Original Article

An Evaluation of Shear Bond Strength of Admira (Ormocer) as an Alternative Material for Bonding Orthodontic Brackets: An *In vitro* Study

Altaf Hussian Thekiya[1], K. R. Aileni[2], Madhukar Reddy Rachala[3], Sathun Dharmender Reddy[1], K. Sena Devi[4], Md. Yaser Ahmed Khan[5]

[1]Reader, [2]Professor and Head, [3]Professor, Department of Orthodontics and Dentofacial Orthopedics, SVS Institute of Dental Sciences, Mahabubnagar, [4]Orthodontist and Dentofacial Orthopedics, Smiline Dental Hospitals, Madhapur, Hyderabad, [5]Senior Lecturer and Dentofacial Orthopedics, SVS Institute of Dental Sciences, Mahabubnagar, Telangana, India

Received : 21-10-17.
Accepted : 11-12-17
Published : 22-02-18.

ABSTRACT

Objective: To evaluate shear bond strength (SBS) of Ormocer-bonded orthodontic brackets with self-etching primer (SEP) and conventional adhesive system and also to assess the amount of adhesive remaining on the tooth surface after debonding using adhesive remnant index (ARI).

Materials and Methods: The study was done on 90 extracted human upper first permanent maxillary premolars. The study sample was categorized into three groups of 30 each to assess the SBS using three adhesives, Ormocer, SEP, and conventional adhesive system. Following debonding, the surfaces of teeth were examined for residual adhesive remaining by means of the optical stereomicroscope at ×50 magnification. ARI (Artun and Bergland) was used to classify the amount of residual adhesive. Obtained data were expressed as mean ± standard deviation, and obtained data was expressed as mean ± standard deviation (SD) and statistical analysis was done using one way ANOVA and Mann-Whitney U-test [SPSS version 17 statistical package (SPSS Inc., Chicago, IL)].

Results: The mean SBS was maximum in Group I followed by Group II and Group III. The difference in the mean SBS among Group I (8.67 ± 1.84 Mpa), Group II (7.72 ± 1.82 MPa) and Group III (6.42 ± 1.55 MPa) was statistically significant. ARI was maximum in Group I followed by Group II and minimum Group III.

Conclusion: Ormocer may be utilized as a substitute to generally used bisphenol A-glycidyl methacrylate-based adhesives; however, its effectiveness should be determined clinically by *in vivo* studies.

KEYWORDS: *Adhesives, bonding, composites, etching, Ormocer, shear bond strength*

INTRODUCTION

Orthodontics is constantly evolving as a specialty with improvements in technique wise, like the use of fixed appliances and introduction of newer materials like resin-based systems that benefit both the patients as well as the clinicians.[1-3]

Newman in 1965 was first to use epoxy resins to bond orthodontic attachments to teeth, starting an era of band less treatment with advantages of easy maintenance of oral hygiene, reduced gingival irritation, and risk of decalcification. The other advantages being simple technique, improved esthetics, no requirement for separation and treating posttreatment band spaces and also being able to place attachments on partially erupted teeth.[4]

Since its introduction in late 1950s, Bowens resin or bisphenol A-glycidyl methacrylate (BIS-GMA), a self-cure resin, was used by orthodontists for many years. Although it offered good strength, it was exceedingly technique sensitive with short setting time.[5]

Access this article online

Quick Response Code:

Website: www.jispcd.org

DOI: 10.4103/jispcd.JISPCD_375_17

Address for correspondence: Dr. Altaf Hussian Thekiya, Department of Orthodontics, SVS Institute of Dental Sciences, Mahabubnagar, Telangana, India.
E-mail: altafhussain123456@rediffmail.com

How to cite this article: Thekiya AH, Aileni KR, Rachala MR, Reddy SD, Devi KS, Khan MY. An evaluation of shear bond strength of admira (Ormocer) as an alternative material for bonding orthodontic brackets: An *in vitro* study. J Int Soc Prevent Communit Dent 2018;8:56-61.

