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Evaluation of micro-tensile bond strength of caries-affected human dentine after three different caries removal techniques

E. Sirin Karaarslan [a,*], E. Yildiz [b], M.A. Cebe [c], Z. Yegin [d], B. Ozturk [e]

[a] Gaziantep University, Faculty of Dentistry, Department of Restorative Dentistry, Gaziantep, Turkey
[b] Gaziantep University, Faculty of Dentistry, Department of Pediatric Dentistry, Gaziantep, Turkey
[c] Mustafa Kemal University, Faculty of Dentistry, Department of Restorative Dentistry, Hatay, Turkey
[d] Selcuk University, Faculty of Dentistry, Department of Pediatric Dentistry, Konya, Turkey
[e] Selcuk University, Faculty of Dentistry, Department of Restorative Dentistry, Konya, Turkey

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ABSTRACT

Objective: This study evaluated the effect that different techniques for removing dental caries had on the strength of the microtensile bond to caries-affected human dentine created by three bonding agents.

Materials and methods: Forty-five human molar teeth containing carious lesions were randomly divided into three groups according to the technique that would be used to remove the caries: a conventional bur, an Er:YAG laser or a chemo-mechanical Carisolv® gel ($n = 15$). Next, each of the three removal-technique groups was divided into three subgroups according to the bonding agents that would be used: Clearfil® SE Bond, G-Bond®, or Adper® Single Bond 2 ($n = 5$). Three 1 mm^2 stick-shaped microtensile specimens from each tooth were prepared with a slow-speed diamond saw sectioning machine fitted with a diamond-rim blade ($n = 15$ specimens). For each removal technique one dentine sample was analysed using scanning electron microscopy.

Results: There were statistically significant differences in the resulting tensile strength of the bond among the techniques used to remove the caries and there were also statistically significant differences in the strength of the bond among the adhesive systems used. The etch-and-rinse adhesive system was the most affected by the technique used to remove the caries; of the three techniques tested, the chemo-mechanical removal technique worked best with the two-step self etch adhesive system.

Conclusion: The bond strength values of the etch-and-rinse adhesive system were affected by the caries removal techniques used in the present study. However, in the one- and two-step self etch adhesive systems, bond strength values were not affected by the caries removal techniques applied. While a chemo-mechanical caries removal technique, similar to Carisolv®, may be suggested with self etch adhesive systems, in caries removal techniques with laser, etch-and-rinse systems might be preferred.

Clinical significance: Caries removal methods may lead to differences in the characteristics of dentine surface. Dentine ultra structure generally affects the bonding of adhesive materials commonly used in restorative dentistry. Whereas etch-and-rinse system, like the ones used

* *Corresponding author at*: Gaziantep University, Faculty of Dentistry, Department of Restorative Dentistry, Kampus, Gaziantep 27310, Turkey. Tel.: +90 342 3606060x76614; fax: +90 342 3610610.
E-mail address: karaarslan.emine@gmail.com (E. Sirin Karaarslan).
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in the present study, are affected by these changes, the self etch systems are not affected. Hence, clinicians may opt for caries removal methods and systems appropriate for each patient and practice.

1. Introduction

Dental caries is an infectious disease which damages the structures of teeth. This disease can lead to loss of the tooth, pain, infection and, in severe cases, death. Currently, dental caries remains one of the most common diseases throughout the world.[1]

Carious dentine consists of two layers: the outer layer, called the caries-infected layer, is soft and necrotic; the inner layer, called the caries-affected dentine, is less infected. Although demineralised, this inner layer is potentially repairable.[2] In clinical conditions, the bonding surface most frequently encountered consists of caries-affected dentine after excavating the caries.[3] The development of new adhesive systems aims to create strong adhesion to all types of tooth substrate, especially caries-affected dentine.[4] Studies have indicated that the strength of a resin bond to caries-affected dentine and sound dentine depend both upon the type of dentine and the adhesive systems used.[5,6]

