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

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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 (1, 2).

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. Szeremeta-Browar et al. (15) found that Super EBA cement was effective in maintaining an apical seal in a ^{45}Ca 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 foramen. The apical portion of the root canal was prepared to a #40 or 45 file and the remainder of the canal system was flared using a conventional step-back technique. Saline was used as the irrigant.

To duplicate the poor apical seal frequently found in endodontically treated teeth that cannot be retreated nonsurgically, a single cone obturation technique was used. A master gutta-percha cone was loosely fitted in the canal, coated with a zinc oxide-eugenol root canal sealer (Roth 801 sealer; Roth International Drug Co., Chicago, IL), and seated to the working length. The excess gutta-percha was removed with a warm instrument and the access opening sealed with IRM (L. D. Caulk, Milford, DE). The roots were then stored at room temperature and 100% humidity for 15 days. Apical root resections were performed on all roots by removing 3 mm of each apex with a #701 fissure bur in a straight, slow-speed handpiece under continuous saline irrigation. A 2-mm deep retrofilling preparation was made with a #35 inverted cone bur in a straight, slow-speed handpiece. The apical preparations were then dried with paper points.

The roots were randomly separated into five groups: three experimental groups of 15 roots each, 3 roots as positive controls, and 3 roots as negative controls. In group 1 the apical preparations received two applications of cavity varnish (Copalite; Bosworth, Skokie, IL) and then were filled with high copper amalgam alloy (Dispersalloy; Johnson & Johnson, East Windsor, NY) mixed according to the manufacturer's instructions. In group 2, the apical preparations were filled with EBA cement (Optow EBA Cement; Teledyne Getz, Elk Grove Village, IL) mixed according to the manufacturer's instructions. In group 3, the apical preparations were filled with IRM (L. D. Caulk) mixed according to the manufacturer's instructions. Apical preparations were performed on the positive and negative controls but no retrofilling material was placed.

All roots were covered with two coats of sticky wax to within 2 mm of the apical end. The remaining root surface was coated with fingernail polish so that only the retrofilling material remained exposed. The positive controls received two coats of sticky wax and fingernail polish, leaving only the unfilled apical preparation exposed. The negative controls also received two coats of sticky was to within 2 mm of the apical end; however, the remaining root surface and unfilled apical preparation were coated completely with fingernail polish.

All experimental teeth and controls were placed into India ink (Duro Art; Duro Art Mfg. Co., Chicago, IL) for 72 h. A previous pilot study indicated that 72 h was adequate time for dye penetration. The roots were then rinsed with saline and the wax and fingernail polish completely removed with hand scalers. The clearing procedure consisted of placing the roots in 5% nitric acid for 5 days. The acid was changed daily. At the end of this time period the roots were rinsed in saline and placed in 100% methyl alcohol for 3 days. The alcohol was changed daily for 2 days and hourly on the third day. Finally, the roots were stored in methyl salicylate to complete the clearing process.

Three evaluators who were unaware of the materials being examined used a stereomicroscope (Wild MPS 515 stereomicroscope, Herrburgg, Switzerland) at a magnification of ×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 examiners.

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

Material	No. of Specimens	Acceptable	Unacceptable
Amalgam + Copalite	15	6	9
EBA	14	14*	0
IRM	15	13†	2

* 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; $p < 0.023$.

