ORIGINAL RESEARCH

Assessment of Metallic and Ceramic Brackets Bond Strength with New Adhesive Systems

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ABSTRACT

Introduction: Metallic brackets are the most commonly used brackets during fixed orthodontic treatment, but the metallic appearance is not acceptable for many patients. In recent years, orthodontic patients have become more aware of the importance of esthetic appearance. The purpose of this *in vitro* study was to assess the shear bond strength (SBS) of different metallic and ceramic brackets by two different adhesive systems.

Materials and Methods: A total of 68 caries-free human maxillary premolars were randomly assigned to four groups of 14 each. Group 1 consisted of metallic brackets bonded with Transbond XT; Group 2 consisted of metallic brackets bonded with Orthofix Adhesive system; and ceramic brackets bonded with Transbond XT and Orthofix adhesive system composed Groups 3 and 4, respectively. A universal testing machine was used to determine the SBS.

Results: The bond strength of metallic brackets was significantly lower than the ceramic ones. Ceramic brackets bonded with Orthofix adhesive system declared the bond strength close to Transbond adhesive system.

Conclusion: Although all adhesive systems provided adequate SBS values, Orthofix adhesive system requires further study with bigger sample size to compete with Transbond XT.

Keywords: Bond strength, Orthodontic adhesive materials, ARI

How to cite this article: Mishra A, Mishra A. Assessment of Metallic and Ceramic Brackets Bond Strength with New Adhesive Systems. Int J Prev Clin Dent Res 2018;5(2):70-72.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Metallic brackets are the most commonly used brackets during fixed orthodontic treatment, but the metallic appearance is not acceptable for most patients. In recent years, orthodontic patients have become more aware of the importance of esthetic appearance. Therefore, companies have changed their focus toward esthetic solutions to meet patients' demands for esthetics. Since the introduction of ceramic brackets, their design and clinical performances have been greatly improved.[1]

The dental advanced has stimulated numerous researches aiming to analyze different adhesive materials which could be used in orthodontic brackets bonding to tooth enamel. In addition, it is of fundamental importance that the material presents an effective bonding to tooth surface, resisting to masticatory, and orthodontic forces constantly applied. However, it is necessary that the material also enables an easy removal without damaging the enamel.[2]

During more than 30 years, the use of the acid etch and composite resin bonding system and methods have been developed to a high degree of reliability. This time-honored bonding system is a multistep process requiring etching with 37%–50% phosphoric acid liquid or gel washing thoroughly, drying, applying, a liquid primer component, and adhesive placing the bracket and light curing.[3]

In our study, we have compared the shear bond strength (SBS) of metal and ceramic bracket with two different adhesive systems; Transbond XT primer (3M Unitek Orthodontic Products, Monrovia, CA, USA) and Orthofix (Anabond Stedman, Chennai)

MATERIALS AND METHODS

The teeth for the study were collected from patients with the following criteria:

1. Premolars extracted for orthodontic indications.
2. Non-carious and non-restored teeth.
3. Teeth with no hypoplastic areas, cracks, or irregularities of the enamel structure.

A universal testing machine was used to determine the SBS, and the adhesive remaining after debonding was assessed.

- Stainless steel metal and ceramic upper and lower premolar brackets of 0.022 × 0.028 slot (MBT prescription) with average surface of the orthodontic

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bracket bases 9 square mm were bonded to the teeth with two different bonding systems.

- Group 1: Metallic brackets bonded with (Transbond XT).
- Group 2: Metallic brackets bonded with Orthofix.
- Group 3: Ceramic brackets bonded with Transbond XT.
- Group 4: Ceramic brackets bonded with Orthofix.

- The bracketed teeth were immersed in sealed containers of deionized water and placed in an incubator at 37°C for 72 h to permit adequate water absorption and equilibration.
- Each specimen was then mounted at the outer edge of a stainless steel pipe using autopolymerizing polymethyl methacrylate.
- A universal testing machine was used to determine the SBS, and the adhesive remaining after debonding was assessed.

Bond Failure Assessment

- The debonded enamel surfaces were examined under ×20 magnification using a stereomicroscope to assess the residual adhesive remaining on the tooth surface.
- A modified adhesive remnant index (ARI) was used to quantify the amount of the remaining adhesive on the tooth surface.

The Following Scale was Used

1. All the adhesive remained on tooth,
2. More than 90% of the adhesive remained on tooth,
3. Between 10% and 90% of adhesive remained on tooth,
4. <10% of the adhesive remained on tooth,
5. No adhesive remained on tooth.

