Ex-vivo Sealing Ability of Different Thicknesses of White and Gray Angelus MTA as an Intra-orifice Barrier in Endodontically Treated Teeth

Original Article

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Received:5 Nov 2014
Accepted: 10 Jan 2015

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Abstract

Introdouction:

It is important for the clinician to be aware regarding the necessary thickness of materials used as intra-orifice coronal barriers to prevent microleakage. The purpose of this in vitro study was to compare coronal microleakage of three different thicknesses of white and gray Angelus mineral trioxide aggregate (WAMTA, GAMTA).

Materials and methods:

A total of 66 canals of extracted maxillary central incisors were instrumented and obturated with gutta percha and AH26 sealer using cold lateral compaction technique. The teeth were randomly divided into two experimental groups of 30 teeth each according to the material tested (WAMTA and GAMTA) and two negative and positive control groups of three teeth each. The experimental groups were then subdivided into three groups of 10 teeth each according to the coronal plug thickness (2, 3, and 4 mm). The obturation material was removed upto the experimental depths and was sealed with tested materials. Sealing ability was evaluated by the dye penetration method using Pelikan ink and a stereomicroscope at ×10 magnification and 0.01 mm accuracy. Data were analyzed by analysis of variance (ANOVA) and t-test.

Results:

t-test analysis revealed that there was no significant difference between coronal microleakage of GAMTA and WAMTA at depths of 2, 3, and 4 mm ($P < 0.88$, $P < 0.285$, $P < 0.62$). ANOVA test revealed that there was no significant difference between leakage of different thicknesses of WAMTA ($P < 0.365$) and GAMTA ($P < 0.217$).

Conclusion:

Coronal microleakage of 2-mm thickness of WAMTA and GAMTA had no statistically significant difference with 3-mm and 4-mm thicknesses of the materials.

Key words:

• Coronal seal • MTA •Thickness

Introduction

The importance of coronal seals in successful endodontic treatments is well known[1-3]. Placement of an intra-orifice barrier is recommended in endodontically treated teeth in order to protect the root canal system from bacterial leakage and saliva contamination prior to the placement of the final restoration or in cases where the temporary restoration is lost.[4,5] Furthermore, it is recommended that the protective barrier should be used over the coronal extent of the root canal filling to prevent leakage of bleaching agents into the periodontium during non-vital bleaching.[6] Among the various sealing materials used to produce a coronal barrier, mineral trioxide aggregate (MTA) has gained much attention in recent years.[7-14]

The original formulation of MTA, developed at Loma Linda University, is manufactured by Dentsply International (ProRoot MTA and Tooth Colored MTA; Dentsply-Tulsa Dental, Tulsa-USA; Dentsply-Johnson City-USA)[15]. Other MTA types available are white and gray Angelus mineral trioxide aggregates (WAMTA, GAMTA; Angelus, Londrina, PR, Brazil). Data reveals that the chemical composition of AMTA differs from that of MTA. The actual composition of GMTA is 75% Portland cement (PC), 5% calcium, and 20% bismuth oxide, whereas AMTA is comprises 80% PC and 20% bismuth oxide [16, 17]. Data from two different investigations demonstrated that the amount of bismuth oxide, magnesium phosphate [18], carbon, oxygen, bismuth, and silica[16] are higher in GMTA than in AMTA, and the amount of calcium [16], calcium carbonate, calcium silicate, and barium zinc phosphate [18] are higher in AGMTA. The investigators also reported that more than 50% of the crystalline structures of GMTA comprised bismuth oxide, in comparison with 40% in AGMTA. AMTA revealed the presence of aluminum and the absence of iron; conversely, GMTA exhibited the presence of iron and the absence of aluminum [16]. Different chemical compositions of MTA may affect the physical properties of the material such as setting time, setting expansion, solubility, compressive strength, and finally, sealing ability.The thickness of the intra-orifice barrier plays an important role in the prevention of coronal microleakage.

