Saudi Journal of Oral and Dental Research (SJODR) **ISSN 2518-1300 (Print)**
Scholars Middle East Publishers **ISSN 2518-1297 (Online)**
Dubai, United Arab Emirates
Website: http://scholarsmepub.com/

Effects of Three Commercially Available Brands of Topical Surfactants on the Surface Hardness of Investment Cast Produced From Polyvinyl Siloxane Duplicating Material - An In Vitro Study

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Original Research Article

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Article History
Received: 01.12.2018
Accepted: 04.12.2018
Published: 30.12.2018

DOI:
10.21276/sjodr.2018.3.12.3

Abstract: PVS (Polyvinyl siloxane) materials are hydrophobic which may encourage formation of surface voids affecting the surface hardness and accuracy of resultant cast. The wettability of dentine surfaces by impression materials depends on the hydrophilicity and viscosity of the material. Surfactant applied to an impression may reduce the number of voids in resultant cast or die. With the above background the present study was aimed to investigate the changes in the surface hardness of an investment material poured in polyvinylsiloxane moulds following the application of three brands of commercially available topical surfactants. 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. PVS duplicating material, Ecosil (Dentaurum) was mixed according to the manufacturer's instructions and poured into the casting ring former to create four moulds. Fifteen specimens were poured into each of the moulds for each model material/ surface treatment combination, yielding a total of 60 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. 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. The surfactant Aurofilm was found compatible with both PVS duplicating material (Dentaurum) and investment material (Bellavest-T). The surfactants Debubblizer and Waxit were found incompatible with investment material.

Keywords: Polyvinyl Siloxane duplicating material (PVS), Surfactants, 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. 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].

Surfactants are surface agents, which lead to reduction in the surface tension of a material. The wettability of PVS impression materials has been shown to be reduced by surfactant agents without affecting their stability and accuracy [3]. Surfactant applied to an impression may reduce the number of voids in resultant cast or die.

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 [4].

METHODOLOGY

This study was performed to investigate the change in surface hardness of an investment cast poured

in polyvinyl siloxane moulds following the application of 3 commercially available topical surfactants.

METHODOLOGY

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.

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 1.

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 1:

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

Calculation of BHN number of 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 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:

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

F = force in Newtons (N)
D = diameter in millimeters of indenter ball
d = mean diameter

Standardization involved in the study:

- All the specimens were obtained by a metallic cylindrical master model 20mm in diameter and 35mm in length which was placed centrally at the base of a casting ring former 40mm in diameter. Metallic cylindrical master model and casting ring former were mechanically machined from private engineering works.
- Base and catalyst ratio for PVS duplicating material was fixed i.e. 1:1 for each mould.
- A 5mm diameter hardened steel ball which was used for BHN testing and a load of 150 Kg which was maintained for 10 seconds in BHN tester was constant for each specimen.

RESULTS

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

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.

Table 1:

The mean BHN numbers of the tested investment material 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 investment material subgroups (group B,

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

Table 3:

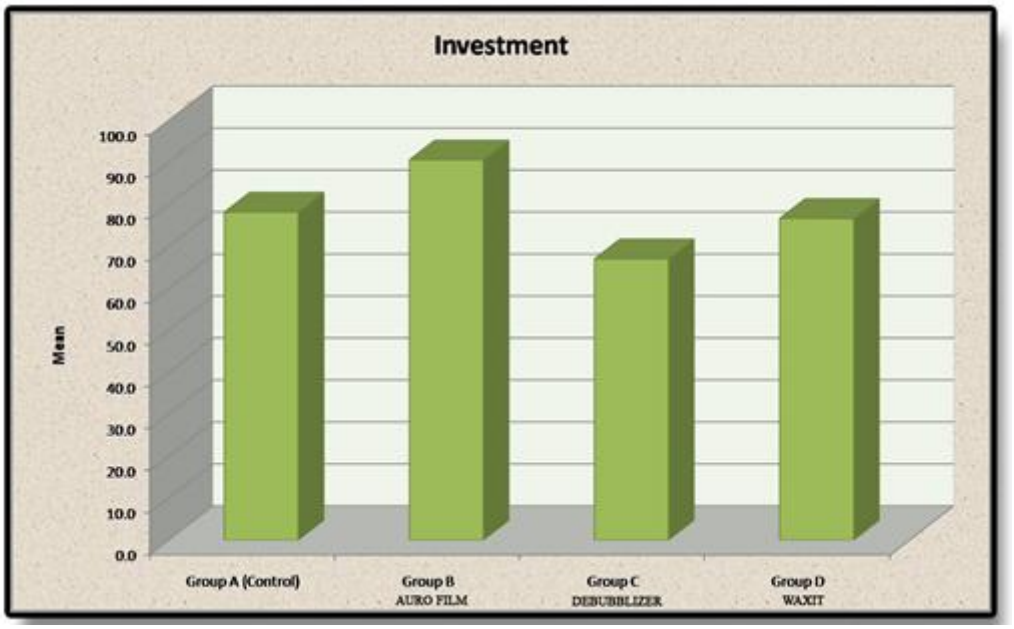
Table 3 depicts the intragroup comparison (with control group) of BHN values in group 1 (investment group). Group B that had been treated with surfactant aurofilm and the group C that had been treated with surfactant debubblizer showed significant value. One way ANOVA was used to determine significant difference between surface hardness of investment material of different subgroups after the application of 3 commercially available surfactants. Post-hoc Tukey's test allowed for groupwise comparison. ANOVA revealed P< 0.001 and hence was statistically significant.

Table 4:

Table 4 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, group C and group D was found statistically significant. The statistical analysis showed P<0.001 which was highly significant.

Graph 1:

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



Graph-1: Investment Material Group

Table-1: 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-2: Mean Difference with Control Group

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

Table-3: Intragroup Comparison

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

Table-4: Multiple Comparison among Sub Groups

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

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. Two phosphate bonded investment materials that were poured into moulds of a duplicating gel and a polyvinyl siloxane duplicating medium were examined for surface hardness. Investments samples cast in polyvinyl siloxane had greater surface hardness than those prepared using the gel-based medium. Peyton and Craig recognized the incompatibility of the investment and the duplicating medium in terms of the roughness and softening of the surface of the cast, although certain investments had been shown to be more susceptible than other to the effect of different duplicating media [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. In the group1 (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 (Graph-1). The results of this study compared favorably with those reported by Tredwin CJ *et al.*, [6].

All pair wise multiple comparison procedures (Tukey's Post hoc test) confirmed the differences between treatment subgroups of group 1. 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).

In a study conducted by Al-johani *et al*., when the surface of Croform WB investment was treated with the surfactants Tensilab and Wax-mate, significant lower BHNs values were observed. However, previous work has shown that investment 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. 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.

Milward PJ *et al*., evaluated the effect of disinfection procedures and the use of a surface wetting agent on the wettability of 4 addition-polymerized silicon impression materials [7]. 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*., 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 [8]. 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 [9]. In this study, as the manufactures of the PVS duplicating material (Dentaurum) did not recommend their own surfactant, the wettability of the PVS duplicating material with investment material varied among the different brands of the commercially available surfactants. The surfactant Aurofilm was found compatible with investment material when poured in PVS duplicating material and increased in the surface hardness. The surfactants Debubblizer and Waxit both were found incompatible with the investment group.

CONCLUSION

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

Among the group 1 (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.

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