Research Article

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Effect of Surfactant on Surface Hardness of Dental Stone and Investment Cast Produced from Polyvinyl Siloxane Duplicating Materials: An In Vitro Study

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ABSTRACT

Background: A serious problem with the use of PVS material is their low surface energy which renders them difficult to wet with gypsum slurries. Laboratory applied surfactants as well as so called hydrophilic elastomers, are effective in reducing the hydrophobic nature of elastomers and increase the probability of obtaining a void free gypsum cast. With the above background the present study was aimed to investigate the changes in the surface hardness of a dental stone and an investment material poured in polyvinylsiloxane moulds following the application of 3 brands of commercially available topical surfactants.

Material and methods: A cylindrical master model was made from an acrylic resin rod 20mm in diameter and 35mm in length. It was placed on a plastic sheet and seated centrally at the base of a casting ring former to create moulds. PVS duplicating material, Ecosil (Dentaurum) was mixed according to the manufacturer's instructions and poured into the casting ring former to create eight moulds. Fifteen specimens were poured into each of the moulds for each model material/ surface treatment combination, yielding a total of 120 specimens for testing. Brinell hardness test was performed using a universal testing machine and the results were compared using one way ANOVA and Post-hoc Tukey's test.

Results: Within the group 1, the surfactant Aurofilm (Bego) greatly increased the surface hardness of dental stone (BHN-69.2)when compared to the control group. The surfactants Debubblizer (Prime dental) and Waxit (Dentsply) increased the surface hardness of dental stone to a certain extent when compared to the control group. In group 2 Aurofilm greatly increased the surface hardness of investment material (BHN-90) when compared to the control group while the surfactants Debubblizer and Waxit decreased the surface hardness of investment material when compared to the control group.

Conclusion: The surfactant Aurofilm was found compatible with both PVS duplicating material (Dentaurum)-dental stone (Kalrock) and PVS duplicating material (Dentaurum)- investment material (Bellavest-T) combinations. The surfactants Debubblizer and Waxit were found incompatible with investment material while in dental stone group both the surfactants were found compatible without significantly increasing the surface hardness.

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Keywords: Polyvinyl siloxane (PVS) duplicating material, surfactants, dental stone, investment material.

INTRODUCTION

An accurate void free impression is an integral part of predictable fixed prosthodontics. The wettability of dentine surfaces by impression materials depends on the hydrophilicity and viscosity of the material. Additional factors in detail reproduction include the rheological characteristics of the impression material, rate of setting and other handling charecterstics of the impression materials.[1]

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 voids free models has been problematic. The impression materials are offered in a number of viscosities from low to putty like consistency, 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 resultant cast.[2]

Surfactant applied to an impression may reduce the number of voids in resultant cast or die. A topical surfactant had been developed for clinical use (Hydrosystem, Zhermack). This was a modified polymethyl siloxane wetting agent that can be sprayed onto prepared tooth surfaces before impression recording. An in vitro study revealed a significant reduction in the number of surface defects in impression materials and in dies from the impressions when this surfactant was used.[3]

Recent works has shown that many chemical and physical methods are effective for increasing the surface energy of elastomeric impression materials, including the application of surfactants and glow-discharge treatment. Many authors have investigated the effects of surfactant modification on dental elastomers. Due to altered surface energy, surfactant modified VPS spreads more easily on a moist dentine surface.[4]

MATERIALS AND METHOD

This study was performed to investigate the change in surface hardness of a dental stone and an investment material poured in polyvinyl siloxane moulds following the application of 3 commercially available topical surfactants.

a. Preparation of cylindrical master model and casting ring:

A precisely machined steel cylindrical master model was made 20mm in diameter and 35mm in length for the fabrication of PVS moulds. A precisely machined casting ring former 40 mm in diameter was made and the master model was mounted centrally on a plastic sheet. A shallow circular groove was given on the plastic sheet for the orientation of casting ring former . A slight amount of petroleum jelly was applied on the plastic sheet for the easy removal of PVS moulds.

b. Preparation of PVS duplicating material moulds:

PVS duplicating material was kept at room temperature according to the manufacturer's instruction. PVS duplicating material was mixed according to the manufacturer's instructions i.e. 1:1 base and catalyst ratio and poured into the casting ring former to create the eight moulds. These moulds were divided into group I and group II. Group I included dental stone group and group II included the investment group.

c. Preparation of Dental stone models with the application of 3 commercially available surfactants.

