Evaluation of wet vs. dry dentinal adhesion by using scanning electron microscope

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Abstract:

The objective of this research was to investigate the resin –dentin interface of the Excite bonding system applied to wet and dry dentin by using scanning electron microscope. The adhesive and the composite were applied according to the manufacturer instruction to a standardized buccal and palatal class V cavities prepared on human upper first premolar. The teeth were sectioned vertically to examine the resin dentin interface, several morphological differences were seen between wet and dry technique, the hybrid layer analysis revealed different hybridization patterns, suggesting that the attachment seems to be influenced by many factors and a standardization of dentinal substrate is impossible.

Key words:

Dentinal adhesive material, resin-dentin interface, scanning electron microscope.

Introduction:

The ability to adhere biomaterials to tooth tissues has dramatically changed today's dental restorative concepts.

Modern adhesive techniques enable dentists to restrict clinical operative procedures to the sole removal of diseased tooth tissue, thus preserving without undermining sound tissue. Unfortunately, adhering restorations to tooth structure involves bonding to two substrates of significantly different natures [1].

The success of an adhesive bond to dentin is dependent largely on the specific state of the interface between tooth and adhesive. Most current dentin adhesive systems use pretreatment to demineralize the initial few micrometers of the dentin surface supposedly leaving a mesh work of collagen into which the adhesive resin can penetrate and polymerize. Good adhesion between dentin and restorative resins is of primary importance in clinical practice because it should reduce marginal leakage and permit more conservative cavity preparations. Dentin bonding agents are used extensively, primarily because of the manufacturers'

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claims that they enhance adhesion to tooth structure [2].

When the etched dentin is dried after rinsing off the etchant, the exposed collagen collapses and porosities generated by degradation of apatite crystallites close [3]. In order to prevent the network from collapsing, a moist bonding procedure has been proposed for some adhesive systems, in which the bonding resin is applied to the moist or wet dentin. [3,4]. The main benefit of using a wet bonding technique is due to the potential of water to keep the friable demineralized collagen network open during primer infiltration. Primers with high water content have been reported to re-expand the collapsed collagen. Moist bonding is therefore not necessary with these materials. After drying, water may help to recover the porous integrity of the demineralized collagen network during a rewetting procedure, a fact which could be critical for optimal hybridization [5].

The purpose of this study was to analyze the resin -Dentin interface of a fifth generation adhesive system applied on dried or wet acid-etched dentin.

Material & Method:

Fourteen human upper premolars (Extracted for orthodontic purposes), free of caries, restorations, cracks, and obvious defects were cleaned and stored in 50% ethanol at 8° C for a maximum of 1 month following extraction in order to avoid microbial contamination. This storage medium was chosen because it produces little change in dentin permeability [6]. Prior to the experiment, the teeth were placed in water for 24 hours at 20° C.

Standardized buccal and lingual class V cavities (3 mm high, 3 mm wide, 2 mm deep) were cut with a high speed hand piece which was adapted to the horizontal arm of a surveyor in such a way that the long axis of the bur will be perpendicular to that of the tooth, using a medium grain diamond bur No.848, under water coolant. The gingival floor of the cavity was 2 mm away from the cemento-enamel junction.

The cavity form was completed with round bur No.2, in a low speed hand piece using water coolant; the enamel margins were not beveled. The teeth were randomly divided in to two groups each one consist of seven teeth. The teeth were etched using the total Etch technique (a 37% phosphoric acid etchant) which was applied to the enamel and dentin, beginning with the enamel margins for 15 seconds.

The cavities were thoroughly rinsed off the phosphoric acid gel with water.

In group 1, when the moist bonding technique was used, the dentin surface was blown with a gentle air stream for two seconds to achieve a slightly moist surface (the surface is slightly glossy); however, no visible

excess water should remain on the tooth surface .

In group 2, when the dry bonding technique was used, the dentin surface was dried with a gentle air stream for 30 sec. until the surface assumed a chalky appearance.

The Excite bond (Vivadent – Liechtenstein) was applied according to the manufacturer instruction onto the conditioned tooth structure with a bonding applicator and then light-cured for 20 seconds.

The Tetric resin based composite (Vivadent – Liechtenstein) was applied in three incremental horizontal layers. Each layer was separately light cured for 20 seconds from all surfaces to ensure complete polymerization. Before curing the final increment, a transparent matrix was placed to contour the restoration. The margins were finished and polished with sand paper disc.

