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The Effect of Different Concentrations of Gilvest with Water on the Setting Time of Phosphate-bonded investment

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المستخلص

الهدف: معرفة تأثير التراكيز المختلفة لمادّة السائل الخاص (لمزج مادّة الإكساء الفوسفاتي، Gilvest) ومزجه مع الماء على وقت التصلب لمادّة الإكساء الفوسفاتي.

المنهجيّة: ستين عينة من مادّة الإكساء الفوسفاتي قسمت الى اربع مجاميع وكل مجموعة تحتوي على خمسة عشر عينة. تم فحص وقت التصلب باستعمال جهاز **(Gillmore needle)** لمادّة الإكساء الفوسفاتي وخلطه مع نسب مختلفة من السائل الخاص والماء.

النتائج: أكدت النتائج من خلال استعمال المتغيرات المعتمدة في كل الفحوصات ان هناك اختلاف كبير بين المجاميع في التحليل الاحصائي باستعمال اختبار (ANOVA)، ما عدا اختلاف معنوي بين مجموعة (A) ومجموعة السيطرة في التحليل الاحصائي باستعمال اختبار (LSD).

التوصيات: استعمال تركيز اخر لجلوفست (0.3ml) ومزجه مع الماء (0.2ml) والباودر (15g) على وقت التصلب لمادّة الإكساء الفوسفاتي. ويأضاً نستطيع ان نستعمل نوع آخر لباودر (الإكساء الجبسي) مع الجلوفست وبتراكيز مختلفة.

Abstract:

Objective: To identify of the effect of the different concentrations of the special liquid (for mixing the investment, Gilvest) and mixed with water/powder ratio on setting time of phosphate–bonded investment.

Method and materials: The present study is (60) specimens made from phosphate bonded investment divided into (4) groups (control and experimental groups), (15) specimens for each group. The Gillmore needle device is used to setting time of phosphate bonded investment mixed with different concentration of Gilvest and water.

Results: Showed that there is a high significant difference ($P<0.01$) between each groups in the ANOVA test and a significant difference ($P<0.05$) between the group (A) and control group in the LSD test.

Recommendations: using other concentration of Gilvest (0.3ml) mixed with water (0.2ml) and powder (15g) on the setting time of the phosphate–bonded investment. We can use another type of powder (gypsum–bonded investment) with the Gilvest at different concentrations.

Keywords: Gilvest, Water, Phosphate–bonded investment

Introduction

The phosphate–bonded investment materials are important part of restorative dentistry. They are used in crown and bridge and removable of partial denture and the accuracy of work in the phosphate–bonded investment has imperative for the success of any types of prosthodontic treatment. The setting time of investment is very important to produce accurate and better laboratory procedure. The most common type of investment for casting high-melting alloys is the phosphate–bonded investment. This type of investment consists of three different components; each of which is responsible for certain characteristic properties (1).

The phosphate–bonded investment is Filler (refractory) = quartz or cristobalite or both (80%), Binder = magnesium oxide and acid phosphate according to following chemical reaction. $NH_4H_2PO_4 + MgO \rightarrow NH_4Mg + PO_4 + H_2O$ (2). The advantages of phosphate–bonded investment is less alloy contamination during decomposition, much more expansion than the other two investment types (gypsum–bonded investment and silica–bonded investment), much more hydroscopic is possible, there is no shrinkage during the initial setting reaction, and they produce the smoothest surface castings of all types (3). Specifies two types of phosphate-bonded investments for alloys having a solid us temperature above 1080C° (4).

- **Type I: For inlays, crowns, and other fixed restorations**
- **Type II: For partial dentures and other cast, removable restorations**

One component consists of materials that are soluble in water to yield a phosphate ion. The second component consists of materials that react with phosphate ions at room temperature (2). The third is a

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ceramic substance that hardens at a high temperature and is responsible for high–temperature strength. Different materials can be used in each group to serve as suitable components and to develop different physical properties (5-6).

