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Review Article

An overview of dentin conditioning and its effect on bond strength

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ABSTRACT

Given the inherent qualities of this medium, particularly when contrasted to enamel bonding, bonding to dentin is considered to be a less dependable approach. Further, when dentin is reduced, a sizable amount of cutting detritus coats the dentin's exterior, forming the smear layer. A steep decrease in interfacial adhesion over time has been attributed to the collagen web's inadequate resin impregnation as a result of the dentinal surface preparation with strong acidic agents like phosphoric acid, which left a zone of vulnerable collagen at the root of the hybrid smear layer. Self-etching priming agents that comprise acidic, non-cleansing, polymerizing monomers cause demineralization of the surface and encapsulate the collagen fibers and hydroxyapatite crystals while dissolving the smear layer or incorporating it into the adhesion interface. The concurrent occurrence of dentinal demineralization and monomeric penetration prevents collagen from buckling and shields an exposed collagen web. There may be a drawback to including the smear layer in the hybrid layer, according to certain investigations. Adhesion issues could arise even though the smear layer is reinforced with impregnated resin. To achieve dependable, robust resin-dentin connections, such defects may need to be removed by integrating a distinct etching process because they can reduce the resistance and longevity of the conjugated smear layer. In relation to a traditional bonding system, is has been discovered that removing the smear layer with 0.5 M ethylene diamine tetra-acetic acid (EDTA) before applying a self-etching primer result in greater bond strengths. Even though this approach integrates the smear layer within the adhesion interface, the pre-conditioning of dentin with just an acidic primer is highly convincing and merits additional exploration for the streamlined total-etching systems.

Keywords: Dentin conditioning, Self-etching primers, Smear layer

INTRODUCTION

Given the inherent qualities of this medium, particularly when contrasted to enamel bonding, bonding to dentin (DB) is considered to be a less dependable approach. Further, when dentin is reduced, a sizable amount of cutting detritus coats the dentin's exterior, forming the smear layer (SL).[1] The issue of whether or not to eliminate the SL entirely or partly is still up for debate. Even though this SL has a limited cohesive force keeping its fragments intact, it is susceptible to microbial byproducts, and may possess bacteria, its complete eradication reduces the opposition to fluid motion through the dentin, enhancing its penetrability and raising the likelihood of postoperative hypersensitivity.[1,2] The majority of bonding agents currently on the marketplace condition the dentinal exterior for the bonding materials by using a conditioner of low pH, often 30 to 40% phosphoric acid.[3] When dentin is etched with such significant amounts of phosphoric acid, the SL is effectively eliminated, and the dentinal surface undergoes morphologic changes as a result of the disintegration of the crystalline hydroxyapatites. This causes the dentin tubules to expand greatly and expose a surface of collagen fibrils diminished of minerals.[4-6] There is frequently a disparity between the degree of dentinal demineralization and monomeric permeation, despite the fact the interplay of the etchant with dentin is restricted by the buffering capacity of the inorganic and biological phases.[7] The residual, vulnerable mineral-depleted collagen surface at the foundation of the hybrid layer (HL) allows for pulpal damage, nanoscopic leakage, flexural motions of the restorative unit, and possibly adhesion loss.[8,9] It has been proposed that the hydrolyzing destruction of the revealed collagen network over an extended duration of time causes a drop in bonding abilities.[10-12] Self-etching priming agents that comprise acidic, non-cleansing, polymerizing monomers cause demineralization of the surface and encapsulate the collagen fibers and hydroxyapatite crystals while dissolving the SL or incorporating it into the adhesion interface.[13] The concurrent occurrence of dentinal demineralization and monomeric penetration prevents collagen from buckling and shields an exposed collagen web.[4] There may be a drawback to including the SL in the HL, according to certain investigations.[14-16] Adhesion issues could arise even though the SL is reinforced with impregnated resin.[14] To achieve dependable, robust resin-dentin connections, such flaws may need to be removed by integrating a distinct etching process because they can reduce the resistance and longevity of the conjugated SL.[17] At a pH of 22, ethylenediamine-tetra-acetic acid (EDTA) is a moderate chelator that, based on the amount and duration of exposure, has diverse impacts on dentinal surfaces.[18] According to research, this etching agent exclusively dissolves the hydroxyapatite while maintaining the collagen matrix's structural integrity.[19,20] Upon the application of 17% EDTA to dentin for 60 seconds, there is an incomplete elimination of the SL with the preservation of around 30% of the smear plugs and no morphologic modifications of the dentinal surface.[21] A variety of substances have been proposed as dentin etchants.[22]

METHODS

This study is based on a comprehensive literature search conducted on 25 November 2022, in the Medline and Cochrane databases, utilizing the medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any possible research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed the information about dentin conditioning (DC) and its effect on bond strength. There were no restrictions on date, language, participant age, or type of publication.

