ISSN: 1812–1217

The Effect of Different Water Types on The Water Powder Ratio of Dental Gypsum Products

Amer A Taqa
BSc, MSc, PhD (Asst. Prof.)
Dept of Department of Dental Basic science
College of Dentistry, University of Mosul

Nada Z Mohammed
BDS, MSc (Lec.)
Department of Prosthodontics
College of Dentistry, University of Mosul

Alia'a W Alomari
BDS, MSc (Lec.)
Department of Prosthodontics
College of Dentistry, University of Mosul

الخلاصة

الأهداف: لتقييم تأثير أنواع مختلفة من المياه على نسبة الماء إلى المسحوق لمادة حجر الأسنان. **المواد وطرائق العمل**: في هذه الدراسة تم استخدام خمسة أنواع مختلفة من المياه (الماء المقطر ، ملاط رقيق القوام ،ماء الحنفية، الماء غيرالايوني و ماء البئر)التي تم مزجها مع نوعين من مادة حجر الأسنان (plaster and stone) . **النتائج**: أظهرت النتائج وجود اختلاف معنوي في نسبة الماء إلى المسحوق لمادة حجر الأسنان عند مزجها مع الأنواع المختلفة من المياه المستخدمة في الدراسة. **الاستنتاجات:** بينت النتائج إن كمية الماء التي تحتاجها مشتقات مادة الجبس تختلف حسب نوع الماء المستخدم في المزج. كما أظهرت النتائج اقل نسبة ماء تحتاج إليها مشتقات الجبس هي عند استخدام الملاط رقيق القوام.

ABSTRACT

Aims: To evaluate the effect of different water types on the water powder ratio of dental gypsum products. **Materials and Methods:** In this study five types of water (distilled, tab, slurry, de-ionized and well water) were used to be mixed with two types of dental gypsum products (plaster and stone). **Results:** Results showed a statistically significant difference at $p \leq 0.05$ in water powder ratio of gypsum products when mixed with different types of water that used in this study . **Conclusions:** Water requirement of gypsum product varies in respect to the type of water used to be mixed with. The most pronounce decrease in water requirement of dental gypsum products was achieved with slurry water.
Key words: types of water, water powder ratio and gypsum product.

Taqa AA. Mohammed NZ. Alomari AW. The Effect of Different Water Types on The Water Powder Ratio of Dental Gypsum Products. *Al–Rafidain Dent J*. 2012; 12(1): 142-147.
Received: 16/9/2010 ***Sent to Referees:*** 21/9/2010 ***Accepted for Publication:*** 22/12/2010

INTRODUCTION

Gypsum materials are popular as a die material because of ease of use, low cost, compatibility with most impression materials and appropriate setting expansion and familiarity. [1-3]

Water powder ratio is an important factor in the quality of gypsum materials, [4,5] many experimental attempts to improve mechanical properties of dental stone are oriented mainly towards the decrease of gauging water requirement. [6-11] Accurate compassion of gypsum properties should be undertaken while all materials are mixed to the same consistency.[12] The principal difference among gypsum products is in the physical shape and nature of the calcium sulfate crystals makes it possible to obtain the same consistency with less excess water with dental stone and high stone than with model plaster.[13-15] Although particle size and the total surface area are the chief factors in determining the amount of gauging water, the particle size distribution, grinding of the particles and adhesion between particles of hemihydrate are also a factor in determining the amount of water requirement.[16-19]

MATERIALS AND METHODS

1: Materials:

Materials used in this study can be classified into: *First* : Dental gypsum products; two types of dental gypsum products used in this study (plaster and stone). Two types of plaster (Al-Ahliya Co. for gypsum industries Ltd, and Al-Alaf Co. for gypsum industries Ltd) and two types of stone (Elite, Zhermack SPA-45021Badia Poesine, Italy and Dental stone China Meheco co.P.R. China).

