COMPARATIVE EVALUATION OF DIAMETRAL TENSILE STRENGTH OF PHOSPHATE BONDED INVESTMENT MATERIALS AFTER DRYING BY VARIOUS METHODS"–AN INVITRO STUDY

Gopinadh Anne[1], Polavarapu Jaya Krishna Babu[2], Oliganti Swetha Hima Bindu[3], Chiramana Sandeep[4]

1. Professor and Head, Department of Prosthodontics, SIBAR Institute of Dental Sciences, Guntur-522509 ,Andhra Pradesh, India.
2. Senior Lecturer , Department of Prosthodontics, SIBAR Institute of Dental Sciences, Guntur-522509 , Andhra Pradesh, India.
3. PG Student, Department of Prosthodontics, SIBAR Institute of Dental Sciences, Guntur-522509 , Andhra Pradesh, India.
4. Professor, Department of Prosthodontics, SIBAR Institute of Dental Sciences, Guntur-522509, Andhra Pradesh, India.

Abstract

The study is to evaluate and compare the Diametral Tensile strength of Phosphate bonded Investment materials (Wirovest, Cromocasting Fast and Accuvest) after drying by Air dried method, Conventional Hot air oven method and Microwave oven method.

A total of 90 cylindrical specimens were prepared from three different commercially available phosphate bonded investment materials. Thus 30 samples for each material were prepared and 10 of each were Air dried for 60 minutes, 10 were dried in a Conventional Hot air oven for 60 minutes at 265˚c to 300 ˚c and 10 were dried in Microwave oven with 600 watts at frequency of 2450 MHz for 10 minutes. All the samples were subjected to diametral compression test using a computer co-ordinated Universal testing machine at 2 hour interval at a crosshead speed of 0.5 cm/min.

The results illustrate that the method of Microwave drying of the samples of all the materials could withstand high compressive loads when compared to the other two methods i.e., Air dried and Hot air oven dried methods respectively. And the material Wirovest is considered to be the one with high diametral tensile strengths of all the compared phosphate bonded investment materials.

Within the limitations of this study, the Mean Diametral tensile strengths of the Microwave oven dried samples were highest, followed by the Hot air oven dried samples and Air dried samples. The Mean Diametral tensile strengths of the Wirovest material show highest values than Cromocasting fast investment material and Accuvest material.

Experimental article* (*J Int Dent Med Res 2011; 4: (2), pp. 54-58)

Keywords: Diametral tensile strength, Investment materials, Hot air oven, Microwave oven, Time saving procedure.

Received date: 25 January 2011 **Accept date: 26 July 2011**

Introduction

The strength of the refractory cast made of Phosphate bonded investment materials for the fabrication of a partial denture framework must be adequate to prevent fracture or chipping during burnout and casting procedures[1], in order to with stand the impact of molten alloy.

Corresponding author:
Dr. P. Jaya Krishna Babu ,
M.D.S, Senior Lecturer,
Department of Prosthodontics,
SIBAR Institute of Dental Sciences,
Guntur, 522509
Andhra Pradesh, India.

Phone: +919885098177
E-mail: drjkprostho@gmail.com

Phosphate bonded investment materials are familiar and versatile dental materials, first patented for use in dentistry by Moore and Watts in 1949. Their use in the construction of removable partial denture frameworks was described by Earnshaw[2] in 1960.

There are various methods to increase the strength of the investment materials. Craig M Powers[3] suggested Air dried method which is time consuming.

Kenneth L.Stewart [4] suggested Hot air oven drying at 265°c to 300 ˚c for 60 to 90 minutes and Leubke R.J[5] suggested Microwave drying at power of 600 watts for 10 minutes. However Investment Materials are brittle materials[6] which are weaker in tension than in compression which may contribute to failure of material in service.

The purpose of this study is to compare the influence of other methods of drying the investment material to the conventional Air drying method and their effects on the diametral tensile strength (DTS) of three commercial available, Phosphate bonded investment materials.

Materials and methods

According the ADA specification number 25, eight metal dies were made out of 304 stainless steel rod, with dimensions of 40 mm of length and 20 mm of diameter. A ring of size 45 mm of height and 100 mm diameter from 304 stainless steel pipe was cut .Care was taken so that all the dies had parallel ends. (Figure 1)

Figure 1. Duplicating mould and dies.

These dies were fixed onto a glass slab with cyanoacrylate drop with even distribution within the ring[5]. An Addition Silicone - Unisil was mixed in vacuum mixer with the ratio of 1:1 and poured on a vibrator into the ring. The mold with dies is left to under go complete polymerization for 48 hours at room temperature. There after the dies were removed using a jet air spray. (Figure 2)

Each phosphate bonded investment material selected for the study was weighed carefully to follow the manufacturer's directions for liquid powder ratio of 60ml/400gm. (Table I)

The materials were vacuum mixed for 20 seconds and gently poured into the mold obtained placed on a vibrator. After the mold was completely filled a flat surfaced glass slab is placed on to ensure even ends of the samples. After the initial setting time the samples were removed carefully without causing any damage.

