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Effect of Surfactant on Surface Hardness of Dental Stone and Investment Casts Produced from Polyvinyl Siloxane Duplicating Materials

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Abstract - *Polyvinylsiloxane duplicating materials are typically treated with a topical surfactant before pouring dental models, but the use of topical surfactants in the dental laboratory may affect the surface hardness of the resultant models. The effect of two different topical surfactants on surface hardness of two dental stones (FujiRock and Dentstone) and one phosphate bonded investment material (CroformWB) produced from polyvinyl siloxane (PVS) dental laboratory duplicating moulds was investigated. Topical surfactants affected the surface hardness of FujiRock, Dentstone and Croform WB investment material. Surface hardness of FujiRock increased with Wax-Mate surfactant. However, surface hardness of Croform WB investment material decreased with both topical surfactants.*

KEYWORDS: Laboratory techniques, Hardness, Dental stone, Dental investment material, Duplication.

INTRODUCTION

Polyvinyl siloxane (PVS) duplicating materials are increasingly being used in dental laboratories in place of agar for duplicating casts. PVS impression materials have now been used for 30 years and despite their accuracy, the production of void free models has been problematic. The impression materials are offered in a number of viscosities from low to putty like consistency[1], however, the duplicating materials have a very low viscosity and are designed for pouring. PVS materials are hydrophobic which may encourage formation of surface voids affecting the surface hardness and accuracy of the resultant cast. This relatively low wetting ability or "wettability" of these materials is considered a major disadvantage and has to be put against their excellent elastic properties and its dimensional stability[2].

Surfactants are surface agents, which lead to a reduction in the surface tension of a material[3]. The wettability of PVS impression materials has been shown to be reduced by surfactant agents without affecting their stability and accuracy[2]. The effects of surface energy alteration of impression materials has advantages in both the recording of the impression as well as in the production of any resultant gypsum based model[4]. Furthermore, topical surfactants have been shown to reduce the number of voids in the impression surface and the dental stone casts poured from them[5].

Surface hardness and accuracy are *sine qua non* for dental stone and investment casts, yet no studies have been reported on the effect of surfactants on the surface hardness of casts poured in laboratory duplicating materials in spite of the fact that surfactants are routinely used in conjunction with these materials. Likeman *et al*[6] reported that investment materials poured against PVS duplicating materials produced a greater surface hardness than those poured against agar duplicating gel and observed that one of the two investments they investigated showed greater surface irregularity and exposure of refractory particles on the surface when set in agar gel rather than polyvinyl siloxane. This difference was reflected in the fit-surfaces of cast cobalt chromium frameworks with the metal framework constructed from the PVS duplicating material producing a considerably smoother fit surface of the framework than produced from the agar gel.

The aim of this study therefore, was to determine any change in surface hardness of dental stone or investment material poured in PVS moulds after application of topical surfactant on the surface of PVS duplicating material.

The null hypothesis to be tested was that there was no difference in surface hardness of dental stone and investment materials when topical surfactants were applied to PVS duplicating materials.

MATERIALS AND METHODS

The principle materials used in this investigation are shown in Table 1. A cylindrical master model was made from acrylic resin rod 20mm in diameter and 35mm in length. It was placed on a plastic sheet and sealed centrally at the base of a casting ring former. PVS duplicating material was mixed according to the manufacturer's instructions and poured into the casting ring former to create nine moulds. Ten specimens were poured into each of the moulds for each model material/surface treatment combination giving a total of 90 specimens for testing.

The powder/water ratio of the two dental stones and the investment material recommended by the manufacturers

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Table 1. *Materials used in this study and manufacturers' details*

Product Name	*Manufacturer*
Model material	
1. GC FujiRock EP	GC Europe Interleuvenlaan, Leuven, Belgium.
2. Dentstone KD	BPB Formula, Newwarks, UK.
3. Croform WB Investment	Davis Schottlander Davis Ltd, Letchworth, UK.
Surfactant agent	
1. Tensilab	Zhermack, Rovigio, Italy.
2. Wax-Mate	Bracon Ltd, Etchingham, UK.
Duplicating material	
1. C&J Pourable Silicone	Chaperlin and Jacobs Ltd., Sutton, UK.

Table 2. *All pairwise multiple comparison procedure (Dunn's Method) for the three materials tested giving statistical significance of Brinell hardness number.*

	Diff of Ranks	*Q*	*P<0.05*
FujiRock			
No treatment vs Wax-Mate	15.350	3.899	Yes
Wax-Mate vs Tensilab	6.250	1.588	No
Tensilab vs no treatment	9.100	2.311	No
Dentstone			
No treatment vs Wax-Mate	2.0	0.508	No
Wax-Mate vs Tensilab	16.0	4.064	Yes
Tensilab vs no treatment	14.0	3.556	Yes
Croform WB			
No treatment vs Wax-Mate	12.15	3.086	Yes
Wax-Mate vs Tensilab	1.95	0.495	No
Tensilab vs no treatment	10.20	2.591	Yes

