



# In vitro bracket bond strength to acid-etched or air-abraded enamel

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## Abstract

**Purpose:** This study evaluated, *in vitro*, the capacity of a dentin bonding agent to improve the bond strength of orthodontic brackets using air abrasion enamel preparation.

**Methods:** Each of the enamel surfaces received a different treatment prior to bonding procedures. Group 1 received acid-etched with 38% phosphoric acid for 30 seconds. Group 2 received acid-etched with 38% phosphoric acid for 30 seconds, dentin bonding agent (Scotchbond MultiPurpose) applied after rinse completed. Group 3 received abrasion-etched (particle size 50 microns, 120 psi). Group 4 received abrasion-etched, dentin bonding agent applied after etching completed. Unfilled adhesive resin (Ormco light cured sealant) was applied followed by a premolar bracket (Ormco meshed mini-twin) with adhesive (Ormco light cured adhesive) placed on the back. Shear bond strengths were measured using an INSTRON machine and the site of bond failure was determined under 3X magnification.

**Results:** The shear bond strength obtained with a traditional acid-etch, *in vitro*, was not improved significantly by the use of a dentin bonding agent. Air abraded surfaces showed very low bond strengths with all treatments.

**Conclusions:** Tested *in vitro*, air-abraded surfaces provide clinically unacceptable bond strength when compared to acid-etched enamel surfaces. (*Pediatr Dent* 21:282-285, 1999)

Buonacore first described acid etching as a means of promoting bonding of restorative to enamel surfaces.<sup>1</sup> The uses of this technology have ranged from the initial tooth restoration to preventive pit and fissure sealants. In the 1980's, acid-etching became the standard surface preparation for bonding orthodontic brackets to the dentition.<sup>2</sup>

Acid-etching of the enamel with 35%-40% phosphoric acid removes tooth structure and produces microscopic porosities in the enamel into which uncured acrylic or Bis GMA resins can flow.<sup>3</sup> Once the resin is cured, it produces taglike projections that mechanically attach the resin material to the tooth surface.<sup>4,5</sup> Currently, acid-etching has been the most effective and predictable form of surface preparation for bonding.

The traditional acid-etching for resin application is technique sensitive and relatively time consuming. In recent years, researchers have begun to study air-abrasive technology as an alternative or adjunct to acid-etching.<sup>6</sup> The potential advantage of abrasion etching over acid-etching is that it eliminates several of these time consuming steps. Kanellis demonstrated that the total chair time for the placement of sealants in children using air-abrasion was one-third of the time required using

the acid-etch technique.<sup>7</sup> With air abrasion, the surface is prepared in a dry field negating the need for rinsing and drying. This procedure reduces the potential for moisture contamination which can adversely affect bond strength.<sup>8-11</sup>

The air-abrasion system uses a narrowly focused stream of non-toxic particles to abrade tooth structure. Using different particle sizes and different air pressures, the abrasion system can be used for cavity preparation as well as for preparation of enamel for micro-mechanical bonding in lieu of acid-etching. Studies evaluating the penetration of resin tags into treated tooth structure have shown that air abrasion has the potential to prepare enamel bonding surfaces equal to those obtained from acid-etching.<sup>12,13</sup> However, there is disagreement in the literature as to how strong the resulting bond is in comparison to bonds formed after using the acid-etch technique. Some studies have found no significant difference in shear bond strength between an acid-etched and air-abraded surface.<sup>14,15</sup> Others have concluded that air abrasive treatment does not eliminate the need for additional conditioning of the tooth before bonding, but can improve the bond strength when used in conjunction with the acid-etch technique.<sup>16-19</sup> Another problem with abrasion etching is in the area of microleakage under the resin, and thus far it appears that surfaces treated with abrasion-etching lack the seal obtained with acid-etching.<sup>20</sup> However, considering the potential advantages of abrasion etching over acid-etching, it is worth investigating ways to increase the bond strength of air-abraded enamel.

Hitt and Feigel evaluated the use of a dentin bonding agent to counteract the negative effects of moisture contamination on acid-etched enamel.<sup>21</sup> They demonstrated increased shear bond strength in moisture contaminated, as well as uncontaminated, enamel surfaces when compared to acid-etching alone.

