ORIGINAL ARTICLE

The effect of various core build-up materials on the polymerization of elastomeric impression materials

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Received 22 September 2012; revised 8 November 2012; accepted 14 November 2012
Available online 25 December 2012

KEYWORDS
Dental impression material; Core build-up restorations; Polyvinyl siloxane

Abstract Objectives: The purpose of this study was to detect whether core build-up materials could be isolated as an inhibitory factor in the polymerization of commonly used types of elastomeric regular set impression materials, and to evaluate several decontamination methods to eliminate the inhibitory effect of core build-up materials.

Materials and Methods: The polymerization of six brands of elastomeric impression materials (Virtual, Aquasil, Genie, Correct Plus, Express and Impregum) was evaluated in vitro after direct contact with various core build-up materials (composite resin, flowable composites and resin-modified glass ionomers). The setting of impression materials was visually scored as either inhibited or non-inhibited independently by three different general practitioners. Different methods to prevent inhibition were also tested. The materials were dispensed according to the manufacturers’ instructions on exposed dentin of the premolar teeth mounted in dental stone. A Chi-square analysis was used to evaluate the results (p < 0.05).

Results: Setting inhibition was found with five brands of Polyvinyl siloxane impression materials when they directly contact four types of core build-up materials. None of the materials used caused inhibition to the polyether impression material. No decontamination method proved adequate in preventing impression material inhibition except grinding 1 mm from the multicore restoration surface. Examiners were in complete agreement (kappa +1).

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Peer review under responsibility of King Saud University.

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1. Introduction

Elastomeric impression materials have been gaining popularity and acceptance ever since they have been released in the market, due to their excellent physical characteristics, good dimensional stability, and ease of use. Elastomeric impression materials have found their uses in fixed and removable prosthodontics, operative dentistry, and implant dentistry.\textsuperscript{11,5,17,4,2,19}

Polyvinyl siloxane (PVS) or addition silicone is an elastomeric impression material based on the polydimethyl siloxane polymer, it usually consists of two components, a base and an accelerator or catalyst. PVSs are thought to give the greatest detail reproduction of all the impression materials\textsuperscript{4} and for that they have become the material of choice for the high precision impressions of fixed prosthodontics.\textsuperscript{17,2} Polyether is another type of elastomeric impression material which has good accuracy, it also has the advantage of hydrophilicity, but its high rigidity can be problematic especially in the presence of undercuts or thin teeth.\textsuperscript{17,5,23}

Despite its numerous advantages, impression materials come into contact directly and indirectly with many different dental materials and there is always the potential for interaction between these materials and the impression that can adversely affect its performance.\textsuperscript{13,17} It is well documented that PVS exhibits polymerization inhibition when it comes into contact with some latex gloves.\textsuperscript{11,17,4,2} Although some studies have indicated that PVS can be inhibited by retraction cord medicaments (such as: Aluminum chloride, Ferric sulfate, and Ferric subsulfate).\textsuperscript{16} Other studies have shown no inhibitory effects to retraction cord medicaments.\textsuperscript{7} A gingival retraction medicament (Hemostop, Dentsply) has shown to cause inhibition of polyether impression materials.\textsuperscript{20} PVSs also exhibited inhibition when it came into contact with Vitrebond, 3 M ESPE a resin-modified glass ionomer base.\textsuperscript{13}

Core build-up materials have been widely used in the last decade, especially when using the prefabricated posts in the endodontically treated teeth. These materials fall into three main categories: silver amalgam, composite resin, and resin-modified glass ionomers.\textsuperscript{14} The use of composite resin to restore endodontically treated teeth has increased.\textsuperscript{21,22} They have shown to be more esthetic and less time consuming than amalgam.\textsuperscript{6} Although a substantial amount of tooth structure is needed for the use of composite resin as core build-up materials, some studies have claimed that composite resin might strengthen the tooth by bonding to the tooth structure.\textsuperscript{22} Composite resin restorations even when used on the posterior teeth showed good long term outcomes, and although the survival rates are not favorable they are still relatively high.\textsuperscript{14,21} Flowable composites have been suggested as a restorative material for anterior teeth and some posterior teeth, but they should not be used in high stress locations or with excessive tooth wearing.\textsuperscript{1} Flowable composites have also been suggested to be used as core build-up materials.\textsuperscript{21} A study by Monticelli and his colleague proved that flowable composites can provide a good foundation for porcelain crowns for at least two years.\textsuperscript{12} Resin-modified glass ionomers have many advantages such as thermal expansion similar to tooth structure, decreased microleakage, chemical bond to tooth structure, and fluoride release. All of these have indicated its use as a core build-up material.\textsuperscript{13}

