SHEAR BOND STRENGTH COMPARISON OF A CONVENTIONAL AND A SELF-ETCHING FLUORIDE-RELEASING ADHESIVE FOLLOWING THERMOCYCLING

Aim: To compare the effect of thermocycling on the shear bond strength of brackets bonded using different primers. Methods: One hundred twenty extracted defect-free premolars were randomly divided into three groups. In all three, Transbond XT was the bonding adhesive of choice. In the control group (I), the standard Transbond primer was used, in group II a fluoride-releasing primer (Reliance fluoride containing light cure bond), and in group III an antimicrobial fluoride-releasing self-etching primer (Clearfil Protect Bond). These three groups were divided into two subgroups of 20 teeth each. In the first subgroups, the teeth were stored in only distilled water for 24 hours, whereas in the second subgroups, they were thermocycled 500 times between 5°C and 55°C. The shear bond strength was determined with a universal testing machine. After bracket failure, the Adhesive Remnant Index (ARI) score was verified. The data were analyzed using two-way analysis of variance, Bonferroni, and chi-square tests. Results: The group with the antimicrobial fluoride-releasing self-etching primer had a significantly lower shear bond strength than all other groups (P < .05). Thermocycling reduced the shear bond strength in all groups considerably. Conclusion: The antimicrobial fluoride-releasing self-etching primer performed comparably worse regardless of thermocycling. Brackets attached with self-etching primers demonstrated a shear bond strength after thermocycling approaching the border of acceptable adhesion. Thermocycling changed the ARI scores of the self-etching primer groups from the bracket-adhesive to the enamel-adhesive interface. World J Orthod 2010;11:6–10.

Key words: shear bond strength, fluoride, adhesive

In 1955, Buonocore introduced acid-etching bonding into dentistry. Acid-etching produces microporosities that allow resin tags to penetrate the tooth surface and mechanically interlock with the enamel. Conventional adhesive systems use three agents: an enamel conditioner, a primer solution, and an adhesive. To shorten working time, self-etching primers were developed. Manufacturers declared that these primers reduce chair time without compromising shear bond strength. Demineralization around brackets still presents a major problem for orthodontic patients. According to Ogaard et al, this is a consequence of the cariogenic plaque around fixed appliances. Initial caries in the form of white spot lesions is a serious adverse effect of fixed appliance treatment. The prevalence of white spot lesions after fixed orthodontic therapy is

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reported to range from 50% to 70%. Vari-
ous attempts were made to modify bond-
ing materials to decrease white spot lesion formation during fixed appliance treatment. These modified materials release fluoride that reduces the caries incidence when readily available in the oral cavity.8

Recently, it was shown that storage of bonded brackets in water and thermocy-
cling led to a decrease in shear bond strength.9,10 Thermocycling simulates the clinical condition and thus the actual performance of a bonding.11

The purpose of this study was to com-
pare the shear bond strength of primers following thermocycling.

MATERIAL AND METHODS

One hundred twenty human maxillary premolars extracted for orthodontic rea-
sions were cleaned of debris and stored in distilled water for 24 hours. The crite-
ria for their selection were intact buccal surfaces; no pretreatment with chemical agents such as (derivates of) peroxide, acid, or alcohol; no visible cracks; no caries; and no restorations. The water was changed weekly to prevent bacterial overgrowth. Before bonding, the labial surfaces of all teeth were cleaned with nonfluorided pumice, rinsed with water, and dried. The teeth were then randomly divided into 6 groups of 20 teeth each. In all groups, Transbond XT (3M Unitek) was the adhesive of choice and was cured with a halogen light for 20 seconds.

The six groups had the following characteristics:

- **Group I** (control): Etching with 37% phosphoric acid for 20 seconds, fol-
  lowed by Transbond primer application.
- **Group II**: Same as group I, but subse-
  quently submitted to thermocycling.
- **Group III**: Etching as in group I, fol-
  lowed by fluoride-containing primer (Reliance Fluoride Containing Light Cure Bond) application for 10 sec-
  onds. Primer removal with water spray.
- **Group IV**: Same as group III, but sub-
  sequently submitted to thermocycling.
- **Group V**: Application of a self-etching fluoride-releasing antimicrobial primer (Clearfil Protect Bond Kuraray) with a microbrush for 20 seconds and air-drying for 5 seconds.
- **Group VI**: Same as group V, but subse-
  quently submitted to thermocycling.

The brackets used in this study were premolar metal brackets (Generus Roth, GAC) with an average base surface area of 12.4 mm².

Following the recommendations of the International Organization for Standard-
ization, all test specimens were prepared at 23°C ± 2°C and stored for 24 hours in water at 37°C ± 2°C. Next, in accordance with ISO/TR 11405 recommendations, groups II, IV, and VI were thermocycled 500 times between 5°C ± 2°C and 50°C ± 2°C. All specimens were exposed to each container for 30 seconds with a transfer time of 5 to 10 seconds.

