Section: Orthodontics

Original Research Article

COMPARISON OF SHEAR BOND STRENGTH OF ORTHODONTIC BRACKETS BONDED WITH SELF-ETCHING PRIMER ADHESIVE SYSTEMS AGAINST CONVENTIONAL ACID ETCHING TECHNIQUE: AN IN-VITRO STUDY

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Abstract

Background: The study was aimed to assess the average shear bond strength (SBS) of orthodontic brackets (OB) that were bonded utilizing Transbond XT™ following conventional acid etching, compared with brackets that were bonded with Transbond XT™ following the usage of Ideal 1 Self-Etching Primer. **Materials and Methods:** Twenty premolar teeth from human subjects were taken specifically for orthodontic reasons and utilized as samples. The maxillary premolar brackets (n=20) made of stainless steel were bonded employing self-etch primers (SP) adhesive systems and a conventional etching bonding system in light cure mode. Subsequently, the specimens were integrated into acrylic blocks, with the coronal part of the specimens being visible. The SBS was assessed using an Instron Universal Testing Machine. The sample testing was conducted utilizing a sensitive load cell with an endurance of 980 Newton and a consistent velocity of 0.5mm/minute. The SBS was the force at which the bond failed, and it was entered into the computer. The data was analyzed by applying the independent sample t-test. A p-value below 0.05 was considered to have statistical significance. **Result:** Shear bond strength values from Groups I and II samples were entered in an appropriate proforma. For brackets bonded using Transbond XT™ in Group I, the mean SBS was 9.669 + 1.129 MPa, and for Ideal 1 in Group II, 5.936 + 1.017 MPa. Transbond XT™ specimens in Group I had a superior SBS than Ideal 1 in Group II. The t-test revealed a statistically significant difference in mean SBS between groups I and II ($p<0.001$). **Conclusion:** The average SBS of OB bonded with SP was considerably lower as opposed to those bonded following standard phosphoric acid etching. When using self-etching primers, practitioners may conserve time and lower the risk of contamination and error during the bonding process by minimizing the number of steps.

INTRODUCTION

The field of orthodontic bonding has recently witnessed the advent of self-etching primers (SP).[1] The initial iteration of bonding adhesives comprised powdered and liquid components. Two pastes and two sealant bonding adhesives were then introduced, and finally, the single-step bonding adhesives. This adhesive technique employs three distinct elements: an enamel conditioner, a priming solution, and an adhesive resin, to adhere orthodontic brackets (OB) to teeth. One notable feature of certain modern etching systems is their ability to integrate the conditioning (Phenyl P) and priming agents (HEMA and dimethacrylate) into a single acidic primer solution. This solution can be used simultaneously on both enamel and dentine, eliminating the need for etching as a distinct clinical procedure. Incorporating conditioning and priming into a single-step procedure leads to enhanced efficiency in the time invested by the clinicians at the chair side, eventually benefiting the individual receiving treatment.

Although originally designed as a restorative material, this material is now used for orthodontic bonding, as it claims to provide superior bonding to the enamel surface. According to an earlier pilot study,[2] the bonding strength of the material meets the requirements for orthodontic bonding. Transbond Plus™, developed by 3M Unitek in the USA, is a two-step SP adhesive system. The SP and adhesive

system Ideal 1 are a single-component product that recently became available by GAC International Inc., USA. The manufacturers assert that the bonding qualities of their product are good and may be compared to those of the presently available conventional bonding systems.
Orthodontic therapy applies a mixture of tensile, shear, and torsion forces on bonded brackets. Accurately measuring and quantifying these forces poses a challenge. Shear bond strength (SBS) refers to the ability of bonded attachments to withstand the stresses of occlusion. The SBS of an adhesive system is the most important indicator in appraising the life expectancy of bonded components in clinical settings. Both shear and tensile loading modalities are suitable methods for examining orthodontic bonding. The study aimed to contrast the average SBS of OB bonded using Transbond XT™ after conventional acid etching against brackets bonded with Transbond XT™ after applying Ideal 1 Self-Etching Primer.