The final setting time is defined as the time at which the material is completely set and can be separated from the impression without distortion or fracture (7). It is usually is measured arbitrarily by some form of penetration test which is called Gillmore needles device when the needle fails to penetrate to the bottom of container, it means the material has reach the final setting time (3, 5, 8).

The Water/ Powder (W/P) ratio has a pronounced effect on the setting time. The much water in the mixture of phosphate–bonded investment, the longer the setting time. While, the effect of spatulation on setting time of investment is the increased spatulation shortens the setting time. Properties of a phosphate–bonded investment by a power–driven mixer with vacuum attachment, the setting time typically is shortened for power mixing compared with hand mixing (9, 10), to decrease the setting time of the phosphate–bonded investment mixed with especial liquid (colloidal silica suspension) with water/powder ratio used for the mix markedly enhances casting surface smoothness but can lead to oversized extracoronal castings (11). Al–taai (2006) stated that the setting time on cement is decrease when different concentration of special liquid with water compared to conversional manufacture of investment materials (12). Other studies they found that the setting time on gypsum–bonded investment need more time for setting when use the different concentration of especial liquid with water (13).

The other effect on the setting time is temperature the warmer the mix, the faster it sets. Mechanical mixing under vacuum is preferred, to give smoothness and accuracy and also give more setting time (14). Therefore, the aim of the present study is to evaluate the effect of the different concentration of special liquid (Gilvest) with water/ powder ratio on setting time of phosphate–bonded investment.

Methods and Materials:

Methods:

Sixty specimens were prepared from phosphate–bonded investment and divided into two groups as the following:-

Control group consist of (15) specimens were prepared from phosphate–bonded investment according to manufacturer instructions (Powder 10g mixed with especial liquid 2ml).

Study group and divided into three Groups as the following:
Group A: consist of (15) specimens were prepared from phosphate–bonded investment (powder 10g mixed with especial liquid 1.5ml and distilled water 0.5 ml).
Group B: consist of (15) specimens were prepared from phosphate–bonded investment (powder 10g mixed with especial liquid 1ml and distilled water 1 ml).
Group C: consist of (15) specimens were prepared from phosphate–bonded investment (powder 10g mixed with especial liquid 0.5ml and distilled water 1.5 ml).

This study used a laboratory experimental method. According to ADA specification, the Gillmore needle Apparatus is used to determine the time of set of phosphate–bonded investment. Apparatus consists of one needle point of each size, base, support shaft and horizontal arms. Weight 2.5 kg, figure 1 (15).

The mixed phosphate–bonded investment was poured in a metal ring mold of exactly 4.8mm height, 11.1 mm external diameter, and 9.5mm internal diameter, figure 2 (16).

The mold was place on a flat glass plate immediately after mixing each specimen in the room temperature 25C°. The setting time was determined with use of the Gillmore needle device. The needle possessed a flat end perpendicular and has a diameter 1.06mm and was cylindrical in shape in all over (17). Separating medium was used to lubricate the Gillmore needle to prevent phosphate–bonded investment sticking to it.

The Gillmore needle was lowered vertically on the surface of the phosphate bonded investment and allowed to rest there for seconds. This procedure was repeated until the bell rings (this means that phosphate – bonded investment was set). The final setting time was considered to be the period of time elapse from the start loss of gloss of mixing until the needle failed to make a perceptible circle on the surface of the specimens, when allowed to rest under needle weight (11,18).

The amount of penetration of the cone is measured at 4, 5 and 6 minutes after the start of the mix and an average value is obtained (19).

Materials:

1. Phosphate–bonded investment: BellaStar XL (Bego – Germany). Batch No. 03607. Exp. Date 05 – 2012.
2. Especial liquid (Gilvest): (Bego – Germany) Batch No.119268. Exp. Date 03 – 2011.
3. Separating medium: Isolit (Dentaurum – Germany).
4. Distilled water: (Al- Mansore Company Iraq).
5. Filter paper: (England).

