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Communication

The effect of NDGA-modified etchant on the enzymatic degradation resistance and mechanical properties of collagen matrix

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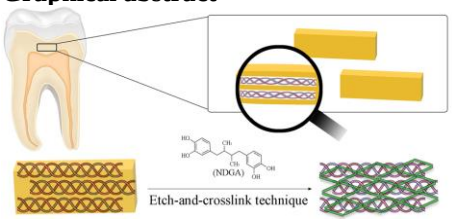
Graphical abstract



Bio-modified etchant can significantly improve the biostability of demineralized dentin collagen matrix, which validates the concept of etch-and-crosslink in dentin bonding.

ABSTRACT

Enzymatic degradation of demineralized collagen matrix seriously impairs durable resin-dentin bonding. In this study, we evaluated the effect of nordihydroguaiaretic acid (NDGA)-modified etchant on the resistance to enzymatic degradation and mechanical properties of demineralized collagen matrix. Dentin beams were randomly demineralized by following solutions: 1) 10% phosphoric acid (PhA) solution, 2) 10% dimethyl sulfoxide (DMSO)-PhA solution, 3) NDGA-modified etchant, and 4) proanthocyanidins (PA)-modified etchant. The demineralized dentin collagen was then digested by type I collagenase solution. The collagenase degradation resistance was evaluated by measuring loss of dry mass, hydroxyproline release, and elastic modulus change. The degradation rate and hydroxyproline release of dentin collagen treated with NDGA-modified etchant were significantly lower than those in the other groups ($P < 0.001$). The elastic modulus of dentin beams treated with NDGA-modified etchant did not increase significantly. However, after 48 h of collagenase degradation, the loss of elastic modulus of dentin beams treated with NDGA-modified etchant was significantly lower than that of the control group ($P < 0.001$). The NDGA-modified etchant could improve the resistance to enzymatic degradation of type I collagenase degradation, and the stability of the mechanical properties of dentin collagen. This proof-of-concept study validates the etch-and-crosslink technique that improves durability of dentin bonding through simultaneous dentin etching and collagen crosslinking.

Keywords:
NDGA
Crosslink
Degradation
Mechanical properties
Collagen

Type I collagen is the major component of connective tissues such as skin, tendons, bone, and dentin. In the field of tissue engineering and regeneration, collagen has been extensively used as the main component of scaffold that provides hierarchical compartments for cells [1-10]. However, dentin regeneration remains challenging, as it does not remodel [11,12]. Resin-dentin bonded interface has been considered a unique form of tissue engineering in which a collagen matrix scaffold is reinforced by resin to produce a hybrid layer that couples resinous material to the underlying intact dentin. However, contrary to firm and stable resin-enamel bonding, the durability of resin-dentin bonding is often unsatisfactory. In 1982, Nakabayashi *et al.* first proposed that hybrid layer formed by the entanglement between collagen fibrils and adhesive resin is the basis for resin-dentin bonding [13]. Since hybrid layer is the mixture of dentin matrix, residual hydroxyapatite, resin monomer and adhesive [14], degradation of any component will affect the stability of hybrid layer, resulting in the failure of dentin bonding. Incomplete penetration of the resin adhesive into the demineralized collagen matrix makes the matrix exposed, and the unprotected collagen is vulnerable to degradation by endogenous and exogenous enzymes and hydrolysis. A large number of studies have shown that the destruction of dentin collagen in the mixed layer is an important reason for the failure of dentin bonding over time [15]. Therefore, taking certain measures to enhance the

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