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Self-etching Adhesive Systems in Operative Dentistry: A Literature Review

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Review Article

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ABSTRACT

The development of a reliable bonding to enamel and dentin substrates along with different bonding agents is an example of a paradigm shift in the way dentistry is practised. The ability to bond in a reasonably predicable way to both enamel and dentin substrates enables dentists to routinely place direct and indirect restorations. In fact, the longevity and predictability of restorative procedures rely on the dentist's ability to bond successfully to tooth structure. Adhesive systems have progressed tremendously since they were first discovered and continuously evolved over the past 30 years. In spite this significant improvements, the adhesive interface remains the weakest area of the restorations and if exposed to oral cavity, marginal discolouration, poor marginal sealing and loss of retentions as well as microleakage and recurrent caries are among the clinical consequences. Moreover, the differences between enamel and dentin substrates with regard to morphology, histology and composition make bonding to tooth structure one of the major challenges in adhesive dentistry. Current adhesive systems employ two major means to achieve a reliable bonding to the tooth structure. The first method is known as etch and rinse technique. In this technique, the smear layer is removed completely and the subsurface is demineralized via etching with acids. The second method uses the smear layer as bonding substrate and is known as self-etching adhesive system. These adhesives are attractive as, theoretically, they have the ability to significantly simplify adhesive protocols, eliminate the sensitive step of etch and rinse and may represent the next evolution in adhesive dentistry. However, whether their effectiveness is truly comparable to etch-and-rinse system is still an issue of investigation. This review aims to explore existing literature and provide information about different adhesive systems, and their protocols, and techniques that have been used to improve the quality of the tooth structure/adhesive interface when self-etching adhesive systems were used. It is useful as it helps dental practitioners with clinical decision during direct restorative procedures. Different types, mechanisms, advantages, disadvantage, morphological evaluation, marginal adaptation leakage and bond strength as well as clinical performance were all reviewed in this paper.

INTRODUCTION

The establishment of a reliable bonding has been known as one of the major challenges in adhesive dentistry although important improvements in adhesive systems have been made in the last 30 years. The goals of using these bonding agents are to provide micromechanical retention of the restoration, enhance the bonding strength between the resin and the tooth structure, reduce the microleakage across dentin-resin interface and distribute the occlusal stress [1].

Current dentin adhesives employ two different means to achieve previously mentioned goals. The first method, known as etch-and-rinse technique, removes the smear layer completely and demineralizes the subsurface via etching with acids. After rinsing, primer and adhesive (one or two separate bottles) are applied to the etched surface to complete the bonding procedure.

The second method uses the smear layer as bonding substrate and is known as self-etching adhesive system [1,2]. Although these adhesives are attractive as they are marketed as simplified, whether their effectiveness is comparable to etch-and-rinse system is still an issue of investigation.

Types of Self-etching Adhesives

Different types of self-etching adhesives are available. One is a self-etching primer that includes two steps [1-3]. These systems use primers that contain acid monomers which do not require rinsing. They consist of polymerizable methacrylate based resin hydrophilic monomers and phosphoric acid esters with a higher pH than that of phosphoric acid etchants. The function of these primers is to modify the smear layer and to partially demineralise the underlying dentin, thus incorporating the smear layer itself into adhesive layer. They are capable of simultaneous conditioning, wetting and preparing the tooth surface for bonding to hydrophobic adhesives. The other type is more simplified and includes a single application to the tooth (one step) [1,2,4]. For these adhesives, hydrophilic as well as hydrophobic monomers, solvents, water and additives are all blended in one bottle [4]. Recently, a new type of adhesives called universal or multimode has been developed. They are one-step self-etching adhesives that can be applied to either acid-etched or intact enamel or dentin. Moreover, it serves as silane for ceramics and indirect restorations as well as adhesive primers for metal alloys and zirconia oxide [5-8].

Mechanisms of Stopping the Continuous Etching Prosses

As the acidic monomer is not rinsed off the tooth, there is a risk of further demineralization to occur after its application. This might result in a layer of demineralized dentin left which undermines the bond strength. However, three mechanisms have been suggested to stop the etching process. Firstly, the acidic groups are neutralized by the reaction with the calcium. Secondly, the primer's viscosity rises after evaporation of the solvent reducing the diffusion of the monomers. Finally, Polymerization reduces the concentration of free acidic monomers [9].

