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EVALUATION OF BOND STRENGTH METAL VS CERAMIC BRACKET USING THREE DIFFERENT COMMERCIAL AVAILABLE LIGHT CURE ADHESIVES - AN IN-VITRO STYDY

Orthodontics

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ABSTRACT

Objectives: To measure the shear bond strength of metal and ceramic brackets and to measure the shear bond strength provided by three different commercially available light cure adhesives. **Materials and Materials:** 60 premolar teeth divided into 6 groups which were bonded in a combination of metal and ceramic brackets with the three adhesives (Transbond XT, Enlight, Orthofix). All the prepared samples were subjected to in-vitro shear bond strength testing using universal testing machine and the results were evaluated. **Results:** All the metal and ceramic bracket combinations with the three adhesives had the bond strength higher than the one suggested for clinical purpose. Metal and Transbond XT group had the highest shear bond strength among the six groups and the least was found with Metal and Orthofix group.

KEYWORDS

Shear bond strength, Brackets, Light cure adhesives, Universal testing machine

INTRODUCTION

Since the introduction of the acid-etch technique in 1955 by Buonocore, bonding to enamel has found a number of applications in all disciplines of dentistry.[1] This brought about a dramatic change in the field of orthodontics, that is, the bonding of orthodontic brackets and attachments, either direct or indirect. Prior to the 1970s, orthodontic brackets were attached to teeth by stainless steel bands. This bonding technique was painful and time-consuming. Direct bonding of attachments revolutionized the placement of orthodontic appliances in the late 1970s and 1980s. The pioneering work of Buonocore, Bowen, Wilson, and Tavas made this valuable improvement in technique possible.[2-5] Conventional adhesive systems uses 3 different agents (an enamel conditioner, a primer solution, and an adhesive resin) in the process of bonding orthodontic brackets to enamel.[6] Composite resins form the basis of most orthodontic adhesives. In clinical use, it is important that material used to bond attachments to etched enamel surfaces can change quickly from a fluid to a solid state. In vitro investigations have suggested that light-cured materials compare favorably with chemically cured adhesives[7] Recently, several visible light– cured orthodontic adhesives have been illustrated.

The main benefits of visible light–cured orthodontic adhesives are the high early bond strength, minimal oxygen inhibition and enough working time. Reynolds[8] stated that 5.9–7.8 MPa resistances are sufficient to withstand masticatory forces. Bishara et al. compared bond strengths of an acidic primer and composite resin with a conventional adhesive system and found mean bond strengths of 10.4 and 11.8 MPa, respectively.[9] The bond strengths of ceramic brackets to teeth with various debonding methods have been studied.[10*] With metal brackets, a key problem is inadequate bond strength to enamel such that they are not able to withstand forces applied during orthodontic treatment.[11*]

With numerous adhesives and orthodontic band and bracket materials available as well as other orthodontic substrates besides enamel, such as esthetic ceramic restorations, in vitro models play an important role in characterizing the bonding potential[3*] Bond failure of brackets not only can be frustrating for the practitioner, but also can significantly affect treatment efficiency and have an economic impact on a practice. One reason for this occurrence, and one focus of this study, can be the differing bond strength of the adhesives used in addition to the type of orthodontic brackets to which the adhesive is placed[12] Unions stronger than 14 MPa can be disastrous to human enamel. In this investigative study, the shear bond strength of the commercially used three light cure adhesives have been compared on metal vs ceramic brackets.

MATERIALS AND METHODS

A total of 60 non- carious maxillary and mandibular human premolar teeth, extracted for orthodontic indications were used in the study. A total of 60 Preadjusted edgewise appliance (PEA) 0.022" * 0.028" brackets were used, of which 30 brackets were Ormco- Mini Diamond MBT metal brackets and 30 brackets were of Ormco – Symetri Clear MBT ceramic brackets.

