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ORIGINAL RESEARCH

Flowable Composite an Alternative Orthodontic Bonding Adhesive: An *in vitro* Study

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ABSTRACT

Objective: To determine the clinical applicability of Ormocer based flowable adhesive (Admira flow) in comparison with BisGMA based adhesive (Transbond XT) and Ormocer based packable adhesive (Admira).

Materials and methods: Sixty human premolars, divided into group I (n = 20) Transbond XT, group II (n = 20) Admira and group III (n = 20) Admira flow were bonded with metal brackets using adhesives. Brackets were debonded in shear on an Instron universal testing machine with a crosshead speed of 1 mm per minute. The mode of bond failure was determined by modified ARI index.

Results: The results obtained from SBS evaluation and modified ARI showed highest shear bond strength for Transbond XT (SD 11.64) 3.68 followed by Admira flow (SD 11.0) 2.87 and least for Admira (SD 9.42) 2.21. However, the difference was not statistically significant, but an intergroup comparison done using Independent student 't' test, showed statically significant difference between Transbond XT and Admira. Kaplan-Meier survival analysis showed least survival median value for Admira, but the survival median value is not statistically significant among the three groups. All groups had modified ARI score of three (60-70%), suggestive of cohesive type of failure.

Conclusion: The *in vitro* study showed that flowable Ormocer can be an good alternative to commonly used BisGMA based adhesive but the its efficacy needs clinical assessment through a survival analysis.

Clinical significance: Admire flow can definitely be considered as an alternative bonding system due to their comparable bond strength and debonding characters and reported properties of biocompatibility.

Keywords: Flowable composite, Shear bond strength, Orthodontic adhesives.

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INTRODUCTION

Adequate shear bond strength and acceptable debonding characters with minimal damage to enamel and ease of handling the adhesive are critical for their use as successful direct bonding adhesives. Biocompatibility and prevention of demineralization of surrounding enamel is other prerequisite for ideal orthodontic adhesive. Though conventionally used BisGMA based composite resin has wide clinical acceptance for bonding of brackets or restorative purpose several drawbacks have been reported one being its incomplete polymerization, residual monomer is readily leached from cured resin. Adverse reactions caused by leaching of residual monomer have been reported based on *in vitro* and *in vivo* studies. BisGMA itself has been found to be cytotoxic in number of cell culture studies.[1-3]

Newer bonding adhesives have been developed and tried with varying degree of success. A new packable composite 'Ormocer' introduced in restorative dentistry addressed drawbacks and concerns associated with estrogenicity and cytotoxicity of BisGMA based composites.[4] Ormocer an abbreviation for organically modified ceramic, was developed at Fraunhofer University, Germany and marketed by Voco as 'Admira, a light cured Ormocer based filling material. Admira when evaluated for bonding of orthodontic attachments, it has been reported that SBS was comparable with BisGMA based composite Transbond XT, without any cytotoxic and estrogenic effects, but the thick adhesive paste of Admira needed to be forcibly pushed into the bracket base during bonding process to engage the retentive pad.[5,6]

Flowable composites are low viscosity composite resins, created by retaining the same particle size of traditional

hybrid composites, but reduced filler content and increasing resin content to reduce viscosity of resin. Admira flow has filler content of 63% by weight whereas Admira has filler content of 77%. Admira flow is the first flowable filling material to be developed based on Ormocer technology, its potential use as an alternate non-BisGMA based orthodontic adhesive with improved handling properties and good SBS is great clinical importance.[7-9]

Hence, the present study was planned to determine the clinical usefulness of Admira flow based on the shear bond strength and debonding character in comparison with conventionally used Transbond XT.

MATERIALS AND METHODS

Methodology for Assessment of Shear Bond Strength

Sixty upper premolar teeth extracted for orthodontic purpose were collected. Inclusion criteria for the tooth selection included anatomically and morphologically well-defined upper first premolar teeth with intact buccal enamel, extracted for orthodontic purpose.

Exclusion criteria for the sample consisted of teeth with caries heavy restorations, variations in crown with enamel structural defects, fractured crowns and fluorosed teeth.

