The effect of giving NaOCL 2.5% and H_2O_2% solution on the initial setting Mineral Trioxide Aggregate (MTA)

Saraswati Dian Wardhani, Munyati Usman, Kamizar

Department of Conservative Dentistry Faculty of Dentistry Universitas Indonesia

ABSTRACT

Today, Mineral Trioxide Aggregate (MTA) is one of the most commonly-used materials to overcome problems in dental pulp as well as periodontal tissue. This substance received its permission from the American Food and Drug Administration (FDA) in 1998 and has been patented as a Portland type I.ASTM C150 cement-base material. However, MTA still has its flaws, such as: its granule form, requirement for moist condition, mass losing during hydration (high solubility), and particularly its time-consuming setting duration (45'-165'). Some researches attempt the usage of regular accelerator together with Portland cement, yet there's still no certainty of the best concentration that can be used to gain optimal result. This research conducted a time test of the initial setting of MTA that was mixed with the strong-oxidation antimicrobial solutions, they are NaOCl 2.5% dan H_2O_2 3%. The instrument used was the Gillmore needle. Data analysis used one-way ANOVA and Mann Whitney significance test ($p<0,05$). The result of the research showed that the mixing of NaOCl 2.5% with MTA the initial setting was ± 11 minutes and the mixing of NaOCl 2.5% with MTA the initial setting was ± 5 minute, it compared with the initial setting of original MTA which was the initial setting ± 50 minutes.

Key words: MTA, NaOCl 2.5%, H_2O_2 3%, initial setting

INTRODUCTION

The development in dentistry, Endodontic area, is now focused on some techniques and materials that are able to optimize teeth tissues repair and their surroundings. Various materials have been tested in order to get the best result in overcoming diseases/disorders in teeth pulp or in periodontium tissue.

A fast development happened to one material, which was introduced in 1998 and the use permission was issued by US Food and Drug Administration, known as Mineral Trioxide Aggregate (MTA) and up to now it has been widely used in endodontic clinic area, such as in perforation repair and root's tip cap material in endodontic surgery, and also as direct pulp-capping, apexification and external root resorption.[1-3]

Deus et al.[4] and Min et al.[5] that studied human cells' response on MTA concluded that this material was non toxic. The same thing happened to tissue reaction which was seen in a 12 week in vitro and in vivo observations on animal. This observation showed that normal cells' growth and recovery in operated area where the material was planted created no infection, and also there was a dentinal bridge in pulp capping which proved that this material was biocompatible.[6-8]

Correspondence author: Saraswati Dian Wardhani, Department of Conservative Dentistry Faculty of Dentistry Universitas Indonesia, Jln. Salemba No. 4 Jakarta, 10430, Telp. (021)3151035 ext 307. Fax. (021)31931412.

There are some problems in MTA use in clinics, the granule consistencies. This matter gives difficulty in its mixing and situating in cavity. The ossification time is rather long, about 45-165 minutes[1,9], and there was also mass loss during ossification period. There was 1% loss mass, in the research held by Bodanezzi[10], which took time 24-672 hours.[10] In its ossification, this material needs damp atmosphere, so it is known as a material with difficult handling.[11] This situation is an obstacle found in clinics when they want to hold action and restoration in one time visit.

There are a lot of researchers that try to find out some solutions on MTA: the ossification period, the compressive strength, and the amenity during mixing. By adding an addition material (accelerator), Kogan et al.[1] held a research on some addition materials, such as chlorhexidin gel, NaOCl 3% (ChlorCid V, Ultradent) gel, K-Y gel, saline and lidokain HCI which are regarded as antimicrobacterial. The research proved that only NaOCl 3% and K-Y gel which showed fast time setting, it was 20 minutes.[1]

Natrium Hypochlorite (NaOCl) is a bactericid and virusid material. In endodontic area, this material is commonly used in concentration between 1-5%. This material possesses alkali pH (11-14), and it is also known as an effective irrigation material since it is able to dissolve protein and microorganism, and also has low surface tension so that this solution can penetrate to narrow root channel.[14,15] In 1-5% concentration, NaOCl can be said as biocompatible.[14,15] Two and half percent NaOCl is widely used in dental clinics because of its odor which is not as sharp as other materials with higher concentration, but it gives the same bactericid effect as the 5% concentration.[16] In this research, the use of 2.5% NaOCl solution is based on the MTA hydration nature that needs sufficient amount of water to start materials mixing. NaOCl solution is a strong oxidator[15,16], so that it is hoped to be an initiator in a chemical reaction with accelerating MTA initial setting effect.