Advantages

Self-etching adhesives reduce clinical steps and are easily used as they eliminate critical procedures like rinsing of the etchant and priming of the hydrated collagen fibers make them less technique sensitive. Because the resin monomers penetrate the depth at which the acidic monomers demineralize the tooth structure, they prevent the risk of defective hybrid layer [3,4]. This corresponds to reduced postoperative sensitivity when compared to etch-and-rinse technique [10,11]. However, two studies reported that when bonding procedure of etch-and-rinse adhesive was applied properly, post-operative sensitivity did not significantly differ between the two systems [12,13]. Perdigao et al. [13] recommended the application of an extra coat of adhesive when etch-and-rinse system is used to cover dry areas that were not protected by the application of the first adhesive coat.

Because self-etching adhesives do not remove the smear layer completely, questions have been raised regarding the presence and activity of remaining bacteria within the smear layer. Therefore, an antibacterial monomer - MDPB (12 methacryloyloxydodecyl pyridinium bromide) has been added to the formulation of these adhesives [14-16]. Gondim et al. [16] reported that other key factors related to bacterial inhibition including the acidic nature of the primer, the release of residual monomers and the incorporation of fluoride into these systems.

Disadvantages

In spite of their advantages, the biocompatibility of the self-etching adhesives is still controversial. The nonpolymerized free monomers can diffuse through the dentinal tubules and reach the pulp [17]. Moreover, uncured components may reach the gingival crevicular fluid or directly into the periodontal ligament [18]. Change et al. [19] reported that 2-hydroxyethyl methacrylate (HEMA), the major component released, can arrest cell cycle in pulp and gingival epithelial cells. Other components such as 2-bis [4-(x-hydroxy-3'-mathacryloyoxy) phenyl] propane (bis-GMA), urethane dimethacrylate (UDMA), and bytriethylene-glycoldimethacrylate (TEG-DMA) all showed cytotoxicity as reported by Ratanasathien et al. [20]. This is in agreement with Sun et al. [21] who evaluated the adverse effect of 4 different types of self-etching adhesives on cultured human periodontal ligament fibroblasts. The authors reported that those adhesives induced cell viability loss, cell morphology alteration, cell death, apoptosis and necrosis.

Morphological Evaluation of the Adhesive/Tooth Structure Interface

Enamel /adhesive interface

Morphological studies are useful to evaluate the quality of bonding interface. When the etching capability of different adhesive systems was examined on enamel, The self-etching adhesive systems demineralise the enamel mildly resulting in shallower intercrystallite resin infiltration and less inter-prismatic resin tag formation when compared to etch-and-rinse adhesive system [22,23].

LI et al. [24] observed ultra-morphological changes at the interface between a two-step self-etching adhesive system containing 10-methacryloyloxydecyl dihydrogen phosphate (MDP) and enamel after an acid-base challenge. They found a new zone resistant to acid-base attack that was called enamel acid-base resistant zone (ABRZ). In general, the ABRZ was thought to play a role in preventing secondary caries, sealing of the restoration margins and improve of the restoration durability [25,26]. The functional monomer in self-etching adhesive system behave as an etchant, enhancing the resin monomers penetration into the demineralised enamel and chemically interact with HAp crystals, protecting them from acid attack and forming an ABRZ [24]. The enamel ABRZ is at the interface, involving those parts of the interface as the HAp crystals are distributed all over the demineralised layer [24]. Moreover, the authors reported that a thicker enamel ABRZ was formed with phosphoric acid pre-etching. This is in agreement with Sato et al. [27] who also reported that the thickness of ABRZ varies according to the acidity and the composition of the self-etching primers. Based on their morphological study, the authors recommended selective enamel etching for one-step self-etching system, but it may be optional for the two-step self-etching systems as the former is ultra-mild and showed minimal exposure of enamel prisms.

With regard to universal adhesives, When the adhesive was used in self-etch mode i.e., without acid etching, Vermelho et al. [28] observed a regular enamel surface with no gaps between enamel and adhesive interface using TEM while micro- porosities were found among the enamel crystallites and the consequence penetration of the adhesive resin when the adhesive was used in etch and rinse mode.

Dentin/adhesive interface

In dentin, Tsuchiya et al. [29] first observed the dentin ABRZ adjacent to the dentin hybrid layer in self-etching systems. Unlike enamel, monomers penetrate into the tissue beyond the hybrid layer and the chemical interaction between the functional monomer and HAp results in ABRZ.