Second : Mixing water; five types of mixing water has been used in this study(distilled water, tab water, slurry water, deionized water and well water(AL- Rashedia well water)).The distilled water was used to prepare the control specimen to study the effect of other types of water on the water requirement of dental gypsum products used in this study.

2: Methods: Water analysis was done in the Nenava environmental center analysis department (Table 1).

Table (1): Chemical analysis of four water types

Type	Distilled water	Tap water	Deionized water	Well water
Calcium	0	49.6	0	820
Magnesium	0	15.6	0	195
Sulfate	0	60	0	2050
carbonate	0	124	0	248

Mixing procedure employed in the preparation of the test specimens followed the ADA specification No. 25 of gypsum products (1975).[20] The mixing water temperature was maintained at 25°C. Mechanical mixer (Degussa AG, Germany) with vacuum for mechanical mixing for 20 seconds. The preparation of test specimens and test procedures were conducted under laboratory environment of 25 ± 2.0 and a relative humidity of 50 ± 10%.

Slurry water was prepared by placing the dental cast made from plaster (mixed with plaster specimens) or from stone cast (mixed with stone specimens) in water for 72 hours. Slurry water was standardized for saturation with help of complex metric titration test.[3,21,22] The water-powder ratio was measured by using modified vicat apparatus (Mumboldt MFG co, Chicaco, U.S.A). Three hundred grams of test sample were added to a known volume of 4% sodium citrate in distilled water and then mixed mechanically with vacuum. The mixture was then poured into the ring mold (vibrated slightly to remove air bubbles) and then it was struck level with spatula at the top of the mold. The conical plunger of the modified vicat apparatus was wiped clean with a moist cloth before each determination, and then it lowered to the surface of the sample. The scale was read then the plunger released quickly by opening the thumbscrew. After the plunger settled, the scale was read again. The difference in scale reading was millimeters of penetration. Determinations were made at 7, 8, 9 minutes after the start of the mix. Three penetrations averaged for each determination. The average of three determinations (9 penetrations) was taken as a measure of consistency. The water-powder ratio that gives the consistency specified in Table (2) was used as a correct water-powder ratio for that sample (ADA specification No.25, 1975). [20]

Table (2): Testing Consistency

Type	Cone Penetration
II plaster, mold	30 ± 2*
III dental stone	30 ± 2**
IV dental stone, high strength	30 ± 2**

*Cone penetration depth (35gm) total weight. **Cone penetration depth (100gm) total weight.
ADA specification No. 25 (1975)

RESULTS

The mean and standard deviation of water powder ratio of gypsum products mixed with different types of water were listed in the Table (3). This table reveals that the water requirement of each type of gypsum specimens used in this study varies according to the type of mixing water. The most pronounced decrease in water powder ratio of both stone and plaster was achieved with slurry water (Table 3)

Table (3): The Effect of Different Water Types on Water Powder ratio of Gypsum Products

Gypsum products	Distilled water		Slurry water		Tab water		De-ionized water		Well water-	
	mean	*SD*	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*
Elite stone	33	0.0	29	0.37	32	0.57	34	0.00	34	0.0
Dental stone	34	0.0	30	0.012	33	0.0	34	0.0	35	0.577
Al-Ahlia plaster	54	0.00	49	0.561	55.5	0.57	56	0.577	58	0.577
Al-Alaf plaster	46	0.577	44	0.045	48	0.00	49	0.0	50	0.577

For both dental stone and plaster specimens increase in their water powder ratio was noted in Table (3) when they mixed with de-ionized water. The most pronounced increase in the water powder ratio of both plaster and stone specimens was achieved with well water.

One way analysis of variance (ANOVA) revealed that their was a statistically significant difference at $p \leq 0.05$ on the effect of water type on the water requirement of all gypsum products that is used in this study at f=78.56, f=37.83, f=24, f=24 for Al-Ahlia, Al-Alaf, Elite stone and Dental stone respectively (Table 4).

