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# Analysis *in vitro* of direct bonding system with cyanoacrylate ester and orthodontic wires

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**Abstract** – The aim of this study was to evaluate the tensile strength of orthodontic wires bonded onto the enamel with cyanoacrylate ester. To obtain the specimens, 120 human premolars (extracted for orthodontic or periodontal reasons) were included in acrylic blocks of rapid polymerization with three teeth each. Four groups were formed with ten specimens each. In the specimens, a dental splint model was made with cyanoacrylate ester and round stainless steel wire. In groups I, II and III, cyanoacrylate ester was used with round steel wires, with variation in diameter: 0.014 inches; 0.016 inches and 0.018 inches, respectively. In group IV, round steel wire 0.018 inches was used with photo polymerizing resin composite with previous acid etching. The adhesive force of the materials was measured in two points under the action of the tensiometer (ETM-USA). The number of loose wires was counted along with those that remained fixed according to the different levels of force applied because of the direction of the tensile force (vertical or horizontal) and the diameter of the wire used. The data obtained were first submitted to a descriptive analysis and then submitted to a statistical analysis (Friedman's Test and Dunn's Test of Multiple Comparison – Epi-info 3.2). Within the limitations of the experimental conditions presented, the cyanoacrylate ester or 'Super Bonder®' maintained bonded to enamel and steel wires (0.016 and 0.018 inches) during the tensile strength tests under different levels of applied forces.

Routinely, avulsed or dislocated permanent teeth require repositioning and splinting (1) with the goal of stabilizing them for a determined time, preventing additional trauma and protecting the fibers of the periodontal ligament, so that these will be able to regenerate (2). During the emergency procedures, splints have to be made with the material available at the moment requiring improvisation.

Many techniques of splints have already been described in the literature: flexible stainless steel wire fixed to the vestibule of the teeth with a photo polymerizing resin composite, after enamel acid etching, (3, 4) splints with metallic wires (5) or with the adaptation of Erich's bar (6, 7), trans-alveolar (3) sutures, splint with a titanium plate flexible and pliable with resin composite (7) or the use of Ribbond (Ribbond Inc., Seattle, WA, USA) as splinting method (8).

Cyanoacrylates and its homologues have a variety of medical, dental and commercial applications as adhesives (9). Some studies have been shown the use of *N*-butyl-2-cyanoacrylate as surgical adhesives (10, 11). However, there are very few reports (all of them *in vitro*) (12–15) on the use of a commercial all purpose cyanoacrylate adhesive.

The designing of a simple practical model, with the use of a bonding agent that dries quickly and is available in the market, could facilitate this procedure in the emergency room.

The aim of this paper was to evaluate *in vitro*, the tensile strength of orthodontic wires bonded onto the enamel with cyanoacrylate ester.

## Materials and methods

The study protocol was approved by the Human Studies Review Committee of Araçatuba Dental School (UNESP) and was conducted with institutional guidelines (UNESP), according to the standards of government authorities.

To obtain the specimens, 120 human premolars (extracted for orthodontic or periodontal reasons) were included in acrylic (Acrilico Auto Polimerizante Clássico

JET incolor, São Paulo, Brazil) blocks of rapid polymerization, with three teeth each (Fig. 1). Four groups were formed with 10 specimens each. The blocks in which the teeth were embedded were rigid.

The dental bonding with cyanoacrylate ester 'Super Bonder®, (Henkel Loctite Adhesives Ltda, Itapevi, São Paulo, Brazil) was carried out in a dry field at room temperature. In the group I (0.014 inches), group II (0.016 inches) and group III (0.018 inches), the glue was used directly on the enamel surface, adapting itself to the round stainless steel wire (Morelli Ortodontia, Sorocaba, São Paulo, Brasil) on the vestibular of the teeth by means of manual adjustment and pliers varying the diameter of the wires according to the groups. The wire was placed in the vestibular enamel surface and the cyanoacrylate was placed on the wire on all teeth at once (two drops for each tooth). In group IV, round steel wire 0.018 inches was used with photo polymerizing resin composite (Spectrum T.P.H. A2, Light-Cure Composite; Dentsply De Trey Gmbh, Konstanz, Germany) with previous acid etching (phosphoric acid 37%; Dentisply De Trey GmbH, Konstanz, Germany). The bonding agent used was Prime & Bond 2.1 (Dentisply De Trey Gmbh).