Caries are generally removed by hand excavation, associated, with rotary burs at low-speed, or not. This technique of removing caries can cause discomfort to the patient and local anaesthesia may be needed.[1] The selective removal of caries-infected dentine is not achieved easily with the currently most popular excavation techniques, such as the rotary bur and a spoon shaped hand excavator.[7] To prevent these problems, other methods for removing dental caries have been proposed, such as chemo-mechanical techniques and laser irradiation.[1]

Chemo-mechanical agents have been developed to be used accompanied by their own hand instruments. Evidence shows that careful use of these agents may offer some element of selectivity between the caries-infected and the caries-affected dentine.[8] Carisolv®, a chemo-mechanical solution for removing caries, is an effective alternative to conventional rotary burs. Carisolv® consists of a pink gel that includes sodium hypochlorite and three amino acids—lysine, leucine and glutamic acid—together with carboxymethylcellulose gel. The gel is applied to the carious surface; after 30 s, the outer carious dentine can be removed more selectively with specially designed hand instruments.[7]

The first lasers used in the dental clinic to remove carious dental tissues or for preparation of cavities were the CO_2 and the neodymium:yttrium aluminium garnet (Nd:YAG) lasers.[9] Next, the erbium:yttrium aluminium garnet (Er:YAG) laser and the erbium, chromium:yttrium scandium gallium garnet (Er,Cr:YSGG) laser were introduced into the dental clinic.[10] The Er:YAG laser (wavelength 2.94 nm) has been proposed for photo-ablation of hard dental tissues. Under a water spray, this laser is able to prepare cavities successfully in enamel and dentine, without damaging the dental pulp tissue.[11]

The aim of this study was to compare the microtensile strengths of composite bonded to caries-affected human dentine using three resin-based adhesives bonding, after the use of different techniques to remove the caries; (1) conventional bur, (2) Er:YAG laser and (3) chemo-mechanical removal/Carisolv®.

The null hypotheses to be investigated in this study were:

1. There are no differences among the bonding values of three different caries removal techniques.
2. There are no differences in the bonding values of etch-and-rinse, one, and two-steps self etch adhesive systems.

2. Materials and methods

The study protocol was reviewed and approved by the Ethics Committee of the University of Gaziantep, Turkey; the protocol number is 05-2009/209.

2.1. Sampling

Forty-five permanent human molar teeth which had a caries lesion extending at least half of the distance from the enamel–dentine junction to the pulp chamber were included for the study. All teeth were stored at 4 °C in physiologic saline for no longer than four weeks after extraction. Any soft tissue was removed and the teeth underwent ultrasonication to remove plaque and other pit and fissure debris. Any teeth showing signs of extraction damage or extensive cavitated lesions with pulpal involvement were discarded from the study. Enamel and superficial dentine of the crown were flattened perpendicular to the long axis of the tooth with a bur until the lesions showed laser fluorescent values of approximately 40–50 (Diagnodent, Kavo Dental, Biberach, Germany). After that, the specimens were washed with de-ionised water for 1 min.[12]

2.2. Experimental groups

The teeth were randomly divided into three groups according to caries removal techniques used (bur, laser, and chemo-mechanical removal) and each group was divided into three subgroups according to adhesive system to be applied.

In the bur removal groups, dentinal caries was removed with a round steel bur (no.: 14-16, ISO: 310204001001 021, Gebr-Lemgo, Germany) in a water-cooled, slow-speed hand piece (Bien Air SN 09B0600, Switzerland).

In the laser removal groups, an Er:YAG laser system (Fidelis Plus III, Fotona) with a laser wavelength of 2.94 μm was used to remove the caries. Power output of 3.5 W, pulse duration of 300 μs (Short Pulse mode – SP mode) and the pulse repetition rate was 10 Hz. Irradiation of a focused beam was performed from 1 mm distance (energy density: 44 J/cm^2). Cylindrical quartz with a diameter of 1 mm (65320, Fidelis Plus III, Fotona) was mounted to the R14 handpiece for dentine ablation. The irradiated area was continuously cooled using an air and water spray system.