

Research Report

Functional relationship of room temperature and setting time of alginate impression material

Dyah Irnawati and Siti Sunarintyas

Department of Dental Biomaterials

Faculty of Dentistry, Gadjah Mada University

Yogyakarta - Indonesia

ABSTRACT

Background: Indonesia is a tropical country with temperature variation. A lot of dental clinics do not use air conditioner. The room temperature influences water temperature for mixing alginate impression materials. **Purpose:** The aim of this study was to investigate the functional relationship of room temperature and initial setting time of alginate impression materials. **Methods:** The New Kromopan® alginate (normal and fast sets) were used. The initial setting time were tested at 23 (control), 24, 25, 26, 27, 28, 29, 30 and 31 degrees Celcius room temperatures ($n = 5$). The initial setting time was tested based on ANSI/ADA Specification no. 18 (ISO 1563). The alginate powder was mixed with distilled water (23/50 ratio), put in the metal ring mould, and the initial setting time was measured by test rod. Data were statistically analyzed by linear regression ($\alpha = 0.05$). **Result:** The initial setting times were 149.60 ± 0.55 (control) and 96.40 ± 0.89 (31°C) seconds for normal set, and 122.00 ± 1.00 (control) and 69.60 ± 0.55 (31°C) seconds for fast set. The coefficient of determination of room temperature to initial setting time of alginate were $R^2 = 0.74$ (normal set) and $R^2 = 0.88$ (fast set). The regression equation for normal set was $Y = 257.6 - 5.5 X$ ($p < 0.01$) and fast set was $Y = 237.7 - 5.6 X$ ($p < 0.01$). **Conclusions:** The room temperature gave high contribution and became a strength predictor for initial setting time of alginates. The share contribution to the setting time was 0.74% for normal set and 0.88% for fast set alginates.

Key words: alginates, room temperature, initial setting time

Correspondence: Dyah Irnawati, c/o: Bagian Biomaterial Kedokteran Gigi, Fakultas Kedokteran Gigi Universitas Gadjah Mada. Jl. Denta, Sekip Utara, Yogyakarta 55281, Indonesia. E-mail: ninnad38@yahoo.com, Phone/Fax no. 062-274-515307

INTRODUCTION

The function of an impression material is to record accurately the dimensions of oral tissues and their spatial relationships.¹ Impression material should fulfill certain requirements to obtain an accurate impression, such as: adaptive to the oral tissues, viscous enough to be loaded in the tray, set into rubbery or rigid solid in a reasonable amount of time, dimensionally stable, biocompatible, and low cost.²

The alginate hydrocolloid, agar hydrocolloid, and synthetic elastomeric impression materials are the most widely used today.³ The general use of alginate exceeds than the other impression materials.² The widely used of alginates results from: the ease of mixing and manipulation, the minimum equipment necessary, the flexibility of the set impression, accuracy on proper handling, and low cost.¹

Alginate impression are used to form study casts to plan treatment, monitor changes, and fabricate crown, bridges, and removable prostheses.³

Alginate impression materials is an irreversible hydrocolloids. The main active ingredient of this materials is soluble alginates such as sodium, potassium or thiethanolamine alginate. The other components are reactor (calcium sulfate), filler particles (zinc oxide, diatomaceous earth), accelerator (potassium titanium fluoride), and retarder (sodium phosphate).²

When the alginate powder is mixed with water, the setting reaction is occurred and the gel alginate is set. The typical sol-gel is a reaction of soluble alginate with calcium sulfate and the formation of an insoluble calcium alginate gel. Structurally calcium ion replaces the sodium or potassium ions of two adjacent molecules to produce a cross-linked complex or polymer network. The production

of the calcium alginate is so rapid that it does not allow sufficient working time. The retarder (trisodium phosphate) is added to prolong the working time. The calcium sulfate will react with this salt in preference to the soluble alginate, so the rapid reaction between calcium sulfate and the soluble alginate is deferred as long as there is unreacted trisodium phosphate.²

