Influence of eugenol-containing temporary restorations on the microleakage of total-etch and self-etching adhesive systems

Influência de restaurações temporárias contendo eugenol na microinfiltração de sistemas adesivos convencional e autocondicionante

Abstract

Purpose: This *in vitro* study evaluated the influence of zinc oxide-eugenol temporary cement (ZOE-TC) on the sealing ability of composite restorations using two adhesive systems.

Methods: Standard Class V cavities were prepared in 20 bovine incisors and restored with either ZOE-TC (IRM®) or eugenol-free cement (Cavit®) (n=10/temporary cement type). After 7 days, five teeth per material group were restored using Single Bond® (SB) and five using Adper Prompt® (AP). The cavities were filled with composite (Filtek Z-250), thermal cycled (500 cycles), immersed in basic fuchsine solution, and longitudinally sectioned. Dye penetration was evaluated using optical-microscopy and scored. Data were analyzed by Kruskal-Wallis test ($P = 0.05$).

Results: Overall, leakage in dentin was similar to that in enamel. In enamel margins, only the group with Cavit® cement associated with AP presented significant higher leakage. In dentin margins, AP exhibited higher leakage than the groups restored with SB; there was no significant difference between eugenol-free cement and ZOE-TC.

Conclusion: In general, SB showed better marginal sealing than AP, and ZOE-TC did not increase dye leakage. Eugenol in the temporary cement did not affect the marginal sealing of adhesive restorations.

Key words: Zinc oxide-eugenol cement; dentin-bonding agents; leakage; adhesive restoration

Resumo

Objetivo: Este estudo *in vitro* avaliou a influência de um cimento restaurador temporário à base de óxido de zinco-eugenol (CT-OZE) no selamento marginal de restaurações diretas, utilizando dois sistemas adesivos.

Metodologia: Cavidades classe V foram preparadas em 20 incisivos bovinos e restauradas com dois cimentos temporários, CT-OZE (IRM®) ou cimento livre de eugenol (Cavit®) (n=10/cimento temporário). Após sete dias, cinco dentes de cada grupo de cimento temporário foram restaurados utilizando o sistema Single Bond® (SB) e os demais cinco com o sistema Adper Prompt® (AP). As cavidades foram restauradas com resina composta (Filtek Z-250), termocicladas (500 ciclos), imersas em fucsina básica e longitudinalmente seccionadas. A penetração do corante foi avaliada em microscópio ótico. Os dados analisados por teste de Kruskal-Wallis ($P = 0,05$).

Resultados: A infiltração em dentina foi similar à do esmalte. Em esmalte, o grupo com Cavit® e AP apresentou infiltração significativamente maior. Em dentina, AP exibiu maior infiltração que SB, e não houve diferença entre CT-OZE e Cavit®.

Conclusão: Em geral, SB produziu melhor selamento marginal que AP, e CT-OZE não aumentou a penetração de corante. A presença de eugenol no material restaurador temporário não afetou o selamento marginal de restaurações adesivas.

Palavras-chave: Cimento de óxido de zinco e eugenol; adesivos dentinários; infiltração dentária; restauração adesiva

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Introduction

Despite the increasing bond strength of adhesive systems, microleakage remains a problem in restorative dentistry (1). Microleakage has been defined as the penetration of fluids, bacteria, and their by-products along the tooth/restoration interface, and it has been related to marginal staining, post-operative sensitivity, pulpal pathology, and secondary caries (2).

In several clinical situations a temporary restoration is needed before the final definitive restoration. Zinc oxide-eugenol (ZOE) cement is the most common temporary filling material used in dentistry (3) because of some material characteristics, such as easy handling, low cost, analgesic, anti-inflammatory and anti-bacterial properties, and good sealing ability (4). However, eugenol is reported to interfere with the polymerization reaction of resin-based materials (5), affecting the mechanical properties of composites (6). As a consequence, the bond strength to dental structure may be reduced (7), and the sealing ability is compromised (8), However, the presence of cement residues on dental surface, which are not removed even after acid etching (9), could be the reason for bond decrease after temporary restoration (8). These residues could affect contact angle and dentin permeability (10).