Before the advent of resins, orthodontic bonding was achieved using glass ionomer cement as adhesive with added advantage of fluoride-releasing property. However, it had disadvantage of lower bond strength, for which resin particles were added to make resin-modified glass ionomer cement (RMGIC). To avoid the problem of moisture sensitivity, light-activated RMGIC were introduced. Conventionally, 3-step etch/prime/adhesive procedure has been in use for successful orthodontic brackets bonding to teeth, with disadvantage of multiple steps and loss of enamel.[6]

Sixth generation bonding agents, containing methacrylated phosphoric acid ester have advantage of using single step technique. Orthodontists adopted the introduction of newer cement and adhesive techniques with improved mechanical properties and improved esthetics.[5,6]

Recently, Ormocer, an organically customized ceramic technology, was introduced for bonding orthodontic brackets to teeth. It has properties such as excellent biocompatibility, considerable lower polymerization shrinkage, high abrasion resistance, and caries protective.[7-9]

We carried our study to evaluate shear bond strength (SBS) of orthodontic brackets bonded with Ormocer, self-etching primer (SEP), and conventional adhesive system as well as to assess the amount of adhesive remaining on the tooth surface after debonding using adhesive remnant index (ARI).

Materials and Methods

This study was carried out after obtaining institutional ethical committee approval (Reference No. 201/SVSIDS/IRB-E/2011) on 90 extracted human upper first permanent maxillary premolars, which were removed for orthodontic treatment and were stored in a normal saline solution. The study period was between January 2015 and September 2015 at SVS Institute of Dental Sciences, Mahabubnagar, Telangana, India. The sample size and procedure was based on Pradeep *et al*. study (2013). The selected teeth had intact buccal enamel without any hypoplasia, attrition, abrasion, erosion or fracture and were noncarious and nonrestored.

Preparation of the teeth

All the teeth were cleaned using ultrasonic cleaner, polished for 10 s with pumice by means of rubber prophylactic cups and stored in normal saline. Later, the teeth were mounted upright on acrylic blocks such that just the crown part was uncovered.

Brackets used in the study

We used stainless steel maxillary first premolar brackets of American Orthodontics MBT 0.022 slot, with a surface area of 12 mm. Three adhesives used in the study were: Transbond XT (3M Unitek, Monrovia, Calif), Transbond plus (SEP) (3M Unitek, Monrovia, Calif), and Admira (Voco, Cuxhaven, Germany).

Bonding procedure

The study sample was categorized into three groups of 30 to assess SBS using three adhesives.

Group I (conventional system)

Transbond XT was used to bond brackets. Initially, the tooth surface was etched with 37% phosphoric acid for 30 s and later rinsed with sterilized water for 20 s and dried with air till enamel had a frosty look. Then, to the etched enamel surface Transbond XT primer was applied as a thin film and light cured for 10 s, and over the bracket base, Transbond XT adhesive was applied. Using bracket placement pliers, the brackets were placed and light cured for 20 s.

Group II (self-etchant primer system)

Brackets were bonded with Transbond plus. It has two partitions: One with methacrylated phosphoric acid esters, initiators, and stabilizers, and the second one with fluoride complex, stabilizers, and water. All the components were mixed, and the resultant was then applied to the tooth surface for 3–5 s per tooth. The tooth surface was then air-dried for 1–2 s for the primer to form a thin film. With Transbond XT adhesive, brackets were bonded and light cured for 20 s.

Group III (Admira bonding system)

Ormocer restorative paste was used for bonding brackets. Vococid (35% orthophosphoric acid) was used as etchant for 20 s. Later, rinsing with water and air drying for 10 s was done till the color of enamel surface was chalky white. Then, the sealant was applied and light cured for 20 s. Then, Ormocer paste was applied to the bracket base, and brackets were placed and light cured for 20 s.

The same light curing unit was used for photopolymerization of all the three materials. Then, before bonding, the sample was stored in normal saline at room temperature.

