Original Article

Assessment and Comparison of Shear Bond Strength of Metal Brackets on Sound Teeth and Porcelain Fused to Metal Crown with Orthodontic Light Cure Adhesive Material

Anshuj Ajay Rao Thetay, Seema Lahoti, Karishma Nahata, Shwetneel Singh

Department of Orthodontics and Deatofacial Orthopedics, RKDF Dental College and Research Center, Bhopal, Madhya Pradesh, India.

Abstract

Aim and Objectives: The aim of the study was to evaluate the shear bond strength of metal brackets between sound teeth and Porcelain fused to metal crown. **Materials and Methods:** A total number of 120 extracted human maxillary and mandibular premolar teeth were collected. After fabrication of porcelain fused to metal crown on half of the teeth, shear bond strength is evaluated. **Results:** Significant difference was noted between the groups suggesting shear bond strength of Group B (Porcelain fused to metal crown) better than Group A. **Conclusion:** This present study concluded that the shear bond strength of metal brackets bonded to porcelain fused to metal crown is greater than sound non restored teeth.

Keywords: Metal orthodontic brackets, Porcelain fused to metal crown, Universal testing machine.

INTRODUCTION

Bonding orthodontic brackets to restorative materials such as ceramic crowns, on the other hand, remains a challenge for orthodontists. Given the growing demand for orthodontic treatment and the presence of teeth with various types of restorations or crowns in the oral cavity, novel adhesives and techniques are needed to enable a stronger bond between metal brackets and various crown types.[1] In orthodontic literature, direct bonding brackets on etched enamel surfaces have received extensive coverage and have a successful clinical track record. The need for adult orthodontic treatment has grown significantly in recent years the orthodontist faces the necessity of bonding accessories to already existing restorations. When it comes to bonding brackets to porcelain, there are at least three variables that are unique to this material and should be mentioned to better understand the subject's complexities: composition, surface integrity and resistance.[2]

Conventional bonding does not guarantee sufficient adhesion to porcelain to withstand orthodontic forces, a number of approaches to changing the surface characteristics of porcelain to provide sufficient bond strength have been attempted. These are divided into three major categories mechanical, chemical or hybrid. It has been suggested that the porcelain surface be etched with hydrofluoric acid (HFA) to increase bond strength.

Access this article online

Website: www.jrad.co.in

DOI: https://doi.org/10.53064/jrad.2022.14.5.380

There are some clinical disadvantages to using HFA. It is highly acidic and must be used with extreme caution because it is extremely corrosive and can cause severe trauma to soft tissues and tooth substance. For several minutes, the working area must be carefully isolated.[3]

The Buonocore enamel-etching method is frequently used to adhere orthodontic brackets to the enamel surface. Debonding should result in a clean separation of the bracket with no adhesive left on the teeth because it takes time and can harm the enamel surface to remove the remaining resin. On the other hand, enamel surface cracks, another unfavorable result, can result from debonding at the adhesive-enamel interface. After debonding, it is crucial to keep the enamel surface intact and smooth.[4]

It is challenging to determine which base design is superior because some base designs performed better with some cements than others. The risk of enamel damage during

Address for correspondence:
Dr. Anshuj Ajay Rao Thetay, 38-39, Indus Empire, Bmopal 462039, Madhya Pradesh, India.
Email: anshujthete82@gmail.com

Received: May 14, 2023; **Accepted:** June 01, 2023; **Published:** June 16, 2023

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

How to cite this article: Thetay AA, Lahoti S, Nahata K, Shwetneel. Assessment and Comparison of Shear Bond Strength of Metal Brackets on Sound Teeth and Porcelain Fused to Metal Crown with Orthodontic Light Cure Adhesive Material. J Res Adv Dent 2023;14(5):1-5.

debonding is not solely dependent on the bracket's base material. Tensile forces can more easily debond the bracket, but they are more likely to cause cohesive failure. Remains of cement will remain on the surface after debonding due to a cohesive failure in the cement between the tooth/restoration surface and the bracket. In addition, improper debonding of the bracket may result in enamel damage.[5]

Bonding is a technique that uses adhesive resins to fix attachments directly over the surface of the tooth's enamel. Most orthodontists today bond attachments to teeth either directly or indirectly. Buonocore had proposed in the late 1960s that the adhesion of the resin to the acid-etched enamel was caused by the formation of resin tags. The resin enters the etched enamel's microporosities and creates a micro-mechanical bond.[6] Direct bonding procedure bonding procedures involves many steps as follows: (1) Cleaning, (2) enamel conditioning, (3) sealing, and (4) bonding.[6]