Conversely, the use of temporary cements, either containing eugenol or not, does not alter the retentive strength of ceramic restorations luted to dentin using self-etching or total-etch adhesive systems, if the temporary cements are removed by excavator or sandblasting (11). The use of endodontic sealers and temporary filling materials containing ZOE had no detrimental effect on the marginal sealing of carbon fiber post/composite resin core restorations (12). Also, Bocangel et al. (13) reported that a temporary cement containing eugenol did not influence microleakage and adhesion of total-etch and self-etching adhesive systems. Nevertheless, it is unkown the influence of temporary cements containing ZOE on sealing ability, especially when self-etching adhesives are used.

Thus, the purpose of this study was to evaluate the influence of temporary fillings, with or without eugenol, on the microleakage of total-etch and self-etching adhesive systems in class V composite restorations.

Methods

Sample Preparation

The temporary cements, adhesive systems, and restorative composite used in this study are shown in Table 1. Twenty recently extracted bovine incisors were selected, and standardized Class V cavities were prepared on the buccal and lingual surfaces of each tooth (3mm length, 2mm deep, 2mm wide) using a #245 carbide bur (SS White, Lakewood, NJ, USA), with high-speed and under air-water cooling. A new bur was used after five cavity preparations to ensure high cutting efficiency. The cervical margin was located in dentin and the incisal margin in enamel.

Table 1. Composition and manufacturer of the materials used in the study

Material	Composition	Manufacturer
IRM®	Zinc oxide, eugenol	Dentsply Caulk, Milford, DE, USA
Cavit®	Zinc oxide, calcium sulfate, barium sulfate, talc, ethylene bis(oxyethylene) diacetate, zinc sulfate, poly(vinylacetate)	3M ESPE, St. Paul, MN, USA
Single Bond®	BisGMA, HEMA, methacrylic/itaconic acid copolymer, ethanol, water	3M ESPE, St. Paul, MN, USA
Adper Prompt®	Liquid 1 (red blister): Methacrylated phosphoric esters, Bis-GMA, initiators based on camphorquinone, stabilizers. Liquid 2 (yellow blister): Water, HEMA, polyalkenoic acid, stabilizers	3M ESPE, St. Paul, MN, USA
Filtek Z-250®	BisGMA, UDMA, BisEMA, Filler 60% vol.	3M ESPE, St. Paul, MN, USA

BisGMA: bisphenol-A glicidyl dimethacrylate; HEMA: 2-hydroxyethyl methacrylate; UDMA: urethane dimethacrylate; BisEMA: ethoxylated bisphenol-A dimethacrylate.

Restorative Procedures

The teeth were randomly assigned to four groups (n=5) according to the different temporary cements and adhesive systems used:

G1: ZOE cement (IRM) + total-etch technique adhesive system (Single Bond);
G2: Eugenol-free temporary cement (Cavit) + total-etch technique adhesive system (Single Bond);
G3: ZOE cement (IRM) + self-etching adhesive system (Adper Prompt);
G4: Eugenol-free temporary cement (Cavit) + self-etching adhesive system (Adper Prompt).

The cavities were temporarily filled with ZOE or eugenol-free cements. After seven days, the temporary cement was removed with a dentin excavator. The adhesive systems were applied according to each manufacturer's instructions, and the cavities were incrementally restored with a microhybrid composite resin. Each increment was photopolymerized for 20s with a light-curing unit (XL 3000 – 3M ESPE, St. Paul, MN, USA) operating at 450mW/cm². The teeth were stored in distilled water at 37°C for 7 days. Polishing procedures were performed with Sof Lex XT discs (3M ESPE, St. Paul, MN, USA).

Microleakage Assessment

Thermal cycling was carried out for 500 cycles, between 5 to 55°C (dwell time of 60 s). Afterwards, the root apexes were sealed, and two coats of fingernail varnish were applied to the entire surface, except for the restorations and 1 mm surrounding them. Specimens were immersed in 0.5% basic fuchsine solution for 24 hours, and then washed in tap water.

