A Comparative Study to Determine the Effect of Latex, Vinyl and Nitrile Gloves on the Setting Time of Four Different Elastomeric Impression Materials: An In-Vitro Study

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ABSTRACT

Increase in transmissible diseases like AIDS, Hepatitis B, Herpes over a last few decades and recently evolved Covid-19 have created global concern which has impacted the treatment mode of all health care professionals. This can be shielded with the use of barrier methods. Sterilized gloves along with other indispensable barrier methods like mask and eye protective glasses are mandatory for examination of patients as well as conducting surgical procedures although while taking impression of patients many a times setting time of the impressions is altered by use of gloves. Taking impression in the field of dentistry is vital in recording the extra-oral and intra-oral details for diagnosis and treatment planning. There is a wide variety of impression materials available, each with their own advantages and disadvantages. One such disadvantage is alteration of setting time along with changes in the surface properties of the impressions in contact with gloves. This study is designed to determine the effect on the setting time of available brands of different elastomeric impression materials when mixed with latex, nitrile and vinyl gloves. This study also aims to evaluate the difference in the setting time of impression materials in contact with the washed and unwashed gloves. Vicat needle has been used for measuring the setting time of each impression material, that were manipulated at first without wearing any gloves, followed by wearing each of the unwashed Latex, Nitrile and Vinyl gloves and finally with washed gloves of different variety. Outcome of this study reveals that Vinyl and nitrile gloves have no effect on setting time of polyvinylsiloxane impression material. Latex gloves have a definite inhibitory effect on setting of polyvinylsiloxane impression material. Washing hands after using latex gloves decreases the inhibitory effect on setting of addition silicone (putty consistency).

Keywords: Effect of Latex, Vinyl and Nitrile Gloves, Elastomeric Impression, Latex Gloves, Vinyl Gloves, Nitrile Gloves

INTRODUCTION

Awareness of infection control in the field of dentistry that involves contact with mucosa, saliva, blood, or blood-contaminated body fluids is necessary to ensure compliance with universal barriers and other methods to minimize infection risks.[1] Latex gloves are popular protective barriers in clinical setup.[1, 2, 3, 4] However 6-12% of health workers in USA have an immediate type allergic reaction to latex gloves.[5, 6] Nitrile is a synthetic polymer that has characteristics of natural rubber latex and is free of any latex proteins that can induce allergic reaction. They are superior to natural latex gloves in resisting punctures and tears with the added advantage of a longer shelf life. Polyvinyl chloride is another synthetic product that is non-biodegradable, protein free material used in manufacturing gloves.

Elastomeric impression materials were developed from synthetic rubber by S.L. Pearson at the University of Liverpool. [7] The introduction of rubber-based polysulfide impression materials was followed by condensation silicone materials, elastic polyether impression materials and polyvinylsiloxane impression materials.

The setting time of these elastomeric impression materials is affected by temperature, humidity, proportions of base and catalyst components and impurities. [8,9] It has been proposed that sulfur is a reactive component which may interfere with silicone polymerization. The sulfur containing chemical zinc diethyl dithiocarbamate is used as a preservative and vulcanization accelerator in fabrication of latex gloves.[10] The element sulfur contained in latex gloves may react with chloroplatinic acid catalyst in addition silicone impression materials. [10,11] This inhibition is limited to surface and causes a rippled appearance of the set impression and even adherence to the tissue surface on removal. There is no study in literature which was designed to assess the effect of latex, vinyl and nitrile gloves on setting time of each type of elastomeric impression material. This study was designed to assess the retarding effect of latex, nitrile and vinyl gloves on setting time of addition silicone, condensation silicone, polysulfide and polyether impression materials and to evaluate whether simple rinsing or washing of gloves can affect the polymerization of these elastomeric impression materials.