Evaluation of shear bond strength

To assess the SBS, "Instron" universal testing machine AGS-10k NG (SHIMADZU) was used, and the measurement was carried at Indian Institute of Chemical Technology, Hyderabad [Figure 1]. The acrylic block with crown part facing upward was placed in the lower crosshead, and the debonding force was applied parallel to the bracket base. A loop made of 0.8 mm

Figure 1: "Instron" universal testing machine AGS-10k NG (SHIMADZU)

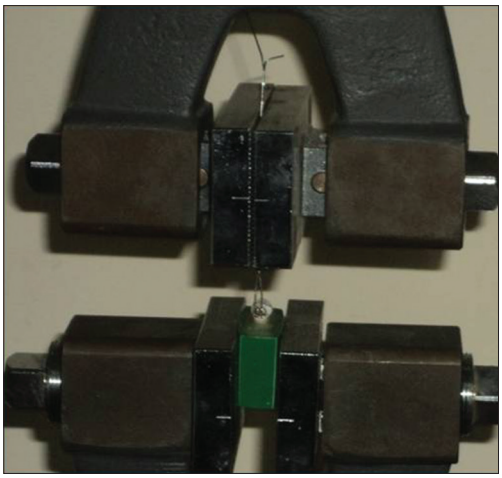


Figure 2: Testing Machine – upper component with wire and the lower component with the sample

stainless steel attached to the upper crosshead was used to apply shear force to debond the bracket. The loop portion was attached below the gingival tie wing of the bracket [Figure 2]. The shear bond was measured at 24 h after bonding.

Adhesive remnant index

Following debonding, all the teeth were examined for any residual adhesive remaining on the tooth surface using optical stereomicroscope at magnification of ×50 magnification. The residual adhesive remaining was categorized based on Artun and Bergland system:

1. Score 0: If there is no adhesive remaining
2. Score 1: If there is less than half of adhesive remaining
3. Score 2: If there is more than half of adhesive remaining
4. Score 3: If all the adhesive is remaining.

Statistical analysis

The observations recorded were tabulated, and statistical analysis (SPSS Version 17, SPSS Inc., Chicago, IL, USA) was carried out using one-way ANOVA and Mann–Whitney U-test.

Results

The mean SBS was maximum in Group I followed by Group II and Group III. The difference in the mean SBS among Group I (8.67 ± 1.84 MPa), Group II (7.72 ± 1.82 MPa), and Group III (6.42 ± 1.55 MPa) was statistically significant. The SBS among three groups by Newman–Keuls *post hoc* procedures showed that the values after 24 h of Group I and Group II to be slightly significant and Group I and Group III: As well as Group II and Group III to be strongly significant [Tables 1-3 and Graph 1].

Frequency distribution of ARI score was calculated. Chi-square test was used to compare the groups. *P* value was found to be higher than 0.05 suggesting insignificant difference among all the three groups. Highest ARI score was seen in Group I indicating that bond failure was seen more commonly at bracket-adhesive interface followed by Group II and least ARI score was shown by Group III, which signified that failure mostly occurred at adhesive and enamel interface [Tables 4-6 and Graph 2].

Table 1: Mean, standard deviation, standard error, coefficient of variation of shear bond strength among the three groups

Group	*n*	Means±SD	SE	CV
Transbond XT	30	8.67±1.84	0.34	21.20
Transbond plus	30	7.72±1.82	0.33	23.58
Admira	30	6.43±1.55	0.28	24.16

SD=Standard deviation, SE=Standard error, CV=Coefficient of variation

Discussion

Adhesion in the field of dentistry is an amalgamation of mechanical, adsorption, diffusion, and electrostatic phenomena. Since last few decades, there is a vast improvement in the field of adhesive agents and bonding procedures. Microscopic interlocking involving the adhesive and adherend, thereby increasing the contact area, is supposed to be the main basis of mechanical adhesion.[3,4]

Based on this phenomenon, Acid-etch technique for bonding was introduced by Buonocore in 1955, which revolutionized the area of adhesive dentistry. It has been showen that by acid etching, there was inclusion of minute resin tags into the enamel surface, resulting in tiny mechanical interlocks linking resin and enamel. Since the initiation of bonding in the field of fixed orthodontics by Newman, attempts have been made for improving the qualities of bonding materials. Reynolds recommended

Table 2: Comparison of shear bond strength among three groups by one-way ANOVA test

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	*F*	*P*
Between groups	2	76.31	38.156	12.5645	<0.05*
Within groups	87	264.20	3.037		
Total	89	340.51			

