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Comparison of Shear Bond Strength of Stainless Steel Brackets Bonded with a Resin Reinforced Glass Ionomer Cement and Adhesive Containing Amorphous Calcium Phosphate-An in Vivo Study

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Abstract: ***Direct bonding revolutionized orthodontic therapy and resin-based adhesives gained the most popularity as a direct bonding agent. However, resin-based composite adhesive systems involve certain amount of enamel demineralization due to the acid etching step involved. Glass ionomer cements (GICs) and amorphous calcium phosphate (ACP) containing resin composites were introduced to overcome this disadvantage but the variability in the bond strengths of these materials have always been topics of discussion. This study was conducted to measure the bond strengths of these materials under in-vivo conditions. Brackets were bonded in vivo using split mouth random technique in 12 patients. The first premolars from the first quadrant, taken as the control group (group1) were bonded with Transbond XT while first premolars from the second and third quadrant were bonded with Aegis Ortho (ACP containing adhesive) and Fuji Ortho light cure(Resin-modified GIC) adhesive respectively. Teeth were extracted after 30 days using periotom to avoid contact with the brackets. An instron universal testing machine was used to measure the shear bond strength at a crosshead speed of 5mm/min. The results of the study were subjected to statistical analysis. Analysis of variance (ANOVA) was used to find the significance of the three study groups and Post-hoc test was used to find the pair wise significance between the three groups. Mean results and standard deviations for the groups 1, 2 and 3 in MPa were 17.15± 7.14, 5.59±3.07 and 12.47±4.02 respectively. ANOVA test revealed a significant difference between the three groups (P<0.001). Group 1 was significantly different from group 2(P<0.001) while group 1 and 3 showed only a difference of suggestive significance (P=0.074+). Groups 2 and 3 also showed significant difference from each other (P=0.006)). This study concluded that the bond strength of Fuji ortho LC was less than Transbond XT but significantly higher than ACP containing adhesive. Aegis ortho had shear bond strength higher than that recommended by Reynolds required for orthodontic bonding. Aegis Ortho and Fuji Ortho LC is potentially adequate for orthodontic bonding needs.***

1. Introduction

Direct bonding of attachments revolutionized the world of fixed orthodontic appliances in the late 90s. The advantages offered by bonding over banding were numerous in almost all aspects, especially in terms of operator convenience and chair side time. Use of bonding led to the elimination of the need for closure of band spaces, maintenance of arch perimeter, improved esthetics, and better oral hygiene. The pioneering work of Buonocore, Bowen, Wilson, and Tavas made this valuable improvement in bonding technique. These researchers were instrumental in developing procedures and materials that have led to present-day standards in orthodontic adhesives. Acid etching, composite resins, glass ionomer cements (GICs), and visible light-curing adhesives have evolved from these early efforts (**S.E.Owens 2000**)

Buonocore advocated the use of phosphoric acid etching to improve the adhesion of acrylic resin filling materials to enamel as early as 1955. This procedure involves dissolution of the organic component of the enamel matrix, creating microporosities in the enamel surface. Etching increases the wettability of the surface and facilitates the penetration of the resin into the enamel to form resin tags, there by a mechanical bond is formed between the resin adhesive and the tooth. Bisphenol A glycidyl dimethacrylate, more commonly known as Bowen's resin or bis GMA, was patented in 1962 and is a diacrylate resin. This resin is an acrylic-modified epoxy resin, combining the setting versatility of acrylic and the strength and dimensional stability of epoxy. The eventual addition of filler particles to these resins to form composites greatly enhanced the strength of this material.

