The effect of various interim fixed prosthodontic materials on the polymerization of elastomeric impression materials

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Statement of problem. After tooth preparation, interim fixed prosthodontic materials are used to fabricate interim restorations until the definitive restoration can be delivered. The polymerization of elastomeric impression materials may be inhibited when in indirect contact with interim fixed prosthodontic materials.

Purpose. The purpose of this study was to detect whether the polymerization of 6 commonly used types of elastomeric impression materials was affected by direct contact with 6 commonly used interim fixed prosthodontic materials and to further evaluate the efficacy of several decontamination methods to eliminate the indirect effect of the interim fixed prosthodontic materials on the setting of elastomeric impression materials.

Material and methods. Six brands of elastomeric impression material (Virtual, Aquasil, Genie, Correct Plus, Express, Impregum) were evaluated in vitro after direct contact with various interim fixed prosthodontic materials (Trim Plus, Unifast, Integrity, Systemp C&B, Tuff-Temp, Protemp IV) by 3 general practitioners. The setting of the impression materials was visually scored as either inhibited or noninhibited. Latex was used as a positive control. The decontamination part of the study was done indirectly on the dentin of prepared natural teeth after they had been relined with the interim fixed prosthodontic material. The decontamination methods were air-water rinse, mouthwash (chlorhexidine 0.12%), 3% hydrogen peroxide, and pumice. A Kruskal-Wallis nonparametric analysis was used to evaluate the results.

Results. Statistically significant setting inhibition was found with 5 brands of polyvinyl siloxane impression materials with all tested types of interim fixed prosthodontic material ($P<.001$) except Trim Plus. No tested interim fixed prosthodontic material caused inhibition with the polyether impression material, except for minimal inhibition with Protemp IV. The decontamination method performed with 3% H_2O_2 alone proved adequate in preventing impression material inhibition. Interexaminer reliability data were analyzed with the kappa correlation analysis. The examiners were in complete agreement (kappa +1).

Conclusion. Under these in vitro conditions, the direct contact of polyvinyl siloxane impression materials to some brands of interim fixed prosthodontic materials resulted in polymerization inhibition. Of the decontamination methods tested, only 3% H_2O_2 showed efficacy in preventing the inhibitory effect of the interim fixed prosthodontic material. For optimal results, definitive impressions should be made before the prepared tooth is exposed to an interim fixed prosthodontic material. (J Prosthet Dent 2014;112:176-181)

Clinical Implications

Polymerization inhibition occurs with polyvinyl siloxane impression materials when in direct or indirect contact with interim fixed prosthodontic materials. Successful definitive impressions with polyvinyl siloxane impression materials can be obtained by delaying the exposure of teeth and tissue to interim fixed prosthodontic material until the definitive impression is made or by decontaminating the exposed surfaces with 3% H_2O_2 for 10 seconds then water rinsing for 5 seconds.

In prosthodontics, impression materials have an important role in recording the intraoral anatomy for the fabrication of definitive prostheses. The quality of the restoration depends on the accuracy of the tooth preparation, the dimensional stability of the impression material, and the impression methodology as influenced by the intraoral and extraoral interaction with various prosthodontic materials.[1] An appropriate duplication of the negative

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likeness of the reduced tooth structure with accurate surface details will result in the optimal marginal adaption and fit of the definitive restoration.[2]

Among many impression materials used for recording the definitive impression, the elastomeric impression materials have gained wider acceptance because of their excellent mechanical properties and dimensional accuracy.[3] Detrimental effects on the dimensional stability of the casting for restorative procedures is evidenced when partial or incomplete polymerization of the elastomers occurs.[4,5] The inhibition of the polymerization of elastomeric impression materials has been studied in relation to rubber dam material[6]; cements, including zinc-oxide eugenol[7] and glass ionomers[8]; gingival displacement cords and medicaments[9-12]; dentin bonding agents[13]; flowable composite resins[14,15]; and direct and indirect contact with latex gloves.[6,16,17] Interim restorations should provide a predictable functional and esthetic interim prosthesis.[7] The choice of the best material is complicated because of the many brands available, their differing properties, and the possibility of interaction with the definitive impression material.[3] Research is lacking on the interaction of elastomeric impression materials with interim fixed prosthodontic materials. Based on clinical observations, the purpose of this study was to assess a possible interaction of interim fixed prosthodontic materials and impression materials, and the influence of decontamination in the overall process. The null hypothesis tested was that no difference exists between the polymerization reaction of elastomeric impression materials and the type of interim fixed prosthodontic material used.

