Effect of Orifice Plugs on Periapical Inflammation in Dogs

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Abstract

Gutta-percha (G) and sealer do not resist coronal leakage. In this study, the effect of orifice plugs using dentin-bonding/composite resin(C) or IRM on coronal leakage was evaluated in vivo. Sixty-one premolar roots in three beagle dogs were instrumented and filled with G and AH 26(S), or G alone. The coronal 2 mm was replaced with C or IRM, or left untreated. The access cavities were kept open for 8 months, the dogs were killed and the periapical regions of the roots were histologically examined. Periapical inflammation was observed in 89% of the group without plugs, but in those with plugs, the occurrence was decreased to 39% (C + G + S), 38% (IRM + G + S) and 58% (C + G), respectively. Furthermore, severe inflammation was observed in 50% of the former group but only 0 to 17% of the latter. The substantial reduction in apical periodontitis by the use of coronal plug underscores the clinical importance of providing an additional barrier to coronal leakage in comparison to that provided by gutta-percha and sealer alone. *(J Endod 2006;32: 524–526)*

Key Words

Coronal leakage, orifice plugs, periapical inflammation

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The goal of the endodontic treatment is to prevent or cure apical periodontitis. Apical periodontitis is caused primarily by microorganisms and/or their by-products in the root canal system (1–4). Even after root canal filling under good microbial control, recontamination of root canal system can occur when microleakage takes place.

Gutta-percha combined with sealer (G/S), the most widely used root-filling material, has been demonstrated to be a poor sealing material (5–8). Swanson and Madison, for instance, reported that when the root canals filled with G/S are exposed to artificial saliva, microleakage occurred in the canal space in 3 days (5). Torabinejad and co-workers reported that over 50% of the root canals filled with G/S were contaminated after 19 days of exposure to *Staphylococcus epidermidis* and 50% were contaminated after 42 days exposure to *Proteus vulgaris* (6). Several in vivo studies have also demonstrated that when inoculated with plaque, 40 to 80% of premolar root canals filled with G/S resulted in mild inflammation (9, 10).

In an attempt to minimize the coronal microleakage upon G/S filling, Barthel and co-workers placed coronal seal with composite resin or IRM in vitro and examined its effect (11). The results showed that the sealability of the former had better sealing against bacteria when compared with the latter. Belli and co-workers (12) also demonstrated that dentin bonding adhesive materials showed less leakage than IRM. Mah and co-workers recently have demonstrated that, when access openings were inoculated with plaque, the placement of white mineral trioxide aggregate (MTA) as orifice plugs reduces the rate of inflammation in comparison to those without plugs (13).

All of these in vitro and in vivo studies have demonstrated that G/S alone leaks and that a placement of orifice plugs may be beneficial to prevent the microleakage (14, 15). The objective of this study was to further evaluate the effects of orifice plugs using IRM or dentin bonding/composite resin on coronal leakage in vivo where the root canals were exposed to oral environment. The coronal leakage was assessed by the occurrence and severity of periapical inflammation.

Materials and Methods

Animal Experiments

The study protocol was approved by the University of North Carolina Institutional Animal Care and Use Committee (IACUC). A total of 61 premolar roots in three beagle dogs were used for this study. The anesthetic induction was achieved by intravenous administration of thiopental (13.2 mg/kg body weight) followed by administration of 1 to 2 % isoflurane via an endotrachial tube. The dogs also received a local anesthetic (bupivacaine 0.5 ml/quadrant) as regional nerve block anesthesia. Animals were constantly monitored during the course of the study to ensure that any of the procedures was carried out painlessly. To minimize any postoperative discomfort for the dogs during the study, three pharmacological approaches were taken: (a) Rimadyl (2.2 mg/kg orally every 12 h) was given preoperatively beginning 24 h before the surgical session. (b) Upon termination of the surgical sessions, the dogs received an immediate subcutaneous injection of butorphanol (0.2 mg/kg) for postoperative analgesia. (c) The dogs were given Rimadyl postoperatively (2.2 mg/kg orally) every 12 h for 48 h to control inflammation or pain. The radiographic examination was conducted every two months for 8 months of experimental period. The dogs were fed their normal soft diet after root canal treatment. The mouths of the dogs were inspected for signs of obvious infections or ulcers. Food intake was also monitored.

