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A quantitative comparison of the fill density of MTA produced by two different placement techniques.

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A QUANTITATIVE COMPARISON OF THE FILL DENSITY OF MTA

PRODUCED BY TWO DIFFERENT PLACEMENT TECHNIQUES

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

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Abstract

A QUANTITATIVE COMPARISON OF THE FILL DENSITY OF MTA PRODUCED BY TWO DIFFERENT PLACEMENT TECHNIQUES

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The purpose of this study was to quantitatively compare the fill density of MTA produced by hand condensation and hand condensation with indirect ultrasonic activation. Thirty acrylic block with 30 degree curved canals (group C) and 30 with straight canals (group S) were instrumented to a final apical size of 45 of 0.06 taper crown-down technique. After irrigating with water and drying with paper points, each block was weighed to the nearest 0.0001g with a digital electronic balance. In half of the specimens, chosen at random, the canal first filled with MTA using the hand condensation method (H) then weighed. The MTA was removed. The canal was rinsed, dried, and refilled using hand condensation with indirect ultrasonic activation (US). In the other half of the specimens, the procedure was carried out identically but in reverse order. The blocks were weighed again after cleaning the MTA from the canal as well as after refilling the canal using indirect ultrasonic condensation. Data comparing the weight of MTA between the two placement methods and the two canal configurations were analyzed by a two-way ANOVA. There was a statistically significant increase in weight of MTA produced by ultrasonic activation than by hand condensation in groups C ($p<.0001$) and S ($p<.0001$). However, there was no statistically significant difference when comparing the straight canal versus the 30-degree curved canal ($p = .08$). In group C, ultrasonic condensation resulted in a 10.07% increase in the weight of MTA over hand condensation alone. Similarly in group S, there was a 9.1% increase in the weight of MTA over hand condensation. In conclusion, hand condensation with indirect ultrasonic activation resulted in an MTA fill that was denser than that accomplished by hand condensation alone.

Background

Mineral Trioxide Aggregate (MTA) was introduced to endodontics by Torabinejad et al in 1993 (1) and has been used successfully in the repair of lateral root perforations and furcal perforations, as a vital pulp capping agent, as an apical plug in one visit apexification and as a root-end filling material. A review article by Alhadainy (2) described the ideal perforation repair material as being non-toxic, biocompatible, nonabsorbable, radio-opaque, bacteriostatic, and having excellent sealing properties. MTA has proven to be a material with many of these qualities. Studies (3-5) have demonstrated cemental repair, formation of bone, and regeneration of the periodontal ligament when MTA is used in endodontics. It has been shown to be biocompatible by several research reports (6-8). Leakage studies indicated that MTA provided a superior seal even when placed under adverse conditions, such as in the presence of moisture and blood (9-12).

Mineral Trioxide Aggregate (MTA) was introduced as a cement that may have some potential as a root canal obturating material. Some investigators have suggested using MTA to obturate the entire root canal system (13-15). In 2004 Vizgirda et al evaluated the potential of using MTA as a root canal filling by comparing its apical sealing ability with that of laterally condensed gutta percha with sealer and high-temperature thermoplasticized gutta percha with sealer in extracted bovine teeth (16). MTA was placed into the canal using a lentulo spiral until the material reached the canal orifice. Their results suggested that gutta percha obturation might provide an apical seal that was superior to MTA. A possible explanation was that MTA was difficult to place and condense in the apical portion of the root canal. Conceivably, the use of ultrasonic activation might improve this. In 2003 Aminoshariae et al. examined the adaptability of MTA to the walls of plastic tubes simulating root canal walls when placed from an orthograde approach using hand placement and ultrasonic methods (17). Samples were evaluated with a light microscope and radiograph for the degree of adaptability of MTA to the tube wall and for the presence of voids within the MTA material itself. They found that hand condensation resulted in better adaptation to the tube walls and fewer voids than the ultrasonic method. However, their study did not analyze the fill density quantitatively.

Up to date, there has not been any studies quantitatively comparing the fill density of MTA produced by hand condensation and ultrasonic activation. The purpose of this study is to quantitatively compare the density of MTA root canal filling produced by two different placement techniques: 1. hand condensation (H) and 2. hand condensation with indirect ultrasonic activation (US). In this study, it was hypothesized placement of MTA with ultrasonic activation would result in a higher fill density than with hand condensation alone. This hypothesis is based on the concept that Portland cement used in construction is poured in place and leveled by a machine that sends vibrations through the cement thus distributing the material evenly as well as minimizing voids.