The restorations were sectioned in the center in a buccal-lingual plane with a water-cooled diamond saw (KG Sorensen, São Paulo, SP, Brazil). Dye penetration was assessed under magnification (40X) in a stereomicroscopy by three calibrated examiners. When disagreement occurred, comparisons were made until consensus was obtained. The degree of leakage at both enamel and dentin margins was scored from 0 to 3 (Fig. 1). Leakage data were analyzed by Kruskal-Wallis test, with the confidence level set in 95%.

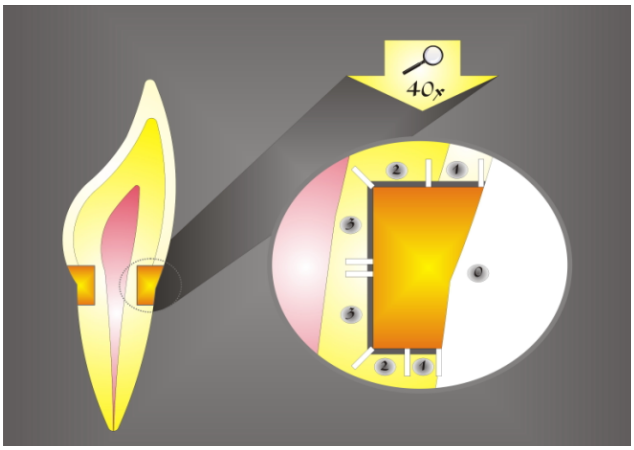

Fig.1. Microleakage scores: (0 = No dye penetration; 1 = Dye penetration up to half of the cavity depth; 2 = Dye penetration to more than half of the cavity depth; 3 = Dye penetration up to the cavity floor)

Results

The leakage scores of the experimental groups are displayed in Table 2. Kruskal-Wallis test disclosed similar dye leakage for dentin and enamel ($P>0.05$), except for the combination of eugenol-free cement and self-etching system, where the leakage in dentin was higher ($P<0.05$).

When comparing the dye penetration between groups in enamel, the presence of eugenol did not influence the microleakage pattern for both adhesive systems. For restorations with Single Bond the majority of the cavities were free of leakage, and no significant difference was observed between groups previously restored with ZOE cement or eugenol free cement. For those cavities restored with Adper Prompt, the previous application of eugenol-containing cement produced similar performance to the cavities restored with Single Bond and better marginal sealing than the combination of a temporary cement without eugenol and Adper Prompt, which exhibited the highest degree of leakage ($P<0.05$).

In dentin margins, cavities restored with Single Bond exhibited lower leakage than the cavities restored with Adper Prompt ($P<0.05$). In relation to the Single Bond groups, there was no significant difference regarding the presence of eugenol in the temporary cement. When evaluating the dye penetration for the self-etching system (Adper Prompt) the leakage was similar between cavities previously filled with eugenol-containing cement or eugenol free cement ($P>0.05$).

Discussion

Materials based on eugenol/zinc oxide components are widely used in dentistry as endodontic filling cement, pulp capping agent, and temporary cement. These cements often are replaced or layered by resin-based restorative materials. However, eugenol-containing materials may have adverse effects on composites, such as changes in dentin wettability (14), decrease of bond strength (7), and increase of microleakage (8), yet there is no consensus about these effects (11-13).

Microleakage along the interface has been related to pulpal problems, hypersensitivity, and secondary caries, which is the most common reason for restoration replacement (15). Despite some limitations of *in vitro* microleakage tests, such as subjectivity of evaluation, high penetration and diffusion of dyes due to their small size of particles (16), the technique is widely used because it is inexpensive, easy, and provides important information on the possible clinical performance of new materials (17).

