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Silicone Impression Materials and Latex Gloves. Is Interaction Fact or Fallacy?

Abstract: This review will explore the mechanism of delayed setting and inhibition of polyvinyl siloxane impression material by latex and examine the evidence for and against this phenomenon. Clinical implications are discussed and recommendations for clinical practice made.

Clinical Relevance: The production of accurate polyvinyl siloxane impressions in the fabrication of indirect restorations/prostheses is vital for a good clinical outcome.

Dent Update 2012; 39: 39–42

The problem of delayed setting of polyvinyl siloxane (addition-cured silicone) when mixed with certain glove types is not new; it has been brought to the attention of the dental profession on a number of occasions in recent years. Other reports in the literature show this effect to be minimal and not as widespread as originally thought. The clinical consequence is unset impression material producing an inaccurate cast and a poorly fitting restoration; a disconcerting outcome for all involved; patient, dentist and technician.

The authors decided to investigate this topic after conducting a literature review and concluding that, since the initial interest in this topic, principally in the 1980s and 1990s, only one paper has been published addressing this topic.[1]

Polyvinyl siloxane impression materials, also known as addition reaction silicones or addition-cured silicones, are amongst the most popular impression materials used in restorative dentistry. They are used in a variety of clinical situations in fixed and removable prosthodontics, operative and implant dentistry.[2] This is a result of their accuracy, favourable handling properties and excellent elastic recovery.[3] The by-product free polymerization reaction makes them dimensionally stable and a preferred option when compared to condensation reaction silicones.

The wearing of gloves during dental treatment is the accepted norm and is an integral part of barrier techniques and cross-infection control.[4] Latex gloves are the most commonly used type of gloves as they offer a comfortable low-cost option with good tear resistance.[5] Other products used in dental practice may also be latex based, such as rubber dam. However, the use of latex-containing materials does not come without its problems. Apart from the well documented problem of a hypersensitivity reaction to latex, latex-containing materials used in the dental setting have been shown to delay, and in some cases completely inhibit, the setting reaction of polyvinyl siloxane impression materials. Noonan *et al*, in 1985, were the first to report a complete inhibition of setting of an addition-cured silicone when an impression was taken with rubber dam *in situ*.[6] A similar problem was reported by Goldbaum in 1985 when an addition-cured silicone impression of a lower molar failed to set. Latex surgical gloves were worn during the preparation procedure and the inhibition was erroneously attributed to talcum powder on the gloves.[7] Welfare reported a similar problem in 1986.[8]

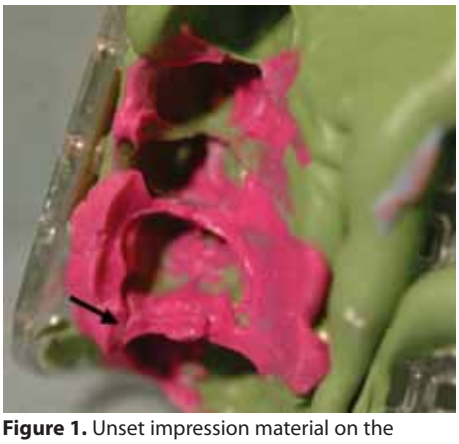

Figure 1. Unset impression material on the surface of the impression.

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The manifestation of this effect is that the surface of the impression material in direct or indirect contact with latex appears tacky and rippled.[9,10] Polymerization inhibition may not always be readily observed as the area of inhibition could be minimal and easily overlooked[1] (Figure 1). Unset impression material can sometimes be seen on the cast or in the gingival area of the prepared tooth.[10]

Mechanism of inhibition

The inhibition of the setting reaction of addition-cured silicones has wrongly been attributed to the use of various donning agents, such as corn starch and talcum powder, while other authors suggested interactions with haemostatic agents.[11]

It has since been shown that sulphur and sulphur-containing compounds used in the manufacturing process of latex gloves are responsible for the retarding effect on polymerization.[4,9,12,13]

Manufacturing latex gloves is a multi-stage process. Glove formers, which are moulds in the shape of the hand, usually constructed from a ceramic material, are dipped into a coagulant bath and then allowed to dry. The coated formers are then dipped into the latex mixture. The latex film is vulcanized by treatment with sulphur or sulphur-containing compounds under heat or pressure in a process to improve its elasticity and mechanical properties.[13]

Preservatives are also commonly added to the latex mixture to extend its shelf-life. A frequently used preservative is zinc dithiocarbamate, with zinc dimethyldithiocarbamate being commonly used in the rubber vulcanization process; both are sulphur containing.