Then the specimens were fixed to a table by means of a number 02 (two) vise and the tensile strength test was applied in two distinct points on the steel wire: T1 (first registration point) and T2 (second registration point). The test was applied in two different directions: vertical (Fig. 2) and horizontal (Fig. 3). In each point of the steel wire, pre-established forces (120, 240, 360 and 480 g) were applied with the use of a tensiometer (ETM – USA) calibrated for forces up to 16 oz(ounces), with three repetitions for each direction. The forces registered in grams by the tensiometer were converted into Newtons (N), according to conversion factors (1 g = 0.00981 N or 1 N = 101.937 g) (16).

During the application of the forces, the observed data were transcribed onto forms elaborated for this purpose, individually for each group, referring to the number of loose wires and wires that remained fixed, according to the direction of the applied force. The specimens on which the wires were loosened during the tensile strength tests were discarded. The data obtained were submitted to a descriptive analysis and statistical analysis, starting with Friedman's Test and Dunn's Multiple Comparison test (Epi-info 3.2) at the significance level of 5%.

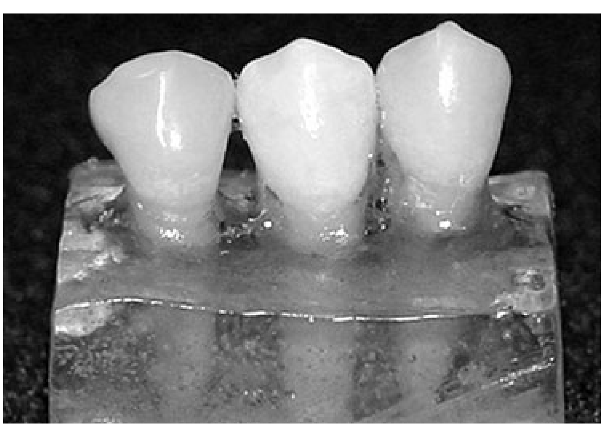

*Fig. 1.* Specimen.

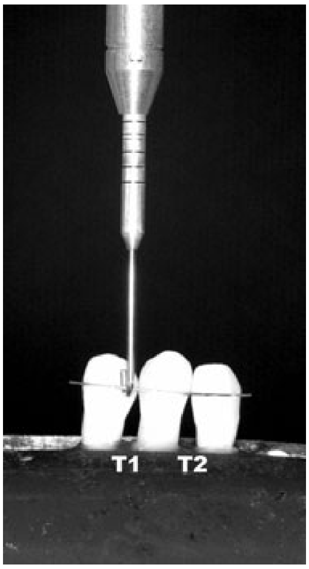


*Fig. 2.* Vertical tensile strength.

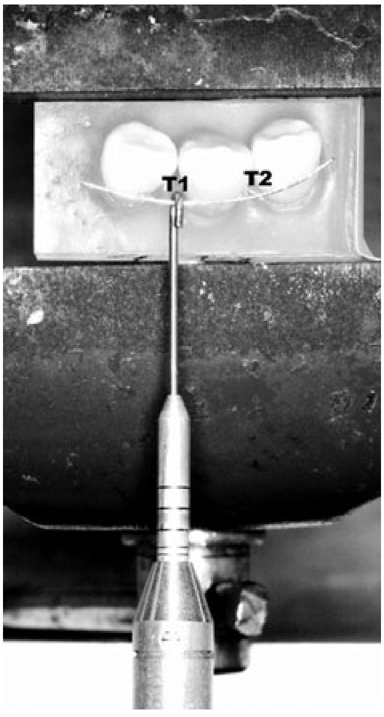


*Fig. 3.* Horizontal tensile strength.

## Results

The results were expressed in the form of a table and were divided according to the direction of the applied

*Table 1.* Number of breaking of the splinting during the application of tensile strength force in the vertical direction

| Groups | Total | 120 g (1.18 N) | 240 g (2.35 N) | 360 g (3.53 N) | 480 g (4.71 N) | Loose wires | Fixed wires |
|---|---|---|---|---|---|---|---|
| Group I | $n$ = 10 | 1 | 1 | 0 | 0 | $n$ = 2 | $n$ = 8 |
| Group II | $n$ = 10 | 0 | 0 | 0 | 0 | $n$ = 0 | $n$ = 10 |
| Group III | $n$ = 10 | 0 | 1 | 0 | 0 | $n$ = 1 | $n$ = 9 |
| Group IV | $n$ = 10 | 0 | 0 | 0 | 0 | $n$ = 0 | $n$ = 10 |
| Total | $n$ = 40 | 1 | 2 | 0 | 0 | $n$ = 3 | $n$ = 37 |

