CONTEMPORARY ORTHODONTIC BONDING ADHESIVES - AN IN VITRO STUDY

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Conventional composites with Bis-GMA have remained largely unchanged since it was introduced by Bowen. In order to overcome the limitations associated with traditional composites, new genre of materials with unique internal structures like ORMOCERS (Organically Modified Ceramics- Admira™) and Polymer Nano-Composites (Grandio) were introduced. Aim- To compare the Shear Bond Strength (S.B.S.) and Adhesive Remnant Index(A.R.I.) of Admira and Grandio with Transbond XT with a view to evaluate the potential of Admira and Grandio as viable adhesives for bonding orthodontic attachments.

45 human premolars obtained from therapeutic extraction were used in the study. Admira , Grandio and Transbond XT were evaluated for S. B.S. and A.R.I. at 0.5mm/min. cross head speed of the universal testing machine. Student't' test and ANOVA were used to analyze the data.

Transbond XT had a shear bond strength of 8.50 ±5.22 Mpa, while that of Admira was 5.59 ± 1.91 MPa, which was the lowest amongst the three adhesives tested and Grandio had a S.B.S. of 8.13± 4.35 MPa.

Though Transbond XT is considered the Gold Standard and an ideal light cured material for direct bonding of orthodontic attachments to teeth, Grandio, a nano-filled composite could be considered a valid alternative. However, Admira would require further research.

Key words: Orthodontic Bonding Adhesives, Shear Bond Strength, Adhesive Remnant Index.

The development of the acid etch technique by Michael Buonocore [1],followed by its use in orthodontics by G.V. Newman[2] and the introduction of "Bowen's resin[3]" have been revolutionary steps ahead in the history of orthodontics. The resin portion comprises of the reaction product of Bisphenol A-Glycidyl Dimethacrylate (Bis-GMA). Recent reports in literature have indicated that Bis-phenol-A, has an estrogenic effect while the Bis-GMA itself has been found to be cytotoxic [4] in a number of cell culture systems.

Keeping in trend to improve material technology in order to overcome the limitations associated with the traditional composites, new packable, 3-dimensionally cross-linked copolymers known as "Ormocers" (Organically Modified Ceramics [5])have been introduced. The abundance of polymerization opportunities in these materials permits cure without leaving residual monomer, with enhanced bio-compatibility. Admira, is the world's first organically modified ceramic restorative paste and contains Bis-GMA, Urethane Dimethacrylate (UDMA), Triethyleneglycol Dimethacrylate (TEGDMA), glass ceramic and 78% inorganic SiO_2 micro filler with particle size of 0.7 μm[6]. Polymer Nano-Composites ("Nano-Filled Composites") are a new class of material with unique internal structure containing nano fillers, 0.005 to 0.01 microns in size. Grandio, is one such nano-filled composite.

Aim and Objectives

1. To test the viability of newer materials like Ormocers and Nano-filled composites for direct bonding in orthodontics.
2. To compare the shear bond strength of Admira (an ormocer) with Transbond XT.
3. To compare the shear bond strength of Grandio (a nano-filled composite) with Transbond XT.

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4. Evaluation of the A.R.I.(Adhesive Remnant Index) to locate the site of bond failure.

Materials and Methods

Forty five extracted, non-carious human premolar teeth with intact tooth surfaces and no fracture lines on the enamel were chosen for the study. They were obtained from therapeutic extractions of orthodontic patients seeking treatment in the department. The teeth were debrided and stored in a solution of 0.1% (wt/vol) thymol . They were subsequently washed to remove all traces of the storage medium and polished with pumice slurry using rubber cup mounted on a low speed hand piece. The teeth were finally rinsed in distilled water and dried using oil free compressed air. The total sample was divided into three groups with each comprising of 15 samples and was designated as Group I, II and III. The teeth were mounted group-wise on color coded acrylic blocks for identification. (Fig. 1)

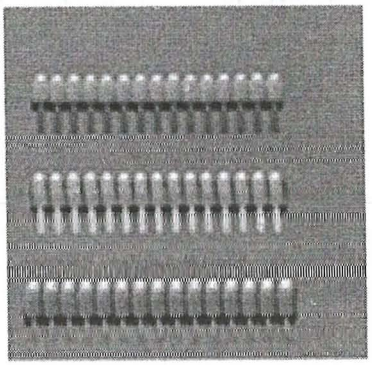


Fig.1-Teeth mounted for bonding

Metal brackets of Gemini series with 0.022" slot Roth prescription were used for the study. The brackets were bonded on Group I samples with Transbond XT. Group II was bonded with Admira and Group III with Grandio. Transbond XT and Grandio were bonded as per the manufacturer's instructions. Ormocer restorative paste was diluted by adding 1 drop of Admira bonding liquid resin to 1 gram of Admira paste on a mixing pad just prior to bonding.

