



ISSN: 0975-833X

## RESEARCH ARTICLE

### COMPARATIVE EVALUATION OF SURFACE HARDNESS AND COMPRESSIVE STRENGTH OF TYPE III GYPSUM AFTER ADDITION OF 2% GUM ARABIC AND 0.2% CALCIUM HYDROXIDE

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#### ARTICLE INFO

##### Article History:

Received 17<sup>th</sup> December, 2016  
Received in revised form  
26<sup>th</sup> January, 2017  
Accepted 11<sup>th</sup> February, 2017  
Published online 31<sup>st</sup> March, 2017

##### Key words:

2% Gum Arabic, 0.2% Calcium Hydroxide, Surface hardness, Compressive strength, Type III gypsum.

#### ABSTRACT

**Objective:** The objective of this study is to compare & evaluate surface hardness and compressive strength of type III gypsum product after addition of 2% Gum Arabic and 0.2% Calcium Hydroxide.

**Method:** For the study, 80 samples were poured out of which 20 were poured with type III gypsum, 20 were poured with type III gypsum and 2% Gum Arabic, 20 were poured with type III gypsum and 0.2% Calcium hydroxide and remaining 20 were poured with 2% Gum Arabic and 0.2% Calcium Hydroxide. 40 samples were tested for surface hardness and remaining 40 for compressive strength. Obtained values were then tabulated, compared and subjected for statistical analysis.

**Results:** Highest compressive strength was seen in samples with no additives. Surface hardness was increased after the addition of additives.

**Conclusion:** There was no effect of Gum Arabic and Calcium Hydroxide on compressive strength of Type III gypsum. Surface hardness was increased after the addition of additives. Highest values were obtained for surface hardness after addition of Gum Arabic and Calcium Hydroxide.

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**Citation:** Dr. Aditya A Chandele, Dr. Nilesh Bulbule, Dr. Dilip Kakade and Dr. Arpita Tandon, 2017. "Comparative evaluation of surface hardness and compressive strength of type iii gypsum after addition of 2% GUM Arabic and 0.2% Calcium hydroxide", *International Journal of Current Research*, 9, (03), 48086-48090.

## INTRODUCTION

Dental stone serves dentistry extensively than any other materials used in dentistry (Craig *et al.*, 1996). They are used for preparation of casts, dies and moulds because of easy manipulation and better physical properties. Dental stone should have adequate strength to withstand various procedures. A good quality dental stone should have good hardness and ample strength to withstand normal laboratory and clinical handling. Surface hardness indicates the extent of force applied during working, which can be tolerated by gypsum casts (Anusavice and Brantley, 2004). Surface hardness of type III gypsum is insufficient and cannot tolerate abrasion, which eventually leads to prosthesis failure due to loss of surface details. To overcome this failure, several methods have been proposed to increase surface hardness satisfactorily, most common method being addition of additives. Compressive strength is also of utmost importance for type III gypsum since it has to undergo various degrees of compression loading for various procedures and withstand heavy forces. There are various methods for enhancing physical properties of gypsum. Surface hardness and compressive strength of gypsum can be

improved by addition of additives and reducing W/P ratio. Various attempts have been made to enhance properties of gypsum. Gum Arabic and Calcium Hydroxide are cheap, easily available and can be easily manipulated. Sadi Al *et al.* (1996) and Abdelaziz *et al.* (2002) reported that addition of Gum Arabic and Calcium Hydroxide significantly improved the surface hardness (Sally *et al.*, 1996; Abdelaziz *et al.*, 2002). Gum Arabic acts a liquid dispersing agent and when used along with water to mix gypsum product, amount of water required becomes less (Sally *et al.*, 1996; Abdelaziz *et al.*, 2002; Abdelaziz *et al.*, 2002; Sanad *et al.*, 1982). Calcium hydroxide acts as microcrystalline additive and improves physical properties by creating crystalline network inside gypsum product. Mixture of both markedly reduces water requirement when used correctly and produces ultrahard casts. Different additives such as rosin, nigella stavia oil, sodium lauryl sulfate, Gum Arabic and Calcium hydroxide has shown improvement in hardness (Taqa *et al.*, 2015). Studies were carried out to increase the physical properties of gypsum by addition of Gum Arabic and Calcium Hydroxide. Some showed increase in surface hardness and decrease in compressive strength while there was decrease in surface hardness and compressive strength in some studies. Hence the current study was undertaken to check the effect of addition of Gum Arabic, Calcium Hydroxide separately and when combined together to

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the type III gypsum before mixing with water on hardness and compressive strength of type III gypsum.