Table I. Elastomeric impression materials

Brand	Type	Manufacturer
Genie	Polyvinyl siloxane	Sultan Healthcare
Aquasil	Polyvinyl siloxane	Dentsply Intl
Express	Polyvinyl siloxane	3M ESPE
Virtual	Polyvinyl siloxane	Ivoclar Vivadent
Correct Plus	Polyvinyl siloxane	Coltène/Whaledent
Impregum	Polyether	3M ESPE

Table II. Interim fixed prosthodontic materials

Brand	Type	Manufacturer
Trim Plus	Poly(ethyl methacrylate)	Harry J. Bosworth Co
Integrity	Bis-acryl	Dentsply Intl
Tuff-Temp	Rubberized urethane	Pulpdent
Systemp C&B	Bis-glycidyl methacrylate	Ivoclar Vivadent
Unifast	Poly(methyl methacrylate)	GC America
Protemp IV	Bis-acryl	3M ESPE

1 Experimental design. Each column was designated for 1 type of interim fixed prosthodontic material (A-J), whereas the rows represent the number of specimens for each brand of impression material (1-3). Three specimens of each interim fixed prosthodontic material were tested against 1 type of impression material.

MATERIAL AND METHODS

Polymerization inhibition test

An in vitro study was designed to evaluate and compare the polymerization of 6 different brands of elastomeric impression materials (Table I) when in direct contact with 6 commonly used interim fixed prosthodontic materials (Table II). A specially fabricated 18×5-cm aluminum template (Fig. 1) with a specimen space 8 mm in diameter and 3 mm deep was used to test and analyze the polymerization of the elastomeric impression materials. The template design had hemispheric slots aligned in 3 columns and 10 rows. The aluminum templates were cleaned with an aluminum cleaning agent (Aluma Wash; Winsol Laboratories), washed under running distilled water, and air-dried before use. A visual method of evaluating the polymerization inhibition of the impression materials was based on previous studies that revealed that inhibition of polymerization is immediately evident as unset residue or partially polymerized impression material, which can be distorted by scraping with a blunt instrument.[6,7,18,19] Assigning 1 type of elastomeric impression material to each template, 3 specimens of each interim fixed prosthodontic material were dispensed in each row and tested against a single impression material. Each type of elastomeric impression material was tested 3 times, which results in 9 specimens of each type of interim fixed

prosthodontic material tested against 1 type of elastomeric impression material. Latex was used as a positive control and empty template wells as negative controls. Care was taken to handle the materials only with vinyl-gloved hands at room temperature. The initial compound of the elastomeric impression mix was discarded to eliminate any possible early unmixed impression material.

The interim fixed prosthodontic materials were manipulated in accordance with the manufacturer's instruction and dispensed into the template wells. The impression materials were then directly applied to the surface of the interim fixed prosthodontic materials. The setting time was predetermined to be, as per the manufacturer's instruction, multiplied by 1.5 to compensate for the intraoral environment temperature and to ensure adequate time for polymerization before the impression material was evaluated.

The degree of polymerization was subjectively and visually scored by 3 separate experienced general practitioners. The examiners were instructed to score according to an original scale developed by previous studies on polymerization inhibition.[6,7,18,19] The observation was subjectively categorized as inhibited ("+," the appearance of an oily uncolored substance on the surface of the impression readily removed with a cotton swab; "++," an oily colored substance readily collected by the cotton swab when it was moved across the surface; "+++," unpolymerized impression material adherent to the specimen surface and collected on a cotton swab) or noninhibited, depending on the criteria in Table III. The observations were made at the time of polymerization inhibition; however, the scoring was done independently to avoid examiner bias.