*P<0.05 - significant

Table 3: Pair-wise comparison of three groups with respect to shear bond strength by Newman–Keuls multiple *post hoc* procedures

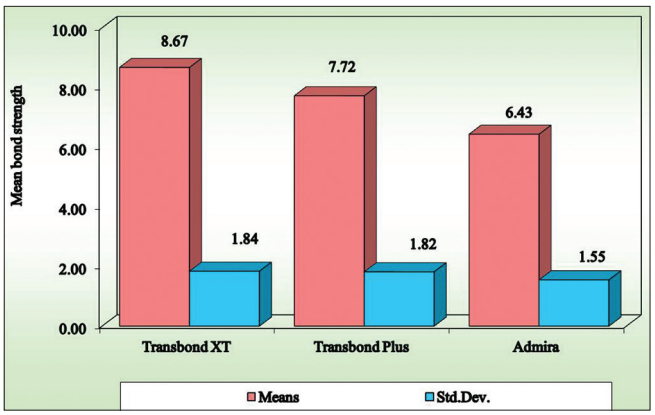
Groups	Transbond XT	Transbond plus	Admira
Means	8.6740	7.7237	6.4273
Transbond XT	-		
Transbond plus (*P*)	0.0376*	-	
Admira (*P*)	0.0001*	0.0051*	-

*P<0.05 - significant

Table 4: Mean, standard deviation, standard error, coefficient of variation of Adhesive Remnant Index scores among the three groups

Group	*n*	Means±SD	SE	CV
Transbond XT	30	1.83±0.91	0.17	49.79
Transbond plus	30	1.73±1.01	0.19	58.55
Admira	30	1.13±0.97	0.18	85.87

SD=Standard deviation, SE=Standard error, CV=Coefficient of variation



Graph 1: Comparison of shear bond strength among three groups

that the bond strength should be optimum (6–8 MPa) not too high or too low. As higher bond strength might damage the enamel during debonding and weak bond strength might cause bonding failure in bonding between enamel and adhesive. During the course of the treatment.[6-8]

Conventional bonding of orthodontic brackets uses three agents, an enamel conditioner, a primer, and an adhesive resin. SEPs were established to lessen the chair-side time and avoid saliva contamination. Moreover, they need not be rinsed off, thereby reducing the technique sensitivity all through the bonding procedure. Their bond strength was comparable with that of conventional acid etch bonding.[7,9]

Newer adhesives and techniques in bonding orthodontic brackets were introduced in last few decades such as addition of filler particles to enhance mechanical properties. However, few ingredients such as BisGMA was shown to be cytotoxic in numerous cell culture experiments.[10]

To prevail over these drawbacks, recently Ormocer, a three-dimensionally cross-linked copolymers was introduced. It has inorganic-organic copolymers along with inorganic silanated filler particles. It showed coefficient of thermal expansion very comparable to normal tooth structure, hence reduced polymerization shrinkage than conventional composites. It also showed a lower wear rate compared with composites.[7-9]

The first objective of our study was to gauge SBS of orthodontic brackets bonded with Ormocer, SEP, and conventional adhesive system. We found that the bracket bonded with conventional method had higher SBS values than SEP and Ormocer system. This indicates that the new adhesive Admira can achieve SBS values comparable to those attained with Transbond XT and Transbond Plus. Our findings are similar to Ajlouni *et al*. They compared SBS of two adhesive materials; modified ceramic matrix Admira and conventional Bis GMA Transbond XT. They found that Admira had lower wear rate and were more biocompatible than traditional composites.[11]

Our findings are also in accordance with that of Park *et al*. They measured the SBS of orthodontic brackets bonded to the teeth using flowable resin. Brackets were bonded using Transbond XT and six other dissimilar flowable resins. They found that Transbond XT adhesive (12.1 MPa) had higher SBS values than Admira flow (7.0 MPa). Unlike their study, our result of ARI showed that bond failure of Admira occurred frequently at enamel-resin interface.[12]

Sunil Kumar *et al*. found that conventional composite showed high bond strength than flowable composites and concluded that flowable composites can be used for orthodontic brackets bonding without primer application.[2]