*Table 2.* Number of breaking of the splinting during the application of tensile strength force in the horizontal direction

| Groups | Total | 120 g (1.18 N) | 240 g (2.35 N) | 360 g (3.53 N) | 480 g (4.71 N) | Loose wires | Fixed wires |
|---|---|---|---|---|---|---|---|
| Group I | $n$ = 8 | 0 | 1 | 0 | 0 | $n$ = 1 | $n$ = 7 |
| Group II | $n$ = 10 | 0 | 0 | 1 | 0 | $n$ = 1 | $n$ = 9 |
| Group III | $n$ = 9 | 0 | 1 | 0 | 0 | $n$ = 0 | $n$ = 9 |
| Group IV | $n$ = 10 | 0 | 0 | 0 | 0 | $n$ = 0 | $n$ = 10 |
| TOTAL | $n$ = 37 | 0 | 1 | 1 | 0 | $n$ = 2 | $n$ = 35 |

forces. The number of breaking of the splinting during the application of tensile strength force in the vertical direction is shown in Table 1.

Following that, a tensile strength test in the horizontal direction was carried out. It is important to comment that because of the test applied previously, and according to the number of loose wires, the number of specimens in groups I and III became different from the initial N ($n = 10$). The results are shown in Table 2.

Therefore, the final rate of rupture of the wires was of 12.5%, considering the total number of specimens ($n$ initial = 40) and the total number of wires loosened during the tensile tests (vertical and horizontal) ($n = 5$).

According to the results obtained, more wires were loosened in group I (wire 0.014) in comparison with groups II (wire 0.016) and III (wire 0.018), without significant differences according to the applied weights and directions of the tensile forces (vertical and horizontal). None of the wires was loosened in group IV (wire 0.018 with resin composite) and this group did not present a significant statistical difference in relation to Groups II and III, presenting only a significant difference in relation to group I as to the horizontal tensile ($P < 0.05$).

## Discussion

Within the limitations of this experimental study it was shown that splints made of cyanoacrylate and orthodontic wires (0.016 and 0.018 inches) maintained intact during various forces applied.

The ideal requirements for the dentoalveolar splints are described in similar ways by several authors (3, 7, 17–21). In short, the splints should have optimal properties for handling, application and removal, resistant, should not cause additional trauma to the teeth and should promote adequate tooth fixation during the period of splinting; have good esthetics, easy cleaning, and should not interfere with occlusion. The splints should not cause periodontal damage nor increase the risk of caries; guarantee comfort to the patient; permit endodontic treatment as well sensitivity testing during the period of splinting. An ideal splint should be passive to permit the reorientation of the periodontal ligament and flexible to allow physiologic tooth mobility.

One of the currently and most widely used types that meets many of the ideal requirements is that in which a flexible stainless steel wire is fixed to the vestibule of the teeth with a photo polymerizing resin composite, after enamel acid etching (3, 4). Since the discovery of the technique of the acid etching by Buonocore (22), the resins composites have become very popular in Dentistry, being widely used in tooth splints since then. The splint model presented in the group IV is used routinely in our services for treatment of dental injuries, with satisfactory results.

The final rate of rupture of the wires was only 12.5%. From the quantitative point of view, the differences observed between the groups III (cyanoacrylate ester) and IV (resin composite) with wire of the same thickness and only alternating the adhesive material, were not significant. The significant difference only occurred between the groups (I and IV) when horizontal tensile strength was carried out. Future studies should compare cyanoacrylate with other materials and various diameters of the wire.

Even though it is commercially known as a highly adhesive agent, the use of this glue in dentistry is limited. Toxicity and hypersensitivity are the reasons described by the manufacturers. Reported toxicity is uncommon in the dental workplace, but may manifest as conditions such as urticaria, contact dermatitis and other dermatoses (9). Despite the laboratory results presented in this study seem satisfactory (the cyanoacrylate ester maintained bonded to enamel and steel wires during the tensile strength tests under different levels of applied forces), we have to consider all those contraindications.

It is important to highlight that these findings are limited to laboratory data and the use of cyanoacrylate as splint adhesive should not be performed routinely unless considerable data with the regard to the biocompatibility is available.

## Conclusions

Within the limitations of this study, in the experimental conditions presented, the cyanoacrylate ester or 'Super Bonder®' maintained bonded to enamel and steel wires (0.016 and 0.018 inches) during the tensile strength tests under different levels of applied forces.

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