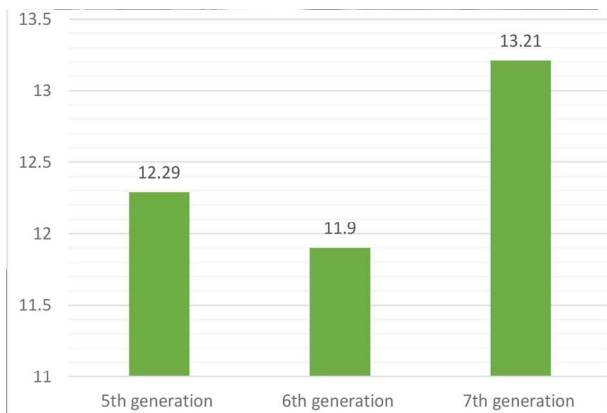


Fig. 3: Mean shear bond strength of 3 groups

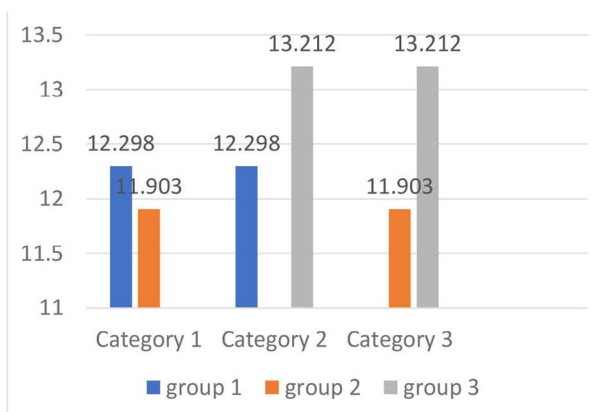


Fig. 4: Mean comparison of shear bond strengths among groups

DISCUSSION

Adequate bond strength of orthodontic brackets is crucial for successful orthodontic treatment. The shear bond strength depends on several factors, including the type of adhesive, polymerization of composite bonding material, bracket base and material, etchant type, enamel condition, and curing methods. Different generations of bonding agents have been developed to improve bond strength, ease of manipulation, and reduce the clinician's time.

Shear bond strength testing is done to determine the maximum bonding capacity of the adhesive and its susceptibility to debonding during orthodontic treatment. The maximum bond strength should be less than the breaking strength of enamel, which is about 14MPa. The minimum bond strength required for orthodontic bonding is in the range of 7-15MPa.

This study comparatively evaluated the shear bond strength of fifth-, sixth-, and seventh-generation bonding

agents. In this study, the average SBS values were recorded as 12.3MPa for group 1, 11.9MPa for group 2, and 13.2MPa for group 3.

The SBS values obtained for Transbond XT in the present study were 12.3MPa, which is consistent with the findings of an in-vitro study conducted by Ajith Rajashekar Pillai et al¹, where they reported SBS values of 11.2MPa for Transbond XT.

Rogelio J. Scougall-Vilchis et al², found the shear bond strength value for Transbond XT was 19MPa, while the value for Transbond XT in the present study was 12.3MPa. Variation in bond strength when the same material was used in different studies, can arise from differences in operator technique and methodology. Fritz et al³, noted that, depending on the method used, shear bond strength can differ significantly even with identical adhesive systems.

The present study is the first to investigate the use of Shofu Bond II and 3M ESPE Adper Single Bond 2, as no prior studies have been conducted on these adhesive systems.

In an in-vitro study conducted by Sudhir Sharma et al⁴, it was found that the SBS (Shear Bond Strength) of SS (stainless steel) brackets with Transbond Plus was 11.57 MPa and Xeno V was 13.51 MPa. In the present study, the values for Shofu Bond II were 11.9 MPa, and Adper Single Bond 2 was 13.2 MPa, which are similar to the findings of the above research.

According to a few authors^{8,9}, the sixth-generation bonding agents have substantially lower bond strength compared to fifth-generation bonding agents. Helen S.I. et al⁵, tested Transbond XT in comparison with Transbond Plus, in both groups they observed no statistically significant difference in bond strength values, which is in concordance with the present study. In a study by Zafer et al⁶, the SBS value for SS brackets bonded with Clearfil SE Bond was 1.75 MPa. However, in the present study, SBS values for Shofu bond II were 11.9 MPa, which contradicts the previous findings.

This variation in the SBS values can be due to the quantity of monomers, diluents, and filler loads which can vary between adhesive products due to differences in the manufacturer's technology.

According to a study by Junaid Ahmed et al⁷, hydrophilic resins exhibit better bond strength than hydrophobic resins. The study found that the SBS (Shear Bond Strength) values for Transbond TX and Transbond Plus

were 7.24 MPa and 8.92 MPa, respectively. However, in our study, the SBS values for Transbond XT and Shofu Bond II were 12.3 MPa and 11.9 MPa, respectively. This contradicts the previous study, which showed that hydrophobic resins have greater bond strength than hydrophilic resins.

An important requirement of an orthodontic adhesive is its ability to debond by clear separation from the enamel surface, leaving no residue. This makes debonding and subsequent polishing much easier. It was reported that greater bond strength was associated with higher ARI scores.^{10,11} On the other hand, it was found that these scores depend not only on the bond strength of the adhesive but also on many other factors, including bracket base design, etching procedures, and adhesive.^{12,13}

This study provides valuable insights for orthodontists seeking to optimize their bonding procedures and achieve optimal results. However, additional research is needed to fully evaluate the effectiveness of current and emerging adhesive systems in vivo. By utilizing SEM studies of newer generation bonding agents, it may be possible to assess etching and adhesive penetration

depths, which could have a significant impact on overall bond strength.

This study did not take into account other factors that can affect bond strength, such as the type of etching, enamel quality, bracket base and material, and curing methods. It is important to note that the results of the study may vary if it was conducted in in-vivo conditions and with a large sample size.

CONCLUSION

This in-vitro study concludes that:

1. The shear bond strength of all the generation bonding agents has an adequate bond strength of more than 10MPa for orthodontic bonding.
2. 7th generation has the highest bond strength compared to the fifth and sixth generations
3. Except for the cost-effectiveness the seventh-generation bonding agents can be effectively used for orthodontic bonding with decreasing chair side time.

CONFLICT OF INTEREST: None.

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