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Review

Bond strength of universal adhesives: A systematic review and meta-analysis

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ABSTRACT

Objectives: A systematic review was conducted to determine whether the etch-and-rinse or self-etching mode is the best protocol for dentin and enamel adhesion by universal adhesives.
Data: This report followed the PRISMA Statement. A total of 10 articles were included in the meta-analysis.
Sources: Two reviewers performed a literature search up to October 2014 in eight databases: PubMed, Web of Science, Scopus, BBO, SciELO, LILACS, IBECS and The Cochrane Library.
Study selection: In vitro studies evaluating the bond strength of universal adhesives to dentin and/or enamel by the etch-and-rinse and self-etch strategies were eligible to be selected. Statistical analyses were conducted using RevMan 5.1 (The Cochrane Collaboration, Copenhagen, Denmark). A global comparison was performed with random-effects models at a significance level of $p < 0.05$.
Results: The analysis of dentin micro-tensile bond strength showed no statistically significant difference between the etch-and-rinse and self-etch strategies for mild universal adhesives ($p \geq 0.05$). However, for the ultra-mild All-Bond Universal adhesive, the etch-and-rinse strategy was significantly different than the self-etch mode in terms of dentin micro-tensile bond strength, as well as in the global analysis of enamel micro-tensile and micro-shear bond strength ($p \leq 0.05$).
Conclusions: The enamel bond strength of universal adhesives is improved with prior phosphoric acid etching. However, this effect was not evident for dentin with the use of mild universal adhesives with the etch-and-rinse strategy.
Clinical significance: Selective enamel etching prior to the application of a mild universal adhesive is an advisable strategy for optimizing bonding.

1. Introduction

Dental adhesive systems can be classified into two main categories according to different bonding techniques to the dental substrates: the etch-and-rinse and self-etch systems.[1,2] The etch-and-rinse strategy involves the prior application of phosphoric acid, which, at enamel, produces deep etch-pits in the hydroxyapatite (HAp)-rich substrate and, at dentin, demineralizes up to a depth of a few micrometers to expose an

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HAp-deprived collagen mesh.[1,3] Thus, etch-and-rinse adhesives are available for use in three steps (acid etching, primer and adhesive) or two steps (primer and adhesive joined into one single material). For these total etching adhesive systems, hybrid layer formation relies on the demineralization of superficial dentin by inorganic acids, which exposes collagen fibrils that are then infiltrated by hydrophilic monomers.[2–4] Although etch-and-rinse adhesives are still the gold standard for dental adhesion and the oldest of the marketed adhesives, the current trend is to develop simplified self-etching materials.[1,2,5,6]

Thereby, self-etch adhesives can involve two steps or a single step, depending on how the acidic primer and adhesive resin are provided by the manufacturer.[1,4] Thus, manipulation has been simplified by reducing the number of steps to a one-step system, with all components (etchant, primer, and bonding resin) incorporated into a single dental material.[5,7] They are a blend of hydrophilic and hydrophobic monomers, polymerization initiators, solvents, stabilizers, and filler particles.[8] Additionally, self-etch adhesives contain specific monomer molecules with carboxylate or phosphate acidic groups that simultaneously act as conditioner (that allow dental superficial demineralization) and primer agents (resin monomers that infiltrates into the dentin) upon the dental substrates.[8,9] Thus, these adhesives are easy-to-use, have a faster application procedure and are less susceptible of differences in the operator's technique when compared with multi-step etch-and-rinse adhesives.[1,10]

