Dentin adhesive superior to copal varnish in preventing microleakage in primary teeth

Michael C. Royse, DMD Norman W. Ott, DMD Gregory P. Mathieu, DDS

Abstract

Microleakage presents a major challenge to the success of all restorations placed in the oral cavity, resulting in postoperative sensitivity, pulpal irritation, and secondary caries formation. The objective of this study was to evaluate the effects of an adhesive cavity liner under amalgam restorations in primary teeth. Sixty class V amalgam restorations were placed on the buccal and/or lingual surfaces of 38 primary molars and canine teeth. A dentin adhesive cavity liner was placed under 20 of the amalgam restorations. Another 20 restorations were lined with copal cavity varnish prior to amalgam condensation. The remaining 20 had no liner. All teeth were thermocycled in 0.5% basic fuschin dye, sectioned, and examined under a stereomicroscope to evaluate microleakage. While all specimens demonstrated leakage around the margins of the restorations, only the teeth with adhesive resin liners prevented leakage into the dentinal walls of the restoration. The copal cavity varnish group displayed microleakage approaching the pulpal chamber, whereas the unlined specimens consistently displayed dye penetration into the pulp chamber. At $P < 0.01$, the use of an adhesive cavity liner under amalgam restorations in primary teeth resulted in significantly less microleakage. (Pediatr Dent 18:440–43, 1996)

Microleakage of oral fluids and bacteria between the cavity wall and restoration has been associated with postoperative sensitivity, pulpal irritation, pulp necrosis, and secondary caries.[1–4] Bauer[3] stated that microleakage is a primary cause of restoration failure. Bullard[5] listed four probable causes of microleakage: capillary attraction, marginal fracture, interfacial pressure changes, and most important, the alternating contraction and expansion of the restorative material when subjected to thermocycling.

Bauer[3] listed numerous techniques used to decrease microleakage, including acid etching, beveling of cavosurface margins, cavity varnishes, and enamel and dentin bonding agents (adhesive cavity liners). Several studies on permanent teeth reported significant reduction in microleakage around amalgam restorations by using various resin liners and dentinal adhesives.[6–9] A review of the literature revealed no studies examining the effects of an adhesive cavity liner on amalgam microleakage in primary teeth.

Historically, dental practitioners have relied upon various bases and cements, cavity varnishes, and the corrosion of amalgam itself to combat the problem of amalgam restoration microleakage. The degree to which these materials control microleakage remains controversial. Ben-Amar et al.[10] and Going[2,9] demonstrated significant reduction in amalgam restoration microleakage when copal cavity varnish was applied to freshly cut dentin. Roydhouse and Weiss[11] noted that cavity varnish was effective in decreasing microleakage as long as it was fresh, with decreased sealing capacity as a function of increased varnish viscosity. Other research has questioned the ability of copal varnishes to seal margins and presumably, the dentin. Jodiakin's[12] review of microleakage around aging amalgam restorations questioned the long-term sealing ability of cavity varnish, citing breakdown of the varnish over time. Ben-Amar,[7] in a later study found that a dentin bonding agent (Scotchbond™, 3M, St Paul, MN) was significantly more effective in decreasing amalgam restoration microleakage than two coats of copal varnish. Charlton et al.[6] found that copal varnish was ineffective in reducing leakage when compared with the untreated (no liner or varnish) control group, in their study of amalgam restorations in permanent teeth. Donly[13] stated that dentin bonding agents are superior to calcium hydroxide liners because the calcium hydroxide does not bond to dentin and presents the risk of hydrolysis. Overall, a review of the literature suggests that adhesive dentin bonding agents are superior to cavity varnishes and calcium hydroxide liners in decreasing amalgam restoration microleakage. The purpose of this study is to examine and compare microleakage at or beyond the dentinoamalgam interface of fresh amalgam restorations and cavity walls in

human primary teeth, using a copal cavity varnish, and an adhesive dentin bonding agent as a liner.

