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Bond strength performance according to the adhesive technique used in universal adhesive systems, literature review

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Abstract

Introduction: Adhesive dentistry faces complex clinical situations, which require the dentist to be able to choose the best adhesive protocol offered by universal adhesives.

Objective: To present current information about the performance in bond strength according to the etching technique used in universal adhesives, evaluating the total etching technique, selective enamel etching, self-etch technique and bonding used in special clinical situations.

Methodology: A search was carried out in the PubMed electronic database using as keywords "universal adhesive", "total etch technique", "selective enamel etching", "self-etch".

Results: In the total acid etching technique, the acid gel to be used must be considered, as well as the type of adhesive. Selective enamel etching seeks to obtain that strong anchorage to the enamel that can only be obtained using a phosphoric acid gel, allowing the self-etching quality of the adhesive to act on dentin. The use of the self-etch technique will simplify the clinical steps in the adhesive protocol, however adhesion may decrease consequently. If there is any type of alteration in the substrate to be adhered, the resulting adhesive force could be modified, regardless of the adhesive technique used.

Conclusion: Universal adhesives will allow the clinician to choose the adhesive protocol, depending on the clinical situation they are facing, as long as the clinician pays attention to aspects such as the acid gel to be used, the adhesive application time and the conditions of the substrate to adhere.

Keywords: Universal adhesive, Total etch technique, Shear bond strength, Selective enamel etching, Self-etch, Dental bonding

1. Introduction

Adhesive dentistry constantly faces complex clinical situations which require the dentist to know the qualities and to be able to choose the best adhesive protocol, depending on the case, offered by the universal adhesive system^[1]. Universal adhesives were introduced to the market approximately 10 years ago due to the constant demand for increased versatility when using this dental material^[2]. These can be used in total etch, selective enamel etch and self-etching techniques^[3]. The adhesive technique to be used has depended a lot on the clinical situation faced by the dentist. In situations where only adamantine tissue is found, the adhesive strength will be improved thanks to phosphoric acid etching^[4], however, the same may not happen when dentin is involved^[5]. The idea that preliminary enamel etching increases adhesive strength values when using universal adhesive systems has been popularized^[6], but other studies have shown that a self-etch technique is as effective as a total etch technique, however, they depend on different adhesion mechanisms^[7].

Due to the different possible ways that exist to make use of universal adhesive systems it is important to expose what many authors have said about the bond strength values that could be expected to be obtained in the various techniques that this system allows the clinician to use. Therefore, the objective of this literature review is to present information about the performance in the resulting bond strength according to the adhesive technique used in universal adhesives, evaluating the total etching technique, selective enamel etching, self-etch technique and bonding used in special clinical situations.

2. Materials and methods

A search of articles was carried out using the PubMed, SCOPUS and Google Scholar electronic databases with emphasis on articles published within the last 5 years. The articles were evaluated using PRISMA guidelines, i.e., identification review, choice, and inclusion. The quality of the reviews was assessed using the measurement tool for evaluating systematic reviews.

The implementation of the search was using Boolean operators AND, OR and NOT. The keywords were used individually, as well as each of them related to each other. Initially, the titles of all the articles were selected, the abstract of each one was evaluated, and the articles were chosen for a complete reading review.

3. Results and Discussion

3.1 Total Etching Technique

The main characteristic of the total etching technique is the use of the phosphoric acid gel, which must be taken into account, since a study that sought to evaluate the resulting bond strength of various phosphoric acids together with the use of universal adhesives found that 3M Oral Care's Scotchbond Etchant, Bisco's ETCH-37 with BAC (benzalkonium chloride), and Densell's Etching Gel improved adhesion to enamel, unlike Eco-Etch and Ultra-Etch when using universal adhesives, for which all of the phosphoric acid should be considered different [8]. Thus, other studies have aimed to evaluate whether the type of resin used has anything to do with the resulting bond strength, however, they found no correlation between this variable, and attributed the best adhesive quality to the total acid etching technique [9, 10].

Investigations from Yamauchi *et al.* and Elkaffas *et al.* report that there is no statistically significant difference in bond strength when comparing the total-etch technique against the self-etch technique, focusing on dentin [7, 11], however, other studies show us that the bond strength in dentin is compromised with this adhesive technique, especially when dentin is moist [12, 13].

An important factor to consider is the type of adhesive to be used, as this can greatly influence the bond strengths we expect to obtain, for example, G-Bond adhesive has a considerably lower bond (25. 8 MPa) strength than Single Bond Universal (34.8 MPa) and Tetric N- Bond Universal (36.0 MPa), among other adhesives, even when used in a etch and rinse technique [5] and other studies show that Scotchbond Universal and All Bond Universal adhesives do not have different bond strength values, regardless of the technique used [14].

Similarly, the surface free energy is another variable that seems to depend on the adhesive to be used in the acid etching technique [15]. There are studies from Moritake *et al.* in 2019 that have been dedicated to show the considerable improvement in the thickness of the resin tags when a total etching technique is used, with scanning electron microscopy they show that the resin tags appear more constant and thicker (approximately 50 μ m) compared to the self-etch technique [4]. In the total etching technique, the acid gel to be used must be considered since they influence the bond strength, as well as the type of adhesive. The great advantage of this adhesive technique is that under scanning electron microscopy we can confirm that the resin tags are thicker and more constant, which enhances adhesion to the substrate.