The light cure adhesives used in the study were as follows:

1) 3M Unitek Tranbond XT light cure adhesive and 3M Unitek Transbond XT Primer
2) Ormco Enlight light cure adhesive and Orthosolo Universal Bond Primer
3) Anabond Orthofix light cure adhesive and Primer

All collected samples were uniformly divided into 6 groups:

Group A (n=10)
- Color coded as red
- Ormco Mini Diamond MBT metal brackets
- Anabond Orthofix light cure adhesive and Primer

Group B (n=10)
- Color coded as red
- Ormco – Symetri Clear MBT ceramic brackets
- Anabond Orthofix light cure adhesive and Primer

Group C (n=10)
- Color coded as blue
- Ormco Mini Diamond MBT metal brackets
- Ormco Enlight light cure adhesive and Orthosolo Universal Bond Primer

Group D (n=10)
- Color coded as blue
- Ormco – Symetri Clear MBT ceramic brackets
- Ormco Enlight light cure adhesive and Orthosolo Universal Bond Primer

Group E (n=10)
- Color coded as pink
- Ormco Mini Diamond MBT metal brackets
- 3M Unitek Transbond XT light cure adhesive and 3M Unitek Transbond XT Primer

Group F (n=10)
- Color coded as pink
- Ormco – Symetri Clear MBT ceramic brackets
- 3M Unitek Transbond XT light cure adhesive and 3M Unitek

Transbond XT Primer

METHODOLOGY:

- All teeth were surface treated with 37% phosphoric acid for 30 secs, washed for 20 secs and dried for 10 secs. After etching a thin layer of the primer belonging to the respective groups were coated on the tooth surface and light cured using (Woodpecker LED.D 5 sec wide spectrum curing light, voltage[AC 100V-240V], frequency[50 Hz], light output[850mW/cm² – 1000mW/cm²]) for 20 secs each.
- Then the brackets were bonded on the long axis of the buccal surface of the premolars according to the manufacturers instructions for each adhesive.
- All the samples were stored in distilled water at 37°C for 24 hrs before testing.

Bond Strength Test:

A Universal Testing Machine was used to measure the shear bond strength. Before debonding, the embedded specimens were secured to the mould kept at the base plate of the testing machine. A chisel edged plunger was mounted in the movable crosshead of the testing machine and position such that the leading edge aimed the enamel -adhesive interface before being brought into contact at a crosshead speed 3mm/min.

The force required to dislodge the brackets was measured in Newtons and the shear bond strength was calculated by dividing the force values by the bracket base area.

Shear bond strength (MPa) = F(N) / Bracket base area(mm²)

Bracket base area:

1) Ormco Mini Diamond MBT metal brackets – 9.32 mm²
2) Ormco – Symetri Clear MBT ceramic brackets – 10.45 mm²

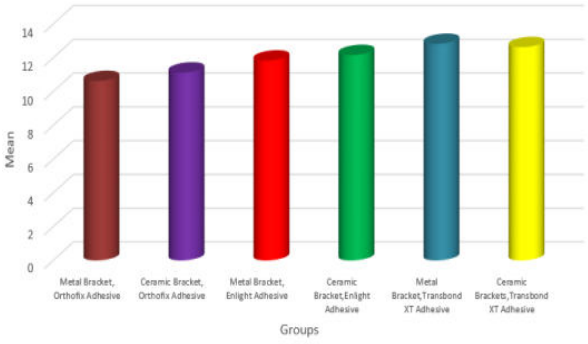
The calculated values were compared and the statiscal results were evaluated.

Stastical Results

Software- SPSS version 20

Statistical tests- One-way ANOVA with post hoc test using Tukey, keeping value of significance p<0.05.

RESULTS



Graph 1: MeanShear bond strength among six groups.

Interpretation:

The results show that among the six groups, the maximum shear bond strength was of metal bracket, Transbond XT adhesive(12.82±0.70) and minimum for metal bracket, orthofix adhesive(10.62± 0.93).

