Journal of Endodontics
Printed in U.S.A.
Vol. 27, No. 11, November 2001


# Ability of Three Root-End Filling Materials to Prevent Bacterial Leakage

**José F. Siqueira Jr., DDS, MSc, PhD, Isabela N. Rôças, DDS, Ernani C. Abad, DDS, Antônio J. R. Castro, DDS, MSc, Sérgio M. Gahyva, DDS, MSc, and Amauri Favieri, DDS, MSc**

**This study evaluated the ability of three materials—a resinous root canal sealer (Sealer 26) prepared in a thick consistence, a reinforced zinc oxide-eugenol cement (IRM), and a glass-ionomer cement (Fuji IX)—in preventing bacterial leakage. Retrofilled teeth were mounted in an apparatus and then challenged by human saliva. The number of days required for the bacteria from saliva to penetrate the root-end filling materials was determined. Evaluation was conducted for 60 days. Leakage was observed in all teeth of the Fuji IX group, and in 95% (19 of 20 specimens) of the teeth retrofilled with IRM. Sixty-five percent (13 of 20 teeth) of the teeth retrofilled with Sealer 26 showed leakage. No difference was detected between Fuji IX and IRM ($p > 0.05$). However Sealer 26 was significantly more effective in preventing bacterial leakage when compared with other materials tested ($p < 0.05$).**

Endodontic surgery may be indicated in the following situations: if there is a strong possibility of failure from nonsurgical treatment; if failure has resulted from nonsurgical endodontic treatment, and retreatment is impossible or would not achieve a better result; and if a biopsy is necessary at or near the tooth apex (1). Endodontic surgery usually consists of exposure of the involved apex, root resection, root-end preparation, and root-end filling.

Several substances have been proposed as root-end fillings, including amalgam, gutta-percha, zinc oxide-eugenol cements, Cavit, resin composite, polycarboxylate and glass-ionomer cements, mineral trioxide aggregate (MTA), and myriad other restorative materials (1–3). An ideal root-end filling material should produce a complete apical seal, have antibacterial activity, and be nontoxic, biocompatible, nonabsorbable, dimensionally stable, easy to manipulate, unaffected by moisture, and radiopaque (1, 2, 4).

Most endodontic failures occur as a result of a persistent or secondary intraradicular infection (5). Therefore a root-end filling material should provide an apical seal to an otherwise unobturated root canal or improve the seal of existing root canal fillings, thereby impeding both the traffic of tissue fluids into the root canal and the egress of microorganisms from the root canal system toward the perirradicular tissues.

In reality the coronal seal of root-end filling materials seems to be probably more important than that of the apical seal. Torabinejad et al. (6) evaluated the time needed for *Staphylococcus epidermidis* to penetrate a 3 mm thickness of root-end filling materials and found no significant differences between the leakage of amalgam, Super-EBA, and IRM. MTA leaked significantly less than the other materials maintained under test for 90 days. However Adamo et al. (7) compared MTA, Super-EBA, composite resin, and amalgam for resistance to bacterial microleakage, and reported that there were no significant differences among the materials tested at 4, 8, or 12 wk of evaluation.

Because a plethora of new materials have been recommended for use as root-end fillings, the purpose of this study was to evaluate the ability of three materials—a resinous cement, a reinforced zinc oxide-eugenol cement, and a glass-ionomer cement—in preventing bacterial leakage.

## MATERIALS AND METHODS

Seventy intact, caries-free human cuspids with straight roots were selected for this study. After initial radiographs conventional access preparations were made in 65 teeth, and the coronal portions of the canals were flared with Gates-Glidden burs #3 and #4. To standardize the diameter the apical foramen was enlarged and kept patent to a #40 file. Preparation was completed using step-back of 1-mm increments. Irrigation was conducted using 2% NaOCl solution.

The apical 3 mm of each root was removed with a fissure bur in a high-speed handpiece, under water spray, at 90 degrees to the long axis of the tooth. Afterward root-end preparations (3 mm deep) were created using diamond ultrasonic retrotips (no. DF-R 3.5–908, ENAC, Osada, Japan). During all procedures throughout the experiment the teeth were kept moist.

A #70 or #80 gutta-percha cone with a snug fit was placed 3 mm from the apical opening of each prepared root canal. It served as a matrix against which the root-end materials were condensed. Sixty teeth were divided into three equal groups of 20 teeth each. The root-end preparations were then filled with each of the following materials: IRM (L. D. Caulk Co., Milford, DE), Fuji IX (GC Corporation, Tokyo, Japan), and Sealer 26 (Dentsply, Petrópolis, RJ, Brazil). All materials except Sealer 26 were prepared according to the directions from the manufacturers. Sealer 26, a root canal sealer, was prepared in a thicker consistency than recommended by the manufacturer for root canal filling (4:1, vol:vol, powder:resin ratio).

Radiographs were made of all specimens to evaluate the quality of the root-end fillings. Five prepared teeth not retrofilled served as the *positive control group*. Another five teeth with intact crowns served as the *negative control group*. In all experimental and control groups no coronal sealing was done.