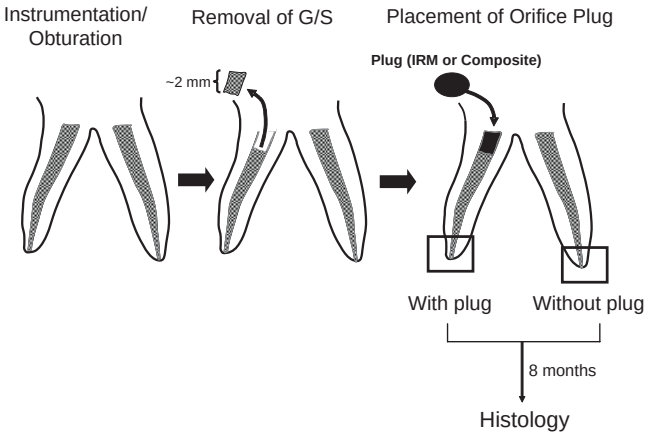

Figure 1. Illustration of the experimental procedures. After instrumentation and obturation are completed, for the group with plugs, 2 mm of coronal part of filled materials were removed and replaced with composite resin or IRM. See details in the text.

Root Canal Instrumentation and Orifice Plug Placement

All procedures were performed under strict aseptic conditions. Before treatment, the teeth were radiographed, pumiced, isolated with rubber dam, and wiped with chlorhexidine gluconate mouth rinse. Root canal instrumentations were performed with ProFile rotary files (Dentsply Tulsa Denatl, Tulsa, OK) and a #40 K file (Kerr, Romulus, MI) to working length. A total of 10 ml of 1.25% sodium hypochlorite (NaOCl) was used for irrigation between instruments with a syringe and a 27-gauge Monoject endodontic irrigation needle (Sherwood Medical, St. Louis, MO). All root canals were dried with sterile paper points and filled immediately after instrumentation. Each root canal was randomly allocated for filling with gutta-percha and AH26 (Dentsply, DeTrey, Germany) except one group that received gutta-percha but not sealer. Gutta-percha was fitted apically and then vertically thermoplastisized using the system B, i.e., continuous wave of condensation technique (System B, Analytic Endodontics, Orange, CA). A back fill with Obtura gutta-percha was carried out using the Obtura II system (Obtura Spartan, Fenton, MO).

After completion of root filling, the roots were divided into two groups. For the group with orifice plugs (a total of 43 roots), coronal 2 mm of filling material were removed and filled with IRM (L.D. Caulk Division, Dentsply International, Inc.) (G + S + IRM, $n = 13$) or composite resin (Kuraray Co., LTD, Japan) (G + S + C, $n = 18$; and G + C, $n = 12$). For the latter case, the canal space was treated with Clearfil SE Bond Primer (Kuraray Co., LTD) for 20 s and gently air dried for 3 to 5 s. Clearfil SE Bond adhesive was then applied with a brush and light cured for 10 s (Optilux501 Demetron/Kerr, Danbury, CT; intensity of 620 mW/cm$^{2)}$. The Photo Core (Kuraray Co., LTD) light cured composite resin was used to fill the space (40 s curing time). Another group, a total of 18 roots (G + S), received no orifice plugs.

The pulp chamber was kept open to the oral environment for 8 months. The procedures are summarized in Fig. 1.

Evaluation of Periapical Inflammation

After 8 months, the dogs were killed with the use of pentobarbital (iv administration), using a dosage of 30 mg/kg body weight. The upper and lower jaws were dissected, fixed with 10% phosphate-buffered formalin, and demineralized with 10% EDTA, embedded in a paraffin block, 5 to 7 μm sections were cut in a mesio-distal orientation to include root canal system with at least 1 mm of periapical tissue and stained with hematoxylin and eosin. At least six sections per root were cut and those exhibiting the canal system and periapical regions were selected. The periapical regions of the roots were then examined under a light microscope at $\times$10 magnification. The evaluators were blinded to the treatment groups and evaluated the histological sections. Periapical inflammation was rated as none: no inflammation with normal appearance of the root surface and surrounding tissue (Fig. 2*A*), mild: with infiltrate localized to the periodontal ligament space without evidence of bone and root resorption (Fig. 2*B*), severe: numerous inflammatory cells surrounded the periapical area with bone/root resorption (Fig. 2*C*).