RESULTS

SBS

Table 1 summarizes the descriptive statistics of the SBS data including mean, standard deviation, minimum, maximum, and the 95% confidence interval. The results of ANOVA revealed statistically significant differences in bond strength, with the highest mean SBS in Group 3 [Table 1]. The lowest mean SBS was 9.59 ± 1.12 MPa which was recorded in Group 2. The Tukey HSD test showed that the bond strengths of Group 3 (12.18 ± 1.11 MPa) and Group 4 (13.77 ± 2.11MPa) were significantly greater than that in Group 1 (9.59 ± 1.12 MPa, $P < 0.001$).

Table 1: Bond strength of various bracket system

Bracket systems	*n*	Mean (mpa)±SD	Min.	Max.
Metal bracket				
Group 1	14	10.52±0.79	9.39	12.10
Group 2	14	9.59±1.12	7.21	11.10
Ceramic bracket				
Group 3	14	13.77±2.11	10.20	17.70
Group 4	14	12.18±1.11	9.98	14.20

Table 2: ARI score

ARI Score	Group 1	Group 2	Group 3	Group 4
1	4	3	1	0
2	2	1	2	1
3	2	2	3	2
4	5	6	4	7
5	1	2	4	4

Similarly, mean SBS of Group 2 (mean: 10.52 ± 0.79 MPa) was significantly lower than Group 3 and Group 4 with a significance of $P < 0.005$ and $P < 0.001$, respectively [Table 2]. Therefore, the first hypothesis was not rejected. A significant difference was found between Groups 3 and 4, where ceramic brackets were bonded with the conventional system and Orthofix adhesive system, revealing higher values in Group 3 ($P < 0.05$).

ARI

The failure of bonding between the bracket and adhesive interface and enamel and adhesive interface was assessed.

Adhesive remnant index reveals the difference between Group 1 and Group 4. ARI score of conventional Transbond XT is slightly higher than the Orthofix adhesive system.

DISCUSSION

Even esthetic issue could not replace the conventional metallic brackets with ceramic brackets. However, the bond strength of both types of the brackets has been studied earlier. Old studies have shown conflicting results.

Reynolds[4] reported that a minimum bond strength of 6–8 MPa is adequate for most clinical orthodontic needs because this provides sufficient strength to withstand masticatory and orthodontic forces during orthodontic treatment. Although ceramic brackets provide adequate esthetics and clinical performance, many clinicians still concern about their bond strength due to the possibility of creating enamel cracks during debonding. Uysal *et al.*[5] have reported that the use of self-etching primer systems in bonding ceramic brackets provides lower bond strength values than the conventional acid-etching method. The current SBS values in metallic

groups were higher than the minimum values and lower than maximum values as recommended.[4,5] According to the results, bond strength of ceramic brackets exhibited\higher values than that of metallic brackets, which was consistent with earlier investigations.[5-7] On the contrary.[8] reported that the bond strength of metallic brackets was higher than ceramic\brackets, coinciding with the results of a recent study.[9] In addition, Habibi *et al*.[10] found that the mean debonding strength for the metal brackets was higher than that for ceramic brackets.

These differences in bond strength reveal large variations among studies which might be attributed to the differences in selection of specimens, storage conditions of the teeth, morphology of the tooth surfaces, enamel surface preparation, type of brackets, mode of testing, and different kinds of adhesives used in studies.[11,12]

In our study, ceramic bracket bond strength was significantly higher with Transbond Xt comparison with orthofix. The predominant mode of bracket failure was mostly at the enamel-adhesive resin interface with orthofix adhesive system revealing greater stress applied to the enamel surface. This is in contrast with other investigations that showed high incidence of bond failure at the bracket-adhesive interface and within the adhesive for ceramic brackets.[13] Bond failure at the bracket-adhesive interface or within the adhesive is more desirable than that at the enamel-adhesive resin interface.[12] We believe that although high SBS during treatment and shorter chair time for residual resin removal during debonding would be beneficial in clinical situations, cohesive failure within the adhesive may be desirable because of less damage or fracturing of the enamel after debonding, especially in ceramic brackets. However, current results with traditional bonding system showed that the remaining adhesive on teeth after debonding involves mostly the cohesive failure within the adhesive. This is desirable because the risk of enamel fracture is reduced during debonding. Results of *in vitro* studies of bond strength should always be interpreted with caution due to the difficulties in simulating the nature of oral environment. Complexity of the oral environment includes differences in temperature, stresses, dental plaque, and other factors which may alter the efficiency of adhesives.

CONCLUSION

Ceramic brackets bond strength is better than the metallic brackets, and Orthofix adhesive system is comparatively slightly lower than the Transbond XT.

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