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Comparison of different adhesive techniques using a universal adhesive system

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Abstract

In order to simplify the technique while maintaining its effective clinical performance, as well as its adhesive properties, universal adhesive systems are constantly launched in the market. Thus, the objective of this study was to compare the presence or absence of moisture in the adhesion technique using a universal adhesive system, the Single Bond Universal (3M ESPE). There were selected forty-five human molars with indications for exodontia that were divided into three experimental groups: Single Bond Universal (3M ESPE) with and without moisture in the dentin; Scotchbond Multi-Bottles (3M ESPE) conventional technique (control). The characterization methods used were: microshear and scanning electron microscopy. Statistical analysis of variance analysis (single-factor ANOVA) and Tukey's multiple comparison, global significance level of 5% were used. It was observed through the micro-test that there were no statistically significant differences between the groups tested. Scanning electron microscopy analysis showed that the most frequent failure mode was the adhesive type (91%), followed by the mixed type fracture (8%) and the cohesive type (1%). It was concluded through this study that, regardless of the moisture (present or absent), the Single Bond Universal adhesive system showed bond strength similar to the conventional adhesive.

Keywords: Adhesive systems, Bond strength, Universal adhesive

Background

The adhesive technique is fundamental to the clinical success of dental rehabilitation. The adhesive procedures have the purpose of promoting adhesion between the restorative material and the tooth—enamel and dentin [1–3]. The literature highlights the need to maintain a certain degree of hydration of the dentin collagen matrix, thus avoiding its collapse and providing satisfactory infiltration of the adhesive in the demineralized portion [2, 4, 5]. However, due to the complex nature of dental cavities that may present very dry or very wet regions in the same tooth, achieving optimal hydration of the substrate is extremely difficult [4]. The excess water in the adhesion site leads to the dilution of the constituent monomers of the adhesive material, interfering in the polymerization thereof and consequently forming a low-quality hybrid layer, which can lead to a decrease in the adhesive strength of the material [5]. The more effective drying of the demineralized dentin promotes the removal of water from the collagen fibers, preventing the formation of voids between the remaining dentin and the dentin/adhesive/

composite interface, responsible for the permeability of this interface and its solubilization [5, 6]. The creation of a porous and thin hybrid layer, besides resulting in lower adhesion strength, allows the passage of residual monomers to the pulp causing irritation and sensitivity [6].

While the collapse of the collagen fibers caused by total water removal causes degradation of the adhesive interface and formation of tooth/composite slits, total cavity drying increases pulpal toxicity and sensitivity. Thus, several types of adhesives and techniques have been developed with the incorporation of different materials to correct or ameliorate these deleterious effects, prolonging treatment longevity [7].

Recently a new adhesive product, the Universal Single Bond [8], has been launched on the market, this adhesive system comprises in a single bottle the self-etching acid and the adhesive, and according to the manufacturer, it can be used in the adhesive preference technique of the professional. This means that the Dental Surgeon has the option of choosing the adhesive technique that favors him during the restorative procedure, be it a total acid conditioning in enamel and dentin, or a self-etching procedure or selective enamel conditioning.

The basis presented by the manufacturer [8], which serves as a basis for explaining the advantages offered by this adhesive system, seems to be related to the unique developed VMS technology. This technology consists of the combination of three important chemical components for the adhesion process: the Vitrebond™ Copolymer, which allows rehydration of the collagen fibers and consequent formation of the hybrid layer, allowing its use even in dry dentin. This adhesive has the MDP (10-methacryloyl oxide decyl hydrogenphosphate), which promotes better adhesion performance to the tooth substrate, improved product stability, increased adhesion in the self-etching technique, and is also used as a metal primer. The added silane allows the adhesion mechanism to occur in glass derived (feldspathic and lithium disilicate) ceramics, in the ceramics infiltrated by glass (alumina) and Lava Zirconia, without the need for application of a separate initiating agent. The Single Bond adhesive, when combined with the exclusive DCA (dual cure activator) system for cementation, also allows bonding between cements, fillers and composite resins of chemical and dual activation [9].

In addition to the aforementioned advantages, this adhesive system also has other significant indications, such as in direct restorations in resin or resin-modified monomers, in root desensitization, as a protective layer for restorations of glass ionomer cement, in resin restorations and in sealant and fissures without previous acid conditioning. It is also indicated in indirect adhesive restorations, allowing cementation of facets, inlays, onlays, crowns with dual cements, in intraoral repairs of indirect restorations and immediate dentin sealing [10].

Considering the versatility of indications and advantages offered by this adhesive, there are few studies in the literature comparing bond strength data in dentin with different adhesive techniques, therefore, the present study had as objective compare through the microshear bond test, the presence or absence of moisture in the dentin in the adhesion technique using an universal adhesive system, the Universal Single Bond (Scotch Bond Universal).

Methods

Teeth preparation

After approval by the ethics committee of the University Santo Amaro (Process No. 1.203.890), 45 healthy human third molars were selected, which were indicated for extraction and were extracted at the Surgery Clinic of the Dental School of University Santo Amaro.

