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RESEARCH ARTICLE - MEDICAL TECHNIQUES

Influence of Different Wax Hardening Agents on Surface Roughness of Refractory Cast Investment Materials

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Abstract

Background: Phosphate-bonded investments produce a refractory cast model with rough surface and undesirable properties. Dental Surface hardening agents are then applied to refractory investment materials to enhance its properties.
Purpose: compare and evaluate the effects of different dental cast hardening agents (Bees wax, Carnauba wax, and Ceresin wax) on surface roughness of refractory model investment material.
Approach: 30 specimens were constructed from commercially available phosphate bonded investment material. Specimens were subjected to a roughness test before dipping in handing agents, then divided into three groups according to the type of wax in which they were dipped. (10 specimens for each type). Surface roughness test was done by a profilometer where three readings were taken for all the specimens' surfaces randomly. The mean was then extracted for the roughness values before and after dipping in waxes.
Results: the mean and standard deviation were tabulated and statistically analyzed using students T- test. The roughness values were decreased after the specimens were dipped in waxes (P value < 0.001 HS highly significant).
Conclusion: The dipping process with hardening agents has significantly improved the surface roughness of the specimens' investment materials.

Keywords: Phosphate investment; Roughness; Bees Wax; Carnauba Wax; Ceresin Wax

1. Introduction

By duplicating the master cast, phosphate bonded investment materials are used to make refractory models for casting high melting temperature alloys like cobalt chromium [1]. Since this material is fragile and weak, it produces a duplicated master model with a roughened surface that making it difficult to maintain the refracts surface details [2]. To enhance surface properties and to obtain refractory models with a smoother and harder working surface, the refractory models are dipped in dental hardeners agents, which increase hardness and reduce the roughness of the refractory models [3]. During the dipping process, wax patterns were made suitable for adaptation on models by enhancing the adhesion and were also smoothened enough by sealing all pores present on the surface of refractory models [4]. Several types of wax that are harder than bees wax can be used as hardening agents in the dipping process, but Bees' wax is a common type used for the hardening treatment of investment materials; they are also natural but vary in origins, such as carnauba and ceresin wax. [5]. Bees wax is a natural animal wax with a melting point range of 62C° to 64C° formed in beehives. It is primarily composed of fatty acid esters, hydrocarbons, and various long chain alcohols, it has a variety of uses in medicine and dentistry such as casting process, coating pills for its antimicrobial properties [6]. Carnauba wax is the strongest natural plant wax, obtained from palm trees (Copernicia cerifera), and is almost entirely composed of esters and saturated long-chain alcohols. It is a non-toxic and stable product, as a result, it is used in the dental floss industry. Generally, it is found in the form of hard flakes with a pale-yellow appearance, and has a high melting point of 80-85C° [7]. Ceresin wax is the most example of natural waxes of mineral origin that refers to waxes derived from natural petroleum or lignite processing. It has a higher molecular weight and hardness, and a medium melting range of about 78 C° [8]. Surface roughness is an important parameter for evaluating a surface's suitability for a specific application. Roughness is a texture component that is measured by deviations in the direction of a real surface's position line from its ideal shape. The surface is rough if these deviations are high, if they are small, the surface is smooth [9].

Nomenclature			
LSD	Least significant difference	SE	Standard Error
HS	Highly significant	T-test	Student test
G	Gram	P-value	Probability values
ANOVA	Analysis of Variance	Symbol	
Cm	Centimeter	C°	Centigrade
Ml	Millimeter	µm	Micrometer
SD	Standard deviation	Ra	Roughness value

2. Materials and Methods

2.1. Mold preparation

A silicone mold, rectangular in shape was prepared by using a block of modeling wax (Renfert , Germany) with dimensions of 5x2x1cm (length, width, and thickness) followed by a duplication process of adding silicon material (Dublisil ,Germany) (Fig. 1). The mold was used for pouring (30 specimens) with phosphate bonded investment materials to achieve a roughness test by a Profilometer analyzing device [3] (Fig. 1).