Alginate powder is mixed with water in a flexible bowl to a soft paste consistency, loaded into a tray to carry it to the mouth, then placed over the patient's teeth and allowed to set.⁴ Ideally the total setting time should be less than 7 minutes.² Setting time of alginate is ranged from 1 to 5 minutes.³ The setting reaction of alginate is a typical chemical reaction.³ This reaction is a temperature-dependence reaction.⁵ To fulfill the critical requirements of a dental impression material, the reaction must be controlled to attain the desirable properties of consistency, working time, setting time, strength, elastic quality, and smooth hard surface on gypsum cast. These requirements are achieved by adding agents to control the rate of reaction, develop strength and elasticity in the gel, and counteract the delaying effect of alginate on the setting of gypsum products.³ The setting time of alginate is best regulated by the amount of retarder added during the manufacturing process.²

Environmental conditions and the characteristics of the tissue often influence the choice of materials, the quality of impression, and the quality of cast.² The setting time of alginate depends on the water and room temperatures of mixing.⁶ The standard room temperature is $23 \pm 2^\circ \text{C}$.⁷ Alginate is normally mixed with water at room temperature.⁴ The water temperature is between 20°C and 22.2°C .⁸ In such a case, the temperature of mixing water should be controlled carefully within a degree or two of standard temperature, usually 20°C , so that a constant and reliable setting time can be obtained.²

Indonesia is a tropical country with dry and rainy seasons. Many cities in Indonesia have different elevation. These factors influence air temperature of the cities in a certain time. In dry season, the temperature is varied from 18°C to 26°C (minimum) and 27°C to 34°C (maximum).⁹ The air temperature will influence room temperature. In dry season, room temperature in Yogyakarta (300 m above sea level) is 27°C to 29°C and in Cianjur (1000 m above sea level) is 20°C to 23°C .¹⁰

Some public health centers, dental private clinics, and laboratory in Faculty of Dentistry do not use air conditioner. Consequently, it is difficult to maintain the room in a certain temperature. Also, it is important to know the room temperature influences and the strength of its relationship on alginate setting time. The aim of this study was to investigate the functional relationship of room temperature and initial setting time of alginate impression materials.

MATERIALS AND METHODS

Two types (normal set and fast set) of The New Kromopan® alginate impression materials (Lascod, Germany) were examined. The analytical balance, measurements glass, rubber bowl, spatula, stopwatch, glass plate, metal ring mould (16 mm in height and 33 mm in diameter),⁷ and poly methylmethacrylate cylindrical test rod (10 cm long and 6.35 mm in diameter)⁷ were used. The initial setting time were tested in air conditioned laboratory room with temperatures of 23 (control group), 24, 25, 26, 27, 28, 29, 30, and 31 degrees Celcius. Five specimens were tested for each group. Before testing, the alginate powder, distilled water, and test equipments were conditioned for 6 hours in these certain temperature and $60 \pm 10\%$ relative humidity. Measurement was done from the beginning of water and alginate powder mixing until the rod is cleanly separated from the mixed material.⁷

The proportion of alginate powder and water was 23:50 (w/v). The metal ring mould was put on the glass plate. The water was poured into the rubber bowl, and then the alginate powder was added. The water and alginate powder was stirred by spatula until a smooth creamy mix results. The mixing time was 30 seconds. The ring mould was overfilled with the mixed material and the top of the mould was strike off with spatula to get a smooth and parallel surface. Immediately, end of the test rod was placed into momentary contact with the unset material, then withdrawn and cleaned with tissue. The contact/withdrawal steps were repeated every 10 seconds until the rod was separated cleanly from the material. The setting time of alginate was recorded. Data were statistically analyzed by linear regression ($\alpha = 0.05$).

RESULT

The mean and standard deviation of initial setting time of normal set and fast set alginate impressions was shown in Table 1. The regression analysis results of the relationship between room temperature and initial setting time can be seen in Table 2.