By using SEM, Moura et al. [30] assessed the morphological characteristics at the bonding interface of a two-step self-etching primer (Clearfil SE Bond; Kuraray) and an etch-and-rinse (Single Bond; 3M) adhesive system. It was concluded that the morphology of the bonding interface varied according to the adhesive system used. Self-etching adhesive produced thinner hybrid layers and less resin tags than those produced by etch-and-rinse system. This was explained by the fact that self-etching primers are weak acids and have a pH of 2 causing less demineralization. Furthermore, as calcium and phosphate ions resulting from demineralization remain in solution, they buffer the primer and limit the depth of demineralization.

Although one of the goals to use self-etching primers is to have an equal depth of demineralization and resin infiltration, several morphological studies reported that a demineralized zone below the hybrid layer was not protected by the adhesive when one or two steps adhesive systems were used [3,4,9]. This is of a great significance as it results in nanoleakage [4]. Nanoleakage within interfaces is not solely caused by incomplete resin infiltration into demineralized dentin. They also represent areas within the adhesive layer in which incompletely removed water or fluid from dentinal tubules inhibits complete polymerization. In addition, phase separation of adhesive ingredients might contribute to this phenomenon [4]. Furthermore, Oliveria et al. [9] reported that the arrest of demineralization does not occur immediately after drying and polymerizing. The authors believe that the residual acid takes time till it gets consumed by reaction with hydroxyapatite. However, Sensi et al. [3] reported that the two-step self-etching adhesives (Optibond Solo Plus; Kerr) produced the most uniform and consistent interfacial morphology while one-step self-etching adhesives (One-Up Bond F; Tokuyama) did not result in a satisfactory ultra-structural morphology. An important feature of two-step self-etching systems that might contribute for the better results is the hydrophobic resin layer that is placed over the primer which might reduce water sorption. Moreover, the ability of single-step adhesives to seal dentin surfaces has been questioned as they are hydrophilic monomers and function as permeable membranes allowing water and fluids movement between the interface and underlying dentin [4]. When universal adhesive systems were used in self-etch mode i.e., without etching, Vermelho et al. [28] observed silver deposition in the hybrid layer. It can be related to degradation areas or to any specific chemical component at the interface (e.g. polyalkenioc acid copolymer) infiltrated by silver ion [31,32]. However, Thanatvarakorn et al. [33] reported that mild self-etching adhesives (one step) did not exhibit any nanoleakage expression when scrubbing technique was used while applying the adhesives.

Marginal Adaptation

The marginal quality of composite restorations using different adhesive systems has been evaluated [34-39]. Chuang et al. [34] used SEM to compare the marginal integrity of composite restoration bonded to enamel by two etch-and-rinse adhesives (Single Bond; 3M, Prime & Bond NT; Dentsply) and a two-step self etching adhesive (Clearfil SE Bond; Kuraray). It was concluded that using self etching adhesive may lead to high incidence of marginal deterioration as they created a weaker etched morphology on enamel surface. When bonded to dentin surface, Loguercio et al. [35] reported that etch-and-rinse systems (Single Bond, Scotchbond Multi-Purpose Plus; 3M) showed the lowest mean of gap formation that remained unchanged for 6 months. On the other hand, self-etching adhesives (Clearfil SE Bond; Kuraray, Optibond Solo Plus; Kerr, Tyrian Self Priming Etchant; Bisco) showed wider initial mean of gap formation which diminished after 6 months of water storage to sizes similar to etch-and-rinse systems. This is in agreement with Tay et al. [36] and Cheong et al. [37] who demonstrated the presence of nano-pores within the hybrid layers that increase the permeability and allow for the swelling leading to gap closure. It was also reported that hybridized smear layer may be more important than water nano-pores as more water and solvent can be trapped within this layer [36,37].

When comparing two steps to one step self-etching adhesive systems, Heintze et al. [38] reported that the one step self-etchant yielded the poorest marginal adaptation results and the highest variability between materials as well as within the same

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material. Another factor that might lead to poor marginal integrity when self-etching adhesives are used is surface treatment with ozone and silica coating prior to bonding as reported by Onisor et al. [39].