Dental stone was mixed according to the manufacturer's instruction and a total of 60 specimens were poured into the PVS moulds. Specimens were divided into four subgroups i.e. A, B, C and D, each group containing 15 specimens. Sixty specimens were poured with each material- fifteen without surfactant (group A), fifteen using Aurofilm (group B), fifteen using Debubblizer (group C) and fifteen using Waxit (group D). The specimens were removed from the mould one hour after pouring, excess was removed and the surface that was exposed to air while the specimens were setting, was smoothened with sandpaper to produce a flat surface for the table of the hardness testing machine.

GROUP A	Without surfactant
GROUP B	With surfactant- Aurofilm(Bego)

GROUP C With surfactant – Debubblizer(Prime Dental)
GROUP D With surfactant – Waxit(Dentsply)

Group 1:

d. Preparation of investment material models with the application of 3 commercially available surfactants: An investment material (Bellavest-T) was mixed according to the manufacturer's instruction and a total of 60 specimens were poured into the PVS moulds. Specimens were divided into four subgroups i.e. A, B, C and D, each group containing 15 specimens. Sixty specimens were poured with each material- fifteen without surfactant (group A), fifteen using Aurofilm (group B), fifteen using Debubblizer (group C) and fifteen using Waxit (group D).

The specimens were removed from the mould one hour after pouring, excess was removed and the surface that was exposed to air while the specimens were setting was smoothened with sandpaper to produce a flat surface for the table of the hardness testing machine.

Group 2:

GROUP A Without surfactant
GROUP B With surfactant- Aurofilm(Bego)
GROUP C With surfactant – Debubblizer(Prime Dental)
GROUP D With surfactant – Waxit(Dentsply)

e.Calculation of BHN number of dental stone and investment material models using travelling microscope:

Each specimen was tested for surface hardness using Brinell hardness tester at 24 hrs. from the time of mixing of a Dental stone and an investment material. A 5mm diameter hardened steel ball was forced into the flat surface of the specimen under a load of 150Kg, which was maintained for 10 seconds. Indentation was identified by drawing the side of a surveyor lead over the surface. A travelling microscope was used to measure the diameter of the indentation. 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. All measurements were executed by a single operator and the readings were tabulated and used for the statistical analysis.

BHN was calculated from the formula :

$0.102 \times 2\ F / \pi D\ (D-\sqrt{D2 - d2})$
F = force in Newtons (N)
D = diameter in millimeters of indenter ball
d = mean diameter

RESULTS

This study was performed to investigate the change in surface hardness of a dental stone and an investment material poured in polyvinyl siloxane moulds following the application of 3 commercially available topical surfactants. One twenty specimens of dental stone and investment material were fabricated. These specimens were divided into group 1 and group 2. In group 1 sixty specimens of dental stone were poured following the application of 3 commercially available surfactants. In group 2 sixty specimens of investment material were poured following the application of 3 commercially available surfactants. surface hardness of Final specimens were checked for BHN number.

Group1: BHN numbers for dental stone.
Group 2: BHN numbers for investment material.

Table 1:

The mean BHN numbers of the tested dental stone specimens are displayed in table 1. The maximum BHN number was noted for subgroup B.

Table 2:

Table 2 depicts mean difference of BHN numbers of dental stone subgroups (group B, group C and group D) with control group (group A). The maximum mean difference was found in group B.

Table 3:

The mean BHN numbers of the tested investment material specimens are displayed in table 3. The maximum BHN number was noted for subgroup B.

Table 4:

Table 4 depicts mean difference of BHN numbers of investment material subgroups (group

Table 1: Dental stone group - BHN values.

Groups	Mean	SD
Group A (Control)	58.1	2.5
Group B	69.2	5.2
Group C	62.2	7.0
Group D	59.4	5.5

Table 2: Mean difference with control (group 1).

Groups	Mean	SD
Group B	-11.1	5.6
Group C	-4.1	7.4
Group D	-1.3	6.9

Table 3: Investment Group - BHN Values.

