Original Article

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Effect of carisolv and papacárie on the resin-dentin bond strength in sound and caries-affected primary molars

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Abstract

Aim: This study evaluated the influence of different chemomechanical caries removal techniques on the bond strength of an adhesive system to caries-affected and healthy dentin. **Methods:** Thirty healthy teeth were randomly divided into three groups: Group 1 (control): no caries removal technique was applied; Group 2: chemomechanical technique using Carisolv®; and Group 3: chemomechanical technique using Papacárie®. Twenty caries-affected teeth were divided into two groups: Group 4: chemomechanical technique using Carisolv; and Group 5: chemomechanical technique using Papacárie. The teeth received the application of an etch-and-rinse adhesive system, were restored with composite resin, and then sectioned to obtain 4 hourglass-shaped slabs from each specimen, which were subjected to a microtensile bond strength test. Data were analyzed statistically by ANOVA and Tukey's test (a=0.05). **Results:** G1 (13.387 ± 6.1074), G2 (18.123 ± 3.2611) and G3 (12.781 ± 4.5652) presented statistically significant higher mean bond strength values than the other groups ($p<0.05$), but did not differ significantly from each other ($p>0.05$). G4 (6.228 ± 5.3435) and G5 (6.482 ± 3.2076) presented the lowest mean bond strength values and were statistically similar to each other ($p>0.05$). **Conclusions:** Neither of the chemomechanical caries removal methods interfered in the resin-dentin bond strength. However, lower tensile bond strength was found to caries-affected dentin.

Keywords: chemomechanical caries removal; microtensile bond strength; etch-and-rinse adhesive system.

Introduction

Current dental restorative concepts are characterized by an increasing effort toward less invasive treatment of carious lesions[1]. Because it appears that only soft, wet dentin is heavily contaminated with bacteria[2], any technique that effectively removes such infected dentin should be adequate to arrest the carious process, allowing altered dentin capable of being remineralized, to remain[3].

Chemomechanical systems have been discussed as an alternative to conventional rotary systems[4-5]. Carisolv® (MediTeam Dental AB, Sävedalen, Sweden) is used to remove soft carious dentin with the aid of special curettes. It can be applied in adults and children, in many cases allowing treatment without the use of anesthesia, and can even be used in patients with special needs[6]. This

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system consists of two gels: one containing 0.95% sodium hypochlorite (NaOCl), and the other containing three amino acids (glutamic acid, leucine and lysine), sodium chloride, carboxy-methyl-cellulose, sodium hydroxide and water[7]. The effect of Carisolv is based on the action of NaOCl, which disintegrates the caries-affected dentin[8-9]. The amino acids are used to intensify the effects of NaOCl on collagen denaturation and reduce the aggressive effect on sound dental tissue[6,8]. According to Morrow et al.[7], when NaOCl is in contact with an amino acid that has a high pH, chlorine reacts with amino groups, forming n-chloride amino acid, in such a way that free chlorine is active on the denatured tissue.

In 2003, a Brazilian formulation for chemomechanical caries removal was introduced to the market under the brand name Papacárie® (Fórmula & Ação, São Paulo SP, Brazil)[10]. This product is a gel based on papain, a proteolytic cysteine enzyme that presents antibacterial and antiinflammatory properties[11]. Papain acts as a debris-removing agent only on affected tissues, with no harmful effect to sound tissues close to the lesion because of the enzyme's specificity. The presence of chloramine in its composition helps softening the carious dentin, thus facilitating its removal. It also helps in the healing process, thus shortening the tissue repair time, and has antiinflammatory properties. toluidine blue, also present in its composition, is a photosensitive pigment that fixes onto the bacterial membrane, and is also a potent antimicrobial agent[10].

In the operative treatment of carious lesions in dentin, the morphology and nature of the prepared dentin surface influences the bonding of adhesive restorative materials[12]. However, little is known about the performance of adhesive systems on caries-affected dentin that has been excavated with these new minimally invasive systems[13]. The purpose of this study was to evaluate the influence of different chemomechanical caries removal techniques (Carisolv and Papacárie) on the microtensile bond strength of an adhesive system to caries-affected and healthy dentin.

