Comparative Ex-Vivo Evaluation of the Frictional and Debonding Characteristics of Composite (Metal Inserted Plastic) Brackets.

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Citation

Abstract
The quest for increased esthetic demands in clinical orthodontic practice has lead to the development of tooth colored attachments like ceramic and polycarbonate bracket systems. First generation brackets of both these systems suffered a lot of shortcomings, which were rectified in successive generations. One such advancement is development of composite brackets and the present study is aimed at to compare 0.56 X 0.71 mm (0.022 X 0.028 inches) slot size, composite brackets - ClassicÔ (Gold inserted), ElationÔ (Stainless steel inserted) and Spirit MBÔ (Stainless steel inserted) for the following parameters- (1) Frictional characteristics using 0.43 X 0.64 mm (0.017 x 0.025 inches) Stainless steel & Nitanium™ arch wires; (2) Tensile shear bond strength using Rely-a-bond™ as bonding adhesive and (3) Surface characteristics. Conventional stainless steel brackets-Gemini™ was used as a control group. An instron universal testing machine was used to evaluate frictional characteristics and tensile shear bond strength. Stereo photomicroscope was used, to evaluate the extension and relation of the metal inserts to their respective slots, from the proximal and facial aspects of the brackets. Scanning electron microscope was used, for the surface characteristics evaluation of bracket slots before and after sliding the wires through slot. The results clearly indicated that Classic™ and Spirit MBÔ brackets produce less friction at the archwire – bracket interface that is similar to Gemini™ brackets. ElationÔ brackets produced significantly higher (p<.05) frictional resistance than all other three brackets. Composite brackets demonstrated shear bond strength significantly lower (p<.05) than that of conventional stainless steel brackets.

INTRODUCTION
In the first century of its existence as a specialty, Orthodontic practice has seen a sea change in principles, precept and practice. A search into history of orthodontic appliances reveals revolutionary advances, which has contributed in a big way to improve the standards of treatment. The pattern of patient demand in orthodontics has changed significantly in the past two decades. With more and more adults seeking orthodontic treatment, the need for application of esthetics into practice and appliance strap up has increased. This has lead to the development as well as constant improvements in tooth colored brackets viz. polycarbonate, ceramic and composite brackets.

The first attempt towards development of tooth colored brackets came from Newman (1969) with the development of polycarbonate transparent brackets. These brackets suffered from creep deformation when transferring torque loads generated by archwire to the teeth. Discoloration of these brackets with clinical aging was another noted problem 1. The introduction of ceramic brackets in 1987 was another major landmark in the development of the “esthetic appliances”. The major drawbacks that limit the use of Ceramic brackets are greater amount of friction, irreversible damage to enamel surface (Fracture, Cracks and/or Flaking) during debonding and the occasional occurrence of bracket tie wing fracture during therapy and subsequent debonding 1.

During the 1990’s, manufacturers came up with reinforced plastic brackets also known as composite brackets 2, i.e. ceramic reinforced, fiberglass reinforced, and metal slot reinforced polycarbonate brackets, with claims of essentially no adverse clinical effects. These brackets claimed to have improved strength and less friction at archwire – bracket interface than original ceramic brackets, when used as part of sliding mechanics of space closure. Feldner 3 reported that reinforcement of plastic brackets with metal inserts appears to strengthen the matrix adequately so that torque could be applied to the same level as with metal brackets. Some recent reports 4 question the integrity of the slot periphery as well as the metal insert, significantly affecting the frictional
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characteristics at bracket - arch wire interface. Better debonding properties have also been claimed for these brackets.

Three new composite (metal inserted plastic) brackets with the above properties have been introduced recently to the orthodontic profession - Classic®, Elation® and Spirit MB®. Manufacturers claim that these brackets combine the esthetics of ceramics along with good mechanical properties, less friction during sliding, a mechanical bonding base which can be bonded by any adhesive (eliminating the need for a plastic primer) and the better debonding characteristics. The present study was aimed at evaluating these three composite brackets for:

- Frictional characteristics,
- Tensile shear bond strength and
- Surface characteristics.

and to compare them with conventional stainless steel brackets.

