

EFFECT OF SODIUM PHOSPHATE DIBASIC SOLUTION ON THE SETTING TIME OF WHITE MINERAL TRIOXIDE AGGREGATE: AN IN VITRO STUDY

Munazzah Ejaz¹, Tahir Ali Khan¹, Aiman Khan², Nayab Amin¹, Amjid Naseer⁵, Sajid Hussain⁶

¹Science of Dental Materials, Sardar Begum Dental College, Peshawar

²Science of Dental Materials, Sardar Begum Dental College, Peshawar

³Science of Dental Materials, Khyber College of Dentistry, Peshawar

⁴Science of Dental Materials, Rehman College of Dentistry, Peshawar

⁵Science of Dental Materials, Sardar Begum Dental College, Peshawar

⁶Post graduate Trainee, Science of Dental Materials, Sardar Begum Dental College, Peshawar

Abstract

Objective: To determine the mean setting time of White Mineral Trioxide Aggregate (WMTA) mixed with distilled water in comparison to White Mineral Trioxide Aggregate mixed with 20% Sodium Phosphate Dibasic Solution.

Materials and Methods: The test for setting time was performed according to ADA (American Dental Association) specification # 57 and C266-03 of ASTM (American Society for Testing Materials). Setting time was measured using Gilmore needle. The specimens of control group were obtained by mixing White Mineral Trioxide Aggregate with distilled water. In experimental group the specimens were obtained by mixing WMTA with 20% Na₂HPO₄ solution. The data for setting time was analyzed by using student-t test

Results: The setting time of White Mineral Trioxide Aggregate was significantly reduced from 4 hours to 94 minutes by using 20% sodium phosphate dibasic solution.

Conclusion: It was concluded from the present study that the addition of 20% sodium phosphate dibasic solution has significantly reduced the setting time of White Mineral Trioxide Aggregate.

Key Words: White Mineral Trioxide Aggregate, Setting time, Sodium phosphate dibasic solution.

Introduction

Advent in bio compatible dental materials was the introduction of Mineral Trioxide Aggregate (MTA) in 1993. Many of the contemporary materials are superseded by this material in a short duration of time. It was basically introduced to seal perforations and root end cavities.^{1,2}

The powder of Mineral Trioxide Aggregate consists of hydrophilic particles containing Tricalcium silicate, Tricalcium aluminate, Tricalcium oxide, silicate oxides. Bismuth oxide is added to powder as a radiopacifier. Mineral Trioxide Aggregate is basically available as Grey Mineral Trioxide Aggregate (GMTA) and White Mineral Trioxide Aggregate (WMTA). The liquid component of MTA is usually distilled water.³

Superior sealing ability good marginal adaptation and possibility of use in the moisture makes MTA better than other restorative materials.⁴ In spite of these extensive

applications, its use is limited in clinical practice due to prolonged setting time (165±5 minutes) and poor handling characteristics.⁵ Different researchers have added various accelerators in MTA powder to reduce its setting time such as CaCl₂.^{6,7,8} Calcium Formate (CF), Chlorhexidine, K-Y Jelly, NaOCl gel.⁹

The setting time of MTA was also reduced by using setting accelerator in liquid phase because liquid is essential for setting of powder. Haung et al found that 15% sodium phosphate dibasic solution significantly accelerated White Mineral Trioxide Aggregate in terms of its final setting time.¹⁶

In this study, the aim of reducing the setting time of WMTA by incorporation of 20% sodium phosphate dibasic solution was pursued.

Materials and Methods

The study was conducted for a period of six months in the Department of Science of Dental Materials, Sardar Begum Dental College and Department of Pathology, Kabir Medical College, Gandhara University, after the approval from Advanced Research and Ethical Committee of Gandhara University Peshawar.

It was an in vitro experimental study in which ten specimen discs were used, each group contained five specimens. In these prepared discs test for setting time was performed according to American Dental Association (ADA) regulations 57 and C266-03 of American Society for Testing

Correspondence:

Dr. Munazzah Ejaz

Lecturer

Department of Dental Materials,

Sardar Begum Dental College Peshawar.