Material and methods

Specimen Selection

Fifty recently extracted or exfoliated human deciduous molars (30 sound and 20 carious teeth), stored in 0.2% thymol solution at 4°C maximum period of 30 days, were selected for this study. The teeth were washed under running water for 24 h to completely remove thymol residues and then examined under a x20 stereomicroscope magnification (Carl Zeiss, Jena, Germany). The sound teeth were selected after confirming the absence of caries lesions, restorations, fracture lines or fissures. The carious teeth were selected after confirming the presence of softened dentin tissue based on visual examination and analysis of surface hardness using an explorer. The selected teeth were subjected to sodium bicarbonate prophylaxis and rinsed thoroughly under running water.

Specimen Preparation

The region corresponding to the area of root resorption of the exfoliated deciduous molars was filled internally with increments of Z250 composite resin (3M/ESPE, St Paul, MN, USA). This procedure was carried out to reproduce the reabsorbed root portion and allow the tooth to be embedded in acrylic resin using a PVC cylinder (25 mm in diameter and 20 mm high) as mold. The extracted molars were also embedded in acrylic resin in the same way as the exfoliated molars.

The teeth were sectioned 2-mm below the oclusal surface using a double-faced diamond disk (KG Sorensen, Barueri, SP, Brazil) in a slow-speed handpiece in a water-cooled high-precision sectioning machine (Minitom; Struers, Copenhagen, Denmark). The occlusal surfaces were then polished (Abramin; Struers) with successively finer grit silicon carbide papers (600- to 1200-grit).

Experimental Groups

All teeth were treated and restored by the same operator and were randomly assigned to groups of 10 specimens each according to the technique used for caries removal. The 30 sound teeth were allocated to 3 groups: Group 1 (control): no caries removal technique was applied; Group 2: chemomechanical technique using Carisolv; and Group 3, chemomechanical technique using Papacárie. The 20 carious teeth were allocated to two groups that were treated with either Carisolv (Group 4) or Papacárie (Group 5). The compositions of the chemomechanical caries removal systems are described in Table 1.

In Groups 2 and 3, Carisolv gel and Papacárie gel, respectively, was applied on dentin surface for 30s, removed with gauze and other two applications were done. The surface was rinsed with distilled water and dried with cotton wool. After this, hybridization and restoration with composite resin was performed.

In Groups 4 and 5, Carisolv gel and Papacárie gel, respectively, was applied on the carious dentin surface and

Table 1 - Materials used for caries removal

	Composition*	Manufacturer	Batch No.
Carisolv gel Multimix	Gel: Amino acids (glutamic acid, leucine, lysine), sodium chloride, NA-CMC 1300-2200 mPas, purified water and sodium hydroxide, pH 11. The transparent liquid contains: sodium hypochlorite solution (0.95%)	MediTeam Dental AB, Sävedalen, Sweden	04-001
Papacárie	Papain, chloramine, toluidine blue, salts, preservatives, thickening agents, vehicle qsp.	Fórmula & Ação, São Paulo, SP, Brazil	0004

* according to the manufacturer

Table 2 - Restorative materials.

	Composition*	Manufacturer	Batch No.
Etchant Scotchbond	35% phosphoric acid, thickening agent composed of pyrogenic silica and water-soluble tensioactive agent.	3M/ESPE	5EJ
Single Bond	Ethanol, Bis-GMA, silane treated with silica filler, 2- hydroxyethyl methacrylate, glycerol 1,3 dimethacrylate, acrylic acid and itoconic acid copolymer, and diurethane dimethacrylate	3M/ESPE	5CL 4TF / 4TL / 5TR /
Composite resin Z 250	Zirconia/Silica, BIS-GMA, UDMA and Bis-EMA	3M/ESPE	5TT

*according to the manufacturer

left for 30 s. The carious tissue was afterwards removed with a blunt curette that comes with the Carisolv® system kit, making back and forth movements were made. The excavated carious tissue was removed with gauze and the gel was reapplied for 30 s. The carious tissue was removed again with the blunt curette, and the gel was applied once again for 30 s. Thereafter, the surface was rinsed with distilled water, and hybridization and restoration with composite resin was performed.

