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Original

Comparison of the sealing ability of mineral trioxide aggregate and Portland cement used as root-end filling materials

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Abstract: Inadequate apical seal is the major cause of surgical endodontic failure. The root-end filling material used should prevent egress of potential contaminants into periapical tissue. The purpose of this study was to compare the sealing ability of four root-end filling materials: white mineral trioxide aggregate (MTA), gray MTA, white Portland cement (PC) and gray PC by dye leakage test. Ninety-six human single-rooted teeth were instrumented, and obturated with gutta-percha. After resecting the apex, an apical cavity was prepared. The teeth were randomly divided into four experimental groups (A: white MTA, B: gray MTA, C: white PC and D: gray PC; *n* = 20) and two control groups (positive and negative control groups; *n* = 8). Root-end cavities in the experimental groups were filled with the experimental materials. The teeth were exposed to Indian ink for 72 hours. The extent of dye penetration was measured with a stereomicroscope at 16× magnification. The negative controls showed no dye penetration and dye penetration was seen in the entire root-end cavity of positive controls. However, there was no statistically significant difference among the four experimental groups (*P* > 0.05). All retrograde filling materials tested in this study showed the same microleakage *in vitro*. Given the low cost and apparently similar sealing ability of PC, PC could be considered as a substitute for MTA as a root-end filling material. (J Oral Sci 53, 517-522, 2011)

Keywords: Mineral trioxide aggregate; Portland cement; microleakage; root-end filling material.

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Introduction

Root-end filling materials are applied after surgical root canal treatment to achieve a good apical seal that prevents egress of potential contaminants into periradicular tissue. Researchers have demonstrated that a proper apical seal is the most important factor for achieving success in surgical endodontics (1).

Several root-end filling materials have been used including silver amalgam, gutta-percha, zinc oxide-eugenol cements (IRM, Super EBA, Rickert), glass ionomer, composite resins, calcium hydroxide cements (Sealapex, Sealer 26), and most recently, Mineral Trioxide Aggregate (MTA). MTA has been favored due to its higher biocompatibility and sealing ability over the currently available root-end filling materials (2), which has been demonstrated by both *in vitro* and *in vivo* studies (3,4).

Recently, some studies which compared MTA with Portland Cement (PC) concluded that the principle ingredients of PC are similar to those of MTA; these include dicalcium silicate, tricalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrit (5). PC may therefore be considered as a possible substitute for MTA in endodontic application because of the low cost and similar properties. MTA contains bismuth oxide which increases its radiopacity, but PC lacks this ingredient (6,7). Root-end filling materials must be radiopaque to make them detectable and assessable by radiography. According to the ISO standard 6876 (International Organization for Standardization 2001), a radiopacity of 3 mm of aluminium is required for root filling materials. According to these standards, the radiopacity of MTA is adequate, but PC in its natural form is slightly radiopaque and does not comply with the requirement of the ISO standards (8). Weak radiopacity is the major disadvantage of PC, if it is applied clinically (2).

Other studies compared the biological effects of ProRoot MTA with PC. MTA and PC are not cytotoxic when evaluated ex vivo (9), while both of them release arsenic well below the level considered to be harmful (10), and both showed no significant cell reactions (11), and similar antimicrobial activity (12,13).

Surprisingly, beside the above mentioned biological comparisons between ProRoot MTA and PC, studies comparing the sealing ability of the two materials showed conflicting results. Therefore, the present study was designed to compare the sealing ability of white and gray MTA and white and gray PC used as root-end filling materials.

Materials and Methods

Ninety-six single-rooted extracted human teeth with mature apices, and without any root caries, root fracture or resorption were selected. The teeth had been extracted for periodontal reasons at the Tabriz Dental Faculty. After extraction, the teeth had been preserved in 10% formalin solution until their use in the present experiment.

The study protocol was approved by the Ethics Committee of Tabriz University of Medical Sciences (TUMS), and was in compliance with the Helsinki declaration.

