Original article International Journal of Dental Materials 2023;5(1) ISSN:2582-2209

Evaluation of physico-mechanical properties of dental plaster modified with pulverized acrylic waste

Sai Vishnu Ponnapalli[1,*], Keerthana Robbi[1], Rama Krishna Alla[2], Majji Vasavi[3], Uma Devi Medicharla[4], Ramaraju AV[5], Suresh Sajjan MC[5]

[1]Undergraduate student, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.

[2]Associate Professor, Department of Dental Materials, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.

[3]Senior Lecturer, Department of Prosthodontics and Implantology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.

[4]Graduate, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.

[5]Professor, Department of Prosthodontics and Implantology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.

Article History

Received 5th *February 2023*

Accepted *2nd March 2023*

Available online *10th April 2023*

*Correspondence

Sai Vishnu Ponnapaplli

Undergraduate student,

Vishnu Dental College, Bhimavaram,

Andhra Pradesh, India.

E-mail: *saivishnu.ponnapalli@vdc.edu.in*

DOI: *http://dx.doi.org/10.37983/IJDM.2023.5101*

Abstract

Background: Dental plaster is most widely used to make temporary casts and as an investment medium during the fabrication of removable complete and partial denture prostheses. Dental plasters exhibit poor mechanical properties.
Aim: This study aimed to evaluate the physico-mechanical properties of dental plaster modified with various concentrations of pulverized acrylic waste.
Materials and Methods: A total of 120 specimens were fabricated using dental plaster and were divided into four groups of 30 specimens each to evaluate setting time, one-hour compressive strength, 24-hour compressive strength, and surface reproducibility. Each group was subdivided into five groups of six specimens (n=6), each with the incorporation of various concentrations of pulverized acrylic powder. The specimens incorporated with various concentrations of pulverized acrylic powder (0.5 wt%, 1.0 wt%, 5.0 wt% and 10.0 wt%) were considered as modified groups and the dental plaster with no additives was considered as a control group. The initial and final setting times were measured using a Gillmore needle apparatus, the compressive strength was measured using a universal testing machine, and the surface reproducibility was analyzed using a stereo microscope. The obtained data were subjected to statistical analysis using one-way ANOVA and post hoc analysis.
Results: The incorporation of 0.5 wt% resulted in more final and initial setting times. The one-hour and 24-hour compressive strengths of the dental plaster increased with increasing concentration of acrylic waste. Poor surface details were observed with an increase in the concentration of acrylic waste.
Conclusions: The addition of acrylic waste resulted in an increase in the one-hour and 24-hour compressive strengths, decreased initial and final setting times, and poor surface reproducibility.
Keywords: Dental plaster, Acrylic waste, Compressive strength, Setting time, Reproducibility.

1. Introduction

Gypsum is a naturally occurring white mineral found all over the world [1]. Gypsum is calcined at temperatures between 120 °C and 130 °C with or without water or moisture to produce gypsum products. The products produced in the absence of water are referred to as beta-hemihydrates, and those produced in the presence of moisture are referred to as alpha-hemihydrates [1,2]. Gypsum products are used in many different applications such as the creation of statues and household objects. They are also widely employed in the medical industry and are frequently used in orthopedics to cast and splint broken bones and joints. Gypsum products are the most popular materials used in dentistry to fabricate study models and dental casts, which are then used in diagnosis and treatment planning [1,2].

Dental plaster and dental stone are gypsum products commonly used in dentistry to create temporary and permanent dental casts, respectively. Despite their low cost, the inherent low compressive strength, poor wear resistance, and dimensional stability of dental plasters have limited their use to make preliminary casts. Numerous researchers have attempted to improve the mechanical and physical properties of dental plaster materials by adding various additives with varying degrees of success [3].

Polymethyl methacrylate (PMMA) resin is frequently used in dentistry to construct partial and complete removable denture prostheses as well as temporary and permanent denture bases [4]. Large amounts of dust are produced during the fabrication of acrylic-based appliances, which

may present occupational hazards to dental professionals [5] and environmental pollution [6] during disposal. The cured acrylic demonstrated superior mechanical properties. Therefore, acrylic dust can be utilized as a reinforcement material in gypsum products to modify their characteristics. Hence, this study was designed to incorporate various concentrations of pulverized acrylic dust into dental plaster material and to evaluate their physical and mechanical properties.

2. Materials and methods

The materials used in this study are listed in table 1.