Tavas and Watts first described the use of visible light to cure composites used in orthodontic bonding in 1979. In 1983, Newman et al investigated the depth of polymerization in teeth using a combination of 11 visible light-cured composite resins and 8 visible lights. He found large variations among the abilities of different light sources to polymerize the various light-cured composite resins. Read (1984) described the use of a single paste, glass-filled resin that was catalyzed by visible light at a wavelength of 440–480 nm. The catalyst consisted of an alpha-diketone and an amine. The activator light was filtered to eliminate all but visible light, and this was transmitted by a quartz rod. Other single paste, light-cured, quartz-filled composite resins have been described that absorb blue light in the 420 to 450 nm range, which initiates polymerization. Visible light-cured composites provide ease of use, extended working time, improved bracket placement, easier cleanup, and faster cure of the composite.[1]

The use of resin- based adhesive has become the most popular method of bonding in orthodontics. The major drawback while using resin-based adhesive is decalcification of tooth enamel around orthodontic brackets. This appears as white spot lesions on the enamel surface as a result of organic acids produced by cariogenic bacteria housed in retained areas of dental plaque. Decalcified lesions may become irreversible and lead to cavitated lesions. Although

fluoride mouth rinses are efficient in reducing enamel demineralization, the patient's cooperation is essential. Advancements in orthodontic adhesive materials serve as one possible avenue to prevent this occurrence.

The ideal bonding material should release fluoride, thereby reducing these unfavorable iatrogenic effects of orthodontic therapy. Several in-vitro studies examined the fluoride release of fluoride-containing adhesives. The success of fluoride as a cariostatic agent can be attributed to at least 2 separate functions: a bacteriocidal effect at higher concentrations and the ability of fluoride to aid in remineralization by shifting solution thermodynamics to favor the formation of fluorhydroxyapatite, which is less soluble to an acidic challenge than hydroxyapatite[7]. Hence glass ionomer cement, which have the dinstinct advantage of fluoride release has been suggested in orthodontic bonding
Wilson and Kent introduced glass polyalkenoate, or GIC, to dentistry in 1972. GIC contains a powder similar to that of silicate cement and a polyacrylic liquid similar to that of polycarboxylate cement. It bonds chemically to enamel, cementum, dentin, nonprecious metals, and plastics. The dry field necessary for composite bonding is not necessary for this type of cement. Early GICs consisted of glass powder, a concentrated solution of polyacrylic acid, or a glass powder blended with polyacrylic powder, which was mixed with diluted tartaric acid or water. Despite the advantages of glass ionomer cements, they have some short comings with respect to bracket bonding. Studies reported poor bracket bond strength with glass ionomer cements in the range of 2.4 to 5.5 MPa

In response to the demand for improvement of the original product, Antonucci et a introduced resin modified glass ionomer cements (RMGICs) in 1988. Light activated RMGICs were formulated to overcome the problems of moisture sensitivity of composites and low early mechanical strength of glass ionomers while maintaining the clinical advantages of conventional glass ionomers. A small amount of resin in addition to a photoinitiator was added to conventional GIC. The development of lightcure resin modified glass ionomer cement (RMGIC) has allowed the clinical orthodontist to take advantage of the positive features of conventional glass ionomers, combining them with the mechanical and physical properties of composites, controlled setting reaction, greater initial strength and hardness, increased working time and reduced sensitivity to moisture.[1]

However, another mechanism can also favor remineralization dynamics: amorphous calcium phosphate (ACP)-filled methacrylate composites have demonstrated the potential to remineralize carious enamel lesions. Skrtic et al demonstrated that ACP-filled polymers can release supersaturated levels of calcium and phosphate ions in proportions favorable for the formation of hydroxyapatite over an extended period of time. Soon after, in 2004, the first commercially available ACP-containing orthodontic resin cement received Food and Drug Administration approval. The potential benefit of this material in orthodontics would be due to ACP remineralization technology, a novel approach and a departure from the many fluoride-containing resin-based materials in dentistry. Studies **(Antonucci et al 1994)** demonstrated the remineralization potential of ACP-containing materials. However, as to our knowledge, no in vivo studies have been performed to investigate their bond strength as orthodontic bracket adhesives. The purpose of this in-vivo study was to compare the shear bond strength of orthodontic brackets to enamel by using a commercially available orthodontic adhesive containing amorphous calcium phosphate (ACP) with resin-modified glass ionomer cement.