MATERIAL AND METHODS

The study was conducted in the Department of

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Prosthodontics and Crown & Bridge, Dr R. Ahmed Dental College & Hospital, Kolkata-70014. The putty form of addition silicone (3M ESPE, GERMANY), condensation silicone (ZHERMACK, ITALY), and polyether (3M ESPE, GERMANY) and medium body consistency of polysulfide impression material (Permlastic, Kerr dental co., CA, USA) were tested (Image 1). Putty material was mixed bare handed and after wearing latex gloves (SURGICARE, INDIA), vinyl gloves (PRICARE, INDIA), nitrile gloves (PRICARE, INDIA) each while medium body polysulfide impression material was manipulated with stainless steel spatula and exposed to gloves (Image 2).

One scoop each of base and catalyst of putty material were dispensed according to the manufacturer's recommendation. Samples were prepared by kneading the base and catalyst putty material with clean dry bare hands into a homogeneous mix. Similar method of mixing was applied in manipulating medium body polysulphide impression material with stainless steel spatula instead of bare hands. Mixing time was completed within the recommended time at room temperature of 25^0 C.

The vicat needle, 1mm in diameter, 5 cm long, and 300gm in weight was used to determine the setting time. The needle was applied to the surface of freshly mixed material and monitored on stopwatch (Image 3). The process was repeated every 15 seconds. The setting time was measured from time of mixing till the time that the needle did not produce any indentation on surface of the material (Table 1). The whole process was repeated six times to obtain a full set of data. A total of 168 samples were collected. 42 samples were tested from each of the 7 group of individual categories of impression materials (including control). Finally, the hands were washed with soap and water. The materials were mixed with washed latex gloved hands and the setting time was measured again. Different pair of gloves was used for each step (Image 4). The process was repeated wearing vinyl and nitrile gloves too. Care was taken so that no cross-contamination occurred during the process.

RESULTS

The collected data was subjected to statistical analysis using SPSS 18.0 software. Mean and standard deviation were calculated to compare the descriptive statistical values of different parameters. Group wise comparisons were made using analysis of variance (ANOVA) (Table 2). If significant difference was found in ANOVA, post-hoc test (Tukey's HSD Test) was done to determine the critical difference and make a pair wise comparison (Table 3). The level of significance was taken as 5% ($p<0.05$). In the present study it was found that no significant delay ($p=0.99$) in setting time of polysulfide and polyether impression materials was observed even on contamination with washed gloves (Fig 1,2,3 &4). The mean setting time of addition silicone material and condensation silicone material was delayed significantly when mixed while wearing latex gloves, (Addition silicone 10.86±0.44 min, Condensation silicone 8.45±0.74 min, $p<0.001$**) compared to control group of each (Addition silicone 3.38±0.12 min and Condensation silicone 6.69±0.34 min) (Fig 5,7; Table 2). Significant delay in setting of addition silicone was also found after washing with soap and water (Fig 6; Table 2).

Type of impression material	Mixing with stainless steel spatula, contact with bare hands	Mixing with stainless steel spatula, contact with latex glove	Mixing with stainless steel spatula, contact with vinyl glove	Mixing with stainless steel spatula, contact with nitrile glove	Mixing with stainless steel spatula, contact with latex glove (washed with soap)	Mixing with stainless steel spatula, contact with vinyl glove (washed with soap)	Mixing with stainless steel spatula, contact with nitrile glove (washed with soap)
Polysulphide	15.2	15.70	15.80	15.64	16.35	16.15	15.4
Addition silicone	3.38	10.86	3.33	3.34	5.36	3.33	3.20
Condensation silicone	6.69	8.45	6.33	6.72	6.78	6.88	6.84
Polyether	6.94	7.02	7.10	7.04	6.93	7.08	7.02

Table-1: Details of the method of mixing and the setting time (in minutes) is documented.