It also has been shown that when a dentin bonding agent was used under a sealant in either dry or moisture contaminated environments, there was less microleakage.<sup>22</sup> It has been suggested that the dentin bonding agent allows better wetting of the surface than can be obtained with an unfilled resin alone. Since a dentin bonding agent can increase the bond strength of an acid-etched surface, it is possible that a similar effect could be obtained on air-abraded surfaces.

The purpose of this study was to evaluate, *in vitro*, the effect of a dentin bonding agent on shear bond strength of orthodontic brackets to both air-abraded and acid etched enamel surfaces.

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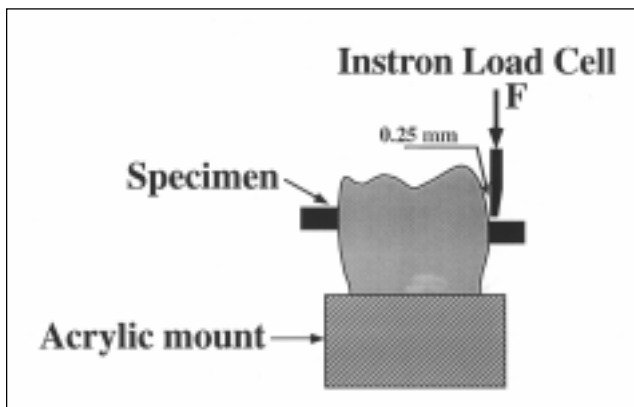


Fig 1. Diagram of bracket shear test.

## Materials and Methods

Freshly extracted human permanent molars and premolars were collected and stored in saline at 37°C within two weeks of extraction. Each tooth had at least one sound buccal or lingual enamel surface. Teeth were discarded if there was evidence of decalcification, fluorosis, or surface irregularities such as forceps scars or fractures. During handling of the teeth, the investigator used appropriate infection control procedures.

The teeth were mounted by their roots in blocks of self-curing acrylic, and the experimental surfaces were identified and marked. Each surface was assigned to one of four groups. Before treatment, each surface was prepared with a rubber prophyl cup using water and pumice for 10 seconds and rinsed in running water for 30 seconds in order to obtain a uniform enamel surface. If the same tooth had surfaces used in multiple groups, acid etching and bracket bonding was performed, and the tooth was replaced in the saline until the abrasion treatment. In this way, the character of the acid etched enamel was unaffected by contact with the particle stream and the surface was not allowed to desiccate before abrasion preparation.

For the acid-etch groups, etching of the enamel consisted of a 30 sec application of 38% phosphoric acid. The etched surface was rinsed with water for 15 sec, and dried with uncontaminated air.

For the air-abraded groups, 50 micron particles of alpha alumina at 120 psi were applied at a distance of 3-4 mm from tooth surface with the nozzle at almost 90° to the surface (KCP 2000, American Dental Technologies). The treatment was continued until the surface exhibited a "frosty" appearance, in accordance with the manufacturer's instructions.

Orthodontic brackets (Ormco meshed mini-twin, Orange, CA) were bonded to the treated tooth surfaces using a light cure adhesive (Ormco "Sequence" adhesive). Prior to application of the adhesive, a thin layer of unfilled resin (Ormco "Sequence" sealant) was brushed on the surface and light cured for 10 seconds. The brackets were placed on the adhesive on the teeth and the adhesive was light cured for 40 sec, orienting the light for 10 sec at each side of the brackets.

For the groups with dentin bonding agent, Scotchbond MultiPurpose was brushed on the surface and dried.

### The four treatment groups were as follows:

- Group I-35 brackets (control)-Acid etched, no dentin bonding agent
- Group II-36 brackets-Acid etched, dentin bonding agent
- Group III-33 brackets -Air-abraded, no dentin bonding agent
- Group IV - 35 brackets-Air-abraded, dentin bonding agent

All samples were stored in saline for five to seven days at 37°C prior to testing. Shear bond strength tests were performed using an Instron Universal Testing Machine (Instron Corp., Canton, MA). The acrylic block sample was positioned so that the surface of the tooth and the bracket base were parallel to the direction of the applied force (Figure 1). The force was applied by means of a beveled loading head placed on the occlusal edge of the bracket. A crosshead speed of 0.05 in/min was used and the shear force at bond failure was recorded. The surface area measurement of the bracket mesh pad was provided by the manufacturer as 0.06 in<sup>2</sup>. The shear bond strengths were analyzed using an Analysis of Variance (ANOVA).