## MATERIALS AND METHODS

This *in-vitro* study was conducted in the Department Of Prosthodontics, Crown, Bridge and Oral Implantology in Dr. D. Y. Patil Dental College and Hospital, Dr. D. Y. Patil Vidyapeeth, Pimpri, Pune and Dr. D.Y. Patil Institute of Engineering and Technology, Pimpri, Pune. Approval.

### Fabrication of stainless steel moulds

Stainless steel cylindrical moulds were fabricated for surface hardness and compressive strength according to ADA specification no 25. A stainless steel split mould of cylindrical shape was fabricated with 20 mm internal diameter and 40 mm height for compressive strength. (Fig. 1) A stainless steel split mould of cylindrical shape was fabricated with diameter 25 mm and height 25 mm for surface hardness. (Fig. 2)

### Preparation of samples

- Group A was the control group, samples were prepared with type III gypsum with no additives. n-20
- Group B was prepared by addition of 2% Gum Arabic to type III gypsum. n-20
- Group C were prepared by addition of 0.2% Calcium Hydroxide to type III gypsum. n-20
- Group D were prepared by addition of 2% Gum Arabic and 0.2% Calcium Hydroxide to type III gypsum. n-20

### Stepwise chronological sequence of study

Water powder ratio for type III dental stone was measured using graduated cylinder and digital weighing machine. Measured quantity of water was taken into the rubber bowl and measured quantity of powder was then added into the bowl.

Vaseline was applied on internal surface of split mould which aid in easy retrieval of gypsum samples. Type III dental stone was mixed with distilled water as per the manufacturer's instructions with straight plaster spatula until desired consistency was reached which was then gradually poured in split cylindrical mould kept on the vibrator to remove air bubbles. After it was completely filled, glass slab was placed over the mould to get a flat uniform surface. After 30 minutes, models were recovered carefully from mould by splitting the mould. All samples were dried in humid free environment and tested after 24 hrs for surface hardness and after 7 days for compressive strength. 10 samples of each group A,B,C,D were tested for surface hardness by using Vicker's surface hardness test. All these 40 samples were tested for surface hardness by using microhardness tester, Reichert Austria under 100gm load, which consists of a pyramid indenter, which contacts and penetrates the surface of a sample under load. The indenter produces pyramidal indentation, the diagnosis was made using a micrometer microscope. 10 samples of each group A,B,C,D were tested for dry compressive strength by using universal testing machine. All these 40 samples were tested for compressive strength at 500N/m until breakage and the values on the universal testing machine were recorded for each sample. Obtained values were then tabulated, compared and subjected for statistical analysis.

## RESULTS

After testing the specimen of groups A, B, C and D on Universal Testing Machine for compressive strength, the results are as follows:

- Group A showed higher compressive strength than Group D, followed by Group B and Group C.
- Highest compressive strength was seen in control group.
- There was no effect of Gum Arabic and Calcium Hydroxide on compressive strength of Type III gypsum.
- Reduction of compressive strength was observed after addition of additives.
- After testing the specimens of groups A, B, C and D for surface hardness on Vickers Hardness testing machine the results are as follows:-
- Group D showed highest values for surface hardness, than Group C, than Group B, than Group A.
- Surface hardness was increased after the addition of additives.
- Highest values were obtained after addition of Gum Arabic and Calcium Hydroxide in combination.

**Table 1. Compressive strength in newtons**

S. No	Compressive strength			
	GROUP A	GROUP B	GROUP C	GROUP D
	CONTROL	GA	CH	GA+CH
1	3500N	3500	3500	3500
2	4000N	4000	4000	4000
3	6000N	5000	5000	5000
4	5000N	5000	4000	6000
5	4500N	4500	4500	4500
6	5000N	4000	4000	4000
7	3500N	3500	3500	3500
8	4500N	4500	4500	5000
9	5000N	5000	6000	5000
10	6000N	4000	4000	4000
MEAN	4700	4300	4300	4450

**Table 2. Comparison of compressive strength in study groups**

Parameter	n	Compressive strength (N)		F Value	P Value
		Mean	SD		
Control	10	4700	888.19	0.61	0.61
Gum Arabic (GA)	10	4300	586.89		
Calcium Hydroxid (CH)	10	4300	752.77		
GA+CH	10	4450	797.57		

Control Vs GA: P=0.65, Control Vs CH: P=0.65, Control Vs GA+CH: P=0.88  
GA Vs CH: P=1, GA Vs GA+CH: P=0.97, CH Vs GA+CH: P=0.97  
Insignificant value by Tukeys test.