Table (4): One Way ANOVA of the Effect Different Water Types on Water Powder ratio of Gypsum Products

S.O.V	Al-Ahlia plaster			Al-Alaf plaster			Dental stone			Elite		
	DF	**MS**	**F***	**DF**	**MS**	**F***	**DF**	**MS**	**F**	**DF**	**MS**	**F***
Factor	5	19.658	78.6	5	6.306	37.83	5	2	24	5	2	24
Error	8	0.25		8	0.16		8	0.0833		8	0.083	
Total	14			14			14			14		

*Statistically Significant at $p \leq 0.05$

Duncan multiple comparison rang test for the effect of different types of water on the water requirement of elite stone and dental stone (Figure 1) revealed that their were statistically significant differences at $p \leq 0.05$ on the water requirement of elite stone and dental stone when mixed different types of water that used in this study.

Duncan's multiple range test Figure(2) revealed that their were a statistically significant differences $p \leq 0.05$ among the effect of water types used in this study on the water requirement of Al-Ahlia plaster and Al-Alaf plaster . Except that there was no statistically significant difference in water requirement of Al-Alaf plaster when mixed with tab or de-ionized water Figure (2).

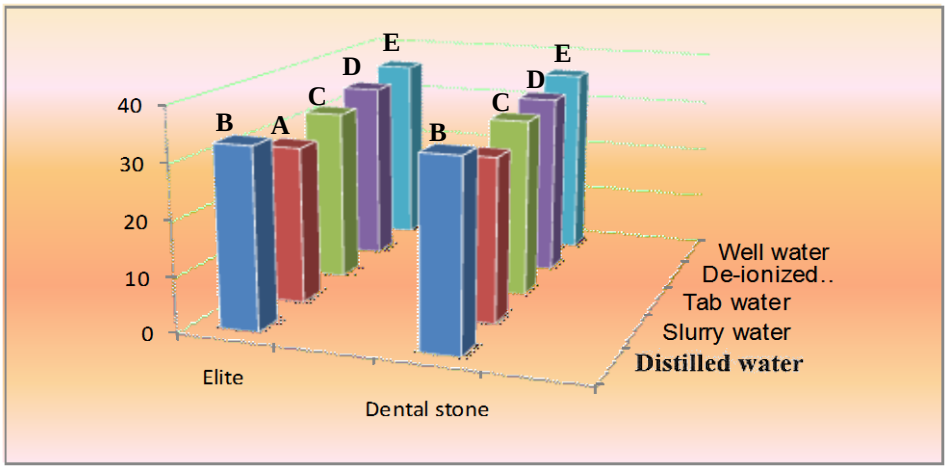

Figure (1): Duncan Multiple Rang Test for the Effect of Different Water Types on The Water Powder Ratio of Elite Stone and Dental Stone

