Effect of Two Different Placement Technique on Interfacial Layer Formation of Modified MTA on Root Apex

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Abstract

Root-end filling material plays important role to achieve good outcome in apical surgery cases. MTA is known to be material of choice for this procedure. However, the existence of material porosity and lack of flowability could affect its adaptation with previously prepared retrograde cavity. Hence, MTA porosity and flowability could be improved by using indirect ultrasonic placement technique.

The objective of this study is to analyze the difference of manual and indirect ultrasonic placement technique towards interfacial layer formation in apical surgery simulation. Retrograde preparation of forty single rooted human's premolar teeth were performed after endodontic treatment and obturation.

Modified MTA was placed using manual (n=20) and indirect ultrasonic placement technique (n=20). All specimens were immersed in Indian ink for 3x24 hours, grinded transversally on 0.25 mm, 0.5 mm, 1 mm section, and the score of microleakage was determined using stereo microscope with 63x magnification. Statistical analysis was done using Chi Square (p<0,05).

Less microleakage scores was detected in indirect ultrasonic group (45%) compared to manual group (63.7%) with significant difference statistically.

Indirect ultrasonic placement technique of modified MTA has shown superior result in terms of micro leakage compared to the manual placement technique.

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Introduction

Material used in apical surgery cases as root-end filling plays an important roles on determining it success.[1] A tight and persistent apical obturation will allow periapical healing with good long-term prognosis[2].

One of the most recently used root-end filling material is Mineral Trioxide Aggregate (MTA) where several studies shows repair of cementum, bone formation, periapical tissue regeneration, produce a good sealing ability when applied with unfavorable condition such as in presence of fluid or blood which often happened in endodontic surgery.[3,4]

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Despite of its favorable characteristics, however, MTA presents less than ideal working properties. The cement resulting from the mixture of powder with liquid is difficult to handle and its setting time has been reported to be 3-4 hours.[1,5,6] Curently, new MTA-based materials have been developed with smaller particle size modifications and marketed under the name of MTA Flow (Ultradent, South Jordan, UT). This material consist of powder and gel , with powder particle size claimed to be less than 10µm.[7] In the other hand, the mean particle size of ProRoot MTA is 10 µm, with all particles being smaller than 50 µm.[8] ProRoot® MTA and MTA Angelus® have particle size ranging from 1.5-160µm, with percentage of particle size of 6-10µm was 73% in ProRoot® MTA and 53% in MTA Angelus®. Faster setting time and consistency that can be set based on cases can provide advantages when used as a root-end filling material.

The final structure that becomes characteristic after MTA undergoes a hydration process is a mixture of cement with micro porosity, capillary channels, and trapped water.[9] Lack of MTA flow ability would produce an interfacial gap between dentine and MTA and would not be able to fill the irregularity of dentinal walls. [10–12]

One of the modifications of MTA placement technique is the addition of agitation using vibration, utilizing ultrasonic waves.[3,9,13] The vibration agitation is intended to increase the flow ability of cement, remove the trapped air, and also to fill the irregularity of the dentinal wall and produce smaller interfacial gap between material and tooth structure (MTA-dentin interface). With the properties of MTA as biomaterials, from its hydration process, an interfacial layer is expected to form and eventually close the interfacial gap, provide a superior sealing ability.[14,15]

However, until now, there is still no research that examine the adaptation of modified MTA as a root-end filling material, measured from the gaps that eventually will be filled with interfacial layer, using the indirect ultrasonic placement technique. Therefore, further research was needed to compare the proper placement technique in placing MTA modification as root-end filling to obtain better sealing ability.

Materials and methods

Forty recently extracted single-rooted mandibular human premolars were examined for fractures and cracks, and stored in saline for use. All teeth were kept moist before and during the experiment. The teeth were decoronated using an Endo-Z Bur (Dentsply Maillefer, Tulsa, OK, USA) in a high-speed hand piece with water spray. The root canals were prepared up to X3 using Protaper Next (Dentsply/Maillefer Instruments, Ballaigues, Switzerland) accompanied by the use of EDTA gel as a lubricant (RC –Prep , Premier® Dental Products Company). Root canals were intermittently and copiously irrigated with NaOCl 2,52% after each instrument change using a notched tip irrigating needle (ProRinse , Dentsply, Maillefer, Switzerland). Sonic irrigating technique was also used (EndoActivator, Dentsply Maillefer, Switzerland) to improve the efficacy of irrigating solution.