The results of this study showed that the presence of eugenol did not influence the leakage of both adhesive systems. However, in general the total-etch technique adhesive exhibited better sealing ability than the self-etching system. Comparing leakage in both substrates, no significant difference was observed, except for G3. Several studies have reported better sealing in enamel than in dentin margins; however, with the evolution of adhesive systems, similar bond strength values can be achieved in enamel and

Table 2. Scores of microleakage* in enamel and dentin of the experimental groups

Group	Technique	Enamel					Dentin				
		0	1	2	3		0	1	2	3	
G1	IRM + Single Bond	9	1	–	–	Aa	9	1	–	–	Aa
G2	Cavit + Single Bond	7	3	–	–	ABa	7	1	1	1	Aa
G3	IRM + Adper Prompt	5	3	1	1	BCa	1	1	2	6	Bb
G4	Cavit + Adper Prompt	–	5	4	1	Ca	2	4	2	2	Ba

* Different small letters indicate significant differences between dental substrates ($P<0.05$).
Different capital letters indicate significant differences between groups ($P<0.05$).

dentin after hybridization of the dentin tissues (18) resulting in similar marginal sealing (19).

In dentin margins, the cavities restored with Single Bond exhibited lower leakage than the cavities restored with Adper Prompt. Etch-and-rinse adhesive systems include a separate step, in which the dentin/enamel is treated with acids before the application of primer/adhesive. This procedure removes the smear layer of dentin, opening the dentinal tubules and exposing collagen fibrils. The posterior application of adhesive results in micro-mechanical interlocking of monomers into the micro-retentive collagen network left by etching (20) and can produce better sealing than self-etching systems (21). Rosales et al. (22) reported that when dentin was treated with acid etching prior to bonding agent application, ZOE had no negative effect on bond strength, and dentin wetting was similar to those specimens with no eugenol. However, for those self-etching adhesives, where an acid-primer simultaneously provides the conditioning and priming of the tooth-structure, a limited demineralization in depth is observed (23). When ZOE filling is removed from the dentin, eugenol can leach through the smear layer achieving the dentin tubules and contaminating the dentin surface (22). If eugenol residues are present at the adhesive interface, they can interact with the polymerization of resin-based materials (9,24), compromising the adhesion to dental substrate.

The high microleakage scores found in dentin substrate when Adper Prompt was used can be related to the presence of remaining eugenol or cements residues at the smear layer, which would inhibit monomer polymerization. A hybrid layer with a large amount of unreacted monomers is more permeable to the dye tracers used in microleakage analysis. However, the present study did not find a negative effect of eugenol-containing cement on the adhesion to enamel with this self-etching adhesive. This can be attributed to the smallest enamel permeability as enamel is highly mineralized and the thinnest smear layer formed in this substrate (20), thus retaining less eugenol to interfere with adhesive polymerization.

Besides the chemical influence of remaining materials on adhesive polymerization, residues of temporary cements may act as a physical obstacle to proper contact between adhesive system and substrate (8). When acid etching with phosphoric acid followed by water rinsing are performed, these residues are removed more easily (22), Thus, despite the eugenol-free temporary cement is composed of oxides and salts relatively inert to adhesive resins, the presence of residues in large amount may be deleterious to the dentin/resin interface and facilitate microleakage. We believe that the presence of residues, with or without eugenol, is the main factor that may compromise quality of adhesion to dental substrate.

Conclusions

In general, the total-etch technique adhesive system exhibited better sealing ability than the self-etching system. Also, the leakage in enamel margins was similar to that of dentin margins for most groups. The presence of eugenol in temporary restorations did not influence the leakage of both adhesive systems.