The selected teeth were cleaned and stored in solution of 0.1%. Weight/volume of thymol solution until bonding. The teeth were then mounted on self-cured acrylic blocks, up to cementoenamel junction with the buccal surface of crown perpendicular to base of the block. The teeth were divided into group I (n = 20) Transbond XT, group II (n = 20) Admira and group III (n = 20) Admira flow. Sixty preadjusted edgewise upper premolar stainless steel brackets (Gemini series 80 gauge mesh Unitek) were used. The buccal surface of the teeth was polished with pumice slurry using rubber cup. After polishing, the teeth were etched with 37% orthophosphoric acid for a period of 15 seconds. The acid was then washed away with a spray of water for 10 seconds. The tooth surface was then air dried using oil and moisture free three way syringe till a white chalky appearance was seen on the surface. The above procedure was done for all the test specimens, to be bonded with the two adhesives to be evaluated.

Table 1: Mean, standard deviation, test of significance of SBS (MPa) of 3 Adhesives

Groups	*Mean ± SD*	*p-value*	*Significant groups at 5% level*
Group I: Transbond XT	11.64 ± 3.68	0.061	NS
Group II: Admira	9.42 ± 2.21		
Group III: Admira flow	11.0 ± 2.87		

NS: Not significant

Table 2: Mean, standard deviation, test of significance of ARI scores of 3 Adhesives

Groups	*Mean ± SD*	*p-value*	*Significant groups at 5%level*
Group I: Transbond XT	2.650 ± 0.85	0.40	NS
Group II: Admira	2.350 ± 0.88		
Group III: Admira flow	2.750 ± 0.67		

Bonding using Transbond XT – Group I

The primer was applied to the etched surface. The adhesive was then applied to the base of the metal bracket directly and then positioned at a distance of 4 mm from the occlusal surface along the long axis of the tooth and the adhesive was cured using a LED (light emitting diode) curing unit from the occlusal, gingival, mesial and distal aspects for 10 seconds each.

Bonding using Admira – Group II and Admira Flow Group III

The procedure for bonding Admira and Admira flow is same as that of Transbond XT with reference to application of primer (Admira Bond), positioning of bracket and curing.

The bonded specimens were stored in distilled water for 24 hours at room temperature before evaluation of bond strength.

Evaluation of Shear Bond Strength

Debonding was carried out with an Instron universal testing machine (Instron Corp - load cell = 1 Kilo Newton) with a crosshead speed of 1 mm/min.

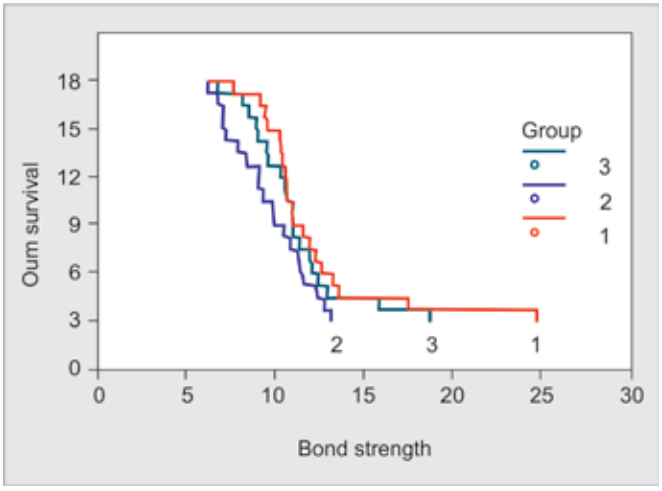
The following formula was used to evaluate the SBS in MPa, shear bond strength (MPa) = Force in Newton/ Base area of the bracket (sq. mm).

Evaluation of the Residual Adhesive

The debonded tooth surface was scanned using an EPSON Scanner attached to a Macintosh computer. The scanned image was then viewed under a resolution of 1,200 dpi (dots/inch). Modified ARI scores was used to determine adhesive remaining on the enamel.

RESULTS

Group I showed highest SBS followed by group II and least by group III (Table 1). Intergroup comparison done using independent student 't' test; a statically significant difference was present between groups I and II. Kaplan-Meier survival analysis showed least survival median value in group II, followed by groups I and III, but the value is not statistically significant. Group II had slightly higher bond failure at lower bond strength values (Table 3, Graph 1). All the three study groups had modified ARI score of three (60-70%), suggestive of cohesive type of failure (Table 2).



