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ORIGINAL ARTICLE

The Effect of Manipulation with Different Types of Gloves on Various Mechanical properties and Setting Time of Putty-Type Silicone Impression Materials

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ABSTRACT

Aim: To evaluate the effects of handling with different type of gloves on the setting time, compressive and tensile strength of putty-type silicone impression materials.

Methodology: The study was conducted at COMSATS Lahore and was approved by IRB FMH College of Medicine and Dentistry**.** In this in-vitro study three different type of gloves (Polythene, Latex and Vinyl) and two different brands each of addition silicone (Flexceed and Elite P&P) and condensation silicone (Zetaplus and Cavex) impression materials were used. These materials were divided into four different groups (A, B, C and D). Each group was subdivided into four sub-groups based on the gloves used for manipulation. Sixty samples(n=20) of two brands each of addition (Elite P&PA, Flexceed B) and condensation silicones (Zetaplus C and Cavex D) were prepared and analyzed to evaluate the setting time, compressive strength and tensile strength of addition and condensation impression materials. The samples were subdivided into groups A_1, B_1, C_1, D_1 (Control), A_2, B_2, C_2, D_2 (Polythene gloves), A_3, B_3, C_3,D_3 (Vinyl gloves) and A_4, B4, C_4, D4(Latex) respectively.

Results: There was a significant effect($p<0.5$) on the setting time of Elite P &P when mixed with latex gloves(A_4) and Flexceed when mixed with polythene(B_2) and latex gloves(B_4) There was significant ($p<0.5$) effect on the setting time of Zetaplus when mixed with vinyl(C_3) and latex gloves(C_4). There was significant ($p<0.5$) effect on the setting time of Cavex when mixed with polythene(D_2), vinyl(D_3) and latex gloves(D_4). There was a significant ($p<0.5$) effect on the tensile strength of both brand of addition and condensation silicone when mixed with polythene, vinyl and latex gloves as compared to control group. There was significant effect on the compressive strength of both brand of addition and condensation silicone except that polythene gloves don't affect the compressive strength of one group of addition silicon B_2(Flexceed)

Practical implications: Dental silicone type of impression materials are widely used to fabricate different indirect restorations. Gloves are essential to control cross infection for the safety of the dentist and the patients and cannot be avoided for manipulation of these materials. Worldwide, dentists use different types of gloves to manipulate silicone impression materials. The composition and type of gloves affect the setting time and properties of addition and condensation silicones, and ultimately, it can affect and compromise the clinical outcome too.

Conclusion: Latex and polythene gloves should be avoided for the manipulation of addition and condensation silicones putty impression materials due to considerable effect on the setting time. Vinyl gloves are a better choice as all others affected the mechanical properties.

Keywords: Addition silicones, Condensation silicones, tensile strength, compressive strength, setting time

INTRODUCTION

Silicone impression materials are the most commonly used impression materials in dentistry[1].These are synthetic polymers that are set by chemical cross-linking. These materials are flexible and rapidly recover to their original dimensions[2].Polysulfide impression materials cause staining of clothes and are messy to work with. Polyether impression materials have a long setting time and are expensive. Silicone impression materials have been famous during the past decade as they have excellent properties when compared with polysulfides and polyether impression materials. These have high tear strength, good dimensional stability and can be electroplated[3].

Silicone impression materials set by polymerization reaction in which polymer chains grow simultaneously and a reaction by-product might form or not[4.] These materials are classified as addition and condensation silicone and are available in four consistencies putty, heavy-bodied, medium-bodied and light-bodied. Putty-type impression materials are widely used in dentistry to take an impression for crowns, bridges, inlays, onlays and cast partial dentures[5,6]. The shortcoming of these materials, particularly addition silicone is their reaction with sulfur-based compounds present in latex gloves[7].