Type of Impression material that is contaminated with latex gloves, vinyl gloves and nitrile gloves (without washing)	P-value (Level of significance)	Type of Impression material that is contaminated with latex gloves, vinyl gloves and nitrile gloves (after washing with soap and water)	P-value (Level of significance)
Polysulphide	0.93	Polysulphide	0.84
Addition silicone	0.001**	Addition silicone	0.001**
Condensation silicone	0.001**	Condensation silicone	0.84
Polyether	0.93	Polyether	0.92

Note: *-significant at 5% level of significance, **-significant at 1%level of significance, NS-Not significant.

Table-2: Comparison with ANOVA among the values of setting time of different elastomeric impression materials, manipulated by mixing with spatula/ bare hands, latex, vinyl and nitrile gloves.

Multiple comparison: Tukey post-hoc test on four methods of contamination of Polysulphide impression materials. (unwashed gloves)			**Multiple comparison: Tukey post-hoc test on four methods of contamination of Addition silicone impression material (unwashed gloves)**			**Multiple comparison: Tukey post-hoc test on four methods of contamination of Condensation silicone impression material (unwashed gloves)**			**Multiple comparison: Tukey post-hoc test on four methods of contamination of Polyether impression material (unwashed gloves)**		
Gr1	Gr2	p-value	Gr1	Gr2	p-value	Gr1	Gr2	p-value	Gr1	Gr2	p-value
A1	A4	0.91	B2	B3	0.001**	C2	C3	0.001**	D3	D1	0.91
A3	A2	0.98	B2	B4	0.001**	C2	C1	0.001**	D3	D2	0.98
A3	A1	0.99	B2	B1	0.001**	C2	C4	0.001**	D3	D4	0.99
A1	A4	0.99	B1	B3	0.99	C4	C3	0.55	D4	D1	0.97
A1	A2	0.99	B1	B4	0.99	C4	C1	0.99	D4	D2	0.99
A2	A4	0.99	B4	B3	0.99	C1	C3	0.61	D2	D1	0.99
Multiple comparison: Tukey post-hoc test on four methods of contamination of Polysulphide impression material (with washed gloves)			**Multiple comparison: Tukey post-hoc test on four methods of contamination of Addition silicone impression material (with washed gloves)**			**Multiple comparison: Tukey post-hoc test on four methods of contamination of Condensation silicone impression material (with washed gloves)**			**Multiple comparison: Tukey post-hoc test on four methods of contamination of Polyether impression material (with washed gloves)**		
A6	A5	0.84	B5	B7	0.001**	C6	C1	0.82	D6	D5	0.93
A6	A7	0.88	B5	B6	0.001**	C6	C5	0.97	D6	D1	0.94
A6	A1	0.97	B5	B1	0.001**	C6	C7	0.99	D6	D7	0.99
A1	A5	0.98	B1	B7	0.88	C7	C1	0.90	D7	D5	0.99
A1	A7	0.99	B1	B6	1.00	C7	C5	0.99	D7	D1	0.99
A7	A5	1.00	B6	B7	0.96	C5	C1	0.98	D1	D5	0.99

Specifications of Table 3 stands for:

A1: Polysulphide impression material mixed with stainless steel spatula **(control)**. **B1:** Addition silicone impression material mixed with bare hands (control), **C1:** Condensation silicone impression material mixed with bare hands (control). **D1:** Polyether impression material mixed with stainless steel spatula (control).

A2: Polysulphide impression material mixed wearing **latex gloves**, A5: mixed wearing washed latex gloves**. B2:** Addition silicone impression material mixed wearing latex gloves, B5: mixed wearing washed latex gloves. **C2**: Condensation silicone impression material mixed wearing latex gloves, C5: mixed wearing washed latex gloves. **D2:** Polyether impression material mixed wearing latex gloves, **D5:** mixed wearing washed latex gloves.

