Coronal Microleakage of Five Materials Used to Create an Intracoronal Seal in Endodontically Treated Teeth

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The purpose of this study was to quantitatively compare the sealing effectiveness of five restorative materials that were used to create an intracoronal double seal. Fifty-two extracted mandibular molars were randomly divided into five groups of 10 teeth, and one positive and one negative control tooth. The crowns were removed and the pulpal floor and canal orifices were sealed with 3 mm of one of the following materials: Amalgabond, C&B Metabond, One-Step Dentin Adhesive with Æliteflo composite, One-Step with Palfique composite, or intermediate restorative material (IRM). Each tooth was affixed to a fluid filtration device and the seal was evaluated at 0, 1, 7, 30, and 90 days. The results showed a significant difference in leakage between the materials. At 7 days, IRM, Æliteflo, and Palfique leaked significantly more than Amalgabond or C&B Metabond. Amalgabond consistently produced the best seal of all the materials throughout the duration of the study.

After endodontic therapy, a coronal restoration that fails to provide a seal could permit the movement of microorganisms or their toxins along the canal walls or through voids in the root canal filling to the periapical tissues, resulting in treatment failure. Swanson and Madison (1) showed that in the absence of a coronal seal this contamination could occur in as little as 3 days. Hovland and Dumsha (2) observed that most of the leakage took place at the cement-canal wall interface or the gutta-percha–cement interface, implicating the sealer as the weak link in long-term successful obturation of the root canal. Because no sealer-cement or obturation technique consistently prevents percolation through the canal (3), it is critical to maintain a coronal seal to prevent microleakage into the canal space.

Intermediate restorative materials, by design, have a finite useful life (4). Anderson et al. (5) showed that access preparations restored with IRM demonstrated significant leakage after 7 days, and Bobotis et al. (6) demonstrated that IRM exhibited extensive microleakage when subjected to thermal stress. One approach to improving the coronal seal has been to place an additional layer of restorative material, or double seal, beneath these materials, directly over the orifices of the root canals. Carmen and Wallace (7) found that glass ionomer cement placed over the gutta-percha reduced dye leakage more than light-cured or self-cured composite or IRM, and Barthel et al. (8) showed that IRM, when combined with glass ionomer cements, may prevent bacterial penetration. In a review of the experimental evidence, Saunders and Saunders (9) concluded that the floor of the pulp chamber should be covered with a lining of glass ionomer after removing excess gutta-percha and sealer. The purpose of this study was to quantitatively compare the microleakage of five restorative materials when placed over canal orifices as an additional intracoronal barrier.

MATERIALS AND METHODS

The crowns of 52 extracted, noncarious, nonrestored human mandibular molars were removed at the cementoenamel junction with a low-speed diamond saw (Isomet 11-1180; Buehler Ltd., Lake Bluff, IL) and the roots removed approximately 2 mm apical to the furcation. Pulpal tissue was removed from the pulp chamber and root canals with a barbed broach, and each canal was enlarged with hand instruments and Gates Glidden burs (L.D. Caulk Division, Dentsply International, Inc., Milford, DE) until a #3 Gates Glidden bur could be passed without resistance through each canal. The pulp chambers and canals were then irrigated with 5.25% sodium hypochlorite for 2 min and rinsed with sterile water for 1 min. Test materials were contained within the chamber by temporarily fitting a medium gutta-percha point (Kerr/Sybron, Romulus, MI) into each canal from the apical end without sealer. Gutta-percha extending into the chamber was then removed flush with the floor with a #15 Bard-Parker blade.

Specimens were randomly divided into 5 groups of 10 teeth each, plus a positive and negative control tooth. The pulp floor and coronal orifice of each experimental specimen was covered to a depth of 3 mm with one of the five test materials. The materials used were (a) Amalgabond Plus—a self-curing dentin bonding agent (Parkell, Farmingdale, NY); (b) C&B Metabond—a self-curing adhesive cement (Parkell, Farmingdale, NY); (c) One-Step
light-cured universal dental adhesive (Bisco, Inc., Schaumburg, IL) used with Eliteflo LV light-cured low modulus microhybrid composite (Bisco, Inc., Schaumburg, IL); (d) Palfique translucent microfilled composite (Tokuyama Corp., Tokyo, Japan), also used with One-Step; and (e) IRM, a reinforced zinc-oxide eugenol cement (L.D. Caulk Division, Dentsply International, Inc.). The materials were mixed and applied according to the manufacturers’ directions. The clear polymethyl methacrylate (PMMA) powder was also added to the Amalgabond Plus and C&B Metabond mixtures. The pulpal floor of the negative control tooth was sealed with cyanoacrylate (Zapit, Dental Ventures of America, Corona, CA). The pulpal floor of the positive control tooth was left untreated. The same operator placed all restorative materials.

Plexiglas squares (2 x 2 x 0.6 cm) were prepared by drilling a single 1.25-mm hole through the center of each square. In accordance with Anderson et al. (5), a 15-mm length of 18-gauge stainless-steel tubing was inserted through the hole until flush with the other side of the block and sealed in place with C&B Metabond mixed with PMMA powder. Once the experimental material was set and the gutta-percha removed from a specimen, the pulp chamber was centered over the tubing, and the flat coronal surface of the tooth segment was affixed to the Plexiglas square with C&B Metabond mixed with PMMA powder. The pulp chamber was filled with water through the needle, taking care to remove any air bubbles that could be seen through the transparent Plexiglas. The empty root canals beneath the sealing materials were also filled with water to maintain hydration of the dentin. Once the system was full of water, the 18-gauge tubing was attached to the fluid filtration apparatus described by Pasley et al. (10) to quantitatively measure the microleakage of each specimen (Fig. 1).