Methods and materials

Thirty-eight noncarious extracted human primary molar and canine teeth with intact buccal and/or lingual surfaces were obtained and stored in normal saline. Their roots were in various stages of physiological resorption. To prevent unwanted dye penetration, the root ends were sealed with cyanoacrylate (Permabond 910™, Permabond International, Englewood, NJ) and covered with sticky wax. Each tooth was mounted in clear orthodontic acrylic to the level of the cementoenamel junction. Sixty class V preparations were placed in the buccal and/or lingual surfaces of the 38 teeth using a #330 bur in a high-speed handpiece with water spray. The preparations were rectangular—approximately 4 mm mesiodistal x 2 mm occlusogingival x 2 mm deep. Preparation margins were enamel butt joint and the pulpal walls were entirely in dentin. Cavosurface corners and internal line angles were rounded and without undercuts. The 60 preparations were split into three groups of 20. Group A consisted of amalgam (Dispersalloy™, Johnson & Johnson, Skillman, NJ) restorations without a liner. Group B consisted of amalgam restorations lined with copal cavity varnish (Plastodent™, Plastodent Inc, Bronx, NY). Group C consisted of amalgam restorations with an adhesive cavity liner (ProBond™, Caulk/Dentsply, Milford, DE). Teeth with preparations on both the buccal and lingual surface received restorations from different groups to avoid placing two restorations from the same group in the same tooth.

Prior to amalgam, copal cavity varnish, and/or ProBond™ placement, all preparations were cleansed with a cotton pellet moistened with tap water and dried. Preparations for the resin adhesive group had the internal cavity preparation surfaces etched with a 37% phosphoric acid gel for 60 sec, rinsed for 30 sec, and dried. Dentin primer was applied for 30 sec and air dried. ProBond resin adhesive was applied to the entire internal surface of the preparation, air-thinned, and polymerized with blue light (Heliolux II™, Vivadent Corp, Austria) for 10 sec. Amalgam (Dispersalloy™) was immediately condensed into the preparation and carved to contour, followed by polymerization with blue light for an additional 30 sec. The copal cavity varnish group received two applications of varnish to the dentin surfaces prior to amalgam placement. In keeping with Ben-Amar et al.[14], who demonstrated that a gentle, prolonged drying time is most effective for copal varnishes, each application was allowed to dry thoroughly for a minimum of 2 min. This was ensured by placing the initial varnish application in all of the group B cavity preparations prior to recoating. The nonlined amalgam group had the amalgam condensed into the cleansed and dried preps.

The crowns of the teeth were covered with clear fingernail polish to within 1 mm of the cavity preparation margin to prevent unwanted dye leakage. The teeth were stored overnight in sterile normal saline, then thermally stressed for 1000 cycles between 5 and 55°C in baths containing 0.5% basic fuschin dye. Dwell time in each bath was 30 sec. Following room temperature storage for an additional 24 hr in the dye, the teeth were sectioned with a diamond saw (Buehler LTD, Lake Bluff, IL). The experimental procedures were performed by the primary author, following a standard protocol of the National Naval Dental Center in Bethesda, Maryland.

Each restoration was viewed under a stereomicroscope (Datco Inc, Clearwater, FL) at 10x magnification, and blindly scored by three examiners to assess the degree of microleakage. The 10x magnification selected falls within the range of 3x to 25x magnification utilized in previous studies of dye microleakage in permanent teeth.[5-8, 10, 15, 16] The grading scale for the teeth is shown as a footnote to the Table, and is slightly modified from those utilized by Ben-Amar,[7, 10] Charlton,[6] Cooley,[8] and Leelawat.[15] Modification further defined the extent of dye leakage through the dentin tubules, but did not subdivide leakage of less than to the axial wall, as leakage to the axial wall may occur from a margin outside the plane of sectioning of the tooth. In cases of disagreement among the examiners, the majority score for the restoration was used. Statistical analysis of variance was made with the Kruskal-Wallis test. Comparison between groups was made with the Mann-Whitney rank sum test at a 0.01 level of significance.

TABLE. MICROLEAKAGE SCORES FOR THE THREE STUDY GROUPS

Group	*Scoring for Microleakage**				*Median Score*
	0	1	2	3	
ProBond™	2	15	1	2	1
Copal varnish	0	4	9	7	2
Non-lined	0	0	0	20	3

* Score: Depth of Microleakage: 0=No penetration of dye into restoration/tooth interface. 1=Penetration of dye limited to restoration/tooth interface. 2=Penetration of dye through restoration/tooth interface and into dentin tubules, extending up to halfway to the pulp. 3=Penetration of dye through dentin tubules completely into pulp chamber.