2. Materials and Methods

1) Teeth
The study included twelve patients undergoing orthodontic treatment for correction of malocclusion in whom the first premolar extraction was indicated. Patients were informed about the procedure and their consent was obtained. Age, sex and racial differences were ignored. Thirty six premolars from twelve patients indicated for extraction during orthodontic treatment were used for the study. Teeth from first, second and third quadrants were selected for the study. All teeth were bonded with stainless steel brackets in-vivo. The selection criteria includes,

a) Teeth with good morphology
b) Intact buccal enamel surface
c) Devoid of any developmental defects
d) Caries free

2) Brackets:
Thirty six stainless steel orthodontic brackets with .022 slots (Maxillary and mandibular first premolar- MBT brackets, Gemini, 3M Unitek^{R}, USA) were used in the study.

3) Adhesives:
a) Composite resin adhesive− Transbond XT− (3M Unitek company, Monrovia, California, USA)
b) Amorphous Calcium Phosphate containing adhesive – Aegis Ortho (Harry J. Bosworth company, Skokie, III)
c) Resin-modified glass ionomer cement – Fuji Ortho LC (GC America, Inc, Alsip, III)

4) Primer used in the study
Light cure conventional/hydrophobic orthodontic bonding primer (Transbond XT− 3M Unitek, U.S.A).

5) Etchant
37% phosphoric acid.

6) Prophylaxis paste
Pumice.

7) Thymol 0.1%(wt/vol)

Equipments

1) Light curing unit:
The curing light used to initiate polymerization from the source is 3M halogen light curing unit (3M, USA) .
Specification of light curing unit:
Light intensity**:** 400-999mW/cm2
Output wavelength**:** 400-500nm

2) Aluminium jig:
An aluminium-mounting jig was fabricated with the dimensions-120mm (L) x 47mm (B) and 4mm thickness, to place the samples and hold it during the test.

3) Plastic (PVC) rings for mounting the premolars
20 mm diameter PVC rings with 25mm height were used, and the premolars with bonded brackets were embedded in the self cure acrylic resin.

4) Instron universal testing machine (UTM):
An Instron Universal Testing Machine (33R 4467) was used to assess the shear bond strength of the brackets.

5) Surgical instrument
Periotome.

6) Rotary hand piece for polishing
7) Contra angle NSK slow speed handpiece MNL-1 with max 25,000rpm

3. Methodology

Twelve patients undergoing orthodontic treatment at Dr.Dentalmulti speciality hospital, indicated for extraction of all first premolars were selected. First premolars of first, second and third quadrant were grouped into three groups using split mouth technique and brackets were bonded invivo by a single operator. 36 premolars were grouped into three groups of 12 premolars each. Informed consent was obtained from each patient.

3.1 Bonding Procedure

Prior to bonding, buccal surfaces of all the premolars involved in the study were polished using a prophylaxis paste with a dental rotary hand piece and rubber cup at slow speed for 5 seconds, then thoroughly irrigated with a stream of water for 10 seconds and then dried with oil free compressed air. Etchant containing 37% phosphoric acid gel was then applied to the cleaned area of the tooth for 15 seconds, then rinsed with water for 20 seconds and dried with oil free compressed air for 10 seconds. The tooth in group 3 were left moist to remain in compliance with the recommended bonding protocol of the manufacturer.

36 premolars were grouped into 3 groups of 12 teeth each.

Group I (control)
First premolars of quadrant I were used for group I. After etching a thin layer of Transbond XT light-cured primer was applied to the tooth and light cured for 10 seconds. Transbond XT adhesive was applied to the bracket base, and the bracket was placed on to the tooth in the center of the crown, with the center of the bracket over the long axis of the tooth. The excess adhesive was removed with a hand instrument, and the bracket was cured for 10 seconds each from the distal, mesial, incisal and gingival aspects.

Group II
First premolars of the second quadrant were used in the second group. After etching, a thin layer of ACP-containing orthodontic adhesive (Aegis Ortho, Bosworth Co.) was applied to the base of the bracket and bracket was placed on the center of the crown with the center of the bracket over the long axis of the tooth. Then the bracket was photopolymerized for 10 seconds each from mesial, distal, incisal and gingival aspects.

