Bond Strength, Resin/Dentin interface and Nanoleakage of Different Multimode Adhesives to Dentin

Thesis

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BY

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I wish to dedicate this work to

My Great Parents,

My Always Supporting Husband.

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The continuous breakthroughs in adhesion science and evolution of dental adhesives had recently led to less technique sensitivity, user friendliness, and less chair-time. All-in-one adhesives have spread in the market and are used extensively for their decreased application time, and reduced possibility of iatrogenic errors in clinical manipulation during etching, rinsing, and drying. This simpler protocol allows for better application standardization. All of these factors are responsible for the large increase in the use of all-in-one adhesives among clinicians.[1]

Some manufacturers have released more versatile adhesive systems that include etch-and-rinse (two step) and self-etch (one or two step) options. These new materials are called multi-mode adhesives. This task of simplification was possible through the inclusion of hydrophilic monomers and the increase in the amount of solvents to make adhesives compatible with the inherent wet dentin substrate. They were introduced with manufacturer's claims that one monomer solution can be used for either adhesive strategy without compromising the bonding effectiveness therefore being able to replace existing simplified adhesives.[2]

In addition to simple application of adhesives, a flawless durable resin/dentin interface is desired. Nakabayashi initially described the hybrid layer as "the structure formed in hard dental tissues by demineralization of the surface and subsurface, followed by infiltration of monomers and subsequent polymerization." [3] The main goal of the self-etching adhesive systems is to infiltrate resin monomer through the smear layer as well as to demineralize and infiltrate the underlying dentin to form a hybrid layer simultaneously so, the durability of the adhesive/dentin bond is directly

related to the quality of the hybrid layer that connects the bulk adhesive to the subjacent intact dentin.[4] A well-formed interface should have minimal imperfections. Ideally, the adhesive monomers should occupy all the spaces that remain following removal of mineral phase and envelop the exposed collagen fibrils thus decreasing the possibility of nanoleakage. Understanding the changing microstructure of the interface and its defects over time continues to be a great challenge.[5]

There is little information in the literature about the performance of this new class of universal adhesives. Thus, this study evaluates the immediate, as well as the one year storage period of micro shear bond strength (μSBS), resin/dentin interfaces, and nanoleakage of newly introduced different multi-mode adhesives applied to dentin according to the etch-and-rinse and the self-etch strategies. This is of high value for both researchers and clinicians.

I-Bonding systems and protocols:

Modifications and researches are directed toward improving the success of dental resin composite restorations. But this success cannot be obtained apart from improvement of dental adhesive systems. So development of different adhesive systems and different considerations and concepts of dental adhesives will be reviewed.

I.a.Classification of bonding systems and protocols:

Classifying dental adhesives into different categories is not straight forward, because of the great supply and vast turnover of adhesives. Several classifications have been suggested in the past in scientific literature; however, no consensus concerning terminology has been reached yet. **Van Meerbeek et al. in 2003** [35] had suggested a scientifically based classification with three main groups of adhesives: etch-and-rinse adhesives, self-etch adhesives and glass-ionomer adhesives. This classification is simple and has proved to be reliable and consistent. All three categories of adhesives exhibit a common adhesion mechanism of hybridization. This is the process of micromechanical interlocking ensuring a demineralization, infiltration and polymer setting process, and was first described by **Nakabayashi et al. in 1982** [117]. A hybrid layer is the resulting resin-infiltrated surface layer of dentin and enamel.

The bonding mechanism of adhesive systems basically involves the replacement of minerals removed from the hard dental

tissue by resin monomers, in such a way that a polymer becomes micro-mechanically interlocked to the dental substrate [117]. However, the adhesive systems available on the market can be classified into two categories: etch and rinse and those applied using self-etch strategies, in versions of three, two or one application step.

I.a.1.Etch and rinse strategy:

When using the etch and rinse strategy, the first step involves the application of a phosphoric acid gel to both dental substrates, which allows removal of the smear layer, exposure of the collagen fibrils in dentine, and increase in surface area and surface energy in the enamel substrate. The primer is then applied (second step) followed by the bond (third step) resin separately or in a single solution. [118,120] Irrespective of the number of steps, the main disadvantage of the etch and rinse system, mainly two step versions, is that there is risk of collagen fibers collapse during the process of demineralized dentine drying, which leads to a decrease in bond strength.[6,121] The collagen collapse is prevented by keeping demineralized dentin moist, which is a difficult task to perform clinically. In fact, adequate moisture depends on both the solvent used in the material and on the clinician's interpretation of the manufacturer's directions.[7]

The incomplete impregnation of collagen fibers and the need to protect them against the degrading mechanisms present in the oral

cavity environment [8, 9, 10] led to the development of the second category, an adhesive using the self-etch strategy.

I.a.2.Self-etch strategy:

In the self etch strategy (one-step or two-step), there is no need to apply a preliminary phosphoric acid gel on dental substrates as dentine demineralization and priming occur simultaneously. [11, 119] The dissolved hydroxyapatite crystals and residual smear layer are incorporated in the hybridized complex. [12] Except for very acidic self etch systems [13, 14] the whole extension of the demineralized dentin depth is impregnated by resin monomers, which may be the reason why self etch systems are not associated with the technique sensitivity characteristic of bonding to moist etched dentine. [7, 15, 16] This advantage makes self etch materials suitable for areas where adequate control of moisture is rather difficult, such as in posterior restorations. A clear disadvantage of the self etch protocol is the reduction in enamel bonding effectiveness. [17, 18] The increase in surface area in intact and ground enamel obtained with self etch adhesives is lower than that achieved with phosphoric acid, and it depends on the pH of the self etch adhesive. [18] The performance of self etch adhesives has improved when these systems were applied to phosphoric acid-treated enamel. [12, 19, 20] However, this procedure has been shown to be unsuitable for use on the dentin substrate [21, 23] because accidental dentin etching may occur during the enamel-etching process, particularly when a low viscosity etchant is used. The effect of intentionally etching dentin with phosphoric acid prior