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Evaluation of Setting Time and Compressive Strength on Various Proportions of Type 2 And Type 3 Gypsum Products in Comparison with Only Type 2 Gypsum; A Comparative Study.

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ABSTRACT

Background: Gypsum products play a major role in dentistry . This study evaluates the influence of setting time and compressive strength in various proportions of Type 2 and Type 3 gypsum in comparison with control group of Type 2 (only plaster) .But addressing the need for these customized formulations in specific applications like fabrication of study models , articulation and flasking is unclear.

Materials and Methods: Two types of gypsum products were used in this study (Plaster of paris and Dental stone). On combination of different ratios, Gypsum manipulation consists of mixture of preproportioned plaster and dental stone that adds to the total of 200g of weighed dried powder with measured standard water based on ADA. Six groups with varying Type 2 and Type 3 gypsum waterpowder ratios were included in this experimental study. Each group consists of five samples which is tested for setting time by Vicat's needle and compressive strength by Universal Testing Machine. Proportions were precisely controlled, and Control Groups 6 (only plaster of paris) served as benchmark. Thirty gypsum samples were prepared for this study in which Mean, standard deviation, mean rank differences were analysed using IBM SPSS statistics, Shapiro-Wilk test and Kruskal-Walli's test respectively.

Results: Kruskal-Walli's test showed that there were significant differences in the initial setting time, final setting time and compressive strength among the groups studied on various proportion between plaster of paris and dental stone.In this study, Group 5(175g of type 3 and 25g of type 2) demonstrated the shortest setting time (4.52 ± 0.45 min) and highest compressive strength (6.76 ± 1.27 MPa) compared with control group 6 (200g of plaster with 100ml of water)

Conclusion: Setting time and compressive strength were tested to check the advantage of various proportions in applications such as fabrication of study models , articulation and flasking. This preliminary study provides insights into mixing type 2 and type 3 in various proportions and estimating their setting time and compressive strength, so that the best proportion can be applied in laboratory procedure. This may overcome certain pitfalls of using only plaster. The future scope of this study lies in evaluating setting expansion of various proportions of type 2 and type 3.

Keywords: Gypsum, Type 2, Type 3, setting time, compressive strength, dental applications.

INTRODUCTION

Gypsum products are extensively used in dentistry with various applications such as fabrication of models and dies, mounting etc. where precise setting time and compressive strength are essential considerations. Among the different types of gypsum available, Type 2 and Type 3 gypsum are commonly employed for fabrication of preliminary cast and diagnostic cast , articulation, flasking. According to ADA , Type 2 exhibits standard water powder ratio of 0.45-0.50, setting time of 8-16 minutes and compressive strength of 24 MPA whereas type 3 exhibits standards water powder ratio of 0.28-0.30,setting time of 8-16 minutes and compressive strength of 70 MPA. Understanding the influence of gypsum type and proportion on properties like setting time and compressive strength is necessary for practical applications. These include a high compressive strength to withstand carving forces and elevated surface hardness to resist scratching during manipulation.[2] Additionally, minimizing dimensional changes (setting expansion) is important, as it directly impacts the fitting and accuracy of the dental prosthesis. While dental plaster is known for its affordability and ease of manipulation, it has notable drawbacks. These drawbacks encompass low compressive strength, susceptibility to abrasion, and high setting expansion. Balancing the setting time and compressive strength helps to enhance the performance in dentistry.[3] The setting time ,as determined by the vicat's needle, closely corresponds to initial

gillmore time.[4] By varying the proportions of Type 2 and Type 3 gypsum in a single manipulation, we aim to demonstrate the influence of change in proportion on setting time and compressive strength .The findings of this study will provide valuable insights into the selection of the best proportion of formulations in dental applications, contributing to enhanced performance.

MATERIALS AND METHODS

In this study, conducted by the Department of Prosthodontics, Crown, and Bridge at a private dental college in Chennai, six groups (1,2,3,4,5 and Control Group 6) were established, each consisting of five samples. The materials used included Type 2(White gold) and Type 3 (Gold stone) Gypsum powder, water, measuring jar, mixing bowls, spatulas, Vicat's needle apparatus, Universal Testing Machine (UTM), cylindrical molds, glass plate, weighing scale and stopwatch.