Figure 2. Samples Retrival.

For the Air dried method, the samples were wrapped in aluminium foil and stored for 2 hrs in open air and were tested for diametral tensile strength[3]. For the Hot air oven drying method, the samples were placed in an oven for 60 minutes at 230˚c for drying[5] after which they were wrapped in aluminium foil and kept for bench drying for 2 hours. For the Microwave oven drying, the samples were placed in an oven for 10 minutes using an output of 600 watts,[5] a 200ml cup of water was placed in the oven to protect the Magnetron. After that they were wrapped in aluminium foil and kept for bench drying for 2 hours before testing the Diametral tensile strength.

Figure 3. Universal Testing machine.

All the samples so prepared were subjected to diametral compression test using a computer co-ordinated Universal testing machine

by DAK Systems,Mumbai. (Figure 3) This mode of testing is an indirect tensile strength measuring test and the results so obtained were used to calculate the diametral tensile strength.

After the DTS values were calculated and the mean and standard error was calculated for all the samples. The method of Statistical Analysis used in this study were One way analysis of variance and Two way analysis of variance to test the difference between groups.

Calculation of Diametral tensile strength[2] (DTS):

The formula used $\sigma x = 2P / \Pi dt$

The tensile stress 'σx' ,Load applied 'P' in compression 'd' is the diameter of the specimen and 't' is the thickness of the specimen.

Results

Among all the drying methods, the Microwave oven dried samples had the maximum compressive load bearing capacity, which is followed by Conventional Hot air oven dried and Air dried samples.

The material Wirovest showed high Diametral tensile strength values than Accuvest and Cromocasting fast.

Table 1- shows the materials and the manufacturers recommendations to use them.

Table 2- shows the Anova Two factor without replication - Summary.

Table 3- shows the Anova Two way factor without replication.

S no	Investment Material	Manufacturer	Liquid
1	Accuvest	HORICO Berlin, Germany	Colloidal Silica and distilled water
2	Cromocasting fast	Ruthinium Group, Italy	Colloidal silica
3	Wirovest	BEGO, Germany	Colloidal silica

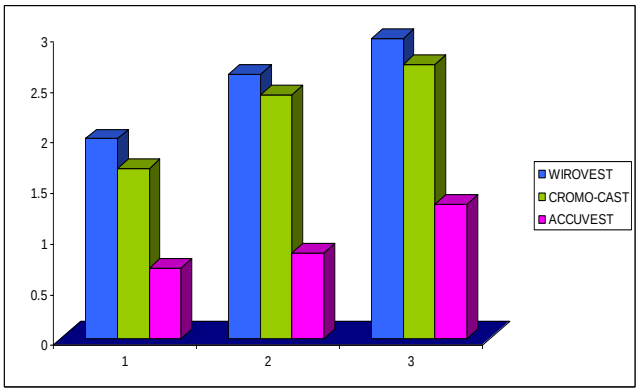
Table 1. Materials and the manufacturers recommendations.

S.no	Material/Method	Groups	Count	Sum	Average	Variance
1	Air dried	Row 1	3	4.3436	1.447867	0.448521
2	Hot Air Oven	Row 2	3	5.8582	1.952733	0.938239
3	Microwave Oven	Row 3	3	6.9868	2.328933	0.777665
4	Wirovest	Column 1	3	7.5432	2.5144	0.252437
5	Cromocasting Fast	Column 2	3	6.7904	2.263467	0.277338
6	Accuvest	Column 3	3	2.855	0.951667	0.108036

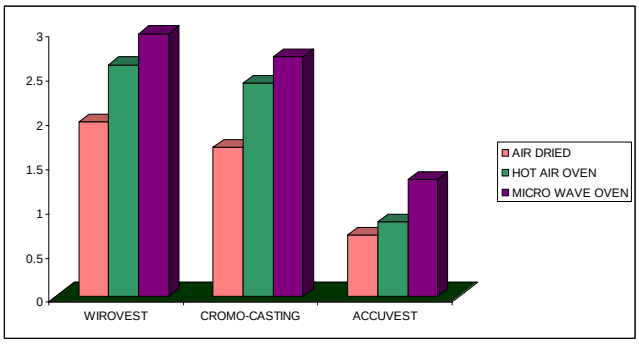
Table 2. Anova: two factor without replication Summary.

Source of Variation	SS	*df*	MS	F	*P*-Value	F Crit
Rows	1.172695	2	0.586348	22.78673	0.006511	6.944272
Columns	4.225922	2	2.112961	82.11421	0.000565	6.944272
Error	0.102928	4	0.025732			
Total	5.501545	8				

Table 3. Anova two way factor without replication.