Subsequently, all specimens were embedded in autopolymerizing polymethylmethacrylate. All teeth were aligned with a mounting jig so that during the shear bond strength test, their labial surfaces were parallel to the force vector. Shear bond strength was evaluated with a universal testing machine (LF Plus, LLOYD Instruments, Ametek) with a crosshead speed of 1 mm/min. The force was applied directly to the bracket-tooth inter-
face using the flat end of a steel rod. The load at failure was recorded by a com-
puter connected to the testing machine. Shear bond strength was calculated as the recorded failure load divided by the bracket base area in MPa.

To determine the ARI13 after debond-
ing, all teeth and bracket bases were examined with a light microscope at 10× magnification. All ARI scores were assessed by the same operator.

Statistical analysis

SPSS 10.1 (SPSS) was used for statistic al analysis. Mean values were compared with the two-way analysis of variance (ANOVA) and Bonferroni tests. The chi-
square test was used to compare the ARI scores among all groups. P < .05 was set as the level of significance.
RESULTS

The mean shear bond strengths and standard deviations for all six groups are presented in Table 1 and Fig 1. The highest values were found for the control group without thermocycling. With thermocycling, group IV showed the best result. The lowest shear bond strengths were observed in groups V and VI (P < .05). Thermocycling significantly reduced the shear bond strength values of all groups.

Table 2 shows the distribution of the Adhesive Remnant Index (ARI) scores for all groups. The predominant failure score for the groups I and II was 2 (failure site mainly at the bracket-adhesive interface), group V, scores 1 and 2 were dominant, whereas 1 was prevalent in group VI.

DISCUSSION

The findings indicate that brackets bonded with conventional acid etching and a fluoride-releasing primer (Reliance Light Bond System) have a substantially higher shear bond strength than brackets attached with an antibacterial fluoride-releasing, self-etching conditioner. Bishara et al\textsuperscript{15} stated that bonding orthodontic brackets with traditional acid etching can be replaced by modern self-etching primers. During conventional etching, between 10 and 30 μm of the surface enamel layer will be lost.\textsuperscript{16}

Decisive questions include whether this loss is acceptable to achieve an adequate bond strength and what the optimum shear bond strength with the least loss of enamel is. According to Reynolds,\textsuperscript{17}...
adequate shear bond strength for orthodontic purposes ranges between 5.9 to 7.8 MPa. Our findings showed that all groups were within this range. Other investigators pointed out that the maximum bond strength should be less than the hardness of enamel, which is about 14.0 MPa. If the shear bond strength of brackets exceeds this value, the enamel surface may be damaged during debonding. Conventional sealing was found to be near this limit. Shear bond strength using self-etching primers is considerably below this limit, making their use preferable in regard to debonding.

Previous studies have shown that water storage and thermocycling affect the shear bond strength of brackets. In the absence of these procedures, shear bond strength tests provide information about only the initial bond strength. Therefore, it is important to thermocycle specimens to assess the durability of a bond.

Overall, thermocycling causes a reduction of the shear bond strength, as supported by the findings of this study. Arıcı and Arıcı found that in no-mix adhesives, the shear bond strength was reduced by approximately 5.7% when the specimens were thermocycled 200 times, but by 17.9% when thermocycling amounted to 20,000 times. To some degree, this is supported by Davidson et al., who found a significant decrease in shear bond strength up to 300 thermal cycles. In contrast to the aforementioned articles, however, the decline in this study varied between 18% and 41%.

The main reason for the shear bond strength decrease after thermocycling is believed to be a possible hydrolysis at the adhesive-hybrid layer interface. Another theory is that the different expansion coefficients of enamel, adhesive, and bracket will weaken the adhesion.

The well-defined pattern of prismatic and aprismatic enamel after conventional etching enhances the formation of resin tags that extend deeply into the enamel. This fact is associated with a high shear bond strength and thus a superior survival rate of bonded brackets in vivo. In contrast, the thin laminar-like resin penetration into the enamel produced with self-etching primers seems to sustain cyclic stresses less favorably.

However, this study showed that the decrease following thermocycling was similar independent of the primer used. Still, in the self-etching primer group, the shear bond strength approached the critical value reported by Reynolds.

The aim of debonding is to remove a bonded attachment from the tooth and safely reestablish its pretreatment condition. The more deeply the adhesive penetrates the enamel surface, the greater the risk of enamel damage becomes. The ARI was developed to help evaluate this problem.

Before and after thermocycling, the mean ARI scores for the conventional and fluoride-releasing primer groups were focused on score 2, which indicates a bond failure predominantly at the bracket-adhesive interface. In the two antimicrobial self-etching primer groups, the ARI was predominantly between 1 and 2, indicating more failures at the adhesive-enamel interface. Failures at the bracket/adhesive interface offer better protection of the enamel during debonding. If the failures occurs mainly at the adhesive/enamel interface, less residual adhesive remains on the tooth whose enamel is, however, more prone to damage.

**CONCLUSION**

From this study, the following conclusions can be drawn:

• The shear bond strength after the use of a standard and a conventional fluoride-releasing primer was significantly higher than that of an antimicrobial self-etching fluoride primer.
• Thermocycling led to a general reduction of the shear bond strength.
• After thermocycling, the shear bond strength using an antimicrobial self-etching fluoride-releasing primer approached the critical shear bond strength limit.
• The bracket failure mode after thermocycling shifted slightly from bracket-adhesive to adhesive-enamel.
REFERENCES