Bond testing

Megapascals (MPa), kilograms per square centimeter (kg/cm^2), and pounds per square inch (lb/in 2 or psi) are the units used to measure bond strength. Bond force is frequently expressed in terms of Newtons (N), kilograms (kg), or pounds (lb). Bond strength is calculated by dividing the bond force by the bonded interface's surface area. The nominal bonding area of a typical bracket is 16 mm.[7]

The adhesive-bracket system should be able to withstand an applied stress of up to 8 MPa because the average force transmitted to a bracket during mastication has been estimated to be between 40 and 120 N. By selecting a bracket with a larger bonding area, retention can be increased.[7] When a bracket is being tested for shear, it is loaded with a blade in tension, compression, or tensioned wire so that it slides off the substrate parallel. Unfortunately, it is difficult to achieve pure shear loading, and most shear tests also include peeling, tension, and torsion elements. The bracket is taken perpendicularly off the substrate during tensile testing. Valid tests for examining orthodontic bonding are those that use both shear and tensile loading.[7]

Materials and Methods

For the study, a total number of 120 extracted human maxillary and mandibular premolar teeth were collected and used within 6 months. All the selected teeth were extracted for orthodontic treatment purpose only which were free from caries, cracks, enamel decalcification, fluorosis, and were not subjected to any use of pre-treatment chemical such as hydrogen peroxide. All the teeth were stored in distilled water at room temperature till the use after thoroughly cleaned the external surface with ultrasonic scaler to remove any tissue tags and plaque. (Figure 1) showing all materials used in our study.

All the selected premolar teeth were embedded in self-cure acrylic resin blocks (sized 2.5 × 1 × 1 cm) to prevent any displacement of teeth during shear bond testing. Care was taken during mounting so the long axis of teeth was positioned parallel to the direction of the shear force to be applied in testing machine. The mounted premolars then randomly divided into two groups, each group contained 60 numbers of teeth and colored coded as follows (Figure 2).

- Group A: Pink color: Non-restored sound tooth
- Group B: White color: Porcelain fused to metal crown

In Group – A (Pink color) (Figure 3)– Non-restored sound tooth, the metal brackets were bonded using 37% phosphoric acid etchant gel for 40 s then rinsed with water spray for 10 s and air dried followed by application of 3M adhesive primer, light cure adhesive paste was used and light curing done for 40 s. Thin layer of primer provided by the manufacturer was applied on the etched enamel and adhesive material on bracket base, then place the bracket on tooth surface accurately and press them firmly to initiate the reaction and wait for 5 min to initially set the material.

In Group-B (White color) (Figure 4)– Porcelain fused to metal crown, the surface was roughened using tapered fissure diamond bur then application of 9.6% Hydrofluoric for 90 s followed by 3M ESPE ceramic primer, light cure adhesive paste



Figure 1: All materials used in our study



Figure 2: 60 numbers of teeth and colored coded

was used and light curing done for 90 s. Thin layer of primer provided by the manufacturer was applied on the etched enamel and adhesive material on bracket base, then place the bracket on tooth surface accurately and press them firmly to initiate the reaction and wait for 5 min to initially set the material.

Shear bond strength testing

Shear bond strength testing – All the teeth were debonded after the 24 h of initial bonding using universal testing machine (Figure 5). For shear bond strength testing, shear force applied on the teeth in occluso-apical direction using a stainless-steel blade at bracket base adhesive resin interface with a cross head speed of 1 mm/min.

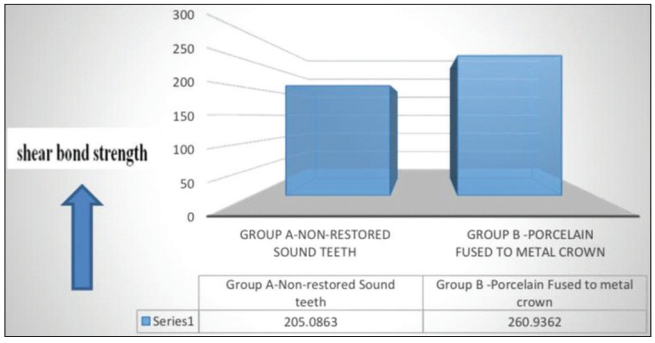
Results and Statistical Analysis

Shear bond strength of each sample was measured. The collected data were entered in Microsoft Excel and the data obtained were subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS Version 23; Chicago Inc., IL, USA). Data comparison was done by applying specific statistical tests to find out the statistical significance of the comparisons.

Kolmogorov–Smirnov and Shapiro–Wilk tests were performed to determine the normality of the data between the two groups to check for shear bond strength between the groups. Both the tests showed no significant differences and hence confirmed that the data obtained were normally distributed. Variables were compared using mean and standard deviation.

