Sealing Ability of MTA and Radiopaque Portland Cement With or Without Calcium Chloride for Root-End Filling

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Abstract

The aim of this study was to evaluate the influence of calcium chloride ($CaCl_2$) on the sealing ability of three Mineral Trioxide Aggregate (MTA) cements, ProRoot MTA, MTA-Angelus, and radiopaque White Portland cement (WPC), for retrograde root filling. Seventy roots of extracted single-rooted teeth were instrumented and obturated. After sectioning the samples at 2 mm from the apex, they received one layer of Araldite and two coats of nail enamel, except for the apical dentinal surface submitted to apicectomy. Standardized retrograde cavities were prepared, filled with one of the materials, and immersed in 0.2% Rhodamine B solution for 72 hours. Dye leakage was analyzed on a light microscope with ocular micrometer. Kruskal-Wallis and Miller tests were used to compare groups arranged in increasing order of leakage, according to mean rank of scores: WPC+$CaCl_2$, MTA-Angelus+$CaCl_2$, ProRoot MTA+$CaCl_2$, MTA-Angelus, ProRoot MTA, and WPC. $CaCl_2$ improved the sealing ability of all three MTA cements. *(J Endod 2006;32:897–900)*

Key Words

Calcium chloride, mineral trioxide aggregate, retrograde obturation

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Several retrograde root filling materials have been proposed and suggested, such as silver amalgam, gutta-percha, zinc oxide–eugenol cements (IRM, Super EBA, Rickert), glass ionomer, composite resins, calcium hydroxide cements (Sealapex, Sealer 26), and more recently the Mineral Trioxide Aggregate (MTA) (1, 2). MTA was originally designed for application in endodontic surgery as a root-end filling material and to seal communications between the root canal system and the periodontium (2–4). Other indications include direct and indirect pulp capping (5, 6), pulpotomies (7, 8), treatment of external and internal resorption (9), treatment of teeth with incomplete root formation (10, 11), and root canal filling (12–14).

Studies comparing MTA to Portland cement suggest that they are shown to be almost identical macroscopically, microscopically, and by X-ray diffraction analysis (15). Other study indicated that Portland cements contain the same chemical elements as MTA (16). For this reason, the manufacturer of ProRoot MTA modified the composition of this cement; according with information supplied in the Material Safety Data Sheet (75% Portland cement, 20% bismuth oxide and 5% calcium sulfate dehydrate).

MTA presents advantages against other obturation materials such as superior sealing ability (1–4, 14) and marginal adaptation (17), and the possibility of use in the presence of moisture (3). However, there are disadvantages when using MTA, such as the extended setting time and the difficulty handling (18).

Based on these results, a MTA cement was introduced into the Brazilian dental market in 2001 (MTA-Angelus, Angelus, Londrina, PR, Brazil), as an alternative to ProRoot MTA (Dentsply Tulsa, Tulsa, OK). MTA-Angelus contains 80% Portland cement and 20% bismuth oxide, with no addition of calcium sulfate (gypsum), in an attempt to reduce the setting time (19).

Abdullah et al. (20) reported that the setting time of Portland cement was successfully reduced by the addition of calcium chloride ($CaCl_2$), and the SEM analysis showed evidence that the accelerated Portland cement was nontoxic and biocompatible. $CaCl_2$ is often used to improve the properties of Portland cement, the major component of MTA. It is the main component of the additives of civil construction known as accelerators. The addition of $CaCl_2$ is intended to reduce the setting time of the Portland cement and to improve its physicochemical properties as well (21, 22).

The purpose of this study was to evaluate the influence of $CaCl_2$ addition on the sealing ability of two types of white mineral trioxide aggregate and a radiopaque white Portland cement, used as retrograde root filling materials.

