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ORIGINAL RESEARCH

Comparison of Setting Time of White Mineral Trioxide Aggregate with and without Disodium Hydrogen Phosphate at Different Liquid-to-powder Ratios

[1]Hadi Mokhtari, [2]Mehrdad Lotfi, [3]Mahdi Rahbar, [4]Aysan Mozafari, [5]Mohammad-Hosein Badri-Nozadi
[6]Hamid-Reza Mokhtari-Zonouzi

ABSTRACT

Aim: The present study was conducted with the objective of evaluating the effect of different liquid-to-powder ratios on setting time of white mineral trioxide aggregate (WMTA) and the effect of adding disodium hydrogen phosphate (Na_2HPO_4) to white MTA (NAMTA).

Materials and methods: Sixty samples were prepared in plastic annular molds with a diameter of 10 mm and a height of 2 mm in order to record setting time where white MTA was placed in 30 samples and 2.5 wt% mixture of Na_2HPO_4 with white MTA was placed in other 30 samples. Setting times in different ratios of liquid to powder (50, 60, and 70%) and at different times including 5, 10, 15, 20, 25, 30, 40, and 50 minutes as well as 1, 1.5, 2.5, 3, 3.5, and 4 hours were measured with Vicat. Statistical Package for the Social Sciences version 16 software was used to examine the differences between groups. The values of $p < 0.05$ were considered to be statistically significant in this study.

Results: The average setting time of samples in two WMTA and NAMTA was 182.17 ± 57.86 and 67.00 ± 14.42 respectively, and this difference was statistically significant ($p < 0.001$). Also, the average setting time of samples in ratio groups of 50, 60, and 70% were 146.00 ± 75.90, 85.00 ± 31.71, and 142.5 ± 64.47 respectively, and results showed that there was no significant difference between groups.

Conclusion: Adding 2.5 wt% of Na_2HPO_4 mixture to white MTA reduces the setting time, which is lower than the WMTA in 50, 60, and 70% liquid-to-powder ratios.

Clinical significance: According to the findings of this study, it can be seen that adding Na_2HPO_4 to white MTA is a good way to reduce setting timing in clinical dentistry, especially in one-visit treatments.

Keywords: Disodium hydrogen phosphate, Mineral trioxide aggregate, Setting time.

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INTRODUCTION

Mineral trioxide aggregate has been used in vital pulp therapy, repair of perforation of the furca and lateral perforations, as an apical plug in open apexes of immatured teeth, and also as a filling material of the root end during periradicular surgery.[1,2]

Nevertheless, the initial reaction of the inflammatory cells to this substance[3-6] and its setting time[7-9] are not ideal. Faster setting of MTA is important in this regard where treatment will be done in one visit and it is not washed out in case of bleeding or splashing.[1] The substance provided to reduce the setting time of MTA is Na_2HPO_4 as liquid phase accelerator.[10-12] Ding et al[10] showed that the solution of Na_2HPO_4 acts as the accelerator of MTA and reduces setting time of MTA and maintains its pH at the same level. Microleakage studies show that sealing power in MTA mixed with Na_2HPO_4 is similar to MTA.[11] The study of adaptive tissue in subcutaneous connective tissue of rat also showed that adding 2.5 wt% (Na_2HPO_4) to

[1,2,5,6]Department of Endodontics, Faculty of Dentistry, Tabriz University of Medical Sciences, Tabriz, Islamic Republic of Iran

[3]Department of Operative and Esthetic Dentistry, Faculty of Dentistry, Dental School, Dental and Periodontal Research Center, Tabriz University of Medical Sciences, Tabriz, Islamic Republic of Iran

[4]Department of Endodontics, Faculty of Dentistry, Zanjan University of Medical Sciences, Zanjan, Islamic Republic of Iran

Corresponding Author: Aysan Mozafari, Department of Endodontics, Faculty of Dentistry, Zanjan University of Medical Sciences, Zanjan, Islamic Republic of Iran, Phone: +982433471161, e-mail: aisanmozaffary@gmail.com

white MTA increases the biocompatibility of white MTA.[13] Hydration of the powder in MTA leads to the formation of colloidal gel and its hardening leads to the formation of hard tissue. Properties of hardened MTA depend on size of the particles, the ratio of powder to liquid, the temperature and humidity of used area, and amount of air condensed in the mixture.[14,15] Mineral trioxide aggregate is essentially a mixture of various metal oxides similar to Portland cement where bismuth oxide is added to its formula to increase the radiopacity of MTA. When Portland cement is mixed with water, a special structure of the micropores and the capillary canals in which water is constituted are formed. Porosity of mixture is increased when ratio of water increases. The amount of water contained in the mixture will be a determining factor in the properties of the substance.[14] According to a study conducted in prestigious scientific literature, there have been no studies evaluating the effect of different ratios of liquid to powder on setting time of MTA and Na_2HPO_4 mixture; therefore, this study intends to address this issue.