DISCUSSION

The setting time of alginate is best regulated by the amount of retarder added during the manufacturing process.² Normal set materials gel in 3 to 4 minutes and fast set materials gel in 1 to 2 minutes.¹¹ Normally, the manufacturer make both fast and normal setting alginate to provide clinicians the opportunity to choose the materials

Table 1. Mean and standard deviation of initial setting time of alginates (seconds)

Room Temperature (° C)	Normal set alginate	Fast set alginate
23 (control)	149.60 ± 0.55	122.00 ± 1.00
24	122.40 ± 0.55	97.60 ± 0.89
25	112.20 ± 0.45	95.00 ± 0.71
26	106.20 ± 0.84	90.60 ± 1.14
27	102.20 ± 0.83	85.20 ± 1.09
28	99.60 ± 0.55	81.20 ± 0.84
29	98.40 ± 0.55	76.00 ± 1.41
30	97.20 ± 0.45	72.20 ± 0.84
31	94.60 ± 0.89	69.60 ± 0.55

Table 2. Regression analysis of the relationship between room temperature and initial setting time of alginate impression

	Normal set alginate	Fast set alginate
The coefficient of determination (R^2)	0.74	0.88
The regression equation	$Y = 257.6 - 5.5 X$	$Y = 237.7 - 5.6 X$
Significancy	$p < 0.01$	$p < 0.01$

that best suit their working style.² The standard setting time is achieved when the alginate is manipulated in 23° C room temperature and mixed with water in this room temperature.

The setting time of alginate is influenced by many factors, such as: the W/P ratio, mixing time, water temperature,² composition (trisodium phosphate content), temperature of mixing,⁶ second alginate layer added, retarder added, and certain liquid products added.¹² Local environment conditions, such as: air temperature, surface temperature, humidity, and wind also have an effect on the final setting time of alginate impression materials.¹³

The setting time of alginate is affected by the room temperature. The higher the temperature the less time is required.¹⁴ Room temperature primarily has an effect on the setting time of the outside surface of the material. On a very hot day, the air temperature can accelerate the set of alginate.¹³

The results of this study showed that there was a significant share contribution of room temperature to the value of alginate initial setting time (0.74% for normal set alginate and 0.88% for fast set alginate). The room temperature influences the temperature of materials (alginate powder and water) and instruments (rubber bowl, spatula, and impression tray) which are put in that room for some hours. Consequently, the setting time of alginate impression materials will be affected.

The setting reaction of alginate impression materials is a chemical reaction.^{1,3} The temperature dependence of the alginate reaction process was of the Arrhenius type.^{5,15} The Arrhenius law is the dependency of chemical reaction rate on the temperature.¹⁶ The chemical reaction rate speed up with increasing temperature. The rate of reaction doubles with a 10° C rise in temperature.^{3,17}

The setting time of calcium alginate is very temperature dependent.¹⁸ The temperature of the water controls the

rate of setting reaction.¹¹ The reaction of alginate is faster at higher temperatures.^{2,6,11,12} An increase in the temperature of the water used to prepare the mix shortens the setting time.¹ The warm water reduce the setting time by accelerating the rate at which sodium phosphate is consumed and by subsequently increasing the rate of cross-linking reaction.¹⁹

The results of this study showed the functional relationship of room temperature and initial setting time of alginate impression materials. For every 1° C room temperature increased, 5.5 seconds (normal set) or 5.6 seconds (fast set) initial setting time reduction of alginate impression materials was occurred. This results is accordance with previous study that examined the rheological properties of alginate impression materials at various temperatures (37.4, 20.5, 15.5, 11.5, and 7.0 degrees Celcius). The setting reaction of alginates was faster at higher temperature and so the alginates in contact with tissues.²⁰

The relationship of room temperature and alginate setting time in this study was relatively similar with the relationship of water temperature and alginate setting time. In general, 1 minute reduction in setting time occurs for every 10° C of temperature increase.² The setting time of one alginate impression materials product has a 10 seconds water temperature dependence for each 2° C departure from 23° C.¹³