Groups	Mean	SD
Group A (Control)	78.1	10.6
Group B	90.6	6.2
Group C	67.0	3.7
Group D	76.6	5.7

Table 4: Mean difference with control (group 2)

Groups	Mean	SD
Group B	-12.43	13.10
Group C	11.12	11.75
Group D	1.52	12.32

Table 5: Intragroup Comparison (Dental Stone – BHN Values)

Groups	Mean	P value, Sig	Comparison with control
Group A (Control)	58.1	P<0.001 HS	-
Group B	69.2		11.1 S
Group C	62.2		4.1 NS
Group D	59.4		1.3 NS
Repeated measures ANOVA test			
Tukey's post hoc test			

Table 6: Multiple comparison among sub groups (group 1).

Groups	Mean	P valu, Sig	Group A (Contro)	Group B	Group C	Group D
Group A (Control)	58.1	P<0.001 HS	-	11.1 S	4.1 NS	1.3 NS
Group B	69.2		-	-	6.9 S	9.8 S
Group C	62.2		-	-	-	2.8 NS
Group D	59.4		-	-	-	-

Table 7: Intragroup Comparison- Investment- BHN Values.

Groups	Mean	P value, Sig	Comparison with control
Group A (Control)	78.1	P<0.001 HS	-
Group B	90.6		12.4 S
Group C	67.0		11.1 S
Group D	76.6		1.5 NS
Repeated measures ANOVA test			kk
Tukey's post hoc test			jnk

Table 8: Multiple comparison among sub groups (groups 2).

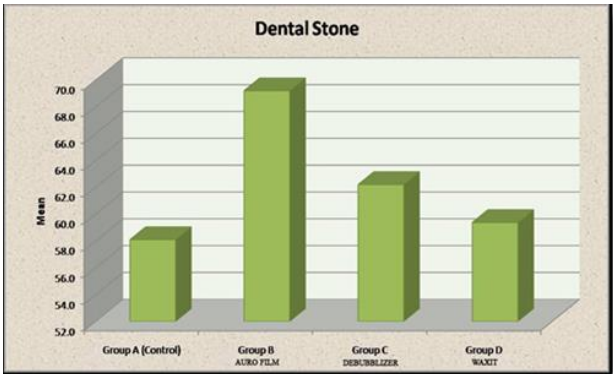
Groups	Mean	P value, Sig	Group A (Control)	Group B	Group C	Group D
Group A (Control)	78.1	P<0.001 HS	-	12.4 S	11.1S	1.5 NS
Group B	90.6		-	-	23.5 S	13.9 S
Group C	67.0		-	-	-	9.6S
Group D	76.6		-	-	-	-

Table 9: Intergroup comparison (between group 1 and group 2).

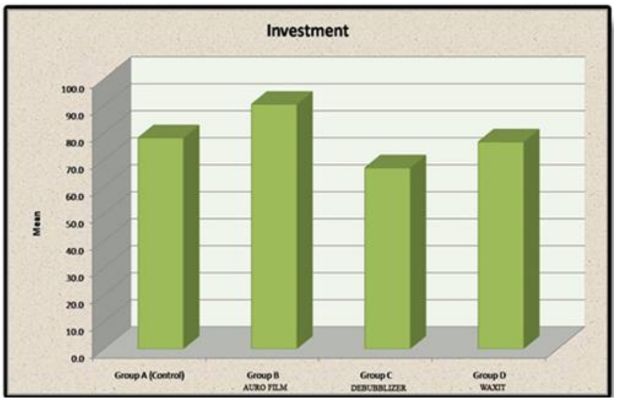
Groups	Dental Stone	Investment	Mean difference	P value , Sig
Group A (Control)	58.1	78.1	20.0	P<0.001 HS
Group B	69.2	90.6	21.4	P<0.001 HS
Group C	62.2	67.0	4.8	P<0.05 S
Group D	59.4	76.6	17.2	P<0.001 HS
Students unpaired test				

Table 10: Mean difference of bhn values of different sub groups with control.

Groups	Dental Stone	Investment	Mean difference	P value, Sig
Group B	-11.1	-12.4	-1.3	P>0.05 NS
Group C	-4.1	11.1	15.2	P<0.001 HS
Group D	-1.3	1.5	2.8	P>0.05 NS
Students unpaired test				



Graph 1: Dental stone group 1.