Email: dr.munazzah84@gmail.com

Cell # 03339111836

and Materials (ASTM).10

The stainless steel mold was used with internal diameter of 10mm and height of 2mm. The material was mixed according to manufacture's recommendation. For control group, WMTA (Nexobio co., Ltd Korea) was mixed with distilled water. (Haq Chemicals Suppliers) For experimental group WMTA was mixed with 20% Na₂HPO₄ solution (BDH. Prolabo Leuven Belgium). The mixed material was placed into stainless steel mold and placed in an incubator (Memmert GmbH+Co.KG D-91126--Germany) at 37°C at 100% relative humidity for about 120 ± 10 seconds. As the setting of WMTA was approached, material was removed from the incubator and was tested for initial setting time at 150 ± 10 seconds using initial Gill more needle

(Humboldt Mfg. Co U.S.A) of 100 ± 0.5g with an active tip of 2.0 ± 0.1 mm diameter. The procedure was repeated after every 60 seconds until the cement has achieved its initial set. The initial setting time of the cement was considered as the time between onset of mixture and the moment when the marks of needle could not be observed on the cement surface. (Figure 1) After the initial set of cement, the mold was placed again in an incubator for evaluation of final setting time. The mold was removed after 30 minutes and was tested for final setting time using final Gill more needle of 456 ± 0.5g with active tip of 1.0 ± 0.1 mm diameter. The procedure was repeated after every 30 minutes until the cement achieved its final set. The final setting time of cement was considered when the cement surface could bear the final Gill more needle without appreciable indentation (Figure 2).

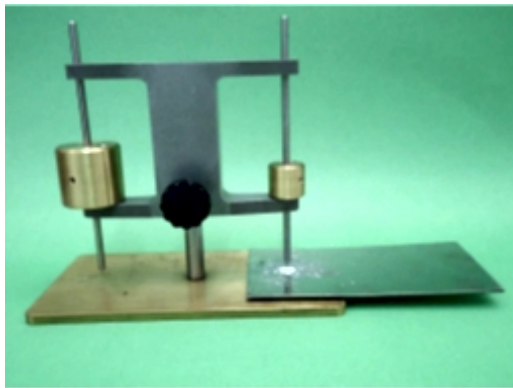


Figure 1: Test for initial setting time

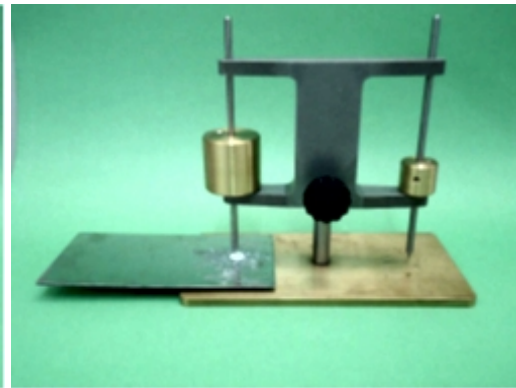


Figure 2: Test for final setting time

Results

The setting time of White Mineral Trioxide Aggregate was significantly reduced from 4 hours to 94 minutes by using 20% Sodium Phosphate Dibasic Solution.

The mean and standard deviation values of initial and final setting time for control and experimental group is shown in table1.

As shown from table 1 the mean initial setting time of WMTA after mixing with distilled water was 9.60 ± 1.18 minutes which was greatly reduced by adding Na₂HPO₄ to 2.30 ± 0.447 minutes. Similarly sodium phosphate dibasic

significantly reduced the final setting time of WMTA down to 94.40 ± 5.847 minutes as compared to distilled water 280.0 ± 9.874 minutes respectively.

Independent t- test was used to evaluate the statistical significance and spss version 16 was used for analysis of the data. The mean values of initial and final setting time of experimental group was significantly less than control group. There is statistically significant difference among two groups of initial setting time and final setting time (p = 0.000) shown in table 2. It is obvious from the results that the addition of 20% Na₂HPO₄ has significantly reduced the initial and final setting time of WMTA.

Table 1: Mean and standard deviation of initial and final setting time of specimens discs in control and experimental group

Cements	Initial setting time	SD	Final setting time	SD
Control Group (WMTA+ distilled water)	9.60	1.187	280.0	9.874
ExperimentalGroup (WMTA +Na ₂ HPO ₄)	2.30	0.447	94.40	5.847

Table 2: Difference between specimens discs in control and experimental group of initial and final setting time

t- test for Equality of Means			
	t	Difference	P value
Initial setting time	8.725	8	0.000
Final setting time	18.168	4.560	0.000

Discussion

In our study White Mineral Trioxide Aggregate powder was combined with 20% aqueous solution of sodium phosphate dibasic (Na_2HPO_4) as an accelerator in an attempt to check its effect on the setting time of White Mineral Trioxide Aggregate. Since MTA is introduced, the excellent biocompatibility with minimum cytotoxicity and long term success of perforation repair makes it the ideal root-end filling material. MTA has many promising properties that support its clinical use also there are few drawbacks of this material. The setting time of MTA has been reported to be about 165 minutes in literature.¹¹ When MTA is used as a root-end filling material, it may wash out of the preparation area if special care is not taken.¹²