Zinc dithiocarbamate inactivates a platinum catalyst (chloroplatinic acid) in the accelerator of the impression material and is considered to be responsible for the retarding effect, with as little as 0.005% of dithiocarbamate completely inhibiting setting.[14]

The chemical structure and structural composition of a rubber glove varies widely from one manufacturer to another. It is the presence of, and variation in the level of, sulphur and sulphur-containing compounds that determine the level of setting inhibition.[13] This can explain the different levels of setting inhibition noted from complete or partial inhibition to no inhibition at all.[15,16]

Direct vs indirect inhibition

Direct inhibition occurs when high viscosity putty materials are hand mixed with gloved hands with sustained contact for the duration of mixing. Indirect inhibition occurs when impression material fails to set against teeth and intra-oral soft tissues that have been previously touched and contaminated with latex gloves.[17]

Kahn and Donovan, in 1989, evaluated the potential polymerization inhibition of three brands of low viscosity addition-cured silicone impression material by indirect contact with latex gloves. To simulate the clinical situation, a stainless steel plate rubbed with latex gloves for 20 seconds was used as a test surface. This is more akin to a clinical situation where sustained contact between latex gloves and impression material is not normally encountered. A clean, untreated stainless steel plate was used as a control surface. Impression materials were expressed on to the contaminated surface and allowed to set. All three brands of addition-cured silicone impression material in contact with the contaminated stainless steel surface failed to set.[18]

A similar study was carried out by the same group where only one type of impression material, *Extrude* (Kerr), was tested for direct and indirect inhibition against 25 different brands of latex gloves, two brands of vinyl gloves and two weights of rubber dam. Direct contamination was tested by expressing the impression material directly on to the glove and allowing it to set. For indirect inhibition, the same method as described above was used. Fourteen brands of latex gloves and both weights of rubber dam were found to inhibit polymerization with direct contact only. Ten brands were found to inhibit polymerization both directly and indirectly. Vinyl gloves had no inhibitory effect.[9]

Kimoto *et al*, in 2005, showed elemental sulphur as well as sulphur compounds to be present on the surfaces of vinyl gloves and gingival retraction cords after a 5-second light rubbing motion with latex gloves simulating a normal clinical situation.[1]

Although the practice of immediate replacement of latex gloves by non-latex gloves prior to impression taking or putty mixing may seem clinically appropriate, the potential for indirect inhibition from particulate sulphur transfer remains high and, as such, this practice is not recommended.[1] The use of non-latex gloves from the outset would seem a more appropriate alternative.

As for the problem of direct inhibition, the use of auto-mixing devices for dispensing various consistencies of addition-cured silicone would avoid the direct contact between gloves and the impression material. The use of ungloved hands for mixing putty could be recommended only if rigorous hand hygiene measures have been followed prior to mixing.

In vivo vs *in vitro* studies

Most studies which have been carried out were laboratory-based studies examining delay of the setting reaction of putty systems with simple experimental designs. Putty systems were hand-mixed with gloved hands and allowed to set. Setting time was determined as being the elapsed time when it was not possible to make a permanent indentation in the putty.[19] Mixing with bare hands or with non-latex gloves was used as a control. Earlier studies had no objective criteria to determine the viscosity and setting changes and only subjective observation was used.[6,20] More recent studies used more sensitive methods to determine setting times using an oscillating rheometer or the Zwick hardness tester. Both systems detect viscosity changes from soft to rigid consistency.[4,14] Rosen *et al* tested four brands of latex gloves with three brands of putty systems. All setting times of the three putty systems were significantly increased beyond that which is clinically acceptable.[21]

Baumann tested eight brands of latex gloves with six putty systems and found only two brands of latex gloves to have an inhibitory effect.[4]

Whilst the test conditions in these studies do not exactly replicate the intra-oral clinical environment, the effect has been observed clinically and can cause obvious problems.[9]

Low viscosity addition-cured silicones dispensed from automatic mixing devices have also been tested and demonstrated a similar inhibitory effect when brought into contact with latex, both directly and indirectly.[18]

In vivo studies in this area have

been limited to a few case reports in the literature.[7,10] No clinical studies to examine this effect have been carried out to date.

Effect of other materials on setting reaction of addition-cured silicones

Glove lubricants

Talcum powder and corn starch are both used as glove lubricants and have been previously implicated in inhibiting the setting reaction of addition-cured silicones.[7,1] Touyz and Rosen investigated mixing three brands of addition-cured silicone impression materials with corn starch and found no retardation in the setting reaction. If anything, the presence of corn starch seemed to accelerate the setting reaction slightly when compared to control mixes.[22]

Rubber dam

The first report of inhibited set of addition-cured silicone impression material was reported when an attempt was made to take an impression of a tooth preparation with latex rubber dam *in situ*.[6] Doing this was believed to increase the overall efficiency of the impression-taking procedure and would afford better moisture control and gingival retraction. One should be aware that a tooth previously isolated with latex rubber dam to be subsequently prepared for a cast restoration, in the same visit, may suffer the same type of indirect inhibition as mentioned above.