Methods and Materials

Preparation of the samples

In this study, 30 transparent acrylic blocks with 30-degree curved canals and 30 blocks with straight canals (Pecina & Associates, Waukegan, IL) were used. The blocks with straight canal were designated as S and those with curved canals as C. For the straight canal, the working length was determined by placing a #15 Flexofile (Denstply Maillefer, Johnson City, TN) into the root canal until it was visible at the reservoir located at the apical end of the canal then 0.5 mm was subtracted from the file length. In the 30-degree curved canal acrylic blocks, the canal exits directly from the side of the block. Thus, the working length was determined to be the point where the tip of the #15 file exits the canal. All the canals were instrumented using K3 0.06 taper nickel-titanium rotary files (Sybron-Endo, Glendora, CA) with a crown-down technique. The apical portion of each canal was prepared to a size 45 file of 0.06 taper. Patency was maintained by passing a #15 file to the apical foramen after the use of each rotary file. The canal was irrigated with 1ml of water between each instrument use. Upon completion of instrumentation, the canal was dried with paper points. Each instrumented block was weighed to the nearest 0.0001g using a digital electronic balance (Model GD603, Sartorius, Gottingen, Germany).

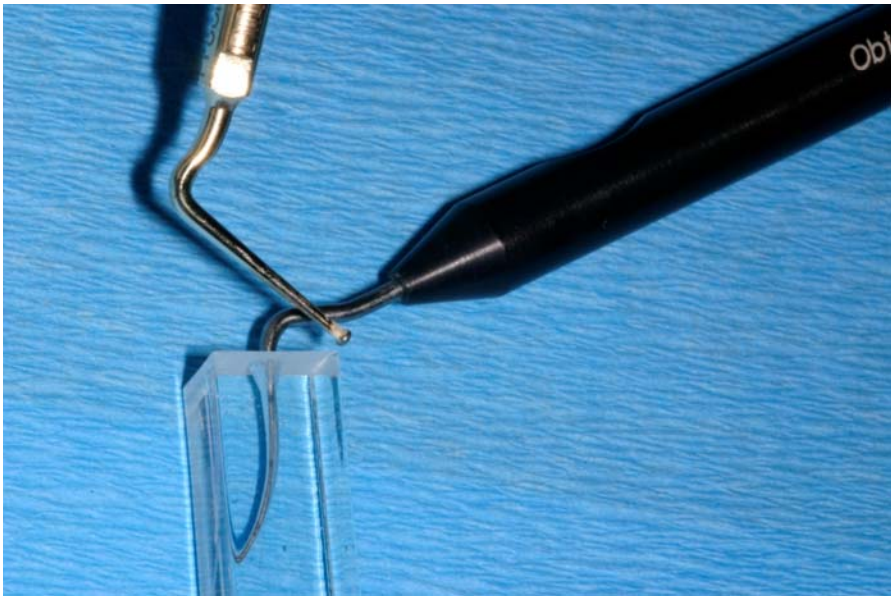
Obturation of the canal

In half of the specimens, chosen at random, the canal was first filled with MTA using the hand condensation method then the block was weighed. The MTA was removed, the canal dried, and the block weighed again. The same canal was refilled using the hand method followed by indirect ultrasonic activation. In the other half of the specimens, the procedures were carried out identically but in reverse order.

The MTA was mixed according to the manufacturer's instruction (Tulsa Dentsply, Tulsa, Oklahoma). MTA was delivered into the canal incrementally using a nonsurgical MTA carrier (Micro Apical Placement System, Vevey, Switzerland). A nickel-titanium plugger (Obtura Corp., Fenton, MO) similar in size and taper to a 1/3 plugger was used to condense the MTA to the appropriate length in the apical third. In the middle and coronal third of the canal, a Ni-Ti plugger similar to a 5/7 plugger was used for the condensation. For both placement methods, each canal was incrementally filled with MTA. Each increment of MTA was immediately condensed using the appropriate Ni-Ti hand plugger. The obturation was judged to be complete when the MTA was filled to the top of the plastic block. A flat metal millimeter ruler was used to wipe off any excess to ensure that the fill was flush. Once completed, each block was immediately reweighed and the difference calculated.

For the US method, after each MTA increment was condensed with a hand plugger to the appropriate length, the end of the plugger remained in contact with the MTA in the canal while it was indirectly activated for one second with a #1 ProUltra ultrasonic tip (Dentsply, Tulsa, Oklahoma) in a lowest power setting unit as shown in figure 1. The application of ultrasonic vibration to the Ni-Ti plugger settled and compacted the MTA apically.