Equipment:

6. Gillmore needle device: ELE. International (USA). Batch No. EL38-2690.
7. Metal ring mold: (Iraq).
8. Electrical balance :(Sartorial b 13100, Germany).
9. Stop watch :(China).
10. Stainless steel spatula :(Germany).
11. Glass slab: (Germany).
12. Wax knife: (Bego, Germany).
13. Lacron carver: (Bego, Germany).

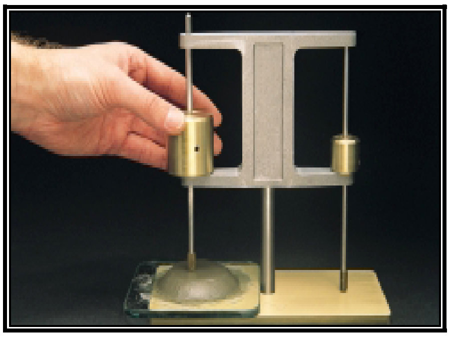

Figure 1. The Gillmore needle device

Figure 2. Metal ring mold

Statistical Analysis:

The suitable statistical methods were used in order to analyze and assess the results, include the following: (20)

1- Descriptive statistics:

a- Statistical tables including observed frequencies
b- Summary statistic of the readings distribution (mean, SD, SEM, minimum and maximum)
c- Graphical representation by Bar-Chart

2 – Inferential statistics:

a- Analysis of variance (ANOVA)
b- Least significant difference LSD
c- Note: The comparison of significant (P-value) in any test were**:**
S= Significant difference ($P<0.05$)
HS= Highly Significant difference ($P<0.01$)
NS= Non Significant difference ($P>0.05$)

Results:

Table 1. Means of setting time (minutes) of groups

	n	Mean minutes	Std. Deviation	Std. Error	Range		ANOVA Test (P -value)	Sig.
					Minimum	Maximum		
1. Control Group	15	2.9153	.3996	.1032	2.40	3.45	.000	HS
2. Study Group								
Group - A	15	3.5400	.6626	.1711	2.40	4.50		
Group - B	15	4.9033	.8372	.2162	3.20	6.20		
Group - C	15	6.5320	.7571	.1955	5.30	7.55		
Total	60							

ANOVA= Analysis of variance; n=Number; P-value= Level of probability at p= P<0.05; Sig.=Significance; Std. Deviation= Standard deviation; Std. Error= Standard error

In this table, the setting time of phosphate–bonded investment was tested using ANOVA and LSD. All groups had highly significant differences at (P< 0.01) when compared with the control group.

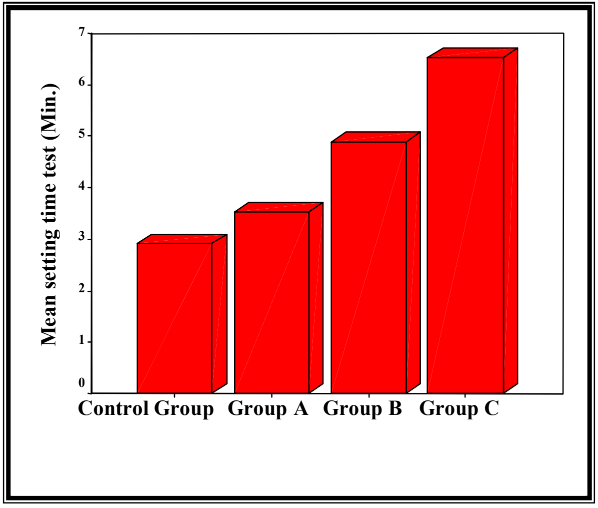

Figure 3. Bar-Chart representing means of setting time (minutes) of the phosphate–bonded investment

Table 2. Dependent variable of setting time (minutes) and LSD test

Groups		LSD test (P–value)	
		P–Value	Significance
Group (control)	Group–A	.015	S
	Group–B	.000	HS
	Group-C	.000	HS
Group – A	Group–B	.000	HS
	Group-C	.000	HS
Group – B	Group-C	.000	HS

HS= Highly significant; LSD= Least significant dose; P-value= Level of probability at p= P<0.05; S=Significant

This table revealed that there was a significant difference between the control group and the study group (A). While, there is a high significant difference between the control group and the study group (B) and the study group (C) (p< 0.01), also it was observed a high significant difference between the study group (A) and the study group (B) and the study group (C), although it was found a high significant difference between the study group (B) and the study group (C).