Manipulation of the gypsum cyclinder block samples used for the experimental study began by weighing 200 g of gypsum powder(plaster and dental stone together) mixed with standard measured water according to ADA on various proportion of type 2 and type 3 gypsum. The standard water ratio of type 2 and type 3 is measured separately in measuring jar and taken together in rubber bowl.Then the gypsum powder mixture of weighed plaster and stone was slowly added and let stand for 30 seconds. Once gypsum contacted water, time noted by stopwatch .Mixing was done for about 60 seconds by spatula without voids to obtain homogenous mixture.

The next step is to pour the mixture into a large end of vicat mold then place the large end down on a glass plate to evaluate setting time by vicat's needle. Lower the needle gently until it comes in contact with the surface of mixture and quickly release the movable rod with needle (1mm) allowing it to penetrate . Time is noted for every 1 minute thereafter until it penertrates 34-36mm or less is obtained in vicat's penetrometer measuring scale. This elapsed time between initial contact of gypsum with water and the penetration of 34-36mm is the vicat's initial time of setting. Then determine the vicat final time of setting until there is no penetration of final setting time needle leaving out only the complete circular impression. This elapsed time between initial contact of gypsum with water and only impression made on gypsum mixture without penetration is the vicat's final setting time.

After which the thirty gypsum cylinder blocks obtained from the mold is tested for compressive strength by Universal Testing Machine in private lab and reports are collected and compared.

Thus,the six groups were defined as follows:

Table 1.Various proportions of type 2 and type 3 gypsum with control group type 2 gypsum

	Type 2	Type 3
Group 1	Water: 87 mL, Powder: 175 g	Water: 8 mL, Powder: 25 g
Group 2	Water: 75 mL, Powder: 150 g	Water: 15 mL, Powder: 50 g
Group 3	Water: 50 mL, Powder: 125 g	Water: 22 mL, Powder: 75 g
Group 4	Water: 50 mL, Powder: 100 g	Water: 30 mL, Powder: 100 g
Group 5	Water: 37 mL, Powder: 75g	Water: 38 mL, Powder: 125 g
Group 6	Water: 100 mL, Powder: 200 g	----------

Setting time measurements were conducted using Vicat's needle apparatus, following American Society for Testing and Material C191 standards, while compressive strength tests were performed using a UTM according to American Society for Testing and Material C109 standards. Data analysis involved statistical examination of setting time and compressive strength data to identify trends and patterns related to gypsum type and proportion. The data underwent statistical analysis using IBM SPSS Statistics for Windows, Version 26.0, with a focus on calculating descriptive statistics such as mean, standard deviation, and standard error for various study parameters. Assessment of data normality using the Shapiro-Wilk test indicated a significant deviation from a normal distribution. Consequently, non-parametric tests were employed for further analysis. The Kruskal-Wallis test, adjusted with Bonferroni correction for multiple comparisons, was utilized to compare the mean rank differences in setting time and compressive strength among different groups. The significance level for this study was set at $p < 0.05$.

