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Placement of Mineral Trioxide Aggregate Using Two Different Techniques

A thesis submitted in partial fulfillment of the
Requirements for the degree of Master of Science at
Virginia Commonwealth University

by

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Richmond, Virginia
February 28, 2003

Acknowledgement

The author wishes to thank several people. I would like to thank Drs. Peter Moon, and Ellen Byrne for all their help and direction and Dr. Al Best for the statistical analysis. Specifically, I would like to thank Dr. Gary Hartwell for his perpetual guidance, mentoring and support during these past two years. I would like to thank my family and husband, Sean, for their unending love and patience during this endeavor. Finally, without the grace and love of my heavenly Father, this project would have not been completed.

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Abbreviations

1. US-----Ultrasonic placement
2. Hand-----Hand placement
3. MTA-----Mineral Trioxide Aggregate
4. MPa-----Mega Pascal
5. SD-----Standard Deviation
6. LS-----Least Square of means
7. SE-----Standard error

Symbols

- -----Ultrasonic/Microscopic evaluation
- -----Ultrasonic/Radiographic evaluation
- -----Hand/Microscopic evaluation
- -----Hand/Radiographic evaluation

Abstract

THE PLACEMENT OF MINERAL TRIOXIDE AGGREGATE USING TWO
DIFFERENT TECHNIQUES

By Anita Aminoshariae, D.D.S.

A thesis submitted in partial fulfillment of the requirements for the degree of Master of
Science at Virginia Commonwealth University

Virginia Commonwealth University, 2002

Major Director: Gary R. Hartwell, D.D.S., M.S.
Chairman and Professor, Department of Endodontics

The purpose of this study was to determine if the adaptation of MTA would differ when placed into simulated root canals of varying length when using two different placement and condensation methods. Hand condensation was compared to ultrasonic condensation. Eighty polyethylene tubes were divided into four groups of twenty tubes each. The tubes in the four groups were prepared to receive 3, 5, 7 and 10-mm lengths of MTA respectively. Each group of twenty tubes was then subdivided so that ten samples of each length would have MTA placed and condensed by the hand method and the other ten by the ultrasonic method. After condensation the samples were evaluated with a light microscope and radiographs for the degree of adaptation of the MTA to the tube walls and for the presence of voids within the MTA material itself. The results demonstrated an 80% agreement for findings between the light microscopy and radiographic

evaluation. Hand condensation resulted in better adaptation to the tube walls and less voids than the ultrasonic method. There was no significant difference in the results for any of the four lengths of MTA placed by the hand method ($p > 0.9$). At this time hand condensation should be considered the preferred method for placement of MTA.

Introduction

Mineral Trioxide Aggregate (MTA , Dentsply, Tulsa, OK) has been shown to be very effective in sealing pathways of communication between the root canal system and the external surface of the tooth (1). It is a powder that consists of hydrophilic particles that set in the presence of moisture (2) and has a pH of 12.5 (1). The initial setting time for the cement is 4 hours (1) and the bond strength to dentin has been shown to increase significantly during the first 72 hours after placement (3). The compressive strength of MTA at 21 days is ~70 MPa, which is comparable with that of IRM and Super-EBA, but significantly less than amalgam (1).

In vitro and in vivo experiments have compared the sealing ability and biocompatibility of MTA with those of amalgam, Super-EBA and IRM . The sealing ability of MTA has been shown in dye and bacterial leakage studies to be superior to that of amalgam and to be equal to or better than Super EBA (1, 2, 4-7). The cytotoxicity of MTA has been investigated using the agar overlay and radiochromium release methods and it was found to be less toxic than either IRM or Super EBA (1). When MTA was implanted in the tibia and mandibles of guinea pigs, the tissue reaction to MTA implantation was most favorable at both sites. Every MTA specimen was free of inflammation and in the tibia samples it was the material most often observed to have direct apposition to bone (4). MTA has proven to be superior to amalgam as a root-end filling material and has been shown to have an inductive effect on cementoblasts (1, 5). MTA has also been used as a capping material for mechanically exposed pulps (8, 9), for root end-induction (4, 9, 10),

repair of root perforations (2, 11) and to form a root-end barrier in cases with open apical foramina (12).