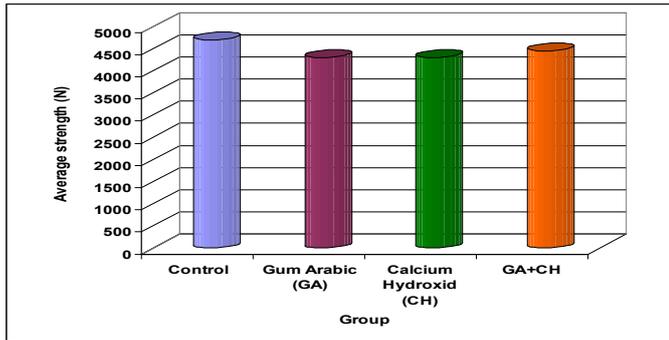
**Table 3. Surface hardness in HV**

S. No.	Surface hardness			
	GROUP A	GROUP B	GROUP C	GROUP D
	CONTROL	GA	CH	GA+CH
1	47.32HV	49.63	50.7	75.8
2	46.80HV	48.56	52.3	66.52
3	48.21HV	51.51	54.22	73.59
4	46.30HV	50.17	50.2	77.87
5	45.88HV	52.8	49.8	68.06
6	49.21HV	50.22	49.9	68.58
7	46.80HV	51.8	50.81	71.86
8	46.80HV	53.21	50.22	67.03
9	47.22HV	50.3	51.08	66.02
10	47.60HV	49.95	50.88	65.11
MEAN	47.21	50.81	51.01	70.04

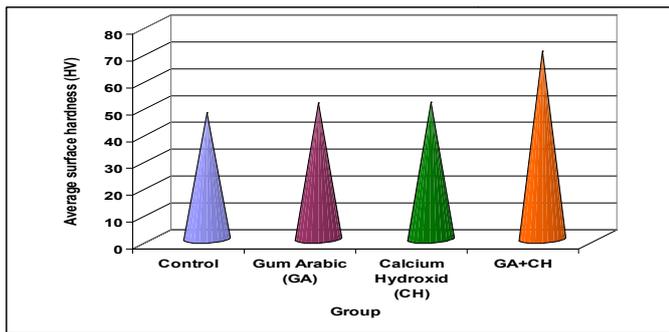
**Table 4. Comparison of surface hardness in study groups**

Parameter	n	Surface hardness (HV)		F Value	P Value
		Mean	SD		
Control	10	47.21	0.96	172.95	<0.0001
Gum Arabic (GA)	10	50.82	1.47		
Calcium Hydroxid (CH)	10	51.01	1.34		
GA+CH	10	70.04	4.45		

Control Vs GA: P=0.013    Control Vs CH: P=0.008  
 Control Vs GA+CH: P<0.0001  
 GA Vs CH: P=1GA Vs GA+CH: P<0.0001CH Vs GA+CH: P<0.0001  
 Significant value by Tukey's test (P<0.0001) followed by Group C,B and A.



**Graph 1. Bar diagram showing comparison of compressive strength in study groups**



**Graph 2. Bar diagram showing comparison of surface hardness in study groups**



A stainless steel split mould of cylindrical shape was fabricated with 20 mm internal diameter and 40 mm height for compressive strength



A stainless steel split mould of cylindrical shape was fabricated with diameter 25 mm and height 25 mm for surface hardness



**Samples for testing surface hardness**



**Samples for testing compressive strength**



**Surface hardness test**



**Compressive strength test**

## DISCUSSION

In our daily dental practice dental stone is used because of its good physical properties, ease of manipulation, dimensional stability, compatibility etc. They have various uses such as making models and dies, for preparation of casts, used as investment materials and for making moulds. Dental stone has to undergo various degrees of compression loading hence should be rigid enough to withstand heavy compression loading. According to Skinner, hardness is resistance to indentation. Studies have concluded that surface hardness of gypsum is not adequate to resist abrasion (Harris *et al.*, 2004). Many problems such as loss of surface detail during fabrication leads to error in prosthesis. This problem should be overcome. Compressive strength should also be enough to resist various processing techniques. Hence, gypsum should have enough surface hardness and compressive strength. According to literature, many studies have been conducted to improve the physical properties of gypsum. The addition of additives such as Gum Arabic and Calcium Hydroxide have yielded better results (Sally *et al.*, 1996). The process is easy, cheap and does not require any extra steps. This study was carried out to evaluate and compare the surface hardness and compressive strength of type III gypsum after addition of 2% Gum Arabic and 0.2% Calcium Hydroxide. Following objectives were accomplished, evaluation of surface hardness and compressive strength of type III gypsum without additives and after addition of additives. This study was carried out in a following manner. Stainless steel split moulds were fabricated as per ADA specification no 25 (ADA specification). Total 80 samples were fabricated as per ADA specifications. 40 samples were fabricated for testing compressive strength and 40 were fabricated for testing surface hardness. 20 samples were poured with type III gypsum only, 20 were poured with type III gypsum and 2% Gum Arabic, 20 were poured with type III gypsum and 0.2% Calcium Hydroxide and remaining 20 were poured with a combination of type III gypsum, 2% Gum Arabic and 0.2% Calcium Hydroxide. Samples were allowed to dry at room temperature and were tested for surface hardness after 24 hours and compressive strength after 7 days. The result showed that there was increase in surface hardness after addition of additives but decrease in compressive strength.