Table 2. Setting time and compressive strength of samples

	SAMPLES	PROPORTION				INITIAL SETTING T	FINAL SETTING T	COMPRESSIVE STRENG
		TYPE II		TYPE III				
		WATER	POWDE	WATER	POWDER			
	SAMPLE A	87 ML	175 GMS	8ML	25GMS	4 MINS	9.30 MINS	4.50 MPA
	SAMPLE B	87 ML	175 GMS	8ML	25GMS	4.30 MINS	10 MINS	3.43 MPA
	SAMPLE C	87 ML	175 GMS	8ML	25GMS	4.30 MINS	9.30 MINS	3.34 MPA
	SAMPLE D	87 ML	175 GMS	8ML	25GMS	4.30 MINS	9 MINS	3.13 MPA
GROUP 1	SAMPLE E	87 ML	175 GMS	8ML	25GMS	4.30 MINS	9 MINS	4.08 MPA
	SAMPLE A	75 ML	150 GMS	15 ML	50 GMS	4.30 MINS	9 MINS	5.75 MPA
	SAMPLE B	75 ML	150 GMS	15 ML	50 GMS	5 MINS	8.30 MINS	4.29 MPA
	SAMPLE C	75 ML	150 GMS	15 ML	50 GMS	5 MINS	8.30 MINS	3.92 MPA
	SAMPLE D	75 ML	150 GMS	15 ML	50 GMS	5 MINS	9 MINS	4.01 MPA
GROUP 2	SAMPLE E	75 ML	150 GMS	15 ML	50 GMS	5.30 MINS	9 MINS	4.08 MPA
	SAMPLE A	72 ML	125 GMS	22 ML	75 GMS	5 MINS	10 MINS	5.16 MPA
	SAMPLE B	72 ML	125 GMS	22 ML	75 GMS	5 MINS	8.30 MINS	4.89 MPA
	SAMPLE C	72 ML	125 GMS	22 ML	75 GMS	6 MINS	9 MINS	4.54 MPA
	SAMPLE D	72 ML	125 GMS	22 ML	75 GMS	5 MINS	9 MINS	4.29 MPA
GROUP 3	SAMPLE E	72 ML	125 GMS	22 ML	75 GMS	5 MINS	9 MINS	4.13 MPA
	SAMPLE A	50 ML	100 GMS	30 ML	100 GMS	5 MINS	10 MINS	5.40 MPA
	SAMPLE B	50 ML	100 GMS	30 ML	100 GMS	4.30 MINS	8.30 MINS	6.71 MPA
	SAMPLE C	50 ML	100 GMS	30 ML	100 GMS	5 MINS	9 MINS	5.23 MPA
	SAMPLE D	50 ML	100 GMS	30 ML	100 GMS	5 MINS	9 MINS	4.64 MPA
GROUP 4	SAMPLE E	50 ML	100 GMS	30 ML	100 GMS	5 MINS	9 MINS	5.47 MPA
	SAMPLE A	37 ML	75 GMS	38 ML	125 GMS	4 MINS	8 MINS	8.67 MPA
	SAMPLE B	37 ML	75 GMS	38 ML	125 GMS	4.30 MINS	8 MINS	7.22 MPA
	SAMPLE C	37 ML	75 GMS	38 ML	125 GMS	4.30 MINS	8 MINS	5.23 MPA
	SAMPLE D	37 ML	75 GMS	38 ML	125 GMS	5 MINS	8 MINS	6.27 MPA
GROUP 5	SAMPLE E	37 ML	75 GMS	38 ML	125 GMS	5 MINS	8 MINS	6.44 MPA
	SAMPLE A	100 ML	200 GMS			5 MINS	9 MINS	4.18 MPA
	SAMPLE B	100 ML	200 GMS			5 MINS	9 MINS	4.18 MPA
	SAMPLE C	100 ML	200 GMS			5 MINS	9 MINS	4.18 MPA
	SAMPLE D	100 ML	200 GMS			5 MINS	9 MINS	4.18 MPA
GROUP 6	SAMPLE E	100 ML	200 GMS			5 MINS	9 MINS	4.18 MPA

Table 3.Mean values of setting time and compressive strength

GROUP	MEAN INITIAL SETTING TIME ± SD [MINUTES]	MEAN FINAL SETTING TIME ±SD [MINUTES]	MEAN COMPRESSIVE STRENGTH ±SD [MPA]
GROUP 1[5]	4.24±0.13	9.32±0.42	3.69 ±0.57
GROUP 2 [5]	4.92±0.37	8.72±0.32	4.41±0.76
GROUP 3 [5]	5.2±0.2	9.06±0.36	4.60±0.42
GROUP 4 [5]	4.86±0.31	9.06±0.36	5.49 ±0.75
GROUP 5 [5]	4.52± 0.45	8±0	6.76±1.27
GROUP 6 [5]	5	9	4.18