Three applications of each gel were standardized in all experimental groups in order to remove soft, stainable, carious dentin was removed, exposing a relatively hard, caries-affected non-staining dentin, in the caries-affected teeth or healthy dentin at the same level in the sound teeth.

Restorative procedures

Enamel and dentin surfaces were etched with 35% phosphoric acid (3M/ESPE) for 15 s, rinsed with distilled water, and the excess was removed with absorbent paper, to leave the dentin visibly moist. Two consecutive layers of Single Bond adhesive system (3M/ESPE) were applied with a microbrush tip (KG Sorensen, Barueri, SP, Brazil) and light-cured for 20 s using a halogen light source (Ultralux EL appliance; Dabi Atlante, Ribeirão Preto, SP, Brazil).

After hybridization, three approximately 2-mm-thick increments of Z250 composite resin (Shade A2) were incrementally applied on dentin surface with a #1/2 spatula, each one light-cured for 20 s, reaching a total height of 6 mm. The restored specimens were stored in distilled water for 24 h. The materials used for hybridization and restoration are shown in Table 2.

Microtensile test

The samples were placed in a high-precision sectioning machine (Struers) and a double-faced diamond disk was used under water cooling to cut sequential 1.0-mm-thick sections in a mesiodistal direction to the long axis of the specimens, with caution not to separate the slices. The specimens were then removed from the acrylic resin base through a cross section to obtain resin/dentin slabs measuring approximately 10-mm high, 5-mm wide and 1-mm thick. The specimens were trimmed on both sides of the resin-dentin interface using a #1093 FF drill (KG Sorensen) in a high-speed handpiece (Kavo, Joinvile, SC, Brazil). The purpose of this procedure was to obtain a 1-mm thick central area, and to configure standard hourglass-shaped specimens (Figure 1). The specimens that suffered pre-test failure were not included on the data analysis.

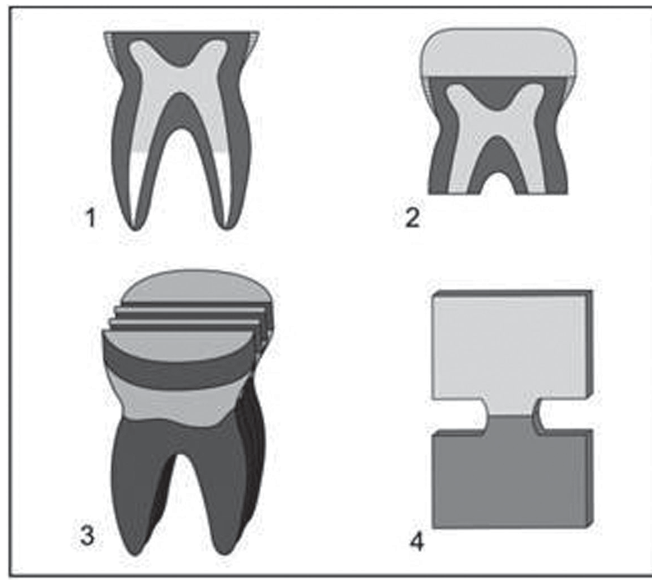

Fig. 1. Schematic diagram of specimen preparation after carious tissue removal. (1) exposed dentin; (2) restored tooth; (3) sectioning of the tooth to obtain four 1-mm-thick slabs *per* specimen; (4) Hourglass-shaped specimen.

The specimens were individually fixed in a metal device Bencor Multi-T[14] with a cyanoacrylate adhesive gel (Loctite Super Bonder, São Paulo, SP, Brazil) so that the resin/dentin interface remained without any contact, allowing the microtensile bond strength test to be performed. The metal device was placed in a universal testing machine (DL 2000; Emic São José de Pinhais, PR, Brazil) and the specimens were tested in microtensile strength at a crosshead speed of 0.5 mm/min until fracture. At the moment of failure, the resistance values were recorded in N using a computer software.

Before the test, the area was measured with a digital caliper (Vonder O.V.D Importadora e Distribuidora Ltda., Curitiba, PR, Brazil) and the bond strength was calculated in MPa using the following equation: $Rt = F/A$, where Rt is the microtensile bond strength, F is the force applied and A is the bond area between the dentin and restorative system.