DISCUSSION

Previous literature has shown a steep decrease in interfacial adhesion over time.[12,23-25] This observation has been attributed to the collagen web's inadequate resin impregnation as a result of the dentinal surface preparation with strong acidic agents like phosphoric acid, which left a zone of vulnerable collagen at the root of the hybrid SL, which has been referred to as a defective territory. According to research by Hashimoto et al, the percentage of bonding breakdowns in the demineralized dentin at the bottom of the HL in specimens matured in vivo was higher than in samples examined after one day in distilled water.[10] The region of exposed collagen fibrils may be subject to hydrolytic deterioration over time, which could deteriorate the resin-dentin contact and reduce the adhesion capacity as a result.[10,12,25,26] Because the HL contains small pores, a phenomenon known as nano-leakage, oral secretions are thought to enter the bonding junction and cause bonding breakdown.[8,27] The long-term degeneration of the junction may also be accounted for by the water-treeing effect.[16] Given the heat created when the adhesives are photocured, water trees that may be seen via transmission electron microscopy along the bonding junction may be the consequence of bulk fluid rising convectively from the dentinal tissues.[28] By breaking down the collagen and gelatin in the exposed collagen network, proteolytic enzymes generated by leukocytes, salivary glands, and plaque pathogens can impair bonding.[28,29] The breakdown of collagen fibrils, as seen in dentin located carious lesions, may also be significantly aided by host-obtained proteinases produced from the dentinal matrices undergoing acidic action.[30] Notwithstanding the deterioration of collagen fibrils, it has also been shown that long-term nanoscopic leakage activities can also degrade resinous compounds.[27,31,32] Extra moisture causes the resin to fail to polymerize, leaving behind remnant monomers that are more prone to withdrawal or deterioration over time.[32,33] Even though no long-term assessment had been done, some of the outcomes seen in the current examination may be