There is another material in dentistry that also has antimicrobacterial nature, that is hydrogen peroxide. Hydrogen peroxide (3%) is quite environment safe due to its easily decomposed into water (H_2O) and oxygen (O_2)).[17,18] H_2O_2 solution with 3% concentration (3% H_2O_2, 97% H_2O_2 is commonly used in medical area as irrigant/wound cleaner, and is a strong oxidator as well, in which in alkali atmospehere it can quickly react and can be decomposed into water and oxygen, and this all is needed for setting.

MTA and its mixing process need water (H_2O) for hydration, and oxygen to help the connection of cemen particles. Both materials (NaOCl and H_2O_2) contain dissolved concentration in water. They are strong oxidators, which are hoped to accelerate setting time.

The determination of solution concentration is mainly focused on its use in clinics, so that it can be easily got when it is needed. Comparing the addition of two solutions H_2O_2 3% and NaOCl 2.5% to MTA, to the initial setting speed. Consequently, according to the ability to initiate, it is estimated that the hydrogen peroxide 3% solution shows faster time than natrium hypochlorite 2.5%.

MATERIALS AND METHODS

MTA sample was made in 3 groups, In group 1 (control), MTA was mixed with steril water (bottled) that is manufactured by a factory. Group 2 the sample was made by mixing 1 gram of MTA powder with 0.30 ml NaOCl 2.5% solution, in group 3 it was made by mixing MTA with 0.30 ml H_2O_2 3% solution. Each mixture was divided into 15 rings, size Ø4 mm, height 3 mm. Five rings were given for each group and time-based indentation measuring was held. Untested samples had to be covered by wet kassa or placed in an incubator with 95% in dampness and 37% in temperature.

Sample testing setting time measurement was conducted by using Gillmore equipment with the indenter needle with its Ø2,12 mm flat tip and a pendulum, mass 113 gram. The procedure was by placing the indenter needle on the sample for five seconds. The first sample testing was conducted during the beginning of the setting with interval 1-5 minutes. The initial setting was defined as the time length until the sample ossificated in the ring in which the indenter needle could not mark the samples' surfaces and it was done in three spots. The writer took note of the time of each sample.

RESULTS

The setting time was treated by mixing MTA with packed liquid (H_2O steril), NaOCl 2.5%

Table 1. The difference of the initial setting meaning MTA+NaOCl, MTA+ H_2O_2 and control

	Average±SD	Value 95%		P value		
		Low	High	Control	MTA+NaOC1	MTA+H_2O_2
Control	50.22±0.44	49.88	50.56		000*	000*
MTA+NaOC1	11.11±0.33	10.85	11.37	000*		000*
MTA+H_2o_2	5.11±0.60	4.65	5.57	000*	000*	
N+9						

***Mann-Whitney test with $p<0.05$ for different meaning value inter group inter research group**

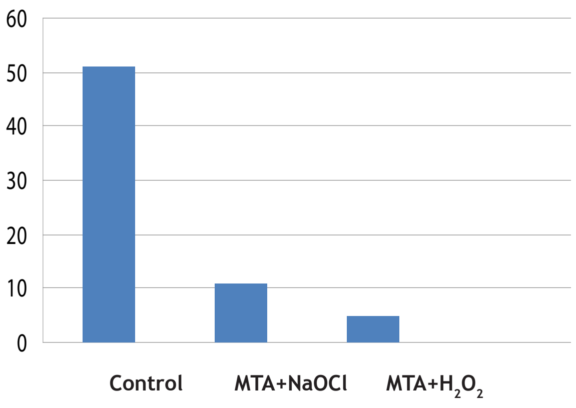

Figure 1. The relationship between MTA initial setting with control with the addition of NaOCl 2.5% or H_2O_2 3%.

solution and H_2O_2 3% solution. The mixture existed in each of those three groups which consisted of 9 samples. The time calculation using Gillmore needle was by noticing indentation existence. Based on the research result, statistical analysis was conducted and noticed the difference of meaning with the result, as seen in Table 1.

Time average result showed that control needed initial setting average 50.22±0.44 minutes which was the longest time to reach the initial setting compared to MTA + NaOCl 2.5% that needed setting time 11.11±0.33 minutes, and the fastest time for initial setting was the mixture between MTA + H_2O_2 3% that needed 5.11±0.60 minutes, as seen in Figure 1.