The data was analyzed by ANOVA and Tukey's multiple-comparison test at 5% level of significance.

Results

Table 3 shows the mean bond strength values (in MPa)

Table 3 - Mean bond strength values (in MPa) of Single Bond after different caries removal techniques.

Groups	N	Mean (± standard deviation)
G1	10	13.387 (± 6.1074)a
G2	10	18.123 (± 3.2611)a
G3	10	12.781 (± 4.5652)a
G4	10	6.228 (± 5.3435)b
G5	10	6.482 (± 3.2076)b

and standard deviations for the control and experimental groups. G1, G2 and G3 presented the highest mean bond strength values ($p<0.05$), but did not differ significantly from each other ($p>0.05$). G4 and G5 presented the lowest mean bond strength values ($p<0.05$) and were statistically similar to each other ($p>0.05$).

Discussion

The traditional caries removal method involves local anesthesia followed by the use of burs in low speed handpieces[15]. This method has the disadvantage of removing healthy, non-infected altered and infected dentin due to the cutting efficiency of the bur, resulting in an over-extended cavity preparation[16-17]. Moreover, the incidence of pulpal alterations due to the pressure or heat generated by the burs have been reported[15,17]. The chemomechanical caries removal methods appeared as an alternative, overcoming some of the inconvenient aspects, such as pain and discomfort, eliminating or diminishing the need for local anesthesia, and eliminating the noise during carious tissue removal[5].

The present study used the microtensile test to evaluate the influence of the two chemomechanical caries removal methods (Carisolv and Papacárie) on the bond strength of the adhesive system to healthy and carious dentin. The use of healthy dentin allowed one to evaluate whether the chemomechanical methods had any influence on bond strength. The use of deciduous exfoliated or extracted teeth does not interfere in the bond strength values, as demonstrated in previous studies[18-19].

Data analysis showed that neither of the chemomechanical methods had influence on the bond strength of the adhesive system to healthy or carious dentin. This indicates that neither of the products seems to alter the dental substrate, which could interfere in the bond strength values. The lower bond strength to caries-affected dentin was probably due to the presence of altered dentin rather than the chemomechanical method *per* se.

Regarding the changes in dentin substrate promoted by the chemomechanical methods, the use of Carisolv on carious dentin caused alterations in the odontoblastic processes, but not in the dentin collagen[20], thus not affecting the bond strength; it is more likely that the alterations in the odontoblasts are caused by the carious lesion before the application of the Carisolv[21]. As this product contains NaOCl in its composition, it breaks the cross-links between the dentinal collagen fibrils, denaturing them and dissolving the necrotic tissue. The bond between NaOCl and the amino acids reduces the effect of whole collagen denaturation and breaks only the bond between the affected collagen fibrils, without causing any molecular alterations. Furthermore, Carisolv removes only the non-remineralizable infected and necrotic dentin, preserving the subjacent non-infected dentin layer[22], and not causing harm to the sound dentin surrounding the lesion[23]. Moreover, no adverse effects to pulp cells[24] or gingival tissue[4,24] have been found.

Wennerberg et al.[12] and Haak et al.[23] have observed that the application of Carisolv makes dentin surface rough, though without interfering in the action of acid etching on dentin. In addition, caries removal with Carisolv does not produce smear layer, resulting in greater opening of the dentinal tubules, which optimizes the penetration of the adhesive systems[9]. Furthermore, Carisolv did not alter the mean bond strength values to dentin in the present study, which is in agreement with the findings of previous studies[16,21,25].

Papacárie, a gel based on papain and containing chloramines and blue toluidine, is less costly than Carisolv and has similar use, indication and chemomechanical caries removal efficiency[10]. It does not harm healthy tissue and accelerates tissue healing. It acts only on carious tissue, which lacks the plasmatic protease inhibitor alpha-1-antitrypsin; its proteolytic action is inhibited on healthy tissue, which contains this substance[26]. In addition to papain, the chloramines present in the product have the potential of dissolving carious dentin by means of chlorination of the partially degraded collagen. This mechanism affects the collagen structure, dissolving hydrogen bonds and thus facilitating tissue removal[27]. In the same way as Carisolv, Papacárie did not change the microtensile bond strength values in the present study, as reported elsewhere[11,28].