Figure 1: Indirect Ultrasonic Activation of the Ni-Ti Plugger



<u>Cleaning the MTA from the canal</u>

After the canal was filled with MTA the first time using either of the two methods, the filling material had to be completely cleaned from inside the canal before the second obturation. In both groups C and S, the MTA was loosened by carefully threading a size 25 flexofile into it until the file reached the full working length in both groups. In group C, the file was also inserted 3mm into the canal from the apical foramen end in order to facilitate the loosening of the MTA around the curve at the apical end. A copious amount of water was used to flush out the MTA from the canal. A radiograph was taken of the block to ensure that the canal was free of residual MTA. The canal was dried and the cleaned block was re-weighed to ensure that no changes in the weight of the block had occurred during the cleaning process. If there were any changes (gain or loss) in weight of the cleaned block from the instrumented block, that specimen would be eliminated from this study. This was done to ensure the volume of the canal remained unchanged. At this point, the canal was ready to be obturated with MTA using the second method.

Statistical Analysis

This study referenced a repeated measures design as used by Deitch et al in 2002 (18). Each sample, serving as its own control, was sequentially filled with MTA using two different placement methods: hand condensation and hand condensation with indirect ultrasonic activation. The weight of the MTA after each placement was compared.

Data comparing the weight of the MTA between the two different placement methods and the two different canal configurations were analyzed by a two-way repeated measures analysis of variance.

Results

In each of the samples of both groups C and S, using 1s of indirect ultrasonic activation resulted in a greater fill density than using hand condensation alone (table 1, table 2, and figure 2). The mean weight increases of the MTA using the two placement methods in the two canal types are presented in table 3. There was a statistically significant increase in weight of MTA in the ultrasonic activation group over the hand condensation group in both canal types. In group S, ultrasonic condensation resulted in a 9.1% increase in the weight of MTA over hand condensation. Similarly in group C, there was a 10.07% increase in the weight of MTA using ultrasonic condensation over hand condensation. In group S, there was a mean net weight increase of 0.0033g in using the US method and this was a 9.1% increase over the hand condensation method ($p<.0001$). In group C, the mean weight increase in the US group was 0.0035g which was 10.07% higher than the hand condensation group ($P<.0001$). There is no statistically significant difference when comparing the straight canals versus the 30-degree curved canal. There was no interaction between the variables.

Table 1: Comparison of the Weight of MTA in Group S

Block #	**Hand (net) g**	**US (net) g**	**% increase**	**Block #**	**Hand (net) g**	**US (net) g**	**% increase**
1	.0418g	.0454g	8.76%	**16**	.0372g	.0413g	11.11%
2	.0359g	.0398g	11%	**17**	.0458g	.0489g	6.97%
3	.0401g	.0426g	6.08%	**18**	.0296g	.0328g	10.73%
4	.0402g	.0431g	7.18%	**19**	.0370g	.0397g	7.40%
5	.0390g	.0417g	6.89%	**20**	.0326g	.0365g	11.70%
6	.0395g	.0437g	10.76%	**21**	.0387g	.0424g	9.80%
7	.0442g	.0481g	8.66%	**22**	.0382g	.0419g	9.83%
8	.0355g	.0387g	9.02%	**23**	.0453g	.0482g	6.22%
9	.0361g	.0386g	7.02%	**24**	.0351g	.0383g	9.30%
10	.0311g	.0340g	9.36%	**25**	.0222g	.0246g	10.99%
11	.0336g	.0368g	9.45%	**26**	.0364g	.0399g	9.56%
12	.0344g	.0380g	10.32%	**27**	.0359g	.0404g	12.44%
13	.0339g	.0375g	10.75%	**28**	.0419g	.0457g	9.12%
14	.0414g	.0447g	7.77%	**29**	.0395g	.0427g	8.26%
15	.0364g	.0397g	8.80%	**30**	.0422g	.0454g	7.76%

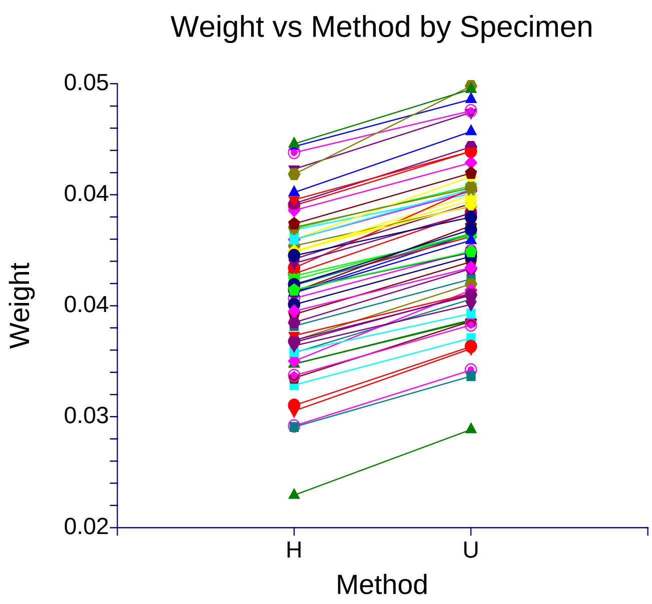
Table 2: Comparison of Weight of MTA in Group C