Discussion:

In general, phosphate-bonded investments consist of $SiO2$ as refractory filler, MgO and $NH4H2PO4$ as a binder, and colloidal silica solution as a mixing liquid. Also it can be mixed with water $H2O$ to obtain the general result (1, 2). When the phosphate–bonded investment (10gm) mixed with especial liquid (2ml) without water it lead to a reduction in the setting time of phosphate–bonded investment (control group), which may be attributed to the steady in the P/L ratio according to manufacture of investment, this result agreed with the result of Carlevaris M. and others (1999) and Finger W. and others (1999) who concluded that high powder/liquid ratio accelerated the setting reaction.

When the phosphate–bonded investment (10gm) mixed with especial liquid (1.5 ml) and water (0.5 ml) there is a slightly increase of the setting time after mixing with water in comparison with the control group, it may be attributed to the solubility of the particles of binder which dissolved during setting time, this comes in agreement with Eames W. and other (2001), who stated that, the precipitated phosphate crystals that are much smaller than the silica particles of the investment can lower the viscosity of the mixture as a result of the temporary adherence of especial liquid and water with phosphate–bonded investment, this is supported by Heiserman D. L.(2005), Lasy A. M. and others (2004).

When the phosphate–bonded investment (10gm) mixed with especial liquid (1 ml) and water (1 ml) it increased in setting time after mixing with water compared with the control group, this results could be explained due to the change of the properties of phosphate–bonded investment after mixed with liquid and water, because of the large of the interparticle spacing of refractory fillers of investment (3, 21).

The interparticle spacing of large and small sizes of phosphate - bonded , when consider it with the interference of fillers, the large size of interparticle lead to the small bulk porosity which result into on increase in the setting time of investment, this result is in agreement with Haddon Cl.(2002), O'Brien W.J.(2008) and Neiman R. and others (2006) .

The phosphate–bonded investment (10gm) mixed with especial liquid (0.5 ml) and water (1.5 ml) was the highest increase of setting time after mixing with water and gives a high significant difference ($P<0.01$) compared with the control group. This is may be due to the slurry which has a high fluidity when the ratio of the binder to the interstitial voids increased, since the binder must flow through a narrower zone (6, 23).

On the other hand, a large amount of small filler particles considerably increases the specific surface, requiring a great amount of water for mixing and resulting in the higher fluidity. These two factors may bring about the maximum fluidity in specimens made with aggregates of medium porosity (12, 15, and 26). When the setting time will be longer by the increase in potential nuclei of crystallization, because of a large amount of binders and large surface area of fillers. So, the conclusion of increase of the setting time is depending upon the bulk porosity (27). It can be concluded that using different concentrations of Gilvest may affect the setting time of phosphate–bonded investment. According to the current study, the best concentration of Gilvest is the study group A consist of Gilvest (1.5ml) mixed with water (0.5ml) and powder (10g) leads to a slightly increase setting time compared with control group than other groups (B, C) and this lead to the faster laboratory procedures work.

Recommendations:

1. Using other concentration of Gilvest (0.3ml) mixed with water (0.2ml) and powder (15g) on the setting time of the phosphate–bonded investment.
2. Use another kind of powder (gypsum–bonded investment) with the Gilvest at different concentrations.