The teeth were decoronated at the cemento-enamel junction with a separating disc (Dentorium, New York, NY, USA). Intra-canal tissue was extirpated by a broach (Moyco Union Broach, York, PA, USA) and canals were prepared by the Profile rotary system (Maillefer, Ballaigues, Switzerland). For the coronal preparation in a crown-down technique, OS #4, OS #3, 0.06/30, 0.06/25, 0.04/30 and 0.04/25 were used. For the apical preparation, 0.04/25, 0.04/30 and 0.06/25 were used. The canals were then obturated with laterally condensed gutta-percha (Ariadent Co., Tehran, Iran) and AH 26 sealer (Dentsply, GmbH, Germany). After canal obturation, the teeth were stored in 100% humidity for 48 h to prevent fracture during the cutting process. The roots were resected longitudinally with a fissure bur under constant water irrigation. Then, a 3-mm deep root-end cavity was prepared with ultrasonic tips (Kis 2d; Spartan, Fenton, MO, USA). The teeth were randomly divided into four experimental groups, each containing 20 teeth, and positive and negative control groups (each containing eight teeth). In group A, the apical cavities were filled with white ProRoot MTA (Dentsply-Tulsa Dental, Tulsa, OK, USA). In group B, C and D, the cavities were filled with gray ProRoot MTA (Dentsply-Tulsa Dental, Tulsa, OK, USA), white PC (Tehran Cement Co., Tehran, Iran), and gray PC (Sufiyan Cement Co., Tabriz, Iran), respectively. Filling materials were applied according to the manufacturer's instruction, using an MTA carrier (Sybro Endo., Orange, CA, USA), and a small cotton pellet was used to condense the material into the cavities. The entire surface of each tooth and the resected portion of root end were double coated with nail varnish. In the positive control group (group E), eight teeth were processed with root-end preparations but without root-end filling. In another set of eight teeth which served as the negative control (group F), apical root preparations were filled with test material (2 teeth for each material). Their entire external root surfaces were double coated with nail varnish, and then, sticky wax was used. The teeth from all groups were placed in Indian ink for 72 h. Vertical grooves were cut on the buccal and palatal aspects of all the specimens, and the teeth were longitudinally sectioned. Gutta-percha was removed, and the length of dye penetration between the filling material and tooth structure was measured separately in millimeters, using a calibrated stereomicroscope (Carl Zeiss, Oberkachen, Germany) at 16× magnification under same conditions. Linear dye penetration was measured independently by two observers at two different times under same conditions; the mean value of the recorded measurements was chosen as the extent of dye penetration into each specimen.

Statistical analysis was performed by SPSS software package, Version 13.0 for Windows (SPSS Inc., Chicago, IL, USA). Quantitative values are presented as mean ± standard deviation (SD). Distribution of variables was determined by Skewness, Kurtosis and Kolmogorov-Smirnov Z tests. Independent sample *t*-test and one-way analysis of variance (ANOVA) followed by a post-hoc Tukey test were used to determine the statistical difference between groups.

