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A comparative study of shear bond strength of five different commercially available composites

[1]Dr. Vishwanath Patil, Reader, Department of Orthodontics and Dentofacial Orthopaedics, H.K. E's S. N Institute of Dental Sciences and Research, Kalaburagi, Karnataka, India.

[2]Dr. Bhavani Aspalli, Post graduate student, Department of Orthodontics and Dentofacial Orthopaedics, H.K.E's S. N Institute of Dental Sciences and Research, Kalaburagi, Karnataka, India.

[3]Dr. Basanagouda C. Patil, Professor, Department of Orthodontics and Dentofacial Orthopaedics, H.K.E's S. N Institute of Dental Sciences and Research, Kalaburagi, Karnataka, India.

[4]Dr. Sudha R Halkai, Professor & HOD, Department of Orthodontics and Dentofacial Orthopaedics, H.K.E's S. N Institute of Dental Sciences and Research, Kalaburagi, Karnataka, India.

[5]Dr. Muhammed Faseehuddin, Post graduate student, Department of Orthodontics and Dentofacial Orthopedics, H.K.E's S. N Institute of Dental Sciences and Research, Kalaburagi, Karnataka, India.

[6]Dr. Anamika Jha, Post graduate student, Department of Orthodontics and Dentofacial Orthopaedics, H.K.E's S. N Institute of Dental Sciences and Research, Kalaburagi, Karnataka, India.

Corresponding Author: Dr. Bhavani Aspalli, Post graduate student, Department of Orthodontics and Dentofacial Orthopedics, H.K.E's S. N Institute of Dental Sciences and Research, Kalaburagi, Karnataka, India.

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Abstract

Aim: To compare and evaluate the shear bond strength of five different commercially available composites.

Methodology: 100 extracted premolar teeth were cleaned with distilled water to remove blood or any tissue debris. They were stored in saline to prevent bacterial contamination and dehydration. The teeth were then divided into following five groups i.e 3M composite, Ormco composite, Optifix composite, Enlight composite and Reliance composite. After division into five study groups, metal brackets were bonded on the tooth surface and Shear bond strength were evaluated for five commercially available composites. Data analysis was done using SPSS -21, IBM Inc.

Results: Results of the study showed that over all significant difference was observed in the shear bond strength of five study groups when compared using One way ANOVA as $p<0.05$.

Conclusion: All materials used in the study produced mean shear bond strength above the minimum value for a clinically effective orthodontic bond of 5.9–7.8 MPa, which suggests that all the materials tested can be clinically acceptable for bonding brackets to teeth.

Keywords: 3M, Bond Strength, Ormco, Optifix, Enlight, Reliance

Introduction

Dental composite resins are widely used in dental practice and are continually being developed to obtain better products. In 1955, Buonocore researched and developed an adhesion method by etching the surface of the enamel with 85% phosphoric acid for 30 seconds and then dropping a mixed acrylic resin onto the surface.[1] Composite resins were originally developed by Dr. 1960. Rafael Bowen is one of the most commonly used adhesives in orthodontics. A composite is any material composed of hard, siliceous, sand-like filler particles, surrounded by a hard matrix of second material that binds the filler particles together. [2]

Matrix materials generally start as a paste, powder, or liquid and begin to cure when activated by the addition of either a catalyst, water, or other solvent. Before it hardens, the matrix can be pressed into a mold. Resin composites are very popular in restorative dentistry because of their esthetic qualities. Orthodontic composites resins are similar to that of those used in restorative dentistry are used for cementing brackets and molar tubes etc.[3]

Orthodontic composites are generally photopolymerizable and release fluoride. These composites for orthodontics in syringe format or as paste in a cartridge. Orthodontic brackets are cemented either to labial or to lingual tooth surfaces acting as a medium for the delivery of forces applied by the arch wire and auxiliaries on the teeth. Among the factors contributing to the success of this procedure, the adhesive cements play a significant role.[4]

The adhesive cements used in order to bond brackets to dental surfaces are glass ionomer cements, resin modified glass ionomer cements and composite resins. Composite resins are gaining more and more ground in everyday orthodontic practice, due to their constantly improving physical and mechanical properties, handling characteristics and due to the simultaneous improvement of curing units, etching and bonding factors. [5]

In dentistry, bond strength is the amount of force required to break the connection between a bonded restoration and the tooth surface with the failure occurring in or near the adhesive/adherent interface.[6] Enamel conditioner and Primer solution are two primary factors affecting shear bond strength.