The result was the meaning difference between control initial setting with MTA + NaOCl. The result of different meaning also occured in control initial setting with MTA+H_2O_2 and in initial setting between MTA+NaOCl with MTA+H_2O_2 as well.

Based on the result, the null hypothesis which meant the NaOCl 2.5% solution could indeed accelerate the MTA initial setting time. Also, the H_2O_2 3% solution could also accelerate the MTA initial setting time and H_2O_2 3% solution and it showed faster initial setting than NaOCl 2.5% solution.

DISCUSSION

The Mineral Trioxide Aggregate (MTA) powder was used in this research which was a packed material that has been used and has an official confession from FDA (Food and Drug Association). Choosing NaOCl 2.5% and H_2O_2. 3% solution was because both of this solution is antimicrobacterial liquid that is commonly used in medical area, and also it is quite easy to get them with friendly price. Chemically, the solution is strong oxidator and it is hoped to be hydration reaction initiator so that it can accelerate MTA setting time. Consequently, initial setting result can be a consideration in clinics when they are going to use this material to shorten visiting time.

The start time of Gillmore needle indentation measuring in MTA setting test with the addition of NaOCl 2.5% was determined by the result of the previous study which got 12 minutes in score. Since the first sample showed faster MTA setting time, the observation time was shortened to 1 minute interval, started from the 9th minute to the 12th minute. Deciding the intervals between 1 minute or 5 minutes was based on the research conducted by Wiltbank et.al. During the concoction, mixture consistency was better and the mixture of powder and liquid seemed faster compared to the mixture of MTA and manufactured steril liquid so that the placement in mold was easy.

As in the test of MTA with NaOCl 2.5% solution, the addition of H_2O_2 3% solution to MTA powder also created the setting time reduction into 5 minutes, so that the Gillmore needle indentation observation was conducted every minute, started in minute 3 to minute 7. The mixture of the solution with MTA powder produced a more solid mixture but after the placement in mold, it showed a smoother and glossy surface. This might be because the H_2O_2[19] decomposition that could plate the material during hydration.

In this research, the chosen accelerator materials were the solution that was commonly used in clinic, they are NaOCl 2.5% and H_2O_2 3%. Both of the solution was antimicrobacterial and easily got, especially NaOCl 2.5% which was the solution that is, up to now, still used as root channel irrigant in endodontic treatment and is biocompatible in nature. Both of the materials are strong oxidator and are able to release free radical ions to be the initiators in MTA polymerization. Free radical is molecules with single electrons and become very reactive: 2 NaOCl $\rightarrow$ 2NaCl+2O_n; $2H_2O_2 \rightarrow 2H_2O + 2O_n$

To form polymer, the initiator (NaOCl dan H_2O_2) with monomer will decompose into free radicals ($O_2 \rightarrow O_n \rightarrow O_n$). Next, these free radical electrons will attach to the condensed monomer and formed oxygen chain to create polymerization. When homopolymers or with other heteropolymers are formed because of the reactive radical ions, the process of polymerization will happen quickly.

As explained before, O_n was a very reactive free radical electron and it initiated condensation (tie release of H-OH from Sillica or Alum hydrate). That was what happened in NaOCl 2.5% addition to MTA powder. NaOCl will release its radical ion (O_n) to initiate hydration process, while Na or Cl ion (composed) can also attach to polymer as balance ions. Consequently, defining the initial setting time of adding NaOCl 2.5% to MTA is faster than in control.

There is an explanation on why H_2O_2 3% solution gives setting time with faster MTA than NaOCl 2.5% solution in MTA. The answer is, the H_2O_2 mobility is better than NaOCl. H_2O_2 solution which in contact with MTA powder will soon decompose into H_2O (water) and radical ion (O_n). With the existence of water, the capability of O_n to initiate to all over the monomer areas is better, so that condensation process will run faster.

Cement setting time (MTA) is also influenced by environment temperature. Higher environment temperature will make setting time runs faster, in other words, it influences condensation process or H_2O_2 release and polymer formation.[21] In this research, measurement was conducted in room temperature 28°C, so in practice, there was big possibility of faster MTA setting time due to different temperature in oral area that was around 37°C.

Consequently, according to the research and discussion, the hypothesis was proved. Mixing NaOCl 2.5% solution with MTA powder could accelerate the setting time into average 11.11 minute. The same thing also happened to the mix of H_2O_2 3% solution with MTA powder that also accelerated the setting time into average 5.11 minutes.

When MTA used packed steril liquid, it needed average time 50.22 minutes. Another hypothesis was also proved, H_2O_2 3% solution mixed with MTA powder showed faster time than NaOCl 2.5% mixed with MTA.