Materials and Methods

Seventy mandibular extracted human premolars with intact and straight roots were used. The crowns of teeth were sectioned at the cemento-enamel junction with a separating disc (Dentorium, New York, NY). After instrumentation and obturation with gutta-percha and zinc oxide–eugenol cement, the roots were kept wrapped in gauze soaked in saline solution for 15 days. After this period, the roots were sectioned (#699, SSWhite, SP, Brazil) 2 mm from the apical end, at an angle of 90 degrees toward the long axis of the root at low speed, under constant irrigation with saline solution. Thereafter, all external surfaces of the roots were coated with one layer of a fast-setting epoxy resin (Araldite, Ciba Specialty Chemicals, Santo Amaro, SP, Brazil) and two additional coats of nail varnish (Risque, Com. Exp. Ind. SP) after 24 hours to avoid dye absorption by any

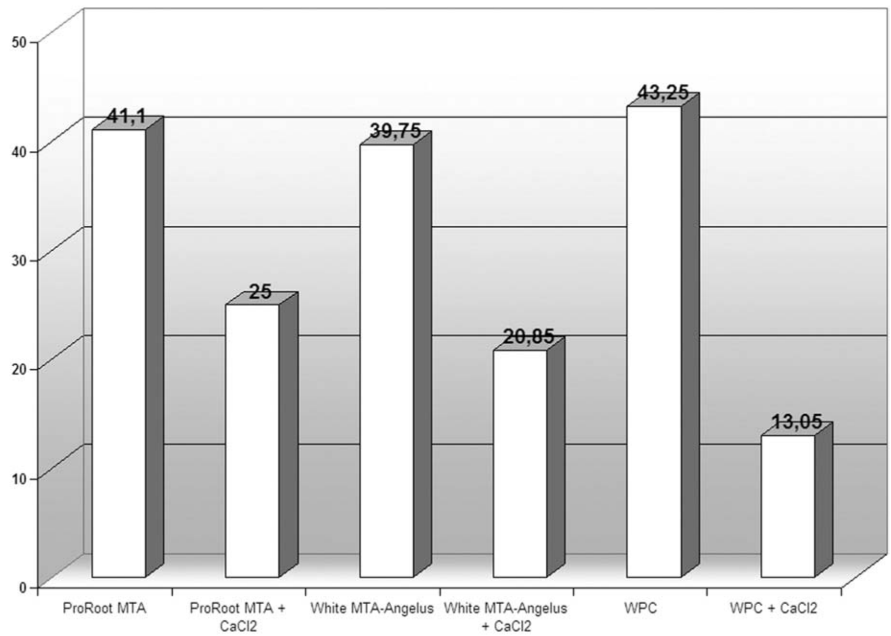

Figure 1. Mean rank of scores for marginal microleakage observed in the cements analyzed.

other tooth surface which was not under interest. Care was taken to prevent application of the materials on the apical dentinal surface exposed by root-end resection.

The root-end cavities (4-mm depth) were prepared in a parallel direction toward the root long axis, with a round bur #2 (Maillefer, Ballaigues, Switzerland) at low speed, under saline solution irrigation. The samples were divided into experimental groups ($n = 10$ teeth) according to the root-end filling material employed, as follows:

Group I: ProRoot MTA (Dentsply Tulsa): 1.0 g.

Group II: ProRoot MTA (Dentsply Tulsa) with 10% $CaCl_2$ (Labsynth, Diadema, SP, Brazil): 1.0 g MTA with 0.1 g $CaCl_2$.

Group III: White MTA-Angelus (Angelus, Londrina, PR, Brazil): 1.0 g.

Group IV: White MTA-Angelus (Angelus) with 10% $CaCl_2$ (Labsynth): 1.0 g MTA with 0.1 g $CaCl_2$.

Group V: White Portland cement (WPC) (Irajazinho, Votorantim Cimentos, São Paulo, Brazil) with bismuth oxide (20% weight) (Seelze, Hannover, Germany): 0.8 g WPC with 0.2 g Bi_2O_3.

Group VI: White Portland cement (WPC) (Irajazinho) with bismuth oxide (20% weight) (Seelze) and 10% $CaCl_2$ (Labsynth, Diadema, SP, Brazil): 0.8 g WPC with 0.2 g Bi_2O_3 and 0.1 g $CaCl_2$.