A3: Polysulphide impression material mixed wearing **vinyl gloves**, **A6:** mixed wearing washed vinyl gloves**. B3:** Addition silicone impression material mixed wearing vinyl gloves, **B6:** mixed wearing washed vinyl gloves. **C3:** Condensation silicone impression material mixed wearing vinyl gloves, **C6:** mixed wearing washed vinyl gloves. **D3:** Polyether impression material mixed wearing vinyl gloves, **D6:** mixed wearing washed vinyl gloves.

A4: Polysulphide impression material mixed wearing **nitrile gloves**, **A7:** mixed wearing washed nitrile gloves. **B4:** Addition silicone impression material mixed wearing latex gloves, **B7:** mixed wearing washed nitrile gloves. **C4:** Condensation silicone impression material mixed wearing nitrile gloves, **C7:** mixed wearing washed nitrile gloves. **D4:** Polyether impression material mixed wearing nitrile gloves, D7: mixed wearing washed nitrile gloves.

Note: *-significant at 5% level of significance, **-significant at 1%level of significance, NS-Not significant.

Table-3: Multiple Comparison with post-hoc Tukey test among the values of setting time of different elastomeric impression materials, manipulated with mixing spatula/ bare hands, latex, vinyl and nitrile gloves.

Image-1: Base and catalyst of each of the elastomeric impression materials. **Image 1A:** Addition Silicone, **Image 1B:** Condensation silicone, **Image 1C:** Polysulphide, **Image 1D:** Polyether.

Image-2: Different types of gloves used for mixing of four different elastomeric materials.

Image-3: Armamentariums and materials used in this study.

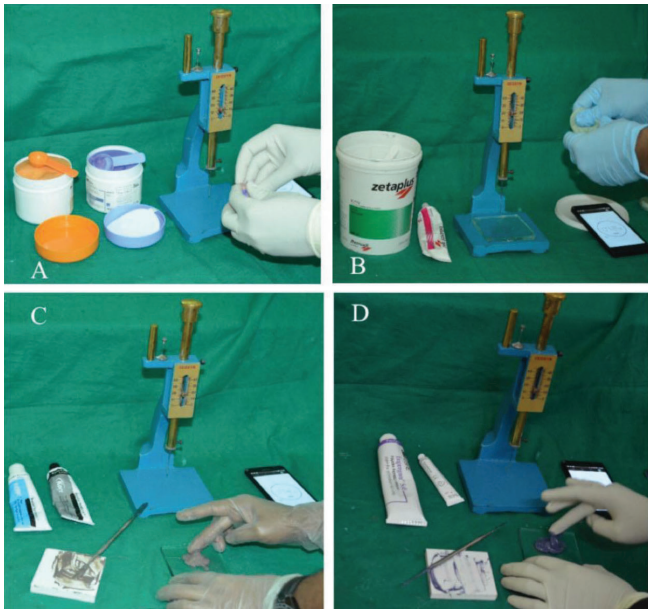

Image-4A: Mixing of putty consistency of Addition silicone impression material, while wearing latex gloves; **Image 4B:** Mixing of putty consistency and light body of Condensation silicone impression material, wearing nitrile gloves; **Image 4C:** Mixing of Polysulphide impression material with vinyl gloves; **Image 4D:** Mixing of Polyether impression material with latex gloves.

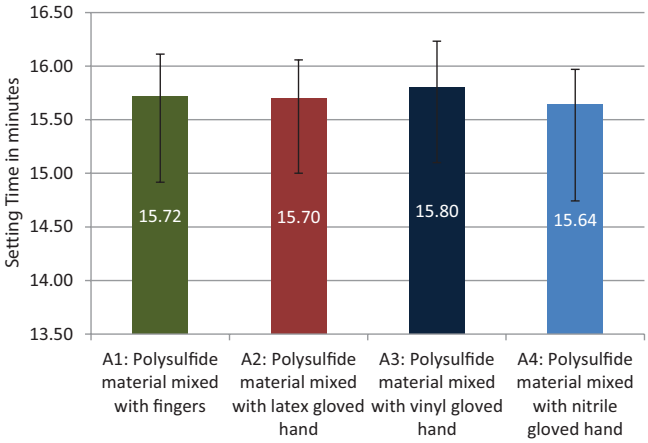

Figure-1: Comparison of setting time of Polysulphide impression material, between control and when mixed with gloved hands.