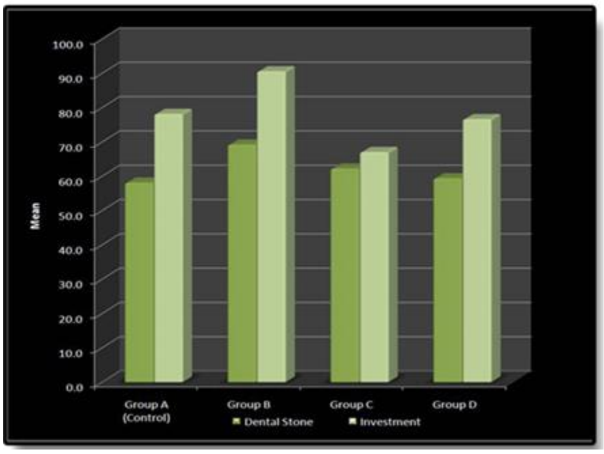


Graph 2: Investment material group 2.

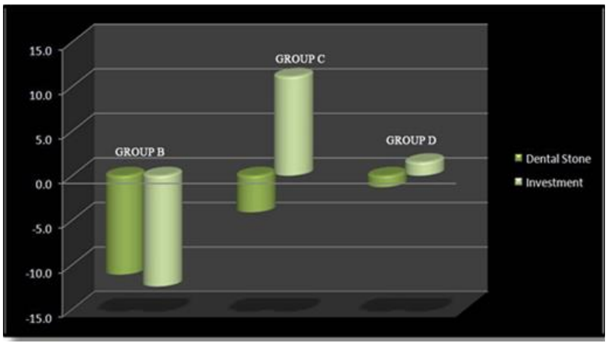
B, group C and group D) with control group (group A). The maximum mean difference was found in group B.

Table 5:

Table 5 depicts the intragroup comparison (with control group) of BHN values in group 1 (dental stone). Group B that had been treated with



Graph 3: Comparision of sub groups of group 1 and group 2.



Graph 4: Mean difference of sub groups of group q and group 2 with control.

surfactant aurofilm showed significant value. One way ANOVA was used to determine significant difference between surface hardness of dental stone of different subgroups after the application of 3 commercially available surfactants and Post-hoc Tukey's test for groupwise comparison. ANOVA revealed P‹ 0.001 and hence was statistically significant.

Table 6:

Table 6 depicts multiple comparison of BHN values of subgroups A, B , C and D in group 1. The comparison between group A and group B, group A and group C, group B and group C, group B and group D was found statistically significant. The statistical analysis showed P‹ 0.001 which was highly significant.

Table 7:

Table 7 depicts the intragroup comparison (with control group) of BHN values in group 2 (investment group). Group B that had been treated with surfactant aurofilm and the group C that had been treated with surfactant debubblizer showed significant value. One way ANOVA was used to determine significant difference between surface hardness of investment material of different subgroups after the application of 3 commercially available surfactants and Post-hoc Tukey's test allowed for group wise comparison. ANOVA revealed P‹ 0.001 and hence was statistically significant.

Table 8:

Table 8depicts multiple comparison of BHN values of subgroups A, B , C and D in group 2. The comparison between group A and group B, group A and group C, group B and group C, group B and group D, group C and group D was found statistically significant. The statistical analysis showed P‹ 0.001 which was highly significant.

Table 9:

Comparison of BHN values of group 1 and group 2 are displayed in table 9. Student's unpaired test was used for inter group comparison and the P‹0.001 was highly significant for group A, B and D.

Table 10:

Table 10 depicts comparison of mean BHN values of group 1 and group 2 with control group. The student unpaired test was used to compare the mean BHN values of group1 and group 2 with control group and the P-value was found highly significant only in group C.

Graph 1:

Graph 1 showed the mean BHN values of subgroups of group 1 (dental stone). Group B showed the maximum BHN value for group B.

Graph 2:

Graph 2 showed the mean BHN values of subgroups of group 1 (investment group). Group B showed the maximum BHN value for group B.

Graph 3:

Graph 3 showed the comparison of mean BHN values of subgroups of group1 and group 2. The graph revealed that maximum increase in surface hardness was found in group B. The manufacturer supplied surfactant Aurofilm was found to maximally increase the surface hardness of both dental stone and investment material.

Graph 4:

Graph 4 depicts the comparison of mean BHN values of different subgroups of group 1 and group 2 with the control group. The graph revealed that decrease in surface hardness was found in subgroups C and D of group 2 (investment material).