The apparatus used to evaluate bacterial leakage was modified from that described previously (8). Briefly glass assay tubes with rubber stoppers were adjusted for use in this experiment. By using a heated instrument a hole was made through the center of every rubber stopper in which a cylinder prepared from insulin syringes was inserted. The tooth crown was inserted under pressure within a rubber tube, which was fixed to the cementoenamel junction by means of cyanoacrylate. Syringe cylinders were then adapted on the another side of the rubber tube to create a reservoir to saliva. Cyanoacrylate was applied in the tooth/rubber tube, syringe/rubber stopper, and rubber tube/syringe junctions. The rubber stopper was then placed in position with the tooth inside the glass tube.

The testing apparatus was sterilized overnight in ethylene oxide gas. The glass assay tubes were then filled with sterile trypticase-soy broth (TSB) (Difco, Detroit, MI) so that ~2 mm of the resected root was immersed in the broth. To ensure sterilization the whole apparatus was incubated at 37°C for 4 days.

Afterward the reservoir of each whole apparatus was filled with human saliva mixed in TSB broth in a 3:1 (vol/vol) ratio. Saliva was collected from the laboratory staff and completely replenished every 3 days. The whole apparatus was then incubated at 37°C and checked daily for the appearance of turbidity in the TSB broth during 60 days. Data obtained were statistically analyzed using the $\chi^2$ test comparing pairs of groups, with the significance level established in 5% ($p < 0.05$).

## RESULTS

No growth was observed when checking the sterilization of the whole apparatus. All specimens of the positive control group showed broth turbidity within one day of incubation. By contrast there was no evidence of broth turbidity in the negative control group throughout the experiment. After 60 days of evaluation bacterial leakage was observed in all teeth of the Fuji IX group, and in 95% (19 of 20 specimens) of the teeth retrofilled with IRM. Sixty-five percent (13 of 20 teeth) of the teeth retrofilled with Sealer 26 showed leakage. Sealer 26 was significantly more effective in preventing bacterial leakage than the other materials tested ($p < 0.05$). No difference was detected between Fuji IX and IRM ($p > 0.05$). Data are shown in Table 1.

**TABLE 1. Distribution of teeth retrofilled with the different materials exhibiting bacterial leakage after 60 days of evaluation**

| Material | Total (*n*) | No Leakage | Leakage | % | Range (days) |
|---|---|---|---|---|---|
| Sealer 26 | 20 | 7 | 13 | 65 | 3–42 |
| IRM | 20 | 1 | 19 | 95 | 2–49 |
| Fuji IX | 20 | 0 | 20 | 100 | 2–42 |
| Positive control | 5 | 0 | 5 | 100 | 1 |
| Negative control | 5 | 5 | 0 | 0 | — |

## DISCUSSION

Dye leakage has been used for many years to evaluate the sealing ability of endodontic materials. Nevertheless when evaluating leakage inadequacies in dye leakage studies should be taken into account (3, 6 8–11). The molecular size of dye particles is less than that of bacteria. Thus dyes can give a false result because they can penetrate where bacteria cannot. In addition most of the studies measure the degree of dye leakage in only one plane. Other factors, such as pH and chemical reactivity, may also influence the degree of dye penetration. Dye leakage may also give false results because short-term exposure is usually required. Therefore because of inherent inadequacies in dye leakage studies, and a lack of correlation between dye particles and bacterial leakage, the sealing ability of endodontic materials may be better determined using a bacterial leakage model, that seems to have more clinical relevance.

To create and maintain a bacteria-tight seal, root-end filling materials should have adhesiveness to dentin, be dimensionally stable, be insoluble and impermeable to tissue fluids, and have antimicrobial activity. Root-end filling materials that have antimicrobial effects can theoretically prevent both microbial growth and leakage at the margins of the retrofillings. Chong et al. (12) assessed the antibacterial activity of a light-cured glass ionomer, three reinforced zinc oxide-eugenol cements and amalgam against two bacterial species and reported that the glass-ionomer cement had the most pronounced antibacterial activity against both bacteria. Torabinejad et al. (13) compared the antibacterial effects of amalgam, zinc oxide-eugenol, Super-EBA, and MTA on 16 bacterial species and found that none of the test materials had the antibacterial effectiveness desired for root-end filling materials.

Glass-ionomer cements have been reported to have several advantageous properties for using as restorative material, such as adhesiveness to tooth structure, fluoride release, and antimicrobial activity (14–16). Because of these properties glass-ionomer cements have also been recommended for use as retrofilling material (14). Nonetheless all teeth retrofilled with Fuji IX, a glass-ionomer cement, showed entire bacterial leakage after 60 days of evaluation. These results discourage the use of Fuji IX as a root-end filling.

