Effect of the Time between Primer Application and No-mix Composite Bracket Bonding on the Enamel Shear Bond Strength

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Abstract

Introduction: Achieving proper bond strength is an important objective in orthodontics, since bracket replacement is a costly and time consuming procedure. Bond failures depend on multiple factors such as etching process, primer application approach and masticatory forces. The aim of this study was to evaluate the effect of elapsed time between primer application and bracket transfer on the shear bond strength of the brackets bonded with no-mix composite.

Materials & methods: One hundred intact bovine incisors were randomly divided into 4 groups (n=25). Brackets were bonded immediately after primer application in the first group and 5, 15, 30 minutes after primer application in the second, third, and fourth groups, respectively. A universal testing machine was used for debonding and measuring shear bond strength, and the failure sites were inspected under a stereomicroscope. One way ANOVA plus Tukey tests and Chi-square test were used to evaluate shear bond strength and adhesive remnant index(ARI), respectively.

Results: Differences in shear bond strength among four groups were significant (p=0.001). The differences in shear bond strength between the first and second groups (p=0.011) and between the second and fourth groups (p=0.002) were significant with greater bond strength mean value for the second group. ARI evaluation showed significant differences among groups (p=0.032).

Conclusions: It could be recommend not to delay bracket positioning more than 5 minutes after primer application, in order to avoid negative effects of elapsing time on the primer properties.

Keywords: No-mix composite; debonding time; shear bond strength.

Introduction

Since bracket replacement is a costly and time consuming procedure, achieving proper bond strength is an important objective in orthodontics. Bond failures depend on multiple factors such as etching process, primer application approach, undisturbed setting, and masticatory forces(Turk, Elekdag-Turk, & Isci, 2007; Yamamoto et al., 2006; Zachrisson & Buyukyilmaz, 2005) and is mostly dependant on the bonding technique rather than the resin type or bracket base quality(Zachrisson & Buyukyilmaz, 2005).

Clean substrate surface, perfect wetting, compatibility of the adhesive and substrate, and adhesive application according to the instructions of the manufacturer are the requirements of a successful bonding (Craig & Powers, 2002; Egan, Alexander, & Cartwright, 1996; Pithon, de Oliveira Ruellas, Sant'Anna, de Oliveira, & Alves Bernardes, 2009).

Various factors affecting the bond strength have been evaluated in studies which one of them concluded that the bonding was the strongest if there was no interval between primer application and bracket positioning, and was the weakest if there was a 5 minute interval(Evans & Powers, 1985). In a similar study, no significant differences found between 5 minutes and 15 minutes interval groups in shear bond strength and in ARI scores(Ostby, Bishara, Laffoon, & Warren, 2007).

The delay between primer application and bracket positioning differs greatly among the clinicians. Since there was not any study regarding the bracket bond strength with 0, 5, 15 and 30 minutes interval times, so the objective of our study is to evaluate the effect of this parameter on the dislodgement resistance of brackets under shear force.
Material and methods

Sample preparation
This in vitro study was performed on 100 bovine incisors. With $\alpha=0.05$, $\beta=0.2$ and considering 0.5 MPa or more as significant difference, the sample size was calculated to be 100 teeth; 25 extra teeth were selected to substitute for the probable sample drop outs during the study procedures (N=100). The teeth were chosen for the study if they had no caries, no visible cracks on labial surface and no shape or size anomaly and if they were without fluorosis. Soft tissues were removed of the samples. The teeth were placed in 0.5% chloramine T solution for 24 hours and then were stored in 37° C distilled water till mounting in acrylic.

Bracket bonding
The samples were randomly divided into 4 groups each containing 25 teeth. No-mix adhesive (Unite, 3M Unitek, USA) was the bonding system used with 0.018 inch slot upper incisor edgewise standard brackets (American Orthodontics, USA). The teeth were etched with 37% phosphoric acid for 30 seconds and then rinsed and dried with water and air sprays for 20 seconds on labial surface (Ozturk, Malkoc, Koyuturk, Catalbas, & Ozer, 2008). In group 1 that was followed by primer application and bracket positioning without any delay, this process was repeated for the other groups with 5, 15 and 30 minutes delay intervals between primer application and bracket placement in groups 2, 3, and 4 respectively. All the samples in four groups were stored in 37° C distilled water for one week before debonding. To simulate the oral temperature changes, the samples were thermo-cycled for 500 cycles within the range of 5°±2 C to 55°±2 C with 30 seconds dwell time and 15 seconds transfer time.