Reference

1. Anderson JN. *Applied Dental Material*. London: Blackwell Scientific Publication;1985.

2. Craig RG. *Restorative Dental Material*. London: Mosby; 1996.

3. Craig RG. *Restorative Dental Material*. London: Mosby; 1997.

4. Craig RG, Power JM. *Restorative Dental Material*. London: Mosby; 2002.

5. Craig RG, Power J, Wataha JC. *Restorative Dental Material*. London: Mosby, St. Lowis; 2004.

6. Comb EC, Grant AA. *Notes on Dental Materials*. New York: Singapore;1991.

7. Brown LJ, Lazar V. Dental procedure fees 1975 through 1995: how much have they changed? *Journal of America Dental Association* 1998; 18(3): 129–35.

8. Eames W, Oneal a SJ, Monterio J, Miller G, Roan J, Cohen K. Techniques to improve the seating of castings. *Journal of America Dental Association* 2001; 96(5): 432–37.

9. Coleman RL. Physical properties of dental materials: (Gold alloys and accessory materials). *Journal of British Standard Restoration* 2004; 90(1): 867–938.

10. Finger W, Jorgensen KD. An improved dental casting investment. *Journal of Dental Restoration* 1999; 88(2): 278–284.

11. Davis WA. The nature of changes involved in the production and setting of investment. *Journal of Dental Restoration*, 1997; 26(1): 727–738.

12. Al–Taai SD. Evaluation of the effects of fluoride and chlorhexidine on some properties of zinc phosphate and polycarboxylate cements. Unpublished Master thesis, College of Health and Medical Technologies, Iraq; 2006.

13. Haddon CL. The mechanism of setting of gypsum–bonded investment. Germany: Translation Farady Publication; 2002.

14. Mahler DB, Ady B. The influence of various factors on the effective setting time of casting investments. *Journal of Prosthetic Dental* 2006; 13(2): 365–377.

15. ASTM. Consistence setting time, workability and flow for investment. London: ELE. International; 2010.

16. American Dental Association Specification: For phosphate–bonded investment. *Journal of America Dental Association* 2006; 8(2): 120–135.

17. Al–Rahmani L. A study to assess and improve a phosphate–bonded investment (An Iraqi product). Unpublished master thesis, College of Dentistry, University of Baghdad, 1994.

18. O' Brien WJ. *Dental Materials and Their Selection.* USA: Quintessence Publishing Coordination; 2008.

19. Tanggal TH. *Time of setting of hydraulic investment by Gillmore needle, Standard method of test.* London: PT Brantas Abipraya; 1997.

20. Sorlie, DE. *Medical Biostatistics and Epidemiology: Examination and board review.* Norwalk, Connecticut: Appleton and Lange; 1995.

21. Carlevaris M, Kaucic V, Gabrovsek R. *The effect of storing conditions on physical properties of phosphate–bonded investment material and the study of change in powdery composition owing to moisture*. National Institute of Chemistry, Slovenia: 1999; 46(2): 68-253.

22. Finger W, Kota K. A modified phosphate–bonded investment. *Journal of Dental Restoration* 1998; 90(2): 48-243.

23. Heiserman DL. *Fundamental of Dental Materials.* Restorative Materials. London: Blackwell Scientific Publication; 2005.

24. Lacy AM, Mora A, Boonsiri I. Incidence of bubbles on samples cast in a phosphate–bonded investment. *Journal of Prosthetic Dental* 2004; 54(3): 129–267.

25. Neiman R, Sarma AC. Setting and thermal reaction of phosphate–bonded investment. *Journal of Dental Restoration* 2006; 59(9): 185–278.

26. Lewis AJ. The influence of the refractory investment on the development of porosity in cast structures. *Journal of Dental Restoration* 2004; 22(6): 257-455.

27. Takahashi J, Okazaki M, Kimura H, Haeuchi Y, Kubo F. Setting time of phosphate-bonded investment, effect of colloidal silica solution**.** *Journal of Dental Restoration* 2003; 26(4): 496-503.