The teeth were cleaned with periodontal curettes, washed in running water and stored in distilled water under refrigeration. The occlusal third of the teeth was sectioned using a diamond disc under water-cooling in a cutting machine (Isomet) to obtain an enamel free flat dentin surface. The specimens were embedded in PVC (polyvinyl chloride) tubes using acrylic resin and leaving the coronary portion out of the tube.

Experimental groups

Considering that the factor analyzed was the moisture in the dentin in the adhesive technique (present or absent) using the adhesive system Single Bond Universal (3M ESPE), the control group was consisted of the conventional technique using the adhesive system Scotchbond Multi-purpose (3M espe). Each of the three experimental groups containing 15 teeth. The smear layer was standardized using 220-grit granulation sandpaper, rubbing the already sectioned tooth for 15 s, perpendicularly to the sandpaper [11–15].

Conventional technique using Scotchbond Multi-purpose (control)

The dentin was etched for 15 s using 37% phosphoric acid (Fusion-Duralink, Angelus) then washed with water/air spray also for 15 s. The excess water was removed with gently air jets [14], maintaining the moisture of the dentin. The primer (solution of resinous monomers diluted in organic solvents, which in this adhesive system is presented in a separate bottle) was applied actively for 10 s. After that the bond was applied on the etched and modified dentin by the primer. Then the adhesive was light cured for 20 s (18 J/cm^2) (Radii, SDI, Australia).

Presence of moisture in the dentin using Single Bond Universal (universal-moist)

This adhesive system eliminates the acidic etching, so after the smear-layer standardization the dentin was washed and gently dried using light air jets [14], maintaining its moisture of the dentin. The universal adhesive system was then applied actively for 10 s, and photoactivated for 20 s (18 J/cm^2) (Radii, SDI, Australia).

Absence of moisture in the dentin using Single Bond Universal (universal-dry)

After the smear-layer standardization the dentin was washed and completely dried using light air jets, resulting in a dentin without the glow suggestive of moisture. The universal adhesive system was then applied actively for 10 s, and photoactivated for 20 s (18 J/cm^2) (Radii, SDI, Australia).

Restorative composite insertion

Five silicon molds of 1 mm high and 1 mm of internal diameter were distributed through the dentin surface already prepared with the adhesive techniques described above. Increments of the restorative composite (Filtek Z350, 3M ESPE) were inserted inside of

each mold and photopolymerized for 20 s. The restored teeth were storage for 24 h in distillated water at 37 °C.

Microshear test

After storage, each specimen was submitted to the microshear test on a universal testing machine (Kratos LKC3, USB, Brazil). The mold was carefully removed with a # 11 scalpel blade leaving only the composite increments. The assembly was fixed to the base of the universal mechanical testing machine and an orthodontic wire (diameter 0.25 mm) [16] was passed surrounding each composite cylinder near the adhesion area, then attached to the load cell of the testing machine and shear force was applied to each cylinder at a speed of 0.5 mm/min until fracture of the specimen. The data obtained in Newton (N) were recorded for the subsequent statistical analysis. The value obtained in Newton is related to the load and through this value we calculated the bond strength by dividing it by the adhered area (RU = N/a). Then we calculate the average of each tooth from the value of the microshear bond strength (μSBS).

Scanning electron microscopy

All specimens (n = 30) were sputtered with by gold and evaluated under 120× magnification using scanning electron microscopy. This magnification was selected aiming to observe the whole circumference of each adhesion surface.

Failure mode were classified as following: *Adhesive failure*: dentin visualization in the majority of the evaluated area; *Cohesive failure:* visualization of peaks and valleys, which represents the fracture of dentin or composite (no distinction were made between the substrates) in the majority of the evaluated area; *Mixed failure:* visualization of both failure mode described in approximately equal proportions of the evaluated area.

Statistical analyses

The data from bond strength were evaluated using ANOVA (one-way) and Tukey's test. For both tests the global level of significance was 5%.

Results

Statistical analyses presented no differences among groups (p = 0.056) for the bond strength results. Data from bond strength are presented in Table 1.

The failure mode were mostly adhesive (91%), followed by the mixed fracture (8%) and only 1% were cohesive. In Fig. 1 there are the most representative images of each failure mode.