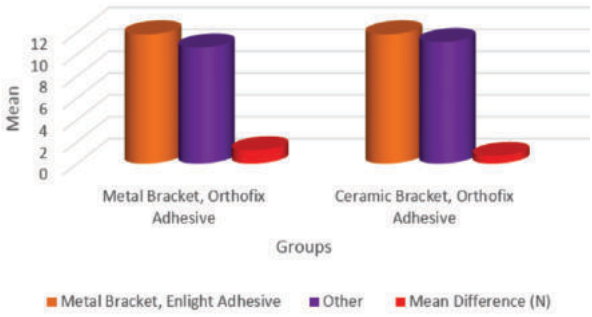
Table 1: Inter group comparison of shear bond strength of test materials.

Between group comparison	F	Mean Square	p- value
Shear Bond Strength	13.48	7.406	0.001

ANOVA, p <0.05 Significant

Inference:

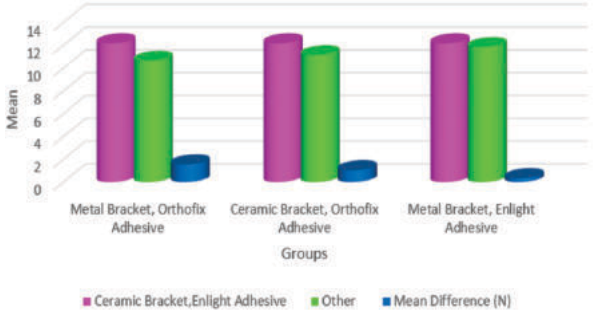
There was a statistically significant difference observed for the shear bond strength among groups as determined by one-way ANOVA (F = 13.48, p = 0.001).The results show that shear bond strength does depend on the type of material and bracket used.



Graph 2: Comparison of Shear bond strength observed in Metal bracket, Enlight adhesive with other groups

Interpretation

The shear bond strength of Metal bracket, Enlight adhesive was higher compared to the other two groups i.e. Metal bracket, orthofix adhesive and ceramic bracket, orthofix adhesive. The results were statistically significant for metal bracket, orthofix adhesive as determined by post hoc Tukey test showing Metal Bracket, Enlight Adhesive was better.

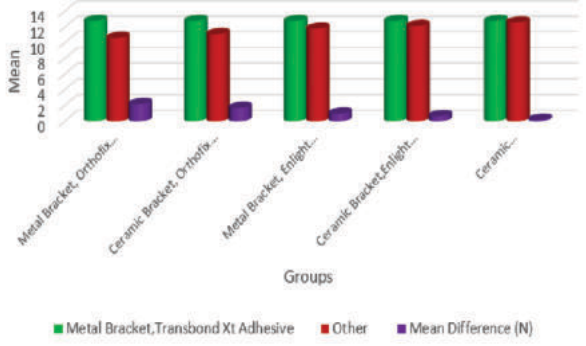


Graph 3: Comparison of shear bond strength observed in Ceramic bracket, Enlight adhesive with other groups.

Interpretation

The shear bond strength of Ceramic bracket, Enlight adhesive was higher compared to the other three groups i.e. Metal bracket, Orthofix adhesive, Ceramic bracket, Orthofix adhesive and Metal bracket, Enlight adhesive.

The results were statistically significant as determined Metal Bracket, Orthofix Adhesive and Ceramic Bracket, OrthofixAdhesive by post hoc Tukey test showing Ceramic Bracket, Enlight Adhesive was better.

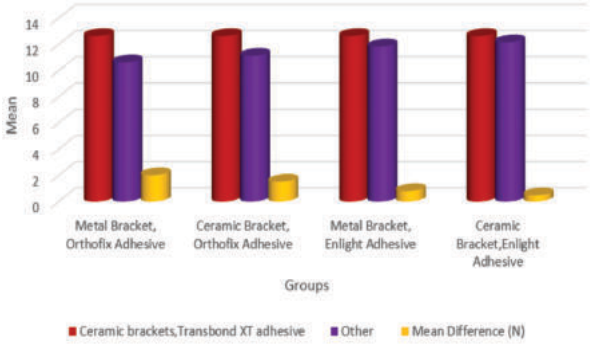


Graph 4: Comparison of shear bond strength observed in Metal bracket, Transbond XT adhesive with other groups.