Inhibition decontamination test

A total of 24 sound human premolar teeth mounted in dental stone were used to assess the influence of the impression decontamination methods.[13] Each tooth was prepared for a complete coverage crown by removing 1.5 mm from the occlusal and each axial surface with a round-ended, medium-grit, tapered diamond rotary cutting instrument (856.31.016; Brasseler USA). The pretested methods included an air-water rinse for 15 seconds, followed by air-drying, mouthwash, chlorhexidine 0.12% (GlaxoSmithKline), 3% hydrogen peroxide (H_2O_2) (Essential Oxygen), and pumice (mechanical). The interim fixed prosthodontic materials were directly dispensed onto the exposed dentinal surface of the premolars by using a prefabricated aluminum crown as a carrier and were allowed to completely polymerize. After complete polymerization, the interim crown was removed. Three teeth for each group were tested against 1 type of elastomeric impression material with 1 decontamination method after relining with the interim fixed prosthodontic material. Water was tested by using a water spray wash for 15 seconds then air-drying. Chlorhexidine 0.12%, 3% H_2O_2, and pumice were applied with a brush for 10 seconds. The teeth were then washed for 5 seconds and air-dried. Two elastomeric impression materials (Correct Plus [Coltène Whaledent] and Virtual [Ivoclar Vivadent]) were tested against Systemp C&B (Ivoclar Vivadent). These interactions had previously shown evidence of inhibition. The impression materials were dispensed directly onto the specimen surface and then allowed to polymerize for 1.5 times the manufacturer's recommendation to assure complete polymerization before assessment. The 3 independent evaluators scored the polymerization visually as either inhibited or noninhibited based on the previously described scoring criteria (Table IV). The data collected were tabulated and analyzed. Significance was calculated with the Kruskal-Wallis nonparametric analysis with software (SPSS for Windows, version 19.0; IBM). The analysis compared the different specimens of inhibited and noninhibited interim fixed prosthodontic material. The kappa correlation analysis determined the interexaminer reliability.

TABLE III. Elastomeric impression material inhibition

	Interim Prosthodontic Materials							
Impression Materials	**Trim Plus**	**Integrity**	**Tuff-Temp**	**Systemp C&B**	**Unifast**	**Protemp IV**	**-ve Control**	**Latex**
Polyvinyl siloxane								
Genie	-	+++	++	++	+	+	-	+++
Aquasil	-	++	+	++	-	++	-	+++
Express	-	++	+	+	-	++	-	+++
Virtual	-	+++	+++	+++	-	++	-	+++
Correct Plus	-	+++	+++	+++	+	+++	-	+++
Polyether								
Impregum	-	-	-	-	-	+	-	-

-, noninhibitory; +++, unpolymerized impression material adhered to prepared specimen surface and collected on cotton swab; ++, oily colored substance readily collected on cotton swab as it was moved across impression surface; +, oily uncolored substance readily wiped away with cotton swab.
[a]-, +, ++, +++ Statistically significant difference among groups, $P<.001$.

RESULTS

Polymerization inhibition

All the elastomeric impression materials polymerized in the specified setting period when not in contact with the interim fixed prosthodontic materials. An interobserver reliability of 100% was found among the 3 examiners in assessing the polymerization inhibition. A Kruskal-Wallis analysis compared the inhibited and noninhibited specimens of the different interim prosthodontic materials and revealed an overall significant difference among the brands ($P<.001$). Interexaminer reliability data were analyzed with the kappa correlation analysis. The examiners were in complete agreement (kappa + 1).

The null hypothesis was not rejected with Trim-Plus (poly[ethyl methacrylate]), whereas only mild inhibition was experienced with polyvinyl siloxane (Genie and Correct Plus) and Unifast (poly[methyl methacrylate]). Polyether proved to cause no inhibition with any of the interim fixed prosthodontic materials, except for a negligible effect with Protemp IV (bis-acryl); an oily substance on the surface of the impression was readily removed when wiped with a cotton swab. Correct Plus and Virtual exhibited a more prominent degree of inhibition as unpolymerized impression material adhered to the specimen surface and was collected on a cotton swab in 4 different types of interim fixed prosthodontic materials (Integrity, Systemp C&B, Tuff- temp, and Protemp IV). Incidentally, the interim fixed prosthodontic materials branded as Systemp C&B and Protemp IV displayed a level of inhibition polymerization similar to polyvinyl siloxane (Aquasil and Express). In contrast, Integrity and Tuff-Temp showed minimal inhibition (Table III).