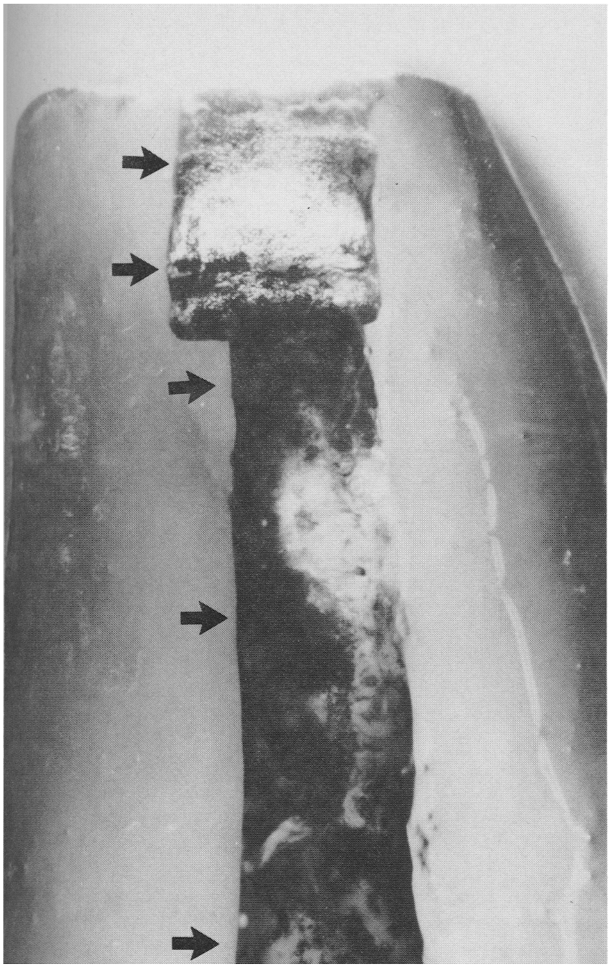

FIG 1. Representative sample from group 1 (amalgam with Copalite). Dye leakage was evident beyond the retrograde amalgam and into the root canal space (*arrows* delineate extent of leakage) (original magnification ×12).

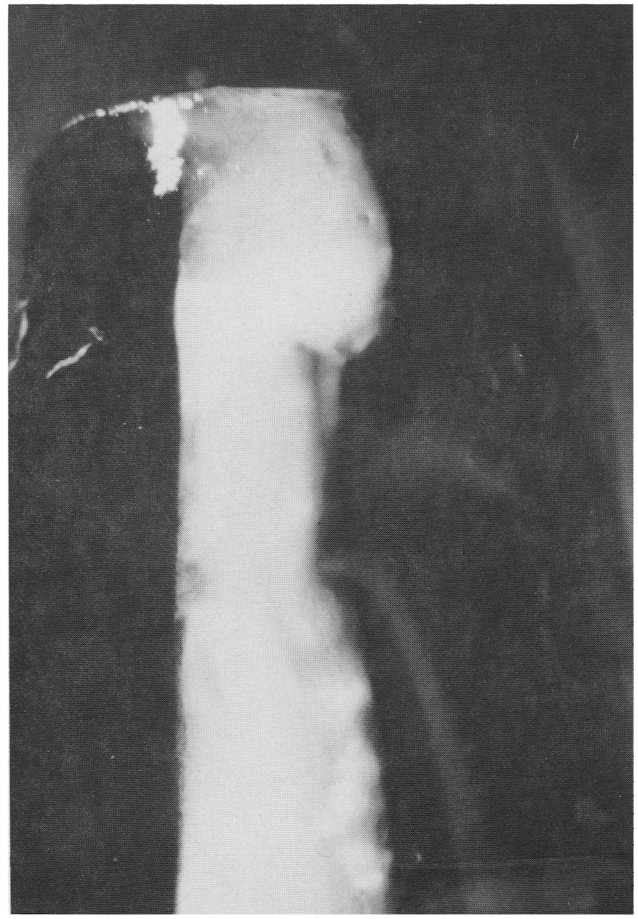

FIG 2. Representative sample from group 2 (EBA cement). No dye leakage is evident (original magnification ×12).

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 μm. 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.

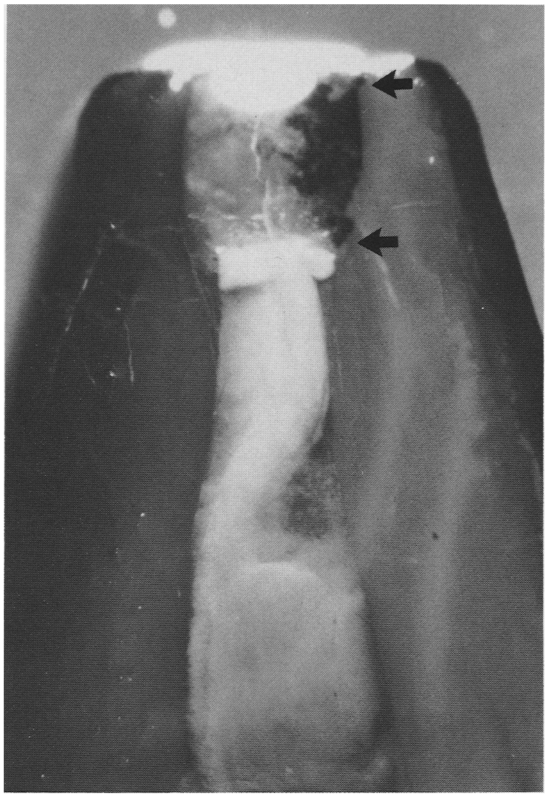

FIG 3. One of the two samples from group 3 (IRM) that was rated unacceptable. Dye leakage is evident to the full extent of the retrofilling material (*arrows* delineate extent of leakage) (original magnification ×12).