2.1. Obtaining pulverized acrylic powder

A disc-shaped (50 × 2 mm) wax pattern was made with the modelling wax and invested in the dental flask. The investment material was allowed to set and dewaxed. Subsequently, a separating medium was applied to the mold cavity. The self-cure acrylic resin powder and monomer liquid were placed in a porcelain jar at a 3:1 ratio by volume [1] and mixed using a glass rod. The mix was collected and kneaded thoroughly with fingers as soon as it reached dough consistency. The dough was packed into the mold cavity, and a trail closure was performed to remove the excess flash and allowed to polymerize. After curing, the dental flask halves were carefully opened to retrieve cured acrylic discs. The attached investment particles were then thoroughly cleaned. The acrylic disc was trimmed using a steel bur to obtain powder. The obtained powder was coarse and gritty in texture. Therefore, the obtained powder was ground manually using a mortar and pestle before being carefully filtered through a household sieve to obtain a fine powder (Figure 1).

2.2 Sample size calculation

Sample size calculations were performed using the G-power software. The calculation was based on a 95% confidence level, 80% power, and estimated effect size of 0.241. The final sample size was set to 120.

2.3 Specimen preparation

A total of 120 specimens were fabricated using dental plaster. One hundred and twenty specimens of dental plaster were further divided into four groups with 30 specimens in each to evaluate setting time, one-hour compressive strength, 24-hour compressive strength, and surface reproducibility. Each group was subdivided into five groups of six specimens (n=6) each with the incorporation of various concentrations of pulverized acrylic powder. The specimens incorporated with various concentrations of pulverized acrylic powder (0.5 wt%, 1.0 wt%, 5.0 wt% and 10.0 wt%) were considered as modified groups and the dental plaster with no additives was considered as a control group.

Table 1: Materials used in this study.

S.No.	Material	Manufacturer
1.	Dental Plaster	Asian Chemicals, India.
2.	Cold-cure acrylic resin material	DPI Cold cure acrylic resin material, Dental Products of India, India.
3.	Polyvinyl siloxane impression material (Putty body)	Elite HD+, Zhermack, Italy

Figure 1. Pulverized acrylic powder

Table 2. Amount of plaster and pulverized acrylic powder mixed with water.

Formulation	Plaster (g)	Pulverized Acrylic Powder (AP) (g)	Water (ml)
Unmodified Plaster	30.0	0	15
0.5 wt% AP/ plaster	29.85	0.15	15
1.0 wt% AP/ plaster	29.7	0.3	15
5.0 wt% AP/ plaster	28.5	1.5	15
10.0 wt% AP/ plaster	27.0	3	15

2.3.1 For the evaluation of setting time

The setting time was determined according to ADA specification No.25 for gypsum products using a Gillmore needle apparatus. The initial and final setting times were determined by using small and large Gillmore needles, respectively. The smaller Gillmore needle weighs 1/4 lb (113.4 g) and is 1/12 inch in diameter, and the larger Gillmore needle weighs around 1 lb (453.65 g) and is 1/24 inch in diameter. The mixed dental plaster material, with and without pulverized acrylic powder, was spread uniformly over a glass slab, and the initial and final setting times were measured. The initial setting time (min) was considered from the start of mixing until the smaller Gillmore needle failed to produce any indentation on the surface of the plaster mix. The final setting time (minutes) was considered from the start of mixing until the larger Gillmore needle failed to produce any indentation on the surface of the plaster mix.

2.3.2 For the evaluation of compressive strength (CS)

To prepare specimens for compressive strength measurements in accordance with ANSI/ADA no.25, a split metal mold with a diameter of 20 mm and a height of 40 mm was used. The water: powder ratios of the plaster and the amount of acrylic resin incorporated into them are listed in Table 2. Pulverized acrylic powder was added to the respective concentrations of the dental plaster powder, as mentioned in Table 1, and mixed with water. The mixture was spatulated using a stainless plaster mixing spatula in circular motion at a rate of 120 revolutions per minute. The mixture was then poured into a split metal mold under vibration. The excess mixture was removed and covered with a glass slab. The cylindrical specimens were carefully separated from the split mold. The one-hour compressive

strength was measured after one hour of the setting reaction. The same process was used to fabricate the specimens for 24-hour compressive strength. The specimens were stored at room temperature for 24 h, and their compressive strength (dry strength) was evaluated 24 h after the setting reaction was completed. The specimen was mounted over the lower jaw of the Universal Testing Machine (Advanced Equipment, India) and a load was applied at a crosshead speed of 1 mm/min until the specimen fractured. The compressive strength (MPa) of the specimens were calculated using the following formula:

CS =F/Cross-section area of specimen

Where F is the maximum breaking load in newtons. The cross-sectional area was calculated using πr^2. where r denotes the radius of the specimen.