The mean for different readings for shear bond strength between groups was compared using independent "t"-test. $P < 0.05$ was considered to be statistically significant. A total of 120 samples were evaluated in the *in vitro* study for shear bond strength, with 60 each in Group A and Group B.

Table 1 and Graph 1 show the mean scores of both groups for shear bond strength. Group A – Non-restored sound teeth had a mean value of 205.0863 ± 88.65303 while Group B – Porcelain fused to metal crown demonstrated a value of 260.9362 ± 108.96971.



Graph 1: Descriptive data of groups evaluated

When compared between the groups for shear bond strength, significant difference was noted between the groups suggesting shear bond strength of Group B (Porcelain fused to metal crown) better than Group A at $P = 0.003$ as shown in Table 2 and Graph 2.

Discussion

Adhesive is used in the direct bonding technique to secure attachments to the tooth surface. To move the attachments quickly and accurately for effective bonding, the operator must be able to judge the proper position for them.[6] Knowing the location of the bond failure allows the orthodontist to modify his or her bonding technique and advise the patient on appliance care. Understanding the significance of "bond strength" in a clinical application is critical because the location of the bond failure may indicate the likely cause. All orthodontic bonding systems have at least two interfaces: The enamel/adhesive interface and the bracket/adhesive interface. If the orthodontist decides to use an unfilled resin (sealant), a third interface, the sealant/adhesive interfaces, is created.[7]

The purpose of our study was to evaluate and compare the shear bond strength of metal orthodontic brackets bonded to porcelain fused to metal crowns and non-restored sound teeth. According to the inclusion criteria, the study was conducted on extracted sound human premolars. A total of 120 samples were collected. Two groups of samples were formed. Mental brackets bonded to sound teeth in Group A, and metal brackets bonded to porcelain fused to metal crowns in Group B. This study will determine whether porcelain fused to metal crown has the same or better shear bond strength as a natural tooth.

Data were compared using specific statistical tests to determine the statistical significance of the comparisons. To check for shear bond strength between the groups, the Kolmogorov–Smirnov and Shapiro–Wilk tests were used to determine the normality of the data between the two groups. Both tests revealed no significant differences, confirming that the data were normally distributed. The mean and standard deviation were used to compare variables.

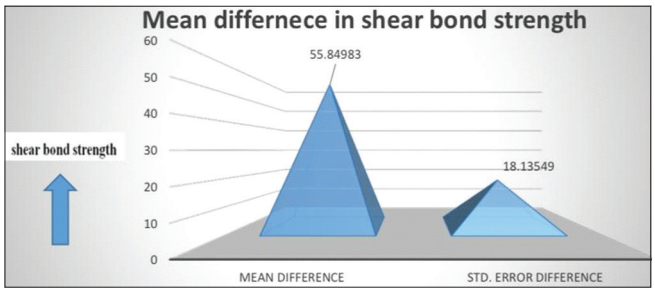
When shear bond strength was compared between the groups, a significant difference was found, indicating that Group B (Porcelain fused to metal crown) had a better shear bond strength than Group A. The mean scores of both groups for shear bond strength. Group A – Non-restored sound teeth had a mean value of 205.0863 ± 88.65303 while Group B – Porcelain fused

Table 1: descriptive data of groups evaluated

Groups	*n*	Mean	Standard deviation	Standard error mean
Group A-non- restored sound teeth	60	205.0863	88.65303	205.0863
Group B -porcelain fused to metal crown	60	260.9362	108.96971	260.9362

Table 2: comparative evaluation of shear bond strength between groups

Groups	Mean	Mean difference	Standard Error difference	'*t*' statistic	Degree of freedom
Group A-non- restored sound teeth	205.0863	-55.84983	18.13549	-3.080	118
Group B - porcelain fused to metal Crown	260.9362				
'*P*' value	E		.003*	Significant	



Graph 2: Comparative evaluation of shear bond strength between groups

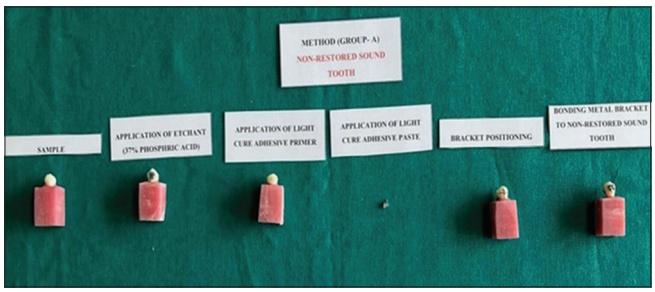


Figure 3: Group A (Pink color)

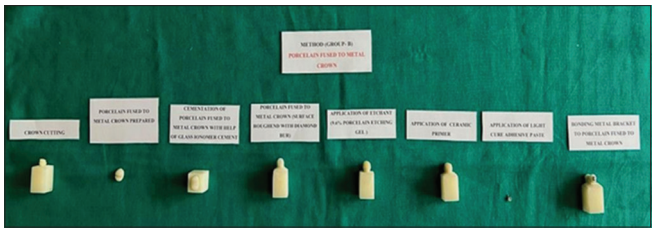


Figure 4: Group B (White color)



Figure 5: Universal testing machine

to metal crown demonstrated a value of 260.9362 ± 108.96971. Standard error difference was 18.135 MPa.