Results

Microleakage scores and their medians for the three treatment groups are listed in the Table. The ProBond-lined restorations had significantly less microleakage than the restorations lined with copal varnish or the restorations with no liner. While most of the restorations in the ProBond-lined group exhibited marginal leakage that extended to the pulpal wall (Fig 1), all of the nonlined (amalgam-only) restorations displayed leakage that extended completely into the pulpal chamber (Fig 2). Specimens lined with copal cavity varnish demonstrated microleakage greater than the ProBond-lined group but less than the unlined group.

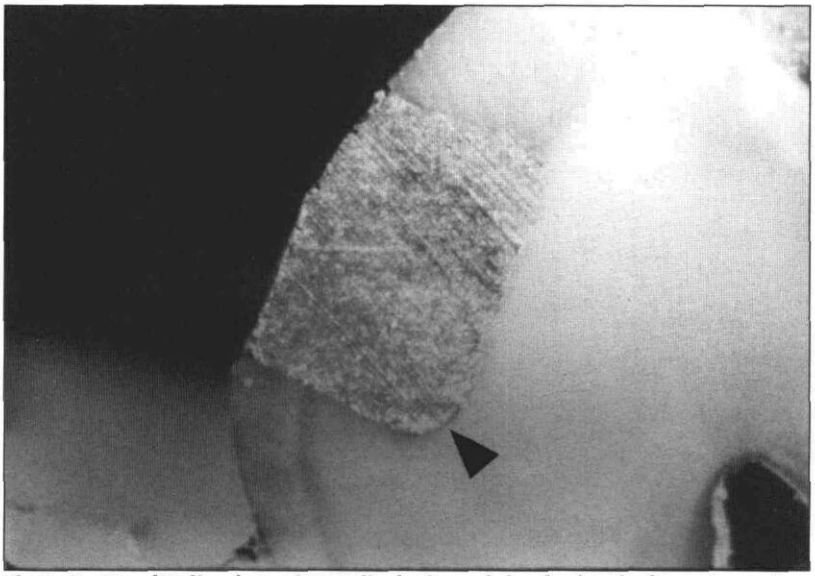

Fig 1. ProBond™-lined specimen displaying minimal microleakage (arrow) limited to the restoration/tooth interface.

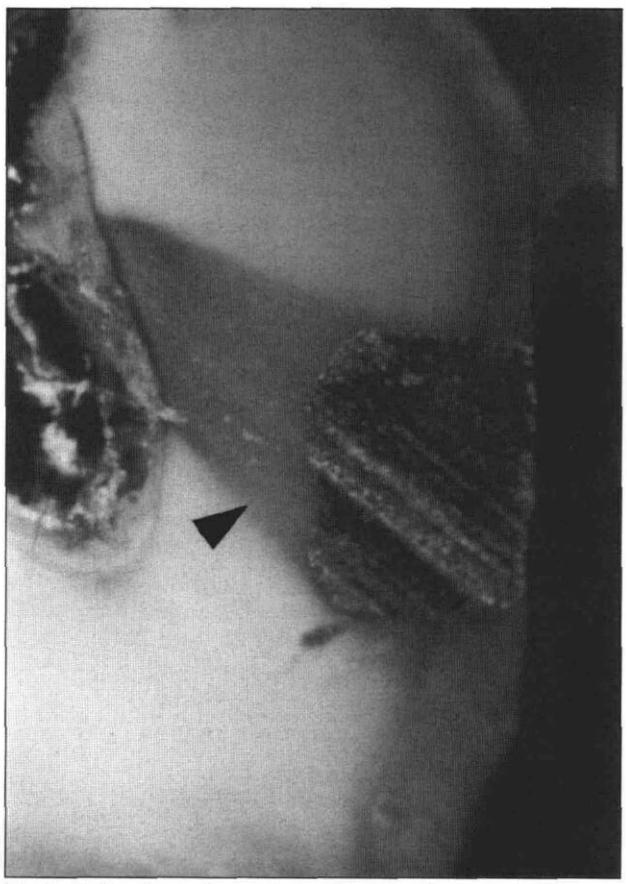

Fig 2. Unlined specimen demonstrating dye penetration into the pulp chamber. Arrow denotes dye penetration only through dentin tubules associated with cavity preparation.