2.3.3 for the evaluation of the surface reproducibility

The metal master die (Figure 2) consisted of a ruled block of the inner ring: 30 mm, outer ring: 38 mm, height 31 mm and three vertical lines: 25 mm, 50 mm, 75 mm, and two horizontal lines with a distance of 25 mm. A mold and riser were used to record the impression of the lines using putty-body polyvinyl siloxane (PVS) impression material. The upper surfaces of the impression material were covered with a glass plate and a load of 100 g was applied. A total of 30 impressions were made with PVS and the dental plaster material was poured with the addition of different concentrations of pulverized acrylic powder, as described in Table 2. After the recommended manufacturer's setting time, the plaster casts were separated and the distance between the horizontal lines was measured under a stereomicroscope (Olympus SZX16, Japan) at 0.7X magnification. The surface reproducibility of the plaster models was analyzed based on the reproduction of the lines using the following score: The scoring was performed by the same operator for all samples.

Score 1: Sharp detailed reproduction of lines.
Score 2: Continuous line but with less sharpness.
Score 3: Deterioration of line details.
Score 4: Rough appearance with less line continuity.

Figure 2. Metal master die.

2.4 Statistical analysis

The data obtained were subjected to one-way ANOVA and Tukey's HSD tests for statistical analyses using the Statistical Package for the Social Sciences for Windows (version 24.0; SPSS Inc., Chicago, IL, USA). Differences were considered statistically significant at a p-value < 0.05.

3. Results

The mean and standard deviation of the initial and final setting time, compressive strength, and surface reproducibility of both unmodified and modified dental plasters are given in Tables 3, 4, and 5, respectively.

3.1 Setting time

The control group showed a shorter initial setting time than the modified group. Among the modified groups, dental plaster incorporated with 0.5 wt% of pulverized acrylic powder demonstrated more initial and final setting times. The final setting decreased as the concentration of pulverized acrylic powder in the dental plaster increased. One-way ANOVA showed significant differences in the initial setting time ($p = 0.049$) and final setting time ($p = 0.004$) between the groups (Table 3). Post-hoc analysis showed significant difference ($p = 0.024$) in initial setting time between the control and dental plaster modified with 0.5 wt% of acrylic powder (Table 6). In final setting time, dental plaster modified with 0.5 wt% of acrylic powder showed significant differences with 5.0 wt% ($p = 0.011$) and 10.0 wt% ($p = 0.017$) groups. However, no significant differences were observed among the other groups (Table 6).

3.2 Compressive strength

The control groups showed less one-hour compressive strength compared to the modified groups. Among the modified groups, a gradual increase in the one-hour compressive strength was observed. The control group exhibited slightly higher compressive strength after 24-hours. Among the modified groups, the compressive strength was increased from 1.0 wt% to 10.0 wt% of acrylic powder incorporation, after 24-hours. One-way analysis showed a significant difference ($p = 0.000$) in the hour and 24-hour compressive strengths among the groups. In post-hoc analysis of one-hour compressive strength, the control group exhibited significant differences from the modified groups except for the 0.5 wt% group. Among the modified groups, significant differences were observed between the different concentrations of pulverized acrylic powder, except between the 0.5wt% and 1.0 wt% groups (Table 7).

On intergroup comparison between the 24-hour compressive strength groups, the control group showed significant differences from the 5.0 wt% and 10.0 wt% groups, except for the 0.5 wt% and 1.0 wt% groups. Among the modified groups, significant differences were observed between the except between the 1.0 wt% and 5.0 wt% groups (Table 7).

3.3 Surface reproducibility

The control group showed better surface reproducibility than the modified groups, except for the 0.5 wt% group. Poor surface reproducibility was observed with an increase in the concentration of the pulverized acrylic powder in the dental plaster. One-way ANOVA showed a significant difference ($p = 0.018$) among the groups (Table 5). Post-hoc analysis showed no significant differences between the control and modified groups. Among the modified groups, no significant differences were observed between the groups, except between the 0.5% and 10.0 wt% groups (Table 8). Stereo microscopic images of the plaster material are shown in Figure 3.

Table 3. Initial and final setting times of control and modified dental plaster.

Groups	Initial Setting time		Final Setting time	
	Mean ± SD#	Significance	Mean ±SD#	Significance
Control	4.4717 ± 0.44808	0.049*	8.0367 ± 1.21518	0.004*
DP + 0.5 wt% of AP	6.0100 ± 0.91468		8.5317 ± 1.71834	
DP + 1.0 wt% of AP	5.0067 ± 0.88369		7.0400 ± 0.95752	
DP + 5.0 wt% of AP	5.2133 ± 0.88908		6.1250 ± 0.75392	
DP + 10.0 wt% of AP	4.4717 ± 0.44808		6.2600 ± 0.85979	

*Significant difference

Table 4. One-hour and 24-hour compressive strength (MPa) of control and modified dental plaster.