Reinforced zinc oxide-eugenol cements were developed in an attempt to increase the strength and reduce the setting time of zinc oxide-eugenol cement. It has been reported that reinforced zinc oxide-eugenol cements, particularly IRM and Super-EBA, have shown favorable results in sealing ability, tissue tolerance, and clinical success (2, 17). It has been said that the sealing ability of IRM depends on how the material is manipulated. We mixed this material as suggested by the manufacturer. Our results revealed that practically all teeth retrofilled with IRM showed bacterial leakage at the end of the experiment. Therefore it appears that IRM does not have a good sealing ability against bacteria, at least in the powder:liquid ratio used herein (6:1 in weight).

Of the materials tested in the present study, Sealer 26 was the most effective in preventing bacterial leakage. Sealer 26 is a resinous cement similar to AH26. However it contains calcium hydroxide, but not silver, in its formulation. Studies have revealed that Sealer 26 as used as a root canal filling material possess antibacterial activity and has good apical and coronal sealing abilities (8, 18, 19). Although it is recommended for use as a root filling material, our findings indicated that Sealer 26 has a potential also to be used in retrofillings when it is prepared in a thicker consistency. Further laboratory and clinical studies can confirm the potential use of this material as a root-end filling.

This study was partially supported by grants from CNPq, a Brazilian Governmental Institution.

The authors are grateful to Mr. Fernando Magalhães and Dr. Wagner Alviano for their valuable technical assistance.

Dr. Siqueira is chairman and professor, and Drs. Rôças, Abad, Castro, Gahyva, and Favieri are assistant professors, Department of Endodontics, Estácio de Sá University, Rio de Janeiro, RJ, Brazil. Address requests for reprints to Dr. José F. Siqueira, Jr., R. Herotides de Oliveira 61/601, Icaraí, Niterói, RJ, Brazil 24230-230.

## References

1. Gutmann JL, Harrison JW. Surgical endodontics. 1st ed. Boston: Blackwell Scientific Publications, 1991.
2. Gartner AH, Dorn SO. Advances in endodontic surgery. Dent Clin N Am 1992;36:357–77.
3. Torabinejad M, Pitt Ford TR. Root end filling materials: a review. Endod Dent Traumatol 1996;12:161–78.
4. Lopes HP, Siqueira JF Jr. Endodontia: biologia e técnica. Rio de Janeiro: Medsi, 1999.
5. Sundqvist G, Figdor D. Endodontic treatment of apical periodontitis. In: Orstavik D, Pitt Ford T eds. Essential endodontology. Oxford: Blackwell Science Ltd., 1998, 242–77.
6. Torabinejad M, Rastegar AF, Kettering JD, Pitt Ford TR. Bacterial leakage of Mineral Trioxide Aggregate as a root-end filling material. J Endodon 1995;21:109–12.
7. Adamo HL, Buruiana R, Schertzer L, Boylan RJ. A comparison of MTA, Super-EBA, composite and amalgam as root-end filling materials using a bacterial microleakage model. Int Endod J 1999;32:197–203.
8. Siqueira JF Jr, Rôças IN, Lopes HP, Uzeda M. Coronal leakage of two root canal sealers containing calcium hydroxide after exposure to human saliva. J Endodon 1999;25:14–6.
9. Barthel CR, Moshonov J, Shuping G, Orstavik D. Bacterial leakage versus dye leakage in obturated root canals. Int Endod J 1999;32:370–5.
10. Khayat A, Lee S-J, Torabinejad M. Human saliva penetration of coronally unsealed obturated root canals. J Endodon 1993;19:458–61.
11. Torabinejad M, Ung B, Kettering JD. In vitro bacterial penetration of coronally unsealed endodontically treated teeth. J Endodon 1990;16:566–9.
12. Chong BS, Owadally ID, Pitt Ford TR, Wilson RF. Antibacterial activity of potential retrograde root filling materials. Endod Dent Traumatol 1994;10:66–70.
13. Torabinejad M, Hong CU, Pitt Ford TR, Kettering JD. Antibacterial effects of some root end filling materials. J Endodon 1995;21:403–6.
14. Barkhordar RA, Pelzner RB, Stark MM. Use of glass ionomers as retrofilling materials. Oral Surg 1989;67:734–9.
15. Fraga RC, Siqueira JF Jr, Uzeda M. In vitro evaluation antibacterial effects of photo-cured glass-ionomer liners and dentin bonding agents during setting. J Prosthet Dent 1996;76:483–6.
16. Prati C, Fava F, Di Gioia D, Selighini M, Pashley DH. Antibacterial effectiveness of dentin bonding systems. Dent Mater 1993;9:338–43.
17. Dorn SO, Gartner AH. Retrograde filling materials: a retrospective success-failure study of amalgam, EBA, and IRM. J Endodon 1990;16:391–3.
18. Siqueira JF Jr, Gonçalves RB. Antibacterial activities of root canal sealers against selected anaerobic bacteria. J Endodon 1996;22:89–90.
19. Siqueira JF Jr, Fraga RC, Filho PF. Evaluation of sealing ability, pH and flow rate of three calcium hydroxide-based sealers. Endod Dent Traumatol 1995;11:225–8.