Because WPC does not contain a radiopaque agent (16, 18) we added bismuth oxide (20% wt.), i.e. the same quantity found in MTA, to simulate a material for clinical use. Retrograde root filling and coating was not performed on five roots, which were obturated with gutta-percha and zinc oxide-eugenol cement and were used as positive controls. In addition, five teeth that were instrumented, obturated, and submitted to apicectomy were completely covered with fast-setting epoxy resin and nail varnish, and these served as negative controls. The cements were placed into the root-end cavity with a condenser, and polishing was performed with an amalgam burnisher. Immediately after completion of the obturation procedures, the specimens were immersed in 0.2% Rhodamine B solution for 72 hours in an oven at 37°C. The coating was subsequently removed; the roots were rinsed in tap water for 12 hours and sectioned in a buccolingual direction at the apical root portion with separating discs (Dentorium Int., New York), exposing the root-end filling.

Analysis of the extension of dye leakage was performed by a surface micrometer technique, using reflected light, under a light microscope with objective lens with 4× magnification and a ocular micrometer, according to a 0-3 scale: 0 (no leakage), 1 (leakage up to the first third of the retrograde obturation), 2 (leakage up to the second third of the retrograde obturation), and 3 (leakage through the retrograde obturation). After calibration, two independent examiners performed the evaluation and were blinded to the material (Kappa value = 0.92). The scores were plotted and submitted to the Kruskal-Wallis test for possible differences between materials, and Miller test for individual comparisons.

Results

Figure 1 shows the mean rank of leakage scores, in the following increasing order: WPC + $CaCl_2$ (MP = 13.05), White MTA-Angelus + $CaCl_2$ (MP = 20.85), ProRoot MTA + $CaCl_2$ (MP = 25.0), White MTA-Angelus (MP = 39.75), ProRoot MTA (MP = 41.1), and WPC (MP = 43.25). WPC + $CaCl_2$ (group VI) and White MTA-Angelus + $CaCl_2$ (group IV) presented the lowest mean scores of leakage. Kruskal-Wallis test revealed statistically significant differences among groups ($H = 28.38$; $p < 0.001$). The Miller's test revealed a statistically significant disparity between White MTA-Angelus + $CaCl_2$ and WPC, White MTA-Angelus and WPC + $CaCl_2$, WPC + $CaCl_2$ and WPC, WPC + $CaCl_2$ and ProRoot MTA. Mann Whitney's test was performed to verify the influence of $CaCl_2$ regardless of the material. The results have shown statistically significant differences ($p < 0.05$) (Fig. 2).

Discussion

MTA has been investigated and used since its introduction. Despite its good physical and biological properties, MTA has some disadvantages such as long setting time and high cost. The search for alternative materials is aimed to reduce costs and to increase the feasibility to professionals and patients. For this reason, MTA has been compared to

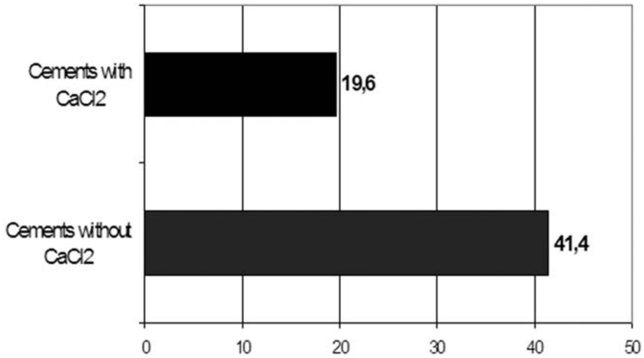

Figure 2. Mean rank of scores for marginal microleakage observed in the cements with or without $CaCl_2$ analyzed.

Portland cement, and the investigations have demonstrated that both cements exhibit similar chemical composition and physical and biological properties (16, 18, 23, 24).

Abdullah et al. (20) added 10% and 15% $CaCl_2$ to Portland cement and found biological results similar to those achieved with pure MTA and Portland cement. $CaCl_2$ has been used in civil construction as an additive to Portland cement since 1873, to regulate its setting time. It is the main component of the substances known as accelerators (21). These elements present a chemical action (25) and are indicated when concrete is required in short-term, such as for foundations, tunnels, paving, canals, plumbing, urgent repairs, etc. They accelerate the onset and final setting of the cement, reduce the incorporation of water, and allow the cement to resist hydrostatic pressure, even at early stages, therefore avoiding the leaching of cement by water (21). These properties are desirable when retrograde obturation cavities are filled during surgery. The inclusion of calcium chloride to the studied materials also accelerated their setting time.