MATERIALS AND METHODS

0.56 X 0.71 mm (0.022 X 0.028 inches) slot size preadjusted edgewise (Roth prescription), composite brackets were obtained and coded as:-

Group I - Classic®- Urethane bracket with gold insert (American Orthodontics, 1714 Cambridge Ave Sheboygan WI USA),

Group II - Elation®- Polycarbonate/Polyethylene terephthalate [PET] bracket with stainless steel insert (GAC Int, Inc. 185 Oval Drive, Central Islip, N.Y. 11722)

Group III - Sprit MB® - Ceramic reinforced polycarbonate bracket with stainless steel insert (ORMCO Corp, Glendora, California).

Group IV – Gemini™ - Conventional stainless steel brackets (3M Unitek, 2724, South Peck Road, Monrovia, CA 91016, USA) used as control group.

The following properties were investigated in the present study –

Frictional characteristics using 0.43 X 0.64 mm (0.017 x 0.025 inches) Stainless steel Preformed arch wires (Ortho Organizers Inc. San Marcos, CA92069-5198, USA) & Nitiainum™ (Ortho Organizers Inc.) arch wires;

Tensile shear bond strength using Rely-a-bond™ (Reliance Orthodontics Products Inc, Illinois, USA) as bonding adhesive and

SURFACE CHARACTERISTICS

FRICTIOANL CHARACTERISTICS

Evaluation of friction produced at archwire – bracket interface, was done following a test protocol described by Tidy 5. This consisted of a simulated half arch fixed appliance with archwire ligated in position (Fig.1).

Figure 1

Figure 1: Setup for evaluation of frictional characteristics

The two incisors and two premolars brackets were aligned with a dummy wire and bonded with a cyanoacrylate resin Super-glue (ALTECO, Alpha Techno Company, Japan) onto a rigid Perspex sheet at 8 mm intervals. A space of 16 mm was left at the centre for sliding the canine bracket to simulate canine retraction. The archwires were secured using Ministik (3M Unitek) elastomeric ligatures. The movable canine bracket was fitted with a 12 mm power arm from which weights of 50/100 gm were hung to represent the single equivalent force acting at the centre of resistance of the tooth root.

All tests were conducted in dry condition with an Instron universal testing machine Model No: 4206 (Instron Corporation, Canton, Mass.). The movable bracket was suspended from the load cell of the testing machine, while base plate (Perspex sheet) was mounted on the cross head below. The full-scale load was set at 5000 gm with a crosshead speed of 5 mm/minute. At the start of each test, a trial run was performed with no load on the power arm to
check whether there was any binding between the archwire and bracket. Then a 50 gm followed by 100 gm weight was suspended from the power arm and the load needed to move the bracket across the central span in apparatus was recorded separately. Five representative readings were taken for each arch wire – bracket combination. The load cell reading represents the clinical force of retraction that would be applied to canine, part of which would be critical friction while the rest would be the translation force on the tooth. The difference between the load cell reading and load on the power arm represents frictional resistance. The coefficient of friction, both static (μsf) and kinetic (μkf), at the archwire – bracket interface was calculated using appropriate formula.

**TENSILE SHEAR BOND STRENGTH EVALUATION**

Forty specimens of intact, non-carious, unrestored human upper premolar teeth were extracted as part of orthodontic treatment and were equally divided into four groups. Specimens were stored in distilled water at room temperature in a glass container until they were used for testing and distilled water was changed periodically. Each specimen was embedded in a cylindrical acrylic block of Polymethyl methacrylate (PMMA) so that only the coronal portion of the specimen was exposed and crowns were oriented along the long axis of the blocks.

The buccal surfaces of all the specimens were polished with a mixture of water and fluoride free pumice using a rubber cup for one minute. The specimens were then thoroughly rinsed with distilled water and dried with oil free compressed air. The enamel surfaces of the teeth were etched with 37% phosphoric acid gel (Rely-a-bond™ etchant) using the conventional acid etch technique. No plastic primer was used with any brackets, as instructed by the manufacturers of brackets. The tooth surfaces and the bases of the brackets to be bonded were coated with the bonding primer supplied with the bonding kit. Bonding procedures were performed and the specimens were stored for 24 hours in distilled water prior to debonding test.

The tensile shear strength of bonded teeth was tested using an Instron Universal Testing following a modified version of test method described by Cook and Youngson. The sample testing was carried out using a sensitive load cell value of 100,000 gm with cross head speed of 0.5mm/minute. Each tooth was oriented with the testing device as a guide and held firmly between the lower cross head of the Instron Universal Testing Machine, so that its labial surface would be parallel to the applied force during the shear bond strength tests. The brackets were held precise by hooking a 21-gauge stainless steel wire loop, between bracket base and gingival tie wings, which apply a gingivo-occlusal load in order to provide a tensile shear force at the bracket-tooth interface (Figure 2).