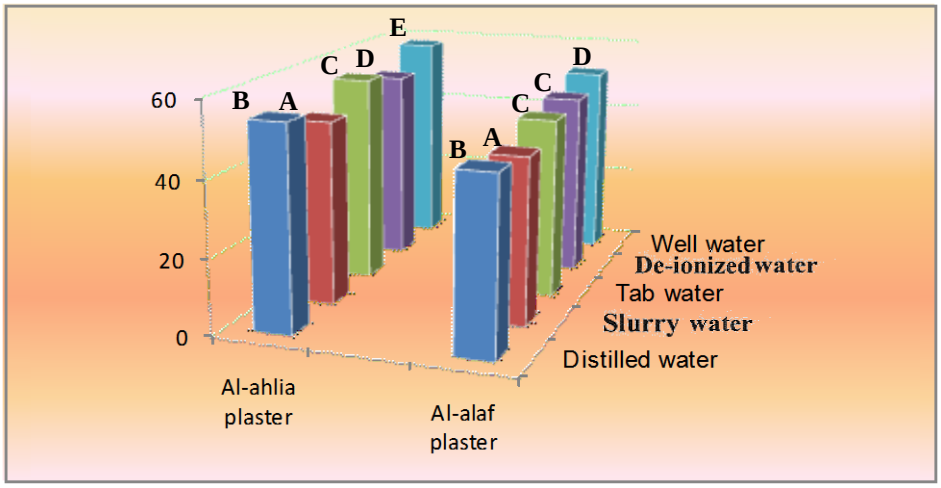

Figure (2): Duncan Multiple Rang Test for the Effect of Different Water Types on The Water Powder Ratio Al-Ahlia plaster and Al-Alaf plaster

DISCUSSION

Calcium sulphate hemihydrates (gypsum) is an ionic solid and is therefore essentially hydrophilic. The surface interactions play an appreciable part in determining the water requirement ; this can act through changing the condition of the grains and forces between the grains.[16,23]

Analysis of the mean and standard deviation Table (3) reveales that slurry water produces the most pronounce decrease in the water powder ratio of both stone and plaster specimens. This can be explained according to the crystallization theory.[15,24-26] Increasing the nucleolus of crystallization (calcium sulfate dihydrate) that present in slurry water enhances the wetting of gypsum crystals by water and thereby decreasing their water powder ratio.[21, 22]

According to this study, a decrease in water powder ratio of stone specimens was noted when mixed with tab water as compared with that when it mixed with distilled water Table (3). Tab water contains large amount of calcium carbonate ions ($CaCO_3$) Table (1) and this salt highly soluble in water and make tab water as soft water ; this means that salt makes tab water easy dispense between the particles of stone powder(it provides sites for nucleation of the newly formed dehydrate) [21] and there by decrease their water powder ratio. While For plaster tab water increases

its water requirement ; this difference may be due to the difference in physical properties of dental stone and plaster or to the addition of chemical materials during manufacturing , that makes distilled water more easily dispense between gypsum particles and there by decrease their water requirement.[10, 27]

In this study an increase in the water powder ratio was noted Table (3) when mixed with de-ionized water. This can be explained by the fact that there are no ions in this type of water Table (1) so that it's more difficult for de-ionized water to dispense between gypsum particles and thereby increasing their water powder ratio. Well water produces the most pronounced increase in the water powder ratio of both plaster and stone specimens was achieved with, this is due to that type of water contain large amount of calcium and magnesium sulphate ions ($CaSO_4$ and $MgSO_4$) Table (1). These ions make the well water as hard water [28, 29] i.e hard dispersion of the ions of well water between gypsum particles and thereby increasing their water powder ratio.

CONCLUSIONS

The results suggest that the water powder ratio of dental gypsum product varies with respect to the water types used to be mixed with. The most pronounce decrease in water powder ratio of dental gypsum products was achieved with slurry water.