Infection prevention is an important aspect of dental treatment[8]. Dental professionals are exposed to a wide range of microorganisms because they have to deal directly with saliva and blood[9]. Latex gloves are the most common protective measure used during different dental procedures[10]. Dental gloves are usually made up of latex, polythene, vinyl and nitrile compounds[11]. All putty type of impression materials are mixed manually and can be mixed without gloves but due to fear of cross infection and allergies some type of gloves need to be worn. Direct or indirect contact with latex gloves causes the risk of polymerization inhibition, particularly while mixing of polyvinylsiloxane impression materials. It is usually due to the contamination of platinum catalyst by Sulphur compounds present in latex gloves[12].

Baumann et al. reported that even in concentrations as low as 0.005%, inhibition of polymerization of polyvinyl-siloxane can be observed. Latex inhibited the polymerization in almost all cases when in direct contact with addition-type silicones. Forty percent of the latex gloves tested also inhibited polymerization upon indirect contact. Sulfur compounds residue can remain on a previously gloved hand, and therefore washing latex gloves or washing hands after using gloves is not recommended[13]. This study includes the real time check on multiple parameters that is setting time, tensile and compressive strength of two different types of addition and condensation silicones and three different types of gloves were tested in a single study.

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MATERIALS AND METHOD

The in vitro study was conducted in COMSATS Lahore and approved by IRB FMH College of Medicine and Dentistry (IRB# FMH-10-2017-IRB-324-M, Date: January 23, 2023). In this study three different type of gloves (Polythene, Latex and Vinyl) and two different brands of addition silicone (Flexceed and Elite P&P) and condensation silicone (Zetaplus and Cavex) were used. These materials were divided into four different groups (A, B, C and D).

Each group was subdivided into four sub-groups based on the gloves used for manipulation, as shown in Table 1.

Table 1: Materials divided into groups according to the gloves used for the manipulation.

Material name	Without gloves	Polythene gloves	Vinyl gloves	Latex gloves
Addition silicone A	A_1	A_2	A_3	A_4
Addition silicone B	B_1	B_2	B_3	B_4
Condition Silicone C	C_1	C_2	C_3	C_4
Condition silicone D	D_1	D_2	D_3	D_4

In the control group the putty impression materials (base and catalyst) were kneaded with clean dry hands till a homogenous mix was obtained as recommended by the respective manufacturer. The materials were then mixed by wearing each of the three different types of gloves (polythene, vinyl, latex).

Setting time: Each type of putty impression material was then mixed with gloved hands (polythene, vinyl, latex) and the setting time was measured. The materials after mixing were packed into cylindrical Teflon moulds having 5cm diameter and 5mm in thickness. Twenty samples (n=5) for each material were prepared. The setting time was periodically measured using Gilmore needle (10mm diameter, 5 cm long and 300gm in weight) at 10 seconds time intervals with a uniform force applied. The setting time is measured from the time of mixing till the time that the needle does not produce any indentation on the surface of material[14].Two types of addition and condensation silicones were tested with control group and three types of gloves.

Compressive strength: Samples were made with a Teflon mould dimensions (28.5mm diameter, 13mm thickness)[15]. Twenty samples (n=5) for each material were prepared. These were then subjected to testing for compressive strength value using the Universal testing machine (Instron: 3382A series, USA Massachusetts) equipped with 50 KN load (Figure 1, 2).

Figure 1: Specimens for compressive strength of putty type silicones

Figure 2: Measurement of compressive strength by Universal testing machine.

Tensile strength: The specimens for tensile strength evaluation had a Instron: length 115mm and width of ends 25mm, Length of narrow portion 33mm, Width of narrow portion 6mm, Transition radius on the outside part was 14mm, Transition radius inside was 25mm, thickness of narrow portion 2mm, test length 25mm[16]. Twenty samples (n=5) for each material were prepared. Samples were then subjected to testing for tensile strength value using the Universal testing machine Instron: 3382A series, USA Massachusetts) (Figure3,4).

Figure 3: Specimen for the tensile strength

Figure 4: Measurement of tensile strength by Universal testing machine

The SPSS 20.0 software program (SPSS Inc, Chicago, IL, USA) was used for statistical analysis to determine the effect of gloves on setting time, compressive strength and tensile strength compared with the control group. Post Hoc Test with control group was used to determine the differences. The data was presented as mean difference and standard error and $p<0.05$ was statistically significant.