Interpretation

The shear bond strength of Metal bracket, Transbond XT adhesive was higher compared to the other five groups i.e.,Metal bracket, Orthofix Adhesive, Ceramic bracket, Orthofix Adhesive, Metal bracket, Enlight adhesive, Ceramic bracket, Enlight adhesive and Ceramic brackets, Transbond XT adhesive.

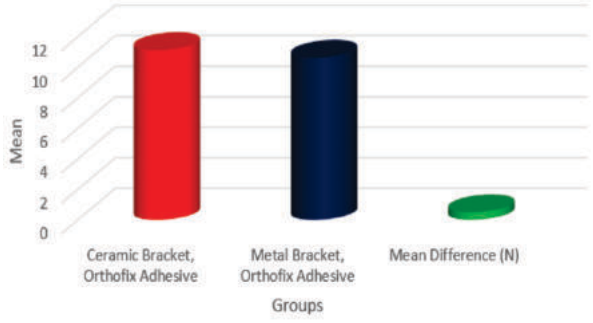
The results were significant for Metal Bracket, Orthofix Adhesive, Ceramic Bracket, Orthofix Adhesive and Metal Bracket, Enlight Adhesive showing Metal Bracket, Transbond XT Adhesive was better.



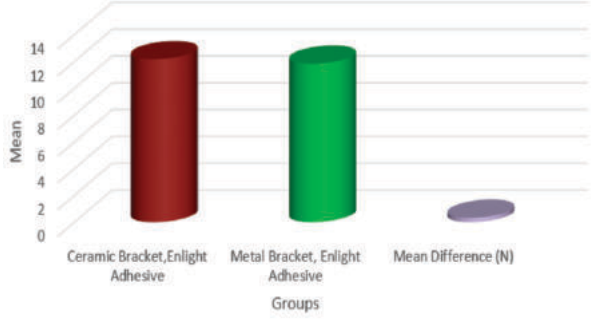
Graph 5: Comparison of shear bond strength observed in Ceramic brackets, Transbond XT adhesive with other groups.

Interpretation

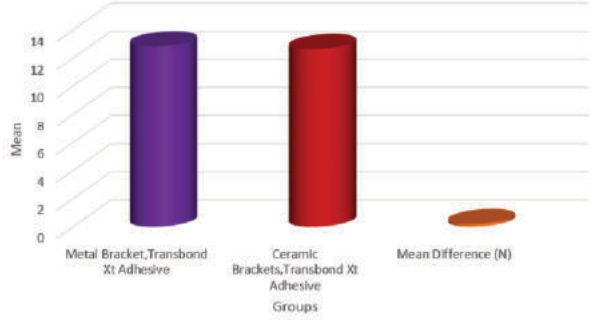
The shear bond strength of Ceramic brackets, Transbond XT adhesive was higher compared to the other four groups i.e. Metal Bracket, Orthofix Adhesive, Ceramic Bracket, Orthofix Adhesive, Metal Bracket, Enlight Adhesive and Ceramic Bracket, Enlight Adhesive The results were statistically significant for Metal Bracket, Orthofix Adhesive and Ceramic Bracket, Orthofix Adhesive as determined by post hoc Tukey test showing Ceramic brackets, Transbond XT adhesive were better.



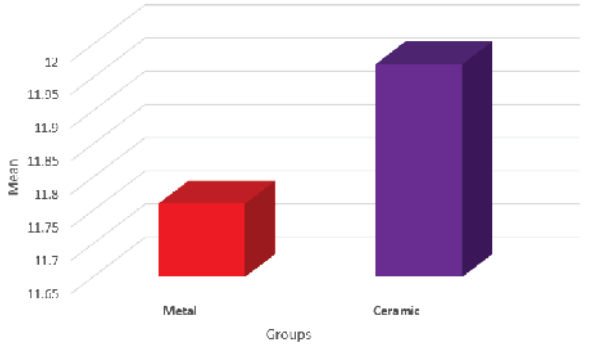
Graph 6: Comparison of shear bond strength observed in Ceramic brackets, Transbond XT adhesive with Metal Bracket, Orthofix Adhesive.