Adhesive strength value of total etching system and self-etching primer system. For these reasons, photoactivated orthodontic composite resins are increasingly being used to attach brackets to tooth enamel. These materials are so similar to the composite resins used in restoration dentistry that fluid composites are now used for bracketing instead of orthodontic composites. The high fluidity of the fluidity composite can be beneficial in mating the brackets for a better fit in the fixed area and in the area of demineralized enamel. In addition, fluid composites are usually cheaper than orthodontic composites, and their low modulus acts as an "elastic layer", preventing stress concentration at the tooth / bracket interface during photoactivation. Allows for better distribution of stress generated during occlusal movement.[7]

Since the introduction of Newman's adhesive process in orthodontic practice, constant efforts have been made to improve the quality of adhesive materials. The search is still in progress. The benefits of direct gluing include

benefits for both patients and physicians. Patients have a reduced risk of enamel demineralization, improved oral hygiene maintenance, less irritation to the gingival tissue, and improved aesthetics.[8]

For dentists, direct bonding eliminates pre-treatment tooth separation and reduces treatment time. Ideally, the bond strength needs to be optimum rather than too much or too less. Excessive bond strength increases the risk of enamel damage during debonding, and too weak bond strength results in frequent bond failures during the course of treatment.

According to Reynolds IR. the optimum bond strength should be in the range of 6 to 8 MPa. Rapid strides in material science over the years have produced progressively advanced materials making the direct bonding procedure more precise, comfortable and time effective. The most common method to evaluate adhesive properties of restorative materials is bond strength assessment. Therefore, the purpose of this study was to measure and compare the shear bond strength of various composite materials.[9]

Methodology

A total of five groups were taken: GROUP I- 20 specimens 3 M COMPOSITE GROUP II- 20 specimens Ormco COMPOSITE GROUP III- 20 specimens OPTIFIX COMPOSITE, GROUP IV- 20 specimens ENLIGHT COMPOSITE and GROUP V- 20 specimens RELIANCE COMPOSITE

A total of 100 extracted premolar teeth were cleaned with distilled water to remove blood or any tissue debris. They were stored in saline to prevent bacterial contamination and dehydration. The teeth were then divided into following five groups, and metal brackets will be bonded on the tooth surface for all the sample of all the study groups, the area where the composite was located was etched with 37% orthophosphoric acid for 30-60 seconds and then were washed with water. The enamel surface was then completely dried with compressed oil-free air. A layer of primer was applied on the tooth. Metal bracket was placed using 3M composite and press firmly against the tooth surface. Excess material was removed from around the base of the bracket, and the adhesive were light cured for 20 seconds following the manufacturer's instruction. The specimens were then mounted in acrylic block (Figure 1). A mounting was used to align the composite base to be perpendicular with the bottom of the mould and parallel to the force during the shear strength test.

Figure 1: The samples mounted on acrylic blocks

A Universal Testing Machine (Figure 2) was used to apply an occluso-gingival load onto the composite, which produces a shear force on the tooth-composite interface with a crosshead speed minimum of 3 mm/min. Chisel shape whose one phase is straight and the other phase has an angulation of 45^0 was used. The force in Newton were recorded for each specimen and divided by the surface area of the composite to obtain the shear stress value in Megapascals (Mpa).

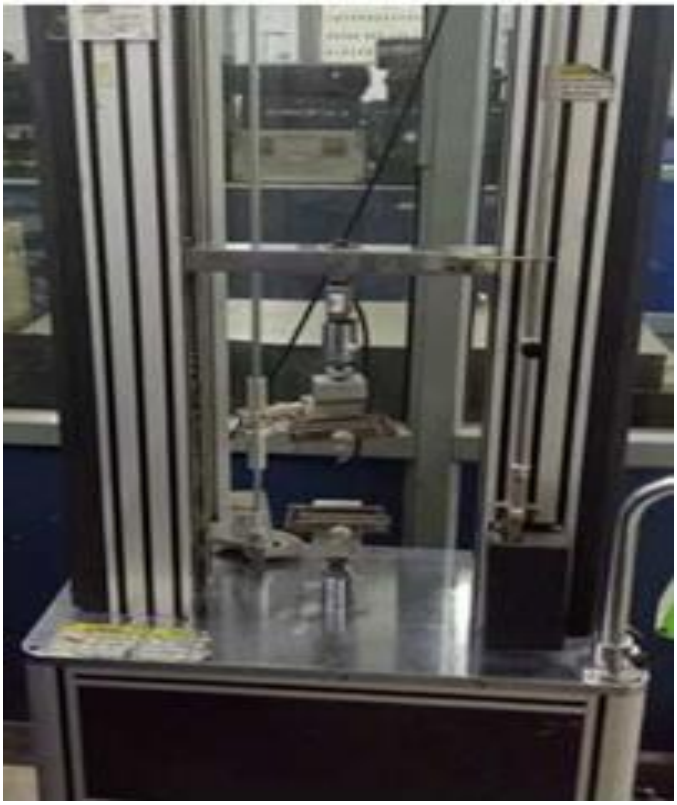

Figure 2: Universal Testing Machine

Data analysis: Data was analysed using Statistical Package for Social Sciences (SPSS) version 21, IBM Inc. Descriptive data will be reported for each variable. Descriptive statistics such as mean and standard deviation for continuous variables and frequency along with percentages of categorical variables were calculated. As Data was found to be normally distributed (p-value was more than 0.05) bivariate analyses was performed using one way ANOVA for inferential statistics. Level of statistical significance will be set at p-value less than 0.05