Group III
After etching, first premolars of the third quadrant were bonded with resin-modified glass ionomer cement (Fuji Ortho LC, GC Corp. Japan). Etched enamel surface was kept moist for better result. Optimum level of surface moisture was obtained by wiping the bonding surface of the teeth with a moistened cotton roll immediately prior to bracket bonding. GIC was mixed with powder liquid ratio of 3:1. Homogenously mixed GIC was applied to the bracket base and the loaded bracket was placed firmly in contact with the tooth and the flash was removed. Light curing was done 10 seconds each from mesial, distal, incisal and gingival aspects.

Extraction
The bonded premolars were maintained in the mouth for at least 30 days before extraction. Teeth were extracted using surgical elevators and periotome to prevent debonding of brackets by forceps application during extraction.

Storage
The extracted premolars were washed and stored in a solution of 0.1% (wt/vol) thymol.

Preparing the Samples for Testing
After collecting all the specimens, premolars were mounted in plastic (PVC) rings with self cure acrylic. A mounting jig was used to place the samples such that each tooth was oriented with its labial surface parallel to the debonding force.

Testing Apparatus
A Universal Testing Machine (Instron) was used to apply a load to the bracket, which produced a tensile force at the tooth-bracket interface. A crosshead speed of 5mm/min was used to debond the brackets. The jig holding the tooth for shear test was positioned so that the force was applied to the bonded bracket parallel to the buccal surface of the tooth. A wire loop was made using 0.030 inch diameter braided stainless steel wire and the ends of the wire were gripped in the upper jaw of the Instron machine and passed under the tie wings. The cross head moved at a uniform speed of 5mm/min. The load was progressively applied till the bracket got debonded from the tooth surface. A computer connected to the machine recorded the results in kilogram-force for every specimen and then converted into Megapascals (MPa) using the following formula.

$$\text{Shear bond strength in Megapascals} = \frac{\text{force in Newton}}{\text{surface area of brackets in mm}^2}$$

1 kgf = 9.81 N

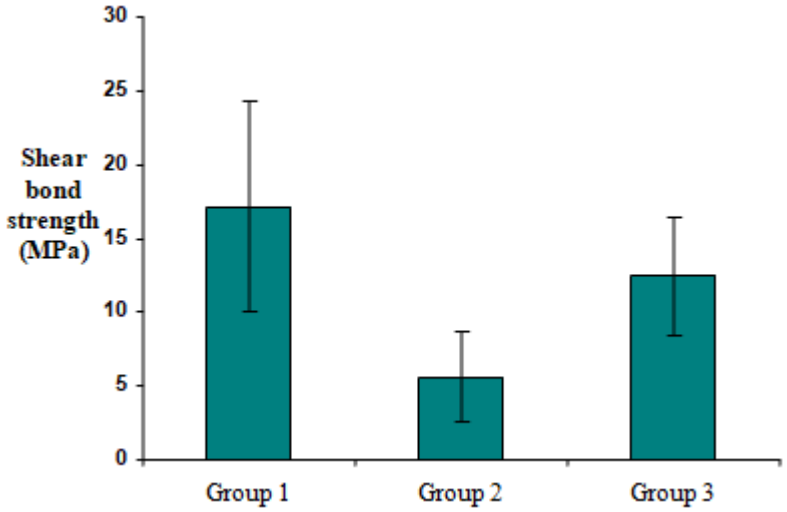
The surface area of each bracket (first premolar Gemini 3M Unitek^{R}) used was 10.61mm^2. All the results obtained were subjected to statistical analysis.

4. Results

Table 1 shows complete tabulation of the results of the shear bond strength assessed in the 12 samples of each of the three groups. The mean, standard deviation, minimum/maximum, and range of shear bond strengths for the three groups are displayed in Table 2. Graph 1 is the Bar graph depicting the shear bond strength in MPa. Group 1 had mean shear bond strength of 17.15± 7.14 while Group 2 and Group 3 showed mean shear bond strengths of 5.59±3.07 and 12.47±4.02 respectively. ANOVA test revealed a significant difference between the three groups (P<0.001). Table 3 shows the pair wise comparison of shear bond strength (Mpa) between the three groups Group 1 was significantly different from group 2(P<0.001) while group 1 and 3 showed only a difference of suggestive significance(P=0.074+). Groups 2 and 3 also showed significant difference from each other (P=0.006)).

