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Evaluation of the shear bond strength of four orthodontic adhesive systems

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ABSTRACT

Aims: To evaluate shear bond strength of four types of orthodontic adhesive systems including two–paste composite (Concise), light–cured composite (Transbond), no–mix composite (Alpha–dent) and light–cured glass ionomer cement (Fuji), and to compare shear bond strength between these four types of orthodontic adhesive systems. **Materials and Methods:** Forty extracted premolars and forty stainless steel mesh edge–wise brackets were used. Each type of orthodontic adhesives were used for bonding of ten brackets according to its manufacturer instructions, after setting the brackets were debonded and the shear bond strength were measured using Instron testing machine. **Results:** Showed that the two–paste composite (Concise) and the light–cured composite (Transbond) gives the highest bond strength, the bond strength of the glass ionomer cement (Fuji) significantly lower than that of Concise and Transbond but it was remained within the accepted level for clinical use, the no–mix composite (Alpha–dent) showed very low shear bond strength which was below the accepted value for clinical application. **Conclusions:** Concise and Transbond have high bond strength so that it can be used to fix orthodontic attachment in areas subjected to high force. The bond strength of the glass ionomer cement (Fuji) remains within the accepted level for clinical use with the benefit of fluoride release. Also the shear bond strength of the no–mix composite (Alpha–dent) is very low makes it not suitable for clinical use.

Key Words : Shear bond strength, glass ionomer cement, orthodontic adhesives.

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INTRODUCTION

Since the advent of bonding brackets, clinicians and researchers have worked to improve the qualities of bonding agents. The qualities that have been of most interest include bond strength, working time, improved ease of use and the introduction of anticariogenic agents.[1]

The failure of a bonded orthodontic bracket during the course of therapy is not an uncommon occurrence[2], a bracket must resist a displacement force of at least 6–8 MPa for clinical success.[3–5]

Various bonding agents were developed after the introduction of acid etch. When phosphoric acid is applied to enamel, a selective dissolution of the hydroxyapatite crystals occurs, this dissolution produces microporosities into which a fluid monomer can penetrate when polymerized a micromechanical union between it and the enamel occurs[6], the union between an orthodontic bracket and resin is also a mechanical union.[7] The first and most popular bonding resin were chemical curing bonding system. A major drawback of the auto–cured adhesive system is the inability of the practitioner to manipulate the setting time of the composite resin. In the use of the light cure bonding system, the material is cured under metal–based brackets by direct illumination from different sides and by trans–illumination because the tooth structure transmits visible light. A rapid polymerization when visible light is applied the composite sets results in a nearly unlimited working time allowing more accurate bracket placement.[8]

There are other materials such as: glass ionomer cements, which due to their chemical composition can adhere chemically to enamel, to dentin, to non–precious metals, and to plastic[7], in addition to its fluoride release capacity over a period of months reducing the risk of enamel decalcification.[8]

Many studies were made to compare the bond strength of the different types of adhesives, King *et al*.,[9]reported that tensile or shear bond strength of self–cured resins (Concise and Right–on) were stronger than bond strength of light cure resins (Heliosit, Heliosit ortho, and Silix) with light exposure for 20,40 or 60 seconds. The significantly lower bond strength of the light cured resin associated with 1–hour suggested an incomplete initial polymerization of the material and question the placement of arch wire on the initial bonding appointment.[9] On the other hand Camda and Stein [10] stated that bond strength obtained with a light–cured resin (Transbond) at 2 minutes and 5 minutes after curing were significantly greater than those obtained by chemically–cured resin (Concise) at similar time periods. The bond strength obtained with a light–cured resin and chemically–cured resin increased with time.[10]

Aims of this study was to determine and compare shear bond strength of two–paste (Concise), no–mix (Alpha–dent), light–cured (Transbond) and glass ionomer cement (Fuji) adhesive systems.

MATERIALS AND METHODS

Forty extracted sound human upper premolars were used in the research. The teeth were extracted for orthodontic purposes, after extraction the teeth were cleaned from blood and debris and stored in distilled water at room temperature till the time of beginning of the research and throughout the period of the research to prevent the dehydration.[10,11]

Stainless steel mesh edge–wise brackets (manufactured by Lancer Orthodontics, USA) were used, each bracket has a surface area of 10.08 mm^2.