Statistical Analysis

Wald Chi-squared tests were used to compare the proportions of inflamed versus noninflamed periapical tissues between treatment groups. This was done assuming that roots were independent, noncorrelated observations.

Results

All dogs tolerated the operative procedures well throughout the experimental period. There was no evidence of swelling or sinus tract associated with any of the treated teeth.

During the 8 months, no distinct periapical radiolucency was observed.

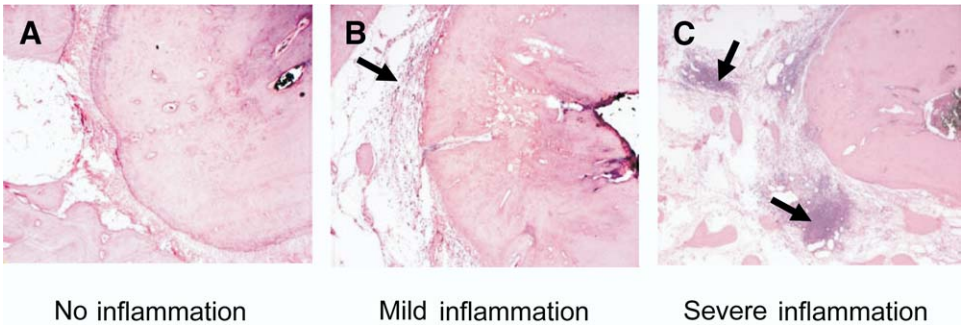

Figure 2. Typical histological images of (*A*) no inflammation, (*B*) mild inflammation, and (*C*) severe inflammation in periapical regions ($\times$10: H&E). With no inflammation, the root surface, periodontal ligament and alveolar bone are normal and the structures are well maintained. In the case of mild inflammation (*B*), in the periodontal ligament space there are some infiltrate but no sign of bone and root resorption. When severe inflammation occurs (*C*), the infiltrate is wide spread in periodontal ligament, and diffuse and dense inflammatory infiltrates are evident. Some cases, root and bone resorptions were observed. Areas of inflammation are indicated by arrows.

TABLE 1. Periapical inflammation with and without plugs

	Materials used		Periapical Inflammation	
	Root filling	Plug	Rate	Severity*
Without plug	G+S	—	16/18 (89%)	M = 7, S = 9
With plug	G+S	IRM	5/13 (38%)	M = 5, S = 0
	G+S	Comp	7/18 (39%)	M = 6, S = 1
	G	Comp	7/12 (58%)	M = 5, S = 2

*M, mild; S, severe.

Typical examples of the histological images of the specimens are shown in Fig. 2*A–C*. The results of histological evaluation are summarized in Table 1.

The group without plugs (G + S) showed an inflammation rate of 89%. Of those, severe inflammation was found in more than 55% of the roots. In the group with plugs, the inflammation rate was reduced to 38% (G + S + IRM), 39% (G + S + C), and 58% (G + C). Of those, severe inflammation was observed in 0, 14, and 30% of the roots, respectively.

The differences in the inflammation rate between the group without plugs (89%) and those with IRM (38%) or composite orifice plug (39%) were statistically significant ($p = 0.001$ and 0.004, respectively).

Discussion

It is well accepted that gutta-percha combined with any sealer used for root filling (obturation) do not sufficiently block the invasion of bacteria and/or their by- products, which leads to coronal microleakage and eventually periapical inflammation (5, 7, 8, 16). The results of the current study provide further evidence that these conventional filling materials alone can not block the coronal microleakage and, after 8 months of exposure to oral cavity, almost all the roots examined (89%) exhibited inflammation. More than half of those cases were severe inflammation.

The placement of orifice plugs showed significantly lowered rates of inflammation (by ~50%) when compared to the group without plugs. Even when only gutta-percha (without sealer) was used for filling, the placement of an orifice plug significantly improved in preventing the occurrence of inflammation. The results indicate that IRM or composite, as an orifice plug, is equally good in the prevention of microorganisms penetration of the entire root canal system. In this study, a potential variation within dogs was not taken into account. To further validate the conclusion, a more extensive study by increasing the number of animals and each treatment may be necessary.