Graph 7: Comparison of Shear bond strength observed in Ceramic Bracket, Enlight Adhesive with Metal Bracket, Enlight Adhesive.



Graph 8: Comparison of Shear bond strength observed in Metal Bracket, Transbond XT Adhesive with Ceramic Brackets, Transbond XT Adhesive.



Graph 9: Meanshear bond strength of metal and ceramic brackets.

Table 2: Comparison of the shear bond strength of metal and ceramic brackets.

t	df	p-value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
2.73	-0.77	0.441	-0.21	0.27	-0.76	0.33

Independent t-Test, p <0.05 Significant

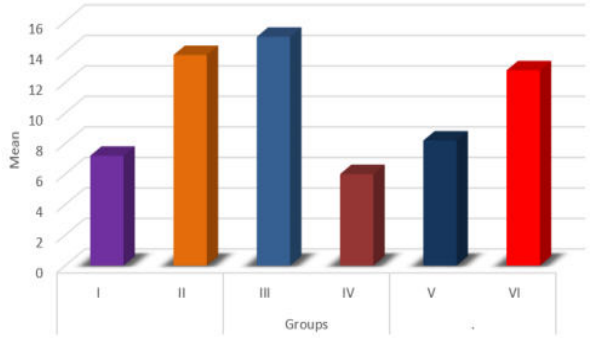
Interpretation:

The comparison between two metal and ceramic brackets groups was found to be not statistically significant showing shear bond strength does not depend on type of bracket.

Table 3: Pair wise comparison of shear bond strength using Mann Whitney U Test for two independent groups.

Groups	Mean rank	Mann Whitney U	p-value
I II	7.20 13.80	17.00	0.013
III IV	15.00 6.00	5.00	0.001
V VI	8.20 12.80	27.00	0.082

P <0.05 Significant



Graph 10: Pairwise comparison of shear bond strength using Mann Whitney U Test for two independent groups.

Interpretation:

The comparison between two independent groups using Mann Whitney U Test was found to be statistically significant for all the groups except Group V and VI.

DISCUSSION

In the present study the bond strength has been compared of the three commercially available light cure adhesives i.e.TransbondXT(3M Unitek, California), Enlight (Ormco), Orthofix(Anabond Stedman) with respect to Metal (Mini diamond brackets, Ormco) vs Ceramic brackets (Asymetri clear brackets, Ormco). The brackets were bonded to the extracted pre molar teeth and tested using Universal Testing machine. According to the statistical result, among the six groups, the maximum shear bond strength was of Metal bracket,Transbond XT adhesive (12.82±0.70) and minimum for Metal bracket, Orthofixadhesive (10.62± 0.93).Shear strength studies for bracket bonding indicate that forces between 5.0 and 7.9Mpa are considered clinically acceptable (Reynolds, 1975; Reicheneder et al., 2009).Reynolds and Fraunhofer stated that the minimum required

bond strength for bracket bonding to enamel is 5.9–7.8 MPa while this value was reported to be 7 MPa by Lopez . Endo et al. and Pannes et al. reported that the clinically acceptable SBS ranges from 6 to 8 MPa. Humberto et al. reported the ideal bond strength value to be 6–10 MPa. Fuhrmann et al. demonstrated that the clinical bond strength should be as high as 5–8 MPa. [13]In this context, all tested adhesives in the present study showed shear strength values over than 7.8Mpa, which characterizes them as clinically adequate for bonding of orthodontic brackets.