### Comparison with control group

- Compared to control group, samples which were fabricated with addition of 2% Gum Arabic showed decrease in compressive strength but increase in surface hardness.
- Compared to control group, samples which were fabricated with addition of 0.2% Calcium Hydroxide showed increase in surface hardness decrease in compressive strength.
- Compared to control group, samples which were fabricated with addition of 2% Gum Arabic and 0.2% Calcium Hydroxide showed decrease in compressive strength but there was a drastic increase in surface hardness.
- Compressive strength was decreased in all the groups as (p<0.61). Surface hardness was significantly more in D2 than all other groups as (p<0.0001)

Abdelaziz *et al.*, have suggested, modifying the gypsum with addition of Gum Arabic and Calcium Hydroxide before mixing

with aqueous solutions of disinfectants, and the result have shown improvement of mechanical and surface properties of gypsum (Abdelaziz *et al.*, 2002). The result of present study is in accordance with study conducted by Gandhi N, Sangur R, Dayakare H R, they evaluated surface hardness of type I, type II and type III gypsum products with addition of Gum Arabic and Calcium Hydroxide in different concentrations were measured with Vickers hardness testing machine and noted that surface hardness was increased for dental plaster and dental stone (Gandhi *et al.*, 2013). Type III gypsum with addition of 2% Gum Arabic and 0.2% Calcium hydroxide showed highest value. The result of present study is also in accordance with study conducted by Alsadi S, Edward C, Combe E, Cheng Y S conducted a study on properties of gypsum with addition of Gum Arabic and Calcium Hydroxide to type III stone and concluded that there was no increase in compressive strength (Sally *et al.*, 1996). The result of present study is also in accordance with study conducted by Alsadi S, Edward C, Cheng Y S, study evaluated properties of gypsum with addition of Gum Arabic and Calcium Hydroxide and concluded that for the type III, the additives significantly improved surface hardness but showed no effect on compressive and tensile strengths whereas for type IV, hardness was not enhanced by additives, and in some instances a reduction in strength was observed. Decrease in compressive strength was observed. The probable cause of decrease in compressive and tensile strength still retained excess water in gypsum ultimately reducing strength (Craig *et al.*, 1999). Excessive water retained in the set gypsum increases the volume of gypsum but reduces strength values. Additives permitted lower L/P ratio, however there was still excess water retained in the set gypsum that lowered strength values of gypsum. The additives used on the hardness has effect of chemical composition on compressive strength. Surface hardness of gypsum products stated to be related to their compressive strength, the higher the compressive strength, the higher being the hardness. (ADA specification) This is disagreeing with Combe and Smith who reported that there is no clear relation detected between the values of both hardness and compressive strength, since the conditions in the surface layer determine the former (Combe and Smith, 1964). As gypsum hardeners were added directly to gypsum products. The used gypsum hardeners decrease the water requirement, so that the reduction of water calcined gypsum ratio provides the most practicable means of producing harder casts, enhanced hardness due to increasing density (Gandhi *et al.*, 2013). Mixture of Gum Arabic and Calcium Hydroxide markedly reduces the water requirement when used correctly and produces ultra hard cast system. Hence there is increase in surface hardness of gypsum after addition of Gum Arabic and Calcium Hydroxide. After reviewing the literatures it has been found that previous studies regarding the effects of additives on type III gypsum is in accordance with this study. Hence it can be concluded that addition of 2% Gum Arabic and 0.2% Calcium Hydroxide increases the surface hardness of type III gypsum but decrease in compressive strength of type III gypsum.

### Conclusion

Within the limitations of this in-vitro study, following conclusions could be drawn- The samples which were fabricated by adding 2% Gum Arabic showed an increase in surface hardness but decrease in compressive strength. The samples which were fabricated by adding 0.2% Calcium Hydroxide showed an increase in surface hardness than

2% Gum Arabic, but decrease in compressive strength. The samples which were fabricated by adding 2% Gum Arabic + 0.2% Calcium Hydroxide showed an increase in surface hardness than other groups, but decrease in compressive strength.

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