Discussion

In this study, primary teeth with a ProBond liner placed under the amalgam restoration showed statistically less microleakage than did specimens lined with copal cavity varnish or no liner ($P < 0.01$). This may be clinically significant in the restoration of carious lesions in primary teeth, by reducing secondary bacterial attack within the restoration/tooth interface.[17] While it has not been proven that bacteria pass through the dentinal tubules into the pulp chamber, Bergenholtz[18] stated that their byproducts may cause severe pulpal reactions. Vadiakis[19] noted that bacterial penetration through the margins of a restoration is considered to be a major source of pulpal irritation. The ability to seal dentinal tubules to bacteria and their byproducts would be beneficial to the success of the restoration and to the health of the pulpal tissue. In this study, the adhesive cavity liner appears to provide this seal in primary dentin, similar to that demonstrated in studies on permanent dentin.[6, 7, 10, 14, 20]

An initial concern when designing this study was the possibility of specimen contamination from retrograde dye penetration. With partially resorbed, wide-open roots, dye uptake and flow from an inside-out direction appeared a possibility that would hinder interpretation of microleakage depth and pattern. In this study, only the tubules associated with the restoration showed dye penetration. If dye had entered the dentin from the pulp chamber, all of the tubules likely would have contained dye. This suggests that our methods to seal against dye penetration, except through the restoration/dentin interface, were effective.

Although we followed the manufacturer's directions in the application of the ProBond adhesive, the enamel etching time was increased to 60 sec to ensure maximum smear layer removal, and to maximize the potential for dye movement through gaps in the adhesive lined primary dentin.[21] It must be emphasized that although etch time affects the depth of the etch, it does not affect the resin bond strength. A 15- to 30-sec etch has been shown to provide etch depth and resin bond strength equal to a 60-sec etch of primary enamel, as has similarly been demonstrated for permanent enamel.[22] When placing adhesive liners, a 15- to 30-sec etch may be advocated for primary teeth.

Other studies have compared microleakage with different amalgam types. Copal varnishes may respond differently under various amalgams, as may dental adhesive resins.

Mahler and Nelson[23] evaluated 15 spherical, six admixed, and five lathe-cut amalgams for microleakage. As a group, spherical amalgams showed a significantly increased propensity for microleakage when compared with admixed or lathe-cut amalgams. This is likely due to the more coarse surface texture of the spherical amalgams that may leave surface channels through which

microleakage can occur. Saiku et al.[16] and Chang et al.[24] evaluated microleakage between an admixed and a spherical amalgam when both were used with copal varnish or a dental adhesive liner. Both studies found significantly less microleakage with dental adhesive liners than with copal varnish or no liners. They also found the spherical amalgam to have significantly more microleakage than did the admixed amalgam, with the spherical/copal varnish specimens showing no benefit from copal varnish placement.

This study evaluated only ProBond dental adhesive agent as a means of reducing microleakage in primary teeth. Other dental adhesives may be equally effective. Numerous articles have evaluated the 4-Meta agent Amalgambond® (Parkell Products, Farmingdale, NY). Leelawat,[15] Saiku,[16] and Ben-Amar[25] all found this dental adhesive agent to be significantly superior to copal varnish in reducing microleakage in permanent teeth.

Conclusion

It is reasonable to expect that as a group, dental adhesive liners will provide improved protection against restoration microleakage in primary teeth.

The opinions or assertions contained in the manuscript are the private views of the authors and are not to be construed as official or as reflecting the views of the Departments of the Army, Navy, or the Department of Defense.

Dr. Royse, Dental Corps, U.S. Navy, is chief of pediatric dentistry, U.S. Naval Station, Naples Italy. Dr. Ott, Dental Corps, U.S. Army is pediatric dentistry consultant, 18th Medical Command, United States Forces, Korea. Dr. Mathieu, Dental Corps, U.S. Army (retired) is former director of the U.S. Army Pediatric Dentistry Residency Program, Fort George G. Meade, Maryland.