Table 1: Shear bond strength of samples in three groups(MPa)

Shear Bond Strength in Mpa			
Samples	Group 1	Group 2	Group 3
1	21.554	1.560	10.567
2	15.110	6.950	12.653
3	8.671	5.686	9.776
4	20.446	0.750	17.591
5	7.681	8.087	17.867
6	5.140	0.518	11.061
7	26.124	9.306	11.701
8	21.773	8.942	17.639
9	22.140	5.930	11.303
10	11.783	6.817	5.907
11	21.646	7.317	16.169
12	23.852	4.955	7.481



Graph 1: Bar graphs depicting the shear bond strength in MPa

Table 2: Comparison of Shear bond strength (MPa) in three groups

	Range	Mean ± SD	95%CI
Group 1	5.14-26.12	17.15±7.14	12.62-21.69
Group 2	0.52-9.31	5.59±3.07	0.88-7.51
Group 3	5.91-17.87	12.47±4.02	1.16-9.92
ANOVA test	F=15.973; P<0.001**		

Table 3: Pair wise comparison of shear bond strength (Mpa)

	Difference	P value
Group 1-Group 2	11.59	<0.001**
Group 1-Group 3	4.69	0.074+
Group 2-Group 3	6.91	0.006**

Significant figures
+ Suggestive significance (P value: 0.05<P<0.10)
* Moderately significant (P value:0.01<P ≤ 0.05)
** Strongly significant (P value : P≤0.01)

Statistical Methods

Descriptive statistical analysis of the data has been carried out in this study using the statistical software namely SAS 9.2, SPSS 15.0, Stata 10.1, MedCalc 9.0.1 ,Systat 12.0 and R environment ver.2.11.1 and Microsoft word and Excel were used to generate graphs, tables etc.. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5 % level of significance. The following assumptions on data is made,

1) Dependent variables is normally distributed
2) Samples drawn from the population is random
3) Cases of the samples is independent

Analysis of variance (ANOVA) was used to find the significance of the three study groups and Post-hoc test was used to find the pair wise significance between the three groups.

5. Discussion

Direct bonding with resin-based adhesives has become the most popular method and the clinical standard for attaching orthodontic brackets to the teeth. However, resin-based composite adhesive systems involve some form of acid etching with subsequent loss of enamel during this etching procedure leading to decalcification and white spot lesions around the bracket**(William.J.D 2007)** Because of this, glass ionomer cements (GICs) and amorphous calcium phosphate (ACP) containing resin composites have been suggested as other alternative bonding agents to prevent decalcification and white spot lesions but their bond strength has been an area of concern. Bond strength is the physical parameter that is of prime importance in orthodontic treatment for success and efficiency. Reynolds(1975) stated that

successful clinical bonding requires adhesives giving in vitro tensile bond strengths of 4.9 MPa or more.

With regard to bond strength, light cured resin cement like Transbond XT has proven itself to be the standard adhesive. Numerous studies have shown that, in clinical situations, this adhesive attains high bond strength(**Juliana G.B 2006**)The success of this material has been so profound that numerous studies have considered using the bond strength of Transbond XT as control while evaluating the adequacy of the bond strengths of other adhesive materials. However these resin cements do not tolerate moisture and resin cement bond failures are often a result of moisture contamination during bonding procedures. It would be desirable to find a material that achieves bond strengths comparable to those of the resin cements while still tolerating moisture during bonding procedures.(**Rudolf et al 2002)**

The bond strength of resin modified GIC (RMGIC) has been a topic for research and discussions as numerous studies have shown conflicting results regarding the presence of moisture required for bonding and whether or not, conditioning of the tooth is required for this. Because glass ionomer cements adhere to tooth surfaces by a chemical mechanism**,** it has been suggested that etching of enamel is not required to achieve a micromechanical bond. **Cook and Youngson(1988) and Tavas and Salem (1990)**found that pretreatment of enamel with polyacrylic acid did not improve the bond strength of glass ionomer cements while **Powis(1982**)reported that pretreatment of enamel surfaces improved the magnitude of adhesion of glass ionomers to enamel. **Bishara et al(1998)**concluded that when the enamel was unetched, the shear bond strength of RMGIC was reduced by half, and this bond strength might not be enough for clinical use. We have used 37% phosphoric acid to etch the enamel before using Fuji Ortho LC (RMGIC) to bond the brackets.