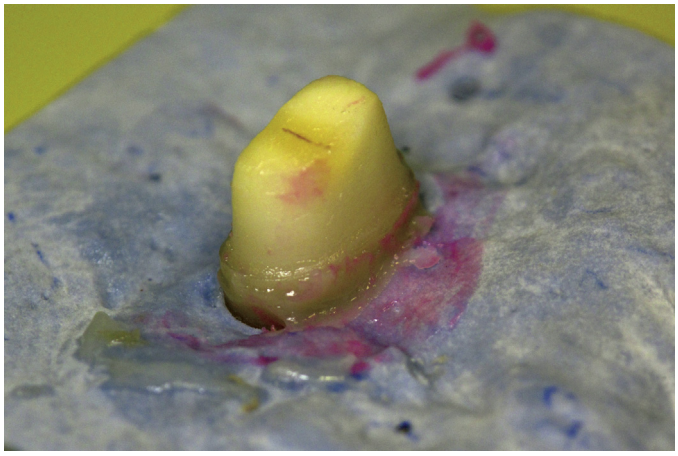
Inhibition decontamination

In the progressive assessment of the effect of the decontaminants on polymerization, strong inhibition was observed on the impression surface with the presence of unpolymerized material on the decontaminated premolar relined with Systemp B&C (bis-glycidyl methacrylate) (Figs. 2, 3). Effective decontamination was only achieved by scrubbing with 3% H_2O_2 for 10 seconds, washing for 5 seconds, and air-drying ($P<.001$) (Fig. 4). All other methods of decontamination proved unsatisfactory (Table IV).

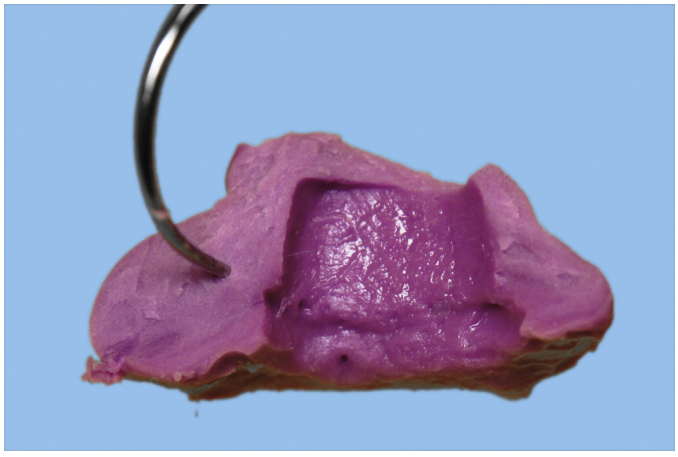
Table IV. Effect of decontamination on elastomeric impression material inhibition

	Virtual	Correct Plus
Systemp C&B–water	+++	+++
Systemp C&B–chlorhexidine	+++	+++
Systemp C&B–hydrogen peroxide	-[a]	-[a]
Systemp C&B–pumice	+++	+++

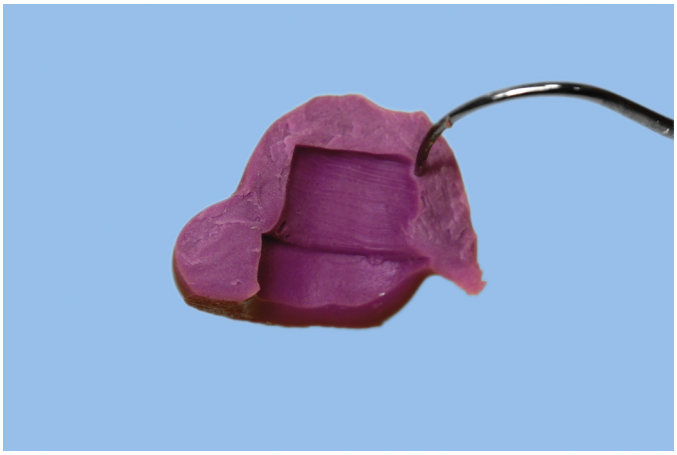
+++, unpolymerized impression material adhered to prepared specimen surface and collected on cotton swab; -, noninhibitory.
[a]Statistically significant difference, $P<.001$.



