Longitudinal Evaluation of the Seal of IRM Root End Fillings

W. Gene Crooks, DDS, MSc, MSEd, Ronald W. Anderson, DDS, MS, Billy J. Powell, DMD, and
W. Frank Kimbrough, DDS, MS

IRM has been recommended for root end filling during endodontic surgery. This study evaluated the seal of IRM root end fillings prepared with various powder to liquid ratios (P:L) at extended time intervals using a fluid filtration method. The P:L of IRM evaluated included 2, 3, 4, 5, and 6 g/ml and the P:L which resulted from the manufacturer's recommended scoop and dropper. Ten teeth were evaluated for microleakage for each group at 1, 2, 3, 4, 8, and 12 wk after insertion. There were no significant differences in the microleakage of any of the various P:L groups at weeks 3, 8, and 12. These results suggest that higher P:L of IRM than those previously recommended for temporary restorations and for endodontic access preparations may be acceptable for root end fillings. IRM of higher P:L has other advantages such as ease of placement and decreased setting time, toxicity, and solubility.

A variety of materials have been used to seal the root canal following apicoectomy and root end preparation. Dental silver amalgam traditionally has been considered the material of choice (1, 2). However, it has many disadvantages including release of mercury and other ions, corrosion and electrolysis, amalgam tattoo (argyrosis), delayed expansion, marginal leakage, difficulty in placement without scatter, nonabsorbability of excess material, and spontaneous expulsion (3). Frank et al. (4) reported that while surgically placed amalgam root end fillings may be successful on a short-term basis, the long-term prognosis is not nearly as favorable. Forty-two percent of 104 cases that had previously demonstrated healing were deemed to be unsuccessful after an average of 11.9 years after surgery.

IRM and EBA cements have been recommended by Dorn and Gartner (3) as the root end filling materials of choice. IRM is a zinc oxide and eugenol cement, reinforced with polymethyl methacrylate. Although the sealing ability of this material as a temporary filling may be adequate, there is some question as to its long-term effectiveness in the presence of tissue fluids. Long-term in vivo and in vitro studies are lacking.

Pashley et al. (5) reported that the powder to liquid ratio (P:L) for temporary filling materials affects the sealing ability. In that study, the optimal P:L for IRM was 4 while the greatest amount of microleakage was with the P:L of 7, which is similar to the manufacturer's recommended dispensing scoop and dropper. Anderson et al. (6) also evaluated the effect of varying P:L of IRM on microleakage when used to restore endodontic access preparations. Their results also indicated that the lower P:L demonstrated the least microleakage. However, the long-term sealing properties of IRM in smaller root end filling preparations may be different than those found in restorative procedures for short time periods. The purpose of this study was to evaluate the seal of IRM prepared with various P:L at extended time intervals using the fluid filtration method (5–8).

MATERIALS AND METHODS

Sixty extracted human teeth were used for this study. Teeth with resorptive defects, caries, or cracks were excluded. The crowns were removed at the level of the facial cementoenamel junction with a low-speed diamond saw (Isomet; Buehler Ltd., Lake Bluff, IL) and stored in water until used. The roots were prepared, instrumented, and filled by one operator. The canals were cleaned and shaped to a size #70 file at the working length with copious irrigation using 2.5% sodium hypochlorite. Following canal preparation, the apical end of each root was resected perpendicular to the long axis of the root using the low-speed diamond saw. To receive a root end filling, the apical end of the root was then prepared to a depth of 3 mm using a #245 bur (Brasseler, Savannah, GA) in a high-speed handpiece utilizing an air-water spray. The coronal root canal was temporarily filled to the level of the apical preparation with a tight fitting gutta-percha cone without sealer to provide a base to support condensation of the root end filling material.

The roots were then randomly divided into six groups of 10 each. IRM (L. D. Caulk Inc., Dentsply International, Milford, DE) of P:L 2, 3, 4, 5, and 6 g/ml and also according to manufacturer's instructions with the recommended scoop and dropper (R) were then mixed on a glass slab and placed into the root end preparations using a Woodson plastic filling instrument. After placement and setting of the IRM, the coronal gutta-percha point was removed to create an empty coronal canal space, and all roots were radiographed to ensure

adequacy of filling procedures. Any root in which the filling was judged to be clinically unsatisfactory due to the presence of voids was discarded and another root was prepared using the same criteria.