The polymerization inhibition is easily determined through visual examination, the material is either completely polymerized or the inhibition is immediately and obviously evident.\textsuperscript{9,8,18} The purpose of this study was to determine whether conventional composite resin, flowable composites and resin-modified glass ionomers, used as core build-up materials, could be isolated as an inhibitory factor in the polymerization of six commonly used types of elastomeric regular set impression materials.

2. Materials and methods

The polymerization of six brands of elastomeric impression materials (Table 1) was evaluated in vitro after direct contact with various core build-up materials (Table 2). The core build-up materials were dispensed according to the manufacturers’ instructions into aluminum templates of $18 \times 5$ cm. Each template has hemispherical slots arranged in 3 columns and 10 rows, with the size of each slot approximately 8 mm in diameter and 3 mm deep (Fig. 1). Each row was designated for one type of impression material, so three samples of each material were tested for one type of impression material. After the complete setting of the core build-up materials, application of the elastomeric impression materials was started after discarding its initial mix. All samples were dispensed according to the manufacturers’ instructions and handled with vinyl gloves under room temperature. Impression materials were allowed to set according to the manufacturers’ instructions multiplied by 1.5 to compensate the intraoral environment temperature. The setting of impression materials was visually scored as either inhibited or non-inhibited independently by three different general practitioners. Inhibited impression criteria: (+) An oily substance on the surface of the impression readily wiped away by a cotton swab as it is moved across

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Table 1 Elastomeric impression materials.

<table>
<thead>
<tr>
<th>Brand</th>
<th>Type</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genie</td>
<td>PVS</td>
<td>Sultan Healthcare, Hackensack, NJ</td>
</tr>
<tr>
<td>Aquasil</td>
<td>PVS</td>
<td>Dentsply, York, PA</td>
</tr>
<tr>
<td>Express</td>
<td>PVS</td>
<td>3 M ESPE, St. Paul, MN</td>
</tr>
<tr>
<td>Virtual</td>
<td>PVS</td>
<td>Ivoclar Vivadent, Schaan, Liechtenstein</td>
</tr>
<tr>
<td>Correct-plus</td>
<td>PVS</td>
<td>Pentron Clinical, Orange, CA</td>
</tr>
<tr>
<td>Impregum</td>
<td>Polyether</td>
<td>3 M ESPE, St. Paul, MN</td>
</tr>
</tbody>
</table>

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Conclusions: Based on the results of our study and for optimal results, when using Multicore composite as a core build-up material, at least 1 mm from the restoration surface should be grinded before the PVS final impressions are taken. Flowable composites should not be used as a core build-up material with PVS impression materials, so polyether is the material of choice.

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Table 2 Core build-up materials.

<table>
<thead>
<tr>
<th>Brand</th>
<th>Type</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPS Empress</td>
<td>Composite</td>
<td>Ivoclar Vivadent, Schaan, Liechtenstein</td>
</tr>
<tr>
<td>Multicore</td>
<td>Composite</td>
<td>Ivoclar Vivadent, Schaan, Liechtenstein</td>
</tr>
<tr>
<td>Tetric N-ceram</td>
<td>Composite</td>
<td>Ivoclar Vivadent, Schaan, Liechtenstein</td>
</tr>
<tr>
<td>Heliomolar Flow</td>
<td>Flowable composite</td>
<td>Ivoclar Vivadent, Schaan, Liechtenstein</td>
</tr>
<tr>
<td>Tetric N-flow</td>
<td>Flowable composite</td>
<td>Ivoclar Vivadent, Schaan, Liechtenstein</td>
</tr>
<tr>
<td>Flows Rite</td>
<td>Flowable composite</td>
<td>Pulpdent, Watertown, MA</td>
</tr>
<tr>
<td>GC Fuji II</td>
<td>Resin-modified glass ionomer</td>
<td>GC America, Alsip, IL</td>
</tr>
<tr>
<td>Riva Self Cure</td>
<td>Glass ionomer</td>
<td>SDI, Bayswater, Australia</td>
</tr>
</tbody>
</table>