Results

Shear bond strength was found to be 10.83±1.12 Mpa in Group I samples, 8.24±1.11 Mpa in Group II samples, 10.09±1.54 Mpa in Group III samples, 9.27±1.00 Mpa in group IV samples and 11.27±1.48 Mpa in Group V samples. Over all significant difference was observed in the shear bond strength of five study groups when compared using One way ANOVA as $p<0.05$. (Figure 3). Post hoc pairwise comparison showed significant differences in Group 1 vs II, Group I vs IV, Group II vs III, Group II vs V, Group III vs V and Group IV vs V. Rest all the pairs failed to reach the level of statistical significance (Table 1).

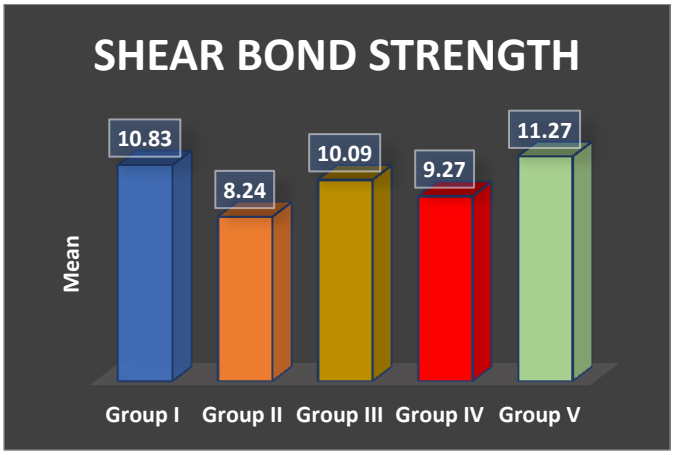

Figure 3: Groupwise distribution of shear bond strength

Table 1: Post hoc pairwise comparison using Tukey's test

Pairwise comparison of groups	Mean Difference	Std. Error	P value	95% Confidence Interval	
				Lower Bound	Upper Bound
Group 1 vs 2	2.59	.401166	.0001*	1.47721	3.70839
Group 1 vs 3	0.75	.401166	.344	-.36829	1.86289
Group 1 vs 4	1.56	.401166	.002*	.44921	2.68039
Group 1 vs 5	-0.43	.401166	.818	-1.54779	.68339
Group 2 vs 3	-1.85	.401166	.000*	-2.96109	-.72991
Group 2 vs 4	-1.03	.401166	.086	-2.14359	.08759

Group 2 vs 5	-3.03	.401166	.000*	-4.14059	-1.90941
Group 3 vs 4	0.82	.401166	.256	-.29809	1.93309
Group 3 vs 5	-1.18	.401166	.033*	-2.29509	-.06391
Group 4 vs 5	2.00	.401166	.000*	.88141	3.11259

Discussion

Thurmond et al.[10] reported that bond strengths higher than 13 MPa resulted in cohesive fractures on the porcelain surface. Retief DH et al.[11] also reported that melt fracture occurred when the adhesive strength exceeded 13.5 MPa. Various adhesives have been developed since the advent of Buonocore's acid etching technology and Newman's orthodontic bracket bonding. The first and most popular adhesive resin was the chemically curable adhesive system. The main drawback of self-curing adhesive systems is the inability to control the curing time of composite resins. Therefore, new composite materials with excellent properties have been developed. Shear bond strength (SBS) is one of the main factors to consider when designing fastener materials. The adhesive strength of the orthodontic bracket must be able to withstand the forces applied during orthodontic treatment. Therefore, this in vitro study was conducted.