Statistical methods applied:

Following statistical methods were applied in the present study.

1. Analysis of variance one way
2. Post Hoc tukey's multiple comparison tests.

DISCUSSION

The fit and ultimate success of a cast dental restoration is dependent upon the accuracy and completeness of the die reproduction. Polyvinyl siloxane impression materials have been found to be the most stable impression materials. A serious problem with the use of silicone elastomeric impression materials is that their low surface energy renders them difficult to wet with gypsum slurries. This poor wetting leads to air entrapment at the surface of cast and dies. The detail reproduction potential of a material is influenced by several factors, such as wettability, viscosity, and compatibility with gypsum. Surfactant applied to an impression may reduce the number of voids in such dies.[5]

In the present study, change in surface hardness of a dental stone and an investment material poured in polyvinyl siloxane moulds was investigated following the application of 3 commercially available surfactants. The change in the surface hardness of an investment material and a dental stone were compared following the application of 3 commercially available surfactants. In the group 1 (dental stone) application of all 3 surfactants increased the surface hardness of stone when compared with the control group (P‹0.001)[Table 5, Graph 1]. In the group 2 (investment material) increase in surface hardness was observed only in subgroup B that was treated with the surfactant Aurofilm (BHN- 90) while both the subgroup C and subgroup D showed decrease in surface hardness (Table 7, graph 2). The results of this study compared favourably with those reported by Tredwin.CJ et al.[5]

All pair wise multiple comparison procedures table 6 (Tukey's Post hoc test) confirmed the differences between treatment subgroups of group 1. Dental stone (Kalrock) gave the highest BHN with the Aurofilm treated surface (BHN-69.2) > debubblizer treated surface (BHN-62.2) > Waxit treated surface (BHN-59.4) > surface with no treatment (BHN-58.1). These results compare favorably with those reported by Al-johani et al.2

All pair wise multiple comparison procedures Table 6, Graph 3 (Tukey's Post hoc test) confirmed the differences between treatment subgroups of group 2. Investment material (Bellavest-T) gave the highest BHN number with the Aurofilm treated surface (BHN-90.6) > surface with no treatment (BHN-78.1) > Waxit treated surface (BHN-76.6) > Debubblizer treated surface (BHN-67).

Milward.PJ et al[6] evaluated the effect of disinfection procedures and the use of a surface wetting agent on the wettability of 4 addition-polymerized silicon impression materials. They recommended disinfection with Actichlor in preference to perform to maintain the wettability of impression materials. Treatment with Vacufilm (surfactant) after disinfection is recommended to improve the wettability of materials.

Millar BJ et al[7] investigated that hydrosystem surfactant appeared to be particularly effective in reducing the number of surface voids when it is used with Elite polyvinyl siloxane impression material for which it is designed for use. Perhaps less surprisingly, no benefit was found when hydrosystem was used with polyether and polysulfide materials. The variation in the number of surface voids for the materials may be explained by the different flow properties of the materials.[8] The surfactant Aurofilm was found compatible with both dental stone and investment material when poured in PVS duplicating material and increase in the surface hardness was observed in both groups (Graph-3) The surfactants Debubblizer and Waxit were found compatible to the dental stone group to a certain extent, while both were found incompatible with the investment group(Graph-4).

CONCLUSION

This study investigated the change in surface hardness of a dental stone (Kalrock) and an investment material (Bellvest-T) poured in polyvinyl siloxane (Dentaurum) moulds following the application of 3 commercially available surfactants (Aurofilm, Debubblizer and Waxit).

1. Among the group 1(Dental stone), subgroup B had significant value that is application of surfactant (Aurofilm) increased the surface hardness of dental stone when compared to the control group.

2. Among the group 2 (investment group), subgroup B and subgroup C had significant value that is application of surfactant (Aurofilm) increased the surface hardness of investment material and application of surfactant (Debubblizer) decreased the surface hardness of investment material when compared to the control group.

3. When intergroup comparison was done, application of Aurofilm surfactant greatly increased the surface hardness of investment material and dental stone. Application of Debubblizer surfactant slightly increased the surface hardness of dental stone while it decreased the surface hardness of investment material. Application of Waxit surfactant greatly decreased the surface hardness of investment material while little effect on the surface hardness of dental stone.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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