The carious dentin groups presented significantly lower bond strength than the healthy dentin groups. These findings are in agreement with those of previous studies[21,25,29]. The weakness of carious teeth was reported by Yoshiyama et al.[29], who observed a larger number of cohesive failures in caries-affected dentin and a larger number of adhesive failures in healthy dentin. This can be explained by the fact that the high mineral loss in caries-affected dentin makes this substrate extremely porous[29] and decreases its hardness[30]. The lower hardness of carious dentin can also be attributed to collagen matrix denaturation and to the smaller number of hydroxyapatite crystals that no longer fit correctly into the inter/intrafibrillar spaces of the collagen matrix. To the extent that there is any chemical bonding between carboxylic or phosphate derivations of methacrylates with the mineral phase, then fewer, larger crystals would offer less surface area for interaction. Moreover, ultrastructural analysis has shown a thicker hybrid layer in affected dentin than in healthy dentin[29], suggesting easier diffusion of the acid and resin monomers due to the increase in porosity of the intertubular dentin. However, the penetration of acid into the dentinal tubules harms the infiltration of the resin monomers into the caries-affected dentin[31], decreasing the bond strength[29].

Although Papacárie and Carisolv present a potential to be used in caries excavation procedures, these products, particularly Papacárie that is more recent in the market, needs further laboratory and clinical investigation to evaluate their efficacy and their effects on the bond strength of restorative materials to dentin.

In conclusion, neither of the chemomechanical caries removal methods interfered in the resin-dentin bond strength. However, lower tensile bond strength was found to caries-affected dentin.