Each bonding site and corresponding bracket was then examined under 3X magnification to determine the site of bond failure.

## Results

The shear bond strengths are summarized in Figure 2. For the acid etched teeth, there was no significant difference in bond strength with the addition of a dentin bonding agent. Similar results were observed for the air abraded teeth. The bond strengths of both acid etched groups (groups I and II) were significantly higher than the air abraded groups (groups III and IV).

Visual examination of the fracture surfaces revealed that in Groups I and II retained up to 25% adhesive on the tooth surface. Eight surfaces in these two groups experienced enamel fracture of the tooth before bond failure. For groups III and IV the bond failure always occurred at the tooth-resin interface.

## Discussion

The etching of enamel surfaces with 35-40% phosphoric acid has continued to be the standard by which all other enamel surface preparation techniques are measured. In this study, the acid etch technique used included an etching time and acid con-

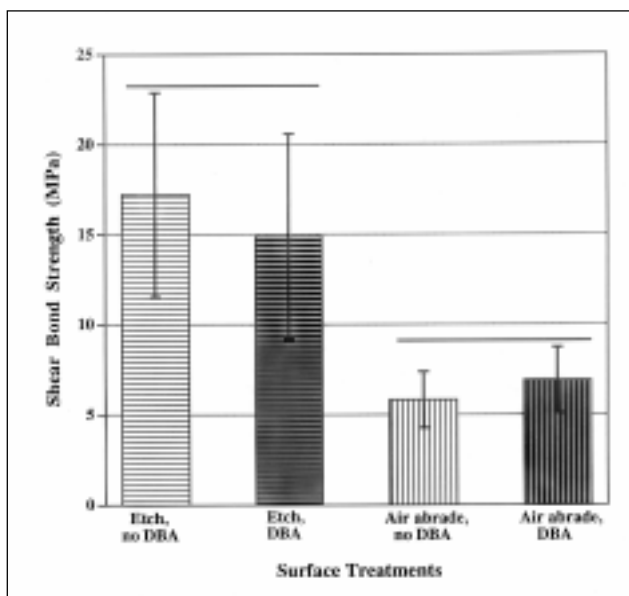


Fig 2. The relationship of shear bond strength to surface treatments.

**Table I. Summary of Bond Strengths**

	Group I	Group II	Group III	Group IV
	Acid-etch	Acid-etch/ Dentin bond	Air abrasion	Air abrasion/ Dentin bond
	N=35	N=36	N=33	N=35
Mean	17.2 MPa	14.9 MPa	5.84 MPa	6.93 MPa
SD	±5.7	±4.6	±1.6	±1.8

centration which were well within the established standards for consistent results<sup>23,24</sup> and the values obtained for both acid etch groups (1 and 2) were within the range of an acceptable enamel bond strength.<sup>17</sup>

The results of this investigation are in agreement with several other studies which demonstrated that air abrasion alone produces a bond that is significantly weaker than acid etching.<sup>16-19</sup> It also confirms the findings by Sargison et al. and Hogervorst et al.<sup>25,26</sup> that “[air abrasion of] enamel does not appear to be a reliable means of enamel preparation for orthodontic bonding” and that sandblasted bonding strengths were significantly lower. There have been other studies, however, which have concluded that the shear bond strength produced by air abrasion preparation was not significantly different than that produced by acid etching.<sup>14,15</sup> While the reason for this discrepancy is not clear, it may be related to abrasion variables such as particle size or pressure.

Hiitt and Feigal<sup>21</sup> demonstrated an increase in bond strength of dental sealants with the use of dental bonding agents on dry and moisture contaminated surfaces. In the current study, the use of Scotchbond MP dentin bonding agent after air abrasion preparation or acid etching did not significantly affect the resultant bond strength.