The root canals were dried with paper points and master cone was then cemented with AH Plus sealer (Dentsply Maillefer, Balaigues, Switzerland). All samples were stored in incubator 37° C for 24 hours until sealer was set. For all samples, a 3-mm section of the root end was resected with 557 bur using a high-speed handpiece. Samples then mounted with acrylic resin using polyethylene tube with diameter 5 mm on servical area. Retrograde preparation was performed using an ultrasonic unit (Satelec P5, Vista Dental, Racine, WI) fitted with an angled, diamond coated micro surgical ultrasonic tip (EndoSuccess™ #AS3D , 3 mm) to make retrograde cavity on the apex.

All procedures were performed by the same operator using 3.5x magnification dental loupe (Perioptix).The teeth were randomly assigned to 2 groups. Group I (retrograde filling using manual placement technique) with 20 samples, and group 2 (retrograde filling using indirect ultrasonic placement technique) also with 20 samples.

In grup I (manual placement technique), modified MTA (MTA Flow, Ultradent) was mixed according to manufacturer's instructions. For root-end filling, putty consistency was attained by mixing 1 large spoon and 1 small spoon with 1 drop of liquid. MTA was delivered into root-end preparation of each sample. A micro-plugger (YDM MS#2, ⌀ 0.6 mm) was used to manually condense each increment of MTA into the root-end preparation. This filling procedure was repeated until MTA completely fill the cavity.

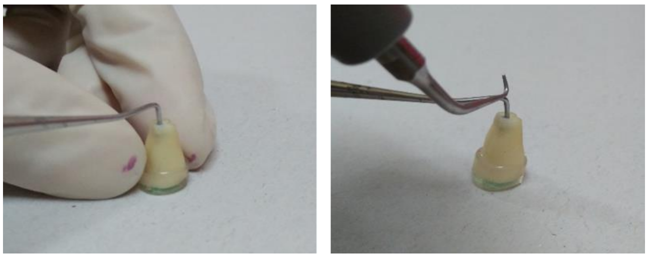

Figure 1. A: Manual condensation using micro-plugger. B: Indirect ultrasonic technique. After modified MTA condensed manually, ultrasonic micro-tip was placed on the sank of micro-plugger and activated for 1 second.

In the other experimental group (Group 2), the same procedures were performed, with additional use of ultrasonic vibration. After completely fill the retrograde cavity manually, the end of the plugger remained in contact with the MTA while the sank of ultrasonic tip

(EndoSuccess™ #AS3D , 3 mm) was placed in contact with the plugger and activated for 1 second on power setting of 1 (on a scale of 1-14) as describe previously by Yeung et al.(Figure 1)

After completing the retro fillings, the roots were kept in incubator and in humid atmosphere for 24 h. The roots were then rendered waterproof with nail polish (Revlon). All specimens then immersed in India ink (Talens) and incubated for 3 x 24 hours. After 3x24 hours, all specimens then cleaned and dried, grinded transversally on 0.25 mm, 0.5 mm, 1 mm section, using grinding machine with fine sand paper grit 2000 (. Every section then evaluated using stereo microscope with 63x magnification (SteREO Discovery. V12, Carl Zeiss) for any micro leakage and scored. Statistical analysis was done using Chi Square at a significance level of 5% (p<0,05) with SPSS 21.

Results

After observation on all samples, statistical analysis was done using SPSS 20.0. The data was processed by Chi-square test, but it was found that 40% of expected count value was less than 5 so the data analysis was continued with Mann-Whitney test with significance value p <0.05. The distribution of micro leakage scores from manual and indirect ultrasonic placement technique is shown in Table 1. For clinical features showing micro leakage scores can be seen in Figure 2.

