The appropriate method for dental adhesive application: A review

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Abstract

Different types of adhesives are used to bond composites for dentin. However, there was no specific manner for the application of adhesive that can enhance the bond strength between resin and dentin, so this review assesses the different techniques for the application of adhesive to the dentin surface; the review used three databases, PubMed, Web of science Embase, and Scielo to search the in vitro studies which can give the insight to the most appropriate bond enhancement technique. The various techniques of adhesive application, such as the application of the hydrophobic coating, the application of two layers of adhesive, and the application of adhesive by electrical current, active agitation, and sonic agitation, can improve the bond strength.

Keywords: dental adhesive, dentin bonding, adhesion

Introduction

Adhesion to dentin is more complex and more challenging than to enamel because of the dentin structure that requires special consideration to obtain reliable and high bond strength [1,2]. Adhesion of resin and dentin involves the formation of the hybrid layer, an interdiffusion

zone that forms the micromechanical retention between the resin and dentin. This hybrid layer is composed of hydroxyapatite, collagen fibrils, solvent, and monomer resin; this layer's durability depends on its component ability to resist the degradation process [3,4,5,6,7,8,9,10].

Self-etch (S.E.), etch & rinse, and universal adhesives are commonly used to bond to enamel and dentin; the bond strength of this adhesive can increase when the steps of the procedure are decreased the by reducing the error and sensitivity [4,7,11].

These adhesives consist of monomers containing hydrophilic and hydrophobic components, polymerization mediators, and solvents. This solvent dilutes the monomers and can help increase the spreading, wetness, and penetration of monomers to dentin structures during the bonding procedure. However, as these solvent percentages increase in the adhesive, the bond strength is negatively affected[12,13,14].

During the bonding procedure, the excess solvent should be removed; this can be achieved by allowing sufficient time for the solvent to evaporate before curing or employing dry air. Solvent evaporation depends on different factors such as the type of solvent and monomers, distance between teeth and air syringe, and air temperature [15,16,17,18].

Numerous techniques such as active agitation, sonic agitation, adding a hydrophobic coat, adding multiple layers of adhesive, using electric current, and increasing the application time can be used for adhesive application attempting to improve the bond strength between dentin and resin material. However, until now, there have been no standard ones that can recommended as the most appropriate method. [6.8.11.12.19.20] .

material and method

The electronic databases of Google Scholar, PubMed, and Science Direct were tried to search for papers about enhancement bond strength. The criteria of this review depend on the results of previous systemic reviews and meta-analyses [21].

A practical method to differentiate a commercial dentinal adhesive solution is by assessing its bonding strength[16,22,23]. The predominant procedures for measuring bond strength involve the application of tensile or shear stress; these tests can be applied to large areas of specimens.

Also, micro shear and micro tensile are created for small areas of spacemen, which produce more accurate results[17.18.19].

This study reviews different application techniques for bonding dental adhesive, such as adding a hydrophobic coat, active and sonic agitation, increasing the application time of adhesive, and adding multiple layers of bonding adhesive; that technique increased the bond strength.

The water-permeable nature of the monomers included in certain adhesives impairs the stability of dentinal bonding due to their hydrophilic properties; these phenomena occur because the monomer has a strong attraction to make the hydrogen ion bond to the hydrophilic part of the monomer that alters the formation of the polymer chain, so Many studies advise applying a hydrophobic coat of adhesive before curing. This approach aids in maintaining adhesive contact by preventing water absorption from the exterior oral cavity and water penetration by osmosis from the dentin substrate[20,24]. Adding a hydrophobic layer increases the bond strength, makes the adhesive layer thicker, increases sealing efficiency, increases the conversion rate, increases the mechanical properties, and reduces the degradation of the adhesive layer[24,25,26,27]. S.E. adhesives exhibit hydrophilic properties, hence requiring further protection. In addition, E&R adhesives, particularly those containing 2-hydroxyethyl methacrylate (HEMA), are hydrophilic. Therefore, applying an additional hydrophobic layer can decrease the amount of solvents and unreacted monomers retained within the hybrid layer[28]. Hence, to enhance the adhesive strength between the adhesive and dentin, it is preferable to apply an additional layer of hydrophobic coating,

The time between applying adhesive on the dentin surface and curing should be increased as it enhances the diffusion of the monomer into the dentin and increases the reaction between the minerals and monomers, increasing the bond strength[28,15]. This method enhances the concentration of collagen fibrils with resin, as it is preferable for the resin monomers to fill the gaps between the exposed collagen. Failure to do so may negatively impact the effectiveness and longevity of adhesive systems. In addition, increasing the duration of the adhesive application allowed for more solvated monomers to evaporate, which, in turn, facilitated the development of a stronger polymer on the dentinal surface and resulted in a higher bond strength between the resin and dentin[29,30].

Presently, the prevailing tendencies in bonding support the use of adhesive systems in a singular application. However, this approach does not allow for the creation of a thicker hybrid layer or adhesive layer that would enable micromechanical retention with the underlying composite resin. Prior studies have suggested that using multiple or triple adhesive layers can improve dentin's binding strength by facilitating monomers' entry into the hybrid layer (H.L.) and enhancing chemical interactions[28,31]. Therefore, it is vital to regard an additional layer application as an essential clinical procedure. Additionally, the 10-MDP monomer requires a specific time of 20 seconds for its chemical interaction to occur. Where is the reference for this statement? However, applying a second coat of this monomer without curing the first one allows the first layer to interact with hydroxyapatite crystals, resulting in effective additional bonding.