MATERIALS AND METHODS

Teeth: The samples comprised 20 premolar teeth extracted during orthodontic therapy from human subjects. The teeth that were sound unrestored, non-carious teeth with no facial surface developmental abnormalities were included. The root surfaces were thoroughly cleared of any remnants of soft tissue. The specimens were gathered and preserved in distilled water at ambient temperature in a plastic receptacle until they were utilized for examination. The distilled water was regularly replaced to prevent the proliferation of microbes.
Brackets: Twenty maxillary premolar brackets made of stainless steel (Gemini Series, 3M Unitek) were utilized. The image analysis equipment was used to compute the base area of each bracket, with a mean value of 9.49 mm2.
Bonding Materials: The Transbond XT™ Light Cure Adhesive system (3M Unitek) was utilized in both groups to provide a consistent bonding pattern to assess two different methods of preparing the enamel before bonding. The conventional 3M Scotchbond™ etchant (manufactured by 3M ESPE Dental Products, located in St Paul, Minn) was utilized with the Transbond™ XT Light cure adhesive primer (produced by 3M Dental Products) and Transbond™ XT Light Cure Adhesive paste for the control group. The manufacturer's recommended guidelines and instructions for preconditioning and pretreating surfaces that were to be evaluated were followed diligently.
Bonding procedure: The maxillary premolars were categorized into two groups and the OB was attached to the outside surface of the teeth. A rubber cup and glycerine-free polishing paste were used to polish the buccal surfaces of each group. Group I (n = 10) received the following treatment: conventional acid etch along with Transbond XT primer and Transbond XT paste (3M Unitek). The teeth were treated with a 37% phosphoric acid gel for 30 seconds, and then thoroughly washed and air dried. The tooth was coated with a coating of Transbond XT primer, and the base of the bracket was coated with Transbond XT paste. The bracket was then firmly pressed onto the tooth. The excess glue was eliminated from the perimeter of the base of the OB, and subsequently, the adhesive was exposed to light for 20 seconds, with the light source positioned on the interproximal sides for 10 seconds.
Group II (n = 10): The experimental group consisted of 10 samples treated with Ideal 1 self-etching primer (GAC International, Islandia, NY) in combination with Transbond XT paste. This self-etching primer is a single-component product that does not require any pre-mixing before application. The primer was administered onto the enamel surface using a brush and let stay on for 20 seconds. The primer was desiccated using a forceful gust of air to thoroughly remove any residual liquid, ensuring total dryness of the tooth. The OB was bonded using Transbond XT paste, similar to group I.
The specimens were encased in a cylindrical acrylic block made of Polymethyl merthacrylate, leaving only the upper part of the specimen visible. The crowns were aligned parallel to the longer side of the blocks and were kept in distilled water at room temperature within a sealed container.
Shear Bond Strength Evaluation: The SBS was assessed by employing an Instron Universal Testing Machine. The sample analysis was conducted utilizing a very sensitive load cell with a capacity of 980 Newton. In this investigation, the crosshead of the Instron machine was adjusted to maintain a consistent speed of 0.5mm/minute. The exterior environment during testing measured a humidity level of 50% and a room temperature of 32ºC.
The methodology used in this study for interpreting findings is equivalent to that of prior investigations, as this technique of assessing shear bond strength has been well documented in the literature.[3] A clamp, specifically constructed for the purpose, was used to stabilize each acrylic block and connect it to the crosshead. The bracket was securely fastened by inserting a 21-gauge stainless steel wire of adequate length through the base of the bracket slot. The opposite extremity of the wire was attached to the upper limb of the apparatus.
The acrylic block was positioned in a manner that the bracket slot was at a right angle to the floor. The computer recorded the SBS of the bonding material as the force at which the bond failure developed. The magnitude of force necessary for the bond breakdown was measured in Newton and organised into a table for each subgroup.
Statistical analysis: The statistical analysis was performed using SPSS version 25.0. The mean and standard deviations of the forces needed for shear bond failure in Groups I and II were computed. The measurements were documented in Mega Pascal. Descriptive statistical functions such as the mean and standard deviation were determined. After acid

etching, the data for Groups I and II were analyzed by applying an independent sample t-test to evaluate the significant difference in the SBS of OB bonded using the self-etching priming method against the conventional bonding system.

RESULTS

The SBS of the samples in Groups I and II were documented in an appropriate proforma during testing. In Group I, the average SBS for OB bonded with Transbond XT^{TM} was 9.669 + 1.129 MPa. In Group II, the average SBS for OB bonded using Ideal 1 was 5.936 + 1.017 MPa (Table 1). The samples bonded using Transbond XT^{TM} in Group I had a superior SBS compared to those bonded utilizing Ideal 1 in Group II. The mean values of the two materials exhibited a statistically highly significant difference (P<0.001).