An Instron Universal Testing Machine was used to record the bond strength in the shear mode at a cross head speed of 0.5mm/min. The experiments were conducted at room temperature of 25°C. A progressive load was applied till the bond failed and the bracket was debonded from the tooth surface (Fig. 2). The load at which the bracket debonded was recorded in Newtons and subsequently calculated in Mega Pascals .The values of S.B.S. obtained were tabulated.

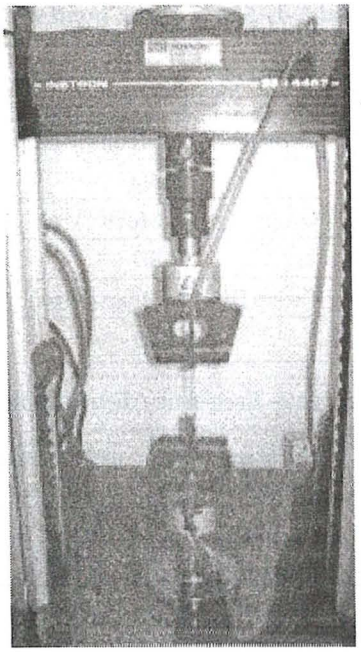


Fig. 2- Instron testing machine

The modified ARI scoring given by Bishara [6] was used to record the score from 1 to 5.

The data of S.B.S. and A.R.I. were subjected to Student's 't' test and ANOVA .

Results

The results were tabulated (Table 1- Table 5) for the comparison of shear bond strength and A.R.I. On analysis of the data, a statistically significant difference in S.B.S. was found between the values of the groups bonded with Admira and Transbond XT. A similar statistically significant difference was evident between the S.B.S. values of Admira and Grandio. ($p < .05$).The values of S.B.S. of the Grandio and Transbond XT groups were comparable. Admira had a higher frequency of bond failure site at the bracket -adhesive interface with the mean A.R.I. score of 2.66 ,which was higher than that of Grandio(3.40) and Transbond XT(3.26). However, this difference in the A.R.I. scores of the three adhesives tested was not statistically significant.

Table 1- Mean shear bond strength

Group No.			No. of Teeth	Bonding Material Used	Cross Head Speed
Group I	Mean (Mpa)	8.50	15	Transbond XT	0.5mm/min
	SD	±5.22			
Group II	Mean (Mpa)	5.59	15	Admira	0.5mm/min
	SD	± 1.91			
Group III	Mean (Mpa)	8.13	15	Grandio	0.5mm/min
	SD	±4.35			

Table 2- Frequency distribution of A.R. I.

Different Groups	Mean ARI Scores	No.of Specimens	Bonding Materials Used	Cross Head Speed
Group I	3.26	15	Transbond XT	0.5mm/min
Group II	2.66	15	Admira	0.5mm/min
Group III	3.40	15	Grandio	0.5mm/min

Table 3 - Inter group comparision of S.B.S.

Groups Compared	t cal	t tab(t28,.o5)	p-value	Comment
Group I Vs. Group II	2.9271	2.05	<.05	Significant
Group I Vs. Group III	0.2121	2.05	>.05	Not Significant
Group II Vs.Group III	2.0702	2.05	<.05	Significant

Table 4- One Way ANOVA (5 % Level) for the comparison of S.B.S.

S. No.	Source of Variation	df	Sum of Squares (S.S)	Mean S.S	F cal	F (2,42,.05)
1.	Between groups	2	70.658	35.329	2.164	3.22
2.	Residual or Error	42	685.607	16.323	-	-
	Total	44	756.265	-	-	-

Table 5- One- Way ANOVA (5 % Level) for the comparison of A.R.I.

S. No.	Source of Variation	Df	Sum of Squares (S.S)	Mean S.S	F cal	F (2,42,.05)
1.	Between groups	2	4.5733	2.2867	2.0939	5.13
2.	Within groups	42	45.67	1.0921	-	-
	Total	44	50.44	-	-	-

Discussion

With the objective of researching for a superior orthodontic bonding material with reduced polymerization shrinkage, adequate bond strength and improved clinical handling properties, this study was undertaken to compare the newer modified materials like ormocers (Admira) and nano-fiiled composites(Grandio) with that of the traditional, popular and standardized bonding material (Transbond XT). The study also intended to evaluate the potential of Admira and Grandio as viable adhesives for bonding orthodontic attachments.