Guidelines for adequate in vitro shear bond strength have not been reported. However, some reports have suggested that previous bonding studies could be used as a guideline for shear bond strength analysis. Shear bond strength studies using metal brackets have reported bond strengths in the 2 to 25 MPa range. However, some data showed mean shear bond strength of metal bracket to enamel with Transbond XT was 17 or 8 MPa. These differences could be because of different experimental conditions [14]

Metal bracket, Transbond XT adhesive when compared with the other five groups was found to have the highest bond strength (12.82±0.70), followed by Ceramic Brackets,Transbond XT Adhesive (12.63±0.55),Ceramic brackets, Enlight adhesive (12.16± 0.63), Metal bracket, Enlight adhesive (11.83±0.80), Ceramic brackets, Orthofix adhesive(11.12±0.74), Metal brackets, Orthofix (10.62±0.93).[Table1] The highest bond strength of Transbond XT has been found in the previous studies also. Researches related to orthodontic adhesives has described superior shear results of Transbond XT® in comparison to other materials for brackets bonding. However, the factors that result in improved adhesion of Transbond XT® are still unknown. It is suggested that characteristics such as resin curing time, paste translucency and chemical composition could determinate superior performance of these systems.[15]Transbond XT™ bond strength has been well researched and documented in past literature .[16]

Ceramic and steel brackets may have different adhesion interactions when the same adhesive systems are used. In this context, literature highlights that ceramic brackets have significantly higher resistance levels than steel devices, requiring greater shearing force for their removal. In our study when the mean shear bond strength of the metal and ceramic brackets were compared, the ceramic brackets showed higher strength but was not statistically significant (p=0.441),[Table 2] giving the inference that shear bond strength does not depend on the type of bracket which does not support the previous studies.

According to the literatures, orthodontic forces can vary between 5 and 20 MPa. This extensive range is owing to the large variations in experimental design and procedures. Bonds are subjected to different stresses such as torsion, tension, shear or a combination of them and it is difficult to precisely quantify these forces. Establishing the threshold for clinical shear bond strength would be valuable; however, this may be impossible because of the previous mentioned limitations. Therefore, individual clinicians must select the type of adhesive to use on the basis of their own clinical experience and available researches.[15]

CONCLUSION

In the present study conducted, in which, the shear bond strength of the metal vs ceramic brackets using three different commercially available light cure adhesives were compared and evaluated, the following were concluded based on the statistical results;

1. The three adhesives used in the study have mean bond strength higher than the minimum bond strength adequate for clinical orthodontic purpose, indicating that these adhesives can be used by the clinician for orthodontic treatment.
2. Among the six groups categorized, the highest bond strength was of Metal bracket, Transbond XT adhesive and the least bond strength was of Metal bracket, Orthofix adhesive.
3. Statistically significant differences were found of Group C (Metal bracket, Enlight adhesive) to Group A (Metal bracket, Orthofix adhesive), Group D (Ceramic bracket, Enlight adhesive) to Group A (Metal bracket, Orthofix adhesive) & B (Ceramic bracket, Orthofix adhesive), Group E (Metal bracket, Transbond XT adhesive) to Group A (Metal bracket, Orthofix adhesive), B (Ceramic bracket, Orthofix adhesive) & C (Metal bracket, Enlight adhesive), Group F (Ceramic bracket, Transbond XT adhesive) to Group A (Metal bracket, Orthofix adhesive) & B (Ceramic bracket, Orthofix adhesive).
4. The comparison of metal and ceramic brackets showed no significant results, suggesting that in this study the bracket type did not influence the bond strength.
5. The independent group comparisons showed significant results except for Groups E (Metal bracket, Transbond XT adhesive) & F (Ceramic bracket, Transbond XT adhesive).

Henceforth, this study concludes that the type of adhesive used for orthodontic bonding plays an important role in the orthodontic treatment, as bond failure is a major issue faced by the clinicians. The three adhesives used in the study do provide the clinically adequate bond strength but Transbond XT adhesive gives a better bond strength in comparison to the Enlight adhesive and Orthofix adhesive.

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