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Effect of Surface Hardeners on a Physical Property of Type IV Gypsum Products.

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ABSTRACT

Background: Gypsum products are being used for construction of dental prosthesis. Most of the researches done so far on gypsum materials are on its use as fixed and removable prosthodontics. And although many studies have looked at a multitude of means for altering its properties, relatively less has been explored on examining the abrasion resistance of the gypsum product itself. Objectives: The current study was done to determine the abrasion resistance of three commercially available type IV gypsum products on application of three die-hardeners when abraded with 20gm and 50gm load stylus. **Methods**: An experimental in vitro study was done in the Dept. of Prosthodontics, UP Dental College & Research Center and the Dept. of Pharmacy, BBD National Institute of Technology & Management, Lucknow. A standardized machined die was fabricated so that the die consisted of 27 vertical ridges of 1mm depth. Three type IV gypsum products viz., Kalrock, Elite Rock and Denstone Plus and three die-hardeners viz., Hartebad die-hardener, Handae die-hardener and Maarc die-hardener were included in the study. 40 samples were prepared from each of the die-stones by pouring into impressions made by using the putty-wash technique. Resultantly, 120 samples were prepared which were let to mature. These 120 samples were divided into 24 groups, each group consisting of 5 samples. They were grouped as uncoated, coated with Hartebad die-hardener, coated with Handae die-hardener and coated with Maarc die-hardener. They were sub-grouped further for abrading under 20gm and 50gm loads by using an abrasion-testing machine. After 10 oscillations, the loss of mass was measured using analytical electronic machine. The different findings were compared by using appropriate statistical analytic tests. **Results**: The abrasion resistance of type IV gypsum products increased with the application of surface-hardeners irrespective of the load and Elite Rock showed better abrasive resistance while Denstone Plus showed lesser abrasion resistance among all the type IV gypsum products tested. **Conclusion**: Elite Rock when coated with Hartebad die-hardener showed maximum abrasion resistance irrespective of the load applied.

Keywords: Abrasion resistance, Die-hardeners, Type IV gypsum products, Weight change.

INTRODUCTION

The dehydrate form of calcium sulfate (2CaSO4.2H2O) also known as gypsum is a white to yellowish coloured mineral found in nature. It and its products (Plaster of Paris and others) have been found to have applications in most dental specialties, especially in prosthodontics for over two and half centuries.

To improve the abrasion resistance of gypsum products manufacturers have tried adding modifiers and processing it. As a result different types of gypsum products are available. Of them types IV and V products are commonly used in the indirect method for the preparation of inlays, three quarter and full crowns, various ridge forms and other dental castings. With the advent of these newer types being used as die materials, there has developed the need for more in-depth knowledge of the physical properties of the dental stones. In addition, an understanding of the best method of impression making and die preparation is felt necessary, so that the gypsum products can be used to its fullest advantage.

Although studies have looked at the multitude of means for altering gypsum's properties, relatively less has been done to examine the abrasion resistance of the gypsum products itself.[1]

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Objectives

The present study was done to determine the abrasion resistance of three popular commercially available brands of type IV gypsum products on

application of three different die-hardeners when loaded with different weights and resultantly to decide on the best combination of die-hardener and type IV gypsum products.

MATERIALS AND METHODS

An in vitro experimental study was conducted in 2007-08 in the Department of Prosthodontics of the UP Dental College & Research Center and the Department of Pharmacy of the Babu Banarasi Das National Institute of Technology & Management, Lucknow.

Three commercial brands of type IV gypsum products and three die-hardeners were selected, the criteria for selection being the most commonly used and available at the time of the study period. The three type IV gypsum products selected were Kalrock (Kalabhai Kersen Ltd., India), Elite Rock (Zhermack Ltd., Germany) and Denstone Plus (Pankaj Enterprises, India). The die-hardeners selected were Hartebad (Renfert Ltd., Germany), Handae die-hardener (Handae Chemical Co. Ltd.) and Maarc die-hardener (Shiva Products Ltd., India).