Groups	One-hour		24-hour	
	Mean ± SD#	Significance	Mean ± SD#	Significance
Control	1.7917 ± 0.51098	0.000*	2.8767 ± 0.18316	0.000*
DP + 0.5 wt% of AP	1.8417 ± 0.38696		2.5900 ± 0.48748	
DP + 1.0 wt% of AP	2.7633 ± 0.42618		4.8133 ± 1.70566	
DP + 5.0 wt% of AP	5.0450 ± 0.88260		6.4150 ± 1.15100	
DP + 10.0 wt% of AP	6.1450 ± 0.50958		8.9333 ± 1.58456	

*Significant difference

Table 5. Surface reproducibility of control and modified dental plaster.

Groups	Mean ± SD#	Significance
Control	1.6667 ± 0.51640	0.018*
DP + 0.5 wt% of AP	1.3333 ± 0.51640	
DP + 1.0 wt% of AP	2.3333 ± 0.81650	
DP + 5.0 wt% of AP	2.1667 ± 0.75277	
DP + 10.0 wt% of AP	3.0000 ± 1.26491	

*Significant difference

Table 6. Intergroup comparison of initial and final setting times of the control and modified dental plasters.

Groups		Initial Setting time		Final Setting time	
		Mean ± SE#	Significance	Mean ± SE#	Significance
Control	DP + 0.5 wt% AP	1.538 ± 0. 472	0.024*	0.495 ± 0.666	0.944
	DP + 1.0 wt% AP	0.535 ± 0. 472	0.788	0.997 ± 0.666	0.574
	DP + 5.0 wt% AP	0.742 ± 0. 472	0.529	1.912 ± 0.666	0.058
	DP + 10.0 wt% AP	0.838 ± 0. 472	0.410	1.777 ± 0.666	0.088
DP + 0.5 wt% AP	DP + 1.0 wt% AP	1.003 ± 0. 472	0.242	1.492 ± 0.666	0.198
	DP + 5.0 wt% AP	0.797 ± 0. 472	0.460	2.407± 0.666	0.011*
	DP + 10.0 wt% AP	0.700 ± 0. 472	0.583	2.272 ± 0.666	0.017*
DP + 1.0 wt% AP	DP + 5.0 wt% AP	0.207 ± 0. 472	0.992	0.915 ± 0.666	0.649
	DP + 10.0 wt% AP	0.303 ± 0. 472	0.967	0.780 ± 0.666	0.767
DP + 5.0 wt% AP	DP + 10.0 wt% AP	0.097 ± 0. 472	1.000	0.135 ± 0.666	1.000

*Significant difference

Table 7. Intergroup comparison of One-hour and 24-hour compressive strength of the control and modified dental plaster.

Groups		One-hour		24-hour	
		Mean ± SE#	Significance	Mean ± SE#	Significance
Control	DP + 0.5 wt% AP	0.050 ± 0.33	1.000	0.287 ± 0.684	0.993
	DP + 1.0 wt% AP	0.972 ± 0.33	0.049*	1.937 ± 0.684	0.063
	DP + 5.0 wt% AP	3.253 ± 0.33	0.000*	3.538 ± 0.684	0.000*
	DP + 10.0 wt% AP	4.353 ± 0.33	0.000*	6.057 ± 0.684	0.000*
DP + 0.5 wt% AP	DP + 1.0 wt% AP	0.922 ± 0.33	0.068	2.223 ± 0.684	0.025*
	DP + 5.0 wt% AP	3.203 ± 0.33	0.000*	3.825 ± 0.684	0.000*
	DP + 10.0 wt% AP	4.303 ± 0.33	0.000*	6.343 ± 0.684	0.000*
DP + 1.0 wt% AP	DP + 5.0 wt% AP	2.282 ± 0.33	0.000*	1.602 ± 0.684	0.165
	DP + 10.0 wt% AP	3.382 ± 0.33	0.000*	4.120 ± 0.684	0.000*
DP + 5.0 wt% AP	DP + 10.0 wt% AP	1.100 ± 0.33	0.020*	2.518 ± 0.684	0.009*

*Significant difference

Table 8. Intergroup comparison of the surface reproducibility of the control and modified dental plaster.