Fig.1 **UNIVERSAL TESTING MACHINE**

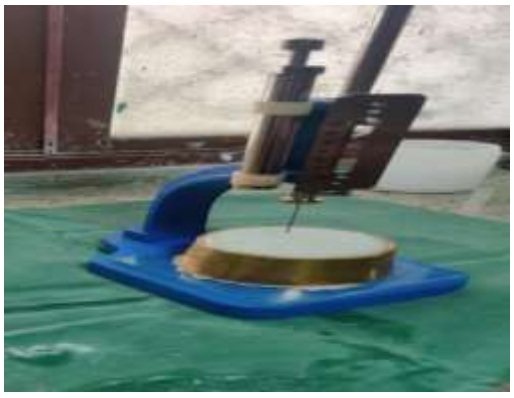


Fig.2 VICAT'S NEEDLE APPARATUS

Fig 3. This figure shows compressive strength testing of the sample collected

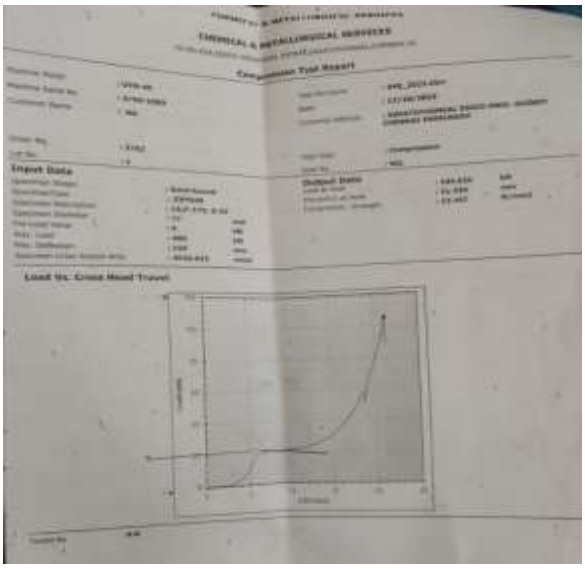


Fig 4. This figure shows the report of compressive strength of group 1 obtained by universal testing machine

RESULTS

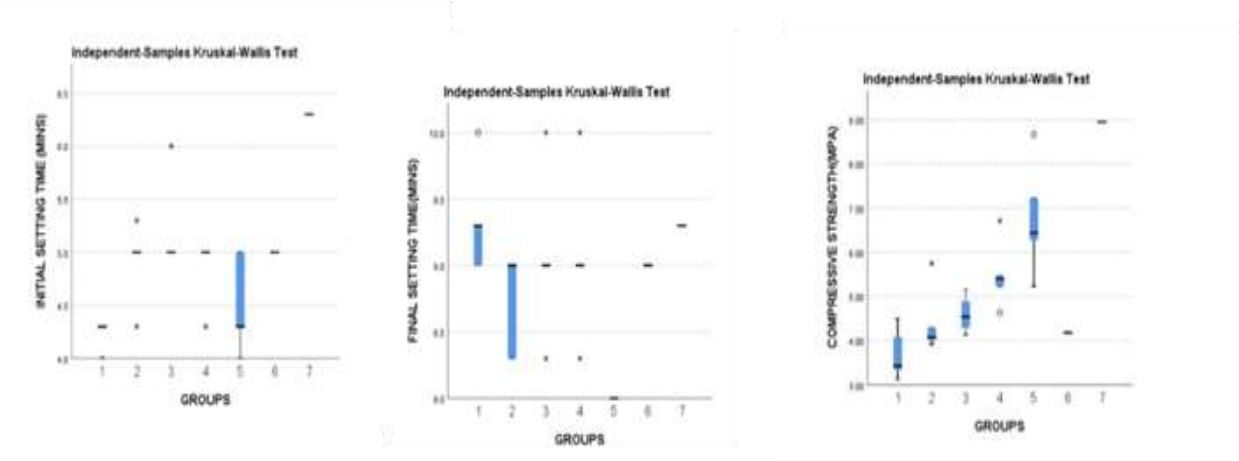
The study encompassed six distinct groups (Group 1 to Group 6), each defined by specific proportions of Type 2 and Type 3 gypsum, with Control Groups 6 serving as comparative benchmark. For each group, mean values and standard deviations were determined for initial setting time, final setting time, and compressive strength. Group 1 exhibited an average initial setting time of 4.24 ± 0.13 minutes, a final setting time of 9.32 ± 0.42 minutes, and a compressive strength of 3.69 ± 0.57 MPa. In Group 2, the mean initial setting time was 4.92 ± 0.37 minutes, the final setting time was 8.72 ± 0.32 minutes, and the compressive strength reached 4.41 ± 0.76 MPa. Group 3 demonstrated a mean initial setting time of 5.2 ± 0.2 minutes, a final setting time of 9.06 ± 0.36 minutes, and a compressive strength of 4.60 ± 0.42 MPa. Meanwhile, Group 4 showcased an initial setting time of 4.86 ± 0.31 minutes, a final setting time of 9.06 ± 0.36 minutes, and a compressive strength of 5.49 ± 0.75 MPa. Group 5, distinguished by a mean initial setting time of 4.52 ± 0.45 minutes, a final setting time of 8 ± 0 minutes, and a robust compressive strength of 6.76 ± 1.27 MPa, demonstrated the shortest setting time and the highest strength among the experimental groups. The control groups (Control Group 6 and Control Group 7) also provided valuable insights. Control Group 6, representing Type 2 gypsum, exhibited an initial setting time of 5 minutes, a final setting time of 9 minutes, and a compressive strength of 4.18 MPa. These findings underscore significant variations in setting times and compressive strength across different gypsum mixtures. Notably, the choice between Type 2 and Type 3 gypsum had a discernible impact on these properties. Further detailed analysis and interpretation of these results are imperative for making informed decisions regarding the selection of gypsum formulations customized to specific applications in construction and dentistry. The test statistics obtained for the Kruskal-Wallis test are as follows:

