CLINICAL AND LABORATORY EVALUATION OF CYANOACRYLATE ORTHODONTIC ADHESIVE

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ABSTRACT

This study was aimed to evaluate the shear bond strength and the bond failure rate of cyanoacrylate orthodontic adhesive (Smartbond). The study was conducted on 30 freshly extracted upper first premolars and 14 orthodontic patients. Metal orthodontic brackets were bonded to the buccal and labial surfaces of the extracted premolars and the teeth mesial to the first molars. Half of the brackets were bonded by no-mix composite resin (Relay-a-Bond, Reliance Orthodontic Products, Inc. USA). The other half was bonded by Cyanoacrylate adhesive (Smartbond, Gestenco International, Göthenburg, Sweden). The shear bond strengths of either adhesives were recorded using universal testing machine. Also, the bond failure of the brackets during the study period (one year) was recorded. Student t-test was used to distinguish the significance of differences detected between the two adhesives. The results of this study revealed that composite resin had significantly higher bond strength value than cyanoacrylate. In addition, the bond failure rate was significantly higher with cyanoacrylate in comparison to composite resin adhesive. Accordingly, it is not recommended to use cyanoacrylate routinely in the orthodontic practice. However, it could be used in certain circumstances where complete isolation is not controlled and other adhesives do not work.

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INTRODUCTION

Direct bonding of orthodontic attachments to the enamel surface has many advantages. It reduces the chairside time, plaque accumulation and gingival inflammation. In addition it improves the aesthetic aspect of orthodontic appliances.[1] Accordingly, the popularity of this technique increased in the orthodontic clinics.

Many adhesive materials have been utilized as bonding agents. Among these materials are; zinc phosphate cement,[2] zinc polyacrylate cement,[3] BIS-GAMA (bis-phenol A glycidyl methacrylate) resins,[4] acrylic resin,[5] and glass ionomer cement.[6,7] Recently, a new generation of cyanoacrylate adhesive (Smartbond) is available. It is moisture activated and does not require the use of either a primer or a curing light during bonding.[8-10]

Different ex vivo studies had been made to evaluate the bond strength of the orthodontic adhesives including cyanoacrylate. Several studies revealed that cyanoacrylate has good bond strength comparable to other orthodontic adhesives.[9,11-13] Others, on the contrary, showed that cyanoacrylate has poor performance and unstable bond strength.[8]

Bond strength value which considered adequate for orthodontic attachments was not the same in different litrutures.[14,15] Furthermore, the optimal ex vivo bond strength for clinical purposes is not yet known.[16] Therefore, other parameters have to be examined, including the recording of bond failure in vivo.

The in vivo bond failure rates have been reported widely in the orthodontic literature.[17-21] Overall failure rates of 4% to 10% were considered as acceptable.[19, 22,23]

Although the in vivo bond failure rates have been reported widely in the orthodontic literature, there is a shortage in the information about the in vivo bond failure of cyanoacrylate. To the best of our knowledge, only one study was found which reported that bracket failure with cyanoacrylate was significantly greater than with a traditional light-cured composite.[24]

The present study was conducted to evaluate the shear bond strength and the bond failure rate of cyanoacrylate orthodontic adhesive (Smartbond).

Materials and methods

A. Evaluation of the shear bond strength:

Thirty freshly human upper first premolars extracted as a part of orthodontic treatment regimen were collected and stored in a solution of 0.1% (weight/volume) thymol. The teeth were devoid of any cracks, caries, attrition, restoration and not subjected to any pretreatment chemical agents.

Teeth were invested into metal rings (3 cm in diameter and height) using a self-curing acrylic resin♥. The buccal surfaces of the teeth were adjusted to be out of the mounting acrylic (Figure 1). Then the teeth were divided into two equal groups. Metal orthodontic edgewise brackets (Zero torque)♥ (were bonded to the buccal surfaces of the teeth. The average surface area of the base of the bracket was 12.3 mm according to the manufactures. In group I the brackets were bonded to the teeth using no mix orthodontic adhesive (Relay-a-Bond)♣. On the other hand, cyanoacrylate (Smartbond)* was utilized for bonding in group II.

The bonding procedure followed the manufacturer's instructions. The teeth were first cleansed and polished with pumice and rubber cups.

In Group I: 37% phosphoric acid etch was applied to the enamel surfaces for 30 seconds. Then the teeth were washed thoroughly with water and dried with air. Thin coat of primer was applied to the etched dry enamel and to the underside of the bracket. Small quantity of the adhesive was applied to the bracket base. Finally, the bracket was placed in its correct position on tooth surface and pressed with compressive force of 300 grams for 10 seconds using force gauge♦.[9] The excess bonding resin was removed using a sharp scaler.