A standardized machined die of dimension 50X50X8 mm and having 27 vertical ridges of 1mm depth,[2,3] each with an internal and external 450 slope on each side of the apex was fabricated from carbon steel alloy at Hindustan Aeronautic Ltd., Lucknow. The ridges were created to represent the margins of the die of prepared tooth. Impressions were made using putty-wash technique. They were checked for surface imperfections and irregularities by naked eye examination and the samples were poured into the impressions. Thus 40 samples were prepared from each of the three die stones making a total of 120 samples [Figure 1]. These samples were stored for at a room temperature of 24-260 Celsius for 14 days to ensure that they were completely dry.

The total 120 samples were arbitrarily divided into 24 groups having five samples in each group. The samples were then grouped as (i) uncoated, (ii) coated with Hartebad die hardener, (iii) (iv) coated with Handae die hardener and (v) coated with Maarc die hardener which were further grouped for abrading under 20gm and 50 gm loads [Figure 1].

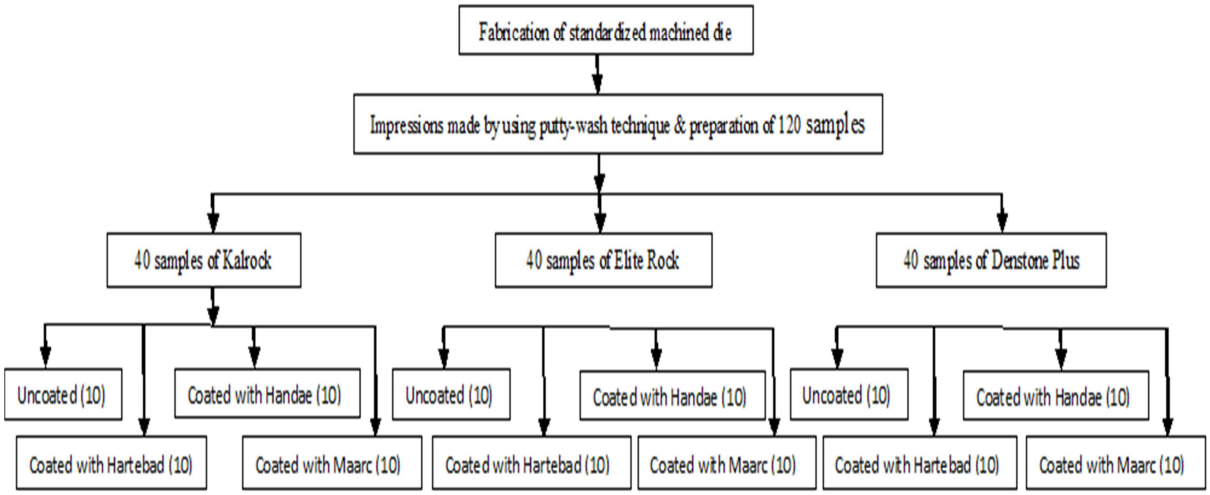

Figure 1: Flowchart of methodology

*Each of the 10 uncoated and the differently-coated samples were divided into two groups of 5 samples each, thereby giving a total of 24 sample-groups. And 5 samples from each group were loaded with 20gm loads while the remaining 5 samples from each group we=re loaded with 50mg loads. Then, the loss in weight of the various samples was measured and statistically evaluated.

The abrasion testing was done by using a abrasion testing machine (HAL, Lucknow) which was designed as per the popular recommendation made by Terry J.[3] For testing the stylus of the machine was allowed to pass at the ridges of the samples. For each ridge passed it denoted one oscillation. After 10 oscillations, loss of mass was measured using a calibrated analytical electronic machine (NAPCO Electronic machine, Japan) which was sensitive to detect up-to a difference of 0.0001gm difference.

The observations were analysed by using HPSS software to determine the most abrasion-resistant material and the best combination of die-hardener and die-stone type. The mean and standard deviation (SD) of each variable was calculated for both the samples loaded with 20gm and 50gm loads. Student “t” test was used for comparison between and within groups. ANOVA test was also

done to compare the within group and between group variances among the study-groups i.e. the three different sealers. ANOVA of these three sealers at a particular time interval revealed the differences among them. The test provided "F" ratio and a higher "F" value depicted a higher inter-group difference. For multiple comparison of loss in weight in different groups among the uncoated and the differently-coated groups with different loads Turkey HSD test was used. A p-value of less than 0.05 was considered as statistically significant.