There are a limited number of studies investigating the coronal sealing ability of MTA and most of them compare the properties of 3 mm thick WMTA with other materials[7-9]. Two investigators evaluated the coronal sealing ability of 2 mm thick ProRoot MTA[10, 11], whereas others compared the coronal sealing ability of 4 mm thick ProRoot MTA with other materials[12, 13]. Only, Jenkins et al[14] compared the sealing ability of 1, 2, 3, and 4 mm thicknesses of cavit, ProRoot MTA and tetric as intra-orifice barriers. Thus, the sealing ability of different thicknesses of WAMTA and GAMTA as a coronal barrier remains uncertain for the clinician. The aim of this in vitro study was to compare coronal sealing ability of different thicknesses of GAMTA with WAMTA as intra-orifice barriers.

Materials and Methods

Sixty-six recently extracted, human, permanent central incisors with single canals and mature apexes were collected. The teeth were disinfected using 5.25% sodium hypochlorite for thirty minutes. All specimens were decoronated at the cementoenamel junction, so that the remaining roots were about 15 ± 1 mm. A #10 K-file (Mani, Japan) was inserted and advanced into the canal until it was seen protruding through the foramen. Working length was calculated by subtracting 1 mm from this level. All root canals were cleaned and shaped with K-files (Mani, Japan) using the step-back technique upto #40 file. Flaring was performed using Gates Glidden #1 through #3 (Mani, Japan), followed by hand files #45-70. Irrigation with 2.5 ml of 2.5% Sodium hypochlorite solution was performed using a 22-gauge needle between each file.

Using #5 Gates Glidden bur, the orifice diameter of all samples was uniformly prepared to a depth of 4 mm. Flaring of the canals was checked for uniformity using 4 endodontic hand pluggers (VDW, Germany) at different depths of 7, 9, 11, and 13 mm from the apical foramen.

All canals were filled with AH26 sealer (Dentsply Detrey, Switzerland) and gutta-percha points (Gapadent, Korea) using cold lateral compaction method. The quality of obturation was checked radiographically in all samples. All preparations were completed by a single operator. The sixty six roots were then randomly divide into two experimental groups of 30 teeth each based on the material (white and Gray Angelus MTA) being tested. Two negative and positive control groups of 3 teeth each were also created. Each experimental group was then subdivided into three groups of 10 teeth each, according to the coronal plug thickness (2, 3, and 4 mm) used. A flamed-heated hand plugger was used to remove gutta-percha upto the experimental depths and were verified using a periodontal probe. WAMTA and GAMTA (Anglus, Brazil) were prepared according to the manufacturers, instructions and then placed into the orifices. Every one spoon of MTA was mixed with one drop of distilled water for 30 s. The homogenous mixtures were placed at depths of 2, 3, or 4 mm into the orifices using a plastic amalgam carrier. Condensation was performed using pluggers (VDW, Germany).

A moist cotton pellet was placed over the MTA and maintained at 100% humidity and 37°C for 24 h to allow the barriers and sealers to set. Two layers of nail polish were applied on all experimental teeth from the root apex to the level of the cementoenamel junction so that the dye could only penetrate coronally. Negative control teeth were obturated using cold lateral compaction of gutta-percha and sealer, and completely coated with nail polish including the orifice. Positive controls were obturated, but their orifices were not coated with nail polish.

After keeping all samples in Pelikan ink (Pelikan, Germany) for 7 days, the roots were washed with water and were left to dry for 24 h. Nail polish was then removed using Acetone and the roots were sectioned buccolingually. The greatest depth of penetration of the dye, measured from the coronal extent of the orifice, was assessed blindly by two examiners using a stereomicroscope (Olympus, Tokyo, Japan) and a digital caliper (LG, Korea) to 0.01 mm accuracy. The mean score was calculated. Finally, collected data were compared using analysis of variance (ANOVA) and t-test at a significance level of $p<0.05$.

Results

One tooth in the 4-mm thick GAMTA group was fractured during longitudinal sectioning. The negative leakage control demonstrated no dye penetration, whereas the positive leakage control showed dye penetration along the entire root canal.

