Leakage In Vitro with IRM, High Copper Amalgam, and EBA Cement as Retrofilling Materials

Daniel L. Bondra, DDS, Gary R. Hartwell, DDS, MS, FICD, FACD, Michael G. MacPherson, DDS, and Frank R. Portell, DMD, MS, FAGD

An in vitro dye leakage study was performed to compare the sealing ability of high copper amalgam with Copalite, IRM, and EBA cement when used as retrofilling materials. Fifty-one extracted anterior teeth were instrumented and then obturated with gutta-percha. The apical 3 mm of the roots were resected and 2-mm deep apical preparations were made. The roots were then randomly placed into three groups and retrofilled with one of the experimental materials. After 72 h in India ink, the teeth were cleared and evaluated for leakage with a stereomicroscope. No leakage was evident in the three teeth used as negative controls and complete leakage was noted in the three positive control teeth. Statistical analysis showed that IRM and EBA cement had significantly less leakage than amalgam with Copalite. The difference between the EBA cement and IRM was not significant.

Ideally, symptomatic teeth with poorly obturated root canal systems should be retreated nonsurgically. Situations arise, however, where nonsurgical retreatment is not practical. An excellent example is when a well-fitting, serviceable dowel and core crown is in place and the endodontic treatment has not been successful. In addition to the cost of replacing such a crown, there is the possibility of fracturing or perforating the root when attempting to remove the dowel and core portion of the restoration. Endodontic surgical procedures enhance the retention of many of these teeth which might otherwise require extraction.

The goals of endodontic surgery are to remove any pathological tissue from the periapical bony defect, evaluate the seal of the root canal system in the apical portion of the root, and perform procedures to create a good apical seal if one does not exist. The desirability of achieving a good apical seal at the time of surgery is well established in the dental literature (1, 3–5). Dow and Ingle (6) suggest that over half of all endodontic failures result from incomplete obturation of the root canal space. According to Weine (2), the most common cause of endodontic failure is lack of an apical seal. The materials best suited to achieve an adequate seal by means of a retrofilling procedure have been widely debated.

Retrofilling materials that have been used include zinc-containing (5, 7–14), zinc-free (4, 9, 11, 13, 15–18), and high copper content amalgam alloys (9, 13, 14); polycarboxylate cements (9, 19–21); Cavit (8, 9, 12, 17, 21, 22); poly-Hema (4); zinc oxide-eugenol (23); IRM (9, 16); (EBA) cement (9, 15, 24); and gold foil (25). The most popular and substantially documented technique consists of placing an amalgam retrofill (3, 5, 7, 19). It has also been reported that cavity varnish will improve the seal obtained with amalgam retrofillings (10, 11, 13, 14).

Although amalgam is the most popular retrofilling material, several disadvantages have been noted when it is used. Gaps have been demonstrated between the amalgam and the prepared root canal wall. A frequent finding in leakage studies is an inadequate seal after initial placement of the amalgam retrofilling. Finally, tissue reactions to the toxic products formed when the amalgam corrodes have also been noted (3, 4, 18, 26).

EBA cement has been advocated as a retrofilling material (24) but to date there have been only two leakage studies reported that deal with EBA cement used for this purpose. Szeremet-Browar et al. (15) found that Super EBA cement was effective in maintaining an apical seal in a 4Ca autoradiographic study. Abdal et al. (9) using a fluorescent dye technique found that EBA allowed considerable leakage.

IRM has also received some recent attention. Smee et al. (16) and Abdal and Retief (9) found that IRM allowed less leakage than amalgam when used as a retrofilling material.

The purpose of this study was to evaluate the in vitro sealing ability of IRM, EBA cement, and high copper amalgam alloy with cavity varnish when they are used as retrofilling materials.

MATERIALS AND METHODS

Fifty-one freshly extracted, human, single-rooted anterior teeth were collected and stored in saline. The root surfaces were debrided with an ultrasonic scaler and placed in 2.5% NaOCl for 30 min to remove any remaining tissue. The crowns were removed with a #557 carbide bur in a high-speed handpiece. Patency of all canals was established by passing a #10 file (Kerr Mfg. Co., Romulus, MI) through the apical foramen.

The working length was determined by subtracting 1 mm from the length at which a #10 file appeared at the apical
Three evaluators who were unaware of the materials being examined used a stereomicroscope (Wild MPS 515 stereomicroscope, Herrburg, Switzerland) at a magnification of \( \times 12 \) to evaluate the roots for leakage. The roots were individually scored by each examiner as either acceptable or unacceptable. An acceptable score was defined as either no leakage or leakage that did not extend beyond the retrofilling material into the root canal space. An unacceptable score was defined as any leakage that extended beyond the retrofilling material into the root canal space. The scores of the independent evaluators were then compared and those scores which differed were reevaluated and a score agreed upon. Statistical analysis included an analysis of variance and a chi-square test.

**RESULTS**

The positive controls showed dye leakage throughout the length of the canals, while the negative controls had no dye penetration.

One root from group 2 was eliminated from the study because it exhibited a vertical fracture that allowed dye penetration into the root canal system.