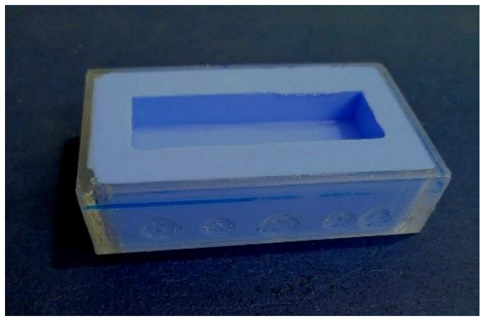

Fig. 1 Mold of roughness test

2.2. Mixing procedure

A (100g: 12ml) Powder- Liquid ratio of the phosphate bonded investment material (Hiro Vest CF30- Romain), was mixed according to the manufacturer's instructions. The mixture was then poured into the silicone mold using a vibrator device to prevent trapping of air bubbles, after 60 minutes the specimens were separated from the silicone molds [10,11]. Specimens were placed in a furnace at 220 C° for 20 minutes to ensure drying them and derive off moisture to get the dense surface. [12].

2.3. Surface roughness testing

Specimens were tested by using a profilometer which consists of the roughness measuring tool (stylus) [12]. In this stylus, a small conical diamond tip is touched and across the along surface of the specimen, while its deflection is recorded, the reading appears on the device's screen which represents the roughness value of the specimen in the micrometer unit (Ra in µm). [13]. Three randomly selected locations on the specimen surface was operated by a stylus to record the desired measurement of roughness values [14]. The total of three readings is calculated and represented by mean.

2.4. Dipping procedure

After recording the roughness values, the specimens were prepared for the wax-dipping process, this process includes melting the wax by wax pot thermostatic controlled device as instructed by manufacturers:

- Bees wax melts at a point range of 62- 64C°
- Carnauba wax melts at a point range of 80-85C°
- Ceresin wax melts at a point of 78C°

Each specimen is dipping into the liquid melted wax until the surface of it covered entirely to close all the pores on the surface. [15, 16].

2.5. Specimens grouping

Thirty specimens were divided into three groups according to the dipping in hardening wax agents as follows [17]:

- 10 specimens dipping in bees wax for 10-15 seconds
- 10 specimens dipping in carnauba wax for 10-15 seconds
- 10 specimens dipping in ceresin wax for 10-15 seconds

After the dipping process, all specimens were placed on paper one minute for drying and kept in a box at room temperature to carry out the same testing that we examined previously before dipping. [18, 19]. (Fig. 2).

Fig. 2 Specimens before and after dipping process

3. Results

3.1. Statistical analysis

3.1.1. Surface roughness test

Descriptive statistics are shown in table 1 for the surface roughness value test which included (minimum, maximum value, mean, SE and SD). The result of the Hiro Vest CF30 company group revealed that the highest mean value (2.4820) before dipping in Bess wax, while the lowest mean value (.7630) after dipping in Carnauba wax (Fig. 3).

Table 1 Summary statistics of surface roughness test

	N	Minimum	Maximum	Mean	SE	SD
Before dipping in Bess wax.	10	1.65	3.22	2.4820	.18503	.58513
After dipping in Bess wax.	10	0.60	1.37	.9290	.07499	.23713
Before dipping in Carnauba wax.	10	1.41	3.55	2.1510	.22755	.71959
After dipping in Carnauba wax.	10	0.34	1.65	.7630	.12776	.40401
Before dipping in Ceresin wax.	10	1.45	3.31	2.3270	.18429	.58279
After dipping in Ceresin wax.	10	0.67	1.85	1.2280	.11548	.36517