Four types of orthodontic adhesives were tested in this research including chemical–cured (Concise), light–cured (Transbond, 3M Unitek Orthodontic Products, USA) , no–mix composites (Alpha–dent, ,Alphadental Products Co., USA) in addition to light–cured glass ionomer cement (Fuji, GC Corporation, Japan).

Mounting of the teeth was carried out on a glass slap fixed on a dental surveyor parallel to the horizontal plane, the teeth were fixed in the center of a plastic ring using a small piece of wax at the root apex in such away that only the crown of the tooth protruded out side the ring and the middle third of the buccal surface of the crown parallel to the analyzing rod of the surveyor. Then dental stone was poured around the tooth to fix it in the plastic ring.

The teeth were prepared for bonding by polishing of the buccal surface using non–fluoridated pumice and rubber caps for 10 seconds, washed by water for 30 seconds then dried with air.

The middle third of the buccal surface of each tooth was etched for 30 seconds using 37% phosphoric acid gel [12,13], then washed for thirty seconds and finally dried for 20 seconds, after dryness the buccal enamel surface showed chalky appearance. The chemical–cured composite (Concise) were mixed according to manufacturer instructions and applied to the bracket base, then the bracket seated at the middle third of the buccal surface of the crown and pressed by finger, excess material then removed using dental probe.

The light–cured composite applied at the bracket base, the bracket seated at the middle third of the buccal surface of the crown, pressed by finger and then the excess removed by using dental probe, after that the composite cured from the mesial and distal sides of the bracket for 10 seconds at each side using light curing unit (Coltolux 50). The glass ionomer cement were mixed according to manufacture instruction and used to fix the brackets in the same procedure as light –cured composite.

For the no–mix group the liquid were applied to the etched enamel and the bracket base, then the paste was placed on the bracket base, after that the bracket was seated at tooth surface, pressed and the excess adhesive removed using dental probe.

After complete setting of all adhesives the brackets were separated from teeth using Instron testing machine [10,14] (Evanston, USA) the head of the rod of the machine applied at the interface between the bracket and the tooth in such away that the long axis of the rod parallel to the middle third of the buccal surface of the crown. The sample were tested at cross head speed of 0.5 mm/min in occlusogingival direction, when the bracket was sheared from the tooth the ultimate magnitude of the reading was taken in kilogram.

The data were subjected to statistical analysis to determine the differences in shear bond strength among the different adhesives, this include descriptive statistics (mean, standard deviation, minimum and maximum), analysis of variance(ANOVA) and Duncan's multiple rang test to determine f–ratio at $P \leq 0.05$ significance level among the different adhesives.

RESULTS

Table (1) showed descriptive statistics of the shear bond strength values in term of mean, standard deviation, minimum and maximum for the different types of adhesive systems, we can notice that the two paste system (Concise) showed the highest mean value followed by the light–cure composite (Transbond) then the glass ionomer cement (Fuji) and finally the no–mix (Alpha–dent) that showed the lowest shear bond strength.

Table (1): Descriptive statistics of the shear bond strength for the four types of adhesives

Group	Mean $\pm$ SD	Minimum	Maximum
two–paste (Concise)	10.970 $\pm$ 2.235	7.526	14.141
light–cured (Transbond)	10.537 $\pm$ 2.089	5.702	12.544
glass ionomer (Fuji)	8.598 $\pm$ 2.380	5.474	11.860
no–mix (Alphadent)	3.968 $\pm$ 1.673	2.737	7.754

Measurements in MPa.

Tables (2,and 3) demonstrated analysis of variance, and Duncan's multiple rang test respectively which showed that there were significant differences in shear bond strength for the investigated various adhesive systems.

