RESEARCH PAPER

A Scoping Review of the Effect of Laser, Diathermy and Different Decontaminants on Bond Strength in Direct Adhesive Restorative Procedures

Nehal Abdelmageed Mostafa Elsharkawy[1], Mohammed Nasser M Anwar[2], Rana Abdelrehim Sedky[3], Reham Khaled Elghazawy[4]

[1]Conservative Dentistry Department, Faculty of Dentistry, Ain Shams University
Email: nehal.elsharkawy.std@dent.asu.edu.eg
ORCID ID: 0009-0009-7061-6875

[2]Associate Professor, Conservative Dentistry Department, Faculty of Dentistry, Ain Shams University
Email: mnasser@dent.asu.edu.eg
ORCID ID: 0000-0003-1125-4332

[3]Associate Professor, Operative Dentistry, Faculty of Dentistry, Ain Shams University
Email: ranaabdelrehim@dent.asu.edu.eg
ORCID ID: 0000-0002-2180-0838

[4]Associate Professor, Pediatric Dentistry and Dental Public Health Department, Faculty of Dentistry, Ain Shams University
Email: rehammohamed@dent.asu.edu.eg
ORCID ID: 0000-0001-5433-2631

***Corresponding Author: Nehal Abdelmageed Mostafa Elsharkawy, Conservative Dentistry Department, Faculty of Dentistry, Ain Shams University**
Email: nehal.elsharkawy.std@dent.asu.edu.eg
ORCID ID: 0009-0009-7061-6875

Received: 18th Feb, 2025 | **Revised:** 18th April, 2026 | **Accepted:** 31st May, 2026 | **Available Online:** 20th June, 2026

ABSTRACT

A scoping review of the effect of laser, diathermy and different decontaminants on bond strength in direct adhesive restorative procedures. This review synthesizes available evidence on the impact of various surface treatments and decontamination protocols on adhesive bond strength in direct restorative dentistry.

This scoping review systematically maps the existing literature examining the effects of laser therapy, diathermy, and various chemical decontaminants on the bond strength of adhesive restorations. The review aims to identify knowledge gaps and provide clinical recommendations for optimizing adhesive procedures in restorative dentistry.

Keywords: Bond Strength, Laser, Diathermy, Decontaminants, Adhesive Restoration, Scoping Review.

How to cite this article: Elsharkawy NAM, Anwar MNM, Sedky RA, Elghazawy RK. A Scoping Review of the Effect of Laser, Diathermy and Different Decontaminants on Bond Strength in Direct Adhesive Restorative Procedures. Int J Drug Deliv Technol. 2026;16(56s): 318-321. DOI: 10.25258/ijddt.16.56s.34

Source of support: Nil.

Conflict of interest: None.

I – Adhesion to the enamel

Adhesion to enamel is considered one of the most significant achievements in modern adhesive dentistry, as it largely determines the success or failure of composite resin (CR) restorations. Compared to dentin, adhesion to enamel was achieved at an early stage by etching the enamel surface with phosphoric acid. After etching, adhesive agents penetrate into the pores and create micromechanical bonding. Successful enamel adhesion depends mainly on the creation of this durable micromechanical bond between the etched enamel surface and adhesive resin. [1]

This bonding process, however, is highly sensitive to contamination during clinical procedures. The presence of saliva, blood, moisture, oil, or chemical contaminants may adversely affect the integrity of the adhesive interface and consequently reduce the bond. [1] Hence, any contamination of the prepared surface with saliva, gingival crevicular fluid, or blood should be avoided to achieve a proper bond between the resin composite and the tooth. If contamination occurs, pores will be filled with contaminants instead of the adhesive, and the micromechanical retention will be decreased.[12]

II – Contamination affecting Adhesion to the enamel

The use of a rubber dam is associated with high-quality patient care and is currently the only way to achieve the dry field that is mandatory to accomplish excellence in composite resin restorations. However, in some clinical situations, this dry field is not always feasible; for example, when cavity preparations are located near or under gingival margins, during the restoration of carious and non-carious cervical lesions. Furthermore, only about 17% of professionals routinely use the rubber dam. [3]