References

1. Cehreli ZC, Altay N. A 3-year clinical evaluation of a polyacid modified resin composite in minimally-invasive oclusal cavities. J Dent. 2000; 28: 117-22.
2. Kidd EAM, Joyston-Bechal S, Beighton D. Microbiological validation of assessments of caries activity during preparation. Caries Res. 1993; 27: 402-8.
3. Ranly DM, Garcia-Godoy F. Current and potential pulp therapies for primary and young permanent teeth. J Dent. 2000; 28: 153-61.
4. Kakaboura A, Masouras C, Staikou O, Vougiouklakis G. A comparative clinical study on the Carisolv caries removal method. Quintessence Int. 2003; 34: 269-71.
5. Kavvadia K, Karagianni V, Polychronopoulou A, Papagiannouli L. Primary teeth caries removal using the Carisolv chemomechanical method: a clinical trial. Pediatr Dent. 2004; 26: 23-8.
6. Fure S, Lingström P, Birkhed D. Evaluation of Carisolv for the chemo-mechanical removal of primary root caries in vivo. Caries Res. 2000; 34: 275-80.
7. Morrow LA, Hassall DC, Watts DC, Wilson NH. A chemo-mechanical method for caries removel. Dent Update. 2000; 27: 398-401.
8. Munshi AK, Hegde AM, Shetty PK. Clinical evaluation of CarisolvTM in the chemo-mechanical removal of carious dentin. J Clin Pediatr Dent. 2001; 26: 49-54.
9. Splieth C, Rosin M, Gellissen B. Determination of residual dentine caries after conventional mechanical and chemomechanical caries removal with Carisolv. Clin Oral Invest. 2001; 5: 250-3.
10. Bussadori S, Castro L, Galvao A. Papain gel: a new chemomechanical caries removal agent. J Clin Pediatr Dent. 2005; 30: 115-9.
11. Piva E, Ogliari FA, Moraes RR, Corá F, Henn S, Correr-Sobrinho L. Papain-based gel for biochemical caries removal: influence on microtensile bond strength to dentin. Braz Oral Res. 2008; 22: 364-70.
12. Wennerberg A, Sawase T, Kultje C. The influence of Carisolv on enamel and dentine surface topography. Eur J Oral Sci. 1999; 107: 297-306.
13. Çehreli ZC, Yazici AR, Akca T, Özgünaltay G. A morphological and micro-tensile bond strength evaluation of a single-bottle adhesive to caries-affected human dentine after four different caries removal techniques. J Dent. 2003; 31: 429-35.
14. Silva NRFA, Calamia CS, Harsono M, Carvalho RM, Pegoraro LF, Fernandes CAO, Vieira ACB, Thompson VP. Bond angle effects on microtensile bonds: Laboratory and FEA comparison. Dent Mater. 2006; 22: 314-24.
15. Rafique S, Fiske J, Banerjee A. Clinical trial of an air-abrasion/ chemomechanical operative procedure for the restorative treatment of dental patients. Caries Res. 2003; 37: 360-4.
16. Banerjee A, Kidd EA, Watson TF. Scanning electron microscopic observations of human dentine after mechanical caries excavation. J Dent. 2000; 28: 179-86.
17. Hosoya Y, Kawashita Y, Marshall GW Jr, Goto G. Influence of Carisolv™ for resin adhesion to sound human primary dentin and young permanent dentin. J Dent. 2001; 29: 163-71.
18. Bengtson AL, Guedes-Pinto AC, Turbíno ML, Mathías RC, Bengtson NG. Força adesiva de um sistema de resina composta à dentina. Comparação entre molares decíduos esfoliados fisiologicamente e com retenção prolongada. RGO. 2002; 50: 93-6.
19. Bengtson AL, Guedes-Pinto AC, Turbíno ML, Bengtson NG, Bengtson CRG. Contribuição na padronização de dentina de dentes decíduos para os ensaios de adesividade de materiais resinosos. Pesq Bras Odontoped Clin Integr. 2003; 3: 21-5.
20. Dammaschke T, Stratmann U, Mokrys K, Kaup M, Ott KHR. Reaction of sound and demineralised dentine to Carisolv in vivo and in vitro. J Dent. 2002; 30: 59-65.
21. Burrow MF, Bokas J, Tanumiharja M, Tyas MJ. Microtensile bond strengths to caries-affected dentine treated with Carisolv. Aust Dent J. 2003; 48: 110-4.
22. Ericson D, Zimmerman M, Raber H, Götrick B, Bornstein R, Thorell J. Clinical evaluation of efficacy and safety of a new method for chemo-mechanical removal of caries. A multi-centre study. Caries Res. 1999; 33: 171-7.
23. Haak R, Wicht MJ, Noack MJ. Does chemomechanical caries removal affect dentine adhesion? Eur J Oral Sci. 2000; 108: 449-55.
24. Hossain M, Nakamura Y, Tamaki Y, Yamada Y, Jayawardena JÁ, Matsumoto K. Dentinal composition and Knoop Hardness measurements of cavity floor following carious dentin removal with Carisolv. Oper Dent. 2003; 28: 346-51.
25. Hosoya Y, Shinkawa H, Marshall GW. Influence of Carisolv on resin adhesion for two different adhesive systems to sound human primary dentin and young permanent dentin. J Dent. 2005; 33: 283-91.
26. Flindt ML. Allergy to alpha-amylase and papain. Lancet. 1979; 1: 1407-8.
27. Maragakis GM, Hahn P, Hellyig E. Clinical evaluation of chemomechanical caries removal in primary molars and its acceptance by patients. Caries Res. 2001; 35: 205-10.
28. Lopes MC, Mascarini RC, da Silva BM, Flório FM, Basting RT. Effect of a papain-based gel for chemomechanical caries removal on dentin shear bond strength. J Dent Child (Chic). 2007; 74: 93-7.
29. Yoshiyama M, Tay FR, Doi J, Nishitani Y, Yamada T, Itou K, Carvalho RM, Nakajima M & Pashley DH. Bonding of self-etch and total-etch adhesives to carious dentin. J Dent Res. 2002; 81: 556-60.
30. Hosoya Y, Marshall SJ, Watanabe LG, Marshall GW. Microhardness of carious deciduous dentin. Oper Dent. 2000; 25: 81-9.
31. Marshall GW Jr, Chang YJ, Gansky SA, Marshall SJ. Demineralization of caries-affected transparent dentin by citric acid: an atomic force microscopy study. Dent Mater. 2001; 17: 45-52.