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# EFFECT OF ACCELERANTS ON THE SETTING TIME OF WHITE PORTLAND CEMENT AND WHITE MTA: AN IN-VITRO STUDY

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## ABSTRACT

**Background:** Despite the good physico-chemical and biologic properties, one of the main disadvantages when using MTA is its extended setting time. The long setting time results in challenging handling characteristics due to its wet-sand like consistency and irrigation of area with newly placed MTA. Although incredibly useful, MTA could be even more so if it could set faster in certain situations. **Material and Method:** Fifty plastic tubes measuring 5mm in diameter and 10mm in length were made. Standardized weight of cement (90mg) in each group was mixed with standardized volume (30 μl) of respective liquid. The plastic tube was filled with the cement paste completely and placed in Vicat mould. The initial and final setting time was measured using Vicats apparatus. **Results**: The results showed that addition of PC accelerators to WPC and WMTA significantly reduced the IST and FST. **Conclusion:** The use of PC accelerators significantly reduced the setting time of WPC and WMTA. The addition of 10% $CaCl_2$ showed maximum reduction of ST of WMTA.

**KEYWORDS:** Portland cement; MTA; setting time; accelerants

## INTRODUCTION

An ideal endodontic repair material should seal the pathways of communication between the root canal systems and its surrounding tissues. In addition, it should be non toxic, non carcinogenic, non genotoxic, biocompatible, insoluble in tissue fluids and dimensionally stable.[1] Since, the existing material did not possess these desired properties, the quest for an ideal endodontic repair material has led researchers to extensively investigate various types of materials. Mineral Trioxide Aggregate has stirred a new revolution in dentistry as its formulation had characteristics that were necessary for an ideal medicament and repair material. MTA was developed and recommended initially as root-end filling material and subsequently has been used for pulp capping, pulpotomy, apexogenesis, apical barrier formation in teeth with open apices, repair of root perforations, and as a root canal filling material.[2] Thus, MTA is panacea for pulpal and periodontal diseases. MTA is Portland cement with 4:1 proportions of bismuth oxide added for radiopacity.[3] The major component of MTA is Portland cement which is a mixture of dicalcium silicate, tricalcium silicate, tricalcium aluminate and tetracalcium aluminoferrite. The major difference between Grey MTA and White MTA is the reduction of FeO (90.8% less) in White MTA causing a change in colour from grey to white.[4] Despite the good physico-chemical and biologic properties, one of the main disadvantage when using MTA is its extended setting time. The long setting time results in challenging handling characteristics due to its wet-sand like consistency and irrigation of area with newly placed MTA can lead to washout of the material. Although incredibly useful, MTA could be even more so if it could set faster in certain situations.[5] Many attempts were made to improve the clinical manageability of MTA by adding a setting accelerator, a viscosity enhancer or a dual functional modifier. The enhancement in clinical manageability of MTA may be more convenient for dentists during endodontic treatment; however, it is important to note that changes in the physical and/or chemical

**Table 1: Cement Tested and Their Respective Admixtures**

| Group | Powder(90mg) | Liquid (30µl) |
|---|---|---|
| 1 | WPC | Deionized water with no accelerants (Control) |
| 2 | WPC | 10%CaCl2 in deionized water |
| 3 | WPC | 15%CaCl2 in deionized water |
| 4 | WPC | 25% CaNO2+1% CaNO3 in deionized water |
| 5 | WPC | 40% CaNO2+8% CaNO3 in deionized water |
| 6 | WMTA | Deionized water with no accelerants (Control) |
| 7 | WMTA | 10%CaCl2 in deionized water |
| 8 | WMTA | 15%CaCl2 in deionized water |
| 9 | WMTA | 25% CaNO2+1% CaNO3 in deionized water |
| 10 | WMTA | 40% CaNO2+8% CaNO3 in deionized water |