RESULTS

Table 2: Mean setting time of putty type silicone impression materials manipulated with different gloves as compared to control group

Material	Gloves	Mean±S.D (Seconds)	Mean Diff.	P-Value
Elite P & P (Addition Silicone) A	Without gloves A_1	312.0±33.4	-	-
	Polythene A_2	318.0±19.2	-6.0	0.994
	Vinyl A_3	376.0±49.7	-64.0	0.70
	Latex A_4	438.0±41.4	-126.0	0.0001
Flexceed (Addition Silicone) B	Without gloves B_1	292.0±22.8	-	-
	Polythene B_2	256.0±27.0	36.0	0.075
	Vinyl B_3	278.0±8.3	14.0	0.735
	Latex B_4	464.0±23.0	-172.0	0.0001
Zetaplus (conden-sation Silicone)C	Without gloves C_1	730.0±10.0	-	-
	Polythene C_2	724.0±177.5	6.0	1.000
	Vinyl C_3	378.0±8.3	352.0	0.0001
	Latex C_4	472.0±25.8	258.0	0.002
Cavex (Conden-sation Silicone) D	Without gloves D_1	202.0±13.0	-	-
	Polythene D_2	542.0±58.4	-340.0	0.0001
	Vinyl D_3	298.0±23.8	-96.0	0.002
	Latex D_4	254.0±18.1	-52.0	0.106

There was insignificant ($p>0.5$) effect on the setting time of Elite P & P when mixed with polythene(A_2) and vinyl gloves(A_3) when compared with control(A_1). There was significant ($p<0.5$) effect on the setting time of Elite P & P when mixed with latex gloves(A_4) as compared to control(A_1).There was insignificant ($p>0.5$) effect on the setting time of Flexceed when mixed with vinyl gloves(B_3) when compared with control(B_1). There was significant ($p<0.5$) effect on the setting time of Flexceed when mixed with polythene(B_2) and latex gloves(B_4) as compared to control group(B_1).There was insignificant ($p>0.5$) effect on the setting time of Zetaplus when mixed with polythene gloves(C_2) when compared with control(C_1). There was significant ($p<0.5$) effect on the setting time of Zetaplus when mixed with vinyl(C_3) and latex gloves(C_4) as compared to control(C_1).There was significant ($p<0.5$) effect on the setting time of Cavex when mixed with polythene(D_2), vinyl(D_3) and latex gloves(D_4) as compared to control(D_1) (Table 2).

There was a significant ($p<0.5$) effect on the tensile strength of Elite P &P and Flexceed when mixed with polythene(A_2), vinyl(A_3) and latex gloves(A_4) as compared to control(A_1) and groups polythene(B_2), vinyl(B_3) and latex gloves(B_4) as compared to control(B_1)respectively. There was significant ($p<0.5$) effect on

the tensile strength of both Zetaplus and Cavexas well when mixed with polythene(C_2), vinyl(C_3) and latex gloves(C_4) as compared to control (C_1) and groups polythene(D_2), vinyl(D_3) and latex gloves(D_4) as compared to control(D_1) respectively (Table 3).

Table 3: Mean Tensile strength of putty type silicone impression materials manipulated with different gloves as compared to control group

Material	Gloves	Mean±S.D (MPa)	Mean Diff.
Elite P &P (Addition Silicone) A	Without gloves A_1	4.1340±.03435	-
	Polythene(A_2)	3.1860±.04450	.94800
	Vinyl (A_3)	4.7020±.01789	-.56800
	Latex (A_4)	3.9580±.01581	.32400
Flexceed (Addition Silicone) B	Without gloves B_1	6.4900±.01581	-
	Polythene(B_2)	8.8100±.01581	-2.32000
	Vinyl (B_3)	8.0620±.02588	-1.57200
	Latex (B_4)	8.9040±.02074	-2.41400
Zetaplus (Condensation Silicone) C	Without gloves C_1	3.8340±.01817	-
	Polythene(C_2)	2.2880±.03899	-1.54600
	Vinyl (C_3)	3.3280±.02588	.50600
	Latex (C_4)	3.9860±.02074	-.15200
Cavex (Condensation Silicone) D	Without gloves D_1	4.4240±.01817	-
	Polythene (D_2)	3.6580±.03114	.76600
	Vinyl (D_3)	4.1260±.02702	.29800
	Latex (D_4)	5.4700±.02236	-1.04600