Gingival retraction cord medicaments

Early reports suggested that haemostatic agents containing ferric sulphate or aluminium chloride may inhibit the setting of low viscosity addition-cured silicone impression materials.[11,23] Camargo *et al*, in 1993, tested a number of gingival retraction cord medicaments available commercially. The active agents in these materials included: racemic epinephrine, aluminium chloride, aluminium sulphate and ferric sulphate. None of the medicaments tested had any inhibitory effect on polymerization. The inhibited polymerization mentioned in anecdotal reports is more likely to have been caused by the inadvertent contamination by latex rubber gloves than by gingival retraction medicaments.[24]

Temporary cements

Eugenol-containing temporary cements have been blamed, anecdotally, for inhibiting the setting reaction of addition-cured silicone impression materials. Jones *et al*, in 1996, investigated the inhibitory effect of four eugenol containing temporary cements: *Dycal* (Caulk Dentsply, Milford, Del), *Temp-Bond* (Kerr, Romulus, Mich), *IRM* (Caulk Dentsply, ESPE Premier, Norristown, Pa), *Cavit* (ESPE Premier, Premier, Norristown, Pa) and one non-eugenol-containing *Mirage* temporary (Chamelon Dental Products, Kansas City, Kan). None of the temporary cements tested was found to have an inhibitory effect on the setting reaction of addition-cured silicones.[25]

Evaluation of mechanical methods to remove contaminants from gloves/tooth surfaces

Teeth and intra-oral soft tissues that have been in contact with latex gloves can have sulphur compound deposits and, as such, can inhibit the setting of addition-cured silicone.[10] Various methods have been suggested to remove such contaminants from tooth surfaces and gloves for prevention of inhibition, including washing of gloved hands.[19,26]

Browning *et al* tested various decontamination protocols of teeth and gingivae after being contaminated with 20 wipes of a latex glove. Decontamination methods included:

- A 30-second rinse with mouthwash and hydrogen peroxide;
- A 30-second toothbrush scrub with water, mouthwash, hydrogen peroxide; and
- A 30-second cleaning with a prophy cup and pumice.

Assessment of inhibition was subjective by wiping the impression surface with cotton-tipped applicators and visually assessing the amount of unset impression material picked up on those cotton tips. No attempt to quantify the amount of residual sulphur present on teeth and gingivae was made. Given that the amount of inhibition can be subtle and subclinical, their conclusion that inhibition may be reduced or eliminated by mechanical decontamination with toothbrush cleansing of teeth and gingivae before impression taking should be viewed with caution.[27] Work carried out by Kimoto *et al*, in 2005, demonstrated, through elemental analysis with x-ray fluorescence (XRF) spectroscopy, the remaining presence of particulate sulphur on the surface of vinyl gloves and gingival retraction cord, after being contaminated with a 5-second light rubbing with a latex glove and subsequently decontaminated using brushing with tap water, soap and cleaning with alcohol-saturated gauze.[1] Their conclusion was that removal of the contaminants from the tested vinyl gloves and gingival retraction cord was not possible with the cleansing protocols used in the study.

Conclusion

The setting reaction of addition-cured silicones may be delayed by contact with latex items such as latex gloves or latex rubber dam. The most probable cause of inhibition is the presence of a specific sulphur-containing compound used in the manufacturing process of latex gloves which interferes with the chloroplatinic acid catalyst of addition-cured silicones. The presence of this contaminant varies in different brands of latex gloves and, as such, the occurrence of this phenomenon is not universal.

Inhibition can occur directly when putty is mixed with gloved hands or indirectly when the impression material fails to set when in contact with areas previously in contact with latex. Various methods to remove contaminants with and without the use of surface surfactants have been shown to be ineffective.

A study looking at all commonly available latex brands in the UK market and their potential inhibitory effect on various brands and consistencies of polyvinyl siloxane is needed. The results of such a study would direct the general dental practitioner to the use of a polyvinyl siloxane impression material/latex item combination with no inhibitory effect. In the absence of such a study, the recommendation would be to use latex-free items in procedures involving the use of polyvinyl siloxane impression materials. The practice of the nurse mixing putty without gloves could only be recommended if rigorous hand hygiene measures have been followed prior to mixing.

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