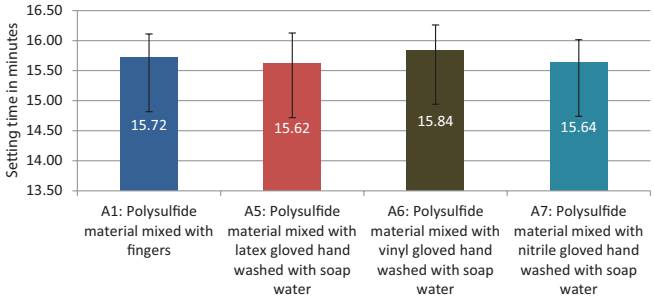

Figure-2: Comparison of setting time of Polysulphide impression material, between control and when mixed with gloved hands after washing with soap-water.

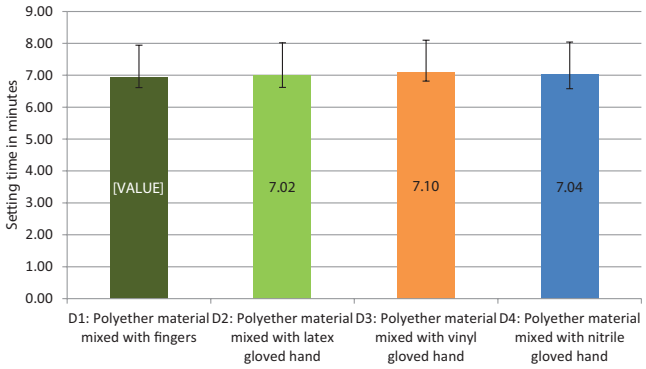

Figure-3: Comparison of setting times of Polyether impression material, among control and when manipulated with gloved hands.

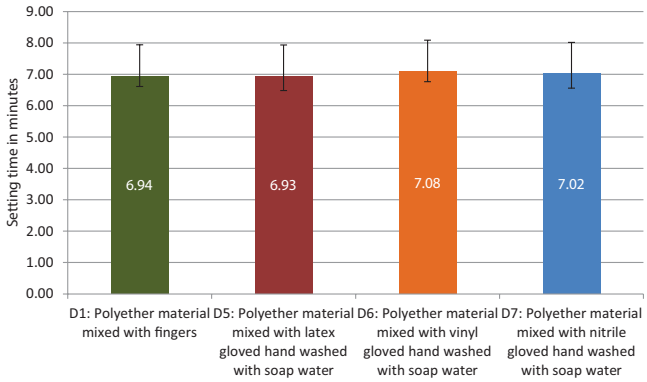

Figure-4: Comparison of setting times of Polyether impression material among control and when manipulated with gloved hands after washing with soap water.

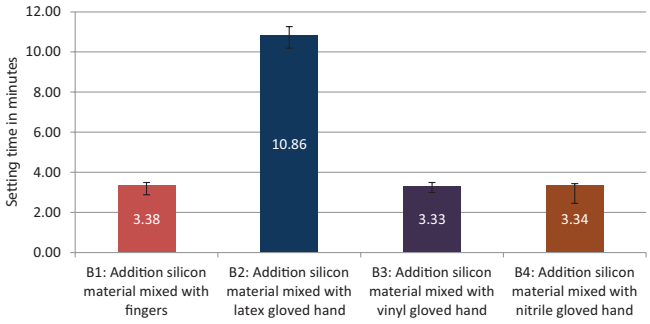

Figure-5: Comparison of setting time of Addition silicone impression material, between control group and when manipulated with gloved hands.