Groups		Surface reproducibility	
		Mean ± SE#	Significance
Control	DP + 0.5 wt% AP	0.333 ± 0.474	0.954
	DP + 1.0 wt% AP	0.667 ± 0.474	0.629
	DP + 5.0 wt% AP	0.500 ± 0.474	0.827
	DP + 10.0 wt% AP	1.333 ± 0.474	0.065
DP + 0.5 wt% AP	DP + 1.0 wt% AP	1.000 ± 0.474	0.247
	DP + 5.0 wt% AP	0.833 ± 0.474	0.418
	DP + 10.0 wt% AP	1.667 ± 0.474	0.013*
DP + 1.0 wt% AP	DP + 5.0 wt% AP	0.167 ± 0.474	0.996
	DP + 10.0 wt% AP	0.667 ± 0.474	0.629
DP + 5.0 wt% AP	DP + 10.0 wt% AP	0.833 ± 0.474	0.418

***Significant difference**

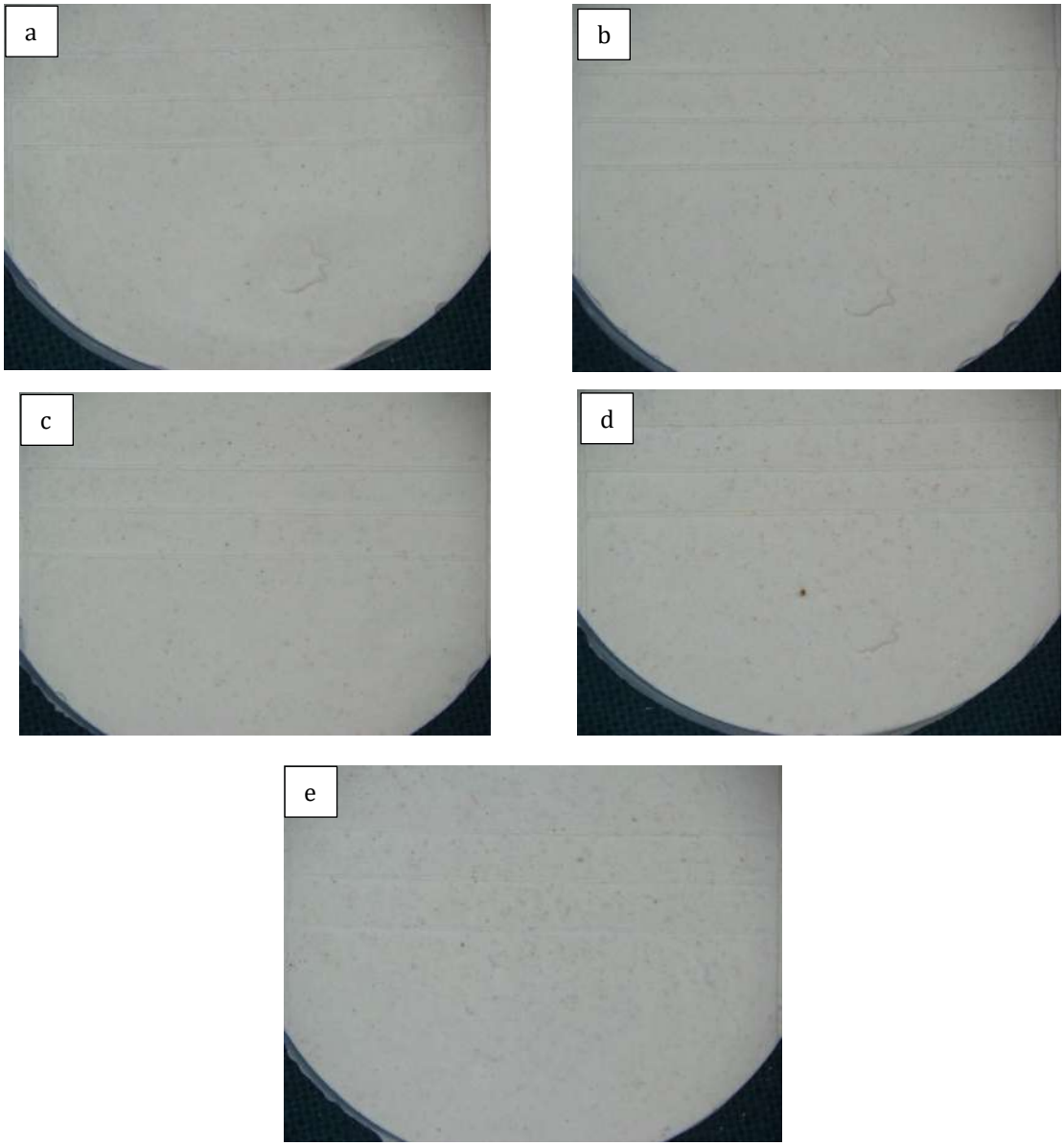

Figure 3. Microscopic images of dental plaster cast. Where, a, b, c, d, and e are with 0.0 wt%, 0.5 wt%, 1.0 wt%, 5.0 wt% and 10.0 wt% of Pulverized acrylic powder, respectively.