MATERIALS AND METHODS

Sixty samples (10 samples for each group) were used for measurement of setting time by considering other similar studies. The studied groups were as follows:

- 1 gm mixture of white MTA (Angelus, Londrina, PR, Brazil) + 0.50 mL of liquid.
- 1 gm mixture of MTA + 60 mL of liquid.
- 1 gm mixture of MTA + 70 mL of liquid.
- 1 gm mixture of 2.5 wt% of white MTA (with disodium hydrogen phosphate) + 50 mL of liquid.
- 1 gm mixture of 2.5 wt% of white MTA (with disodium hydrogen phosphate) + 60 mL of liquid.
- 1 gm mixture of 2.5 wt% of white MTA (with disodium hydrogen phosphate) + 70 mL of liquid.

Tested substances, molds, spatula, and glass slides were kept at room temperature for 24 hours before mixing. Setting time of samples was calculated based on International Organization for Standardization 6876-16.[16]

Mentioned mixtures were placed in circular molds of 10 mm in diameter and 2 mm in height. Ten molds were used for each group. A combination of 1 gm of MTA with each of the liquids filled with three circular molds was done. Molds were transferred to a 37° incubator and 95% moisture content and setting time was determined by Vicat (Humboldt Mfg. Co., Norridge, Illinois). This device has several components, including frame and a moving rod with a weight of 300 gm and a 10 mm plunger at one end and a movable flat needle at the other end of the device which has a diameter of 1 mm and which creates a pressure of 300 gm on the samples. Samples were evaluated after 5, 10, 15, 20, 25, 30, 40, and 50 minutes as well as 1, 1.5, 2.5, 3, 3.5, and 4 hours. Setting time was recorded to be the time when needle fails to create a dent on substances. The two-way analysis of variance test was used to test the difference between groups, and nonparametric tests, such as Kruskal–Wallis and Wilcoxon–Wallis were used in case there is difference due to non-normal distribution. The values of $p < 0.05$ were considered to be statistically significant.

RESULTS

Sixty samples in combination with two groups of WMTA, NAMTA and also in three groups of 50, 60, and 70% ratios were evaluated in this study. Results of descriptive statistics of setting time are presented in Tables 1 and 2 based on the order of groups.

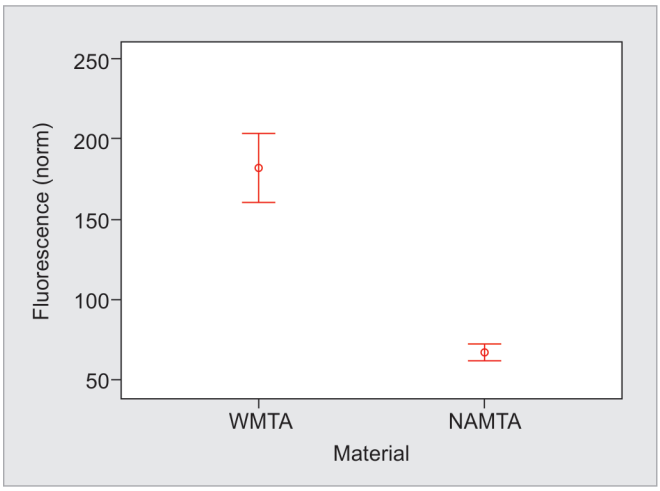
- Also, analysis of the results showed that the distribution of data in the relevant groups does not follow the normal pattern. Therefore, nonparametric tests were used for analysis.
- It was determined using Mann–Whitney U test that type of WMTA and NAMTA substance had a significant effect on setting time ($p < 0.001$) (Graph 1) and it was lower in NAMTA group.
- Kruskal–Wallis test was used to compare setting time in three groups of weight ratios. Results showed no significant difference between groups ($p = 0.052$) (Graph 2).

Table 1: Descriptive statistics of setting time of samples based on the type of substance

