

Shear bond strength of composites using an adhesion booster

Edivaldo de Morais*, Fábio Lourenço Romano**, Lourenço Correr Sobrinho***, Américo Bortolazzo Correr****, Maria Beatriz Borges de Araújo Magnani*****

Abstract

Objective: To evaluate the shear strength of two composites (Transbond XT and Concise) using an adhesion booster (Ortho Primer). **Methods:** The sample consisted of 90 bovine incisors divided into six groups (n=15). All teeth were subjected to prophylaxis with pumice and enamel etching with phosphoric acid. Transbond XT was used conventionally in Group I. Group II was handled similarly to Group I, except that Ortho Primer was applied instead of XT Primer. After etching, the enamel in Group III was contaminated with saliva, Ortho Primer was then applied and bonding performed using Transbond XT. In Group IV, Concise was used conventionally. Group V was handled similarly to Group IV, except that Ortho Primer was applied instead of the fluid resin. After etching, the enamel in Group VI was contaminated with saliva, Ortho Primer was then applied and bonding performed using Concise. The specimens were stored in distilled water at 37 °C for 24 hours and subjected to shear strength testing. Data were analyzed with ANOVA and Tukey's test (5%). **Results:** Bond strength in Group IV was statistically higher than in Groups II, III and VI (p<0.05). No statistically significant differences were found among Groups I, IV and V, and between I, II, III and VI (p>0.05). When used conventionally, both Transbond XT and Concise yielded the highest bond strength values. When applied to dry enamel, Ortho Primer acted effectively as a bonding agent for the composites under evaluation. When applied to contaminated enamel, Concise yielded low bond strength.

Keywords: Orthodontic brackets. Shear strength. Orthodontics.

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* Specialist in Orthodontics, Piracicaba Dental School, University of Campinas - UNICAMP.

** PhD and Professor of Orthodontics, Department of Pediatric Clinic, Preventive and Community Dentistry, Ribeirão Preto Dental School, University of São Paulo - USP.

*** Head Professor of Dental Materials, Department of Restorative Dentistry, Piracicaba Dental School, University of Campinas - UNICAMP.

**** PhD in Dental Materials, Piracicaba Dental School, University of Campinas - UNICAMP.

***** PhD and Professor of Orthodontics, Department of Child Dentistry, Piracicaba Dental School, University of Campinas - UNICAMP.

INTRODUCTION

For many years orthodontic treatment was performed with the aid of orthodontic bands placed on all teeth. Not only was this procedure rather laborious, it also caused considerable discomfort to patients, compromised oral hygiene, presented unfavorable esthetics and remaining spaces between the teeth after removal of the orthodontic appliance.^{3,30}

Changing from banding teeth to bonding brackets directly to tooth enamel was one of the most significant advances in orthodontic appliance placement procedures of all times. This procedure was only possible thanks to Buonocore⁸ (1955), who introduced the technique for etching dental enamel with phosphoric acid, and to Newman¹⁹ (1965) who spearheaded the bonding of orthodontic attachments.

Currently, a broad range of orthodontic attachments such as brackets, hooks and tubes are available to orthodontists as well as a variety of bonding materials, among which composites are undoubtedly the most widespread. The procedure for bonding brackets to enamel with these materials needs to be conducted in an orderly and cautious manner in order to prevent bond failures when applying orthodontic mechanics, which might undermine treatment effectiveness. This procedure is time consuming and requires a dry surgical field free from any type of contamination.⁴ The bonding of accessories with composites in the presence of contamination or moisture may cause a higher number of bracket bond failures, delaying treatment and increasing costs to orthodontists.^{2,28}

With the purpose of finding a solution to this critical issue in orthodontic bonding, manufacturers have developed materials that can be used in moist or contaminated environments without compromising bond strength.^{11,12,14,18,29} Additionally, these products save consultation time, decreasing the number of bond failures and consequently affording greater ease and effectiveness to orthodontists.^{21,24,25}

A new product was recently introduced in the market known by its commercial name as Ortho Primer (Morelli, Sorocaba, Brazil). According to the manufacturer it is an adhesion booster with hydrophilic properties suitable for bonding brackets in adverse clinical situations, including cases where saliva or moisture contamination occurs after enamel etching. This material acts as a bonding agent with the function of chemically activating orthodontic composite adhesion and is suitable for all types of brackets.