Additionally, it is essential to acknowledge that the increased strength of the dentin bond when applying the material twice is a result of multiple mechanisms functioning simultaneously; during the application of adhesive layers, the solvent contained within the adhesive evaporates; this causes an increase in the concentration of co-monomers that remain after each layer is applied. As a result, the quality of the H.L. (adhesive) improves; a prior study demonstrated that the dentin bond performance improved when several adhesive layers were applied without being cured[32].

This phenomenon cannot be attributed to the increase in the thickness of the adhesive layer but rather to the improved quality of the adhesive layer. The thickness of the adhesive film only grows when each coat is subjected to light curing. This ensures that the demineralized dentinal substrate will be adequately shielded, reducing the harmful consequences of oxygen inhibition by creating faulty bonds for self-etch (S.E.) and etch-and-rinse (E&R) adhesives. In summary, it is recommended that clinicians use multiple application layers, and they should evaluate the material and substrate contents of each adhesive[28,29].

The bond strength can be increased by applying an electric current to the dentin surface; this method enhances the chemical interaction between adhesive systems and tooth structures, resulting in increased infiltration of monomers into the demineralized dentinal substrate. This was achieved by modifying the surface charges and hydrogen bonding potential of the dentin substrate[33,34]. As a result, there is an improvement in the capacity of dentin to be wetted,

which causes the evaporation of solvents[32]. In addition, electrically assisted techniques improve the strength of the link between dentin and other materials and decrease the occurrence of nano leakage in the H.L. [35,36,37].

Nevertheless, the application of adhesive necessitates the use of a specific device that dispenses the adhesive solution through the utilization of an electrical potential difference between the adhesive system and the surfaces of the teeth[34].

Applying an electric current can improve the diffusion of resin monomers into etched dentin. This is because polar components like HEMA, polyalkanoic acid, biphenyl dimethacrylates copolymers, and dipentaerythritol penta-acrylate phosphate present in the adhesive formulation can interact with the electric field[33]. Previous research has indicated that electrical currents facilitate the mobility of a substrate that has been ionized[38,39]. However, it is still unclear whether the formation of appropriate dentin hybridization may be achieved by promoting the penetration of ionized substrates under various conditions and improving the elimination of water for self-etching adhesives[40,41]. Furthermore, applying an electric current can enhance the pace at which water is replaced by modifying the water dipoles. This modification promotes the exchange of water with the solvent during resin infiltration[20]. According to a claim, using electric currents ranging from 30 to 35 μA significantly enhanced the strength of bonds and the quality of bonding[42]. Using a current of 35 μA during bonding techniques has been shown to have no negative impact on cell viability, indicating that it can be considered safe. So, using electrical current is preferred for adhesive applications such as self-etch and ecth&rinse adhesive systems, which helps increase monomer penetration into dentin[34].

Applying adhesive with a bonding brush linked to an endo activator can increase the bond strength as it works at a speed of 10,000 CPM, which equals 3333 cycles in 20 seconds. This action produces an acoustic streaming force that increases the diffusion of monomers into dentin and increases the bond strength[43].

Another method to increase the bond strength is the application of adhesive with sonic energy that can enhance the bond between dentin and resin composite; a previous study confirms this improvement that applying the adhesive with a bonding brush linked to an endo activator can

increase the bond strength as it works at a speed of 10,000 CPM, which equals 3333 cycles in 20 seconds, This action produces an acoustic streaming force, and it increases the dynamic of adhesive solution that creates pressure and energy that enhances the diffusion of monomer to dentin, leading to a thicker hybrid layer with more extended resin tags[43].

Manual agitation is one of the recommendations for bonding application. Research indicated that active agitation of a two-step self-etch adhesive technique increased bond strength. The explanation for this phenomenon might be attributed to the complete dissolving of the smear layer into the adhesive[41]. while Miyazaki et al. discovered a dissimilar result while examining the identical adhesion approach[40]. Another research found that the effectiveness of S.E. adhesive systems was linked to the length of time the adhesive was agitated .[35]Overall, the stirring of the adhesive was able to enhance the movement of the particles and allow for improved diffusion of the monomers inside the dentinal tubule[41].

Ultrasonics is a branch of acoustics that focuses on using sound waves at frequencies higher than what humans can hear. It should be noted that the oscillating devices used in dentistry practice often operate at ultrasonic frequencies, specifically spanning from 20,000 to 40,000 Hz. Furthermore, a sound is classified as sonic when its frequency falls within 1000 to 6000 Hz[44]. Ultrasonic activation of adhesive was attempted to increase the bond strength by creating acoustic energy that increases monomer diffusion to the dentin. A systemic review found that ultrasonic agitation did not detect an improvement in dentin bond strength in all of the examined adhesives[45].

In summary, it is advisable to understand the chemistry of the adhesive being used and the previous application technique to assist in enhancing the bond strength.

conclusion

The bond strength between dentin and resin composite can be increased by using any of the application techniques: application of a hydrophobic resin layer, prolonged application period, a double-layer application, the use of an electric current to help the application, sonic agitation and actively applying the adhesive. It is advisable to understand the chemistry of the adhesive being used and the previous application technique to assist in enhancing the bond strength.

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