Initial Setting Time (minutes): H = 25.312

Final Setting Time (minutes): H = 22.553

Compressive Strength (MPa): H = 27.752

In summary, these Kruskal-Wallis test statistics provide evidence that there are significant differences in initial setting time, final setting time, and compressive strength among the groups studied.



DISCUSSION

The initial and final setting times observed in the study provided valuable insights into the workability and setting characteristics of the gypsum mixtures. Notably, Group 5 demonstrated the shortest initial (125g of type 3 and 75g of type 2) setting time of 4.52 ± 0.45 minutes, suggesting rapid solidification upon mixing compared with group 6. This characteristic can be advantageous in scenarios where expedited setting is desirable. The variations observed underscore the significance of gypsum type and proportion in controlling the setting kinetics. The variation in gypsum setting time in this study is also attributed to composition. The examined gypsums are sourced from distinct manufacturers, featuring diverse proportions of calcium sulfate hemihydrate and other chemicals in their composition. The compressive strength results provide information about the structural integrity and load-bearing capacity of the gypsum formulations. Group 5, characterized by a unique composition, displayed the highest compressive strength among the experimental groups at 6.76 ± 1.27 MPa. This finding indicates that the specific proportions in Group 5 resulted in a gypsum mixture with superior mechanical strength, which could be advantageous in applications where structural strength is important.[5] According to Imelda Darmawan's study, the construction gypsum exhibited the shortest average initial setting time at 10 minutes and 39 seconds, while the SIRIUS® dental gypsum showed the longest average at 24 minutes and 46 seconds. Similarly, the construction gypsum had the briefest final setting time at 15 minutes and 97 seconds, whereas the dentistry gypsum SIRIUS® had the lengthiest final setting time, averaging 33 minutes and 37 seconds.[6] In a separate study conducted by AP W et al. on gypsum products, it was observed that the average setting time for self-made gypsums was approximately 8 minutes and 7 seconds, with a notably shorter time of 3 minutes and 40 seconds in certain instances.[7] The variations in setting times and compressive strengths observed across different formulations highlight the importance of selecting the appropriate gypsum type and proportion based on the specific requirements of dental applications. For instance, a formulation with rapid setting time and adequate strength may be preferable for certain dental procedures, while others may benefit from formulations emphasizing higher compressive strength at the expense of setting speed. It is necessary to acknowledge the limitations of this study, including the controlled laboratory setting and the need for further investigation into the effects of other influencing factors, such as environmental conditions and storage. The future scope of this study lies in evaluating setting expansion of various properties of type 2 and type 3.This could explore a broader range of gypsum formulations and consider the impact of environmental variables on the properties studied.[8]

CONCLUSION

In conclusion, this study provides valuable insights into the setting times and compressive strengths of gypsum products with varying proportions of Type 2 and Type 3 gypsum so that the best proportion can be applied in laboratory procedure. The findings contribute to the understanding of gypsum behavior and can inform practitioners in selecting material choices for enhanced performance in various scenarios. Further research and exploration of gypsum formulations under diverse conditions will undoubtedly enrich our understanding and refine the applications of these essential dental materials.

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