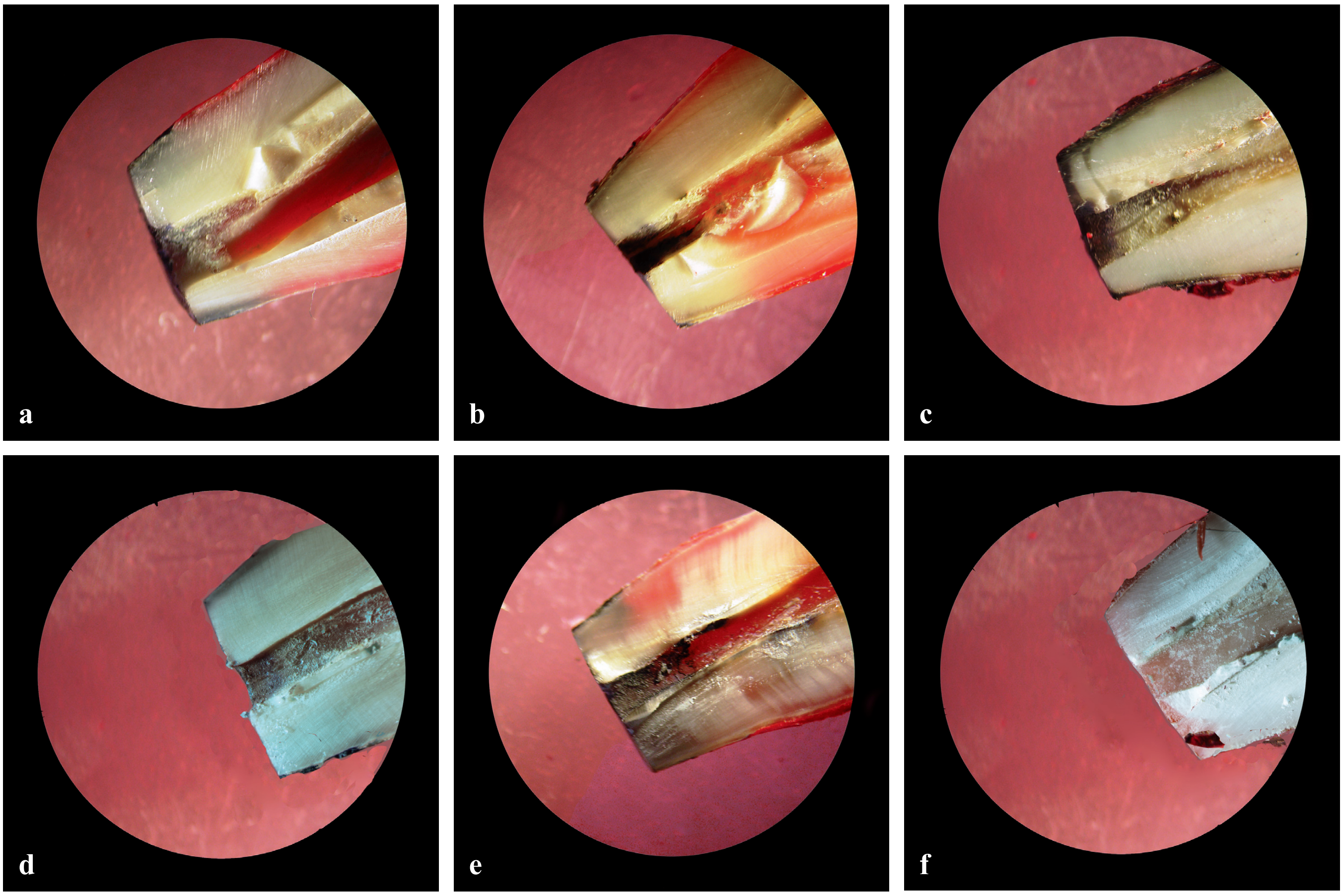

Fig. 1 Microscopic photographs of the experimental and control groups. (A) White mineral trioxide aggregate; dye penetration is shown between the white mineral trioxide aggregate and tooth structure. (B) Gray mineral trioxide aggregate; dye penetration is demonstrated between the gray mineral trioxide aggregate and tooth structure. (C) White Portland cement; dye penetration is revealed between the white Portland cement and tooth structure. (D) Gray Portland cement; dye penetration is shown between the gray Portland cement and tooth structure. (E) Positive control; dye penetration is seen in the entire root-end cavity. (F) Negative control; no dye penetration is seen.

Table 1 Results of microleakage assessment of the four experimental groups

Groups	Mean ± SD (mm)	Number of teeth	P*	P§	P†	P‡
A (WMTA)	0.18 ± 0.31	20	-	0.571	0.327	0.092
B (GMTA)	0.24 ± 0.31	20	0.571	-	0.650	0.248
C (WPC)	0.29 ± 0.32	20	0.327	0.650	-	0.461
D (GPC)	0.37 ± 0.35	20	0.092	0.248	0.461	-

SD: standard deviation, GPC: gray Portland cement, WPC: white Portland cement, WMTA: white mineral trioxide aggregate, GMTA: gray mineral trioxide aggregate. P*: compared with WMTA, P§: compared with GMTA, P†: compared with WPC, P‡: compared with GPC.

Results

Complete dye penetration into the prepared root-end cavities was observed in the positive control group, while, there was no dye penetration in the negative control group (Fig. 1). The microscopic photographs of the other four groups are presented in Fig. 1.

The mean levels of leakage in the experimental groups are shown in Table 1. Comparison of the degree of leakage did not show any statistically significant difference between the four experimental groups ($P = 0.355$). Post-hoc Tukey test, used for one-by-one comparison of the groups, demonstrated no statistically significant difference between the studied groups (Table 1).