Shear tests were used in this study for several reasons: First, the shear strength value is higher than the value obtained in the tensile test, so it is easy to determine. Second, shear stress is considered to be more representative of the clinical situation. Measurements of shear bond strength have been shown to be very sensitive to adhesive application methods and test assembly designs.[12,13] These factors can lead to misinterpretation of the resulting bond strength data. The Shear Adhesive Strength Test is a simple evaluation method used to test the adhesiveness of Barkmeier and Cooley dental adhesives. In vitro adhesive strength testing is useful and essential to predict possible correlations between adhesive system performance and clinical problems. Therefore, shear bond strength tests are performed using Instron, a traditional universal testing machine for assessing the adhesiveness of adhesives / repair materials.[14]

Results of the present study showed that shear bond strength is higher in the Reliance sample followed by the 3M composite. Optimal shear coupling was observed in the Ormco sample. Overall, this study showed that there was a statistically significant difference in the bond strength of the materials used. This was higher than the previous studies but was comparable to the studies of Tecco et al[15] (23.23 MPa ± 5.23 MPa), Atillio et al[16] (23.47 MPa ± 4.86 MPa), Rock and Abdullah (823 MPa)[17], Sinha et al (18.9 MPa)[18], Sunna et al[19] (1122 MPa) and Rix et al[20] (20.19 MPa). In a study conducted by Sharma et al[21], SBS of Transbond Plus with Transbond XT was 11.57 MPa which is found to be wery much similar to the Enlight composite used in present study. Findings of our study were found to be similar to Mondelli and Feitas[71] who conducted a study to assess the shear bond strength of the resin/bracket interface using three resin composites (Concise orthodontic, Transbond XT and Filtek Z250).

Valletta et al[22] also conducted a study on Ninety lower adult bovine incisors and orthodontic brackets were bonded using three adhesive systems: Concise, Transbond, and Fuji Ortho. Results of which showed that the difference between shear and torsion failure loads was statistically significant only for the Fuji GC sample ($P < 0.01$) Similar to our study, Verma G et al[23] in their study showed that in the normal light curing group, the shear strength ranged from 8.54 to 10.42 MPa

and in the field of compound of the double curing group, the shear strength ranges from 10.45 to 12.17 MPa. This shows that the shear strength of the double treatment group is significantly higher than that of the conventional light treatment group.

These results were also found to be similar in studies performed by Manabe A and Itoh K et al.[24]. A study by Heights et al. showed that the GIC group of glass-filled resins was not significantly different in shear strength compared with the Transbond control group. Mean shear bond strength of the glassfilled resin GIC group was 10.03 MPa and 11.36 MPa for the Transbond, which may be attributed to the hydrophilic sealant that is a combination of an unfilled resin sealant and Reliances Enhance Adhesion Booster (Reliance Orthodontic Products, Inc). Shear bond strength values of Reliance composite was found to be very much similar to the one obtained in the present study. No other studies of this material for bonding brackets were found in the literature making comparisons difficult.

The mean shear bond strengths of Enlight were 13.92 ± 3.92 MPa in a study conducted by Shaik et al which is slightly higher than the results obtained in the present study. Result of the present study also did not corroborate with the results obtained from Giannini and Franciscon et al, wherein the ConciseTM orthodontic composite appeared stronger than TransbondTM XT composite. An in vitro study by Verma et al was performed to evaluate the shear strength of Light cure and Dual cure Composite (Ormco). The results of their study showed that SBS of the conventional light curing group provided stronger shear strength than the double curing group, which is different from the results of the present study. In addition, Smith RT and Shivapuja PK[25], Newman GV[26] in their study found that SBS of conventional composites is better. The results of all of these studies were inconsistent with the results of this study. These differences may be due to the samples subjected to cyclic heat treatment at different test temperatures or to different compositions of materials used.

Contamination of enamel blood during bonding of conventional and hydrophilic primers significantly reduces the bond strength values and may produce clinically inadequate bond strength. Through this study, a clearer picture of the shear strength of new and conventional double-adhesive materials is obtained. When the five groups are compared, this study tells us exactly about the clinical performance of these five materials and also gives us insight into how they can be used in different situations. different clinical situations. Keeping these factors in mind, the use of dual-curing composite resins can be encouraged as an alternative to the bonding of orthodontic brackets. Hence it can be concluded that All materials used in the study produced mean shear bond strength above the minimum value suggested by Reynolds for a clinically effective orthodontic bond of 5.9–7.8 MPa, which suggests that all the materials tested can be clinically acceptable for bonding brackets to teeth.

No research comes without limitation. The laboratory assessment cannot predict clinical performance fully. As oral conditions are difficult to simulate in the laboratory, the results obtained should be interpreted with caution in the clinical practice and further clinical studies are necessary for validation and generalisability.

Conclusion

Hence it can be concluded that all materials used in the study produced mean shear bond strength above the minimum value which suggests that all the materials tested can be clinically acceptable for bonding brackets to teeth. Smaller sample size and study duration add to

limiting the generalizability of present research hence further studies with larger sample size are needed to generalize the results obtained from the present study.

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