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The effect of pre-curing waiting time of different bonding resins on micro-tensile bond strength to dentin

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Abstract

Objective: To evaluate the effect of 30 s waiting time of different bonding resins on their micro-tensile bond strength (μTBS) to dentin.
Method: The occlusal enamel of freshly extracted human third molars was removed to expose the middle dentin. The specimens were randomly assigned into four groups namely, Group I, two-steps-total-etch bonding system (Adper Single Bond 2/Filtek Supreme XT, ASB2/FSXT), Group II, two-steps-self-etch bonding system (Silorane System Adhesive/Filtek Silorane, SSA/FS), Group III, two-steps-self-etch bonding system (Adper SE Plus/Filtek Supreme XT, ASEP/FSXT) and Group IV, one-step-self-etch bonding system (Adper Easy One/Filtek Supreme XT, AEO/FSXT). Each group was further divided into two sub-groups according to the application time of the bonding resin (following manufacturer recommendation and 30s more than manufacturer recommendation). The corresponding resin composite (shade A3) was applied in 4 increments of 0.5–1 mm thickness each to build resin composite stump of 3–4 mm height. Each increment was light polymerized for 20 s using LED at intensity 1000 mW/cm^2. The specimens were stored in deionized water at 37 °C for 24 hrs. The specimens were cut into bars according to the non-trimming technique (n = 20/group) with surface area of 0.81 mm^2. The μTBS of the bars was tested using a micro-tensile device on a Universal testing machine at a crosshead speed of 1 mm/min.
Result: Two-way ANOVA revealed a statistical significant difference in the two main effects, the types of bonding systems (P = 0.0024) and the application times of bonding resins (P = 0.0005). There was no statistical significant interaction between the two main effects (P = 0.9257). The methacrylate-based two-steps-total-etch bonding system and two-steps-self-etch bonding system showed significant higher values than that of the one-step-self-etch bonding system.
Conclusion: i. Thirty-seconds pre-curing waiting time for bonding resins has a role in achieving higher μTBS to dentin. ii. One-step-self-etching bonding system ranked as the lowest bonding system.

Keywords: μTBS; Dentin; Bonding systems; Pre-curing waiting time; Dwell

1. Introduction and review of literature

Since the innovative work of Buonocore, the concept of bonding has been continuously developing over the years till now. Bonding to enamel has been

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demonstrated to be simply attainable and can be durable [1]. Bonding to dentin is far more complicated due to the complex challenging nature of dentin. Since the nineties, two main approaches for bonding systems has been endlessly evolving namely; total-etch (etch and rinse) and self-etch (etch and dry) [2,3].

The concept of total-etch approach is to apply an acid to simultaneously etch enamel, remove the smear layer, demineralize mainly the superficial inter-tubular dentin at different depths, and to open the collagen network. After rinsing those etching products, a primer is applied, which is a double function highly hydrophilic monomer carried on a solvent vehicle. The primer penetrates and infiltrates the demineralized collagen network to intermingle with its fibers increasing its low surface energy. This will be followed by the application of a hydrophobic photo-polymerizable co-monomer to link the resin impregnated collagen network (hybrid layer) with the subsequently applied resin composite. The aforementioned approach was marketed as total-etch-three-steps bonding systems [3,4].

Alternatively, manufacturers started to launch modifications to total-etch-three-steps bonding systems such as the total-etch-two-steps (primer and bonding resin together) and the self-etch bonding systems. Such modifications were heavily marketed based on a concept that three-steps-total-etch bonding systems are more complicated, time-consuming and technique-sensitive. Self-etching systems were introduced to mainly overcome the sensitivity to humidity of the etch-and-rinse technique as well as to simplify the clinical procedures of adhesive application and to reduce its clinical time [5–9].

The concept of self-etch approach is to instantaneously condition and prime the dental substrate by the action of their hydrophilic acidic monomers. Therefore, these self-etching primers do not require a separate etching step and do not require rinsing after conditioning. Such promising features have led to the gradual growing popularity of self-etch bonding systems in the dental profession. Currently, self-etch bonding systems are available as two-steps systems or one-step systems. Two-steps-self-etch system is provided as a self-etching primer in one bottle and bonding resin (usually solvent-free) in another bottle. One-step-self-etch system is provided either as two-component system (two separate solutions to be mixed together) or one single-component system (one single solution that do not require mixing). The single-component one-step-self-etch system is considered as the only true one-bottle or all-in-one bonding system [10,11].

The key factor in the success or failure of a resin composite restoration depends on many factors, but mainly on the performance of the bonding system and the performance of the resin composite. The bonding system is supposed to efficiently infiltrate and impregnate the entire demineralized and opened collagen network to overcome its humidity and to form a high cross-linking polymer inside the collagen network [3,12]. The consequential resin–dentin hybrid layer would have an increased resistance to degradation [13]. Resin composite restorative materials have been extensively used in dental practice, but yet they still have inherent shortcomings. One of the main shortcomings of the resin composite is polymerization shrinkage. Therefore, manufacturers have developed many formulas to overcome such inherent deficiencies of resin composites as; the innovative low-shrinking monomers (silorane-based resin composite) [14] and the use of monomers with increased molecular weight [15,16]. Also, manufacturers optimized filler morphology, utilized a range of filler particle sizes and smaller average particle size to reduce polymerization shrinkage and to improve material's mechanical and esthetic properties [17]. To have a strong and durable bond with dentin, researchers also proposed many application techniques to overcome the effect of resin-composite-polymerization-shrinkage-stresses on the bond interface with dentin as; different photo-activation protocols [16] and incremental technique [18].

Manufacturers of bonding systems and resin composites are always competing with each other claiming that their products are less technique sensitive, have shorter time of application, less complicated and have better performance and durability. Even the same manufacturer has different bonding systems that follow both main bonding approaches as well as different types of resin composites. Manufacturers trials to suite all the preferences, demands and believes of different natures of practitioners sometimes confuses them. Adding to the confusion, in the last few years, studies evolved over the failure of bonding resin to efficiently cover the collagen fibers of demineralized dentin. Partially covered collagen fibers will trigger the action of collagen matrix metalloproteinase (MMPs) especially in the presence of residual water in the hybrid layer leading to declined bond strength to dentin upon aging of restorations [19–21]. Resin–dentin interfaces formed under current manufacturer recommended application times seems insufficient to produce a stable polymer within the hybrid layer. Meanwhile, certain modifications in the manufacturer recommended