Block #	**Hand (net) g**	**US (net) g**	**% increase**	**Block #**	**Hand (net) g**	**US (net) g**	**% increase**
1	.0375g	.0428g	14.22%	**16**	.0282g	.0322g	14.08%
2	.0426g	.0467g	9.66%	**17**	.0358g	.0394g	9.87%
3	.0394g	.0428g	8.64%	**18**	.0318g	.0344g	8.16%
4	.0367g	.0398g	8.51%	**19**	.0360g	.0386g	7.21%
5	.0402g	.0429g	6.62%	**20**	.0438g	.0498g	13.58%
6	.0386g	.0421g	9.03%	**21**	.0387g	.0417g	7.93%
7	.0387g	.0412g	8.93%	**22**	.0323g	.0351g	8.64%
8	.0268g	.0306g	14.06%	**23**	.0303g	.0337g	11.30%
9	.0364g	.0401g	10.22%	**24**	.0384g	.0410g	6.77%
10	.0310g	.0340g	9.59%	**25**	.0459g	.0496g	8.03%
11	.0318g	.0354g	11.38%	**26**	.0268g	.0302g	12.83%
12	.0301g	.0339g	12.72%	**27**	.0405g	.0439g	8.44%
13	.0326g	.0356g	9.27%	**28**	.0325g	.0357g	9.99%
14	.0312g	.0350g	12.16%	**29**	.0346g	.0375g	8.49%
15	.0329g	.0358g	8.61%	**30**	.0279g	.0315g	13.09%

Table 3:Comparison of Mean Weight of MTA between groups

Group	Hand (g)	US (g)	Difference	% increase	P
Straight	.0374g	.0407g	.0033g +/- .0004	9.1% ± 1.66	<.0001
Curved	.0353g	.0388g	.0035g +/-.0008	10.07% ± 2.66	<.0001

Figure 2: Weight vs Method by Specimen



Discussion

In this study, hand condensation of MTA followed with a one second ultrasonic activation resulted in a 10.07% increase in mean weight in the group C and 9.1% increase in group S.

This study used the weight of the MTA as an indicator of fill density. This could be explained by using the formula for density: Density = Mass / Volume. Since the volume of the canal was kept constant in this study, any increase in weight of MTA could correlate to a respective increase in the fill density.

In the pilot phase of the study, we examined the difference in fill density of MTA that resulted from varying the number of seconds of indirect US activation at the lowest power. We varied the time of ultrasonic activation from 1s to 5s and found that one second of indirect ultrasonic activation resulted in the highest density of MTA by weight. Longer activation time produced voids with sufficient diameter detected radiographically and, less MTA by weight. For this reason, one second of ultrasonic activation was chosen to compare with hand condensation.

The results of our study are at variance with those reported by Aminoshariae et al in 2003. Their study evaluated the adaptability of MTA to the walls of polyethylene tubes using hand condensation and ultrasonic placement and concluded that hand condensation resulted in a fill that was more uniform and had fewer voids compared to ultrasonic placement. There were several differences between these two studies. First, our study was quantitative in nature and theirs was qualitative. Their samples were evaluated with a light microscope and radiograph for the degree of adaptability of MTA to the tube wall and for the presence of voids within the MTA material itself. Their analysis was based on a two-dimensional view of a three dimensional object. Any voids present below the superficial layer could easily remain undetected. We felt that a quantitative analysis measuring the mass of the MTA in a canal could provide a more objective evaluation of the density of the fill and thus the quality of it. Second, their study used direct ultrasonic activation whereas we used indirect activation. In our study, the ultrasonic tip was not used to directly activate the MTA because even the smallest US tip was not able to extend to the full length of the curved simulated canal, therefore a small nickel-titanium plugger which was flexible enough to follow the canal curve was used instead. Third, the time duration of ultrasonic activation might also differ between these two studies. They first obturated the MTA to different levels (3, 5, 7mm etc) in the polyethylene tubes and then activated the ultrasonic tip continuously as a last step to condense the MTA apically. Although the exact duration of activation in their study was not specified, we speculated that perhaps a longer duration of ultrasonic activation used in their study might have incorporated air into the MTA and thus contributed to a fill that was less dense and less uniform comparing to hand condensation. Based on our pilot work with different times and intensities, it was demonstrated that very low intensity vibration for a short time period was necessary to prevent this occurrence.

This study compared the fill density of MTA in simulated root canal using two placement methods: hand condensation and hand condensation with indirect ultrasonic activation. The results simply demonstrated that hand condensation followed by one second of indirect ultrasonic activation resulted in an MTA fill that was denser than that accomplished by hand condensation alone.

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Literature Cited

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