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Review

Dentin bonding systems: From dentin collagen structure to bond preservation and clinical applications

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ABSTRACT

Objectives. Efforts towards achieving durable resin–dentin bonds have been made for decades, including the understanding of the mechanisms underlying hybrid layer (HL) degradation, manufacturing of improved adhesive systems, as well as developing strategies for the preservation of the HL.

Methods. This study critically discusses the available peer-reviewed research concerning the formation and preservation of the HL, the mechanisms that lead to the degradation of the HL as well as the strategies to prevent it.

Results. The degradation of the HL occurs through two main mechanisms: the enzymatic degradation of its collagen fibrils, and the leaching of the resin from the HL. They are enabled by residual unbound water between the denuded collagen fibrils, trapped at the bottom of the HL. Consequently, endogenous dentinal enzymes, such as the matrix metalloproteinases (MMPs) and cysteine cathepsins are activated and can degrade the denuded collagen matrix. Strategies for the preservation of the HL over time have been developed, and they entail the removal of the unbound water from the gaps between the collagen fibrils as well as different modes of silencing endogenous enzymatic activity.

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Significance. Although there are many more hurdles to be crossed in the field of adhesive dentistry, impressive progress has been achieved so far, and the vast amount of available research on the topic is an indicator of the importance of this matter and of the great efforts of researchers and dental material companies to reach a new level in the quality and longevity of resin–dentin bonds.

Contents

1. Introduction

Adhesive systems can be considered revolutionary in many aspects of conservative dentistry, making possible previously inconceivable clinical maneuvers. Current adhesive systems allow clinicians to bond to tooth structure without the need of a retentive cavity since they provide immediate bond strength.

Two different strategies can presently be employed in resin bonding procedures: the etch-and-rinse technique (E&R) and the self-etch (SE) or etch-and-dry technique. Regardless of the strategy used, dentin bonding relies on the formation of the "hybrid layer" (HL), a structure composed of demineralized collagen fibrils reinforced by the resin matrix [1,2].

The goal of adhesive procedures is to form and maintain a tight adhesive-dentin interface that is stable for a number of years, providing retentive strength, marginal seal, and clinical durability [3]. However, regardless of the advances in dental materials, the HL created on the variable and dynamic organic dentin phase is not perfect, and may fail over time, inducing marginal discolorations, marginal leakage and subsequent loss of retention of the composite restoration [3–8].

The aim of this review is to analyze and critically assess the available research on the factors that influence the stability of the resin–dentin bonds and the strategies for preservation of the adhesive interface over time.

2. Adhesive systems and adhesion strategies to dentin

Since resin monomers themselves cannot infiltrate mineralized tissues, traditionally, adhesive bonding systems consist of an acid, primer and adhesive. Acid is used for the removal of mineral crystals and exposure of the collagen fibrils. Primer is a hydrophilic solution of resinous monomers, which allows the infiltration of the resinous monomers, especially in demineralized dentin. The adhesive itself contains mixtures of monomers that penetrate the surfaces treated with the primer, creating a mechanical adhesion to dentin [9]. These components can be presented in separate bottles or together, being carried out in one, two or three clinical application steps.

Van Meerbeek et al., in 2003, suggested a classification of the adhesive systems according to the way they interact with the dental substrate, dividing it into two categories: E&R and SE technique (Fig. 1) [10]. In the E&R strategy, an acid etchant is used to remove the smear layer and create a superficial layer of demineralized dentin approximately 5–10 μm deep. The exposed mineral-free network of collagen is suspended in the rinse-water. That water must be completely replaced by adhesive blends if one wishes to achieve a stable bond [4,10,11]. However, complete infiltration of monomers into the wet and demineralized dentin is not consistently achieved,

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