The root segments were then cemented onto a 2-cm², piece of Plexiglas with cyanoacrylate adhesive (Zapit; Dental Ventures of America, Anaheim Hills, CA). Each piece of Plexiglas had an 18-gauge stainless steel tube placed through its center and the root segment was positioned over the tube to permit a means of direct communication between the root canal and the fluid filtration apparatus. The fluid filtration apparatus (7) consisted of a pressurized tank of nitrogen, a pressurized fluid reservoir, polyethylene tubing containing a 25-μl micropipette, a microsyringe, and the root segment attached to the Plexiglas. Microleakage measurements were made by applying nitrogen gas at a pressure of 10 psi to the pressure reservoir which held a plastic beaker of phosphate-buffered saline containing 0.2% fluorescein dye. Polyethylene tubing then connected the pressure reservoir to the 25-μl micropipette which contained a tiny air bubble. Movement of the air bubble in the micropipette toward the root per unit time provided a means of measuring microleakage as fluid moved from inside the root toward the external surface. Measurements were made at 1-min intervals for 4 min and were then averaged to obtain the mean microleakage in μl/min. All roots were stored in Ringer's solution with 0.2% sodium azide at 37°C between microleakage evaluations which were made at 1, 2, 3, 4, 8, and 12 wk. The microleakage data for each P:L group at each measurement period were pooled and subjected to statistical analysis. Analysis of variance and Duncan's multiple range test were used to determine whether differences were significant at the 0.05 confidence level.

RESULTS

The mean microleakage measurements for each P:L at each time period are summarized in Table 1. Duncan's multiple range analysis of measured microleakage indicated significant differences in the various P:L groups for some of the time periods evaluated. At week 1 measurement, P:L 2 had statistically less microleakage than P:L 4 and 6. Additionally, at the week 2 measurement period, P:L 3 was significantly less than P:L 6, and at week 4 measurement, P:L 5 was significantly less than P:L 4. There were no statistically significant differences in the microleakage of any of the various P:L groups at weeks 3, 8, and 12.

DISCUSSION

Microleakage of IRM root end fillings was evaluated in this study using the fluid filtration method (5–8). This method forces fluid from inside the root through microchannels between the restoration/tooth interface as a means of measuring microleakage. Leakage measurement of the entire sample is in three dimensions and the sample is not destroyed, thus permitting repeated measurements over extended periods of time. This method has been previously used to evaluate root end fillings by King et al. (8), Yoshimura et al. (9), and Inoue et al. (10).

The P:L ratios used in this study were similar to those reported by Pashley et al. (5) and Anderson et al. (6). Although the results of those two studies showed the best seal was achieved when lower P:L of IRM were used, the results of this study found that in root end fillings, the P:L did not affect the seal. This difference may be related to the size of the preparations. In the studies by Pashley et al. (5) and Anderson et al. (6), the teeth evaluated were molars with relatively large restorations. In this study of root end fillings, the size of the restoration and the circumference are very small in comparison. In those studies in crowns, thin mixes would be easier to handle and place. Dorn and Gartner (3) recommend that IRM of P:L 4 be used for root end fillings. This recommendation is based on the findings of Pashley et al. (5) in class I preparations in molars. Dorn and Gartner (3) state that the IRM should be wiped into the preparation in one increment because the material does not adhere well to itself and cannot be added incrementally. In this study, we found mixtures of P:L 2, 3, and 4 to be extremely difficult to insert in small root end preparations due to its adhesiveness to the placement instruments resulting in the creation of voids in the restoration.

Our results demonstrate the ability of IRM to provide a relatively good seal. Other studies have reported that IRM provided a better seal when compared with amalgam root end fillings (10–13). The IRM used in these studies was either the manufacturer's recommended proportions (13), a mixture of a firm putty-like consistency (10, 11), or the proportions were not stated (12).

The study by Inoue et al. (10) also used a fluid filtration method. Their study extended over a 24-wk period with results that were very similar to those reported in this study. Scanning electron microscopy of an IRM root end specimen showed marginal defects of 5 μm between the root dentin and IRM. They also reported that the IRM root end filling demonstrated some thin-layered crystals that persisted on the surface even after wiping the surface with moist cotton pellets. They sug-

TABLE 1. Mean microleakage in μl/min · 10 psi ± SEM

	Time Interval					
	1 wk	2 wk	3 wk	4 wk	8 wk	12 wk
P:L 2	0.06 ± 0.01	0.14 ± 0.02	0.12 ± 0.02	0.11 ± 0.04	0.15 ± 0.02	0.11 ± 0.04
P:L 3	0.22 ± 0.05	0.08 ± 0.01	0.16 ± 0.03	0.15 ± 0.06	0.17 ± 0.02	0.10 ± 0.02
P:L 4	0.27 ± 0.06	0.22 ± 0.03	0.18 ± 0.08	0.22 ± 0.06	0.18 ± 0.03	0.19 ± 0.02
P:L 5	0.16 ± 0.03	0.09 ± 0.02	0.08 ± 0.02	0.09 ± 0.02	0.13 ± 0.02	0.08 ± 0.02
P:L 6	0.27 ± 0.10	0.23 ± 0.11	0.22 ± 0.11	0.19 ± 0.05	0.24 ± 0.13	0.15 ± 0.06
R	0.19 ± 0.04	0.13 ± 0.02	0.14 ± 0.03	0.10 ± 0.01	0.16 ± 0.03	0.09 ± 0.02

gested that these crystals on the surface may be evidence of its solubility.