MTA has proven to be a material with several potential clinical applications due to its superior sealing property, ability to set up in the presence of blood, bactericidal effects and biocompatibility. Some clinicians (9, 11-13) have suggested using MTA as an obturating material for the entire root canal system. When used in this manner, it is not known how well the MTA will adapt to the root canal walls when placed from an orthograde approach. Will there be enough moisture available from the periodontal tissues and a moistened cotton pellet to allow the central portion of the MTA core to properly adapt and harden? At the present time there are two suggested methods for placement of the MTA, but to date there are no reported studies that have investigated how well the MTA will adapt when placed from an orthograde approach using either of these two placement methods. The purpose of this study was to evaluate how well MTA adapts to the walls of simulated root canal system of varying lengths. Both radiographic and microscopic techniques were used to evaluate the adaptation of the MTA after it was placed by hand and ultrasonic methods.

Materials and methods

In this study, eighty polypropylene tubes (Kendall Monoject, Tyco, Mansfield, MA) were used. The tubes had an inner diameter of 0.7 mm at the tip and a final diameter of 1.7 mm at an end point 10 mm from the tip. The eighty tubes were initially divided into four groups of twenty tubes each. Tubes were prepared to receive 3 mm lengths of MTA for group A, 5 mm for group B, 7 mm for group C and 10 mm for Group D. The four groups were then further divided into two groups of ten, for each of the two placement techniques.

The MTA was mixed in the 3:1 powder to liquid ratio as recommended by the manufacturer. The tubes were then obturated with MTA using either an ultrasonic or conventional (hand) placement method. The ultrasonic placement method consisted of selecting a Spartan MTS, CPR 1 tip (Tulsa Dentsply, Tulsa, OK), which would fit freely into the tubes. The ultrasonic tip was used to pick up and initially place the MTA material into the selected tube. The MTA was then packed into the apical portion of the tube by activating the ultrasonic Spartan tip and slowly moving the MTA material apically using a 1-2 mm vertical packing motion. The packing procedure was accomplished in 30 seconds for each tube in ultrasonic group (Groups A-1, B-1, C-1 and D-1). In the conventional (hand) placement method, a small amount of MTA was picked up with a number 5/7 endodontic plugger (Thompson Dental, Missoula, Montana) and

placed into the selected tube. The 5/7 plugger was then used to pack the MTA to the appropriate length. The conventional placement (hand) subgroups were designated as groups A-2, B-2, C-2 and D-2.

All tube-wall surfaces had to be covered with MTA to be an acceptable completed sample. After each tube was obturated to the appropriate length, a cotton pellet moistened with 1 cc saline was placed coronally and the remaining unfilled coronal length of the tube was temporized with Cavit (ESPE America, Norristown, PA). The 3-4 mm length of unfilled coronal space for the cotton pellet and Cavit was the same for all the tubes. The tubes were then placed into a moistened "oasis", modified from that described by Lee, Monsef and Torabinejad, (2), for 1 week. At the end of the one-week, each length of MTA sample was examined for voids using radiographs and a light microscope (10X) at 1-mm intervals starting at the apical end. Standardized radiographs were taken before the tubes were removed and developed in an automatic processor (Air Technique , A/T2000 Automatic Processor, CA).

In order to properly view the specimens with the light microscopic, it was necessary to eliminate the plastic tube. As a result of a pilot study, it was concluded that placing the plastic tubes and MTA in an oven (K. H. Huppert Co, Chicago, IL) at 400-450° F for 30 minutes would melt and vaporize the plastic tubes without affecting the MTA sample. This pilot study demonstrated that there was no change in the physical appearance of the MTA before and after heating to this high temperature. The material remained

chemically stable. The MTA was also examined before and after heating with the microscope and radiographs in the pilot study. No changes were observed in the material when the pre and post-heating examination results were compared.

