EDITORIAL

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Clinical management of dentin exposure following tooth preparation.

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Abstract
Introduction: Dentin exposure during tooth preparation is a factor that influences adhesion, the long-term survival of adhesive restorations, and pulp vitality. Immediate Dentin Sealing (IDS) protocols and selective surface disinfection redefine the management of the dentin surface.
Aim: This manuscript aims to synthesize recent data from the literature on dentin surface disinfection, adhesive system compatibility, and IDS efficiency related to the micromechanical and biological stability of the dentin–adhesive interface, achieving adequate and long-lasting adhesion for restorations. According to the literature data, IDS significantly enhances bond strength and contributes to the reduction of postoperative sensitivity, minimizing microbial infiltration. The most commonly used and efficient disinfectants, CHX and EDTA, are compatible with IDS procedures. Promising bioactive adhesives incorporating antimicrobial and remineralizing agents have been tested, showing positive clinical outcomes and offering new alternatives.
Conclusion: Selective dentin disinfection combined with adequate IDS represents a modern approach in adhesive prosthodontics. Biofunctional adhesive systems, capable of sealing and protecting the dentin surface, offer new perspectives for long-term restorative success and pulpal preservation.

Keywords: Immediate dentin sealing, disinfection, adhesive systems, bond strength.

Introduction

Tooth preparation often results in dentin exposure after enamel removal. The composition of the teeth's hard tissue is different. While enamel contains more inorganic components, the structural composition of dentin is different. Dentin is a hydrated tissue with a tubular structure, rich in collagen, which reacts to mechanical and chemical external stimuli. It plays a biological role in preserving tooth vitality and mediating interactions with disinfectants, cement, and restoration materials.

Improper surface treatment can directly influence the retention of restorations, postoperative hypersensitivity, and the longevity of the restoration. The smear layer results from tooth preparation and plays an essential role in the adhesive cementation mechanisms. It contains organic and inorganic components, water, and microorganisms [1]. Inorganic components predominantly consist of hydroxyapatite crystals, while type I collagen fibers and non-collagenous proteins constitute the structure of organic components. This layer temporarily seals the dentinal tubules, acting like a mechanical barrier and inhibiting the penetration of the adhesive monomers. For successful adhesion, decontamination and stabilization of the smear layer is necessary in a moisture-free environment. Achieving an adequate environment can be challenging for dentin surfaces. The collagen matrix collapses when the surface is over-dried, making it impossible for the resin to penetrate. Excessive moisture will dilute the adhesive and compromise the bonding force. The goal of dentin treatment is to balance cleanliness, moisture control, and chemical reactivity at the dentin-bonding interface.

Immediate and adequate management of the exposed dentin can be the key element of the long-term success of adhesive cementation. The use of a filled, hydrophilic dentin primer on the tooth surface, with or without a flowable composite, is a suitable approach [2,3]. This technique was introduced in the early 1990s by Pashley et al. [4], named "Immediate Dentin Sealing (IDS)," being first popularized by Magne in 2005 [5].

IDS improves bond strength while minimizing bacterial penetration into the dentinal tubules, reduces sensitivity, and prevents pulpal inflammation. In the past, before cementation, only conventional disinfection of the abutment was considered essential by using different antimicrobial agents

(chlorhexidine, sodium hypochlorite, hydrogen peroxide, or EDTA) [6]. Nowadays, the key element is considered the chemical compatibility of the disinfectants and the adhesive systems used. These interactions can influence the magnitude and longevity of bonding forces.

From this perspective, Immediate Dentin Sealing has completely redefined the management of exposed dentin. After IDS, resin monomers can penetrate collagen fibers, forming a hybrid layer with optimal thickness and superior micromechanical retention. Through the distribution of polymerization and functional tensile during the cementation, this hybrid film acts as a stress-absorbing intermediate layer. Recent studies [7,8] analyzed the clinical performance of the IDS and demonstrated its clinical success. Using a bonding layer on the dentin surface immediately after tooth preparation will significantly increase both the immediate shear bond strength and the shear bond strength after aging, especially when combined with an adequate disinfection protocol.

Post-disinfection IDS protects the exposed dentin, preventing its contamination with saliva, blood, or temporary cements, which can compromise adhesion, as can happen in conventional, delayed dentin sealing (DDS).

Several studies have demonstrated the positive biological effects of IDS. Its significance is related to the protection of the dentin-pulpal complex during tooth preparation [9,10] and to the long-term maintenance of a good marginal seal of the restorations. IDS reduces microleakage, postoperative hypersensitivity, and pulpal inflammation by creating a pre-polymerized barrier at the dentin-adhesive interface.

In a novel study by Pérez-Soto et al. [11], IDS resulted in an optimal dentin-resin interface with higher stability in the case of the total etch technique (3 steps) or when combined with a thin flowable composite layer, improving mechanical resistance and long-term durability. This combination results in biological protection through stable adhesion, leading to fewer postoperative complications [3,8].