**Table 2: The mean FST of WPC and WMTA with their intergroup comparisons:**

| GROUPS | Mean ± SD | INTERGROUP COMPARISONS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | 132.2 ± 1.92 | - | .000 | .000 | .000 | .000 | .000 | .000 | .859 | .859 | .000 |
| 2 | 30.2 ± 1.48 | .000 | - | .000 | .000 | .000 | .000 | .012 | .000 | .000 | .000 |
| 3 | 124 ± 2.34 | .000 | .000 | - | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 4 | 17 ± 1.22 | .000 | .000 | .000 | - | .000 | .000 | .000 | .000 | .000 | .000 |
| 5 | 61.4 ± 1.14 | .000 | .000 | .000 | .000 | - | .000 | .000 | .000 | .000 | .000 |
| 6 | 132.4 ± 1.51 | .000 | .000 | .000 | .000 | .000 | - | .000 | .000 | .000 | 1.000 |
| 7 | 26.6 ± 1.51 | .000 | .012 | .000 | .000 | .000 | .000 | - | .000 | .000 | .000 |
| 8 | 127 ± 1.58 | .859 | .000 | .000 | .000 | .000 | .000 | .000 | - | 1.000 | .000 |
| 9 | 123.4 ± 2.40 | .859 | .000 | .000 | .000 | .000 | .000 | .000 | 1.000 | - | .000 |
| 10 | 133.6 ± 2.51 | .000 | .000 | .000 | .000 | .000 | 1.000 | .000 | .000 | .000 | - |

component of MTA may adversely affect its physical and biological properties. Setting accelerators such as calcium chloride, a mixture of calcium nitrate/nitrite, calcium formate[5] sodium hydrogen phosphate[6] calcium lactate gluconate[7] in various percentages have been used to improve handling characteristics of MTA. Very few studies have been done with 15% calcium chloride as an accelerant and till now no study has been carried out with the percentages of calcium nitrate and calcium nitrite used in this study. Thus, the purpose of this study was to evaluate and compare the effect of Portland cement accelerators on the setting time of white Portland cement and white ProRoot MTA.

## MATERIALS AND METHODS

The groups studied are listed in Table 1. Group 1 and Group 6 served as control groups. In Group 1 White Portland cement was mixed with deionized water while in Group 6 White MTA was mixed with deionized water. In Group 2 and Group 7, 10% calcium chloride was mixed with White Portland cement and White MTA respectively. While in Group 3 and Group 8, 15% calcium chloride was added to White Portland cement and White MTA respectively. Group 4 and Group 9 included a mixture of 25% calcium nitrite and 1% calcium nitrate mixed with White Portland cement and White MTA respectively. Group 5 and Group 10 consisted of a mixture of 40% calcium nitrite and 8% calcium nitrate mixed with White Portland cement and White MTA respectively. Fifty plastic tubes were made measuring 5mm in diameter and 10mm in length. Standardized weight of cement (90mg) in each group was mixed for 30 seconds with standardized volume (30 µl) of respective liquid to obtain a powder: liquid ratio of 3:1. The time of gauging was counted from the time of addition of water to dry cement. The plastic tube was filled with the cement paste completely and placed in Vicat mould, both of which were rested on a non-porous plate. The top surface of the cement paste was smoothed-off, to make it in level with the top of the mould.

## INITIAL SETTING TIME

The Vicat mould and the non porous plate were placed under the rod bearing the initial set needle having 1sq mm cross section. The needle was lowered gently till in contact with the surface of the test block and quickly released allowing it to penetrate into the cement. The procedure was repeated for every 10 seconds till the needle failed to pierce the cement paste beyond a point 5.0 ± 0.5mm measured from the bottom of the mould. The time period elapsed since the addition of water to the cement and the time till the needle failed to pierce the test block beyond a point 5.0 ± 0.5mm as measured from the bottom of the mould, was called as the initial setting time.

**FINAL SETTING TIME**

The initial set needle was replaced by the final set needle. It consisted of a needle with an annular metal attachment hollowed out so as to leave a circular cutting edge which is placed 0.5mm behind the tip of the needle. The final setting time was the time when the paste became so hard that the annular attachment to the needle, under standard weight of 300 grams, failed to leave a mark on the hardened cement paste while the needle made an impression. The time period elapsed since water was added to the cement and the time when the needle made an impression on the surface of the test block, while the attachment failed to do so, was called as the final setting time.

**DATA ANALYSIS**

Each group was tested five times and the readings were tabulated. Results were analysed by two-way analysis of variance ($p < 0.05$) and Post hoc, Bonferroni multiple comparison tests were performed to examine differences between the groups. Paired t-test was performed to examine the intergroup differences among all the groups.

## RESULT

The mean FST of WPC and WMTA with their intergroup comparisons are listed in Table 2. Groups 2 & 3 showed a significant reduction in mean setting time ($p < .05$) as compared with their respective control. Groups 4 & 5 showed a statistically significant reduction in mean setting time ($p < .05$) as compared with their respective control. Similarly groups 7 & 8 showed a significant reduction in mean setting time ($p < .05$) as compared with their respective control. Groups 9 & 10 showed a significantly reduction in setting time ($p < .05$) as compared with their respective control (group 6).