In Group II: 35% phosphoric acid etching gel was applied for 10 seconds. The teeth were washed thoroughly with water and kept moisted (not dried with air). A thin layer of cyanoacrylate was applied to the base of the brackets then the brackets were placed in its correct position on the tooth surface and subjected to compressive force in the same manner as in group I.

♥ American Orthodontics, Shebougan, USA.

♣ Reliance Orthodontic, Inc. USA.

* Gestenco International, Göthenburg, Sweden

♦Somfy tec, France

All specimens were incubated[ϕ] 30 minuets after bonding in distilled water at $37 \pm 0.1^{\circ}C$ for 24 hours before conducting the shear bond strength test.

In debonding procedure the specimens were oriented horizontally on the lower fixed member of the Lloyd Universal Testing Machine[ϒ] (Figure 2). Shear dislodging force was applied through a knife edged metal bar attached to the upper member of the testing machine that moves at a crosshead speed of 2mm/min (figure 3). The metal bar was adjusted to apply the load under the incisal wings of each bonded bracket and parallel to the long axis of each mounted tooth. Loads required to dislodge each bracket were recorded in Newtons and the shear bond strength was calculated in MPa using the following equation:

$$\delta = \frac{F}{A}$$

Where, δ = Shear bond strength, F = Load at dislodgement in Newtons,

A = Bracket base surface area in mm.

Figure 1: Tooth invested into metal ring using self-curing acrylic resin

[ϕ] Binder Incubator, Type B28, B53, Germany
[ϒ] Lloyd Instrument, England

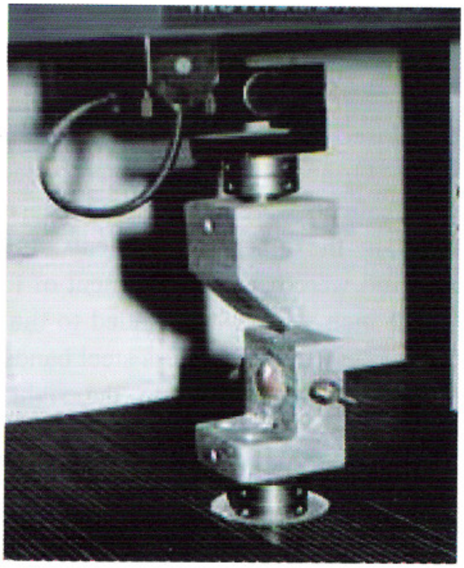

Figure 2: A specimen oriented horizontally on the lower fixed member of the Lloyd Universal Testing Machine.

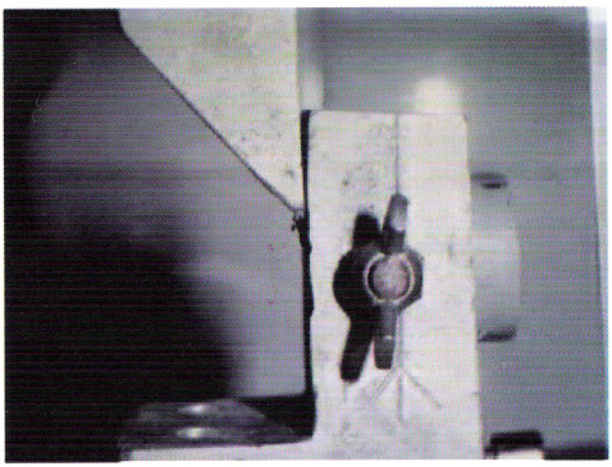

Figure 3: Shear dislodging force applied through a knife edged metal bar attached to the upper member of the testing machine.

B. in vivo assessment of the bond failure:

Sample :

The sample comprised 14 patients (8 females and 6 males) seeking orthodontic treatment at Orthodontic Department, Faculty of Dentistry, Mansoura University. Ten patients were non extraction cases while the four first premolars were extracted in the other four patients. Full fixed orthodontic appliances of the same brand were used for treatment of the patients. Stainless steel brackets (Roth, 0.022 inch slot)• were bonded to the teeth mesial to first molars. On the other hand, ready made stainless steel bands with welded buccal tubes were cemented to the first molars. In the right maxillary and left mandibular quadrants the brackets were bonded utilizing the cyanoacrylate adhesive. On the other hand, the no-mix composite resin was used in the left maxillary and right mandibular quadrants.

The bonding procedures were similar to that in the laboratory part of this study. In addition, isolation was made using cheek retractors, cotton rolls, saliva ejectors and high suction.