**Figure 2**

Figure 2: Setup for evaluation of tensile shear bond strength
STATISTICAL ANALYSIS

All the data obtained from the two parameters described above were tabulated and entered into SPSS (version 10), a computer-based statistical program. Means and standard deviations were calculated, and One-Way analysis of variance (ANOVA) and the Post hoc - Duncan’s multiple range tests were performed to find out the level of significance ($p \leq 0.05$) between the values obtained from specimens in groups I–IV.

SURFACE CHARACTERISTICS

Stereo photomicrographs of unused bracket samples from group I–III were obtained using stereomicroscope (M2 lab microscope, Great scopes, North Carolina, 27282) to evaluate the extension and relation of the metal inserts to their respective slots from the proximal and facial aspects of the brackets.

The surface characteristics of canine bracket slots were studied from Group I–III with the help of scanning electron microscope (SEM) (JEOL JSM 5600LV), before and after friction testing, to evaluate the surface changes that have been produced. Specimens from all three groups were mounted on studs and gold sputtered to make them visible under SEM. The specimens were later placed in the vacuum chamber of the SEM. The accelerating voltage, angle of fit and the aperture was adjusted to optimize the quality of the micrograph. The surface was scanned and viewed on the monitor at different magnifications and representative micrographs (5000X) of each bracket slot were obtained.

RESULTS

FRICTIONAL CHARACTERISTICS

The load values for frictional resistance obtained were substituted in the Tidy’s formula, for finding out the coefficients of static ($\mu_{sf}$) and kinetic friction ($\mu_{kf}$) for each group, for both the wires. The values were then tabulated and mean and standard deviation were calculated (Table 1).

One-Way ANOVA test results (Table 2) showed a statistically significant difference at the level of $< 0.05$, between the all four groups with both the wires (stainless steel and Nitanium™) at 50 and 100gm.

TABLE: 2 Values of One-Way ANOVA test (F-Ratio) for mean coefficient of static friction ($\mu_{sf}$) and kinetic friction ($\mu_{kf}$) between brackets

<table>
<thead>
<tr>
<th>Sample</th>
<th>Stainless steel wire</th>
<th>Nitanium™ wire</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\mu_{sf}$</td>
<td>$\mu_{kf}$</td>
</tr>
<tr>
<td></td>
<td>$\mu_{sf}$</td>
<td>$\mu_{kf}$</td>
</tr>
<tr>
<td>Group I (Classic™)</td>
<td>0.13 ± 0.01</td>
<td>0.19 ± 0.04</td>
</tr>
<tr>
<td>Group II (Enamel)</td>
<td>0.16 ± 0.03</td>
<td>0.14 ± 0.13</td>
</tr>
<tr>
<td>Group III (Apex (II))</td>
<td>0.17 ± 0.07</td>
<td>0.15 ± 0.03</td>
</tr>
<tr>
<td>Group IV (Gumel)</td>
<td>0.11 ± 0.03</td>
<td>0.23 ± 0.09</td>
</tr>
</tbody>
</table>

One-Way ANOVA test results (Table 2) showed a statistically significant difference at the level of $< 0.05$, between the all four groups with both the wires (stainless steel and Nitanium™) at 50 and 100gm.

Figure 4

TABLE: 2 Values of One-Way ANOVA test (F-Ratio) for mean coefficient of static friction ($\mu_{sf}$) and kinetic friction ($\mu_{kf}$) between brackets

<table>
<thead>
<tr>
<th>Sample</th>
<th>50 gms</th>
<th>100 gms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless steel</td>
<td>5.442*</td>
<td>18.73*</td>
</tr>
<tr>
<td>Nitanium™</td>
<td>9.697*</td>
<td>22.89*</td>
</tr>
</tbody>
</table>

Post hoc Duncan’s multiple range values (Table 3) showed that Group II brackets exhibited statistically significant higher values ($p < 0.05$) for all tests when compared with other three bracket groups.
Comparative Ex-Vivo Evaluation of the Frictional and Debonding Characteristics of Composite (Metal Inserted Plastic) Brackets.