The results (Table 1) from group 1 (amalgam) showed that 9 (60%) of 15 specimens were scored as unacceptable (Fig. 1) because dye leakage was found in the root canal space beyond the retrofilling material. All 14 specimens in group 2 (EBA) were scored as acceptable (Fig. 2) because no leakage could be demonstrated beyond the retrofilling material. In group 3 (IRM) only 2 (13.3%) of 15 specimens were rated as unacceptable (Fig. 3).

The data from all three groups were submitted for statistical analysis. Chi-square tests revealed a statistically significant difference between groups 1 and 2 (\( p \leq 0.002 \)) and between groups 1 and 3 (\( p \leq 0.023 \)). The difference between groups 2 and 3 (EBA and IRM) was not significant (\( p < 0.05 \)).

The independent evaluations were in agreement in 86% of the 44 teeth evaluated for apical leakage. The remaining scores were reevaluated and a score was agreed upon by all three evaluators.

**DISCUSSION**

The function of a retrofilling material is to provide an adequate seal of the root canal system when one does not exist after apical root resection. This prevents leakage of irritants from the root canal into the periradicular tissues. Dye leakage to the full extent of the retrofilling material or beyond was considered as total leakage within the parameters of this study. When dye was prevented from penetrating the full extent of the retrofilling material it was considered that an adequate seal has been provided. With these criteria, it was not deemed necessary to measure linear leakage of the dye along the retrofilling materials.

**TABLE 1. Results of leakage tests for three retrofilling materials**

<table>
<thead>
<tr>
<th>Material</th>
<th>No. of Specimens</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amalgam + Copalite</td>
<td>15</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>EBA</td>
<td>14</td>
<td>14*</td>
<td>0</td>
</tr>
<tr>
<td>IRM</td>
<td>15</td>
<td>13†</td>
<td>2</td>
</tr>
</tbody>
</table>

* Leakage significantly different from amalgam + Copalite, \( \chi^2 = 9.54; df = 1; p < 0.002 \).
† Leakage significantly different from amalgam + Copalite, \( \chi^2 = 5.17; df = 1; p < 0.023 \).
Although amalgam generally has been the most accepted retrofilling material, it does have a number of disadvantages such as scattering of amalgam particles into surrounding tissues, corrosion, and setting properties which allow dimensional changes and fluid leakage. Moodnik et al. (3), using the scanning electron microscope, examined amalgam retrofills and found defects at the amalgam-dentin interface ranging from 6 to 15 \( \mu \)m. Although the clinical significance of these defects was not determined, it was speculated that these gaps could harbor microorganisms or other toxic products, which could result in inflammation of the periradicular tissues.

Studies (16, 23) on the sealing properties of various zinc oxide-eugenol-based compounds have shown that these materials have excellent sealing properties.

Within the parameters of this study the EBA cement showed virtually no leakage. This confirms the findings of Szeremeta-Browar et al. (15). In contrast fluorescent dye study of Abdal and Retief (9), no unacceptable leakage was found in any of the specimens tested using EBA as a retrofilling material.

IRM, while not statistically different from EBA cement, did show a trend toward more dye leakage; however, leakage was significantly less with IRM than with amalgam. Abdal and Retief (9) and Smee et al. (16) also found less leakage with IRM than with amalgam.

Although this study shows less leakage with EBA and IRM, it was noted in the pilot study that amalgam working time was more predictable than that for EBA or IRM. Day to day variations of temperature and humidity within the operatory were found to drastically alter the working time for both cements, especially EBA. This could prove to be an extremely important factor when performing surgical retrofilling procedures.

In a histological evaluation of one clinical case that had been in place for 12 years, Oynick and Oynick (24) found that collagen fibers had not only been deposited on the surface of, but had also apparently grown into, the EBA retrofill material. From their clinical experience it appears that EBA cement is biocompatible. Since so little toxicity data are presently available, it is suggested that further research is necessary to determine the true biocompatibility of both IRM and EBA cements. Solubility of these cements when placed in contact with periradicular tissues must also be determined before these materials can be considered for routine clinical use.
FIG 3. One of the two samples from group 3 (IRM) that was rated unacceptable. Dye leakage is evident to the full extent of the retrofilling material (arrows delineate extent of leakage) (original magnification ×12).

SUMMARY

In this study of retrofill sealers, IRM and EBA cements showed markedly less leakage than amalgam with Copalite. There was no statistically significant difference in leakage between the EBA cement and IRM. If further research determines that EBA cement and IRM are acceptable in terms of toxicity and solubility in the periradicular tissues, they can be considered for clinical use as retrofilling materials.

The opinions or assertions contained herein are the private ones of the authors and are not to be construed as official or as reflecting the views of the U.S. Army or Department of Defense.

Dr. Hartwell is the former director and Dr. Portell is the former assistant director of the Endodontic Residency Program at the U.S. Army Dental Activity. Fort Gordon, GA. Dr. Bondra is a second-year endodontic resident and Dr. MacPherson is a first-year resident in this program. Address requests for reprints to Dr. Gary R. Hartwell, Department of Endodontics, Box 566, School of Dentistry, Medical College of Virginia, Virginia Commonwealth University, Richmond, VA 23298.

References