There was no significant difference in shear bond strength between the two–paste system (Concise) and the light–cure adhesive system (Transbond) at $P \leq 0.05$ level, the shear bond strength of the glass ionomer cement (Fuji) was significantly lower than that of Transbond and Concise at $P \leq 0.05$ level, the shear bond strength of the no–mix adhesive (Alpha–dent) was found to be significantly lower than that of the three previous types at $P \leq 0.05$ level.

Table (2): ANOVA test between the different adhesives

Source of variance	DF	Sum of square	Mean square	F–value	*P*-value
Adhesive	3	307.975	102.658		
Error	36	160.487	4.457	23.03	0.0001
Corrected total	39	468.463			

Df: Degree of freedom

Table (3): Duncan's multiple rang test demonstrate the differences between the groups

Group	Number of sample	Mean(MPa)	Duncan's groups*
two–paste (Concise)	10	10.970	A
light–cured (Transbond)	10	10.537	A
glass ionomer (Fuji)	10	8.598	B
no–mix (Alphadent)	10	3.968	C

Different letters mean significant difference at $p \leq 0.05$

DISCUSSION

The results of this research showed that the two paste composite (Concise), light–cured composite (Transbond) and the glass ionomer cement (Fuji) provide bond strength higher than the clinically adequate shear bond strength (6–8 MPa) as reported by Reynolds and Martin and Gartia.[3,5]

This was in agreement with Mustafa[14], Alexander *et al* [15] in their work on chemical–cure composite adhesive and with Sargison *et al*., [16] Mustafa and Abu Al Naaj [14,17] for light–cured composite (Tranbond) and with Newman *et al*., [1] Cacciafesta *et al*., [18] and Al–Ibrahhim [19] in their work on glass ionomer cement.

The no–mix adhesive (Alpha–dent) showed very low shear bond strength not reach to the accepted level for clinical use, this result disagreed with the results obtained by Mustafa [14] and Abu Al Naaj[17] and this difference due to the different types of the no–mix adhesive (Right–on and Brackfix) used in their studies.

In Table (3) for comparison of shear bond strength between the four types of adhesives, no significant difference was found between the two paste adhesive (Concise) and the light–cured adhesive (Transbond). This result was in agreement with Trimpeneers *et al.*[20] and Mustafa [14], on the other hand Toledano *et al.*[8] found higher shear bond strength for two paste adhesive.

The shear bond strength of the glass ionomer cement (Fuji) was lower than that of the two paste adhesive (Concise) and was agreement with Toledano *et al.*[8], Newman *et al.*,[1] Al–Ibrahhim [19] and Knox *et al.*[21]; Also the shear bond strength of the glass ionomer cement (Fuji) was lower than that of the light–cured composite (Transbond), this was in agreement with Toledano *et al.*[8], Trimpeneers *et al.*[20] and Larmour and Stirrups[22]. Although the glass ionomer cement (Fuji) showed lower shear bond strength than the self–cured and light–cured composite but it was higher than that of the no–mix composite (Alpha–dent) and remaind with in the accepted clinical value with the advantage of fluoride release to decrease enamel demineralization and white spots formation.

The no–mix composite (Alpha–dent) showd low shear bond strength which was significantly lower than that of the two–paste adhesive (Concise), this result came with an agreement of Mustafa's results [14], on the other hand Smith and Shivapuja [23] found that the no mix composite adhesive (Unite and Right–on) had higher shear bond strength than the two–paste composite (Concise) this different result due to the type of the no–mix adhesive used.

The shear bond strength of the no–mix composite (Alpha–dent) was significantly lower than that of the light–cured composite (Transbond), this was agreed with Sunna and Rock [24] who stated that Transbond had a significantly higher bond strength than Right–on. Mustafa[14] found no significant difference in shear bond strength between light–cured (Transbond) and no–mix (Right–on) adhesives.

CONCLUSIONS

Concise and Transbond had high shear bond strength so that it can be used to fix orthodontic attachment in areas subjected to high force.

The bond strength of the glass ionomer cement (Fuji) was significantly lower than that of Concise and Transbond but it remains with in the accepted level for clinical use with the benefit of fluoride release.

The shear bond strength of the no–mix composite (Alpha–dent) was very low makes it not suitable for clinical use.

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