In a hot weather, the standard setting time of alginate impression materials can be achieved by using water that is cooler than room temperature.² Although, alginate mix made with water at room temperature is the most comfortable for the patient.⁸ It may even be necessary to pre cool the mixing bowl and spatula, to avoid premature gelation of alginate. Because the materials exhibit different degrees of sensitivity to temperature, it is better to select a product with the desired setting time and less sensitivity

to temperature change.² In the future, it is necessary to produce alginate impression materials which has standard setting time in hot weather with room temperature higher than 23°C.

It concluded that the room temperature gave high contribution and became a strength predictor for initial setting time of alginates. The room temperature has significant share contribution to the value of alginate initial setting time (0.74% for normal set alginate and 0.88% for fast set alginate). For every 1°C room temperature increase, 5.5 seconds (normal set) or 5.6 seconds (fast set) initial setting time reduction of alginate impression materials was occurred.

REFERENCES

1. Craig RG, Powers JM, Wataha, JC. Dental materials properties and manipulations. 7th ed. St Louis: Mosby Co; 2000. p. 138–41, 145–56.
2. Anusavice KJ. Phillips' science of dental materials. 11th ed. St. Louis: Elsevier; 2003. p. 205–9, 231–48.
3. Craig RG, Powers JM. Restorative dental materials. 11th ed. St. Louis: Mosby Co; 2002. p. 330–40.
4. Vanable DE, LoPresti LR. Using dental materials. New Jersey: Pearson Prentice-Hall; 2004. p. 87–91.
5. Craig RG. Review of dental impression materials. Adv Dent Res 1988; 2(1): 51–64.
6. Combe EC. Notes on dental materials. 6th ed. Edinburgh: Churchill Livingstone; 1992. p. 115–6, 121–5.
7. Council on Dental Materials, Instruments and Equipment, American National Standard/American Dental Association (ANSI/ADA Specification no. 18, Alginate impression materials, 1992).
8. Ferracane JL. Materials in dentistry principles and applications. 2nd ed. Philadelphia: Lippincot Williams & Wilkins; 2001. p. 173–201.
9. Badan Meteorologi dan Geofisika, Prakiraan cuaca kota propinsi Indonesia, 2007, <http://meteo.bmg.go.id/cuacaindo.jsp>. Accessed January 18, 2007.
10. Purwanti S. Kajian suhu ruang simpan terhadap kualitas benih. Journal online universitas Sriwijaya, 2004. Available at: <http://journal.unsri.ac.id/detail.php?no=15>. Accessed August 16, 2007.
11. Gladwin M, Bagby M. Clinical aspects of dental materials. Philadelphia: Lippincot Williams & Wilkins; 2000. p. 100–1.
12. Parvin D. How to extend the setting time of alginate. Contemporary Art Media 2003; 1–3.
13. Accu-cast, Life casting instruction for Accu-cast products. 2006, Available at: http://www.accucast.us/prod_instruct.html. Accessed July 7, 2007.
14. Hollins C. NVQs for dental nurses. Oxford: Blackwell Pub Professional; 2003. p. 136–7.
15. Ellis B, Lamb DJ. The setting characteristics of alginate impression materials. Brit Dent J 1981; 151: 343–6.
16. Bird T. Kimia fisik untuk Universitas. Cetakan ke-2. Jakarta: PT Gramedia; 1993. p. 282.
17. Anonymous. The encyclopedia Americana international edition. Vol. 2. Americana Corporation. 1973. p. 377.
18. Doubleday B. Orthodontic products update impression materials. BJO 1998; 25(2): 133–40.
19. McCabe JF, Walls AWG. Applied dental materials. 8th ed. Cambridge: Blackwell Science Ltd; 1998. p. 118–26, 133–40.
20. Fish SF, Braden M. Characterization of the setting process in alginate impression materials. J Dent Res 1964; 43(1): 107–17.