Microleakage

Sealing of a cavity is one of the most important requirements for the durability of a composite restoration. Microleakage of restorations may be the starting point of secondary caries and treatment failures. In this regard, several studies reported that mild and ultramild self-etching adhesive systems exhibited poor adhesive capacity to enamel when compared to etch and rinse systems [40-43]. Other studies reported a better sealing ability of self-etching adhesives in dentin than in enamel surfaces [44,45]. Leal et al. [45] evaluated the sealing ability of etch-and-rinse (Prime & Bond NT, XP Bond; Dentsply, Adper Scotch Bond 1 XT; 3M, Syntac; Ivoclar Vivadent) and self-etching adhesives (Xeno III; Dentsply, i-Bond; Kulzer, Clearfil SE Bond; Kuraray) in Class-V cavities. The results revealed that leakage was prevented with etch-and-rinse in enamel margin. In dentin, self-etching obtained higher dentin sealing capability than that of etch-and-rinse adhesives. The authors reported that the lower primer acidity of these adhesives promotes less dentinal tubule opening, and therefore tubule sealing was demonstrated to be easier. In contrary, Khoroushi et al. [40] reported that there was no significant difference in adhesive capacity to dentin between self-etching and etch and rinse adhesives systems.

Bond Strength to Tooth Structure

The durability of bonds between resin and tooth substrates is of significant importance for the clinical longevity of adhesive restorations. When shear bond strength was measured immediately after bonding to enamel, Borges et al. [46] reported that bond strength was reliable and durable when etch-and-rinse (Scotchbond Multi-purpose;3M) or two-step self-etching (Clearfil Liner Bond 2V; Kuraray) was used. However, single step self-etching adhesive (Etch & Prime 3.0; Degussa AG) showed lower shear bond strength means than Clearfil Liner Bond 2V. Several reasons have been suggested to account for the suboptimal performance of this adhesive: the combination of acidic hydrophilic and hydrophobic monomers into a single step may compromise polymerization of the adhesive, the inherent weak strength of the adhesive polymer, and the lower degree of polymerization of the resin monomer due to oxygen inhibition effect during light activation of these materials. Moreover, single step self-etching adhesives are more hydrophilic than other systems and thus, water absorbed may rapidly dilute adhesive monomers. On the other hand, Koshiro et al. [47] stated that the bonding interface using two steps self-etching primer (Unifil Bond; GC) was relatively more stable over time when compared to etch-and-rinse system (Single Bond; 3M). One possible explanation is the fact that Unifil Bond contains 4-META (4-methacryloyloxyethyl trimellitic acid) as a functional monomer which has been reported to have a chemical bonding capacity to hydroxyapatite that remained around collagen fibrils after self-etching treatment as a result of its relatively high pH value [2]. The ability of the functional monomers 10-methacryloyloxydecyl dihydrogen phosphate (MDP) to establish an intensive ionic bond with the Hydroxyapitite has been demonstrated [27,48]. Sato et al. [27] reported that glycerol phosphate dimethacrylate (GPDM) is also an analogous phosphate monomer that may play similar role to that of MDP. The authors recommended further studies to clarify the chemical bonding potential of GPDM to Hydroxyapitite [27].

Bonding to dentin still faces questions related to the appropriate humidity level for better hybridization in order to provide strong and durable bonds [49]. For this reason, adhesion of resins to dentin has been the main subject of numerous studies [49-51]. In 2007, Susin et al. [49] compared the tensile bond strength of a two-step self-etching (Clearfil SE Bond; Kuraray), a one-step self-etching (One up Bond F; Tokuyama) and an etch-and-rinse (Single Bond; 3M) adhesive systems to dentin. It was concluded that the two steps self-etching provided the highest tensile bond strength while the lowest bond value was presented by the single step self-etching adhesive system. Several other studies confirmed these results [50,51].

Factors Affecting Bond Strength

Factors related to the tooth

1. **Caries-affected dentin**: It contains properties that are different from normal dentin, such as reduced permeability because of sclerotic dentin formation and partially demineralized intertubular dentin. Therefore, several studies reported that bonding to caries affected dentin with etch-and-rinse adhesives, which use an aggressive phosphoric acid etchant, resulting in significantly higher mean bond strength compared to those obtained by single step self-etching adhesives [52,53]. However, several other studies reported that a two- step self-etching adhesive was able to provide bond strength values comparable or even superior to the etch and rinse adhesive system and outperform one step self-etch adhesive systems [53-56].

2. **Fluorosis:** Fluorosed enamel is characterized by outer hyper-mineralization and subsurface hypomineralization. The pores in the subsurface enamel are occupied by water as well as secretary proteins which are retained due to excessive fluoride level on ameloblasts. A self-etching bonding system was found to be inferior to phosphoric acid etching when bonding is performed on moderate and severe fluorosed enamel because this surface is more acid resistance [57]. In contrast to the fluorosed enamel, mild and moderate fluorosed dentin is reported to be significantly susceptible to caries formation. The incompletely mineralized fluorosed dentin is made of more organic components which may be related to the higher permeability [58]. This fact can justify the results revealed by Waidyasekera et al. [58] who reported higher bonding performance of two steps self-etching adhesive (Clearfil SE Bond; Kuraray) to fluorosed dentin than etch-and-rinse (Single Bond; 3M) and single step self-etching adhesives (Tri S Bond;

Kuraray). The authors believe that the ability of two steps self-etching adhesive to chemically bond to compromised dentin is proof of the superior bonding effectiveness of this adhesive.