4. Discussion

Dental plasters are widely used to fabricate studies and working models in dentistry. These models and casts must satisfy specific requirements for the fabrication of precise prostheses. Compatibility with impression materials, dimensional stability, surface hardness, abrasion resistance, ease of manipulation, lack of toxicity, and low surface roughness are among the basic requirements of dental plaster material [7-9].

The trimming of custom-made trays, temporary denture bases, and removable partial and denture prostheses produces a significant amount of acrylic dust/waste in dental laboratories. The inhalation of acrylic dust causes local and systemic effects on dental professionals [5,10]. In addition, the disposal of acrylic dust may pollute the environment. Reusing it as reinforcement in some dental materials is preferable for discarding and harming the environment [6]. Therefore, this study was designed to incorporate various concentrations of pulverized acrylic powder into a dental plaster to evaluate its effect on the physical and mechanical properties.

4.1 Setting time

The setting time of gypsum products is significantly influenced by the particle size, shape, and water-powder ratio. The larger the particle size, the slower the rate of the setting reaction, as more time is required to completely wet the powder particles and delay the setting time. The smaller and finer particles increased the rate of the setting reaction. The higher the water- powder ratio, the longer the setting time, as fewer nuclei of crystallization are available in a given volume of the mix and delay the reaction. According to American Dental Association specification number 25, the initial setting time of dental plaster was 5±1 min and the final setting time was 12±4 min for both materials [1,2].

In this study, the control group had lower initial and final setting times. Among the modified dental plaster groups, the 0.5 wt% addition of pulverized acrylic powder showed more initial and final setting times than the other modified groups (Table 3). The actual water required for the setting reaction of the gypsum products was approximately 18.6 ml per 100 g of the powder. However, they are always mixed with large amounts of water to obtain adequate working characteristics. As a result, excess water slows down the setting reaction without contributing to it. The decrease in the setting time of the dental plaster among the modified groups can be attributed to the amount of acrylic resin powder incorporated. Because acrylic resin has a greater capacity for water absorption [2], it might have absorbed the extra water in the mixture. Therefore, the rate of setting the reaction was faster, and the setting time decreased. In addition, the lack of adequate water and large particle sizes of the dental plaster produced a grainy mass. The modified specimens did not accurately reproduce the surfaces, as was clear from this study.

4.2 Compressive strength

The specialties for removable prosthodontics have long relied on dental plasters. Compressive strength has always played a significant role in the traditional processing of prosthetics, necessitating reporting to the American Dental Association. The compressive Strength is a measure of a material's resistance to compressive stress, which is created by any force applied to the plaster mass. This compressive stress occurs in removable prosthodontic technology when the finished wax-up of a specific prosthesis is flasked, trial packed, final packed, and pressed for curing [11].

In the current study, the modified groups showed greater compressive strength after one-hour and 2 h compared to the unmodified groups. There was a correlation between the amount of pulverized acrylic powder present and the increase in compressive strength (Table 4). Dental plasters typically require a higher water-to-powder ratio to have a workable consistency. As the extra water evaporated, voids developed in the mass. The compressive strength was lower if there were more voids in the gypsum mass. In addition, the large size and irregular shape of hemihydrate particles [12] also play an important role in void formation. In this study, however, it was found that the compressive strength of the dental plaster increased over time. This improvement in compressive strength can be attributed to the acrylic powder filling up the voids and reducing the number and size of voids, which led to an improvement in the compressive strength.

The compressive strengths at different time intervals were comparable to those of the respective unmodified groups of dental plasters at the lowest concentration, such as 0.5 wt%. Between the unmodified and 0.5w% modified groups, there were no statistically significant differences in the compressive strengths measured after one-hour ($p = 1.000$) and 24-hour ($p = 0.993$). The acrylic powder concentration was minimal (0.5 wt %) to fill up the voids created due to the evaporation of water after setting, which could have been the reason for the lack of improvement in the compressive strengths compared to other modified groups.

Compressive strength is influenced by several factors, including the water/powder ratio, manipulation and spatulation, mixing procedures, relative humidity of the room, and the size of calcium sulfate hemihydrate particles [13-15]. According to American Dental Association (ADA) Specification No. 25 and ISO standard 6873:1998, the compressive strength of gypsum products used for the construction of final casts and dies should not be less than 35 MPa [7]. In this study, the water-to-powder ratio and mixing techniques employed were in accordance with ADA Specification No. 25.