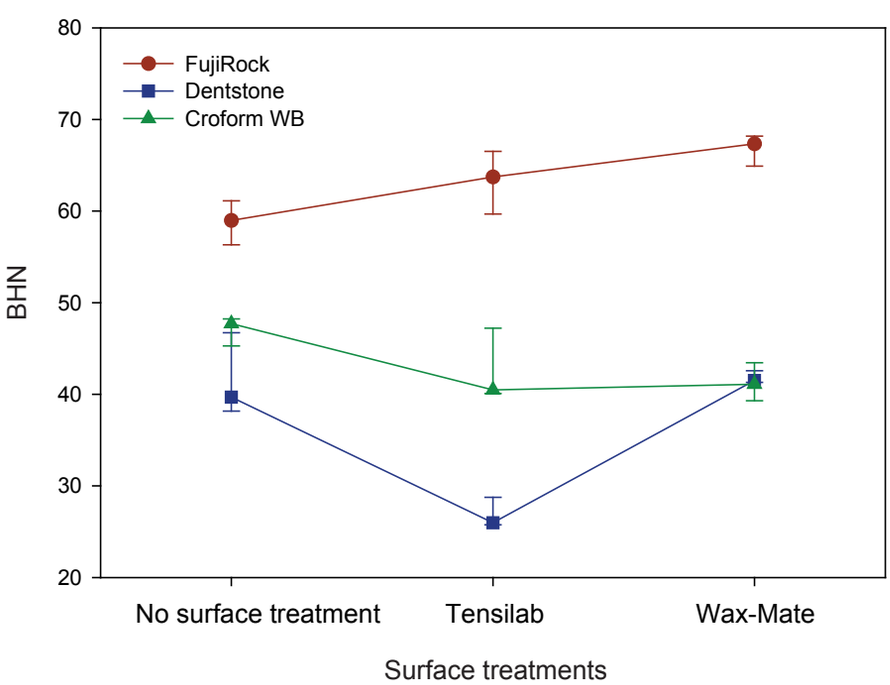

Figure 1 . *Scatter plot giving the median together with the 25th and 75th percentiles for the three different surface treatment material combinations.*

was carefully followed. Thirty specimens were poured with each material – ten without surfactant, ten using Tensilab and ten using Wax-Mate. The specimens were removed from the mould 1 hour after pouring, excess was removed and the surface that was exposed to the air while the specimens were setting, was smoothed with sand paper to produce a flat surface for the table of the hardness testing machine.

Brinell hardness tests were performed in an Instron 1193 Universal Testing Machine. A 5mm diameter hardened steel ball was forced into the surface of the specimen under a load of 150kg, which was maintained for 10 seconds. Five indentations were created for each specimen. The indentations were identified by drawing the side of a surveyor lead over the surface. A travelling microscope was used to measure the diameter of the indentations. Each indentation was measured in the x and y axes. A total of ten readings were recorded for each specimen and the mean value calculated. Brinell hardness number (BHN) was calculated from the formula:-

Constant × Test Force / Surface area of indentation

$0.102 \times 2F / \pi D (D-\sqrt{D^2 - d^2})$

Where:-

F = applied force in Newtons

D = diameter (in millimetres) of the indenter ball

d = mean diameter (in millimetres) of the indentation

Data was tested for normality and then Kruskal Wallis one way ANOVA was performed for each of the materials tested. Multiple comparison procedures were performed using Dunn's Test.

RESULTS

Results giving the median, 25 and 75 percentiles are shown in Fig 1. All pairwise multiple comparison procedures Table 2, (Dunn's method) confirmed the differences between treatment groups illustrated in Fig 1. FujiRock gave the highest BHN with the Wax-Mate treated surface > Tensilab treated surface >surface with no treatment. There was a statistically significant difference between the BHNs of the Wax-Mate treated surface and that with no treatment. Denstone gave the lowest BHNs with Tensilab surfactant but with Wax-Mate giving a higher value than with Tensilab. Wax-Mate treated surface > surface with no treatment > Tensilab treated surface. Croform WB investment gave significantly lower BHNs with both surfactant surface treatments.

DISCUSSION

Application of surfactant agents to the surface of PVS duplicating material moulds in this investigation had a statistically significant effect on the surface hardness of the model poured into the mould. The null hypothesis that there was no difference was therfore discounted. However, the effect of the surfactant agent varied with different model materials and between surfactant agents. FujiRock, a hard type IV dental stone, became harder with both surfactant agents used, possibly due to a reduction in the number of small voids in its surface. Dentstone, a type III hard dental stone, had a much less hard surface with Tensilab, which has a volatile alcohol base. When Wax-Mate, a water based product, was used the surface hardness of Dentstone was marginally harder than when no surfactant agent was used. This difference between the two surfactant agents is important as Dentstone and other type III dental stones are the work horses of the dental laboratory. The choice of surfactant agent could have a significant effect on the accuracy and durability of the resultant models. Both surfactant agents reduced the surface hardness of Croform WB investment material. However, previous work has shown that investments poured against PVS duplicating materials produced a harder surface than those poured against agar. This was particularly the case if the investment was mixed with the manufacturer's "special liquid" (Rema Exakt)[6]. In practice therefore, a value-judgement may need to be made between the slight loss of surface hardness and the possible benefit of a reduction in the number of small voids in the surface which might affect the surface of the resulting metal casting.

CONCLUSION

Application of surfactant agents to PVS laboratory duplicating materials may affect the surface hardness of resulting dental gypsum based and phosphate bonded models. Care must be taken in the laboratory to ensure a combination of surfactant type and dental stone do not interact to produce a model of reduced surface hardness.

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MANUFACTURER'S DETAILS

- FujiRock EP GC Europe Interleuvenlaan, Leuven, Belgium.
- Dentstone KD BPB Formula, Newarks, UK.
- Croform WB Investment Davis Schottlander Davis Ltd, Letchworth, UK.
- Tensilab Zhermack, Rovigio, Italy.
- C&J Pourable Silicone Chaperlin and Jacobs Ltd., Sutton, UK.
- Wax-Mate Bracon Ltd, Etchingham, UK.
- Instron 1193 universal testing machine Instron, High Wycombe, UK.
- Travelling microscope Graticules Ltd, Tonbridge, UK.

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