A small 1- to 2-μl air bubble was introduced into the system with the microsyringe and advanced into the micropipette to serve as an indicator of fluid movement. A pressure of 239 cm of water (approximately 3.4 psi) was then applied to the phosphate buffer reservoir. Linear movement of the air bubble in millimeters was recorded at 2-min intervals for 8 min. The fluid flow rate in the untreated specimen was measured by collecting in a graduated cylinder the amount of saline that flowed through the system in 1 min. This specimen served as the positive control and provided a 100% leakage value to which the sealed values could be compared.

The microleakage of each sample was measured immediately upon setting of the materials, at 1 day, 1 week, 1 month, and 3 months after placement. Between successive microleakage measurements each crown/Plexiglas unit was stored in a container filled with a 0.2% solution of sodium azide at 37°C. Mean values at each time period were converted to μl per min · 239 cm H2O (mean microleakage). Final data were analyzed by the Statistical Analysis System (SAS Institute, Cary, NC). A one-way analysis of variance followed by Student-Newman-Keuls test on ranks was used to determine leakage of each material. The level of significance was set at p < 0.05.

**RESULTS**

The mean microleakage measurements in μl per min at the specified time intervals are summarized in Table 1. The positive control demonstrated extreme leakage with mean leakage being 5.985 μl/min. The negative control produced no detectable bubble movement and thus exhibited no leakage. There was a significant (p < 0.0001) effect of treatment material but no significant effect of time after placement (p < 0.215). Immediately upon setting and at 1 day, there was no significant difference in the amount of microleakage between the materials. By 7 days, the difference between the groups became noticeable; all the adhesive resins allowed less leakage than IRM, with Amalgabond consistently showing the least leakage.

**DISCUSSION**

All of the adhesive resins evaluated in this study produced coronal seals superior to those produced by IRM, which demonstrated extensive leakage at 1 and 3 months. Amalgabond provided the most effective and consistent barrier to leakage throughout the duration of the study.

C&B Metabond and Amalgabond are the easiest of the resin systems to place because they are self-curing and do not require the use of a resin composite. The One-Step dentin adhesive system must be placed in two to four increments, which must be air-dried, light-cured, and followed by a filled resin composite. The potential for error due to the complexity of the technique may explain in part why One-Step did not perform as well as Amalgabond and C&B Metabond in this study. Composite resins undergo polymerization shrinkage when cured, which may explain the greater leakage of Eliteflo and Palfique, at least initially. The improved seal of Palfique by day 7 may reflect expansion due to water sorption.

The transparency of Palfique could facilitate localization of the underlying gutta-percha in the event that retreatment was necessary. For this reason we used the clear PMMA powder with the Amalgabond and C&B Metabond liquids. Because the clear powder is also radiolucent, this fact should be noted in the patient’s chart to avoid potential radiographic misinterpretation.

No sealer was used in our study, as the gutta-percha provided a sufficient seal to contain the test materials until they set up, after which it was removed to evaluate the seal of the test materials alone. Clinically, however, the potential interaction between the eugenol from sealers and these materials may be of concern. The manufacturers of C&B Metabond, Eliteflo, and One-Step specifically warn that contact with zinc oxide-eugenol-based materials may inhibit or prevent polymerization of the resin.

In conclusion, our results indicate that all four adhesive resins were effective in decreasing coronal microleakage, with Amalgabond producing the best seal at all times. IRM, however,
demonstrated extensive leakage at 1 and 3 months, contraindica-
ting its use for extended periods. Use of these resins to
produce an intracoronal seal may prevent microleakage in an
endodontically treated tooth before placement of the final
restoration.

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| TABLE 1. Microleakage of resin seal on pulpal floor (10^{-4} \mu L \ min^{-1} \ cm H_2O^{-1}) |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
|                                | Immediately                     | 1 day                          | 7 days                         | 1 month                        | 3 months                        |
| Amalgabond                     | 0.79 ± 0.78^a                   | 0.60 ± 0.69^a                  | 0.20 ± 0.26^a                  | 0.70 ± 0.35^a                  | 0.35 ± 0.41^a                   |
| C&B Metabond                   | 0.99 ± 0.62^a                   | 0.50 ± 0.60^a                  | 0.45 ± 0.28^b^b               | 0.70 ± 0.63^a                  | 0.45 ± 0.44^b^b               |
| One-Step Æliteflo              | 1.24 ± 0.88^a                   | 0.45 ± 0.50^a                  | 0.89 ± 0.80^b^b               | 0.89 ± 1.12^a                  | 1.34 ± 1.35^b                  |
| One-Step Palfique              | 5.32 ± 6.38^a                   | 3.53 ± 6.22^a                  | 0.94 ± 0.76^c                 | 0.75 ± 0.82^a                  | 0.65 ± 0.67^c                  |
| IRM                            | 1.89 ± 2.32^a                   | 2.58 ± 3.51^a                  | 1.19 ± 0.58^c                 | 43.6 ± 125^b                 | 55.4 ± 144^c                  |

Groups identified by the same superscript letters are not significantly different (p > 0.05). Groups identified by different superscript letters are significantly different (p < 0.05).
Values are mean ± SD (N = 10).