The findings of this study were consistent with those of Hamdy *et al.* [16], who reported that dental plasters reinforced with alumina nanoparticles showed a significant improvement in compressive strength. In contrast to the values found in the present study, the compressive strengths of the specimens were extremely high. The reason for this difference is the type of reinforcement used. Comparatively, alumina nanoparticles have greater compressive strength than acrylic powders. The drying method also plays an important role in the compressive strength of gypsum products. It has been reported that microwave drying increases compressive strength [17]. However, in the present study, both dental plaster specimens were dried at room temperature.

4.3 Surface reproducibility

Dental plaster materials are widely used to fabricate temporary and permanent casts/models during the fabrication of removable partial and complete denture prostheses, respectively. The surface reproducibility of these materials is essential to determine the fit of the final prosthesis in the oral cavity. Ideally, the cast materials should reproduce the impression details. Therefore, this study focused on evaluating the surface reproducibility of dental plaster materials modified with various concentrations of pulverized acrylic powder.

In the present study, the modified groups of dental plasters with pulverized acrylic powder demonstrated poor surface details compared with the control group. The increased concentration of acrylic powder in the dental plaster resulted in very poor surface details. The dental plaster incorporated with 0.5 wt% showed better surface reproducibility compared to the control groups. However, post hoc analysis showed no significant differences between the unmodified and modified groups or between the modified groups, except between the 0.5-and 10 wt% groups (Table 8). The reason for the poor surface details of the modified plaster material could be the presence of acrylic powder, which has more water sorption characteristics. The sorption of water by the acrylic resin powder may have produced hygroscopic expansion, which could have affected the surface details of the modified plaster samples.

Porosity on the surface is another significant factor that influences the accurate reproduction of surface details; however, it needs to be controlled because of its strong effect in reducing the strength of the set material [18]. The porosity of the dental plaster depends on the water/powder ratio. A dental plaster requires a high w/p ratio. It was evident from this study that dental plaster specimens displayed poor surface reproducibility. This can be attributed to the higher w/p ratio.

The type of impression material also influence the surface details of the dental plaster. The literature reported that casts made from polyvinyl siloxane (PVS) impression material under dry conditions produce better surface details than those made from polyether impression material [19]. In the present study, the impression of the metal die was made using PVS putty body impression material. Therefore, the impression made with the PVS material did not affect the surface details of the gypsum models, and they were largely influenced by the amount of acrylic powder incorporated into them. Petrie et al. [20] investigated the surface detail reproduction of PVS impression materials tested under dry, moist, and wet conditions using macroscopic evaluation of smooth surfaces. They concluded that both materials performed satisfactorily under dry conditions, but inconsistently under moist and wet conditions.

In summary, the present study reported a decrease in the initial and final setting times, an increase in one-hour and 24-hour compressive strengths, and poor surface details with an increase in the addition of pulverized acrylic powder to the dental plaster. The concentrations of the acrylic waste used in this study were 0.5, 1.0, 5.0 and 10.0 wt%. Further studies should focus on decreasing the concentrations of acrylic waste, especially between 1.0 wt% and 5.0 wt%, and evaluating the other physical and mechanical properties of dental plaster.

5. Conclusion

Based on the results of the present study, the following conclusions may be drawn,

- The initial and final setting times of the dental plaster decreased with an increase in the concentration of pulverized acrylic powder. However, the initial setting time of the modified groups, except for the 10.0 wt% group, was greater than that of the control group.
- The one-hour and 24-hour compressive strengths of the dental plaster increased and were directly proportional to the concentration of the pulverized acrylic powder.
- Poor surface details were obtained with an increase in the concentration of pulverized acrylic powder, except at 0.5 wt% incorporation.

Conflicts of interest: Authors declared no conflicts of interest.

Financial support: Part of this work was supported by Dr YSR University of Health Sciences, Vijayawada, Andhra Pradesh, India through Undergraduate Student Research Support (UGSRS) Scholarship.