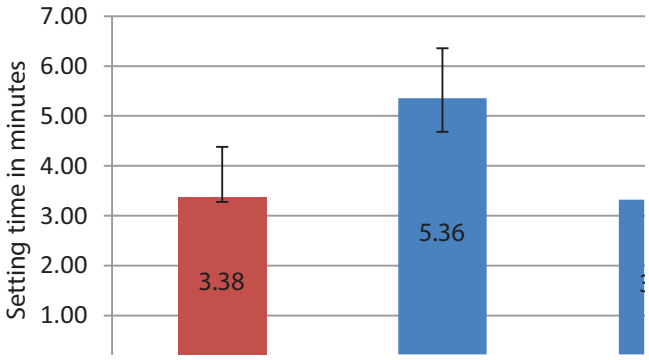

Figure-6: Comparison of setting time of Addition silicone impression material, among control and when manipulated with gloved hands after washing the gloves with soap water.

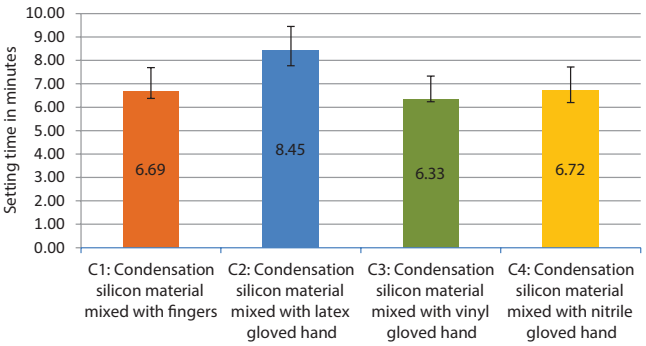

Figure-7: Comparison of setting time of condensation silicone impression material, among control and when manipulated with gloved hands.

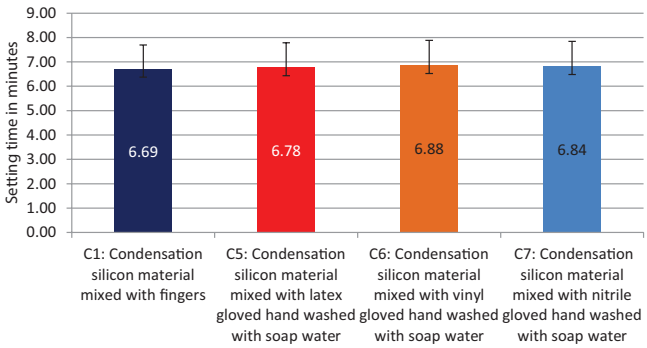

Figure-8: Comparison of setting time of Condensation silicone impression material, among control and when manipulated with gloved hands after washing with soap water.

This finding was insignificant for condensation silicone material (Fig 8; Table 2). The overall influence of setting time of the four elastomeric impression materials on mixing with control group and different types of gloves (before and after wash) has been illustrated graphically in Fig 9.

DISCUSSION

The present study attempts to evaluate the interference of three types of gloves on setting time of four types of elastomeric impression materials. Although manipulation of medium body polysulphide materials is performed using stainless steel spatula, during mixing bare hands or gloved hands may contact the impression material which may alter the setting time. Influence of various types of gloves and

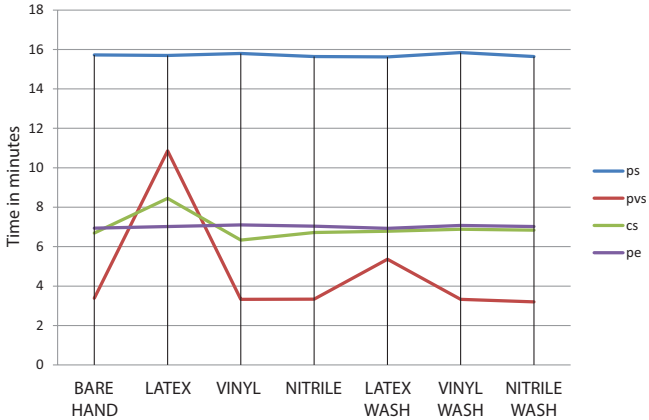

Figure-9: Chart shows difference of setting time of elastomeric impression materials when mixed with different gloves (before wash and after wash).

bare hands on setting time of elastometic impressions were thus analysed.