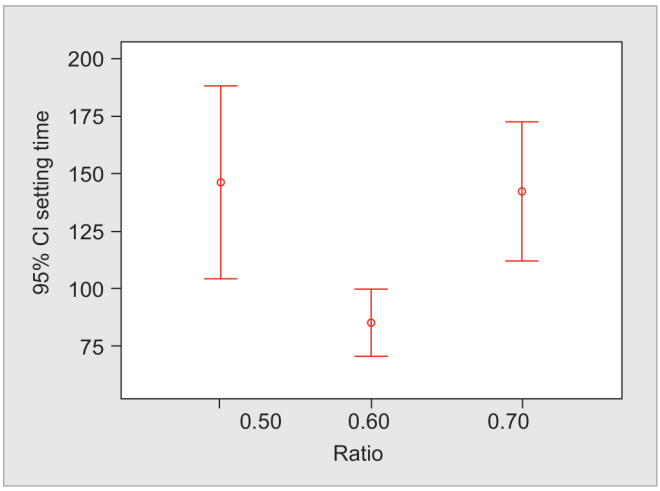
Type of substance	*Number of substance*	*Average*	*Standard deviation*	*Minimum*	*Maximum*	*Mid-range average 95%*
WMTA	30	182.00	57.86	90	240	160.40–203.60
NAMTA	30	67.00	14.42	50	90	61.62–72.38

Table 2: Descriptive statistics of setting time of samples based on weight ratios (50, 60, and 70%)

Ratio	*Number of substance*	*Average*	*Standard deviation*	*Minimum*	*Maximum*	*Mid-range average 95%*
50%	20	146.00	90.751	50	240	103.53–188.47
60%	20	85.00	31.706	50	50	70.16–99.84
70%	20	142.50	64.472	60	210	112.33–172.67



Graph 1: Comparison of setting time of NAMTA and WMTA



Graph 2: Comparison of setting time of samples in different weight ratios

DISCUSSION

In the case of perforations, many substances have been used to repair these lesions. Materials that are in direct contact with connective tissue should have characteristics, such as having osteogenicity, cementogenesis, biocompatibility, nontoxicity, noncarcinogenicity, availability, convenient application, and appropriate price.[17-20] Based on studies done on MTA, this material has many of these characteristics. This substance hardens after approximately 4 hours of mixing with sterile water. This substance also exhibits good biocompatibility in the presence of periapical tissues and tissue reactions.[21,22] This substance is also suitable for sealing in low thicknesses.

The aim of the present study was to mix MTA with liquid to powder ratios of 3 to 1, 4 to 1, and 5 to 1; but according to a pilot study, more fluid is needed for mixing and as a result, ratios were changed proportional to the desired consistency. The reason for this can be due to the type of MTA (Angelus) used in this study, which contains 80% Portland cement and 20% bismuth oxide and has no gypsum sulfate and has smaller particle size.

According to studies, a comparison between MTA and Portland cement has shown that there is no significant difference between the compounds of these two substances except the presence of bismuth oxide in the MTA to produce opacity. Therefore, it seems that some materials and techniques used to improve the properties of Portland cement can also be used in MTA and can have good results. Accordingly, the accelerating compounds of Portland cement, including calcium formate, calcium nitrite mixed with calcium nitrate, calcium chloride, and sodium hydrogen sulfate also reduce the setting time in MTA.

Other accelerators of Portland cement, such as calcium formate and calcium nitrite mixed with calcium nitrate can also reduce the setting time in MTA. In a study by Wiltbank et al,[23] the addition of calcium-formaldehyde to MTA resulted in a significant reduction of pH during the setting, and also the addition of calcium nitrite/nitrate to MTA resulted in a significant decrease in pH and a significant increase in the temperature during setting of substance in comparison to the control group (MTA without accelerator). Therefore, due to the impaired biocompatibility of the above materials, Na_2HPO_4 was used as an accelerator in this study and its biocompatibility has been proven.[13]

Haung et al[24] evaluated the effect of adding Na_2HPO_4 as an accelerator to WMTA. Setting time was measured using Gilmore Needle. Setting time decreased significantly to 26 minutes by adding 15% Na_2HPO_4 as the liquid phase to the MTA. The results of this study also showed that the type of WMTA and NAMTA substance has a significant effect on setting time and NAMTA mixture significantly reduced setting time to 50 to 60 minutes, but there is no significant difference between groups with powder to liquid ratios. The reason for this difference in reduced setting time can be due to the type of powder used in the study.

Various methods have been used in studies on how to place and compress MTA within the molds. In a study by Nekoofar et al,[25] an ultrasonic device was used for 30 seconds with moderate power (5 out of 10) in such a way that the tip of ultrasonic was moved in the MTA mix without having contact with the mold's wall. However, Aminoshariae et al[26] performed comparisons between hand condensation and ultrasonic condensation of MTA in the polyethylene tubes. In this study, samples which were manually compressed has better matching with tube walls and also showed less voids compared with ultrasonic method. In the present study, MTA was compressed inside molds manually using plugger.

CONCLUSION

Adding 2.5 wt% of Na_2HPO_4 mixture to white MTA reduces the setting time, which is lower than the WMTA in 50, 60, and 70% liquid-to-powder ratios. According to these findings, it can be seen that it is a good way to reduce setting timing in clinical dentistry, especially in one-visit treatments.

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