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Full Length Research Paper

Comparative investigation of marginal adaptation of mineral trioxide aggregate (MTA) and Portland cement as root-end filling materials: A scanning electron microscopy (SEM) study

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Apical seal is a major cause of surgical endodontic failures, so the use of suitable substance as root-end filling material that prevents egress of potential contaminants into periapical tissue is very important. The purpose of this study was to compare the marginal adaptation of four root-end filling materials [white mineral trioxide aggregate (WMTA), gray mineral trioxide aggregate (GMTA), white Portland cement (WPC) and gray Portland cement (GPC)] by SEM study. 40 human single-rooted teeth were instrumented, and obturated with gutta-percha. After resecting the root-end, apical cavity preparation were done. The teeth were randomly divided into 4 experimental groups (each containing 10 teeth). Root–end cavities in each group were filled with experimental materials. After 24 h, SEM examination was done to determine the distance between the root-end filling materials and the dentin of cavity walls. Statistical analysis of data showed that GMTA had significantly better adaptation between the experimental materials. GMTA and GPC have the highest and lowest degree of marginal adaptation respectively. The marginal adaptation in WMTA was better than WPC; however, there was statistically significant difference just between GMTA and GPC groups (p<0.001).

Key words: Marginal adaptation, root-end filling material, mineral trioxide aggregate (MTA), Portland cement, scanning electron microscopy (SEM).

INTRODUCTION

When nonsurgical root canal treatment fails to resolve periradicular lesion of endodontic origin, surgical endodontic treatment may be needed, so in these teeth the retrograde root canal therapy is the preferred approach (Torabinejad et al., 1995). The important factor in surgical endodontic treatment is achieving a good seal between the tooth and repair material (Lee et al., 1993). A number of materials have been advocated for this reason, such as amalgam, composite resins, cavit, glass Inomer, Portland cement and recently mineral trioxide aggregate (MTA) (Torabinejad et al., 1999).

Portland cement (PC) consist of dicalcium silicate, tricalcium silicate, tricalcium alominate, tetracalcium alominoferrite (Islam et al., 2006). The overall composition of PC is similar to MTA, except for the presence of bismuth oxide in PC (Camilleri et al., 2005; Islam et al., 2006; Asgary et al., 2009). Oxide bismuth

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Abbreviations: WMTA, White mineral trioxide aggregate; **GMTA,** gray mineral trioxide aggregate; **WPC,** white Portland cement; **GPC,** gray Portland cement; **SEM,** scanning electron microscopy; **PC,** Portland cement.

has been added to MTA to make the mix radiopacity (Torabinejad et al., 1993).

MTA is currently available commercially in two formulations; GMTA, a gray variety and WMTA (tooth colored formula), which do not have iron (Islam et al., 2006). Several studies compared biological effects of Pro root MTA with Portland cements showed both MTA and PC, were not cytotoxic *in ex vivo* (Ribeiro et al., 2005), and had no difference in cell reactions (Saidon et al., 2003) and have similar antimicrobial activity (Estrela et al., 2000).

From the point of sealing ability, Torabinejad et al. (1994) evaluated the sealing ability of amalgam, super EBA and intermediate restorative materials with dye leakage methods. The results showed that MTA leaked significantly less than all the materials.

In another study of Torabinejad et al. (1993) that compared the sealing ability of MTA with amalgam and super EBA with scanning electron microscopy (SEM), the same results were obtained.

Although, the physical properties and biocompatibility of MTA is well documented, there have been fewer studies evaluating the white MTA. Also, studies comparing the properties of GMTA and WMTA with Portland cement had conflicting results (Islam et al., 2006).

Among the retrograde material's properties, marginal adaptation is very important in endodontic surgery success (Stabholz et al., 1985; Peters and Peters, 2002). Because these properties will determine if the material is suitable for clinical use (Islam et al., 2006), so the purpose of this study was to compare the marginal adaptation of the GMTA and WMTA with GPC and WPC.

MATERIALS AND METHODS

40 single-root human teeth were used for this study. The teeth was preserved in formalin 2% and kept at 4°C before use. A standard coronal access cavity was prepared by using high-speed burs with water spray.

Intracanal tissue extirpated by a broach (Moyco Union Broach, York, PA, USA) and canal were prepared by the profile rotary system (Maillefer, Ballaigues, Switzerland). For the coronal preparation of a crown-down technique, OS #4 and OS #3 and the 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. Then the canals were obturated with laterally condensed gutta-percha (Ariadent Co, Iran) and AH 26 sealer (Dentsply, Germany). After canal obturation, the teeth were stored in 100% humidity for 48 h to prevent fragility during the cutting process. Then the teeth were apicected with a fissure bur (Denstply/Maillefer, Tusla, Ok, USA) under constant water spray. After preparing a 3-mm-deep root-end cavity with an ultrasonic tip (Kis 2d Spartan-Missouri-USA) on the resected root end, each cavity was irrigated with normal saline.