Since IRM contains eugenol, concern has been expressed about possible harmful effects on the periapical tissues. Maher et al. (14) reported that the tissue response to IRM root end fillings in ferrets showed an active, acute inflammatory reaction in periapical bone that persisted for 15 wk. Resorptive cells were noted several micrometers from the tissue/IRM interface. None of the specimens showed new bone formation within 1 mm of the root apex.

According to Markowitz et al. (15), low concentrations of eugenol exert beneficial anti-inflammatory effects, whereas, high eugenol concentrations are cytotoxic. Hume (16) states that the pharmacological effects of eugenol are complex and depend on the free eugenol concentration to which the tissue is exposed. He states that beneficial pharmacological responses are most probable at low eugenol concentrations and that high concentrations capable of cytotoxic effects can be delivered to tissues by placing eugenol or zinc oxide and eugenol cement in direct contact with vital tissue. Hume (17) also studied the effect of P:L on the amount of leached eugenol released from mixtures of zinc oxide and eugenol cement and found that released eugenol was indirectly proportional to the P:L. Wetter mixes (low P:L) resulted in more release of eugenol over the time periods examined. It appears from these three studies that thicker mixes of IRM, i.e. high P:L, would be less toxic to the surrounding tissues.

Civjan et al. (18) have evaluated the effects of varying the P:L of IRM on the physical properties of the set material. As the P:L was increased, the compressive strength of the set material increased and the solubility decreased. They also reported that the setting time was decreased for the higher P:L. In a clinical situation, these enhanced properties plus the ease of manipulation and placement in small root end fillings may be additional advantages when using IRM at higher P:L.

Dr. Crooks is a former postgraduate student, Department of Endodontics, Dr. Anderson is chairman, Department of Endodontics, Dr. Powell is associate professor, Department of Oral Diagnosis and Patient Services, and Dr. Kimbrough is assistant professor, Department of Endodontics, School of Dentistry, Medical College of Georgia, Augusta, GA. Address requests for reprints to Dr. Ronald Anderson, Department of Endodontics, School of Dentistry, Medical College of Georgia, Augusta, GA 30912.

References

1. Arens DE, Adams WR, DeCastro RA (eds). Endodontic surgery. Philadelphia: Harper & Row, 1981:154–7.
2. Friedman S. Retrograde approaches in endodontic therapy. Endod Dent Traumatol 1991;7:97–107.
3. Gartner AH, Dorn SO. Advances in endodontic surgery. Dent Clin North Am 1992;36:357–78.
4. Frank AL, Glick DH, Patterson SS, Weine FS. Long-term evaluation of surgically placed amalgam fillings. J Endodon 1992;18:391–8.
5. Pashley EL, Tao L, Pashley DH. The sealing properties of temporary filling materials and bases. J Prosthet Dent 1988;60:292–9.
6. Anderson RW, Powell BJ, Pashley DH. Microleakage of IRM used to restore endodontic access preparations. Endod Dent Traumatol 1990;6: 137–41.
7. Derkson GD, Pashley DH, Derkson ME. Microleakage measurements of selected restorative materials: a new in vitro method. J Prosthet Dent 1986;56:435–40.
8. King KT, Anderson RW, Pashley DH, Pantera EA. Longitudinal evaluation of the seal of endodontic retrofillings. J Endodon 1990;16:307–10.
9. Yoshimura M, Marshall FJ, Tinkle JS. In vitro quantification of the apical sealing ability of retrograde amalgam fillings. J Endodon 1990;16:9–12.
10. Inoue S, Yoshimura M, Tinkle JS, Marshall FJ. A 24-week study of the microleakage of four retrofilling materials using a fluid filtration method. J Endodon 1991;17:369–75.
11. 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.
12. Abdal AK, Retief DH. The apical seal via the retrosurgical approach. 1. A preliminary study. Oral Surg 1982;53:614–21.
13. Bondra DL, Hartwell GR, MacPherson MG, Portell FR. Leakage in vitro with IRM, high copper amalgam, and EBA cement as retrofilling materials. J Endodon 1989;15:157–60.
14. Maher WP, Johnson RL, Hess J, Steiman HR. Biocompatibility of retrograde filling materials in the ferret canine. Oral Surg 1992;73:738–45.
15. Markowitz K, Moynihan M, Kim S. Biologic properties of eugenol and zinc oxide-eugenol. Oral Surg 1992;73:729–37.
16. Hume WR. The pharmacologic and toxicological properties of zinc oxide eugenol. J Am Dent Assoc 1986;113:789–91.
17. Hume WR. An analysis of the release and the diffusion through dentin of eugenol from zinc oxide-eugenol mixtures. J Dent Res 1984;63:881–4.
18. Civjan S, Huget EF, Wolfhard G, Waddell LS. Characterization of zinc oxide-eugenol cements reinforced with acrylic resin. J Dent Res 1972;51: 107–14.