Table 1: Shear bond strength of samples bonded with Transbond XT after conventional acid etching and those bonded with Ideal 1 self-etching primer

	N	Mean±SD	t-test	p-value
Group 1	10	9.669±1.129	-7.769	<0.001**
Group 2	10	5.936±1.017		

**Highly significant

DISCUSSION

The direct bonding of OB has significantly transformed and enhanced the clinical implementation of orthodontic treatments. Nevertheless, there is a necessity to enhance the bonding method to optimize time efficiency and minimize enamel damage, while ensuring the capability to sustain clinically acceptable bond strength. Historically, the bonding process of composite adhesives has relied on the application of acid etchants in conjunction with a primer. This step is crucial for ensuring effective wetting and penetration of the sealant into the enamel surface.

The observed findings in this investigation were analogous to the results reported by Bishara et al,[4] who conducted a comparative analysis of two bonding methods. He revealed that the shear bond strength was notably reduced (7.1 ± 4.4 MPa) when an SP was utilized, in contrast to the control sample (10.4 ± 2.8 MPa) wherein etching and priming were performed independently using a standard adhesive method. These novel primers are believed to streamline the clinical use of adhesive materials by consolidating the etchant and primer into a single application. The results show a substantial decrease in comparison to the traditional approach, while still within an acceptable range for therapeutic purposes.

Yamada et al,[5] conducted a study to assess the impact of using SP on the bonding of OB. They contrasted the usage of a composite resin adhesive with 40% phosphoric acid, a resin-modified Glass Ionomer adhesive with 10% Polyacrylic acid enamel conditioner, and the same resin-modified Glass Ionomer with SP. He utilized bovine teeth for the study. The tooth surfaces were examined using a field-emission scanning electron microscope to identify any changes in their appearance following acid etching or priming. The combination of Megabond^{TM} SP and resin-modified Glass Ionomer cement demonstrated comparable SBS to Polyacrylic acid etching. However, when Megabond^{TM} self-etching primer was utilized in conjunction with composite resin adhesive, it resulted in noticeably reduced shear bond strength compared to phosphoric acid etching. The traditional bonding technique yielded a bond strength of 12 ± 3.3 MPa, whereas the self-etching system resulted in a bond strength of 8.8 ± 2.9 MPa. The findings of the current investigation are supported by the outcomes of the prior study, regarding the composite resin adhesive.

Traditional adhesive methods employ three distinct agents, namely an enamel conditioner, a priming solution, and an adhesive resin, to facilitate the adhesion of OB to teeth. By integrating the processes of combining, conditioning, and priming into a single treatment phase, the requirement for rinsing and drying the enamel layer after etching is eliminated. Self-etching primer/adhesive systems integrate the conditioning and priming chemicals into a solitary acidic primer solution, allowing for their concurrent application on both enamel and dentin. Consequently, there is no longer a requirement to rinse and dry the enamel surface following etching. This leads to a reduction in the amount of time the clinician spends with the patient, resulting in improved efficiency. Eventually, this benefits the patient. The initial acidic primers that were developed exhibited selective compatibility with specific adhesives, leading to either a notable decrease in binding strength or requiring a much longer working time. The efficacy of the novel SP for orthodontic applications has not been comprehensively assessed.

The current study is clinically significant because, despite the significantly lower shear bond strength observed in these newly developed self-etching primer/adhesive systems, the clinical (5.9 to 7.8 MPa) and laboratory (4.9 MPa) results obtained fall within the average range proposed by Reynolds et al.[6] Self-etching primer/adhesive solutions streamline the chair side process for medical practitioners by combining enamel conditioning and priming into a single treatment phase. This leads to increased efficiency and cost-effectiveness for both the practitioner and the patient. Nevertheless, the current study suggests that the utilization of an SP system is not advisable in specific clinical scenarios where there is a greater need for strong bonding, such as Class II division 2 malocclusion, cases involving occlusal prematurities, traumatic occlusion, significant deep bite, and patients with insufficient or flawed enamel.

One further drawback of SP adhesive systems is the decrease in SBS when they are utilized to bond on enamel that is contaminated.[7-10] The utilization of SP could have been advantageous in specific therapeutic scenarios, such as those involving surgically exposed impacted teeth or unerupted teeth, or instances of bleeding from hypertrophied gingiva, when efficient chair side time management and maintaining a dry field are crucial. Many investigations were conducted to appraise the effectiveness of the SP system in compromised settings.

In-vitro trial results may differ from the results of clinical studies, and therefore these in-vitro studies should be interpreted with caution. Hence, more investigation is warranted to ascertain the SBS of these novel SP under typical clinical circumstances through in-vivo experiments.

CONCLUSION

When compared to brackets bonded following traditional phosphoric acid etching, the self-etching primer-bonded brackets had a considerably lower mean shear bond strength. Using self-etching primers during the bonding technique can help professionals save time and minimize the risk of errors and contamination by minimizing the number of steps involved.

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