All samples were radiographed before tube removal, and each radiograph was viewed using a standard view box (Henry Schein, Melville, NY). The radiographs were inspected for voids at 1 mm intervals on each 3, 5, 7 and 10 mm length specimen. After tube removal, microscopic evaluation, Figure 1, was made at 10X magnification using a light microscope (Bauch and Lomb, Rochester, NY). Voids were noted at the same 1 mm intervals as with the radiographs, Figure 2. Each specimen was evaluated using a scoring system of 1, 2 or 3. The scoring was based on the following criteria: 1 = no voids were present; 2 = if the void(s) extended less than half way through the diameter of the area of the specimen being examined (measured by a ruler), 3 = if the void(s) extended to a depth greater than half the diameter of area of the specimen being examined (measured by a ruler). Since there were multiple measurements of samples for each length and placement condition, a repeated-measures analysis method was necessary. A mixed-model repeated measurement analysis was performed separately for each assessment method with length, placement and the interaction included in the analysis.

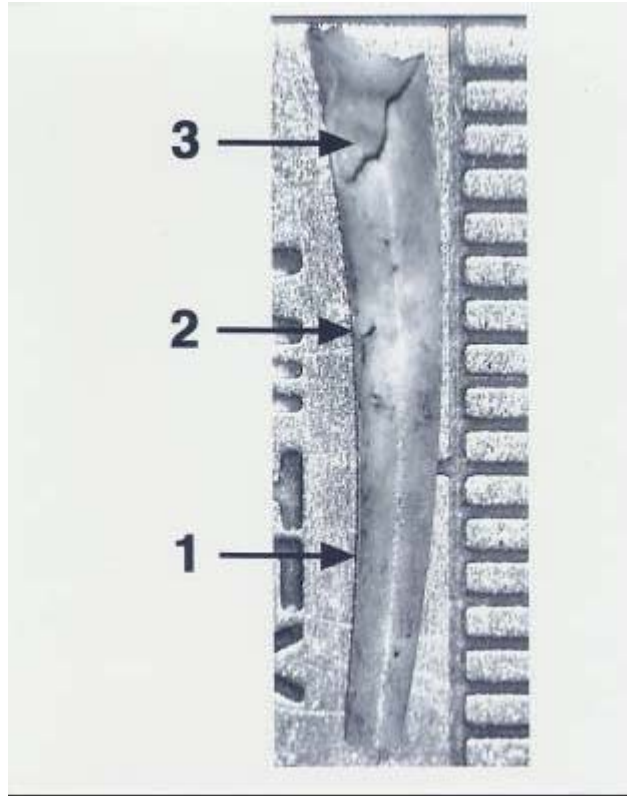


Figure 1. Example of microscopic analysis

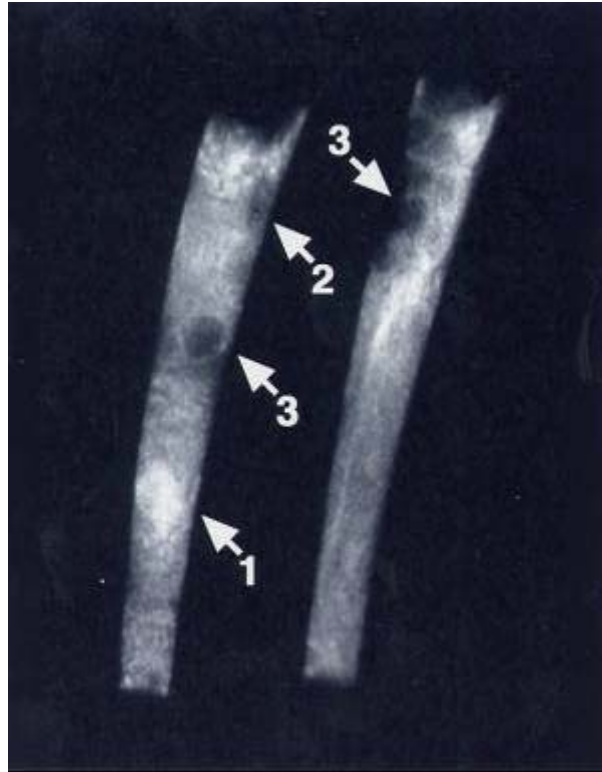


Figure 2. Example of radiographic analysis

Results

Across all of the assessments, the agreement between the two methods (radiograph and microscope) was good, with over 80% of the assessments in complete agreement. The largest disagreement occurred where no voids were evident microscopically but the same sample had observable grade 3 voids when examined radiographically (n = 54 cases).

There were also 18 cases where the radiograph indicated no voids but the microscopic exam indicated voids covering more than half of the individual specimen.