Discussion

The present study compared the sealing ability of two root-end filling materials (MTA and PC). The results of the present study failed to demonstrate any significant difference in sealing abilities of the four root-end filling materials used: white MTA, gray MTA, white PC and gray PC.

Several studies have indicated that MTA exhibits significantly lesser leakage than other materials (4,14,15). As the components of MTA and PC are similar, these materials are expected to have similar properties and effects (16). Accordingly, PC may be used as a cheaper substitute for MTA in endodontic application. Our study findings were not consistent with the results of Matt et al. (17), who demonstrated greater microleakage for white MTA in comparison with gray MTA. However, the present study did not show any difference in microleakage between white and gray MTA. The disparity in results of these two studies may be attributable to differences in the methodology employed; Matt et al. placed MTA in an orthograde approach, but the present study inserted MTA in a retrograde approach into the cavities prepared at the root end. Coneglian et al. (18) also observed different results. They evaluated the sealing ability of apical plugs made of white and gray MTA-Angelus® and white PC placed via the root canal. The results showed that gray MTA and PC had better sealing ability than white MTA. In another study by Shahi et al. (19), sealing abilities of white and gray MTA mixed with distilled water and 0.12% chlorhexidine gluconate as root-end filling materials were compared. Their results were in agreement with the present results, which revealed similar leakage for gray MTA and white MTA. The results of the present study were also supported by Islam et al. (20), who compared the *in vitro* sealing ability of gray MTA, white MTA, ordinary PC and white PC when used as root-end filling materials. None of the teeth showed leakage beyond the retro-fillings, and the authors suggest that the cheaper PC with apparently similar properties could be considered as a logical substitute for MTA in endodontic application, if the results are supported by further *in vitro* and *in vivo* studies. De-Deus et al. (21) also did not find significant differences between the sealing ability of PC and MTA, when used as furcation repair materials.

Shahi et al. (22) compared the effectiveness of gray MTA and white MTA and both white PC and gray PC used as furcation perforation repair materials in a protein leakage study; they reported statistically insignificant differences between gray MTA and white MTA or white PC and gray PC, while significant differences were observed between the MTA group and PC group. They suggested that PC has better sealing ability than MTA, and can be recommended for repair of furcation perforation. However, they suggested further investigations, especially *in vivo* biocompatibility tests, to be conducted before PC can be recommended for clinical use.

Previous reports have demonstrated that MTA and PC are biocompatible (6, 23). Holland et al. (24) showed that MTA and PC demonstrate similar results when used in pulpotomy and protection of remaining tissue. Saidan et al. (11) revealed that the morphology and number of L929 cells found adjacent PC and MTA displayed no significant differences.

Shahi et al. (25) evaluated the effects of white MTA, gray MTA on inflammatory cells in rat and concluded that there were no significant differences between the two types of MTA after 21 days. In another study by Shahi et al. (26) on inflammatory cells, they concluded that MTA was more biocompatible than PC, but the difference was not significant after 90 days. Tenorio (27) showed that PC has physical, chemical and biological properties similar to MTA and levels of arsenic release are low; therefore, it does not exhibit toxic effects. According to Ribeiro et al. (28), MTA and PC were not genotoxic and do not induce cellular death, so, the physical properties of MTA and PC could also be similar.

Aquilina (29) demonstrated that accelerated PC had good sealing ability and adequate physical and mechanical properties for a restorative material. Results of these studies indicate that PC may show potential as a good root-end filling material.

In the present study, a dye penetration method was used for assessing the degree of microleakage; because, it is inexpensive to use, has a high degree of staining and has a molecular weight even lower than that of bacterial toxins. The limitation of dye leakage studies is that they measure the degree of leakage in only one plane, making it impossible to evaluate the total amount of leakage (30-32).

In conclusion, the results of the present study revealed no difference in microleakage between gray MTA, white MTA, gray PC and white PC. Given the low cost and apparently similar sealing ability of PC (20), PC may be considered as a possible substitute for MTA as a root-end filling material. Furthermore, the results of this study show that PC has the potential to be used in clinical situations similar to those in which MTA is currently being used, although the lower radiopacity of PC is its major disadvantage if it is to be employed clinically. However, further *in vitro* and *in vivo* investigations should be conducted to determine the suitability of PC for clinical application.

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