Shear test
Debonding was performed by the Hounsfild test equipment (Hsk-5 model, Safords, Redhill, Surrey, England) to estimate the bond strength for each sample. The knife edge cross head of the apparatus was oriented occluso-gingivally with 0.5 mm/min speed (Fig 2). The apparatus recorded the maximum forces applied on failure points and reported them in numerical and graphic form. Shear bond strengths were calculated in MPa by dividing the maximum forces by the bracket base surface area (11.77 mm$^2$).

The labial enamel surface of each sample was investigated by stereomicroscope ($\times$ 10 magnifications) to assess adhesive remnant index (ARI). The ARI scores were determined according to the criteria defined by Artun and Bergland (Oliver, 1988)

Statistical analysis
Descriptive statistics including mean values and standard deviations were computed for each group. One way ANOVA test was used for comparison among groups followed by the post hoc. Tukey test. Chi-square statistical test was used for ARI analysis. $p$-values less than 0.05 were considered significant in this study.

Results
Mean shear bond strength values are depicted in Table 1 for each group besides the shear bond strength in the group 2 and group 3 were more than group 1 and 4 with the group 2 and 4 having the highest and lowest values for the mean shear bond strength, respectively. maximum and minimum bond strengths of each experimental group. The mean values for one way ANOVA test showed statistically significant differences in shear bond strength among groups. Post hoc. Tukey test uncovered the significant differences between groups 1 and 2, and groups 2 and 4. The chi-square test displayed statistically meaningful differences among the groups ($p=0.032$). The failure site was closer to the bracket-adhesive interface in the first group and closer to the enamel-adhesive interface in other three groups.
Discussion

The current bonding investigations in orthodontics tend to search for a strong bonding system, because the bonding failure encountered during the treatment time has been a time consuming and costly process in clinical orthodontics (Turk et al., 2007; Yamamoto et al., 2006). The effect of different periods of time intervals between primer application and bracket bonding with No-mix adhesives has been the subject of investigation in this paper. However, there have been very few papers in the literature about this subject.

The results of this study showed meaningful differences among different groups, which is in concert with the results for the study of Evans et al (Evans & Powers, 1985).

The time intervals chosen for this study were 0, 5, 15 and 30 minutes. The delay between primer application and bracket positioning differs greatly among the clinicians. The maximum delay interval in this study has been chosen considering the beginners. But in the study of Evans et al the difference between the minimum 0 minute and the maximum 5 minutes delay intervals appears to be very small.

The results showed that the 5 minutes and 30 minutes delay intervals lead to the maximum and minimum mean values of shear bond strength, respectively. These findings are different from the results in the study of Lawrence et al who reported the maximum and minimum mean bond strength values with the 0 and 5 minutes delay intervals, respectively. Some possible reasons for these differences could be as follows:

1. The samples were thermo-cycled after bonding in this study; but in the study of Evans et al, the samples were stored in the humidor at the same study stage. It has been reported that the in vitro bracket bond strength shows smaller values if the thermo-cycling process is considered as a stage of a study before debonding, compared to otherwise similar studies without such a process (Delport & Grobler, 1988).

2. The force used to estimate bond strength in the study of Evans et al was in tensile form, not in concert with the shear bond strength estimation in this study. Practically, studies using tensile forces for bond strength evaluation have half the clinical credit of the otherwise similar studies using shear bond strength evaluation (Craig & Powers, 2002).

Mutual comparisons between each two groups in this study depicted meaningful mean shear bond strength difference between groups 1 and 2. Theoretically, the bond strength decreases as the adhesive thickness increases; since there would be more thermal expansion, increased polymerization shrinkage and more chance of air bubble and vapor trapping along with reduced elastic buffering (Cozza, Martucci, De Toffol, & Penco, 2006).