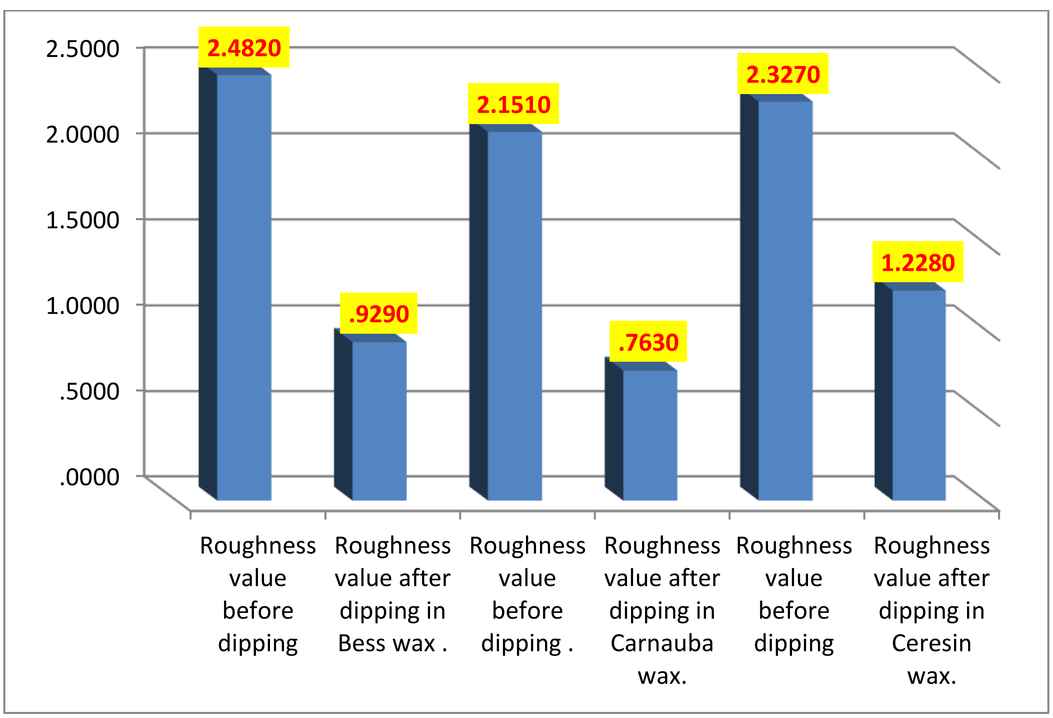

Fig. 3 Bar chart the mean value of Roughness test of specimens before and after dipping in waxes

In table 2, the results of T-test were recorded significant different $p< 0.05$ in surface roughness test before and after dipping in three different waxes.

Table 2 t-test between before and after dipping

	before and after dipping in Bess wax		before and after dipping Carnauba in wax		before and after dipping in Ceresin wax	
	t-test	p-value	t-test	p-value	t-test	P-value
Roughness Test.	9.568	0.005 S	9.623	0.0006 S	14.531	0.00019 S

The result of ANOVA (F-test) shows that High-significant difference among all tested groups as in table 3.

Table 3 F-test among tested groups

	After dipping in Bees wax.			After dipping in Carnauba wax.			After dipping in Ceresin wax.		
	F-test	P-value	Sig	F-test	P-value	Sig	F-test	P-value	Sig
Roughness Test.	1120.1	P<0.001	HS	2463.5	P<0.001	HS	1940.1	P<0.001	HS

*P<0.001 High significant.

Table (4) indicates LSD the Least Significant Difference for comparison between three different types of waxes. The results recorded non-significant difference among tested groups.

Table 4 LSD of value after dipping in waxes

		Mean Difference	**Std. Error**	**P-value**
Least S	**Bess wax.**	1.14199	1.20587	.352
	Carnauba wax.	.97599	.75962	.210
	Ceresin wax.	1.15099	.92624	.225

4. Discussion

The phosphate-bonded investment is brittle and thin material, resulting in a duplicated master model with a roughened surface and contains pores [1]. It's difficult to maintain the surface details of the refractory cast model when fabrication of wax patterns. [2].In this study all specimens prepare by phosphate-bonded investment were dipped in dental hardeners agents to improve surface properties and to obtain a better surface for working [3].The dental agents used in this study are mostly natural waxes, which are thermoplastic materials that melt into a liquid when heated [5].Usually, materials that contain pores on their surface when immersed in liquids, all its pores were filled with liquid and its surface was covered meaning another substance was added to it [20]. Thus, increasing its strength and making it smoother. For this reason, the rate of roughness decreased [10, 11]. This study revealed that specimens dipped in hardening agents have lower roughness values. The hardening wax is established to be effective on improving the roughness of cast investment materials. This result agrees with a previous study who concluded that the handing agents is effective on lowering and improving surface roughness of phosphate bonded –investment refractory cast. Also, with work of Saji et al., 2017 who used two commercially refractory materials and three dental hardeners agents (Paraffin wax, Bees wax, Okodur cold hardener) and found these hardening agents have an efficient on improving the surface hardness and surface abrasion resistance of refractory investment substances.

5. Conclusion

Based on the results and the values in this study, we concluded that natural hardening wax agents that contain natural elements should be added to improve its roughness and strength.

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