Figure 5
TABLE 3: Duncan’s Multiple Range test - Significance of Difference in mean coefficient of static friction ($\mu_s$) and kinetic friction ($\mu_k$) between brackets

<table>
<thead>
<tr>
<th></th>
<th>50 g SS</th>
<th>100 g SS</th>
<th>50 g Nitanium™</th>
<th>100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classic™</td>
<td>0.18</td>
<td>0.11</td>
<td>0.20</td>
<td>0.14</td>
</tr>
<tr>
<td>Elation™</td>
<td>0.22</td>
<td>0.20</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Spirit MB™</td>
<td>0.21</td>
<td>0.18</td>
<td>0.16</td>
<td>0.14</td>
</tr>
<tr>
<td>Gemini™</td>
<td>0.21</td>
<td>0.14</td>
<td>0.16</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Mean for $\mu_k$

<table>
<thead>
<tr>
<th></th>
<th>50 g SS</th>
<th>100 g SS</th>
<th>50 g Nitanium™</th>
<th>100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classic™</td>
<td>0.19</td>
<td>0.12</td>
<td>0.20</td>
<td>0.17</td>
</tr>
<tr>
<td>Elation™</td>
<td>0.16</td>
<td>0.13</td>
<td>0.13</td>
<td>0.19</td>
</tr>
<tr>
<td>Spirit MB™</td>
<td>0.23</td>
<td>0.11</td>
<td>0.11</td>
<td>0.14</td>
</tr>
<tr>
<td>Gemini™</td>
<td>0.21</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Mean for $\mu_s$

All the other three groups did not show any statistically significant difference between them for both static and kinetic friction, when stainless steel wires (at 50 and 100gm load) and Nitanium™ wires (at 50 gm of load) were used. Nitanium™ at 100gm showed also statistically insignificant results for kinetic friction.

Evaluation of static friction showed significant difference between the three groups. There were no statistically significant differences (p < 0.05), between values of Group I and Group III. But the groups exhibited a significantly lower value than Group IV brackets.

The rank order of the brackets (at 50 gm & 100gm of load) in ascending order of static friction and kinetic friction can be summarized as (Figure.3):

With Stainless wire: Spirit MB™ < Classic™ < Gemini™ < Elation™

With Nitanium™ wire: Classic™ < Spirit MB™ < Gemini™ < Elation™

TENSILE SHEAR BOND STRENGTH EVALUATION

The values obtained for tensile shear bond test of all specimens were recorded and tabulated. Mean and Standard deviation were calculated for each group (Table 4).

Figure 6
TABLE 4: Mean tensile shear bond strengths of Samples Group I-IV (MPa)

<table>
<thead>
<tr>
<th>Samples Deviation</th>
<th>Mean</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUP I (Classic™)</td>
<td>3.11</td>
<td>0.93</td>
</tr>
<tr>
<td>GROUP II (Elation™)</td>
<td>3.20</td>
<td>0.50</td>
</tr>
<tr>
<td>GROUP III (Spirit MB™)</td>
<td>2.96</td>
<td>0.43</td>
</tr>
<tr>
<td>GROUP IV (Gemini™)</td>
<td>12.66</td>
<td>0.55</td>
</tr>
</tbody>
</table>

The values obtained for the One-Way ANOVA test (Tables 5) showed a statistically significant difference for bond strength between all the bracket groups at the level of <0.05 (Figure 4).

Figure 7
TABLE 5: One-Way ANOVA test of Significance between Mean tensile shear bond strengths of Groups I, II, III & IV

<table>
<thead>
<tr>
<th>Source of Sig. Variation</th>
<th>Sum of Squares</th>
<th>d.f.</th>
<th>Mean Squares</th>
<th>F Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between the brackets</td>
<td>689.44</td>
<td>3</td>
<td>229.82</td>
<td></td>
</tr>
<tr>
<td>With in &lt;0.0001 the brackets</td>
<td>32.53</td>
<td>30</td>
<td>0.90</td>
<td>254.240*</td>
</tr>
<tr>
<td>Total</td>
<td>721.97</td>
<td>39</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 9  
Figure 4: Comparison of mean tensile shear bond strength

Post hoc Duncan’s multiple range test (Tables 6) showed no statistical significant difference between Groups I, II and III brackets.

Figure 10  
TABLE 6: Post hoc Duncan’s multiple range test of Significance between Mean tensile shear bond strengths of Groups I, II, III & IV

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Tensile Shear Bond Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classic</td>
<td>3.11</td>
</tr>
<tr>
<td>Eltion</td>
<td>3.20</td>
</tr>
<tr>
<td>Spirit MB</td>
<td>2.86</td>
</tr>
<tr>
<td>Gemini</td>
<td>12.07</td>
</tr>
</tbody>
</table>

When these were compared with the control group (Group IV), there were statistically significant differences at <0.05 level.