Scanning electron microscope (SEM) investigation was performed to observe the morphology of the dentin substrate and the inter diffusion zone formed on the conditioned wet and dry dentin surface.

The teeth were sectioned longitudinally using a microtome separating each tooth into two parts (making a total 14 sections for each group). They were fixed with 2.5% glutaraldehyde in 0.1mole sodium cacodylate buffer for 3 hours and then further rinsed three times in 0.1 mole sodium cacodylate buffer (pH = 7.4). They were then dehydrated in an ascending ethanol series (30, 50, 70, 80, 95, and 100%) for 20 minuets each. The specimens were left in incubator at 37°C for 2 days. The completely desiccated samples were mounted on aluminum stubs, sputtered coated with gold for 4 minuets at 10 mA, and examined using a scanning electron microscope operating at 10 kv.

Results:

In group one, when the moist bonding technique was used, the SEM micrograph showed true hybridization (The average thickness of the hybrid layer was 8-9μm). Fig. 1

Fig.1: SEM micrograph showed true hybridization
H= Hybrid layer

No area of de-bonding were seen, beads of tags was distinctly visible adhering to the composite resin restoration. The hybrid layer was homogenous and constant. The resin tags appear wide and thick, having many lateral branches. Fig. 2

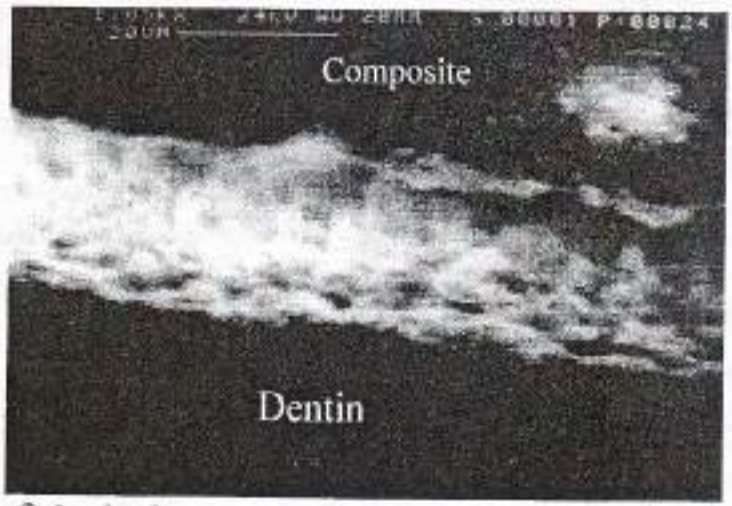

Fig.2: beads of tags was distinctly visible adhering to the composite resin restoration.

In group two, when the dry bonding technique was used, the SEM micrograph showed incomplete true hybridization (The average thickness of the hybrid layer was 8-12μm). Fig. 3

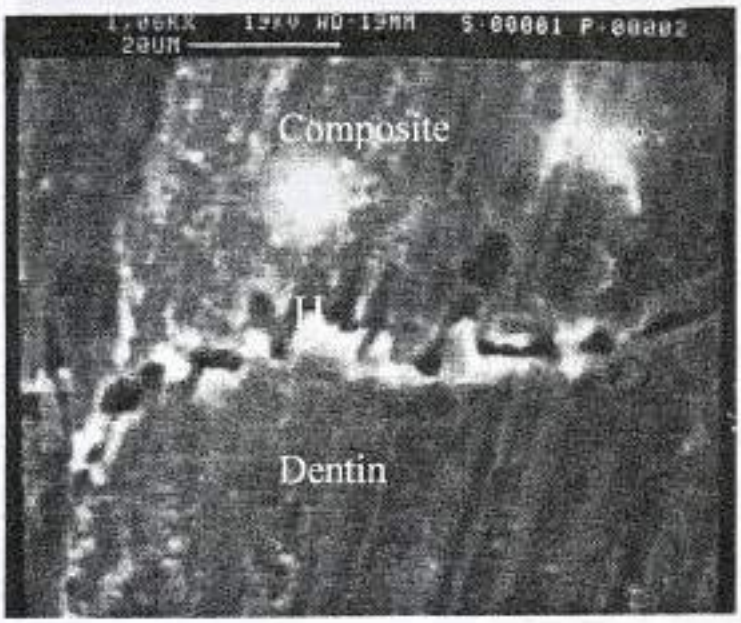

Fig.3: Incomplete true hybridization.