Placement Technique	Microleakage Score									
	0		1		2		3		4	
	n	%	n	%	n	%	n	%	n	%
Manual	22	36.7%	14	23.3%	17	28.3%	3	5%	4	6.7%
Indirect Ultrasonic	33	55%	14	23.3%	10	6.7%	2	3.3%	1	1.7%

Tabel 1. Distribution of microleakage score in manual placement technique group and indirect ultrasonic placememnt technique.
0 : No microleakage
1 : Microleakage found in one quadrant
2 : Microleakage found in two quadrant
3 : Microleakage found in three quadrant
4 : Microleakage found in four quadrant

From all samples, 22 samples in manual group (36.7%) and 33 samples in indirect ultrasonic group (55%) was found with no leakage (Score 0). Fourteen samples on each group (23.3%) was found with leakage on one quadrant (Score 1). Score 2 could be seen on 17 samples in manual group (28.3%) and 10 samples in indirect ultrasonic group (6.7%). Three samples in manual group (5%) and 2 samples (3.3%) in indirect ultrasonic group showed score 3. Four samples in manual group and one samples in indirect ultrasonic group was found with leakage on all quadrants (score 4). Total cross-section view of samples showing micro leakage despite of the score was 38 samples (63.7%) in manual group and 27 samples (45%) in indirect ultrasonic group.

There was a significant difference statistically between both experimental group with the significance of p = 0.019 (p <0.05). From these results, it could be seen that indirect ultrasonic placement technique of modified MTA has shown less micro leakage than the manual technique with statistically significant difference. Figure 2. shows the clinical features seen from the stereo microscope during sample observation with 63x microscopy.

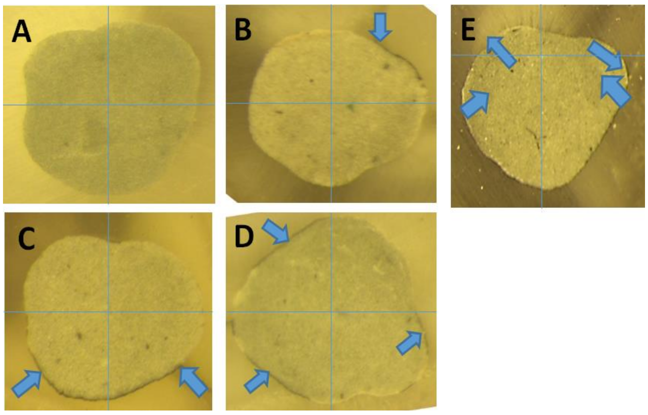

Figure 2. Representative of samples showing a microleakage score between root-end filling material and root canal wall based on quadrant distribution.
A, Score 0. B, Score 1. C, Score 2. D, Score 3 E. Score 4.

Discussion

The modified MTA used in this study has better consistency due to its particles size (<10μm). It is easier to placed and condensed and it has a faster setting time of 15 minutes, in fact it was stated that after 5 minutes of placement, it could be rinsed and dried without dissolving the cement.[7] This provides an advantage when this material is used as root-end filling material because in surgical conditions it is quite difficult to isolate the working area and at risk of being flooded by blood after placement.[4]

The source of ultrasonic vibration in this study came from an ultrasonic scaler device that produced 27 KHz vibration at the lowest power setting (power setting 1). This means there are 27,000 vibrations generated in one second. The ultrasonic tip used in this study is the endodontic micro-tip surgery that was previously used for retrograde preparation. In this study, indirect placement technique was used, where the ultrasonic tip was not contact directly with the cement but it was in contact with the micro-plugger placed on top of the retrograde filled cavity.

The time of ultrasonic vibration application in this study is one second. This is based on preliminary research by Yeung et al. (2006) which compares the marginal adaptation of the MTA cement with time variation. The best marginal adaptation time from that study is one second. Excessive application will change the arrangement of solid particles, and when applied after the cement begins to harden increases the risk of micro crack to occure.[3].