Reynolds J.R [9] advocated ,that clinically, bonded brackets should exhibit adequate bond strength in the range of 5.9 to 7.9 Mpa in order to withstand forces generated by treatment mechanics, occlusion and masticatory stresses. Simultaneously, it is imperative that the brackets should debond without causing damage to the enamel structure. Since the 1975 report [9], a large number of publications have cited this conclusion, to the point that the 6-8 MPa force level has become a de facto standard in laboratory bond strength testing procedures. Studies conducted by Olsea E.M , Damon P , Graenlaw R and David C.W [10,11,12,13,14] endorsed the S.B.S. of Transbond XT to be in the range of 5.3 to 19.3 Mpa . In the present study, Transbond XT exhibited a shear bond strength of 8.50±5.22 Mpa at 0.5mm/min of cross head speed and was considered the benchmark for comparing the newer bonding adhesives being evaluated.

The shear bond strength of Grandio in the present study was found to be 8.13+ 4.35 MPa . The S.B.S. value of Grandio was comparable with that exhibited by the benchmarked material (Transbond) in the current study. This provides validity (based on bond strength values) to consider Grandio as one amongst the orthodontic bonding adhesives with clinical viability.

Admira adhesive paste in the as received condition has a high viscosity .This property necessitates it to be forcibly pushed into the bracket base during the bonding procedures. This has been cited as a disadvantage leading to increased incidence of bracket failure[7]. Zachrisson and Artun[8] set precedence by pre diluting the viscous paste of restorative Concise with an appropriate proportion of Concise liquid to enhance the handling properties of the material and achieve a viable composite resin for bonding orthodontic attachments. Similarly, in the current study, Admira was diluted (prior to bonding) by adding 1 drop of Admira liquid resin to 1 gram of Admira paste on a mixing pad for enhancing the clinical handling properties.

The SBS of Admira in the present study was 5.59 ± 1.91 MPa , which was the lowest amongst the three adhesives tested. This was in contrast to the study results by Bishara and Ajlouni[7] where the mean SBS of Transbond XT (4.6 ± 3.2MPa) was found to be lower than that of Admira (5.1±3.3 MPa).

The A.R.I. scores for the three materials tested at a cross head speed of 0.5mm/min indicated that the location of the bracket failure was at the adhesive itself .Though Admira had a higher frequency of bond failure site at the bracket -adhesive interface with the mean A.R.I. score of 2.66 ,there was no statistically significant difference amongst the groups. No previous studies have reported the evaluation of the A.R.I. scores of Grandio and Admira.

Advances in the field of material sciences is simultaneously linked with numerous laboratory testing procedures before the commercial availability of the material into clinical practice. The key focus areas invariably zoom into bond strength. The first goal in this process is to measure the debonding force and calculate the shear bond strength. The second goal is to observe the location of bond failures. Bond disruption is a clinician's nightmare during the period of orthodontic mechanotherapy, while it is an essential requirement at the end of treatment involving debonding and clean up procedures. The clinician has an array of orthodontic bonding adhesives flooded in the market with research providing valuable inputs on bond strength. Most

of the orthodontic adhesives are tested in-vitro on extracted human or bovine teeth as there are ethical and clinical issues involved with testing these materials in-vivo. However, it is difficult to correlate the results of in-vitro bond strength tests with clinical performance in totality as there is a lack of standardization in testing procedures and numerous factors may impact the results. A step toward improving the in-vitro studies of orthodontic bond strength would be to standardize test protocols and devices to achieve meaningful clinical research in orthodontic bonding.

Summary and Conclusion

In this study, when the shear bond strength of newer composite resins like Admira and Grandio were evaluated against Transbond XT at 0.5mm/min cross head speed of the Instron testing machine it was found that :-

1. Transbond XT, the gold standard for bonding of orthodontic attachments to teeth exhibited S.B.S. values which were in consonance with previous studies. This validated the benchmark used in this study.

2. Admira, an ormocer, (diluted 1:1) in the current study showed lower shear bond strength values when compared to Transbond XT and Grandio.The recommendations would agree with previous research[7] that for orthodontic use, the manufacturer should consider reformulating the composition into a thinner and more flowable paste that can readily penetrate the bracket mesh. Further research may be needed on Admira by optimizing values of its shear bond strength by testing with varied dilutions.

3. Grandio exhibited shear bond strength comparable to Transbond XT. Therefore it could be considered a viable alternative for bonding orthodontic attachments to teeth by virtue of its optimal shear bond strength .

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