The hybrid layer was irregular and not homogenous. The resin tags appear thin with few lateral branches filled with resin.

Beads of tags were distinctly visible adhering to the composite resin restoration; areas of de- bonding were clearly seen near the top of the hybrid layer. Fig. 4

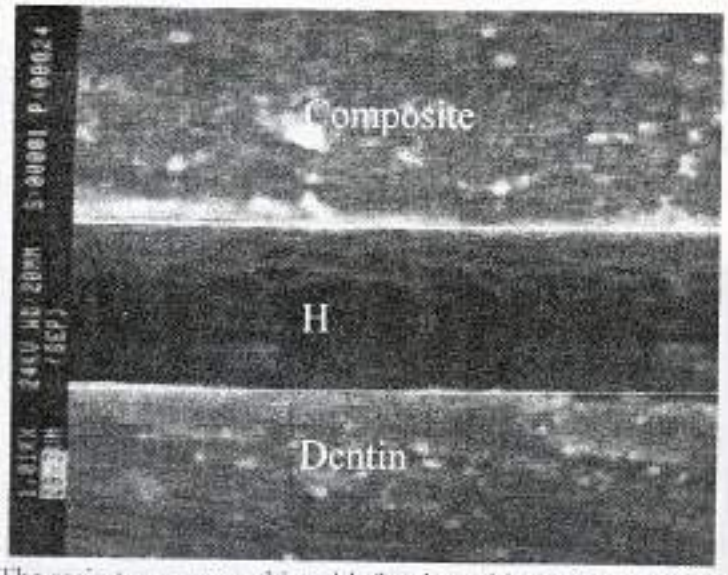

Fig.4: The resin tags appear thin with few lateral branches filled with resin.

Discussion:

The longevity of composite fillings is, among other factors, dependent on the properties of the junction between tooth substances and filling materials. Most modern bonding agents use acid etching with approximately 35% phosphoric acid etching gel to demineralize a surface layer. The bonding mechanism of resin to dentin is described as micromechanical, and is generated by monomer impregnation of the exposed collagen of demineralized superficial dentin, wherein the monomers polymerize in-situ to create a so-called "hybrid layer" [7].

The hybrid layer, resin tags, and adhesive filling of lateral branches of dentinal tubules have been suggested as the essential mechanisms of adhesion. The most important factor should be the hybridization between resin and demineralized collagen. However, several groups have speculated that the demineralized zone, namely a collagen network, may not contribute directly to bond strength [8, 9].

In this study, when the moist bonding technique was used, all the scanning electron micrographs showed better resin infiltration in to the demineralized dentin than dry bonding. This may be due to the collapse of the collagen fibril network due to air dryness, so become a relatively impermeable, amorphous collagen

layer. In order to obtain complete penetration of adhesive resin into demineralized dentin, water must be added either in the bond or to the dentin surface (i.e. moist bonding) [10].

The finding of the study is in agreement with Santini *et al* [11], this was responsible about the homogenous well organized hybrid layer formed when using the moist bonding technique

The resin tags in the moist bonding technique showed very little constriction where they passed into the hybrid layer; unlike when we use dry bonding technique, which showed greater constriction. This agrees with Nakajima *et al* [10] and it can be considered as a factor for decreasing the bond strength.

The area of de-bonding principally occurred near the resin-hybrid layer interface when using dry bonding technique due to poor resin infiltration which disagrees with Santini and Mitchell [12] who showed this pattern of de-bonding with both wet and dry bonding techniques.

It has been suggested that poor infiltration of the adhesive resin into the collagen-rich area of the demineralized dentin leaves gaps in the hybrid layer that are vulnerable to degradation. If incomplete penetration occurs, water and microleakage can infiltrate these spaces, producing hydrolysis of exposed collagen peptides not protected by hydroxyapatite or resin. This exposed collagen is not only susceptible to degradation from water, but also from bacterial enzymes that cause collagen breakdown. When collagen is protected by hydroxyapatite, peptide enzymes are unable to break down the collagen peptides, possibly contributing to the integrity of the tooth restorative interface.

The findings of this qualitative study do not represent a hybridization standard for the adhesive system used, since other factors are also involved including the dentinal substrate and the relationship between dentinal substrate and adhesive system. The hybrid layer analysis revealed different hybridization patterns, suggesting that the attachment seems to be influenced by many factors and a standardization of dentinal substrate is impossible.

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