CONCLUSION

NaOCl 2.5% solution could accelerate MTA initial setting. H_2O_2 3% solution could accelerate MTA initial setting. Addition of H_2O_2 3% solution to MTA showed faster initial setting than addition of NaOCl 2.5% to MTA.

REFERENCES

1. Kogan P, He Jianing, Glickman GN, Watanabe I. The effect of various additives on setting properties of MTA. JOE 2006;Jun(32):6,32.
2. Ford TR, Torabinejad M, Abeli HR, Bakland LK, Kariyawasam SP. Using Mineral Trioxide Aggregate as a pulp-capping material. J Am Dent Assoc 1996;127:1491-4.
3. Torabinejad M, Chivian N. Clinical applications of Mineral Trioxide Aggregate. JOE 1999;Mar (25)3.
4. Deus GD, Ximenes R, Gurgel-Filho ED, Plotkowski MC, Coutinho-Filho T. Cytotoxicity of MTA and Portland Cement on human ECV 304 endothellial cells. Intern Endod J 2005;38:604-6.
5. Min KS, Kim HI, Park HJ, Pi SH, Hong CU, Kim EEC. Human pulp cells response to Portland cement in vitro. JOE 2007 Feb;33(2).
6. Saidon J, He J, Zhu Q, Safavi K, Spangberg LSW. Cell and tissue reactions to Mineral Trioxide Aggregate and Portland cement. Oral Surg Oral Med Oral Pathol Oral Radiol Endod

2003;95:483-9.

7. Menezes R, Bramante CM, Garcia RB, Letra A, Carvalho VGG, Carneiro E, et al. Microscopic analysis of dog dental pulp after pulpotomy and pulp protection with Mineral Trioxide Aggregate and White Portland Cement. J Appl Oral Sci 2004;12(2):104-7.
8. Razmi H, Sharifi D, Mottahari P, Khosravi MR. Pulp tissue reaction of dog canises to root MTA and Portland Cement compared to proroot mta as pulp capping agent. J Dent Teheran University of Medical Science 2006:3(2).
9. Bortoluzzi EA, Broon NJ, Duarte MAH, Demarchi ACCO, Bramante CM. The use of a setting accelerator and its effect on ph and calsium ion release of Mineral Trioxide Aggregate and White Portland Cement. JOE 2006 Dec;32(12).
10. Bodanezi A, Carvalhon, Silva D, Bernaldineli N, Bramante CM, Garcia RB, et al. Immediate and delayed solubility of Mineral Trioxide Aggregate and Portland Cement. J Appl Oral Sci. 2008;16(2):127-31.
11. Islam I, Chng HK, Yap AUJ. Comparison of the physical and mechanical properties of MTA and Portland Cement. JOE 2006 Mar 32(3).
12. Hong ST, Bae KS, Baek SH, Kum KY, Lee WC. Microleakage of accelerated Mineral Trioxide Aggregate and Portland Cement in an in vitro apexivication model. JOE 2008 Jan;34(1).
13. Ber BS, Hatton JF, Stewart GP. Chemical modification of pro root MTA to improve handling caracteristics and decrease setting time. JOE 2007 Oct 33(10).
14. Clarkson RM, Moule AJ. Sodium hypochlorite and its use as an endodontic irrigant. Australian Dent J 1998;43(4):000-000.
15. Estrela CRA, Barbin EL, Spano JCE, Marchesan MA, Pecora JD. Mechanism of action of sodium hypochlorite. Braz Dental J 2002;13(2):113-7.
16. Siqueira JF, Rocas IN, Favieri A, Lima KC. Chemomechanical reduction of the bacterial population in the root canal after instrumentation and irrigation with 1%, 2,5%, sodiumhypochlorite. JOE2000Jun;26(6):331-4.
17. Hidrogen peroksida. Available from:http://wwwh2o2.com/intro/overview.html.
18. Dental Care Issues: Hydrogen peroxide. Environment, Health and Safety Online. [cited 2008 Apr 28].
19. Thomas JJ, Jennings HM. A colloidal interpretation of chemical aging of the c-s-h gel and its effect on the properties of cement paste. Cement and Concrete Research 2006;36:30-8.
20. Inorganic Polymer Science. (Chapt.2). Available from:fr:adt.curtin.edu.au/theses/available.
21. Czernin W. Cement chemistry and physics for civil engineers. London: Crosby Lockwood&Son Ltd.; 1984.