Adhesive remnant index (ARI) scores to evaluate the fracture site were obtained from the base of bracket and surface of the enamel and tabulated (Table 7 & Figure 5)

Figure 11  
TABLE 7: Adhesive Remnant Index, Number of samples and their distribution according to ARI

<table>
<thead>
<tr>
<th>Score</th>
<th>ARI Score</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Group I (Classic™)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Group II (Elion™)</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Group III (Spirit MB™)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Group IV (Gemini™)</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 12  
Figure 5: Comparison of adhesive remnant index

SURFACE CHARACTERISTICS

Stereo photomicrography: There were deficient areas in all composite brackets, where inserts are not covering up whole of the slot surface. The metal inserts in all the three bracket groups were not extending to the top of the tie-wings (proximal view) (Figure 6a, 6b and 6c), and to mesial and distal margins (facial view) (Figure 7a, 7b and 7c).

Figure 13  
Figure 6: Stereomicroscopic view of unused brackets from proximal surface
Comparative Ex-Vivo Evaluation of the Frictional and Debonding Characteristics of Composite (Metal Inserted Plastic) Brackets.

One interesting finding in group II brackets (Figure 6b and 7b) was the presence of only two stainless steel struts along the gingival and occlusal wall on mesial and distal end of stainless steel insert i.e. stainless steel insert does not extend along the full length on occlusal and gingival walls of slot mesiodistally.

Scanning electron microscopy: The slot (Gold insert) surfaces of unused Group I brackets (Figure 8a) revealed surface marks in the direction of slot. The slot (stainless steel insert) surfaces of unused Group II brackets (Figure 8b), showed a smoother surface without striations or cracks, while slot (stainless steel insert) surfaces of unused Group III brackets (Figure 8c) showed some parallel marks and cracks.

DISCUSSION
Esthetics plays a very important role in contemporary orthodontic practice and the quest for it has lead to the development of esthetic appliances like ceramics and polycarbonate brackets. Constant improvements in technology has presented us with reinforced ceramic and polycarbonate brackets, which are known as composite brackets combining the properties of strength and cosmetics. The present study is aimed at evaluating three recently introduced composite brackets for its frictional characteristics, tensile shear bond strength and surface characteristics. The properties evaluated have been compared with stainless steel brackets, which are routinely used in clinical orthodontic practice.

Frictional force has of long been an important consideration in orthodontic mechanotherapy. It is a well-known fact that any force needed to retract teeth necessarily requires to overcome friction. The present study utilized a method...
Comparative Ex-Vivo Evaluation of the Frictional and Debonding Characteristics of Composite (Metal Inserted Plastic) Brackets.

proposed by Tidy for evaluating the frictional characteristics. This test closely simulates the clinical retraction of canine as compared to other experimental set ups. The results of the present study have clearly indicated that Spirit MB™ brackets show lower frictional resistance than conventional stainless steel bracket (Gemini™), when stainless steel and Niti wire are used. This is in concordance with the study of Bazakidou et al, who reported the same type of results when 0.43 X 0.64 mm stainless steel and Niti wire were slide through 0.56 X 0.71 mm bracket slots. Thorstenson and Kusy, however showed that Spirit MB™ produced higher kinetic friction values than conventional stainless steel brackets (both in dry and wet state) when 0.46X 0.56 mm (0.018 x 0.22 inches) stainless steel wire was slide through 0.56 X 0.71 mm bracket slots. This could possibly be explained due to the differences in dimension and wire test setups used in their study.

SS wire with Spirit MB™ combination produced the minimum frictional resistance among all the archwire – bracket combinations. The second in order is stainless steel – Classic™ combination, which could be attributed to the presence of a nonoxidizing surface for gold. Elation™ showed highest friction than all other three brackets. This is explained on the basis of stereomicrographs showing very deficient margins as far as stainless steel inserts are concerned (Figure 6b and 7b). So when wire is slide through slot, wire comes in contact with the polycarbonate material producing binding and friction. The same was not applicable to Classic™ brackets because (Figure 6a and 7a), of softer nature of gold. As wire is drawn through the slot, the gold will wear off and might extend to the slot margins reducing the friction. In the case of Spirit MB™ (Figure 6c and 7c) the stainless steel insert neither extends to the upper extent of the insert, nor maintains a constant slot width at the upper extent of the insert. This could present problems when torquing of the teeth is performed.