Contemplating these two bonding strategies, adequate bonding to dentin can be completely achieved with either etch-and-rinse or self-etch adhesives; however, at enamel, the etch-and-rinse approach using phosphoric acid remains the preferred choice.[1,11,12] The main challenge for current dental adhesives is to provide an equally effective bond to dental substrates of different natures (i.e., sound, carious, sclerotic dentin, as well as enamel).[1] Considering the differences in professional judgment regarding the selection of the adhesive strategy and the number of steps, some manufacturers have released more versatile adhesive systems that give the dentist the opportunity to decide which adhesive strategy to use: etch-and-rinse or self-etch. This new family of dental adhesives is known as "universal" or "multi-mode" and represents the latest generation of adhesives on the market.[13–16] They are designed under the "all-in-one" concept of the already existing one-step self-etch adhesives but also incorporate the versatility of being adaptable to the clinical situation.[16] An adhesive that can be applied both ways enables the practitioner to decide on a specific adhesive protocol that is most suited for the cavity being prepared.[14]

Despite manufacturers' efforts to develop and market new materials, the question still remains whether clinicians should consider using these new adhesives with prior acid etching over the self-etch strategy. Which adhesive protocol is best for multi-mode adhesives cannot be indisputably answered based on the scarce clinical evidence available and with the short follow-up periods that have been assessed. Nevertheless, in vitro evaluations of the bonding efficacies of these new adhesives by application under different etching modes are already available in the literature. Thus, the aim of this study was to systematically review the literature to evaluate whether the bond strength to dentin and enamel is improved by universal adhesives with prior acid etching. The hypothesis tested was that there is no difference in bond strength to dental substrates using multi-mode adhesives by the etch-and-rinse or self-etch strategy.

2. Methods

This systematic review was conducted in accordance with the guidelines of the PRISMA statement.[17] The research question was as follows: does the etch-and-rinse strategy improve the bond strength of universal adhesives to dentin and/or enamel?

2.1. *Systematic literature search*

The literature search was performed by two independent reviewers until 30 October 2014 (considering unlimited publication years). Eight databases were screened: MEDLINE (PubMed), ISI Web of Science, Scopus, SciELO, LILACS, IBECS, BBO (*Biblioteca Brasileira de Odontologia*) and the Cochrane Library. The keywords related to the search strategy are listed in Table 1. The reviewers hand-searched the reference lists of included articles for additional papers, and the cited articles were also tracked using SCOPUS citation tools. After the

Table 1 – Search strategy used in PubMed (MEDLINE).

	Search terms
No. 3	Search no. 1 and no. 2
No. 2	Search (Universal adhesive) OR (adhesive, universal) OR (universal adhesives) OR (adhesives, universal) OR (Multimode adhesive) OR (multi-mode adhesive) OR (multimode adhesives) OR (multi-mode adhesives) OR (G Bond Plus) OR (Adhese Universal) OR (All-Bond Universal) OR (One-step Universal Dental adhesive) OR (One-step plus universal) OR (Peak Universal Bond) OR (Clearfil Universal Bond) OR (iBond Self Etch) OR (FuturaBond U) OR (Prime&Bond Elect) OR (Universal bond) OR (Universal bonding agent) OR (multi-mode bond) OR (multimode bond) OR (multi-mode bonding agent) OR (multimode bonding agent)
No.1	Search (Dental Bonding) OR (Bonding, Dental) OR (Dental Bonding, Chemically-Cured) OR (Chemically-Cured Dental Bonding) OR (Dental Bonding, Chemically Cured) OR (Dental Bonding, Self-Cured) OR (Dental Bonding, Self Cured) OR (Self-Cured Dental Bonding) OR (Chemical-Curing of Dental Adhesives) OR (Chemical Curing of Dental Adhesives) OR (Dental Bonding, Dual-Cure) OR (Dentin-Bonding Agents) OR (dental primer) OR (Dental Materials) OR (Materials, Dental) OR (Dental Material) OR (Material, Dental) OR (dental resin) OR (Dental Resins) OR (Resin, Dental) OR (Resins, Dental) OR (bonding interface) OR (adhesive) OR (Dentin-Bonding Agents) OR (Agents, Dentin-Bonding) OR (Bonding Agents, Dentin) OR (Agents, Dentin Bonding) OR (Dentin Bonding Agents)