Figure 1 Experimental template illustrating columns and rows, each row was designated for one type of impression material (A, B, C...), while the columns representing the number of sample per each brand (1, 2, 3), so three samples of each core build-up material were tested for one type of impression material.

Materials that caused the inhibition of elastomeric impression materials were tested for methods to prevent inhibition. These materials were dispensed according to the manufacturers’ instructions on exposed dentin of the premolar teeth mounted in dental stone. Five decontaminating methods were tested (i) Air water rinse, for 15 s followed by air drying; (ii) Mouthwash (Chlorhexidine 0.12%) scrub (iii) 3% Hydrogen Peroxide (H₂O₂) scrub (iv) Flour of pumice scrub (v) Grinding 1 mm of the external surface of the core build-up material. Methods from (ii) to (iv) were done by a brush for 10 s followed by 5 s water rinsing then air drying. One more sample group with no decontamination was used as a control group. Three types of core build-up materials that showed a strong inhibitory effect: Multicore (composite resin), Heliomolar Flow (flowable composite), and Flows Rite (flowable composite) were used in this part of the experiment. Materials were dispensed directly onto exposed dentin of the premolar teeth and were allowed to set according to the manufacturers’ instructions; afterward the appropriate decontamination methods were undertaken. Two (PVS) impression materials (Correct Plus and Virtual) were used and dispensed directly onto the sample surface and were allowed to set according to the manufacturers’ instructions multiplied by 1.5. The setting of impression materials was visually scored as either inhibited or non-inhibited independently by three different general practitioners with the same criteria used before. Statistical analysis of the data was done using SPSS program for Windows (version 16.0). A Chi-square analysis compared inhibited/non-inhibited samples within core build-up materials. Intere-xaminer reliability data were analyzed with the kappa correlation analysis.

3. Results

All tested elastomeric impression specimens were polymerized consistent with the manufacturers’ instructions when not in contact with any core build-up materials as a negative control. Latex gloves were used as the positive control with PVS. All tested elastomeric impression materials were also polymerized when in contact with IPS Empress Tetric N-ceram (composite resin), Fuji II (resin-modified glass ionomers) and Riva (glass ionomer) with no effect. An oily substance readily wiped away with a cotton swab was shown between Genie (PVS), Heliomolar and Tetric N Flow (flowable composites). The same effect was shown between Aquesil (PVS), Multicore (composite resin), Heliomolar, Tetric N Flow and Flows Rite (flowable composites). More prominent degree of inhibition was observed as an oily substance on the surface of the impression readily collected by a cotton swab as it is moved across the impression surface between Express (PVS) and two types of flowable composites (Heliomolar and Tetric N flow). Four types of PVS (Genie, Express, Virtual and Correct plus) showed unpolymerized impression material that adhered to the sample surface when in contact with Multicore (composite resin) and Flows Rite (flowable composite) (Fig. 2). Correct Plus and Virtual (PVS) showed the same results when in contact with Heliomolar (flowable composite). Polymer impression material (Impregum) showed no inhibition with all types of core build-up materials (Table 3). A Chi-square analysis compared inhibited/non-inhibited samples within core build-up materials and the total revealed a significant difference between the brands ($p < 0.05$). Examiners were in complete agreement (kappa $+1$).