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.

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References

1. Gutmann JL, Harrison JW. Posterior endodontic surgery: anatomical considerations and clinical techniques. Int Endod J 1985;18:8–34.
2. Weine FS. Endodontic therapy. 3rd ed. St. Louis: CV Mosby, 1982:419–30.
3. Moodnik RM, Levey MH, Besen MA, Borden BG. Retrograde amalgam filling: a scanning electron microscopic study. J Endodon 1975;1:28–31.
4. Kos WL, Aulozzi DP, Gerstein H. A comparative bacterial microleakage study of retrofilling materials. J Endodon 1982;8:355–8.
5. Negm MM, Grant AA, Combe EC. Sealing quality of newly designed root canal filling material following apicoectomy compared with amalgam and heat sealed gutta-percha. Int Endod J 1982;15:181–3.
6. Dow PR, Ingle JI. Isotope determination of root canal failure. Oral Surg 1955;8:1100–4.
7. Kaplan SD, Tanzilli JP, Raphael D, Moodnik RM. A comparison of the marginal leakage of retrograde techniques. Oral Surg 1982;54:583–5.
8. Stabholz A, Shani J, Friedman S, Abed J. Marginal adaptation of retrograde fillings and its correlation with sealability. J Endodon 1985;11:218–23.
9. Abdal AK, Retief DH. The apical seal via the retrosurgical approach. I. A preliminary study. Oral Surg 1982;53:614–21.
10. Abdal AK, Retief DH, Jamison HC. The apical seal via the retrosurgical approach. II. An evaluation of retrofilling materials. Oral Surg 1982;54:213–8.
11. Mattison G, von Fraunhofer JA, Delivanis PD, Anderson AN. Microleakage of retrograde amalgam. J Endodon 1985;11:340–5.
12. Finne K, Nord PG, Persson G, Lennartsson B. Retrograde root filling with amalgam and Cavit. Oral Surg 1977;43:621–6.
13. Tronstad L, Trope M, Doering A, Hasselgren G. Sealing ability of dental amalgams as retrograde fillings in endodontic therapy. J Endodon 1983;9:551–3.
14. Vertucci FJ, Beatty RG. Apical leakage associated with retrofilling techniques: a dye study. J Endodon 1986;12:331–6.
15. Szeremeta-Browar TL, Van Cura JE, Zaki AE. A comparison of the sealing properties of different retrograde techniques: an autoradiographic study. Oral Surg 1985;59:82–7.
16. Smee G, Bolanos OR, Morse DR, Furst ML, Yesilsoy C. A comparative leakage study of P-30 resin bonded ceramic, Teflon, amalgam, and IRM as retrofilling seals. J Endodon 1987;13:117–21.
17. Flanders DH, James GA, Burch B, Dockum N. Comparative histopathologic study of zinc-free amalgam and Cavit in connective tissue of the rat. J Endodon 1975;1:56–9.
18. Omnell K-A. Electrolytic precipitation of zinc carbonate in the jaw: an unusual complication after root resection. Oral Surg 1959;12:846–52.
19. Barry GN, Heyman RA, Elias A. Comparison of apical sealing methods. Oral Surg 1975;39:806–11.
20. Barry GN, Selbst AG, D'Anton EW, Madden RM. Sealing quality of polycarboxylate cements when compared to amalgam as retrofilling material. Oral Surg 1976;42:109–16.
21. Delivanis P, Tabibi A. A comparative sealability study of different retrofilling materials. Oral Surg 1978;45:273–81.
22. Persson G, Lennartsson B, Lundstrom I. Results of retrograde root-filling with special reference to amalgam and Cavit as root filling materials. Swed Dent J 1974;67:123–34.
23. Nicholls E. Retrograde filling of the root canal. Oral Surg 1962;15:463–73.
24. Oynick J, Oynick T. A study of a new material for retrograde fillings. J Endodon 1978;4:203–6.
25. Kopp WK, Kresberg H. Apicoectomy with retrograde gold foil. NY State Dent J 1973;39:8–11.
26. Tanzilli JP, Raphael D, Moodnik RM. A comparison of the marginal adaptation of retrograde techniques: a scanning electron microscopic study. Oral Surg 1980;50:74–80.