Kolmogorov–Smirnov and Shapiro–Wilk tests revealed that mean SBS of porcelain fused to metal crown (260.9362 ± 108.96971 MPa) and for non-restored sound tooth (205.0863 ± 88.65303 MPa). Standard deviation error for the present study is (18.135 MPa).

The result showed that these findings of SBS are similar to the results of previous studies done by Sant'Anna *et al*. in 2002.,[2] Alhaija and Al-Wahadni in 2007,[3] and Reisner *et al*. in 1997.[8]

In the study conducted by Sant'Anna *et al*. 2002, the shear bond test was performed was higher mean values 17.68 MPa when bonding to porcelain fused to metal crown.[2]

Alhaija and Al-Wahadni in 2007[3] found that the SBS for the two different porcelain surfaces as ceramo-metal and the In-ceram groups were comparable and averaged 13.44 MPa and 13.47 MPa, respectively, also showed similar shear bond strength as seen in our present study.

Reisner *et al*. in 1997 found that SBS of porcelain fused to metal crown was 17.2 MPa which also show a similar results when compared to our study while in his study sandblasting without acid etching, produces lower bond strengths. The most consistent results were achieved when an 1172 bur at slow speed was used to prepare the enamel surface before acid etching.[8]

Result of this present study contradicted the results of the study conducted by Hakan and Küçükesmen in 2006[9] indicated that SBS of porcelain fused to metal crown with HFA application found to be 11.38 MPa which was not similar to your present study and showed non-significant result in his study. Surface treatment with HFA and a silane coupling agent produced the highest bond strength. Similarly, Pouyanfar *et al*. in 2019[1] indicated that surface treatment with sandblasting yielded the highest SBS 7.81 MPa of zirconia to orthodontic brackets while the lowest bond strength was noted in samples etched with hydrofluoric acid 5.84 MPa.

Thirteen direct bonding orthodontic cements were tested for penetration coefficient, tensile strength, and bond strength. The cements were mixed to measure tensile and bond strength. Metal bracket bond strength ranged from 270 to 757 pounds/square inch, with the majority of failures occurring at the cement-bracket interface. The bond strength of plastic brackets ranged from 240 to 870 pounds/square inch, while the rebond strength ranged from 260 to 930 pounds/square inch.[10]

Conclusion

This present study concluded that the shear bond strength of metal brackets bonded to porcelain fused to metal crown is greater than sound non-restored teeth.

References

1. Pouyanfar H. Shear bond strength of metal brackets to Zirconia following different surface treatments using a universal adhesive. J Clin Diagn Res 2019;13:20-3.
2. Sant'Anna EF, Monnerat ME, Chevitarese O, Stuani MB. Bonding brackets to porcelain *in vitro* study. Braz Dent J 2002;13:191-6.
3. Alhaija ES, Al-Wahadni AM. Shear bond strength of orthodontic brackets bonded to different ceramic surfaces. Eur J Orthod 2007;29:386-9.
4. Shahabi M, Heravi F, Mokhber N, Karamad R, Bisharae SE. Effects on shear bond strength and the enamel surface with an enamel bonding agent. Am J Orthod Dentofacial Orthop 2010;13:375-8.
5. Alzainal AH, Majud AS, Al-Ani AM, Magee AO. Orthodontic bonding: Review of the literature. Int J Dent 2020;2020:8874909.
6. Yadav J, Mehrotra P, Kapoor S, Mehrotra R. Basis of orthodontics-bonding-A review. Int J Dent Sci Res 2013;1:28-33.
7. Powers JM, Kim HB, Turner DS. Orthodontic adhesives and bond strength testing. Semin Orthod 1997;3:147-56.
8. Reisner KR, Levitt HL, Mante F. Enamel preparation for orthodontic bonding: A comparison between use of a sandblaster and current technique. Am J Orthod Dentofac Orthop 1997;111:3366-73.
9. Hakan T, Küçükesmen CH. Porcelain surface-conditioning techniques and the shear bond strength of ceramic brackets. Eur J Orthod 2006;28:440-3.
10. Faust JB, Grego GN, Fan PL, Powers JM. Penetration coefficient, tensile strength, and bond strength of thirteen direct bonding orthodontic cements. Am J Orthod 1978;73:512-25.