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Review

Looking for the ideal adhesive – A review

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ABSTRACT

The introduction of the acid-etch technique by Dr. Buonocore in 1955 was the genesis of adhesive dentistry. Currently, bonding to dental substrates may be accomplished through two adhesion strategies: (1) etch-and-rinse and (2) self-etch, which includes glass-ionomer based materials. More recently, a new family of dentin adhesives has been introduced (universal or multi-mode adhesives), which may be used either as etch-and-rinse or as self-etch adhesives.

In this paper the basic bonding mechanisms to enamel and dentin will be discussed to give the reader an overall understanding of the main differences among them.

The learning objectives are the understanding of the evolution of adhesive systems and which adhesion strategy might be more useful to clinical practice.

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A procura do adesivo ideal – uma revisão da bibliografia

Palavras-chave:
Condicionamento ácido
Adesão
Esmalte dentário
Dentina
Sistemas adesivos

RESUMO

A introdução do conceito de condicionamento ácido do esmalte pelo Dr. Buonocore em 1955 iniciou a era da dentisteria adesiva. Atualmente, as resinas compostas podem ser aderidas ao esmalte e à dentina segundo duas filosofias adesivas: (1) os adesivos de condicionamento ácido total e (2) os adesivos de auto-condicionamento, que incluem os materiais derivados de ionómeros de vidro. Mais recentemente foram introduzidos adesivos universais que podem ser usados com condicionamento ácido total ou como adesivos auto-condicionantes.

Neste artigo pretende-se dar a conhecer os mecanismos que estão subjacentes a cada estratégia de adesão.

No final, os leitores conseguirão entender a evolução dos sistemas adesivos e, desta forma, qual a estratégia mais indicada para a sua prática clínica.

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Overview

The paramount goal of bonding restorations is to achieve an intimate contact between restorative materials and dental hard tissues.[1] For durable adhesion to occur in the mouth, the liquid adhesive must wet the solid adherent to allow structural interaction; the stress concentration at the interface must be reduced; and the interface must be protected from degradation in the oral environment.[2]

Dental adhesives are solutions of resin monomers that make the resin–dental substrate interaction achievable.[3] Adhesive systems are composed of monomers with both hydrophilic groups and hydrophobic groups. The former enhance wettability to the dental hard tissues, while the latter allow the interaction and co-polymerization with the restorative material.[4] The chemical composition of adhesives also includes curing initiators, inhibitors or stabilizers, solvents and, in some cases, inorganic fillers.[4]

The mineralized part of the tooth is a complex structure made of different hard tissues, which have a quite distinct ultra-morphology and composition. Enamel is composed of a hard solid crystalline structure – hydroxyapatite (HAp) (96% by weight) – with strong intermolecular forces, a high-energy surface,[1] besides water and organic material (4% by weight) (Fig. 1).[5] Dentin is a biological composite of HAp (50% by volume) that envelops collagen (30% by volume, mainly type I) (Fig. 2).[6] Dentin is intrinsically humid (20% by volume of water),[6] and less hard than enamel, with low intermolecular forces and low-energy surfaces.[1] Dentin is also a substrate that undergoes change with age in an asymmetrical physiological aging process, leading to an increase of dentin thickness and decrease in dentin permeability.[7] Furthermore, sclerotic and carious dentin suffer structural changes that result in an higher mineralization and a consequently reduced permeability.[7,8] Unlike dentin, enamel can be dried easily, making the bonding process to enamel different from that of dentin.[8]

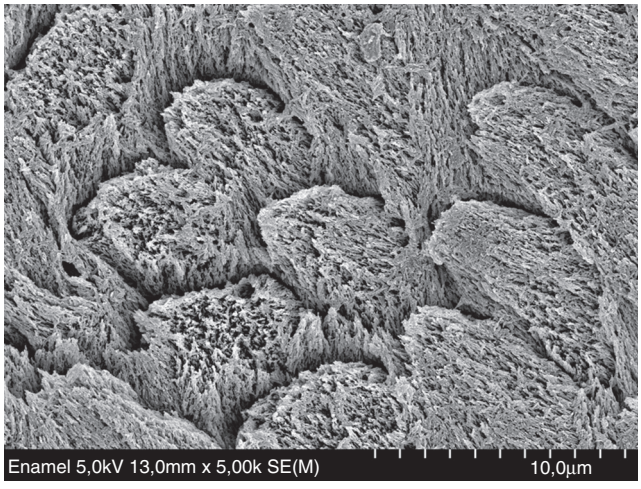

Fig. 1 – Field emission scanning electron microscopy (FESEM) micrograph of human enamel etched with 32% phosphoric acid (3M ESPE) for 15 s. Original magnification = ×5000.
Courtesy of Professor Jorge Perdigão, Department of Restorative Sciences, University of Minnesota, Minnesota, USA.

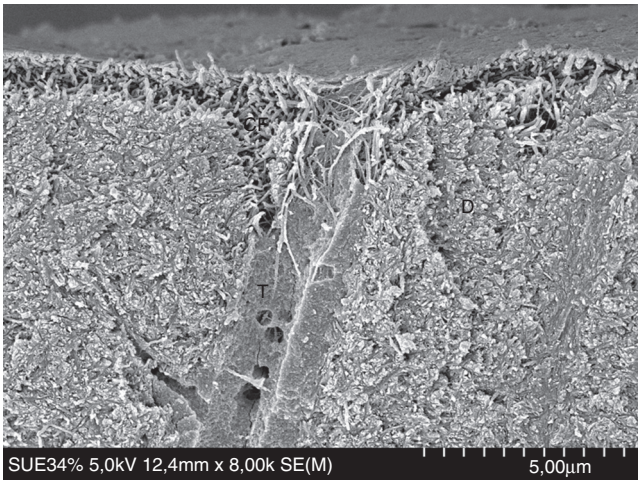

Fig. 2 – FESEM micrograph of human dentin etched with 32% phosphoric acid (3M ESPE) for 15 s. Original magnification = ×8000. CF = collagen fibrils exposed by the acid; D = dentin; T = dentinal tubule.
Courtesy of Professor Jorge Perdigão, Department of Restorative Sciences, University of Minnesota, Minnesota, USA.

Contemporary adhesive strategies

The new era of adhesive dentistry began with Dr. Buonocore in 1955.[9] As a visionary, Dr. Buonocore proposed etching enamel with 85% phosphoric acid to improve the retention of acrylic resin to pit-and-fissures. This was the pioneering research of Minimally Invasive Dentistry.[10] Enamel conditioning with phosphoric acid results in the formation of microporosities where resin penetrates to form "prism-like" resin tags.[11] This yields an enamel bonding predominantly micromechanical.[12] Recommendations for simultaneous etching of enamel and dentin were published in the 1970's.[13] It was the beginning of the total-etch concept.

When a tooth is instrumented with a cutting instrument the surface becomes covered with an adherent layer of debris,[14] forming a low-energy smeared layer.[15] Salivary films and composite resins also have a low-energy surface.[15] The smear layer (Fig. 3) is mainly formed of HAp and denatured collagen,[16] plugging the dentinal tubules with smear plugs (Fig. 3). Smear layer behaves as a true physical barrier, reducing dentinal permeability by 86%.[17] However, smear layer is permeable due to submicron channels that allow the flux of dentinal fluid.[18]

Contemporary adhesive strategies depend on how adhesive systems interact with the smear layer – dissolving it or making it permeable (Fig. 4). The classification of adhesive systems in generations is obsolete[19] and may serve the purpose of making current adhesives sound as more advanced (6th generation, 7th generation, and so on) for marketing purposes.

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