Bar Diagram 1. Column Chart for three Methods. (1- Air dried, 2- Hot air oven, 3- Microwave oven)



Bar Diagram 2. Column Chart for Each Material.

Bar Diagram 1. shows the column chart for the three methods in which the X axis

represents the methods and the Y –axis represents the Diametral tensile strengths in Mpa.

Bar Diagram 2. shows the column chart for the three materials in which the X axis represents the materials and the Y –axis represents the Diametral tensile strengths in Mpa.

Discussion

The Accuracy of a partial denture framework is affected by many variables such as the total compensating expansion of the casting investment[7,8,9] the duplicating material, the compressive strength of the investment at the casting temperature[10] and the technique of handling the materials[11].

Many years of dental application have made phosphate bonded investments a familiar and versatile class of materials used in the laboratory. The present study was to compare and evaluate the Diametral Tensile strengths of three different commercially available Phosphate bonded Investment materials, after drying by three Methods i.e., Air dried, Hot Air Oven Dried And Microwave Oven Dried Methods.

Luebke and Schneider[5] tested the compressive strength of various dental stones using air conventional oven and micro wave oven drying which was also conducted at a high power. They found that the microwave and oven drying methods produced similar compressive strength results.

Tuncer[12] et al observed the optimal length of drying time and degree of power for the microwave drying method. Type III and Type IV dental stones and a type III investment material were studied .The results showed that after 24 hrs Compressive strength values of the two gypsum products did not show much difference , but the investment subjected to 2 hour low-power microwave oven drying had a higher compressive strength than the air dried specimens.

Senay canay[13] et al compared the diametral tensile strength of phosphate bonded investment materials by conventional dried and microwave oven dried methods and found higher DTS values for microwave dried specimens. The study was performed at two intervals i.e., 2 hours and 4 hours but no significance of time is observed.

The present study conducted to find out compressive strength of three different investment materials (Wirovest , Cromocasting fast and Accuvest) when dried by the Microwave oven method ,when compared to the Air dried and Hot air oven dried methods at a 2 hour.

Conclusions

Within the limitations of this study the following conclusions can be drawn. The Mean DTS of the Microwave oven dried samples showed highest values followed by the Hot air oven dried samples and Air dried samples. The Mean DTS of the Wirovest material used were of highest values followed by Cromocasting fast investment material and Accuvest material .

Microwave oven use is considered to be acceptable time saving procedure for drying any investment material, when compared to the use of other mehtods. It not only saves the time but also increase the strength of the Investment material.

Declaration of Interest

The authors report no conflict of interest and the article is not funded or supported by any research grant.

References

1. Ahmed A. Evaluation of compressive strength for refractory casts made from different investment materials. Al Rafidian Dent J 2007; 7: 166-172.
2. Andrej S J and David R R, Sensitivity of disc rupture test to test to air bubble pores in phosphate bonded investment materials at elevated temperatures. J Dent Mater 2002; 18: 255-262.
3. John M Powers, Ronald L Sakagachi , Mechanical Properties of Dental Materials and Gypsum Products and Investments; Craig's Restorative Dental Materials, 12th edition, St Louis, Mosby ,2007; 65-87, 324-332.
4. Stewart,R and Kuebker, Laboratory procedures for Frame work construction, Kenneth L .Stewart ,Clinical removable partial prosthodontics, 2nd edition, Medico dental media international 2003: 27-361.
5. Leubke R J and Schneider R L Microwave drying of artificial stone. J Prosthetic Dentistry 1985; 53: 261-265.
6. Tay W.M. and M Braden load deformation behavior during a diametral test. Biomaterials 1990 ; 11: 361-366.
7. Takao F, Factors and technique of Precision Casting. Part I. J Prosthetic Dentistry 1959; 9: 468-485.
8. Takao F Factors and technique of Precision Casting Part II. J Prosthetic Dentistry 1959;9:468-485.
9. Earnshaw R, The effect of Casting ring liners on the potential expansion of a gypsum bonded Investment J Dent Res 1988; 67 1366-1370.
10. Pedro C and Gelson L, Influence of the final temperature of the investment heating on the tensile strength and Vickers hardness of CP TI and Ti-6AL-4V alloy. J Oral Sci 2007; 15: 44-48.
11. Edmea L, Josete B, Expansion of high flow mixtures of gypsum bonded investments in contact with absorbent liners. Dent Mat 2005; 21: 573-579.

12. Tuncer N, Investigation on the compressive strength of several gypsum Products dried by microwave oven with different programmes. J Prosthet 1993; 69: 333-339.
13. Senay C and Nur H, comparison of diametral tensile strength of microwave and oven dried investment materials. J Prosthetic Dentistry 1999; 82: 286-290.