IRM is one of the most commonly used temporary cement that contains zinc oxide-eugenol that has an anti-bacterial and anti-inflammatory effect. Although some in vitro studies reported that a sealability of IRM is poorer than that of composite (14), this material may prevent and/or delay the penetration of bacterial ingress for a certain period because of the anti-microbial effects.

Dentin adhesive composite resins have long been used in operative dentistry because of the tight bonding to dentin and a superior sealing ability (17). Though the use of this material as an orifice plug significantly reduced the rate of inflammation in comparison to the group without plugs, 39% of the roots still showed periapical inflammation indicating that the blockage was not sufficient. A possible explanation for this is an incomplete light cure because of the very limited access to the cavity space, and relatively narrow and deep cavities of orifice plugs (18). Utilization of other composite materials or modified techniques may be required to further improve the sealability. More extensive and long-term studies are clearly warranted to establish a better and more efficient system for orifice plug placement.

In conclusion, the results of this study demonstrate that the placement of orifice plug after root canal filling is beneficial to delay and prevent coronal microleakage.

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References

1. Kakehashi S, Stanley HR, Fitzgerald RJ. The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. Oral Surg Oral Med Oral Pathol 1965;20:340–9.
2. Saunders WP, Saunders EM. Coronal leakage as a cause of failure in root-canal therapy: a review. Endod Dent Traumatol 1994;10:105–8.
3. Bergenholtz G. Micro-organisms from necrotic pulp of traumatized teeth. Odontol Revy 1974;25:347–58.
4. Möller AJ, Fabricius L, Dahlén G, Ohman AE, Heyden G. Influence on periapical tissues of indigenous oral bacteria and necrotic pulp tissue in monkeys. Scand J Dent Res 1981;89:475–84.
5. Swanson K, Madison S. An evaluation of coronal microleakage in endodontically treated teeth. Part 1. Time periods. J Endod 1987;13:56–9.
6. Torabinejad M, Ung B, Kettering JD. In vitro bacterial penetration of coronally unsealed endodontically treated teeth. J Endod 1990;16:566–9.
7. Magura ME, Kafrawy AH, Brown CE Jr, Newton CW. Human saliva coronal microleakage in obturated root canals: an in vitro study. J Endod 1991;17:324–31.
8. Ray HA, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. Int Endod J 1995;28:12–8.
9. Shipper G, Teixeira FB, Arnold RR, Trope M. Periapical inflammation after coronal microbial inoculation of dog roots filled with gutta-percha or resilon. J Endod 2005;31:91–6.
10. Freidman S, Torneck CD, Komorowski R, Ouzounian Z, Syrtash P, Kaufman A. In vivo model for assessing the functional efficacy of endodontic filling materials and techniques. J Endod 1997;23:557–61.
11. Barthel CR, Zimmer S, Wussogk R, Roulet JF. Long-term bacterial leakage along obturated roots restored with temporary and adhesive fillings. J Endod 2001;27:559–62.
12. Belli S, Zhang Y, Pereira PN, Pashley DH. Adhesive sealing of the pulp chamber. J Endod 2001;27:521–6.
13. Mah T, Basrani B, Santos JM, et al. Periapical inflammation affecting coronally-inoculated dog teeth with root fillings augmented by white MTA orifice plugs. J Endod 2003;29:442–6.
14. Roghanizad N, Jones JJ. Evaluation of coronal microleakage after endodontic treatment. J Endod 1996;22:471–3.
15. Pisano DM, DiFiore PM, McClanahan SB, Lautenschlager EP, Duncan JL. Intraorifice sealing of gutta-percha obturated root canals to prevent coronal microleakage. J Endod 1998;24:659–62.
16. Beckham BM, Anderson RW, Morris CF. An evaluation of three materials as barriers to coronal microleakage in endodontically treated teeth. J Endod 1993;19:388–91.
17. Shindo K, Kakuma Y, Ishikawa H, Kobayashi C, Suda H. The influence of orifice sealing with various filling materials on coronal leakage. Dent Mater J 2004;23:419–23.
18. Schwartz RS, Fransman R. Adhesive dentistry and endodontics: materials, clinical strategies and procedures for restoration of access cavities: a review. J Endod 2005;31:151–65.