The teeth were randomly divided into four groups. In group 1 (n=10), each cavity was filled with gray Portland cement (Sufiyan Cement company, Tabriz, Iran) and in group 2, 3 and 4 the cavity were filled with WPC (Tehran cement Company, Tehran, Iran), GMTA (Dentply Tulsa Dental, Tulsa, Ok, USA)and WMTA (Densply- Tulsa Dental, Tulsa, OK, USA) respectively.

The samples were stored in 100% humidity at 37°C. After 48 h, the teeth were decoronated and each root was mounted on an aluminum stub. Then sputter coating with gold were done. The distance between the root end filling materials and cavity walls was measured under a scanning electron microscope (JSM 6320F; Japanese Electon Optics Laboratory, Tokyo, Japan) at four corners of each sample with 16× power. Kuruskal wallis and Man withney analyse were used to determine statistical difference between various groups.

RESULTS

The SEM examination of root end-filled teeth showed marginal gap at (57.5%) detin-filling interface. In 20% GMTA group, there was gaps between root-end filling and dentin, but 60% WPC and WMTA groups had gaps. The most gaps were seen in GPC group (90%) (Figure 1). Table 1 shows the mean ± SEs (µm) of gaps found in each group.

According to the results of Kruskal-Wallis tests, there was significant difference in marginal adaptation between the 4 experimental groups (p=0/006). Man Whitney test, which was used for two-by-two comparison of the groups demonstrated statistically significant difference just between GMTA and GPC groups (p<0/001). Although, the marginal adaptation in WMTA group was better than WPC, but there was not statistically significant difference between them (Figure 2).

DISCUSSION

Several studies have indicated that MTA is a suitable material for perforation repair and suitable for apical stop in endodontic application, because of its high sealing ability compared with other materials (Torabinejad et al., 1994; Tang et al., 2002; Camps and Pashley, 2003).

The present study compared the marginal adaptation of two root-end filling materials (MTA and PC). Because of similarity between the components of MTA and PC, it would be expected that these materials have similar properties and effects (Bidar et al., 2007).

Holland et al. (2001) showed that MTA and Portland cement have similar comparative results when used in pulpotomy. Saidan et al. (2003) revealed no significant difference in the morphology and number of L929 cells found adjacent Portland cement and MTA.

Shahi et al. (2006) evaluate the effects of WMTA, GMTA on inflammatory cells in rats and concluded that there were no significant differences between WMTA and GMTA after 21 days. In another study by Shahi et al. (2010) on inflammatory cells, they concluded that MTA were more biocompatible than Portland cement, but after 90 days the difference was not significant. Tenorio et al. (2010) showed PC has physical, chemical and biological properties similar to MTA but arsenic levels release are low, therefore unable to cause toxic effects. Ribeiro et al. (2006) concluded that MTA and Portland cement are not genotoxic and are not able to induce cellular death, so it