Table 1 Means (standard deviation) for the bond strength (MPa)

Groups	Bond strength (MPa)
Universal-moist	8.9 (1.5)A
Universal-dry	7.1 (1.7)A
Control	9.9 (2.8)A

Statistical analyses showed no differences among groups

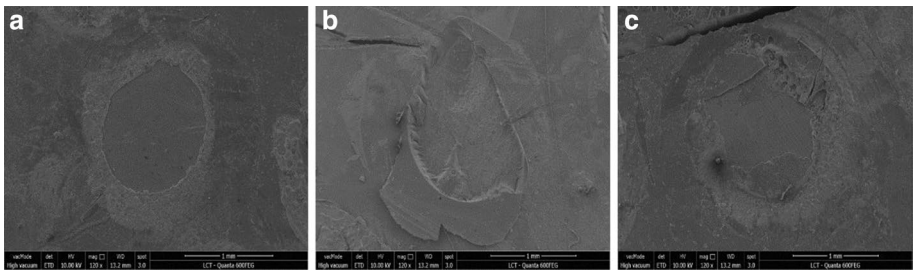

Fig. 1 Representative images of the failure mode. Respectively: **a** adhesive failure, **b** cohesive and **c** mixed

Discussion

The aim of this study was to evaluate the micro shear bond strength in dentin of the universal adhesive system (universal bond), varying the moisture in the dentin during the adhesion technique. We know that adhesion in dentin is achieved through the process of formation of the hybrid layer, initially described by Nakabayashi and Hiranuama [17]. The adhesive systems have undergone several evolutions until the present arrival of the universal adhesive systems, where its self-etching mechanism promotes a modification or dissolution of the smear layer thus allowing its incorporation into the formation of the hybrid layer [17].

Due to the rapid development of new products, in vitro assays have become indispensable for comparing the bond strength of the adhesives to the substrates. The commonly used tests are those of tensile, micro tensile and shear [18]. The micro-shear test was chosen for this study considering their advantages: it allows multiple samples in the same tooth without the need of cutting the teeth, being therefore easier and cheaper, and specially do not induce stress in the interface during the process [18–20]. According to Zohairy et al. directly compare the results from tensile and shear is impractical, but both tests are capable of ranking materials properly [15].

The dentin moisture did not affect the bond strength when the universal system was used. This finding probably can be explained by the presence of the copolymer that is highly hydrophilic and the MDP molecule that improves the self-etching technique [9]. The conventional three-step adhesive system, the Scotchbond Multi Purpose (3M espe), was used in the control group, where it was mandatory to condition the dentine with phosphoric acid prior to the application of the adhesive. It is of great importance that after the acid conditioning, the dentin presents moisture since the water, in adequate quantities, avoids the collaborative collagen fibrils preventing the infiltration of the adhesive system in the interfibrillar spaces and consequently obtaining a weak union between restorative material and Dental structure [10]. In view of this, the exclusion of the dry Scotchbond Multi Purpose group was not significant since poor adhesion or even non-adhesion was expected in completely dry dentin.

The results of this study showed that there was no statistical difference between the groups ($p = 0.056$), allowing to state that regardless of the technique, the Single Bond Universal adhesive system showed micro-shear bond strength similar to the conventional adhesive. Few studies show bond strength comparing the two techniques for this adhesive system. Marchesi et al. conducted a study with the objective of evaluating the

adhesive stability over time through the micro tensile test and observed that the Universal Single Bond used in both the self-etching mode, the condition and wash mode, and dentin wet or dry, exhibited similar bond strength values to the control group after 24 h storage in water, corroborating with the results of the present study [21].

Garcia et al. carried out a study with the objective of evaluating the bond strength of all-in-one adhesives on different substrates, and observed that after a week of storage, through the micro-cleavage test, there were no differences Between the Single Bond Universal and the control group, where the substrate was dentin [22]. In another study, Thanaratikul et al., evaluated the bond strength in primary dentin for different universal adhesive systems in both the self-etching mode and the conditional mode and washed through the microcuts test, and observed that the Universal Single Bond Used in the condition and wash mode obtained results of union strength superior to the control group. In addition, the same adhesive used in the self-etching mode obtained results of bond strength similar to the control group [23].

As for failure mode, it was observed that majority of the failures found were adhesive-type, with about 91% of all failures, followed by fractures of the mixed type, with about 8% of the total and almost no failures of the cohesive type, equivalent to only 1% of the total failures and found only in the Universal Single Bond (control technique group).

The adhesive failures indicate a rupture of the bond at the dentin/composite interface, the cohesive fractures breaking the dentin or composite, while mixed-type fractures, indicate cohesive disruption in the composite and adhesive in the dentin [24]. In the micro-shear test the load cell was aligned parallel to the adhesive interface so that an application of the force closest to this joint occurred, ensuring correct orientation of the shear forces [25]. Therefore, the higher prevalence of adhesive fractures indicated that the bond strength of the specimens was analyzed and not the internal resistance of the material.

Based on the results of the present study it can be concluded that the dentin moisture did not affect the bond strength when the universal adhesive was used, which is a very important fact considering that the moisture is the main concern during adhesion procedures.

Authors' contributions

FVC and MADP contributed to the preparation of teeth and data acquisition; LMC and WCB contributed to the microscopy analyses; CVRT contributed to data acquisition and interpretation; WMJ and LCCB contributed to conception design, analysis and interpretation. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

Not applicable.

Consent for publication

This manuscript is not concurrently under consideration for publication in any other journal. All the named authors were involved in the work leading to the publication of the paper, and all the named authors have read the paper before it is submitted for publication.

Ethics approval and consent to participate
The research protocol was approved by the ethics committee of the University of Santo Amaro (Process No. 1.203.890) before the study started.

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