References

1. Cenci M, Demarco F, de Carvalho R. Class II composite resin restorations with two polymerization techniques: relationship between microtensile bond strength and marginal leakage. J Dent. 2005; 33:603-10.
2. Mjör IA, Toffenetti F. Secondary caries: a literature review with case reports. Quintessence Int. 2000; 31:165-79.
3. Yap AU, Shah KC, Loh ET, Sim SS, Tan CC. Influence of ZOE temporary restorations on microleakage in composite restorations. Oper Dent. 2002; 27(2):142-6.
4. Trowbridge H, Edwall L, Panopoulos P. Effect of zinc oxide-eugenol and calcium hydroxide on intradental nerve activity. J Endod. 1982; 8: 403-6.
5. Hansen EK, Asmussen E. Influence of temporary filling materials on effect of dentin-bonding agents. Scand J Dent Res. 1987; 95:516-20.
6. Bayindir F, Akyil MS, Bayindir YZ. Effect of eugenol and non-eugenol containing temporary cement on permanent cement retention and microhardness of cured composite resin. Dent Mater J. 2003; 22:592-9.
7. Salama FS. Influence of zinc-oxide eugenol, formocresol, and ferric sulfate on bond strength of dentin adhesives to primary teeth. J Contemp Dent Pract. 2005; 6:14-21.
8. Woody TL, Davis RD. The effect of eugenol-containing and eugenol-free temporary cements on microleakage in resin bonded restorations. Oper Dent. 1992; 17:175-80.
9. Terata R. Characterization of enamel and dentin surfaces after removal of temporary cement-study on removal of temporary cement. Dent Mater J. 1993; 12:18-28.
10. Terata R, Nakashima K, Obara M, Kubota M. Characterization of enamel and dentin surfaces after removal of temporary cement-effect of temporary cement on tensile bond strength of resin luting cement. Dent Mater J. 1994; 13:148-54.
11. Abo-Hamar SE, Federlin M, Hiller KA, Friedl KH, Schmalz G. Effect of temporary cements on the bond strength of ceramic luted to dentin. Dent Mater. 2005; 21:794-03.
12. Mannocci F, Ferrari M, Watson TF. Microleakage of endodontically treated teeth restored with fiber posts and composite cores after cyclic loading: a confocal microscopic study. J Prosthet Dent. 2001; 85:284-91.
13. Bocangel JS, Demarco FF, Palmar RG, Turbino ML, Matson E. Influence of temporary filling with eugenol-containing cement on adhesion: bond strength, microleakage and SEM evaluation. Dent Mater J. 1999; 9:83-94.
14. Baier RE. Principles of adhesion. Oper Dent. 1992; 5:1-9.

15. Mjör IA, Moorhead JE, Dahl JE. Reasons for replacement of restorations in permanent teeth in general dental practice. Int Dent J. 2000;50:362-6.
16. Gale MS, Darvell BW. Dentine permeability and tracers tests. J Dent. 1999;27:1-11.
17. Raskin A, D'Hoore W, Gonthier S, Degrange M, Dejou J. Reliability of in vitro microleakage tests: a literature review. J Adhes Dent. 2001;3:295-08.
18. Eick JD, Gwinnett AJ, Pashley DH, Robinson SJ. Current concepts on adhesion to dentin. Crit Rev Oral Biol Med. 1997;8: 306-35.
19. Duquia RCS, Osinaga PWR, Demarco FF, Habekost LV, Conceição EN. Cervical microleakage in MOD restorations: In vitro comparison of indirect and direct composite. Oper Dent. 2006;31:674-9.
20. De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, Van Meerbeek B. A critical review of the durability of adhesion to tooth tissue: methods and results. J Dent Res. 2005; 84:118-32.
21. Gueders AM, Charpentier JF, Albert AI, Geerts SO. Microleakage after thermocycling of 4 etch and rinse and 3 self-etch adhesives with and without a flowable composite lining. Oper Dent. 2006; 31:450-5.
22. Rosales-Leal JI, Osorio R, Toledano M, Cabrerizo-Vilchez MA, Millstein PL. Influence of eugenol contamination on the wetting of ground and etched dentin. Oper Dent. 2003;28:695-9.
23. Burke FJ, McCaughey D. The four generations of dentin bonding. Am J Dent. 1995;8:88-92.
24. Yap AU, Shah KC, Loh ET, Sim SS, Tan CC. Influence of eugenol-containing temporary restorations on bond strength of composite to dentin. Oper Dent. 2001;26:556-61.