A Tukey post-hoc analysis of the data of polysulphide impression materials revealed that there was no significant difference (p=.99) amongst the setting time of the control group (15.72±0.43) and groups that were contaminated with latex (15.70±0.39), nitrile (15.64±0.36) and vinyl (15.80±0.47) gloves (Fig 1). Intergroup comparison also did not differ significantly (Table 3). This corroborates with the study by M.A. Baumann in 1995 [12] who concluded that there was no inhibition of setting time of polysulfide material when mixing with rubber gloves. The base paste of polysulfide contains a multifunctional mercaptan (–SH), a filler (lithopone or titanium oxide), a plasticizer, and a small quantity of sulfur, approximately 0.5%, as an accelerator. The catalyst paste contains lead dioxide, filler and plasticizer. Sulfur present in latex gloves is therefore not expected to interfere with the polymerization reaction of polysulfide.

No significant delay (p=0.99) in setting time of polysulfide material was observed even on contamination with washed gloves (Fig 2).

Tukey post-hoc comparisons of the four groups indicate that setting time of Addition silicone when mixed wearing latex gloves (10.86±0.44 min) delayed significantly (p<0.001**) compared to control (3.38±0.12 min) (Table 3). While vinyl gloves (3.33±0.17, p=0.99) and nitrile gloves (3.34±0.11, p=0.99) showed no significant delay when compared with the control. Intergroup comparison showed that setting time on contamination with latex gloves differed significantly in comparison to vinyl and nitrile gloves (p<0.001).

Setting time differed significantly even on contamination with washed latex gloves (Table 2). Tukey post-hoc test indicated that the setting was delayed significantly (p<0.001) on contamination with washed latex gloves (5.36±0.74) when compared to control (3.38±0.12) (Table 3). Washed vinyl (3.33±0.18, p=0.99) and nitrile gloves (3.30±0.36, p=0.99) did not delay the setting significantly. Intergroup comparison revealed significant difference (p<0.001) amongst setting time on contamination with washed latex, vinyl and nitrile gloves.

It was concluded that contamination of polyvinyl siloxane impression material with latex gloves causes significant delay in setting time. Impression material comes in direct contact with the latex glove or a region of the mucosa previously in contact of latex glove [11,13,14]. It has been suggested that corn starch powder used as a lubricant in the gloves acts as retarder. Atmospheric oxygen and interaction with haemostatic agents or luting agents has been suggested to delay setting time. Though both the theories are contradicted in the studies conducted by Camargo et al. [15] and Jones et al. [16]

Sulfur containing compound has been identified as being responsible for the retarding effect on polymerization. Zinc diethyl dithiocarbamate is an accelerator used in the manufacture of the latex gloves. It reacts with the platinum catalyst in the polyvinyl siloxane to cause a delay or total inhibition of polymerization [11,14,16]. Baumann [12] reported that Sulphur component even in concentrations as low as 0.005 percent in latex gloves, can cause complete inhibition of polyvinyl siloxane polymerization. Interestingly, not all latex gloves cause retardation. It has been observed that synthetic latex gloves do not cause retardation while some natural latex gloves do. [13,14] Reitz et al [17] evaluated the interaction of numerous brands of regular body polyvinylsiloxane material and putty consistency condensation and addition silicone impression material with washed and unwashed latex and vinyl gloves and with powder residue left on the hands after glove removal. They found that not all gloves or brand inhibited the polymerization of the impression material.