This study did not examine the effect of air abrasion when used in conjunction with acid etching, which has been shown to be as good as or better than acid etching alone<sup>16-19</sup> and may be worth future examination for use with the bonding of orthodontic brackets. Further, with the current rapid advancement in adhesives technology, it is possible that newer adhesive systems may be able to make air abrasion a more clinically predictable procedure for the placement of orthodontic brackets and will merit future study.

## Conclusions

This study evaluated the capacity of a dentin bonding agent to improve the bond strength of orthodontic brackets using air abrasion enamel preparation *in vitro*. Within the parameters of this study:

1. The shear bond strengths of orthodontic brackets to enamel prepared by air abrasion technique were significantly lower than the values obtained with acid etch technique. These strengths obtained were below clinically acceptable values.
2. Use of a hydrophylic dental bonding agent did not significantly affect the shear bond strengths of brackets to either the air abraded or acid etched enamel.

Air abrasion enamel preparation prior to bonding, either alone or with a hydrophilic dental bonding agent, cannot be recommended currently for the bonding of orthodontic brackets.

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## ABSTRACT OF THE SCIENTIFIC LITERATURE



### COMPARISON OF VARIOUS DRUGS FOR PEDIATRIC SEDATION-PRELIMINARY REPORT

To date no single drug or drug combination has proven to be reliable in achieving adequate sedation for pediatric patients undergoing restorative dentistry. Failure rates have been reported as between 25%-50% according to the authors. Chloral hydrate is one of the most commonly used oral sedative agents and was used as the standard by which the proposed sedation technique was measured.

Fifteen uncooperative patients were divided into three similar groups based on age weight and sex. Group 1 received oral chloral hydrate at 50 mg/kg and nitrous oxide at between 60%-70%. Group 2 received IM ketamine at 2 mg/kg followed by IV access. Meperidine 1.5 mg/kg and promethazine .75 mg/kg were injected transmucosally into the masseter muscle. Nitrous oxide was administered at 60%-70%. The third group was given 3 kg/kg ketamine IM, IV access, and nitrous oxide, meperidine and promethazine at the same dose and site as Group 2. The patients were all given 2% lidocaine with 1:100,000 epinephrine for local anesthesia keeping the total dose below 3 mg/kg. A rubber dam was used in all cases. All patients were appropriately monitored and vital signs recorded automatically every five minutes. According to the authors, 80% of the patients in Groups 2 and 3 received additional ketamine (0.5-1.0 mg/kg) via the IV to maintain an adequate depth of anesthesia for the procedures. The chloral hydrate group did not receive any additional medication.

The results were that the times for induction of sedation were greater for the chloral hydrate group than the ketamine groups (48.3 minutes vs. 16.6 minutes). The recovery times for the ketamine groups were greater than the chloral hydrate group (45.6-63.2 minutes vs. 37.2 minutes). There were six instances of airway obstruction in the chloral hydrate group, three in Group 2, and four in Group 3. One patient in the chloral hydrate group had one episode of desaturation below 92%, which was corrected by suctioning and positioning of the airway. One patient in Group 2 vomited without aspiration. More care was provided to the patients in the ketamine groups than the chloral hydrate group due to the ability of the operator to supplement the sedation with ketamine as needed. Two of the chloral hydrate patients did not have any treatment completed. The authors found that in spite of the addition of IM meperidine, the sedative effects were no different for any of the groups and they had to supplement the ketamine groups to complete planned treatment.

The authors conclude that IM ketamine induction and maintenance with IV ketamine and possibly a narcotic is a viable sedation technique that offers no higher risk of adverse reactions than chloral hydrate. However, there are additional training requirements and staffing for ketamine, which is, considered a general anesthetic in most states.

**Comments:** This is an interesting concept, but there does not seem to be a safe and effective alternative to general endotracheal anesthesia for a certain group of pediatric patients. MGP

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**Campbell, RL, et al; Comparison of oral chloral hydrate with intramuscular, ketamine, meperidine, and promethazine for pediatric sedation-preliminary report. *Anesthesia Progress* 45:2 46-50, 1998**