RESULTS

The mean (SD) loss in weight and the mean (SD) percentage change in weight among the uncoated specimens and the differently-coated specimens at 20gm load are shown below in [Table 1]. No statistically significant percentage change in weight could be detected in the uncoated, the Handae die-hardener coated and Maarc die-hardener groups. But there was a significant change in weight for the Hartebad die-coated group with Kalrock group showing the least percentage change (0.0020%) while the Denstone Plus group giving the highest figure of 0.0032%. Multiple comparisons using Turkey test revealed no statistically significant difference for any of the combinations ($p > 0.05$).

The following table shows the same comparison at 50mg load [Table 2]. There was no statistically significant difference in the percentage change in weight in the Kalrock and Denstone Plus groups. But the mean change in weight and the percentage weight change were found to be statistically significant in the Harteband die-hardener coated specimens in the sense that among these specimens Elite groups had the minimum mean change in weight ($p < 0.001$) as well as in the percentage change in weight ($p < 0.001$). Among the Maarc die-hardener coated specimens, too the Elite group had the lowest percentage change in weight ($p < 0.001$). On multiple comparisons statistically significant difference could be seen for almost all the combinations in the Hartebard die-hardener coated specimens ($p \leq 0.341$) and for all the combinations in the Maarc die-hardener coated groups ($p \leq 0.0275$).

Table 1: Comparison of loss in weight in different groups of coated and differently-coated specimens at 20mg load

Groups (n)	Mean change in wt. (SD)	ANOVA (F)	p-value	% change in wt. (SD)	ANOVA (F)	p-value
Uncoated		3.585	0.06		2.167	0.157
• Kalrock (5)	1.96 (0.3050)			0.0048 (0.0010)		
• Elite Rock (5)	1.34 (0.2408)			0.0038 (0.0007)		
• Denstone Plus (5)	1.76 (0.5177)			0.0050 90.0013)		
Hartebad die-hardener coated		0.898	0.433		4.859	0.028
• Kalrock (5)	0.92 (0.0837)			0.0020 (0.0003)		
• Elite Rock (5)	0.96 (0.1517)			0.0023 (0.0003)		
• Denstone Plus (5)	1.12 (0.3962)			0.0032 (0.0009)		
Handae die-hardener coated		1.693	0.255		2.253	0.138
• Kalrock (5)	1.00 (0.1871)			0.0025 (0.0006)		
• Elite Rock (5)	0.88 (0.2168)			0.0021 (0.0006)		
• Denstone Plus (5)	1.14 (0.2608)			0.0030 (0.0006)		
Maarc die-hardener coated		1.231	0.326		2.578	0.117
• Kalrock (5)	1.00 (0.1581)			0.0022 (0.0004)		
• Elite Rock (5)	0.78 (0.4764)			0.0019 (0.0012)		
• Denstone Plus (5)	1.08 (0.2459)			0.0030 (0.0005)		

Table 2: Comparison of loss in weight in different groups of coated and differently-coated specimens at 50mg load

Groups (n)	Mean change in wt. (SD)	ANOVA (F)	p-value	% change in wt. (SD)	ANOVA (F)	p-value
Uncoated		2.982	0.089		3.567	0.061
• Kalrock (5)	2.94 (0.1817)			0.0072 (0.0008)		
• Elite Rock (5)	2.98 (1.1145)			0.0084 (0.0032)		
• Denstone Plus (5)	6.42 (4.3356)			0.0174 (0.0110)		
Hartebad die-hardener coated		15.937	<0.001		21.661	<0.001
• Kalrock (5)	1.86 (0.5128)			0.0041 (0.0013)		
• Elite Rock (5)	0.90 (0.1732)			0.0021 (0.0004)		
• Denstone Plus (5)	2.34 (0.4615)			0.0066 (0.0012)		
Handae die-hardener coated		0.172	0.844		0.076	0.927
• Kalrock (5)	1.64 (0.4037)			0.0041 (0.0013)		
• Elite Rock (5)	1.66 (1.5518)			0.0040 (0.0035)		
• Denstone Plus (5)	1.34 (0.4879)			0.0036 (0.0015)		
Maarc die-hardener coated		32.404	<0.001		26.849	< 0.001
• Kalrock (5)	1.60 (0.0707)			0.0038 (0.0002)		
• Elite Rock (5)	0.96 (0.1517)			0.0022 (0.0003)		
• Denstone Plus (5)	2.20 (0.3873			0.0061 (0.0014)		