3. **Molar incisor hypomineralization-MIH:** The developmental enamel defect that involves the first permanent molars and incisors (Molar incisor hypomineralization-MIH) negatively affects the bond strength as adhesives have a lower ability to adhere to tooth surface [59-61]. Therefore it is recommended to treat the enamel surface with 5% sodium hypochlorite, or to remove defective hypomineralized enamel prior to bonding resin composite restorations [62]. Souza et al. [61] suggested that self-etching as well as etch-and rinse adhesives can be used in restoration of molars affected by MIH when the cavity preparation is conservative. Once the cavity margins are in hypomineralized enamel, modern adhesives maybe the material of choice. When William et al. [63] compared microshear bond strength and failure modes of etch-and rinse (Single Bond, 3M ESPE) and a self-etching adhesives (Clearfil SE Bond, Kurary Medical) in hypomineralized enamel, the authors found that self-etching adhesives presented significantly higher micoshear bond strength than that of etch-and-rinse due to inadequate micro tag formation with the latter.

4. **Bleaching:** It is another factor that can reduce bond strength to enamel as the free oxygen radicals may affect the polymerization of adhesive systems regardless of the type used. Several studies [64,65] supported this statement and reported that single step self-etching provided the lowest bond strength value [64]. It was therefore recommended by Adebayo et al. [65] to use conditioners on bleached teeth (30-40% phosphoric acid, 15% EDETA or 20% polyacrylic acid) prior to bonding with self-etching primer as it significantly improved bond strength. For bleached dentin, Souza et al. [66] recommended pretratment with glutaraldehyde when the etch and rinse adhesive (Adper Scotchbond Multi-Purpose Plus, 3M ESPE; St Paul, MN, USA) was used and with chlorhexidine when self-etching adhesive (Clearfil SE Bond, Kuraray Noritake; Tokyo, Japan) was used as they increased the bond strength.

Surface treatment

1. **Cutting burs:** It is well known that the smear layer is defined as a layer of debris on the surface of dental tissue created by cutting a tooth. It varies in thickness, roughness, density and degree of attachment to the underlying tooth structure according to the surface preparation. Using diamond burs can create a thick smear layer that may affect the ability of weak self-etching adhesives to permeate this layer and demineralize the underlying dentin [67,68]. Therefore, it was reported by Semeraro et al. [68] that when Clearfil SE Bond (two steps self-etching; Kuraray) and SSB-200 (one step self-etching; Kuraray) were bonded to dentin cut with the regular grit diamond bur, the micro-tensile bond strengths were significantly lower than that of superfine bur-cut dentin. On the other hand, other types of single step self-etching adhesives (G Bond; GC, Prompt L Pop; 3M) showed no significant differences in micro-tensile bond strength between the two differently cut surfaces. The results can be related to the low pH of these adhesives that showed complete dissolution of the smear layer and exposure of the collagen fibrils. Moreover, Rocha et al. reported that when dentin surface was prepared with carbide bur at low speed, a thicker smear layer was produced that resulted in reduced micro-tensile bond strength of two step self-etchant (Clearfil SE Bond) when compared to diamond burs [69].

2. **Aluminum oxide:** Surface treatment using aluminum oxide air abrasion has been suggested to be an effective procedure to increase bond strength. It removes smear layer and thus improving the infiltration of adhesive systems to the underlying dentin [70]. When composite is to be repaired, Cavalcanti et al. [71] recommended to treat the surface using air abrasion as it can cause micro retentive features that cannot be created by self-etching adhesives.