1. Trowbridge HO: Model systems for determining biological effects of microleakage. Oper Dent 12:164–72, 1987.
2. Going RE: Microleakage around dental restorations: a summarizing review. J Am Dent Assoc 84:1349–57, 1972.
3. Bauer JG, Henson JL: Microleakage: a measure of the performance of direct filling materials. Oper Dent 9:2–9, 1984.
4. Kidd EAM: Microleakage in relation to amalgam and composite restorations: a laboratory study. Brit Dent J 141:305–10, 1976.
5. Bullard RH, Leinfelder KF, Russell CM: Effect of coefficient of thermal expansion on microleakage. J Am Dent Assoc 116:871–74, 1988.
6. Charlton DG, Moore BK, Swartz ML: In vitro evaluation of the use of resin liners to reduce microleakage and improve retention of amalgam restorations. Oper Dent 17:112–19, 1992.
7. Ben-Amar A, Liberman R, Judes H, Nordenberg D: Long-term use of dentine adhesive as an interfacial sealer under class II amalgam restorations. J Oral Rehabil 17:37–42, 1990.
8. Cooley RL, Tseng EY, Barkmeier WW: Dentinal bond strengths and microleakage of a 4-META adhesive to amalgam and composite resin. Quintessence Int 22(12):979–83, 1991.
9. Going RE: Reducing marginal leakage: a review of materials and techniques. J Am Dent Assoc 99:646–51, 1979.
10. Ben-Amar A, Nordenberg D, Liberman R, Fischer J, Gorfil C: The control of marginal leakage in amalgam restorations using a dentin adhesive: a pilot study. Dent Mat 3:94–96, 1986.
11. Roydhouse RH, Weiss ME: Penetration around the margins of restorations: 1. Review and experiments. J Canadian Dent Assoc 33:680–89, 1967.
12. Jodaikin A: Experimental microleakage around aging dental amalgam restorations: a review. J Oral Rehabil 8:517–26, 1981.
13. Donly KJ, Wild TW, Jensen ME: Posterior composite Class II restorations: in vitro comparison of preparation designs and restoration techniques. Dent Mat 6:88–93, 1990.
14. Ben-Amar A, Cardash HS, Liberman R: Varnish application technique and microleakage of amalgam restorations. Am J Dent 6:65–68, 1993.
15. Leelawat C, Scherer W, Chang J, Schulman A, Vijayaraghavan T: Addition of fresh amalgam to existing amalgam: microleakage study. J Esthet Dent 4:41–45, 1992.
16. Saiku JM, St Germain HA Jr, Meiers JC: Microleakage of a dental amalgam alloy bonding agent. Oper Dent 18:172–78, 1993.
17. Brannstrom M, Nordenvall KJ: Bacterial penetration, pulpal reaction, and the inner surface of concise enamel bond. Composite fillings in etched and unetched cavities. J Dent Res 57(1):3–10, 1979.
18. Bergenholtz G, et al: Reactions of the dental pulp to microbial provocation of calcium hydroxide treated dentin. In: Endodontics, 3rd Ed. Ingle JI, Taintor JF, Eds. Philadelphia: Lea & Febiger, 1985, p 330.
19. Vadiakas GP, Oulis C: A review of dentine-bonding agents and an account of clinical applications in paediatric dentistry. Int J Paediatr Dent 4:209–16, 1994.
20. Staninec M, Holt M: Bonding of amalgam to tooth structure: tensile adhesion and microleakage tests. J Prosthet Dent 59:397–402, 1988.
21. Pashley EL, Galloway SE, Pashley DH: Protective effects of cavity liners on dentin. Oper Dent 15:10–17, 1990.
22. Redford DA, Clarkson BH, Jensen M: The effect of different etching times on the sealant bond strength, etch depth, and pattern in primary teeth. Pediatr Dent 8:11–15, 1986.
23. Mahler DB, Nelson LW: Sensitivity answers sought in amalgam alloy microleakage study. J Am Dent Assoc 125:282–88, 1994.
24. Chang JC, Chan JT, Chheda HN, Inglesias A, Ladd GD: Microleakage of amalgam restorations with a 4-Meta bonding agent. J Dent Res 72:223, 1993. [Abst 961]
25. Ben-Amar A, Urstein M, Serebro L, Liberman R: The effect of new sealants around class V amalgam restorations. J Dent Res 69:1036, 1990. [Abst 42]