The scientific literature shows conflicting reports regarding the moisture requirement while using RMGIC for bonding. Some studies have shown that humidity does not reduce the bond strength of this material (Caccifrta 1998) Others have reported that humidity even increases it(**Douglas 2001).**Jobalia et al(1997) reported that RMGIC needs a moistened environment to achieve acceptable bond strength, but **Chung et al(1999)** reported that this material needs dry enamel to obtain clinically acceptable bond strength. Although **Valente et al(2002**) reported that under wet conditions an acceptable bond strength with Fuji Ortho Light Cure (FOLC) was achieved when there was a previous enamel etching, regardless of the acid used or concentration, **Flores et al(1999) and Graf and Jacobi(2000),** in agreement with this study, verified that the maximum bond strength was achieved when the enamel was pretreated with 37% phosphoric acid. According to **Bishara et al(2000)** when the acid concentration is increased, the bond strength is also increased. This happens because 37% phosphoric acid produces a rougher enamel surface, thus facilitating the penetration of Fuji Ortho Light Cure (FOLC) resin. Owens and Miller verified that Fuji Ortho Light Cure yielded significantly lower bond strength values when compared with Transbond XT in dry enamel conditioned with 37% phosphoric acid. In certain clinical situations like when bonding brackets in areas of difficult access with salivary and water contamination or when decalcifications can be anticipated, transbond XT may not be the best choice and resin-modified glass ionomers may be a valuable alternative to composite resins because of the properties that include fluoride release, anticariogenic effects, biocompatibility, and chemical adhesion to enamel without the need of acid etching.

Bezerra et al(2006) reported that the presence of saliva does not significantly decrease its bond strength. **Itoh et al(1999)** compared the effects of saliva and water contamination on the bond strength and found that saliva had a less deleterious effect on bond strength than water. According **to Mojon et al(1996),** this happens because some components from natural or artificial saliva protect the cement cure reaction and compensate for the deleterious effects of the water contained in saliva. Our study revealed that, in in-vivo conditions, there was only a slight difference (P value =0.074) in the bond strengths of Fuji Ortho Light Cure (12.47±4.02) and resin composite(17.15±7.14) which is quite adequate enough for regular clinical use. It had a significantly higher bond strength (P value =.006) than amorphous calcium phosphate (ACP) containing adhesive. Transbond XT has been found to have a superior bond strength to Fuji Ortho LC in the majority of studies that have investigated them together. These same studies concluded that Fuji Ortho LC exhibited sufficient bond strength to be used as an orthodontic adhesive.

From the in vitro study, Foster et al found that Transbond XT (15.2 ± 3.6 MPa) showed significantly (P<0.001) higher shear bond strength than Fuji Ortho LC (8.3 ± 2.8 MPa). Summers et al(2004) noticed similar findings of significant differences (P<0 .05) between the composite resin adhesive, Light Bond (18.46±2.95 MPa) and Fuji Ortho LC at 24 hours. Owens et al found that Fuji Ortho LC had significantly lower (P<0 .05) mean shear bond strength than Transbond XT.

On the other hand Bezerra et al found that there were no significant differences between the shear bond strength of Transbond XT and Fuji ortho LC when it is used with 37% phosphoric acid pretreatment, even though Fuji Ortho LC showed lower shear bond strength**. Cacciafesta et al(2003)** also found that there was no significant difference between FOLC's bond strength and that of transbond XT when using 37% phosphoric acid. Valente et al reported that acceptable bond strength with Fuji Ortho Light Cure was achieved when there was previous enamel etching under wet conditions which was comparable to the shear bond strength of Transbond XT. **Toledano et al(2003)** had findings that were in agreement to this. Our study revealed that even though the shear bond strength of Fuji ortho LC was less than that of Transbond XT, there was no statistically significant difference between these values.