The mean linear dye leakage for all groups is shown in Table-1. Analysis showed that there was no significant difference in coronal microleakage between GAMTA and WAMTA used at depths of 2, 3, and 4 mm ($P < 0.88$, $P < 0.285$, $P < 0.62$). ANOVA test showed that there was no significant difference in leakage with different thicknesses of WAMTA ($P < 0.365$) and GAMTA ($P < 0.217$).

Table 1. Mean dye leakage (mm) in all groups

Groups	AWMTA	AGMTA	P value
2-mm thickness	2.74 (1.48)	2.67 (0.55)	0.88
3-mm thickness	3.44 (1.55)	2.88 (0.04)	0.28
4-mm thickness	2.58 (1.16)	2.34 (0.92)	0.62
P value	0.36	0.21	

Discussion

Longitudinal sectioning of the roots and linear measurement of Pelikan ink penetration were used in this study to measure coronal leakage. Previously published reports showed that MTA is a bioactive material that produces calcium hydroxide [19, 20], which is released in solution.[21, 22] Therefore, we used Pelikan ink in this study because this dye is not discolored by calcium hydroxide, as shown previously. [23, 24] In this study, extracted central teeth with large and straight canals were selected and were instrumented to # 40 file. The diameter of the orifices and root canal flaring were also checked to be equal. In this way, variability in anatomy, canal size and diameter, which can affect the dye leakage, were minimized. As it has been reported that longer roots have a potential for greater leakage [25], roots with 15 ± 1 mm length were used.

In order to eliminate operator variability, all preparations were completed by a single operator. Two examiners measured dye leakage levels in order to eliminate or reduce possible bias and evaluator error. A simple irrigation method (without chelating agents) was used to avoid the effects of the calcium-chelating property of EDTA on the apical seal. EDTA has been shown to disrupt the hydration of MTA, resulting in decreased hardness and less than optimal biocompatibility.[26]

According to the results of the present study, there was no significant difference in coronal microleakage between GAMTA and WAMTA at depths of 2, 3, and 4 mm. This was supported by previously published reports of John et al [10] and Tselink et al. [9] Using a fluid flow model, John et al [10] reported no significant differences in leakage between 2 mm intra-orifice barriers of Fuji Triage glass ionomer, ProRoot gray and white MTA. Tselnik et al [9] also reported no statistically significant difference in bacterial leakage between 3 mm barriers of gray and white MTA in 30, 60, or 90 days.

Our results also showed that there was no significant difference in leakage with different thicknesses of WAMTA and GAMTA.

These results were in agreement with the study performed by Jenkins et al. [14] Using dye penetration method, they compared sealing ability of 1, 2, 3, or 4 mm of cavit, ProRoot MTA or Tetric. They reported no significant interactions between the test materials and orifice depths, or any significant effects of orifice depth. However, our results did not comply with those of Coneglian et al. [27]

Using 0.2% Rhodamine B solution, Coneglian et al [27] compared the sealing ability of different thicknesses of apical plugs made of white and gray MTA-Angelus and white Portland cement as root-end filling materials, and reported that dye leakage was lower for 5- and 7-mm thick plugs compared with 2-mm-thick plugs, regardless of the material utilized.

One possible reason for this difference may be that placement and compaction of MTA in the apical region of the canal is more difficult than that of the coronal part due to the differences in root canal diameter and anatomy. Another possible explanation could be differences in methods used for fabrication and condensation of MTA. We used amalgam carriers for fabrication of the coronal plugs and then condensed the materials using pluggers, as previously recommended by Torabinejad and Chivian.[28] Coneglian et al used a size 4 lentulo spiral for fabrication of apical plugs and condensed the materials with a K-file, which was compatible with the root canal diameter and had its tip wrapped in cotton mesh.

Conclusion

Coronal microleakage seen with 2-mm thick WAMTA and GAMTA had no statistically significant difference with 3-mm and 4-mm thicknesses of the materials.

Acknowledgment

This investigation was based on a thesis submitted by the second author to the faculty of Dentistry of Medical Sciences (GUMS) in Iran, in partial fulfillment of the requirements for receiving a Doctoral degree.

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