REFERENCES

1. Craig RG. Restorative Dental Materials. 10th Ed, Mosby company. 1997; Pp: 333-354.
2. VanNoort R, Brown D and Causton BE. Review of dental material. *J Dent*. 1989; 17(1):1-20.
3. Doshi B. and Gangadhar . Efficacy of slurry water. *Journal of Indian prosthodontics socity*.2005; 5(4) :23-24
4. Craig RG, O'Brien WJ and Powers JM . Dental Materials. 6th Ed, Mosby Company. 1996; Pp: 156-232,181-199.
5. Lindquist TJ, Stanford CM and Knox E . Influence of surface hardner on gypsum abrasion resistance and water sorption. *J Prosthet Dent*. 2003; 90(5): 441-6.
6. Mori T and Yamane M . Fractography of cast gypsum. *Aust Dent J*.1982; 27(1): 30-47.
7. Kotsiomiti E, Diakoyianni I, Pissiotis A and Kaloyannides A. Effect of the addition of ammonium salts on improved dental stone's surface hardness. *Hellenic Dental Journal*. 1995; 5:45-50.
8. Ridge MJ and Boell GR . Physical properties of calcined gypsum. *J Appl Chem*.1962a; 12: 437-444.
9. Combe EC and Smith DC . Improved stones for the construction of models and dies. *J Dent Res*. 1971; 50(4): 897-901.
10. Zakaria RM, Johnston WM, Reisbick MH and Campagni WV . The effects of a liquid dispersing agent and a microcrystalline additive on the physical properties of type IV gypsum. *J Prosthet Dent*, 1988; 60(5): 630-637.
11. Duke P, Moor BK, Haug SP and Andres CJ .Study of the physical properties of type IV gypsum, resin-containing, and epoxy die materials. *J Prosthet Dent*. 2000; 83(4): 466-73.
12. Schneider RL and Taylor TD. Compressive strength and surface hardness of type IV die stone when mixed with water substitutes. *J Prosthet.Dent*. 1984; 52(4):51-514.
13. Prombonas A and Vlissidis D . Compressive strength and setting temperatures of mixes with various proportions of plaster to stone. *J Prosthet Dent*. 1994; 72(1): 95-100.
14. Al-Sadi S, Combe EC and Cheng Y. Properties of gypsum with the addition of gum arabic and calcium hydroxide. *J Prosthet Dent*. 1996;76(5):Pp:530-4.
15. Craig RG and Powers JM . Restorative Dental Mterials.11th Ed, Mosby Company. 2002; Pp: 392-404.
16. Ridge MJ and Boell GR . Effects of some additives on the water requirement of calcined gypsum. *J Appl Chem*.1962 b; 12:521-526.
17. Anusavice KJ . Phillip's science of dental materials. 10th Ed, WB Saunder Company. 1996; Pp: 185-208.

18. Griswold J and Uricheck S. Loss compensation methods for stone. *JAIC*. 1998; 37(1):89-110.
19. Kazanji MN and Rejab LT . The effect of particles size distribution of gypsum powder on cast surface roughness. *Al-Rafidian Dent J*. 2002; 2(1):50-55.
20. American Dental Association Specification Guide to dental materials and device. 1974-1975 ؛Pp 86-96,255-260.
21. Brukl CE, McConnell RM, Norling BK and Collard SM . Influence of gauging water compostion on dental stone expansion and setting time. *J Prosthet Dent*. 1984;51(2) Pp:218-223
22. Rudd KD, Marrow RM, Brown CE and Major BJ. Comparison of effects of tap water and slurry water on gypsum cast. *Dental technology*. 1970; 24(5) Pp:563-570.
23. O'Brien WJ. Dental Materials and Their Selection.2nd Ed, Quintessence books. 2002; Pp: 49-60.
24. El-Tannir MD. The Effect of nucleation as indicated by the setting time on the dimensional behavior and crushing strength of the set plaster. *Egypt Dent J*.1971; 17(3) Pp: 265-270.
25. Winkler MM, Monaghan P, Gilbert JL and Lautenschlager EP. Comparison of four techniques for monitoring the setting kinetics of gypsum. *J Prosthet Dent*.1998; 11(4) Pp: 226-230.
26. Amathieu l and Boistelle R. Crystallization kinetics of gypsum from dense suspension of hemihydrate in water. *Journal of Crystal Growth*. 1988; 88, Pp:183-192.
27. Zuhair NM . The Effect of adding some chemical materials on the physical and chemical properties of dental stone. Thesis. 2005; Pp 9-12,52-53;93-94.
28. Clarence A . Modern Inorganic Pharmaceutical Chemistry. 1st Ed., ohn welly and sons,IN,London. 1964; Pp:134.
29. Rashad MM, Mahmoud MH , Ibrahim IA and Abdel-Aal EA. Crystallization of calcium sulfate dehydrate under simulated conditions of phosphoricacid production in the presence of aluminum and magnesium ions. *Journal of Crystal Growth*. 2004; Article in Press, Pp:183-192.