References

1. Anusavice KJ. Phillip's Science of Dental Materials. 11th ed. Philadelphia; WB Saunders; 2003. p. 621-54.
2. Alla RK. Gypsum Products (in) Dental Materials Science. 1st Edition, Jaypee Brothers Medical Publishers, India. 235-247.
3. Firas Abd Kati, Ihab N. Yassin, Wael Abdul Razak, Effect of Adding some Additives and Drying Method on Compressive Strength of Gypsum Products. TJDS. 2017; 5(2):25-32.
4. Alla RK, Swamy KNR, Vyas R, Konakanchi A, Conventional and contemporary polymers for the fabrication of denture prosthesis: Part I: Overview of Composition, Chemistry and Properties. Int J Appl Dent Sci, 2015:1(4):82-9.
5. Gosavi SS, Gosavi SY, Alla RK. Local and systemic effects of unpolymerised monomers. *J. Dent. Res*. 2010;7(2):82.
6. Thopegowda NB, Shenoy K, Shankarnarayana RK, Kukkila J, Vaddya SB, Gingipalli K. Recycling of materials used in dentistry with reference to its economical and environmental aspects. Int J Health Rehabil Sci. 2013;2(3):140-5.
7. American Dental Association. Specification No. 25 for dental gypsum products. In: Certification program for dental materials. Chicago: American Dental Association 1990. p. 1-14.
8. Millstein PL. Determining the accuracy of gypsum casts made from type IV dental stone. J Oral Rehabil 1992;19(3):239-43. https://doi.org/10.1111/j.1365-2842.1992.tb01098.x
9. Elshereksi NW, Alshabah BL, Abouod NM, Albahloul RK. Physical properties of dental plaster filled with marble powder: a pilot study. Int J Dent Mater. 2022;4(2):32- 36. https://doi.org/10.37983/IJDM.2022.4202
10. Duke P, Moore BK, Haug SP, 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. https://doi.org/10.1016/S0022-3913(00)70043-6
11. Craig Pickett. Why Compressive Strength Is Important When Choosing a Dental Stone or Plaster. https://info.whipmix.com/why-compressive-strength-is-important-when-choosing-a-dental-stone-or-plaster accessed

on 02.11.2022.
12. Khan JA, Ginjupalli K, Upadhya NP, Bhat NB, Awatramaney T, Khan S, Ballal M. Development and Evaluation of Silver Nanosystem-based Novel Antimicrobial Dental Stone. World J Dent. 2022;13(2):105. https://doi.org/10.5005/jp-journals-10015-1914
13. Hatkar P. Preserving natural tooth structure with composite resin. J Cosmetic Dent. 2010;26(3):26-36.
14. Halawany HS. A review on miswak (Salvadora persica) and its effect on various aspects of oral health. Saudi Dental J. 2012;24(2):63-9. https://doi.org/10.1016/j.sdentj.2011.12.004
15. Amaral CM, Rodrigues JA, Erhardt M CG, Araujo MWB, Marchi GM, Heymann HO, et al. Effect of whitening dentifrice on the superficial roughness of esthetic restorative materials. J. Esthet. Restor. Dent. 2006;18(2):102-9. https://doi.org/10.2310/6130.2006.00017_1.x
16. Hamdy TM, Abdelnabi A, Abdelraouf RM. Reinforced dental plaster with low setting expansion and enhanced microhardness. Bulletin of the National Research Center. 2020;44(1):1-7. https://doi.org/10.1186/s42269-020-00334-8
17. Dulaimi, Fadhil S, Kanaan SM. The Effect of Microwave Oven Drying on the Compressive Strength of Type III and IV Dental Stones at Different Time Intervals. Open Dent J. 2018;12:494-500. https://doi.org/10.2174/1874210601812010494
18. Darvell BW. Gypsum Materials (in) Materials Science for Dentistry. 10th Edition. Woodhead Publishing Series in Biomaterials. 2018, Pages 40-69. https://doi.org/10.1016/B978-0-08-101035-8.50002-X
19. Vadapalli SB, Atluri K, Putcha MS, Kondreddi S, Kumar NS, Tadi DP. Evaluation of surface detail reproduction, dimensional stability and gypsum compatibility of monophase polyvinyl-siloxane and polyether elastomeric impression materials under dry and moist conditions. J. Int. Soc. Prev. 2016;6(4):302. https://doi.org/10.4103/2231-0762.186795
20. Petrie CS, Walker MP, O'mahony AM, Spencer P. Dimensional accuracy and surface detail reproduction of two hydrophilic vinyl polysiloxane impression materials tested under dry, moist, and wet conditions. J Prosthet Dent 2003;90(4):365-72. https://doi.org/10.1016/S0022-3913(03)00515-8

How to cite this article: Ponnapalli SV, Robbi K, Alla RK, Vasavi M, Medicharla U, Ramaraju AV, Sajjan MCS. Evaluation of physico-mechanical properties of dental plaster modified with pulverized acrylic waste. Int J Dent Mater. 2023;5(1):1-8. DOI:*http://dx.doi.org/10.37983/IJDM.2023.5101*