In Table 1 the number of graded voids for each specimen length and placement method is given along with the number of samples with grades 1, 2 or 3. The means and standard deviations for all of the observations under each experimental condition are also noted in Table 1.

As can be seen the worst result (grade 3) occurred rarely with the hand packing method but quite often in the samples that were placed with the ultrasonic (US) methods.

A mixed-model repeated measurement analysis was performed separately for each assessment method with length, placement and the interaction included in the analysis, and the results are given in Table 2. Sample length and placement method had a significant effect on the mean grades for both the microscopic and radiographic analysis.

As is shown in Table 2, the microscopic analysis of the Hand and US placement methods were significantly different for the 5 mm and 7 mm sample lengths but not for the 3 mm

and 10 mm lengths. The radiographic analysis showed that the Hand and US placement methods were significantly different for all sample lengths but the magnitude of the difference varied, depending upon length. The means and 95% confidence intervals are also demonstrated in Figure 3. The hand placement method was uniformly good (low values) and the results for the four lengths were not significantly different for this method ($p > .9$).

Table 1. The results of the number of graded voids for each specimen length and placement method, Ultrasonic (US) and Hand placement (Hand).

Length	Placemer	n	Grade			Mean	SD
			1	2	3		
Microscope							
3	Hand	30	30	0	0	1.000	0.000
3	US	30	22	1	7	1.500	0.861
5	Hand	50	47	3	0	1.060	0.240
5	US	50	8	8	34	2.520	0.762
7	Hand	70	68	2	0	1.029	0.168
7	US	70	34	2	34	2.000	0.993
10	Hand	100	97	1	2	1.050	0.297
10	US	100	78	5	17	1.390	0.764
Radiograph							
3	Hand	30	28	2	0	1.067	0.254
3	US	30	17	2	11	1.800	0.961
5	Hand	50	47	3	0	1.060	0.240
5	US	50	8	2	40	2.640	0.749
7	Hand	70	67	3	0	1.043	0.204
7	US	70	36	5	29	1.900	0.965
10	Hand	100	92	5	3	1.110	0.399
10	US	100	62	17	21	1.590	0.818

Table 2. The mean and 95% confidence intervals of Ultrasonic and Hand placement.

Method	Length	LS Mean	SE	95% Confidence		adjusted p-value
Microscope						
Hand	3	1.00	0.143	0.72	1.28	0.0619
US	3	1.50	0.143	1.22	1.78	
Hand	5	1.06	0.128	0.80	1.32	< .0001
US	5	2.52	0.128	2.26	2.78	
Hand	7	1.03	0.122	0.79	1.27	< .0001
US	7	2.00	0.122	1.76	2.24	
Hand	10	1.05	0.117	0.82	1.28	0.1713
US	10	1.39	0.117	1.16	1.62	
Radiograph						
Hand	3	1.07	0.153	0.76	1.37	0.0046
US	3	1.80	0.153	1.49	2.11	
Hand	5	1.06	0.139	0.78	1.34	< .0001
US	5	2.64	0.139	2.36	2.92	
Hand	7	1.04	0.133	0.78	1.31	0.0001
US	7	1.90	0.133	1.64	2.16	
Hand	10	1.11	0.127	0.86	1.36	0.0381
US	10	1.59	0.127	1.34	1.84	