3. **Pre-treatment etching:** In an attempt to improve the performance of self-etching systems, some studies evaluated whether pre-treatment etching would improve the resin-tooth bond strength [72-77]. It has been shown that the bond strength values of self-etching adhesives when bonded to enamel can be improved by the adjunctive use of phosphoric acid [75,76]. It is likely that the phosphoric acid pre-treatment increase the enamel roughness and removes superficial layer of enamel. In dentin, Soares et al. [76] reported that 24% EDTA is a mild chelating agent that can dissolve the hydroxyapatite selectively without altering the collagen matrix structure thus providing higher mean bond strength to dentin than phosphoric acid. Unlike previously mentioned studies, Erickson et al. [77] reported that pre-etching enamel with phosphoric acid did not improve the performance of the Prompt L Pop (single step). This controversy could be related to the differences in the methodology of the two studies. Vermehlo et al. [28], on the other hand, found that although enamel pre-etching with phosphoric acid improved microtensile bond strength of multimode adhesive systems, the bond strength decreased after one year. The authors also reported that no significant difference was found in the bond strength between two-step self-etch (Clearfil SE Bond), etch and rinse (Optibond FL) and multimode (All-Bond Universal) adhesive systems in dentin. However, etch and rinse mode was suggested for Scotchbond Universal as the bond strength decreased after one year when the adhesive was used in self-etch mode. Additional phosphoric acid etching to dentin should be approached with caution when multimode adhesives used in etch and rinse mode as bond strength decreased with increased pre-etching time. Takamizawa et al. [78] recommended reducing the etching time to 3 seconds as it mitigates the risk from inadvertent pre-etching of dentin.

4. **Laser:** Irradiation of enamel by laser was suggested to improve resin bond to the surface due to the roughness created, allowing mechanical interlocking with resin materials [79]. The effectiveness of this procedure is controversial; while several studies support the etching ability of laser to enamel [79-81] others deny its efficiency [82,83]. Ayar et al. [84] reported that the bond strength of universal adhesives was significantly increased when used in etch and rinse mode, while laser etching provided similar bond strength compared to the adhesive in self-etch mode.

Application Technique

Application of the adhesives using a scrubbing technique, also called active application, has been reported to increase the bonding performance to enamel and dentin of one step self-etching adhesives as it facilitated the smear layer removal [33,85-87]. Moreover, it increased the degree of conversion of the adhesive at the interface due to enhancement of solvent evaporation and improves the enamel bond strength as reported by Loguercio et al. [88]. Furthermore, it promoted monomer infiltration into the dentin substrate and water chasing from the adhesive/ dentin interface which could improve the quality of the interface [33,88-90].

Drying Time

It has been suggested that water, solvents or primer mixed into adhesive resin result in reduced mechanical properties, bonding performance and hybrid layer quality. Therefore, removing those components from the adhesive by adequate drying seems to be critical [91]. Several studies recommended increasing drying time of self-etching adhesives as it improved shear bond strength significantly [91-93]. Moreover, since drying the material in the patient's mouth is difficult due to some restrictive variables such as cavity shapes and tooth position, increasing drying time seems to provide another advantage; that is preventing pooling of the material [91].

Toledano et al. [93], investigated the micro-tensile bond strength of a one-step self-etching adhesive (Futurabond; Voco) to dentin following different bonding treatment. These protocols were according to manufacturer's directions, acid etched with 36% phosphoric acid for 15 seconds, 10% sodium hypochlorite treated for two minutes after etching, doubling the application time of the adhesive and doubling the number of adhesive coats. The authors concluded that doubling the application time attained the highest micro-tensile bond strength.

Desensitizers

It is important for clinicians to evaluate desensitizing treatments as some of these agents negatively affect the bond strength. This is because of their ability to induce protein and Ca-salts precipitation in dentin liquid or to form calcium fluoride globules that block the open dentinal tubules [94]. On the other hand, desensitizing agents that contain HEMA were reported to have no adverse effect on bond strength [95].

Clinical Performance

Studies reported that single step self-etching adhesives in non-carious lesions showed acceptable clinical retention after two and five years [96,97]. Akimoto et al. [98] reported that 10 years of clinical evaluation of two steps self-etching adhesive (Clearfil Liner Bond 2) showed only slight marginal change of some restorations. However, these changes were not severe and did not require replacement since no recurrent caries were present.

CONCLUSION

Within the limitation of this review, the following can be concluded:

1. Equal depth of demineralization and resin infiltration cannot always be achieved by self-etching adhesives.
2. The initial marginal gap that is formed with self-etching adhesive can be compensated by water sorption. However, this can affect the bonding physical properties.
3. In enamel, etch and rinse adhesive provides the least microleakage. On the other hand, the least microleakage in dentin can be achieved with the self-etching adhesives.
4. Single step self-etching adhesives provide the least bond strength while two steps adhesives produce comparable bond strength to etch-and-rinse systems.
5. Several factors should be considered to increase the bond strength of self-etching adhesives.

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