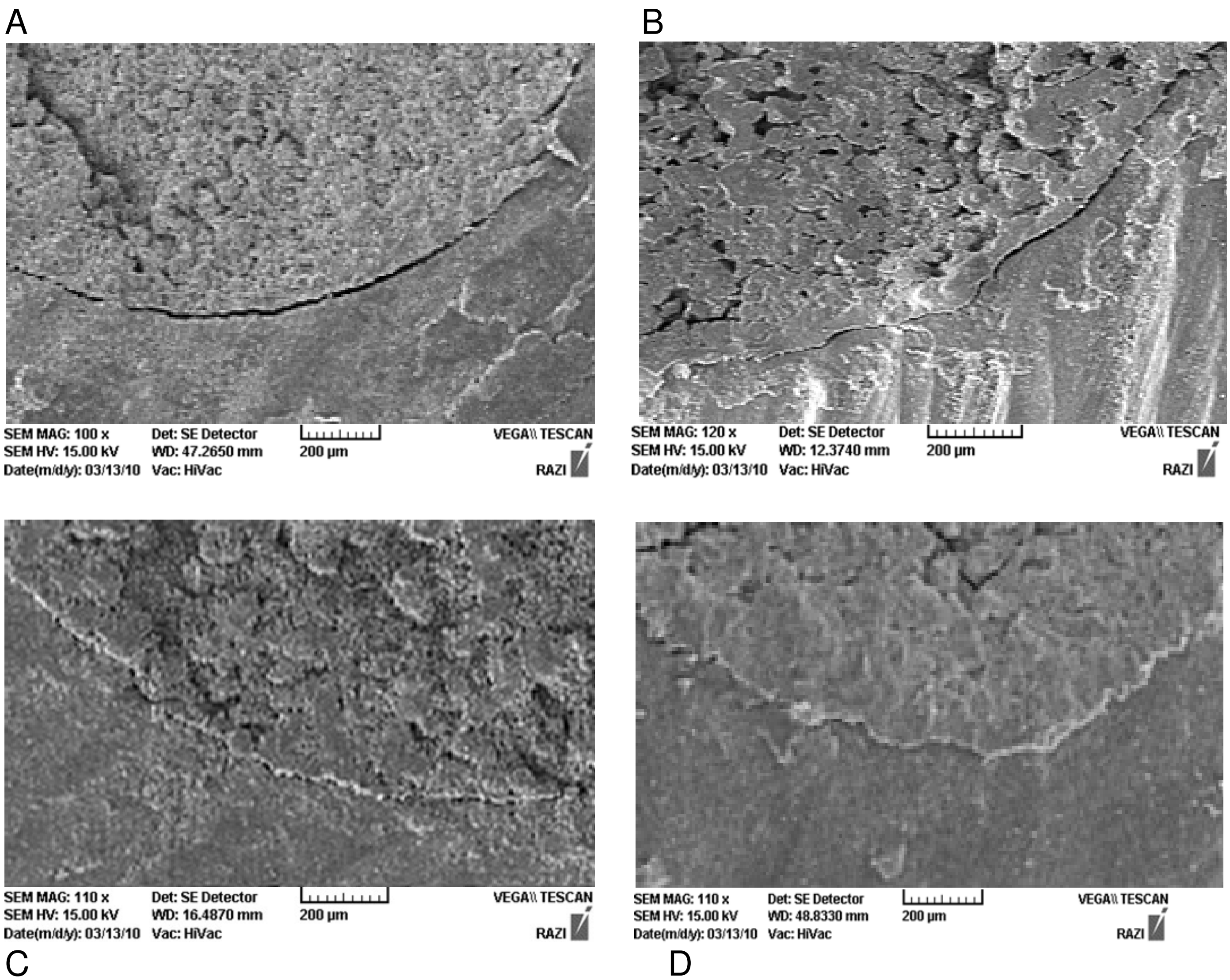

Figure 1. Scanning electron micrograph of samples filled with WPC(A), GPC(B), WMTA(C) and GMTA(D).

Table 1. The mean ± SEs (µm) of gaps between the experimental filling materials and dentinal walls.

Groups	Mean±SD (µm)	Minimum (µm)	Maximum (µm)
GPC	3.42±0.93	0	26.69
WPC	1.51±0.58	0	13.73
GMTA	0.33±0.25	0	9.44
WMTA	1.31±0.43	0	9.50

could be considered the same physical properties between MTA and PC. So if the other physical and mechanical properties of PC, such as marginal adaptation and microleakage, are similar to MTA, it is reasonable to consider Portland cement as a cheaper substitute for MTA in endodontic application.

In many studies a dye penetration method was used for the assessment of microleakage; however, the limitation of traditional dye leakage evaluation such as dissolution during the process; in addition, it is difficult to observe its maximum penetration depth in some cases and have been previously well addressed (Wu and Wesselink, 1993; Tamse et al., 1998). So in the present study, SEM examination was used to determine the marginal adaptation of root-end filling materials to the surrounding tooth structure. It should be noted that SEM examination