The mere introduction of a new product in the market, however, is not enough to ensure that such material is suitable for clinical use. Product effectiveness and suitability must be verified in laboratory experiments and clinical trials. The aim of this study was to examine the shear strength of metal brackets bonded with different composites onto dry surfaces contaminated with saliva using Ortho Primer as an adhesion enhancing agent.

MATERIAL AND METHODS

The study made use of 90 right and left mandibular permanent bovine²² incisors, freshly extracted, properly cleaned with periodontal currettes (Duflex, Juiz de Fora, Brazil), which were stored for one week in an aqueous solution of 0.1% thymol and subsequently stored in distilled water in the refrigerator at 4 °C. Criteria for tooth selection required intact crowns, no decalcification (softening), cracks or fractures.

After storage, the teeth were dried and handled in the following manner: The crown and part of the tooth root were placed in a wooden box containing plasticized wax until the desired depth was reached. While placing the teeth in the wax, care was taken to position the buccal surface perpendicular to the bottom of the box. In this position, the remaining portion of the root was centered in a PVC tube (Akros, São Paulo, Brazil) with 20 mm internal diameter by 20 mm height. After this procedure, acrylic resin (Dental Vipi, Pirassununga, Brazil) was poured inside the PVC

tube in the sandy phase under vibration (Fig 1), and the excess removed from the bottom of the die with a LeCron spatula (Duflex, Juiz de Fora, Brazil). Then the tooth crowns were removed from the wax and cleaned (Fig 2).

To verify the correct positioning of the crown in the PVC tube a glass square ruler was used with the 90-degree angle resting on the upper portion of the die and on the buccal surface of each tooth (Figs 3A and B). This verification was necessary to ensure proper shear testing. Badly positioned teeth were excluded from the experiment. The entire tooth-PVC tube set was filled with resin, numbered for better identification and stored again in distilled water under refrigeration.

All buccal surfaces were subjected to prophylaxis with rubber cup, non-fluoridated pumice and water for 10 seconds, then washed and dried for the same period of time. After five prophylaxis procedures the rubber cup was replaced to ensure standardization. Subsequently, all teeth had their enamel etched with phosphoric acid gel at 37% for 30 seconds, followed by washing and drying for about 20 seconds.

The specimens were divided into six groups (n=15), as described in Table 1.

In Groups II, III, V and VI, after Ortho Primer bonding agent had been applied, light-curing was performed for 10 seconds.

Ninety maxillary central incisor metal brackets Dyna-lock Standard, with mesh base, no torque or angulation (code 018-501, 3M Unitek, Monrovia, USA) (Fig 4), were positioned on the buccal surface of each tooth with the aid of bracket placing tweezers (Orthoply, Philadelphia, USA). All bonding procedures were performed by the same examiner after properly positioning each attachment and pressing them against the tooth surface in order to reduce composite thickness between bracket and enamel. At this time, all bonding material excess was removed with an explorer probe (Fig 5).

In the groups using Transbond XT, bonding was light cured for 40 seconds, i.e., 10 seconds on



FIGURE 1 - Steps taken to insert bovine teeth in PVC tube.



FIGURE 2 - Bovine tooth inserted in PVC tube.

each surface (mesial, distal, incisal and gingival) as close as possible to the base of the bracket with a halogen light unit XL 2500 (3M/ESPE, St. Paul, USA) with 500 mW/cm² power. This light intensity was verified prior to each light curing session with a radiometer (Demetron, Danbury, USA).