Table 4: Mean Compressive strength of putty type silicone impression materials manipulated with different gloves as compared to control group

Material	Gloves	Mean±S.D (MPa)	Mean Diff.
Elite P &P (Addition Silicone) A	Without gloves A_1	27.8000±.12247	
	Polythene A_2	47.50000±.22361	-19.70000
	Vinyl A_3	49.1800±.14832	-21.38000
	Latex A_4	40.0220±0.1924	-12.22200
Flexceed (Addition Silicone) B	Without gloves B_1	48.3400±.17633	
	Polythene B_2	48.3000±.29155	.04000
	Vinyl B_3	47.2200±.19235	1.12000
	Latex B_4	47.1200±.19234	1.22000
Zetaplus (Condensation Silicone) C	Without gloves C_1	49.4440±.02608	
	Polythene C_2	23.2500±.02739	26.19400
	Vinyl C_3	47.2440±.02074	2.20000
	Latex C_4	47.1020±.01924	2.34200
Cavex (Condensation Silicone) D	Without gloves D_1	29.7280±.01304	
	Polythene D_2	33.6000±.25495	-3.87200
	Vinyl D_3	41.8540±.02510	-12.12600
	Latex D_4	37.7400±.03391	-8.01200

There was significant ($p<0.5$) effect on the compressive strength of both Elite P &P, Flexceed when mixed with polythene(A_2), vinyl(A_3) and latex gloves(A_4) as compared to control(A_1) and groups vinyl (B_3) and latex gloves(B_4) as compared to control(B_1) respectively. There was significant ($p<0.5$) effect on the compressive strength of both Zetaplus & Cavex when mixed with polythene(C_2), vinyl(C_3) and latex gloves(C_4) as compared to control(C_1) and groups(D_2), vinyl (D_3) and latex gloves(D_4) as compared to control(D_1) respectively(Table 4).

DISCUSSION

Protective gloves are important, although only secondary barrier and safeguards against factors hazardous to the hands, in dentistry. There is no glove material ideal for working with silicones. The composition of materials to be handled should determine which type of gloves should be chosen.

The polymerization reaction of silicone impression materials was observed to be inhibited if the material came in contact with the gloved hand.[17] The group A_1 and A_2showed shorter setting time. It can be attributed to warmer ambient temperature as the study was conducted in the month of December.

As indicated by the manufacturer the setting time of Elite P &P is 330 seconds. The group A_1 showed the setting of the material (312±33.4), A_2(318±19.2) both are in accordance with the manufacturer instructions. The group A_3 showed slightly delayed (376±49.7) butA_4showed much delayed setting (438±41.4). In group B the recommended time by manufacturer for setting is 280 seconds. The group B_1showed setting of the material 292.0±22.8 andB_2 had setting time (256±27) close to set that indicated by the manufacturer. The group (B_3) (278±8.3) coincides with the manufacturer recommendations and hence no significant change was observed. Setting reaction was delayed in B_4 (464±23).It was in accordance with the previous studies which reported that latex gloves inhibited the polymerization of addition silicon[13].

The setting time provided by manufacturer for condensation silicones of both brands group C and group Dis 350 seconds. For group C the setting time was longer than the recommendations of manufacturer with all the gloves. In group $C_3$the setting time (378±83) was reduced as compared to all used and it is closed to the recommended time by manufacturer, followed by C_4(464±23). The setting time of C_2 (724±177) andC_1 (730±10) were very similar, but there is marked delay in setting time without gloves and while using polythene gloves. This can be due to the sticky nature of the catalyst, effect of temperature and manipulative variables. In the group D the setting time with all gloves was lower than the manufacturer recommendations except D_2 (542±58.4). The mixing with polyethylene gloves was difficult in the group C and D as the catalyst was in paste form, and polyethylene gloves do not have a good fit to the hands.