The first arch wire was placed 24 hours after bracket bonding. Instructions for oral hygiene care and appliance maintenance were given for the patients.

The patients were examined during their orthodontic visits every month for any bracket looseness (bond failure). This was done during the study period which lasted for one year. Any bond failure was recorded and the tooth was no longer included in the bonding failure assessment.

Statistical analysis of the collected data was done by the aid of Microsoft Excel Program on a personal computer. The means and standard deviations of the bond strength of cyanoacrylate and composite resin were calculated. Also, the means and standard deviations of bond failure percentage for both adhesives were calculated for each patient and for all the patients. Student t-test at 0.05 level of significance was used to distinguish the significance of differences detected between means.

• American Orthodontics, Shebougan, USA

RESULTS

The means and standard deviations of bond strength of cyanoacrylate and composite resin and the results of t- test are shown in table 1. The bond strength of composite resin was significantly higher than that of cyanoacrylate. Table 2 shows the number of successful and failed bracket bond in the two adhesives. The percentages of bond failure for each adhesive and the results of t- test are presented in table 3. Cyanoacrlate had significantly higher bond failure rate than composite resin.

DISCUSSION

Direct bonding of orthodontic attachments has improved the clinical practice of orthodontics.[9] Traditionally bonding procedures should be done in complete dry and isolated field to obtain good bond strength. Bond failure of orthodontic attachments has many disadvantages. It leads to rebonding with lesser bond strength.[13] Also, it increases treatment time and cost. The present study compared a cyanoacrylate orthodontic adhesive which is moisture activated adhesive and the composite resin.

The laboratory findings of this study revealed that the bond strength of cyanoacrylate (6 ± 1.07 MPa) was significantly lesser than that of the composite (8.39 ± 1.8 MPa). These results were in agreement with those of Al-Munajed et al[8]. On the other hand, the results were in disagreement with those of Örtendahl and Örtengren[11] and Bishara et al[9,12]. This could be attributed to the difference in bracket base adaptation and design or the composite resin used.

The clinical (in vivo) results of the present study supported the laboratory one. The bond failure rate of the cyanoacrylate (19%) was significantly higher than that of the composite resin (6.6%). These clinical outcomes were in agreement with the results of Le et al[24]. However, Le et al reported higher bond failure ratio of cyanoacrylate than that found in this study. This could be explained by the longer study period of Le et al. Also, in this study the arch wires were placed 24 hours after bracket bonding. According to Bishara et al[12] the bond strength of cyanoacrylate after 24 hours increased significantly than after 30 minutes. However, the time of arch wire placement in Le et al study was not clear.

Material	Mean ± SD	P
Composite	8.39 ± 1.8	0.0004
Cyanoacrylate	6 ± 1.07	

Table 1: bond strengths of cyanoacrylate and composite resin and the results of t-test.

Bracket bond	Cyanoacrylate	Composite
Success	111	124
Failure	21	8
Total	132	132

Table 2: bond failure and success of cyanoacrylate and composite resin

Material	Mean±SD	P
Composite	6.6%±0.077	2.4765E.06
Cyanoacrylate	19%±0.085	

Table 3: bond failure percentages of cyanoacrylate and composite resin and the results of t-test.

In general, the high failure rate of cyanoacrylate could be attributed to deterioration of cyanoacrylate in the oral environment, or insufficient adaptation of the brackets on the tooth surfaces.[24] Also, the difference in concentration and time of etching between the two adhesives might be another factor to be considered. However, white chalky appearance of the enamel surfaces necessary for successful bonding procedure was obtained in all teeth in the present study.

The results of the present study also revealed that the in vitro bond strength of cyanoacrylate (6 MPa) lies in the accepted level as described by Keizer et al[14] and Renolds[15]. However, the clinical bond failure rate (19%) was higher than the accepted level (4-10%) as reported by Zachrisson,[22] Millet and Jordon[23] and Sunna and Rock[19]. This supports the opinion of Linklater and Gordon[16] who reported that the optimal ex vivo bond strength for clinical purposes is not yet known.

In addition to the disadvantages of low bond strength and high failure rate, cyanoacrylate adheres to the instruments and bonds skin in seconds. Also the setting time is very short, hence limited time is available for placement of the brackets in the correct position on the tooth surfaces.

CONCLUSIONS

The laboratory and clinical performance of cyanoacrylate is not as good as composite resin. It is not recommended to use cyanoacrylate routinely in the orthodontic practice. However, it could be used in certain circumstances where complete isolation is not controlled and other adhesives do not work.

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