Table 5: Frequency distribution of Adhesive Remnant Index scores according to three groups

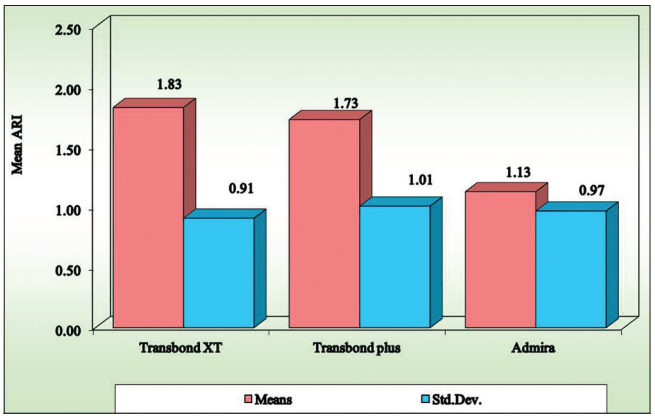
Group	Score 0 (%)	Score 1 (%)	Score 2 (%)	Score 3 (%)	Total
Transbond XT	1 (3.33)	12 (40.00)	8 (26.67)	9 (30.00)	30
Transbond plus	3 (10.00)	11 (36.67)	7 (23.33)	9 (30.00)	30
Admira	8 (26.67)	14 (46.67)	4 (13.33)	4 (13.33)	30
Total	12 (13.33)	37 (41.11)	19 (21.11)	22 (24.44)	90
χ^2, df, *P*	10.5202, 6, 0.1044 (NS)				

NS=Not significant

Table 6: Evaluation of Adhesive Remnant Index scores among three groups by Kruskal–Wallis ANOVA test

Group	Means±SD	Median	Sum of ranks	*H*	*P*
Transbond XT	1.83±0.91	1.00	1566.00	8.7176	0.0128*
Transbond plus	1.73±1.01	2.00	1489.00		
Admira	1.13±0.97	3.00	1040.00		

*P<0.05 - significant. SD=Standard deviation



Graph 2: Comparison of adhesive remnant index scores among groups

Studies have shown that the perfect site of bond failure should be at the enamel-adhesive interface, as this might make bonding and succeeding debonding a lot easier. This is essential as enamel damage is not only due to acid etch but also during bracket debonding. Hence, orthodontist should not only concentrate on bonding adhesive and its bond strength but also on debonding method along with the amount of adhesive remaining after procedure.[11,12]

Our second objective was to measure the amount of adhesive left over on the tooth surface after debonding using ARI. We found that Transbond XT showed the highest ARI score and mode of bond failure was at the adhesive-bracket interface. This shows that bond strength at the enamel-adhesive interface was relatively stronger. The mode of bond failure of Admira was located at the enamel-adhesive interface, indicating easy clean up after debonding causing lesser enamel damage.

Kumar *et al*. compared Ormocer based flowable adhesive (Admira flow) with BisGMA-based adhesive (Transbond XT) and found that the later had high SBS value. They suggested that flowable Ormocer may be used as a substitute to generally used BisGMA-based adhesive; however, its effectiveness should be determined clinically by *in vivo* studies. Both the groups showed a modified ARI score of three, suggesting a cohesive type of failure.[1]

Rajeev *et al*. carried out an *in vitro* study to estimate SBS of Ormocer flowable resin and conventional total etch cement and found almost similar values suggesting it as a potential addition in the field of adhesive dentistry.[7]

Pradeep *et al*. compared SBS and debonding characters of the Transbond XT (BisGMA-based composite) and flowable composites and found an insignificant difference in SBS among the groups. Modified ARI revealed that the common bond failures were seen at enamel-adhesive interface or cohesive type failure in both the groups. Hence, flowable composites may be successfully used for orthodontic bracket bonding.[3]

We did not observe any enamel fracture in this study. As studies showed enamel fractures when adhesion force was >14 MPa. Hence, this aspect should be given importance by orthodontists by means of special techniques and gentler clinical debonding.

To summarize, we found that the brackets bonded with conventional method had higher SBS values than SEP and Ormocer system and also found that Transbond XT showed the highest ARI score and mode of bond failure was at the adhesive-bracket interface.