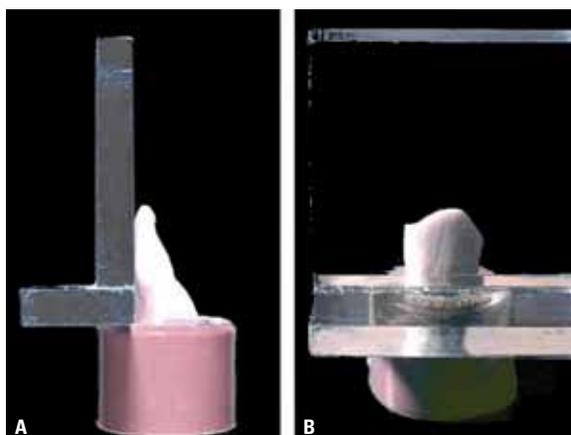


FIGURE 3 - Proper tooth positioning verification. **A)** Lateral view. **B)** Front view.

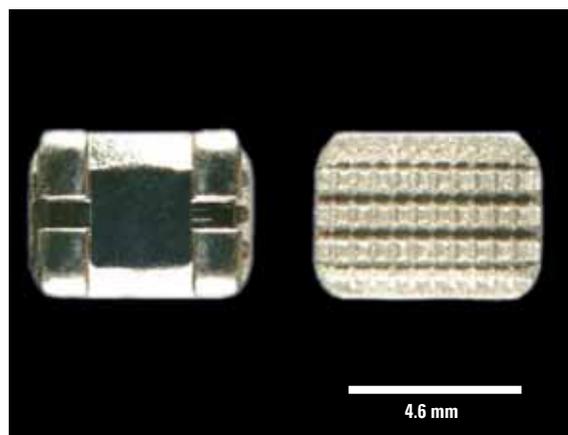


FIGURE 4 - Bracket used in the experiment.



FIGURE 5 - Specimen with bracket bonded to buccal surface.

In the groups using Concise composite no light curing was performed as this is a self-curing material.

After bracket bonding, the specimens were once again stored in distilled water in an oven (Odontobrás, Ribeirão Preto, Brazil) for 24 hours at 37 °C to simulate oral conditions. Thereafter,

TABLE 1 - Groups used in the experiment.

Group	Enamel condition	Bonding agent	Composite
I	Dry	XT Primer	Transbond XT
II	Dry	Ortho Primer	Transbond XT
III	Contaminated with human saliva	Ortho Primer	Transbond XT
IV	Dry	Fluid resin A and B	Concise*
V	Dry	Ortho Primer	Concise*
VI	Contaminated with human saliva	Ortho Primer	Concise*

all samples were subjected to shear bond strength testing on an Instron machine, model 44.11, (Canton, USA) with a speed of 0.5 mm/minute with a chisel-shaped tip resting on the upper enamel/bracket interface.

Shear bond strength values were obtained in Kgf (kilograms-force), transformed into N (Newton) and divided by the area of the bracket base (15.64 mm²), yielding values in MPa.

Statistical treatment

Data on shear strength were analyzed using multifactorial analysis of variance and Tukey's test at 5% level of significance for comparison between groups.

RESULTS

Mean shear strength values obtained for the six groups as well as statistical comparisons between them are shown in Table 2.

Group IV showed a mean shear strength value statistically higher than Groups II, III and VI ($p < 0.05$). Groups I, II and V were statistically higher than Group VI ($p < 0.05$). No statistically significant difference was observed between Groups I, IV and V, between I, II and III, nor between Groups III and VI ($p > 0.05$).

DISCUSSION

In orthodontic bonding, tooth surface conditions and type of bonding material greatly affect bond strength. In some situations, enamel preparation is not adequate to ensure bracket adhesion during orthodontic mechanotherapy, causing treatment delays and damage to tooth structure due to the need for repeated rebonding.^{5,9,10,13,17}

Groups I, II and III were bonded with Transbond XT light-cured composite, a material used as control in several studies available in the lit-

erature.^{1,4,6,7,11,12,15,24,25,26} There were no statistically significant differences between them, regardless of surface treatment. In Group I bracket bonding was performed with Transbond XT in a conventional manner, i.e., according to the manufacturer's directions, yielding a shear strength value of 11.35 MPa. This is close to values found by other authors^{6,7,11,15} and higher than other studies.^{1,25} The differences found between the results of this and other studies are probably due to the different methodologies used during the mechanical tests as well as the different substrates.