Exogenous/endogenous bacterial contamination of the hybrid layer can influence its chemical stability and pulp vitality [6,12,13]. The cavity disinfection protocol is standardized in accordance with European regulations and WHO recommendations, supported by several scientific studies. Selective dentin disinfection before an IDS affects the long-term success of adhesive restorations [14]. The ideal disinfectant must have a high efficacy without affecting collagen structure or the polymerization process. In this context, it has been demonstrated that self-etch adhesives tolerate residual disinfectants more effectively than total-etch systems [15]. The interaction between resin and disinfectants can be critical. When dentin surface disinfection precedes IDS, the disinfectant used must not interfere with resin infiltration or polymerization. Recent studies have demonstrated the neutral or even positive effect on bond strength of low-concentration CHX or EDTA-based disinfectants used before IDS procedures [6,12]. Understanding the chemical interactions between different disinfectants, the dentin surface, and various adhesive systems is essential for achieving predictable and successful clinical performance.

CHX is considered the gold standard for tooth surface disinfection. It is a good antiseptic solution, while a matrix metalloproteinase inhibitor (MMP), which contributes to the long-term maintenance of adhesive interactions. It can efficiently inhibit bacterial growth and block the endogenous dentinal enzymes, which can compromise the collagen from the hybrid layers [12]. Disinfecting the dentin surface with chlorhexidine 2%, followed by a hydrophobic adhesive, will not interfere with adhesion forces but can significantly increase long-term bond durability. Besides CHX Ethylenediaminetetraacetic acid (EDTA) and ethanol are also promising. EDTA acts by eliminating the smear layer, exposing collagen fibers without denaturation, allowing efficient adhesive penetration [6]. Ethanol, a dehydrating and antibacterial agent, monomer infiltration through ethanol-wet bonding techniques; however, excessive dehydration may induce collagen collapse. Sodium hypochlorite has a significant antimicrobial effect but can reduce resin conversion [13]. A recent review highlighted that the

micromechanical performance of the adhesive systems depends on chemical interactions of disinfectants with the dentin surface [16].

Recent studies have focused on the development of bioactive adhesive systems that combine the IDS with effective antimicrobial properties and good remineralization capabilities, including photodynamic therapy (PDT), the use of silver nanoparticles, and bioactive agents containing quaternary ammonium methacrylates, leading to a long-lasting antibacterial effect of the adhesive system itself [17]. The development in this direction will result in a biofunctional interface with better clinical performance, eliminating the need for disinfection before IDS. On the other hand, newer studies [18] explore different natural agents (propolis, hyaluronic acid, Aloe vera extracts) as biocompatible alternatives to these disinfectants.

The clinical performance of IDS is influenced significantly by the type of adhesive systems-total etch, self-etch, or universal- and by the cementation protocols.

Total etch systems are more technique-sensitive, while requiring a moisture-free environment for bonding application. After acid-etching the surface with 35–37% phosphoric acid for 15 seconds, the surface is rinsed and gently dried. The application of a hydrophilic primer and bonding resin will form a pre-polymerized hybrid layer. The combination of this layer with a thin flowable composite provides adequate surface protection and contributes to increased micromechanical and chemical retention [5,7]. de Carvalho et al. demonstrated that combining lightly filled adhesives with flowable resins will reduce microleakage and will lead to interfacial stability under simulated stress conditions [19].

The acidic monomers used in self-etch systems demineralize and infiltrate dentin, making the procedure less technique sensitive. Adhesive application by active brushing for 20 seconds on the prepared tooth surface facilitates its penetration into the dentinal tubules. Gently air-drying the surface helps with solvent evaporation. Light-curing the self-etch adhesive is the final step of the IDS. The stabilization of the smear layer with functional monomers containing 10-MDP (Methacryloyloxydecyl dihydrogen phosphate) facilitates its partial integration into the hybrid layer, making the chemical bonding to the hydroxyapatite crystals durable [5,6]. Self-etch systems can better tolerate residual disinfectants (CHX or EDTA) [15].

The universal adhesives are the latest generation of adhesive systems. These systems enable selective surface treatment on enamel or dentin, depending on substrate characteristics. The optimal bonding efficiency can be achieved by enamel etching and applying a self-etch system to the dentin [20], resulting in high enamel bond strength and a long-lasting dentin seal [7]. IDS must be performed under glycerin gel regardless of the adhesive system used. In this way incomplete polymerization and the formation of the oxygen inhibition layer can be avoided [19].

Conclusions

Modern prosthodontics opens new opportunities with good perspectives in terms of adhesive approaches. To benefit from the advancements in adhesive techniques, clinicians must integrate the proposed basic protocols regarding surface disinfection and dentin surface management into their activities. According to these protocols, all cases require IDS following tooth preparation. The IDS surface needs to be reactivated for optimal bonding prior to cementation by gentle cleaning with brushes or air-abrasion [21,22]. Correlating IDS procedures with adequate adhesive systems provides long-term clinical performance and fever complications [2,7].

Today's clinicians must understand that dentin exposure is a critical moment during tooth preparation with high potential for the long-term success or failure of adhesive restorations. IDS is not an optional, but a mandatory clinical step in modern, minimally invasive, and adhesive dentistry.

Conflict of interest: None to declare.

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