Limitations of the study

1. Since the brackets were bonded by hand, the adhesive thickness might vary from one sample to other
2. We could not carry SBS test in half an hour of bracket position, due to technical issues
3. As with other *in vitro* studies, our study cannot exactly mimic intraoral conditions.

Scope for future studies

1. More *in vivo* studies should be done to assess SBS of recently introduced material, that is, Admira
2. Further studies using Admira can be done to evaluate bond strengths on fluorized teeth

3. Multidisciplinary studies involving orthodontists, conservative dentists in collaboration with dental institutions and dental laboratories should be carried out.

Conclusion

An *in vitro* study was done on 90 maxillary premolars to evaluate and compare the SBS of orthodontic brackets bonded to enamel surface with Transbond XT, Transbond SEP, and a new adhesive material Admira. The quantity of adhesive remaining on the tooth surface after debonding was also assessed using ARI. The mean SBS of newer material was within the range required for most clinical orthodontic needs, and it showed the least ARI score signifying that failure mostly occurred at adhesive and enamel interface.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Kumar KS, Rao CH, Reddy KB, Chidambaram S, Girish H, Murgod S, *et al.* Flowable composite an alternative orthodontic bonding adhesive: An *in vitro* study. J Contemp Dent Pract 2013;14:883-6.
2. Sunil Kumar M, Mahantesh C, Umesh HM, Talwar A, Qaiser S, Sahasrabudhe S. A comparison of shear bond strength of orthodontic brackets bonded with four flowable composites bonded under contamination: An *ex-vivo* study. Int J Mater Sci Appl 2015;4:47-51.
3. Pradeep S, Shanthraj R, Kiran HJ, Shivalinga BM. Comparative evaluation of the shear bond strength and debonding properties of a conventional composite and flowable composites used for orthodontic bracket bonding. World J Dent 2013;4:6-16.
4. Meeran NA. Iatrogenic possibilities of orthodontic treatment and modalities of prevention. J Orthod Sci 2013;2:73-86.
5. Shaik MS, Pattanaik S, Pattanaik S, Pathuri S, Sivakumar A. Shear Bond strength of different adhesive materials used for bonding orthodontic brackets: A comparative *in vitro* study. Orthod J Nepal 2015;5:22-6.
6. Nayak RS, Valecha S, Pasha A, Mamatha J, Khanna B, Shafiuddin B. A comparison of shear bond strength of new nanofilled composite and nano-ionomer restorative materials with traditional adhesive material for orthodontic bracket bonding: An *in vitro* study. J Int Oral Health 2015;7:70-6.
7. Rajeev V, Arunachalam R, Nayar S, Arunima PR, Ganapathy S, Vedam V, *et al.* "Ormocer an innovative technology": A replacement for conventional cements and veneer? A comparative *in vitro* analysis. Eur J Dent 2017;11:58-63.
8. Bacchi A, Feitosa VP, da Silva Fonseca AS, Cavalcante LM, Silikas N, Schneider LF, *et al.* Shrinkage, stress, and modulus of dimethacrylate, ormocer, and silorane composites. J Conserv Dent 2015;18:384-8.
9. Monsarrat P, Garnier S, Vergnes JN, Nasr K, Grosgogeat B, Joniot S, *et al.* Survival of directly placed ormocer-based restorative materials: A systematic review and meta-analysis of clinical trials. Dent Mater 2017;33:e212-20.
10. Salehi S, Gwinner F, Mitchell JC, Pfeifer C, Ferracane JL. Cytotoxicity of resin composites containing bioactive glass fillers. Dent Mater 2015;31:195-203.
11. Ajlouni R, Bishara SE, Soliman MM, Oonsombat C, Laffoon JF, Warren J, *et al.* The use of ormocer as an alternative material for bonding orthodontic brackets. Angle Orthod 2005;75:106-8.
12. Park SB, Son WS, Ko CC, García-Godoy F, Park MG, Kim HI, *et al.* Influence of flowable resins on the shear bond strength of orthodontic brackets. Dent Mater J 2009;28:730-4.