Between Groups II (dry enamel, Ortho Primer and bonding with Transbond XT) and III (enamel contaminated with saliva, Ortho Primer and bonding with Transbond XT), the mean shear strength values were very close and therefore not statistically significant. This was not the case with Concise since Group V, where Ortho Primer was used on dry enamel, yielded better adhesion than on saliva-contaminated enamel (Group VI), and was therefore statistically significant.

Self-curing composites – Concise in particular – have been used to bond orthodontic accessories for several decades primarily thanks to their adequate bond strength in a dry environment.^{21,25} Table 2 shows that Group IV, which used Concise as bonding material according to the manufacturer's recommendations, achieved the highest shear strength mean value in this study (16.34 MPa). This is close to values found by other authors^{15,22,27} and higher than other studies cited in the literature.^{1,24}

In situations where maintenance of a dry surgical field becomes challenging, the literature shows inadequate or even absence of bond strength of this type of material (composite) to enamel.¹⁶ Group VI, which was bonded with Concise after application of Ortho Primer to saliva-contaminated enamel, showed the lowest shear strength in this study (5.62 MPa). This result is lower than the value proposed by Reynolds²⁰ for laboratory trials and confirms that saliva contamination after acid etching is a key factor undermining bracket adhesion to

TABLE 2 - Mean shear strength (MPa) and statistical analysis of experimental groups.

Groups	Shear Strength (MPa)
IV	16.34 (4.76) ^a
V	12.43 (3.83) ^{ab}
I	11.35 (3.62) ^{ab}
II	9.85 (3.12) ^b
III	7.68 (4.52) ^{bc}
VI	5.62 (3.33) ^c

Means followed by different letters differ by Tukey's test at 5% level. Standard deviation in parentheses.

enamel using composites.^{10,12} The bond strength of 12.43 MPa found in Group V (dry enamel, Ortho Primer and bonding with Concise) was statistically higher than in Group VI, which reinforces the argument that bonding with composites is significantly enhanced in a dry environment.

Groups V and VI used a light-cured material (Ortho Primer) with a self-curing composite (Concise). Potential lack of compatibility between curing methods²³ was not investigated in this work.

It is worth mentioning the work of Grandhi et al¹⁵ in 2001, who found that the low effectiveness of a self-curing composite (Concise) associated with a hydrophilic primer (Transbond MIP) in a contaminated environment could be related to a failure to activate the hydrophilic primer, since in this experiment the primer was not light-cured prior to bonding. In the present study another hydrophilic bonding agent was utilized (Ortho Primer) which was cured after application. Given these methodological differences one cannot state that light-curing Ortho Primer enhanced bond strength in the infected groups.

In a comparison between bonding materials (Transbond XT and Concise), both showed similar bond strength values in light of a variety of surface treatment approaches and different types of bonding agents (Tables 1 and 2). When the composites were bonded to dry enamel using their respective bonding agents the highest bond strength values were obtained, followed by the condition of dry enamel and saliva-contaminated enamel associated with Ortho Primer, which exhibited lower bond strength values.

CONCLUSIONS

1) Composites Transbond XT and Concise™ Orthodontic Bonding System, when used conventionally, achieved the highest bond strength values.

2) When applied to dry enamel, Ortho Primer acted effectively as a bonding agent for the composites mentioned above.

3) Bonding to surfaces contaminated with saliva using Concise after application of Ortho Primer yielded low bond strength.

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Contact address

Fábio Lourenço Romano
 Av. Engenheiro José Hebert Faleiros, 600 Casa 78
 CEP: 14.098-780 - Ribeirão Preto/SP, Brazil
 E-mail: flromano@terra.com.br