It appears that with instant application of the adhesive after primer application in the first group with no delay interval between them, the resultant primer vaporization would be less than the second group, therefore having greater adhesive thickness and lower shear bond strength values.

The mean bond strength value differences between the second and forth groups also were statistically significant. One could conclude that the 30 minutes delay interval in the fourth group has led to the vaporization of large amounts of monomer and increased primer concentration. In the No-mix systems, polymerization starts as the primer and adhesive get in contact (Craig & Powers, 2002; Evans & Powers, 1985). Increased primer concentration after 30 minutes of delay results in decreased chance of primer and adhesive paste blending and minimum free radical release from these two fronts; so polymerization takes place incompletely, reducing the shear bond strength values (Evans & Powers, 1985; Swift & Jorde, 2002). However in this study, mean shear bond strength values of the study groups are all more than the acceptable clinical threshold values (Cozza et al., 2006).
Evans et al. concluded that primer concentration increase with increased time delay is the reason for decreasing shear bond strength values from the 0 minute to the 5 minutes delay groups. They recommend not delaying bracket placement more than 1 minute after primer application (7).

The preferred bonding failure site is the bracket-adhesive interface to decrease the probability of enamel damage while debonding (D'Attilio et al., 2005; Ryou, Park, Kim, & Kwon, 2008; Zachrisson & Buyukyilmaz, 2005). Although some studies say that the final enamel damage would be minimal with the least amounts of adhesive remnants on the enamel, due to the less need for mutilating resin removal procedures (Montasser & Drummond, 2009; O'Brien, Watts, & Read, 1988; Sinha, Nanda, Duncanson, & Hosier, 1995). However, this type of enamel damage is controllable and can be minimized by means of standard methods and armamentaria (Ryou et al., 2008; Zachrisson & Buyukyilmaz, 2005). It has been claimed that enamel topography does not show noticeable differences between well-polished enamel surfaces after debonding and sound enamel surfaces (Diedrich, 1981). Little adhesive remnants on the enamel indicate bonding failure in the enamel-adhesive interface; which points out that fluoride-enriched superficial enamel layer has been eliminated (Diedrich, 1981). By the way, enamel-adhesive interface bond failure increases the risk for enamel cracks.

Statistically analyzed adhesive remnant indices in this study showed significant differences among groups. The first group showed the bracket-adhesive interface to be the most common failure site, whereas the most common site for bonding failure in other groups was the enamel-adhesive interface. There may be a probable effective role for the elapsed time after primer application and increased primer concentration in this regard (13, 17). In the first group the adhesive is placed on a low viscosity adhesive with high penetration. With increased primer penetration, the adhesive is able to access deeper in the etched enamel porosities. With increased primer concentrations in the other groups, the decreased primer penetration potential inflicts air bubble trapping and sites of increased stress, all which ultimately end in bonding failures in enamel-adhesive interfaces (13).

The results in this study lead us to the conclusion that may be there is no correlation between ARI and shear bond strength. Brien et al., in their study, reported a similar judgment (O'Brien et al., 1988). However, the amount of adhesive remained on the enamel surface or bracket base, is also a factor of debonding technique and the adhesive type (O'Brien et al., 1988; Ryou et al., 2008; Zachrisson & Buyukyilmaz, 2005). There has been an effort to make all these factors analogous in this study for all four groups; but the ARI values have been estimated with significant inter-group differences. Therefore, it appears that the independent variable of “delay interval” is the reason for different adhesive properties among groups which lead to significant shear bond strength and ARI differences.

**Conclusion**

Considering the findings of this study, one could recommend not to delay bracket positioning more than 5 minutes after primer application, in order to avoid negative effects of elapsing time on the primer properties. This time delay is also a determinant factor of in vitro ARI values, with probable clinical significance.
Table 1. Shear bond strength statistics for each group (MPa)

<table>
<thead>
<tr>
<th>group</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard deviation</th>
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<td>10.42</td>
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References