2 Unpolymerized polyvinyl siloxane impression material adheres to tooth surface in contact with Systemp C&B interim prosthodontic material during interim restoration fabrication.



3 Inner surface of polyvinyl siloxane impression material, showing unpolymerized rippled surface after direct contact with tooth surface in contact with Systemp C&B interim fixed prosthodontic material during interim fabrication.



4 Inner surface of polyvinyl siloxane impression material after direct contact with tooth surface decontaminated with 3% hydrogen peroxide (H_2O_2), showing successful prevention of polymerization inhibition.

DISCUSSION

This in vitro study demonstrated the polymerization inhibition of polyvinyl siloxane impression materials after direct and indirect contact with certain interim fixed prosthodontic materials. Therefore, the null hypothesis was rejected. Conventionally, a range of restorative materials are observed to interact with elastomeric impression materials. Earlier prosthodontic studies have reported the inhibition of polymerization of polyvinyl siloxane in interaction with latex[16,17] and with impregnated gingival displacement cord.[9-12] Studies have also been performed to investigate the interaction of interim luting materials,[7] restorative cements,[8] and dentin bonding agents.[13] Recent studies have also evaluated the inhibited polymerization of polyvinyl siloxane impression materials when in direct or indirect contact with flowable composite resins.[14,15] Polyether has been found to interact with hemostatic agents, for example, Hemostop, and produce undesirable effects.[12] However, the interaction of elastomeric impression materials through direct and indirect contact with interim prosthodontic materials has not been previously reported.

The inhibition of polymerization varied among the elastomeric impression materials when in contact with the tested interim fixed prosthodontic materials. A strong polymerization inhibition of polyvinyl siloxane impression materials was demonstrated when in direct contact with bis-acryl, bis-glycidyl methacrylate, or rubberized urethane prosthodontic interim materials. However, only a negligible level of inhibition was observed with poly(methyl methacrylate) and poly(ethyl methacrylate) when directly interacting with the polyvinyl siloxane. Further, polyether impression materials had stable polymerization reactions, with no major influence of contact with the tested interim prosthodontic materials.

The actual contaminant that causes polymerization inhibition is not well known. One possible explanation of polymerization inhibition is the presence of an oxygen inhibited layer appearing on the surface of the polymerized resins.[8,20] However, a contradictory opinion conceived through previous studies excludes an oxygen-inhibited layer as the contaminant that causes inhibition.[15,20,21] Polymerization inhibition does not occur when in contact with the oxygen-inhibited layer that covers the surface of conventional composite resin.[15] The oxygen reported to inhibit polymerization is reported to be 40 μm deep; however, even when 1 mm of the resin surface material was removed, the observation of inhibition was still evident.[20,21]

Commonly practiced methods of decontamination such as rinsing with mouthwash, or washing with an air-water syringe, or scrubbing the surface with pumice have proved ineffective. Only scrubbing the contaminated tooth surface with 3% H_2O_2 proved effective. Definitive impressions planned with polyvinyl siloxane impression materials should be scheduled before the fabrication of the interim prosthodontic material. In situations in which the interim crown is made before the impression, preferred decontamination by 3% H_2O_2 ahead of impression making is ideal to avoid polymerization inhibition; or polyether must be the material of choice. One limitation of this in vitro study was the inability to ensure the blindness of the investigators during visual scoring because of the different colors of different brands of impression materials. Another limitation was the inability to quantify the extent of polymerization inhibition because of the subjective nature of the scoring method used to identify its presence. The actual contaminant that causes polymerization inhibition could not be determined. Additional studies are needed to identify the chief contaminant and to avoid the problem.

CONCLUSIONS

Within the limitations of this in vitro study, the polymerization inhibition of polyvinyl siloxane impression materials occurred when in direct contact with bis-acryl, bis-glycidyl methacrylate, and rubberized urethane interim materials. Polymerization inhibition was only removed by decontaminating the tooth surface with 3% H_2O_2.

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