Table 3: Comparison of weight-loss irrespective of load

Groups (n)	Mean change in wt. (SD)	ANOVA (F)	p-value	% change in wt. (SD)	ANOVA (F)	p-value
Uncoated		2.012	0.153		2.465	0.104
• Kalrock (10)	2.45 (0.5681)			0.0060 (0.0015)		
• Elite Rock (10)	2.16 (1.1510)			0.0061 (0.0032)		
• Denstone Plus (10)	4.09 (3.8086)			0.0112 (0.0099)		
Hartebad die-hardener coated		0.030	0.970		0.052	0.950
• Kalrock (10)	1.32(0.4492)			0.0033 (0.0013)		
• Elite Rock (10)	1.27 (1.1225)			0.0031 (0.0026)		
• Denstone Plus (10)	1.24 (0.2826)			0.0033 (0.0011)		
Handae die-hardener coated		3.224	0.014		8.599	0.001
• Kalrock (10)	1.39 (0.6045)			0.0031 (0.0014)		
• Elite Rock (10)	0.93 (0.1567)			0.0022 (0.0004)		
• Denstone Plus (10)	1.73 (0.7602)			0.0049 (0.0021		
Maarc die-hardener coated		6.695	0.004		9.475	0.001
• Kalrock (10)	1.30 (0.3367)			0.0030 (0.0009)		
• Elite Rock (10)	0.87 (0.3466)			0.0021 (0.0009)		
• Denstone Plus (10)	1.64 (0.5566)			0.0046 (0.0019)		

The loss in weight in the different groups among the uncoated and the differently-coated specimens were also checked irrespective of the load used (Table 3). ANOVA test showed minimum mean weight change as well change minimum percentage change in weight in the Elite Rock specimens when coated with Handae die-hardener ($p = 0.014$ and 0.001 respectively) and also in Elite Rock and Kalrock specimens when coated with Maarc die-hardener ($p = 0.004$ and 0.001 respectively). Multiple comparisons made through Turkey HSD did not show any significant difference both in the uncoated as well as the Hartebad die-hardener coated groups. But six combinations in the Hartebad group and five combinations in the Maarc die-hardener coated group were found to have the least change in weight which was statistically significant.

When the percentage weight-losses among the three different groups of specimens (Kalrock, Elite Rock and Denstone Plus) were compared irrespective of the load and type of treatment, it was found to lowest among the Elite specimens. This finding was statistically significant ($p = 0.006$) [Figure 2]. But on multiple comparisons, no statistically significant inter-group difference in weight-loss was seen in any combination either for weight-loss or percentage weight-loss.

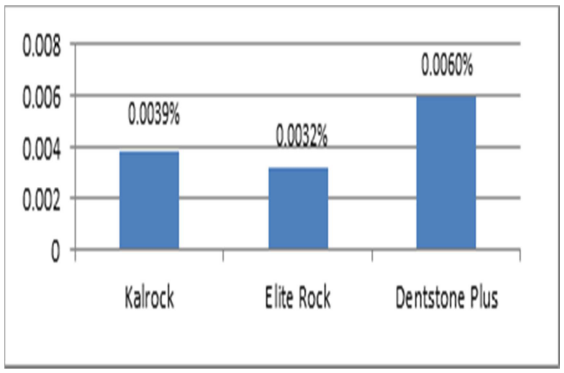

Figure 2: Percentage weight-loss among the different group of specimens

Lastly, the data on effect of treatment on abrasion was compared by using "t" test and found that the mean weight-loss and the percentage weight-loss in uncoated samples was significantly higher as compared to coated samples ($p \leq 0.001$).