Dye penetration method was used in this study to observe micro leakage. Samples were immersed in coloring dye for certain amount of time, then cut and observed at the border area of material and tooth. Indian ink was used as coloring agent with ≤3µm particle diameter because this diameter is smaller than the size of bacteria inside the root canal[16]. Presence of ink coloration on the border area showed micro leakage. Dye penetration method is the most frequently used method for sealing ability , it is easy to apply without triggering any chemical reactions.[16] Cross-sectional (transversal) cutting method was performed to achieve comprehensive view of marginal adaptation and to compensate longitudinal cutting method that allowed unidentified micro leakage on other quadrant separated from cutting line.[17]

In this study, the presence of dye penetration seen in samples showed that there were gaps or spaces between the dentinal wall of the root canal and modified MTA (MTA-dentin interface). Statistical test using Chi-square followed by Mann-Whitney showed statistically significant difference of micro leakage between two experimental groups, with less micro leakage found in indirect ultrasonic group compare with manual group.

These result was similar with the previous research by Bernabe et al (2013), who compared the sealing ability of MTA as root-end filling materials where ultrasonic placement has better adaptation compared with manual techniques, although with statistically insignificant difference. These differences may occurred due to difference method in cutting techniques, which in the former study, samples were cut longitudinally, with possibility of invisible leakage area outside the quadrant of the cutting area. In addition, the number of samples of the previous study was fewer (10 samples) compared with the number of samples in this study (20 samples with 3 cutting on each = total of 60 cross-section view per group).

The compression force from ultrasonic device in this study will lower the surface friction between cement particles, resulting in unstable cement mixture, single cement particles begin to rotate, and the cement becomes more flowable. During this process, the cement particles will positioned themselves into a denser mass in the cavity, where the trapped air will eventually rise to the surface.[3] Successfully expelled air, replaced with cement particles, will decrease the porosity, resulting in a denser mixture of cement, weight gain, and better adaptation with the cavity wall. The distance and volume of the gap between material and dentinal wall will decrease.

Calcium hydroxide from the hydration of MTA when contacted with phosphate ions from body fluid will form amorphous calcium phosphate which is a pre-nucleation of hydroxyapatite crystals.[6] Continuous precipitation of calcium and phosphate ions will form hydroxyapatite on interfacial layer that would eventually bond biologically with the dentinal wall that also has hydroxyapatite as the main structure.[18,19]

Micromechanical tag-like structure will also continue to form creating physical binding on the MTA-dentin interface and interior of dentinal tubules. These tag-like structures are believed to be the result of ionic dissolution of MTA which resulted in growth and nucleation of the apatite layer.[15]Ultimately, an interfacial layer with an hydroxyapatite-like composition will unite the MTA with dentine walls, closing the interfacial gap physically, chemically, and biologically.[15,18,19] With smaller particle size of modified MTA and compression force from indirect ultrasonic placement technique, it is to be expected that the irregularities of dentinal wall can be filled to minimize the gap and from the hydration process, interfacial layer with hydroxyapatite as the main structure will form, filling MTA-dentin interface gap faster and provide superior sealing ability.

Increased density with ultrasonic agitation was also found from research by Yeung et al. (2006). Condensation of MTA with the addition of agitation using indirect ultrasonic resulted in heavier and denser MTA both in straight and curved root canals compared to manual condensation.[3] Kim et al. (2009) comparing the density of MTA used as an apical plug with manual condensation placement technique and indirect ultrasonic placement technique. It was stated that condensation method with ultrasonic agitation produces MTA plug with higher density.[13]

The apex surgical simulation in this study was also conducted on study by Friedl et al (2016) ,comparing MTA placement with manual and indirect ultrasonic placement technique. From this research, indirect ultrasonic placement technique resulting in increased of MTA weight with average 4.42 mg increase compared to manual placement technique. The increased weight was assumed to be related to the increased volume of compressed material in the retrograde cavity due to the reduced amount of porosity and free space in the material[20]

Conclusions

Indirect ultrasonic placement technique of modified MTA had shown a superior result compared to the manual technique. Less micro leakage showed less gap or space between material and dentinal walls, thus, faster formation of interfacial layer was expected to occur. From this research, indirect ultrasonic technique for placement of modified MTA in apical surgery cases was suggested to obtain denser apical filling and achieve better sealing adaptation of MTA.

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Declaration of Interest

The authors report no conflict of interest.

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