3.2 Selective enamel etching

It is known that the main attraction of universal adhesives is

the wide variety of ways in which they can be used, however, studies confirm that as long as the step where the acid etching gel is used is added, at least on the enamel surface, bond strength will be improved^[16], while other studies mention that bond strength varies according to the type of universal adhesive used, however, they agree that bonding to enamel with this system is better when using a phosphoric acid gel^[17, 18]. Another way to improve the bond strength and keep it stable is by performing aprismatic enamel grinding, complemented by selective enamel etching^[19, 20]. But it is not always good to use a selective enamel etching technique without care, since this could affect the adhesive strength in dentin, so some authors recommend reducing the pre-etch times in enamel, in order to improve dentin bond strength^[21]. According to a study that sought to evaluate bond strength in primary teeth, performing a selective enamel etching technique found better bond strength values than with a self-etching technique^[22], similarly, the selective etching technique of enamel surpasses that of the self-etching technique when it comes to bonding to fluorotic enamel^[23]. When mild universal adhesives are used, the best bond strength results are found with the selective enamel etching technique^[24], and we can also see this when non-carious cervical lesions are restored which, in addition to improving retention, decrease the probability of postoperative sensitivity^[25].

Other studies looked at how to improve bond strength by selectively etching enamel and found that rubbing the adhesive for 20 seconds substantially improved bond strength^[26]. The selective enamel etching technique seeks to obtain that strong anchorage to the enamel that can only be obtained using a phosphoric acid gel and allows the self-etching capacity of universal adhesives to act on dentin reducing post-operative sensitivity providing good bond strength results in the long-term.

3.3 Self-etching technique

There is a great deal of evidence in the literature that the self-etching adhesive technique does not reach the adhesive values achieved by the total etching or selective etching technique, although many studies show that there are similar adhesive values that may or may not depend on the phosphoric acid gel used^[8, 11]. However, there are studies that suggest not using a phosphoric acid gel to specifically etch dentin, and prefer to use a self-etching technique only, since there is no statistically significant difference in bond strength in said tissue whether acid is used or not so and to simplify the steps in the clinic a self-etch technique is chosen^[5, 27] and other authors mention that the adhesive values in dentin do improve using acid etching instead of a simple self-etch^[28].

Other studies do not seem to find much hope in the self-etch technique, as they showed that restorations bonded with the self-etch technique alone are 2.6 times more likely to decement or fracture^[16].

In fluorotic enamel, if it is preferred to use a self-etching adhesive technique and carry out an active application of the adhesive, since this will considerably improve the adhesive force^[23]. Carrying out this active application will increase bond strength with a self-etching technique comparing it with a total etch technique^[29]. When talking about the stability of the bond strength in the self-etch technique, studies show that only slight drops in bond strength levels are observed using this mode^[5]. Other authors mention that the adhesive quality in the self-etching technique is very dependent on the universal adhesive used^[17, 30, 31], for example, in a study it shows that the Scotchbond Universal adhesive showed greater

adhesion strength in a self-etching technique, compared to All-Bond Universal adhesive, which obtained its best performance from an acid etching technique^[10].

Another way to improve the adhesive quality in this technique is by using zoledronate-based primers, just before performing the adhesive protocol for this technique as this will cause less degradation of the resin-tooth interface, however in an acid etching technique the use of this type of primer could be counterproductive^[32]. The use of the self-etch technique will simplify the clinical steps when performing the adhesive protocol, however, the bond strength may be decreased because of this simplification. However, there are studies that show that using this technique results in good long-term clinical results.

3.4 Bonding used in special clinical situations

In clinical situations where the enamel is demineralized, there will be a 50% lower bond strength compared to the bond strength found on sound enamel using a universal adhesive system^[22]. Similarly, when performing adhesive techniques on fluorotic enamel, the same quality of adhesion as on sound enamel cannot be expected regardless of whether an acid-etching or self-etch technique is used^[23], however other studies showed that in an self-etching an improvement in the degree of conversion of the adhesive, a greater pattern of etching of the fluorotic enamel and similar bond strength to those that would be obtained with a total etching technique can be observed if an active application of the adhesive is carried out^[33]. Nowadays, it is sought to evaluate the cariogenic index of patients before subjecting them to dental surgery treatments. In these cases, the use of antimicrobial agents is indicated, which have been shown to improve dentin bond strength when universal adhesive systems are used^[34].

According to studies, in the given situation where a medium strong universal adhesive system must be used, its bond strength is said to drop considerably after any kind of aging test^[24]. Other studies indicate that the use of mild universal adhesives can be a good clinical option when restoring primary teeth^[35] and similarly, it has been found that the dentin bond strength in primary teeth remains stable regardless of whether we are or not in carious tissue^[36, 37]. There are alternative techniques that can be considered when using universal adhesive systems, such as the use of metalloproteinase inhibitors, increasing the application time of the adhesive and increasing light curing, which have been shown to improve adhesion in this adhesive system^[38], as well as other authors have found that in total etching techniques in hypomineralized teeth, the way to improve the resulting bond strength is by using a papacarie-based gel before using phosphoric acid^[39, 40].

Authors evaluated the bond strength in dentin treated with hydroxyapatite-based desensitizers and found that there is no statistically significant difference in bond strength regardless of the adhesive technique used^[41]. The fact that there is some type of alteration in the substrate to be adhered could modify the resulting adhesive force, regardless of the adhesive technique to be used. Demineralized or fluorotic enamel surfaces, high cariogenic indices, among other situations, could be the ones that influence the resulting bond strength quality.

4. Conclusions

Universal adhesives are evolving constantly due to clinicians concern to enhance their adhesive protocols. In this review we presented current information involving the clinical situations that the clinician can be involved into when needing adhesive usage. Either with the selective use of phosphoric acid gel, or with the simple use of the adhesive as an etchant of the surface to be bonded, a good bond strength can be obtained

for the restoration to be placed, as long as the clinician pays attention to aspects such as the acid gel to be used, the application time of the adhesive and the conditions of the substrate to be adhered.

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