DISCUSSION

In the present study when tested against a load of 20mg, it was found that the loss of weight as well as the percentage weight-loss to be maximum in uncoated die stones and minimum in the Elite Rock. But when loaded with 50mg maximum weight loss was seen in the Denstone Plus while the minimum was in the Kalrock group. This might be because of the difference in water/powder ratio used in them (Kalrock -23mg/100ml; Elite Rock-20mg/100ml and Denstone Plus-25mg/100ml). Also the compressive strengths of the die stones are different from each other. This finding is supported by Paffenbarger GC et al who concluded that the physical properties between the different products were too little to be of practical value.[4]

No significant difference was seen in the present study on multiple comparisons were done at 20gm and 50gm loads for any combination of die-stone and hardener. This finding is comparable to the findings made by Terry J et al in 2003.[3] The samples when coated with Hartebad die-hardener and loaded under 20gm had the maximum weight-loss and percentage weight loss in Denstone Plus while the minimum weight-loss was seen in Kalrock, which was not statistically significant. Also, on multiple comparisons no statistically significant inter-group difference could be detected for the change in weight. Lyon HE et al in 1983 evaluated the abrasion resistance of coated gypsum dies and found no significant differences between the different coatings.[5]

When coated with Hartebad die-hardener, there was statistically significant inter-group difference between Kalrock and Elite Rock, and Elite Rock and Denstone Plus a load of 50gm, but no

significant difference was seen between Karlock and Denstone Plus. However, on comparison of percentage weight-loss in the different groups, significant difference was seen for all the combinations. This could be due to the difference in water/powder ratio during preparation of specimens. Also the compressive strength of Elite Rock (52Mpa) is more than Kalrock and Denstone Plus (40.78Mpa each). This finding is in accordance with an earlier finding made by Terry J et al.[3]

The samples when coated with Maarc die-hardener and loaded under 50gm showed maximum weight-loss as well as percentage weight-loss in Denstone Plus and minimum in Elite Rock, the difference being statistically significant. Again, on multiple comparisons significant inter-group differences could be seen for all the combinations with Elite Rock showing the minimum weight-loss. This might be due to the difference in the physical properties of the die-stones tested, Elite Rock having the highest compressive strength. Maarc die-hardener forms a surface-coating of calcium cyanoacrylate that helps in increasing resistance to abrasion. Eames WB et al also made similar findings from their study.[6]

No significant weight-loss could be detected in the different groups in the present study. Bajada SB et al evaluated the effect of surface treatments to dental modelling stones and Vel-Mix die-stone in 1974 and found that both responded similarly in the abrasive resistance scratch test upon the application of polystyrene coating.[7] On comparison between the uncoated and the coated groups a significant difference was found in the abrasion resistance. This could be because of the effect of surface-hardeners used. Die-hardeners form a self-hardening acrylic solution on reacting with calcium of the die-stone which makes the stone resistant to abrasion. This finding is supported by earlier study findings made by Lyon HE et al, Bajada SB et al and Fukui H et al.[5,7,8]

Although care was taken to conduct the study properly, some shortcomings were there. For example, the sharpness of the blade of the abrasion-testing machine might have become blunt as the abrasion-test proceeded. This might have caused lesser abrasion of the samples tested later. Using fresh blade for every sample group is recommended for similar studies in future. Again, as the samples were prepared manually, the uniformity of the film-thickness could not be assured. Lastly, although the present study was conducted on a sample size of 40 in each group which is larger than other studies conducted in abrasion resistance, still a larger sample size would have been more appropriate to assert the findings with greater statistical significance.

CONCLUSION

It can be concluded that the abrasion resistance of type IV gypsum products increases with the application of surface-hardeners irrespective of the load applied and Elite Rock shows the best abrasive resistance whereas Denstone Plus shows the least abrasion resistance. And Elite Rock when coated with Hartebad die-hardener shows the maximum abrasion resistance irrespective of load applied.

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