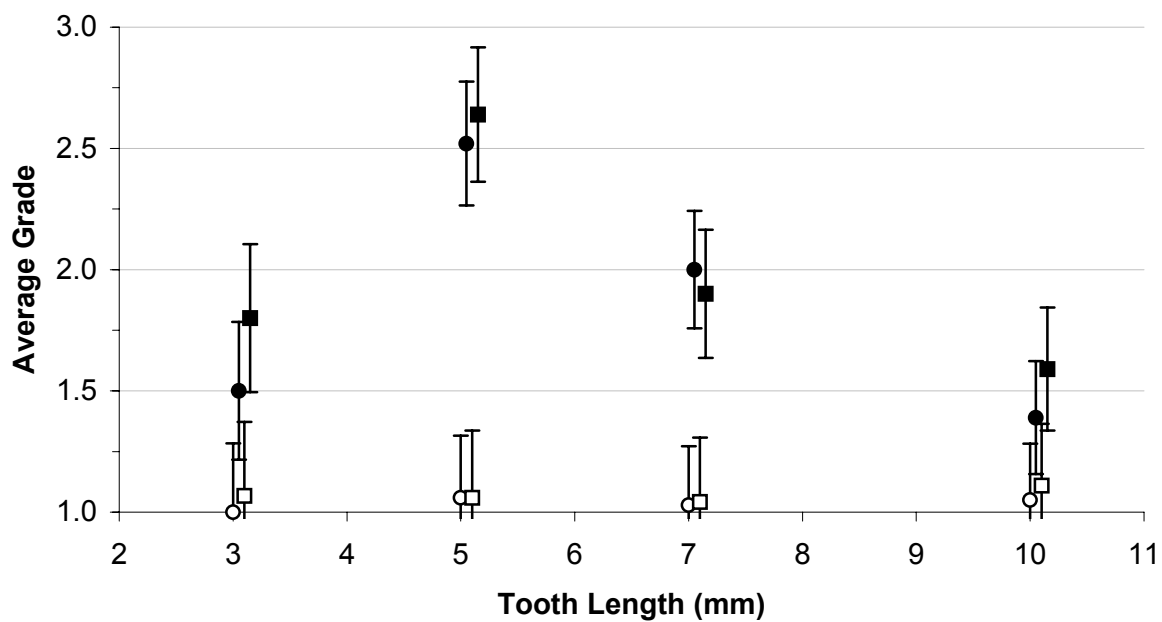


Figure 3. Means and 95% Confidence Intervals

- Ultrasonic/Microscopic
- Ultrasonic/Radiographic
- Hand/Microscopic
- Hand/Radiographic

Discussion

The results of this study demonstrated that there were significantly less voids at all lengths when the hand placement method was used. The ultrasonic method in this study resulted in poorer adaptation to the tube walls and more surface voids in the set material. The radiographic and microscopic evaluations were in agreement more than 80% of the time. The largest disagreement occurred when no voids were evident with the microscopic evaluation but the specimen had a void that was demonstrated by the radiographic method. This phenomenon occurred more frequently in the ultrasonic placement groups than in those groups packed with the hand instrument. The reason for this difference is conjecture at this time but may have been the result of the ultrasonic tip pushing the MTA material against the wall of the plastic tubes and leaving voids in the body of the material as the tip was removed from specimen.

After the obturation procedure, the tube-wall surfaces were visually inspected to be sure that walls were covered with MTA. This was done to assure that the samples were acceptable. This initial visual observation would have benefited from a radiographic evaluation. This could have detected many of the internal voids and allowed corrections to have been taken at that time. As a result, though the tube-wall surfaces appeared visually covered with MTA, the core of the MTA specimens had voids and thus created radiolucent areas that could be seen radiographically. Voids in the material could affect

the seal of the root canal system. The results of this study suggest that whether analyzing the specimens microscopically or radiographically, the method of placement and the length of the MTA sample had an effect on the outcome.

One weakness of the evaluation method was that the measurements were arbitrary and, at best, ordinal in nature. However, there is currently no consensus for a standardization method to be used when evaluating adaptation and condensation of MTA.

The plastic tube used in this experiment is only one of the many models that could have been used for testing the placement of the MTA material. It was selected for this initial study because the shape and diameter could be better controlled than would be the case with human teeth (14). Future studies with natural teeth could be attempted if the shape and size of the prepared canal can be standardized. More importantly can methods be developed whereby the tooth structure can be removed so as to not damage the MTA samples? This is key if an accurate microscopic evaluation is to be performed. The natural tooth model would certainly better simulate the actual clinical situation.

In a similar study using calcium hydroxide powder, Metzger and Solomonov (15) found that hand condensation of calcium hydroxide was better retained in root canals than either lentulo-placed paste or commercial injected paste. It is conceivable that the manufacturer's recommended powder: liquid ratio of 3:1 for MTA may not be the most favorable for the ultrasonic placement and was a potential cause of the voids which resulted with this technique. Further research is warranted to determine if the MTA

samples of varying lengths would react differently if tested using experimental models such as extracted teeth.

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Literature Cited

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Vita

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