In this context, the contamination of the operatory field is a recurrent reality that emphasizes the value of studies in this area. Saliva is one such element existing in the oral cavity, which has a high probability of contaminating the surface to be restored. Saliva contains water, proteins, glycoproteins, and electrolytes that rapidly form an acquired pellicle over the etched enamel surface. This pellicle reduces surface energy and blocks enamel microporosities, resulting in decreased wettability and impaired resin infiltration. Several studies demonstrated that salivary contamination significantly reduces shear bond strength, particularly when contamination occurs after acid etching and before adhesive application. The reduction in bond strength has been attributed to the adsorption of salivary proteins onto the enamel surface, preventing adequate penetration of resin monomers. Furthermore, the duration of contamination plays an important role, as prolonged exposure to saliva may produce greater deterioration in adhesive performance.[4]

Blood contamination has been reported to exert a more detrimental effect on enamel adhesion than saliva contamination. Blood contains a high concentration of proteins and fibrin, along with macromolecules such as fibrinogen and platelets, which can form a dense organic layer over the etched enamel surface, obstructing the penetration of the adhesive system into enamel pores. In addition, blood contamination is difficult to remove completely by simple rinsing procedures. Several investigations demonstrated a substantial reduction in bond strength following blood contamination, especially in surgical or orthodontic procedures where bleeding from gingival tissues is common.[3]

At the site of the gingival wound, coagulated blood clots must adhere to the wound site to achieve hemostasis and seal the injured vasculature. Several components of blood like fibrin, coagulation factor XIII (FXIII) and platelets are known to have adhesive properties during bleeding.[5] This adhesiveness nature of the blood clot would magnify the negative effect of the blood contamination on enamel composite bond strength. [5]

Moisture contamination also plays a critical role in adhesive failure. Excess water on the enamel surface may dilute adhesive monomers, interfere with polymerization, and reduce resin infiltration into etched enamel. Conventional hydrophobic adhesive systems are particularly sensitive to moisture contamination. In contrast, some self-etch and universal adhesive systems contain hydrophilic components that enhance moisture tolerance. Despite this improvement, excessive moisture remains capable of negatively affecting bond durability and marginal integrity.[6]

The influence of contamination on enamel adhesion is affected by several variables, including the type of adhesive system, timing of contamination, and decontamination protocol. Etch-and-rinse systems generally demonstrate greater sensitivity to contamination because the etched enamel surface remains exposed before adhesive application. Self-etch adhesives may exhibit reduced sensitivity due to simultaneous etching and infiltration. Universal adhesives have gained increasing attention because of their versatility and improved tolerance to moisture contamination. Nevertheless, evidence regarding their superiority remains inconsistent.[7]

Timing of contamination is another critical factor. Contamination occurring immediately after acid etching has been associated with the greatest reduction in bond strength because the exposed microporosities are highly susceptible to blockage. Contamination after adhesive application may have a less pronounced effect depending on whether polymerization has already occurred. Additionally, the duration of contamination and the method used for surface decontamination significantly influence bonding outcomes.[8]

IV- Different means of bleeding control

The three primary ways for managing soft tissue and controlling hemorrhage are: chemical, mechanical or physical. [(12)]

Using a topical chemical hemostatic is one of the most popular ways to control intraoperative hemorrhage. [14] Chemical hemostatic agents may also influence enamel adhesion. Hemostatic agents containing ferric sulfate or aluminum chloride are commonly used to control gingival bleeding; however, their acidic nature and residue formation may interfere with bonding procedures. They may alter the enamel surface or affect resin polymerization depending on their concentration and application time.[14]

However, prior to applying the adhesive system, cleaning with water cannot entirely eliminate chemical hemostatic residue. [11] Consequently, using chemical agents has been raising concerns among researchers due to their effects on bond strength. This led to the consideration of other options for hemostasis. [17,15]

A surgeon can use direct pressure for 15 to 20 seconds will form small clots at the end of blood vessels to mechanically control bleeding at a bleeding site. This is typically a surgeon’s first choice to attempt to control bleeding, as this may be the simplest and fastest method. However, this bleeding may not always be controlled with direct pressure.[9]

Various studies have demonstrated the benefits of diode laser in various oral soft tissue procedures. Precise cutting abilities, good coagulation effect, the extremely small zone of thermal necrosis to surrounding tissues, reduced postoperative pain, no gingival recession, reduced swelling and discomfort and better wound healing are the advantages of using laser.[10]

Diode lasers are more precise as compared with other laser systems, including carbon dioxide and Nd:YAG lasers. They are optimal for gingival surgery due to their ability to be absorbed by gingival tissue and not by the adjacent structures. The interaction of laser wavelength and energy density with tissues at the tip of fibreoptic contact delivery system allows simultaneous coagulation of tissue. [10]