During the removal of impression material from the oral cavity, it withstands forces associated with separation of the impression from the hard and soft tissues. Tensile and compressive strength play an important role in the accuracy of impression, especially when used in undercut areas. The use of different gloves plays a vital role in manipulating materials properties[18]. The material will less likely to tear if it has higher tensile strength. Manipulative methods of impression materials have a significant role in the final mechanical properties of the materials.

There was significant difference in tensile strength of addition and condensation silicone putty type of material when mixed with different type of gloves (table 3). Two brands of addition silicone behave differently in our study. In group A the control A_1 showed tensile strength of 4.134 MPa, group A_2 showed the least tensile strength value 0f 3.18Mpa, group A_4 showed the tensile strength of 3.958MPa and group A_3 showed higher tensile strength value of 4.702 MPa. While tensile strength of groupB was 6.49 MPaand groups B_2, B_3 and B_4 showed high value of tensile strength (8.810 MPa, 8.062 MPa and 8.904 MPa) as compared to control.

Condensation silicone responds differently with different type of gloves. Both brands of condensation silicone when mixed with polythene gloves showed the least tensile strength of group C_2 (2.280 MPa) and group D_2 (3.658MPa) when compared with the tensile strength of control group C_1 (3.83 MPa) and D_1 (4.424MPa) respectively. Tensile strength of group C_3 (3.328MPa) and D_3 (4.126MPa) showed less tensile strength than control groups. However, condensation material mixed with latex gloves showed the highest values of tensile strength with group C_4 (3.986MPa) and group D_4 (5.470MPa).

All four putty type materials show significant difference in compressive strength when mixed with different type of gloves. Elite P &P (A) the group A_3 showed the highest compressive strength value of 49.18 MPa, and the group A_2 showed the strength of 47.5MPa when compared with A1 (27.8Mpa).The group A_4 showed the strength of 40.02 MPa that is more than A_1 but less than that of group A_2 and A_3 respectively. In group B, the difference in compressive strength of group B_3 and B4 was significantly less (47.2 MPa, 47.1 MPa) respectively than that ofB_1 (8.3MPa). The group C showed less compressive strength values when mixed with polythene gloves (group C_2) 23.2MPa, vinyl gloves (47.24MPa) and Latex gloves (47.12MPa) as compared with C_1 (49.44MPa).The group D_2(33.6MPa), D_3 (41.85MPa) and D_4 (37.74MPa) show more compressive strength than D_1(29.72MPa)

CONCLUSION

Addition silicone putty impression materials exhibited significant variation in the setting time when mixed with latex gloves but there was no significant variation when mixed with vinyl gloves and the control group. Addition silicone(Elite P&P) showed insignificant difference in setting time when mixed with polythene gloves but addition silicone (Flexceed) showed significant difference when mixed with polythene gloves which might be attributed to the inherent stickiness of silicones which might interfere with the manipulation.

Condensation silicone putty impression material of both types showed significant variation in setting time when mixed with latex gloves, vinyl gloves and without gloves but one group (Zetaplus) shows insignificant change in setting time when mixed with polythene gloves as compared to control group. Other group of condensation silicones (Cavex) showed significant difference when mixed with polythene gloves.

Addition and condensation silicone impression materials show significant difference in tensile and compressive strength when mixed with polythene, vinyl and latex gloves as compared with the control group except one group of addition silicones (Flexceed) showed insignificant difference in compressive strength when mixed with polythene gloves. Further studies with a larger sample size should be carried out to validate the results of this study.

Authors Contribution: SA, designed and did statistical analysis, data collection& manuscript writing, **NANOOR** did study design, review and final approval of manuscript, **AQ** data collection and manuscript writing, **MA** data collection and statistical analysis

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