Bruke et al [18] described three levels of inhibition of addition silicone material due to sulfur component. Complete inhibition showing infinite delay, partial inhibition along with deleterious effect on the mechanical properties of the material and no inhibition.

Similar mechanism of polymerization inhibition due to dithiocarbamate has been suggested. Custon et al [19] tested 25 types of gloves and reported that dithiocarbamate is mildly soluble in acidic solutions (diluted etchant, astringent) which may result in dithiocarbamate leaching, leading to polymerization inhibition.

The present study showed significant delay (p = 0.001**) in setting time of condensation silicone impression material on contamination with latex gloves (8.45±0.74 min) when compared to control (6.69±0.34 min) (Table 3). Contamination with vinyl gloves (6.33±0.11 min, p=0.99) and nitrile gloves (6.72±0.56 min, p=0.99) did not cause significant delay compared to control group. Intergroup comparison among setting times while manipulating with latex, vinyl (p<0.001**) and nitrile (p<0.001) gloves differed significantly (Table 3). No significant delay of setting was observed on contamination with washed latex, nitrile and vinyl gloves (p=0.99). Also, intergroup comparison between washed latex, nitrile and vinyl gloves did not show significant delay (p=0.99). This study corroborates with that of Clair D Reitz and Nereyda P Clark in 1988 [17] who concluded that there is a minimal retardation of condensation silicone setting when mixed with latex gloves although after washing the gloved hand, no retardation was seen. This study is supported by the findings of M.A. Baumann in 1995 [12] who concluded that there was no inhibition in setting of polyether materials on mixing with rubber gloves and no effect was seen on setting time after washing the gloves.

There was no significant (p=0.99) delay in setting time of polyether impression material (6.94±0.36) on contamination with latex (7.02±0.43), vinyl (7.10±0.31, p=0.99) and nitrile gloves (7.04±0.51) (Table 3). Also, as expected there was no significant delay (p=0.99) in setting on contamination with washed latex, vinyl and nitrile gloves.

Polyether impression material polymerizes through ring-opening cationic reaction. Cationic polymerization is similar to addition polymerization except that instead of a free radical cation is the reactive molecule. Polyether-based polymer is cured by a reaction between aziridine rings which are at the end of branched polyether molecules. The main chain is a copolymer of ethylene oxide and tetrahydrofuran. Cross-linking and setting are initiated by aromatic sulfonate ester initiator. Though the polymerization is like addition silicone, but due to absence of free radical, polymerization reaction is not inhibited by sulfur molecule (inhibits chloroplatinic acid in addition silicone). [20,21]

In the present study the four types of elastomeric impression materials were manipulated with latex, vinyl and nitrile gloves and allowed to set at room temperature. All the elastomeric impression materials set within recommended setting time except addition silicone. It is affirmative to the hypothesis that sulfur compound present in latex gloves contaminates the platinum catalyst of addition silicone and thus inhibits the setting time.

Within the limitation of the study, the following conclusion can be drawn

1. Neither the latex nor the vinyl and nitrile gloves affected the polysulfide and polyether impression materials.
2. Vinyl and nitrile gloves had no effect on setting time of polyvinylsiloxane impression material.
3. Latex gloves caused significant retardation or complete inhibition of setting of polyvinylsiloxane impression material.
4. Washing hands after using latex gloves decreases the inhibitory effect on setting of putty addition silicone but did not eliminate it.
5. For maintaining proper barrier technique vinyl or nitrile gloves should be worn over the latex gloves during mixing of putty.
6. Vinyl and nitrile gloves tested had no effect on setting time of condensation silicone putty material.
7. Latex gloves showed retardation of setting of condensation silicone impression material although no significant retardation after the hands were washed.

1.5 Limitations of study include

1. In this study no other property of material except setting time was evaluated.
2. Study was restricted to only a few commercially

available brands of both impression materials and gloves.

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