Abdullah et al. (20) reported that the improvement of the setting time by addition of $CaCl_2$ does not interfere with the biocompatibility and osteoconductive potential of pure cement. They also observed that the incorporation of $CaCl_2$ did not change the basic shape of cement crystals and did not interfere with the chemical composition of cement, which is primarily composed of calcium and phosphate ions.

Figure 1 reveals that group VI (WPC + $CaCl_2$) and group IV (White MTA-Angelus + $CaCl_2$) displayed the lowest mean rank of leakage scores, providing better sealing than the other cements. In this study, ProRoot MTA exhibited high values of leakage, similar to Silva Neto et al. (26), but different from the findings of other authors (1, 27). This divergence may be explained by the methodology employed by these researchers, who allowed for a 24-hour period in a moist environment before placing the specimens in dye. This interval is sufficient to allow for the MTA to set and undergo some expansion, increasing its sealing ability as a consequence (2). In this study, the specimens were immersed in dye immediately after retrograde obturation. This allows the evaluation of the material sealing immediately after insertion in the cavity, during the setting time, reproducing more closely the clinical conditions.

Torabinejad et al. (1) observed greater leakage when teeth receiving MTA retrograde obturation were immediately placed in dye. The authors suggested that this occurred because of the long setting time of the material. The studies of Torabinejad et al. (3) demonstrated that marginal leakage from MTA was minimal or absent, despite the dye employed in their study was methylene blue. It should be remembered that methylene blue is discolored by contact with the alkaline material, thus losing its labeling ability (28–30). MTA presents high pH (12.5) and contains calcium oxide, which leads to calcium hydroxide formation when it contacts water, revealing discoloration by methylene blue.

Rhodamine B is an organic dye compounded by a red-violet powder, classified as a xanthenic dye (31). It presents greater diffusion on human dentin than methylene blue (32, 33). According to Franci (34), the molecules of Rhodamine B are nanometric, and are optimal to simulate enzymes and toxins of leakage resulting from bacterial metabolism.

According to Azoubel and Veeck (35), Rhodamine B dye should be used in leakage studies because of the small particle size, ease of visualization and large dissemination into dentinal tubules. This dye solution contains low molecular weight particles, which could best represent the spread of toxic by-products into micro spaces between the root canal filling and the root canal wall. Recent studies has shown dyes presenting these properties (14, 17).

The Miller's test demonstrated a statistically significant difference between groups White MTA-Angelus + $CaCl_2$ and WPC, White MTA-Angelus and WPC + $CaCl_2$, WPC + $CaCl_2$ and WPC, WPC + $CaCl_2$ and ProRoot MTA. Generally, $CaCl_2$ improved the sealing ability of the cements (Fig. 2). The White Portland cement with calcium chloride was statistically superior to the other cements, according with Miller test ($p < 0.05$). This finding can be explained by the nonstructural constitution of this cement, which contains lower content of calcium sulfate (gypsum) when compared to structural cements. Calcium sulfate (gypsum) permits a delay in the setting time of the Portland cement (25). For this reason, it was removed from the formula of White MTA-Angelus, which exhibited the second best result. When combined to the effect of $CaCl_2$ addition, the calcium sulfate accelerated the setting time, probably reducing dye leakage. The nonstructural Portland cement is rich in carbonate materials, such as limestone. Such addition makes concretes and mortars easier to handle, because the grains or particles of these milled materials present proper dimensions to intersperse within the grains or particles of the other components of cement, therefore acting as a lubricant. When these particles are present in the cement, they are termed calcareous fillers (25). This led to greater affinity between $CaCl_2$ and the cement, enhancing the preparation and handling of the material. A pilot study conducted by the present authors also demonstrated that the setting time is reduced. $CaCl_2$ provided higher luster, shorter drying time on the glass slab, and lower amount of water in the mixture.

Conclusion

The addition of $CaCl_2$ improved the sealing ability of all three MTA cements. Among the materials investigated, white $CaCl_2$–containing Portland cement presented the lowest mean rank of marginal leakage scores.

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