## DISCUSSION

Despite many ideal qualities possessed by MTA, it is often difficult to manipulate and its slow initial setting time necessitates a second appointment for placement of final restoration since the material is easily washed out during procedures that require irrigation or rinsing. Any ability to gain initial setting time within the time frame of a single dental appointment without significantly altering its properties would enhance the clinical usefulness of MTA. Studies have shown that the addition of accelerators to Portland cement reduced its setting time. Since, MTA and Portland cement share the same chemical elements, the Portland cement accelerators have been used to reduce the setting time of MTA without significantly affecting its physical properties. Some of the accelerators used for altering the setting time of Portland cement and MTA include 2%, 5% and 10% calcium chloride, 20% calcium formate, a mixture of calcium nitrate and calcium nitrite etc. Few studies have been conducted with the use of 15% calcium chloride as an accelerator and with different percentages of mixture of calcium nitrate and calcium nitrite. In this study, the FST of WPC & WMTA mixed with accelerators was significantly shorter than WPC & WMTA mixed with deionized water ($p<.05$). These findings are in corroboration with the findings of Bortoluzzi *et al.*,[8] Wiltbank *et al.*,[5] Ber BS *et al.*,[9] Bortoluzzi *et al.*,[10] Shie MY *et al.*,[11] Lee *et al.*,[12] Ahmed HMA *et al.*,[13] who reported reduction in setting time of MTA with the addition of accelerants. Groups 2 & 3 showed a significant reduction in mean setting time ($p< .05$) as compared with their respective control. Similarly groups 7 & 8 showed a significant reduction in mean setting time ($p<.05$) as compared with their respective control. This could be due to the penetration of calcium chloride in the pores of WPC or WMTA which accelerates the hydration of silicates leading to faster formation of nuclei of crystallization. This reduces the setting time. These findings are in accordance with the results of Bortoluzzi *et al.*, (2009)[6] who demonstrated a reduction in the final setting time of WMTA to 31 minutes and of WPC to 60 minutes with the use of 10% calcium chloride. Similar findings have been reported by Wiltbank *et al.*,[5] Ber BS *et al.*,[9] and Lee *et*

*Al*.,[12] who demonstrated reduction in setting time with the addition of various concentrations of $CaCl_2$. Groups 4 & 5 showed a statistically significant reduction in mean setting time ($p<.05$) as compared with their respective control. Similarly groups 9 & 10 showed a significantly reduction in setting time ($p<.05$) as compared with their respective control (group 6). These findings are in accordance with the results of Wiltbank *et al*.,[5] who reported a decrease in the setting time with the use of these accelerators. The setting time value of group 3 was higher as compared to group 2. Similarly, the setting time value of group 8 was higher as compared to group 7. This might be due to calcium chloride at higher concentration (15%) acting as a setting retarder and inhibiting the growth of nuclei of crystallization. The mean final setting time value of group 7 was significantly less as compared with that of group 2. These findings are in accordance to the findings of Bortoluzzi *et al*.,[10] who observed that final setting time of WMTA was 31 minutes and the final setting time of WPC was 60 minutes when mixed with 10% calcium chloride. When group 4 was compared with group 9 and when group 5 was compared with group 10, a significant reduction in the mean setting time was found in group 4 & 5 as compared to group 9 & 10 respectively. These findings are in agreement with that of Wiltbank *et al*.,[5] who reported that calcium nitrite/nitrate mixture reduced the IST markedly in GMTA and PC but not in WMTA. The present study focuses on the improvement of setting time of WPC and WMTA with the use of various accelerants. Based on the results of our study, 10% $CaCl_2$ is the most effective accelerant. Further clinical studies are required to assess the clinical efficacy of these accelerants.

## CONCLUSION

In the light of the present study, we can conclude that the use of a mixture of 25% calcium nitrite and 1% calcium nitrate as an accelerator markedly reduced the setting time of WPC. However, the setting time of WMTA was not markedly reduced. WMTA showed the shortest setting time when 10% calcium chloride was used as an accelerant. The use of 15% calcium chloride as an accelerant did not markedly reduced the setting time of both WPC and WMTA. Thus, within the limitations of this study, 10% calcium chloride was found to be the most effective accelerant when mixed with both WPC and WMTA. Further clinical studies are required to substantiate the findings of this study.

## CONFLICT OF INTEREST & SOURCE OF FUNDING

The author declares that there is no source of funding and there is no conflict of interest among all authors.

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