Aegis Ortho is the first bonding system to incorporate amorphous calcium phosphate (ACP) in its formulation. ACP is a precursor in the formation of hydroxyapatite and, when incorporated into a composite resin, provides sustained release of calcium and phosphate ions, promoting or

enhancing the remineralization process of enamel that has been challenged by acid and it also reduces the risk of smooth-surface caries activity. The reduction in recurrent caries and enamel demineralization adjacent to orthodontic brackets bonded with adhesive containing ACP could be compared to the fluoride effect of resin-filled glass ionomer adhesives. The development and incorporation of ACP materials in dentistry is a different approach to reverse the effects of demineralization on enamel surfaces.

ACP-containing materials are a new class of "smart" materials that self-activate in low pH oral environments and return to a dormant state when the pH has returned to normal. Skrtic et al(2004)demonstrated that ACP accelerates the tooth's natural calcium phosphate remineralization process to prevent demineralization that could be attributed to microleakage or poor oral hygiene. Unfortunately, pyrophosphate- stabilized ACP-filled composites are mechanically weak because ACP does not reinforce the composite like silanized fillers do in most resin-based composites**(Antonucci 1986). Minick G T et al(2004)** were of the opinion that Aegis Ortho had bond strengths sufficient for orthodontic purposes but the low viscosity of the material allowed the bracket to drift during bonding which might cause a significant clinical problem. Another disadvantage of Aegis Ortho is that it had a significantly lower flexural strength than Transbond XT which may cause material failure at the adhesive-bracket interface rather than the enamel adhesive interface. Previous investigators suggested that ACP-containing dental materials should be limited to situations where mechanical demands are less. Skrtic et al demonstrated that ACP-containing composites can be made stronger by the addition of glass-forming agents and with silica or zirconia-hybridized ACP in Bis-GMA/ TEGDMA/HEMA/ZrDMA-based composites.

We found that the mean bond strength of Aegis Ortho adhesive was 5.59±3.07MPa which was significantly less than the bond strengths of resin composite(P value <0.001**)** or resin modified glass ionomer cement (P value= 0.006**).** Our results were in accordance with previous studies done by **Foster et al(2008) Dunn J W, Skrtic et al.**

Dunn J W(2007)compared the shear bond strength between Aegis Ortho adhesive and Transbond XT. Results showed a highly significant difference in the mean shear bond strength between Aegis Ortho (119N) and Transbond XT (14.2N) (P< .001).

Minick et al in their study compared the shear bond strength of Aegis Ortho with that of Transbond XT. They found that Aegis Ortho had significantly lower bond strength (5.3 ±0.5) than that of Transbond XT (10.1±.8 MPa).

Our study found that under in vivo conditions, both the materials possessed mean shear bond strengths above the amount recommended by Reynolds to perform as an orthodontic bracket adhesive. The bond strength of 1, 2, and 3 groups were 17.15±7.14, 5.59±3.07 and 12.47±4.02 MPa, respectively. The ACP-containing adhesive presented with the lowest mean shear bond strength(5.59±3.07) and the statistical analysis showed that there is significant difference between this adhesive and the resin- modified glass ionomer cement(P value=0.006**)**. When the bond strengths of these materials are compared with the standard composite resin (Transbond XT), we found that there was a significant difference between Transbond XT and Aegis ortho(P value<0.001) and only a suggested significance in the difference between bond strengths of Transbond XT and Resin Modified Glass Ionomer Cement (P value= 0.074).

The mean shear bond strength may not be the only useful indicator of performance for evaluating orthodontic adhesives. Of greater significance to the clinician are the weaker values in the result, because these represent instances which may result in the possibility of early clinical bond failure. If bond strength alone is considered in the selection of an adhesive for orthodontic bonding, then the results of the present study, as well as other relative research suggest that the continued use of composite resins in bonding is advised instead of glass ionomers. Even though the bond strength of Resin Modified Glass Ionomer Cement is less than that of composite resin, the difference between the two materials may not be of any clinical significance as clinically no more bracket failure occured when using a glass ionomer cement than when using a composite bonding resin material. But ours being an in vivo bond strength study done under facilitating conditions, caution is advised in extrapolating the results of this study to all clinical situations where the adhesives are subjected to stresses, temperature fluctuations, variable electrolytes, microorganisms, and other factors that may affect performance.

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