explained by the existence of a faulty region at the root of the HL. Single Bond's average micro tensile bond strength (40.9±14.3 MPa) was considerably lower than the average achieved when the same bonding formulation was applied to dentin that had merely been preconditioned with a self-etchant priming agent. (58.5±20.8 MPa). Although the findings were statistically identical to those received following the preliminary treatment with phosphoric acid, Francci et al discovered greater bond strength for Single Bond placed post dentin conditioning with self-etchant priming solution.[34] In the beginning, self-etching primers were created as an aqueous solution containing HEMA and phenyl-P, a phosphoric acid methacrylate product, in a strength larger than 5%.[35] The caustic resin monomers in more contemporary systems, like Clearfil SE Bond, is 10-methacryloxydecyl dihydrogen phosphate (MDP). Breakdown of air-dried, demineralized fibers is resisted since there is no reduction of bulk from dentinal tissues since independent acid conditioning and cleansing are not necessary.[36] Additionally, because dentin conditioning and priming take place simultaneously, a more uniform and void-free region may be created, which enhances the HL's effectiveness. Because a self-etching process must be capable of piercing the SL and demineralizing the dentin underneath to generate genuine HL, the harshness of the system is correlated with its acidity.[37] Intense systems, as Prompt L-Pop (pH 1.0), can produce HL that are as extensive as those made by phosphoric acid.[37] With a pH of 2.0, Clearfil SE Primer is regarded as a slightly caustic substance. The width of the genuine HL produced by this technique is only five collagen fibrils, or roughly 0.5 mm. Significant microtensile bonding abilities were achieved in one investigation when the Clearfil SE Bond system was administered on the SL coated dentinal surface (31.93±12.5 MPa), in spite of the fine HL created. Irrespective of the bonding system used—Clearfil SE Bond or Single Bond—the bond strengths were found to be statistically comparable to those attained to phosphoric acid prepared dentin, measuring 36.4 15.2±MPa and 40.9±14.3 MPa, correspondingly. In this method, DC with phosphoric acid prior to applying a self-etchant and priming agent failed to effectively enhance the adhesion. Additionally, Inoue et al discovered that a number of self-etchant primer products and two-step total etching adhesives had equal adhesion capacity.[38] Once more, the findings might be explained by the suppression of collagen web breakdown in highly dry settings and the lack of residual water in overmoist settings.[39] Furthermore, there is no relationship between HL width and bonding abilities.[39,40] The inclusion of the SL within the bonding contact is a potential drawback of self-etchant priming systems. The hybrid SL, despite being fortified by saturated resin, indicates a vulnerable region since it may cause bonding faults.[14,15] It is also feasible to distinguish between the hybridized SL and the genuine HL because only resinous substance that dispersed in the vicinity of the globular particle clusters that make up the smear's foundation connects these two layers.[37] Additionally, some self-etchant priming agents, including Clearfil Liner Bond II and Clearfil SE Bond, incorporate hydrophilic HEMA and 10-methacryloxydecyl dihydrogen phosphate (DMP), that encourage greater water sorption and significantly increase the amount of water that penetrates the bonding surface.[41] Sano et al found greater porosity over time at the surface of the HL and in the bonding resin, which was most likely caused by extracted water of resinous material, particularly from interfibrillar areas, despite the fact that in vivo adhesion capacities remained constant over a 12-month duration.[31] Also, for the self-etchant priming system, Li et al discovered significant nanoscopic leakage after a 12-month storage duration, demonstrating that the hydrolytic stress on the junction produced by this family of bonding agents may also develop over time.[42] With its ability to remove hydroxyapatite with precision while protecting the collagen matrix's integrity, EDTA is a chelator that is effective at neutral pH.[19,20] Brännström created a DC agent with 0.2% EDTA (pH 7.4) and 0.1 benzalkonium chloride as a surface-active disinfecting agent due to the possibility that SL harbors pathogens.[2] These treatments were applied for 60 seconds, removing the SL while maintaining the smear plugs in place and ensuring minimal dentinal permeation.[22] Yet, pH, length of treatment, and quantity of EDTA treatments all affect how effectively dentin is demineralized.[19] While etching dentin with 1.5 or 5% EDTA concentrations was insufficient to remove the SL, etching dentin with 15% EDTA did so while only exposing a small number of collagen fibrils.[19] The administration of 2% 4-META/MMA-TBB resin after preparing bovine dentinal surfaces with a preparation containing 0.3 M EDTA (NH4)2 and 0.2 M EDTA Fe/NH4 (EDTA 3-2) for 60 seconds resulted in ongoing HLs with the undamaged dentin underneath.[43] Since human dentin was more difficult to demineralize and these results could not be replicated, Miyasaka and Nakabayashi coupled the administration of EDTA 3-2 solution with a phenyl P/HEMA primer to produce high-quality HLs with sufficient adhesion capacities.[44] In the current investigation, scanning electron microscope analysis of samples that were exposed to 0.5 M EDTA pH 7.2 for 30 seconds revealed full eradication of the SL and smear plug. Following EDTA DC, the use of the self-etchant and priming adhesive system, Clearfil SE Bond, was noted to result in a significantly greater microtensile bonding (47.8±15.1 MPa) than when the system was applied to dentin that had been coated with SLs (32.0±12.5 MPa). In light of the findings, we hypothesize that tougher and more uniform HLs were likely produced by eliminating the SLs and allowing the self-etching material to come into direct contact with the dentin. Because the coefficient of variance for this category was 83% in one study, the use of Single Bond in conjunction with EDTA DC created a wide range of adhesion strengths. Of the 50 specimens that were chosen for testing, 17 shattered even prior to being put into the microtensile apparatus. Because Single Bond has a pH of 4.3, which is not sufficiently harsh to demineralize the dentin on its own, the absence of uniformity in strength properties in this instance may be accounted by this. Since EDTA is only a moderate etching agent, demineralizing

the dentin adequately necessitates the aid of a more caustic substance.[14] Without conditioning with phosphoric acid, the dentin provides a high shear bond strength of All Bond 2 (pH 5.2) after being exposed to a highly concentrated EDTA (24%) mixture for 30 seconds.[45] In comparison to traditional chemical etching, the shear bonding was much stronger after three minutes of application of a 24% EDTA gel and All Bond 2.[46]

CONCLUSION

It has been discovered that removing SL with 0.5 M EDTA before applying a self-etching primer result in greater bond strengths. When a traditional system was employed, the same was not evident. Even though this approach integrates the SL within the adhesion interface, the pre-conditioning of dentin with just an acidic primer is highly convincing and merits additional exploration for the streamlined total-etch system Single Bond. Overall findings imply that DC with gentler etchants can lead to stronger bonds, while deeper demineralization can hinder appropriate resin entry, weakening the connection. Because the original SL is absorbed into the HLs, longer-term clinical trials are still necessary to fully comprehend the process of degeneration of the bonding interface formed by self-etching systems.

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