In the decontamination part, after application of the core build-up materials on exposed dentin of the premolar teeth, the designated decontamination methods were carried out, unpolymerized impression material adhered to the sample surface after direct contact with the core build-up surface (Fig. 3). Gridding 1 mm from the external surface of the Multicore (composite resin) build-up material proved as the only adequate decontamination method (Fig. 4). Otherwise no decontaminating methods were sufficient to prevent the inhibitory effect of the test core build-up materials.
4. Discussion

Previous studies have reported the possibility for inhibition of elastomeric impression materials with some dental materials, inhibition of polymerization of PVS impression materials after direct contact with latex, and some of the retraction cord medicaments such as ferric sulfate are well known. Other studies were done with provisional luting agents, base/core materials, and dentin bonding agents. No studies showed a significant inhibitory effect of elastomeric impression materials after direct/indirect contact with core build-up materials such as flowable composite.

Studies have claimed that the oxygen-inhibited layer that appears on the surface of polymerized resins leads to inhibition of the PVS impression materials. This statement can be refuted based on the lack of inhibition of the PVS when in contact with conventional composite resin. Also, the oxygen inhibited is up to 40 Microns deep, and in this study 1 mm has been removed from the surface of the materials and yet the inhibition was still observed.

Flowable composite is indicated mainly for conservative restorations, it can also be used as a core build-up material with physical properties comparable to that of conventional composite. Monticelli et al. demonstrated that flowable composites can serve as a foundation for porcelain crowns for at least two years.

With evidence that favors the use of flowable composite as a core material, one should always keep in mind the

<table>
<thead>
<tr>
<th>Table 3 Results.</th>
<th>Core build-up materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impression materials</td>
<td>IPS empress</td>
</tr>
<tr>
<td>Genie</td>
<td>–</td>
</tr>
<tr>
<td>Aquasil</td>
<td>–</td>
</tr>
<tr>
<td>Express</td>
<td>–</td>
</tr>
<tr>
<td>Virtual</td>
<td>–</td>
</tr>
<tr>
<td>Correct Plus</td>
<td>–</td>
</tr>
<tr>
<td>Impregum</td>
<td>–</td>
</tr>
</tbody>
</table>

– Non-inhibitory.  
+ Oily substance readily wiped away with cotton swab.  
++ Oily substance readily collected on a cotton swab as it is moved across the impression surface.*  
+++ Unpolymerized impression material adherent to the prepared sample surface and collected on a cotton swab.**  
*, ** (Pearson’s Chi square, p < 0.05).
inhibitory effect it has on PVS. Unfortunately none of the decontamination methods used in this study proved useful in preventing inhibition. Reconsideration of the selected PVS material is advised.

Furthermore, all the tested elastomeric impression specimens were polymerized consistent with the manufacturers’ instructions when not in contact with any core build-up materials as a negative control, while the latex gloves were used as the positive control which showed Unpolymerized impression material adherent to the sample surface and collected on a cotton swab.

Multicore is a fluoride containing composite resin filler, its physical properties have been improved to allow its use as a core build-up material. In this study, Multicore has shown a significant inhibitory effect on PVS. Decontamination of Multicore material should be done prior to impression taking; this can be achieved by grinding 1 mm of the surface of the material, while Polyether showed stable polymerization when contacting all core build-up materials.

The actual contaminant could not be determined, and the different results seen with relatively similar materials increase the difficulty in isolating the causative agent. More studies are needed to identify the main contaminant and further understand and prevent this phenomenon.

5. Conclusion

Under these in vitro conditions, the direct contact of polyvinyl siloxane impression materials to some types of core build-up materials (Flowable composite and multicore) resulted in polymerization inhibition. Grinding 1 mm form the core build-up surface as a decontamination method showed success in preventing the inhibitory effect of Multicore restorations only. Based on the results of our study and for optimal results, when using Multicore composite resin as a core build-up material, at least 1 mm from the restoration surface should be grinded before the PVS final impressions are taken. Flowable composites should not be used as a core build-up material with PVS impression materials, so polyether is the material of choice. More research is needed to identify the main contaminant and prevent inhibition.

Acknowledgment

The authors would like to thank Dr. Jagan Kumar for his assistance in biostatistics. Grateful thanks to Mr. Muath Al-Dosari for his assistance in photography.

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