Another approach considered lately with similar uses and advantages is diathermy. The electrical current is used for similar application of laser including coagulation. [(18)] The concept of diathermy is based on the usage of electrical energy to cause histological changes in tissue by being transferred directly to it. It provides excellent hemostasis during surgery but can lead to generation of excess heat leading to thermal damage. [(18)]

III – Different decontamination protocols

Due to adverse effects of enamel contamination on bonding, Different methods have been suggested to overcome the adverse effects of the contamination. Simple air drying is usually insufficient to restore the original etched enamel surface. Water rinsing has been suggested as a reliable procedure for cavity decontamination. Conversely, rinsing followed by re-etching has been reported to significantly improve bond strength recovery. Some researchers also suggested that modern universal adhesives containing hydrophilic monomers exhibit greater tolerance to moisture contamination compared with conventional etch-and-rinse systems. Nevertheless, complete elimination of contamination remains essential for optimal bonding outcomes. [11.(4,10,11,14)]

Few researchers suggest resurfacing with a rotary instrument, followed by water irrigation and reapplication of an adhesive system. Park et al. proposed the blot drying of saliva from an etched surface to regain the bond strength. [11]

VI- Micro-shear bond strength testing method

Natural and regular tooth structure transfers external biting loads via enamel into dentine as compression forces that are spread over a giant internal volume, therefore local stresses are lower, whereas a tooth which is filled with a restorative material reacts to stress a lot differently than a natural intact tooth. Any force on the restoration produces tension, compression, or shear stress alongside the tooth/ restoration interface, leading to complicated stress distributions, a combination of compressive, tensile, and shear stresses. Since the manner of mastication is one of indentation, basically associated with the shearing or slicing away phenomenon, the real nature of the adhesive strength of the materials at the interface is portrayed via the shear bond strength.[12]

Dental adhesive science has skilled speedy developments in recent years. Manufacturers proceed to introduce new adhesive systems with claims about the ease of use, improvement in adhesive composition, and enhancement in the adhesives' bond strength to the tooth structure. Bond strength measurement tests are used internationally to substantiate these claims and to evaluate the bonding effectiveness of other adhesive systems to the tooth structure.[13]

Bond strength testing of adhesive systems is regarded as a dependable predictor of the durability of dental restorations. Bond strength is described as the preliminary mechanical load to fracture divided by the simple, geometrically defined, cross-sectional area of the bond. Nevertheless, bond strength checks to predict the overall clinical performance of dental adhesives have in no way been well-standardized, even though a variety of necessary recommendations have been made.[14]

Bond strength can be tested following different kinds of testing methods. There are many elements that can have an effect on the resultant bond strength values, even though the validity of these test techniques is questionable. [13]

Bond strength can be tested by means of both laboratory techniques or through evaluation of bond durability and clinical performance. Laboratory bond strength trying out techniques are divided into static and dynamic tests. In static tests, load is applied whilst the specimen is held fixed, whereas in dynamic tests, the specimen is in a dynamic state. Static tests, the more common of the two types of testing, measure bond strength through applying a load to a test specimen while the specimen is stationary. Static tests are broken into two categories: Macro tests (where the bond area is larger than 3 mm^2) and micro tests (where the bond area is less than 3 mm^2 and is usually 1 mm^2 or less). [14]

Micro testing allows for testing of small tooth areas, though three methods: micro shear, micro tensile and micro push-out.[15]

First introduced in 2002, µSBS testing requires small samples, which allows for preparation of multiple specimens from the same tooth. This gives tests a more uniform approach and eliminates variables that could affect testing outcome. It is typically used to test glass ionomers, enamel or other properties that might be too delicate for the stressors of micro-tensile bond testing.[13,15,16]

The SBS is described as the most stress that a material can face up to earlier than failure in a shear mode of loading. In a shear bond test, two materials are connected by using an adhesive agent and loaded in shear till fracture occurs. The SBS test gains its excessive popularity in companies and research institutes because no further specimen processing is wished after the bonding procedure; thus, it is the easiest and quickest method.[13,15,16]

The µSBS test would allow small areas to be tested, and it has the same advantages as the µTBS, without the need for sectioning procedures to obtain specimens, as these laboratory procedures themselves may induce early micro-cracking within the specimen[13,15,16]

The data from bond strength studies may depend largely on experimental factors such as the type of composite, stress rate, sample size and geometry, and the actual test method. With regard to resin composite, some authors use flowable instead of microhybrid composites to fill the Tygon tube in µSBS testing due to their easy placement. [13,15,16]

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