Graph 1: Kaplan-Meier Survival analysis

Table 3: Kaplan- Meier survival analysis

Groups	*Median survival value (95% CI)*	*p-value*	*Significant groups at 5% level*
Group I: Transbond XT	10.49 (9.63-11.35)	0.09	NS
Group II: Admira	9.12 (7.32-10.93)		
Group III: Admira flow	10.54 (9.53-11.55)		

NS: Not significant

DISCUSSION

Advances in material sciences have tried to improve the quality of bonding by refining the composition of bonding materials, dispensing systems and modes of curing, enhancing bond strength, handling characteristics and simplifying the procedure. The main requisite of orthodontic adhesive is to produce a strong and durable bond to with stand both occlusal and orthodontic forces during the course of treatment but at the same time permit bracket removal at the end of the treatment without enamel damage and ease of cleaning.[4,5,13]

BisGMA based products are most commonly used composites as orthodontic adhesive. Limitations such as decalcification around brackets during treatment, loss of enamel during etching and debonding, loss of bond strength in presence of saliva and incomplete polymerization with residual monomer are noted. Studies reported cytotoxic effects of these leached free monomers on living cells mainly due to bisphenol component of residual monomer. Bisphenol A was found to act as endocrine disrupting chemical that had an affinity to estrogen receptors. Exposure to this could give rise to effects like reduced sperm count, reproductive system abnormalities and even testicular cancer.[10,19]

In an attempt to overcome the limitations and concerns associated with traditional BisGMA based adhesives, a new packable composite, Ormocer was introduced in restorative dentistry was tried as an orthodontic adhesive. It has inorganic back bone based on SiO_2 functionalized with organic methacrylate units with filler particles resulting in a three-dimensional network. Aljouni and Bishara evaluated the SBS of Ormocer in comparison with widely used BisGMA based composite—Transbond XT and reported that there is no statistically significant difference in their SBS values, but concluded that the material is too viscous and a better clinical performance can be achieved if the flow of the material was improved. The flow property is a special feature and is important clinical consideration that influences both the penetration of the adhesive into the retentive mechanism of the bracket base and the ability of the adhesive to resist bracket drift during direct bonding.[11,12,14,15,17,18,21]

The values of SBS and modified ARI scores obtained for three adhesives were statically analyzed. The statistical analysis shows that Transbond XT has slightly higher mean strength value compared to Admira flow. Admira has lowest SBS value. When pair wise comparison of the three adhesives was done, a significant difference was noted between Transbond XT and Admira. At this juncture it is worth while to note that the bond strength of three adhesives is quite above the clinically acceptable level of 5.9 to 7.8 Mpa as suggested by Reynolds.[3]

Evaluation of debonding characters based on modified ARI scores in the present study revel that all the three adhesives had mean scores ranging between 2 and 3 and the difference was not statically significant. The frequency distribution of the ARI scores revel that 60 to 70% of the samples in the study showed score-3, suggestive of cohesive type of bond failure. The cohesive fracture noted in the present study is favorable as it facilitate easy debonding after treatment, further it requires minimal clean up and less damage to enamel during debonding.[5,10,16]

According to Fox et al,[20] mean bond strength and standard deviation may not be best indicators for evaluating the bond strength of bonding materials.

The survival graph plotted as a function of cumulative survival rate and debonding strength for all the three adhesives revel that Admira flow had marginally higher median survival value compared to Transbond XT and least for Admira, however the difference were not statistically significant.

In the present study, during handling of Admira, though it is in clinically acceptable levels of SBS, it was noted that it needed more pressure for positioning the bracket due to its lesser flowablity attributed to its filler content (77% by weight). The reduced flowablity inhibits proper penetration of resin material into the bracket base. Admira flow on the other hand has a filler content of 63% and is marketed as a 'flow-on-demand' restorative material, i.e. it flows while being applied and contoured but remains firm when stationary. The

three-dimensional cross-linking network of Admira and Admira flow provides abundance of polymerization opportunities and allows them to cure without leaving residual monomer and better biocompatibility with the tissues.[21,22]

CONCLUSION

Though Transbond XT is clinically efficient material as again confirmed from this study, if flow and viscosity are balanced to improve handling property, Admira flow can definitely be considered as an alternative bonding system due to their comparable bond strength and debonding characters and reported properties of biocompatibility.

CLINICAL SIGNIFICANCE

The quality of orthodontic treatment is being constantly improved with increasing sophistication of technique and orthodontic bonding materials. Thinner and flowable consistency of bonding materials will facilitate better penetration of adhesive into the mesh of the bracket base and the microporosities of the etched enamel surface and improve its bond strength. Admire flow can definitely be considered as an alternative bonding system due to their comparable bond strength and debonding characters and reported properties of biocompatibility.

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