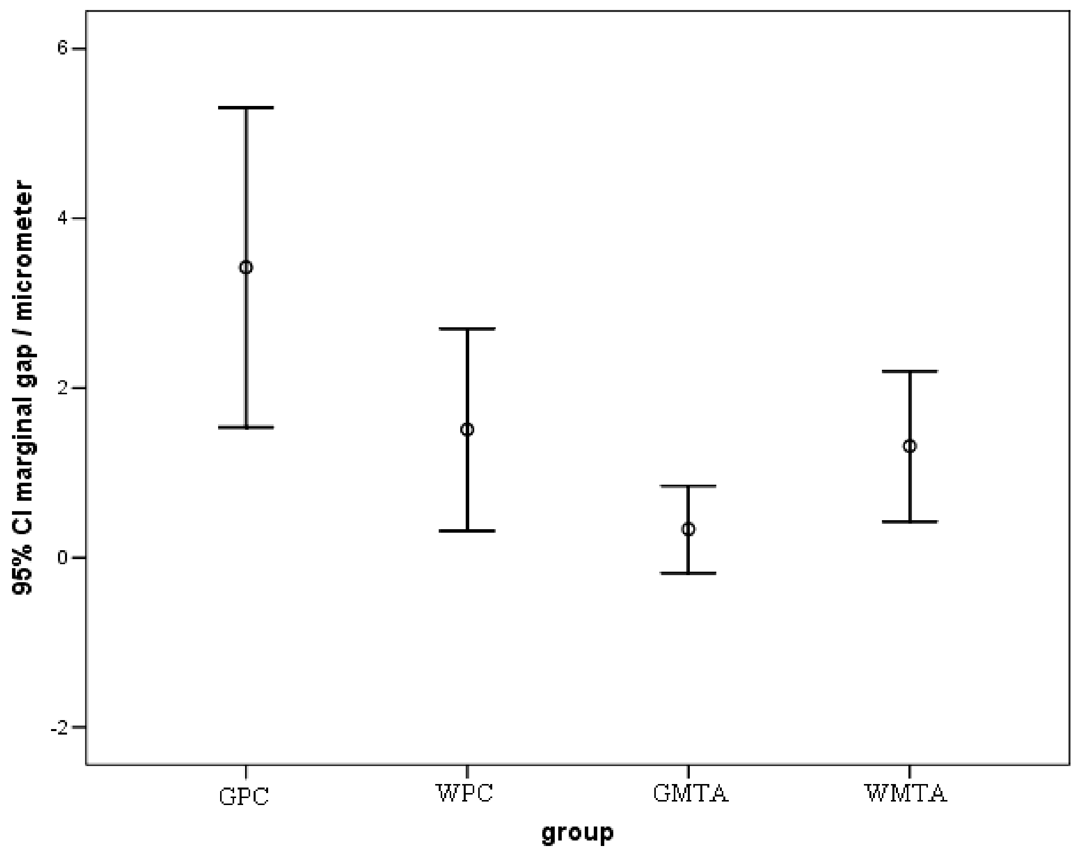

Figure 2. Mean gaps (µm) between root-end filling materials and dentinal walls.

is a suitable method for assessment of marginal adaptation (Bidar et al., 2007) and were developed because of its high magnification and good resolution (Torabinejad et al., 1995).

According to the present study, GMTA had high marginal adaptation than GPC. These finding are consistent with Bidar et al. (2007) study, which found the less gap between gray MTA and dentin wall than white MTA and Portland cement.

Mett et al. (2004) also showed gray MTA demonstrated significantly less leakage than white MTA. Conflicting results have been reported by Islam et al. (2005) who compared the *in vitro* sealing ability of GMTA, WMTA, GPC and WPC when used as root-end filling materials. None of the teeth in any of the test groups showed leakage beyond the retrofillings and they concluded that considering low cost of Portland cement and apparently similar properties, it is reasonable to consider Portland cement as a possible substitute for MTA in endodontic application. However, they suggest that further tests, especially *in vivo* biocompatibility tests, need to be conducted before recommendation of Portland cement as clinical use.

In De-Deus et al. (2006) study, by comparing the abilities of Portland cement and MTA to prevent coronal leakage through repaired furcal perforation, found no significant differences between them. Nevertheless, their study was conducted by methylene blue as dye tracer which the problem of discoloration of methylene blue in contact with MTA has been demonstrated (Wu et al., 1998).

Shahi et al. (2009) compared the sealing ability of GMTA, WMTA, GPC and WPC as furcation perforation repair material, and concluded that Portland cements have better sealing ability than MTA, and can recommended for repair. The difference in the results may be attributable to differences in components of materials. PC has the same major components in MTA except for bismuth oxide which resulting in rough amorphous pattern in surface topography. The fineness of cement is another major factor influencing rate of hydration and strength and setting characteristic of cement, as demonstrated the superiority of sealing ability of Portland cement that correlated to these physical properties (Asgary et al., 2008, 2009). But industrially manufactured PC is not approved currently for use in the United States and therefore no clinical recommendation can be made for its use in the human body (Islam et al., 2006).

Considering the results that are suggested in several previous studies as regard to physical and chemical consideration, MTA has superiority compared to cheaper

Portland cement (Abdullah et al., 2002; Saidon et al., 2003; Dammaschke et al., 2005).

The result of this study showed MTA has better performance in marginal adaptation than Portland cement, and it can be stated that MTA cannot simply be substituted by cheaper Portland cement, although, further studies by considering some variable such as larger samples and using the teeth with multiple roots are required in these regard.

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