Clinically all these findings imply that composite brackets with innovative design of gold and stainless steel inserts into the arch wire slots (Classic™ and Spirit MB™), affect almost similar tooth movement as stainless steel brackets due to the similar arch wire – bracket friction. These brackets will promote rapid tooth movement than Elation™ bracket system, which exhibits higher friction at archwire - bracket interface. In short, less friction with new composite brackets will produce less taxation and better control on anchorage providing a more comfortable force system in addition to esthetics, ultimately benefitting our patients.

The need for adequate bond strength to withstand masticatory forces and easy removal after treatment has led to many innovative designs of esthetic appliances. It is difficult if not hazardous to compare the bond strengths of different brackets because of many factors that contribute to the variation, which include selection of adhesive, the testing technique, and the design of the bracket base (whether it was designed with a mechanical bonding or with a chemical bonding union for the adhesive). In the present study in order to minimize the variables that can influence the debonding characteristics all conditions for bonding have been kept normal for all specimens.

Reynolds reported that minimum bond strength of 5.9~7.9 MPa could give a satisfactory clinical performance and successful clinical bonding. In present study the shear bond strengths of composite brackets ranged from 2.9 to 3.2 MPa and other studies also reported that plastic brackets in general had lower bond strength. These values are comparable to those in the study by Liu et al, which reported the bond strength for plastic brackets to be in the range of 1.4- 19.07 MPa and that of Spirit MB™ to be in the range of 1.4 -10.3 MPa, with most values being in the 3-6 MPa range. On the contrary, Urabe et al, however showed a higher range of bond strength for Spirit MB™ (6.45-8.32 MPa) where Phase II composite (Two–paste) was used as bonding agent in the study. This might be due to the fact that Phase II composites have higher filler content than Rely-A-Bond™. As filler concentration of composite increases, it produces higher bond strength. Laboratory and clinical studies on Rely-A-Bond™ noted that it is more viscous and had a shorter working time than two-paste composite. These features might combine to leave a thicker composite film of Rely-A-Bond™ underneath the brackets resulting in weakening of adhesive layer.

The base of bracket and surface of the enamel were examined to evaluate the fracture site with the help of Adhesive remnant index (ARI) scores. None of the composite bracket showed enamel – adhesive failure but it occurred at adhesive – bracket interface. The average ARI scores of the metal brackets were lower than those of the composite brackets. The lower ARI scores of the metal brackets may be due to their higher bond strengths. Lower ARI scores mean that the mode of failure is closer to the enamel/adhesive interface and the risk of enamel fracture
increases increases.

The surface topography of the bracket slot is known to affect its working characteristics because an irregular surface is usually associated with greater friction. The slot surfaces of unused Classic™ bracket with gold inserts revealed surface marks in the direction of slot, which may be mechanical tool marks or forming marks made during the process of manufacturing the brackets. The used gold insert slot surface of Classic™ revealed a smoothing effect after sliding of wire on the slot due to the peeling of surface layer, which explains the decreased amount of friction demonstrated by the gold inserts. The used stainless steel insert of Elation™ brackets exhibited a relative rougher surface with metal and plastic debris after wire sliding. This may be due to the wear of either the wire or the slot surface. Elation™ metal inserts were not extending fully in the slot, which could possibly explain the cause of more friction with this bracket. Elation™ and Nitiniam™ wire combination showed more debris and rougher surface than stainless steel wire. This could be due to the rough nature of Nitiniam™ wires.

CONCLUSION

The results of the present study shows that Classic™ brackets (gold inserted) and Sprit MB™ brackets (stainless steel inserted) evidently produce less friction at archwire – bracket interface and is comparable to Gemini™ brackets (conventional stainless steel). Elation™ brackets (stainless steel inserted) produce significantly higher frictional resistance than all other three brackets. Composite brackets have demonstrated significantly lower shear bond strength stainless steel brackets. Bond strengths of three composite brackets showed lower values than Reynolds’ minimum recommended for satisfactory clinical performance and successful clinical bonding. The site of failure of composite brackets is found to be favorable as far as integrity of the enamel surface is concerned. With reduced friction, smooth surface, better debonding characteristics and of course improved esthetics, composite brackets may bring a marked change in clinical orthodontic practice.

References
Comparative Ex-Vivo Evaluation of the Frictional and Debonding Characteristics of Composite (Metal Inserted Plastic) Brackets.

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