Both initial and final setting time of WMTA were assessed using Gillmore needle. The initial setting time is an important property but not easily evaluated. The initial set indicates the beginning of solidification and can be determined with a penetration test.¹³ The mean initial setting time obtained in this study with distilled water is 9.60 minutes which is different from the literature that is 12, 14.15, 15.40, 45.16, minutes. A shorter setting time is desirable to minimize the filling material washout.¹² So after the addition of 20% Na_2HPO_4 the initial setting time of MTA was reduced to average of 2.30 minutes. The mean final setting time of MTA with distilled water in this study is 280 minutes which is different as reported by Torabinejad et al in 1995 which is 165 minutes.¹¹ This difference can be associated to many factors like, changes that have been incorporated into MTA powder since it was first introduced. The other factor responsible for change in setting time is that different brands of MTA has been introduced. Asgary et al has stated that a significant change has occurred in composition of MTA after its introduction. Mineral Trioxide Aggregate mixture may be affected by many factors such as quantity of water used during mixing, environment humidity, the mixing procedure itself, and temperature.¹²

A shorter setting time will allow less time for contaminants in the oral cavity to adversely affect it and allow safer placement of a restorative material over it (pulp capping).¹⁵ Haung et al had incorporated Na_2HPO_4 in a concentration of 5%, 10% and 15% as an accelerator in order to reduce the setting time of WMTA. The results of their study showed that 15% concentrations of Na_2HPO_4 in WMTA powder brought a significant change in the setting time of MTA from 151 minutes with distilled water to 26 minutes.¹⁶ These results are correlated with our study in which setting time of WMTA has been reduced from average of 280 to 94.4 minutes. It was concluded in the study that after adding Na_2HPO_4 , the setting time of MTA could be reduced by a factor of five as compared with distilled water.¹⁶ So the attempt was made with 20% sodium phosphate dibasic solution in WMTA powder in order to decrease the setting time of WMTA. According to the findings of both studies it can easily be seen that phosphate solution brought about the reduction in setting time of WMTA. According to Chow and Kon et al rapid formation of hydroxyapatite crystals occurs in calcium phosphate cement after the addition of phosphate solution which causes reduction in setting time of cement. The calcium phosphate cements show a common ion effect for phosphate

containing aqueous solution which in turn accelerate the setting reaction.¹⁷

Although it is not clear why this occurs, this role of phosphate could be explained by the strong ionic interactions between phosphate and calcium and/or silicate cations, thereby enhancing the formation of calcium silicate hydrates or other phases. In short it can be suggested that phosphate solution may influence the kinetics of setting reaction.¹⁶

Different researchers have added various accelerators in order to reduce the setting time of MTA with different approaches for evaluation. Ber et al have added mixture of methylcellulose and calcium chloride in MTA which has reduced the setting time to 57 minutes.¹⁸ Kogan et al reported that K-Y Jelly, NaOCl gel and 5% CaCl_2 has reduced the setting time from 50 minutes (sterile water) to 20 to 25 minutes.⁶ In both studies vicat apparatus was used for evaluation of setting time. Wiltbank et al evaluated the MTA setting time using Gillmore needle and added CaCl_2 , Calcium nitrite/nitrate and calcium formate and have found that calcium formate significantly reduced the setting time of MTA (70 minutes) to less than 10 minutes.¹² Bortuzzi et al added CaCl_2 as an accelerant in MTA and WPC using Gillmore needle and found that the addition of CaCl_2 provided a significant reduction in both initial and final setting time of experimental cements.³ A possible explanation for the differences in above mentioning setting times is the use of different needles with differing weights (300 g Vicat vs 453.6 g Gillmore needle) and the amount of time the needle rests on the surface to produce the indentation. None of these investigators used the same technique. Determination of setting times is merely an estimation of when a given probe fails to indent a sample, and there is no uniformly accepted test procedure for all cements.¹⁸

Conclusion

The addition of Na_2HPO_4 solution brings about significant reduction in the final setting time of White Mineral Trioxide Aggregate

Recommendations

Considering the present study results, although the addition of 20% sodium phosphate dibasic solution in White Mineral Trioxide Aggregate has potentially decreased the final setting time of MTA but this study needs to be tested further clinically.

Conflict of interest

The author declared no conflict of interest

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