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Featured Article

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Vinyl Siloxanether Elastomeric
Impression Material

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Accuracy of the newly formulated vinyl siloxanether elastomeric impression material

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Statement of problem. A newly formulated vinyl siloxanether elastomeric impression material is available, but there is little knowledge of its accuracy in relation to existing materials.

Purpose. The purpose of this in vitro study was to assess the accuracy of disinfected vinyl siloxanether impressions and compare the accuracy to a common vinyl polysiloxane and a polyether impression system.

Material and methods. Impressions were made from a modified dentoform master model containing a simulated crown preparation. Dimensional changes (mm) between the master model and working casts (type IV gypsum) were assessed. The following were evaluated: vinyl polysiloxane in a 1-step, dual-viscosity technique (VPS Dual), polyether as monophase material (PE Mono), and vinyl siloxanether in a 1-step, dual-viscosity (VSE Dual), and monophase technique (VSE Mono). Measurements of the master model and working casts, including anteroposterior (AP) and cross-arch (XA) dimensions, were made with a measuring microscope. The simulated crown preparation was measured in mesiodistal (MDG, MDO), buccolingual (BLG, BLO), and occlusogingival dimensions (OGL, OGB). Disinfection involved immersion for 10 minutes in potassium peroxomonosulfate, sodium benzoate, tartaric acid solution, or no disinfection (control) (n=8). A multivariate GLM statistical approach (MANOVA) was used to analyze the data (α=.05). Pearson's correlation test was used for related dimensions.

Results. The AP and XA dimensions of working casts were larger than the master for the disinfected condition and control. Whether disinfected or not, the working dies were shorter in height (OGB, OGL), larger in the buccolingual dimension (BLO, BLG), somewhat larger in the MDO dimension, and somewhat smaller in the MDG dimension compared to the prepared tooth of the master model, resulting in an irregular or oval profile. There were significant differences among the impression systems for each dimension except AP. Differences between the disinfected and nondisinfected conditions were significant (*P*=.03) with respect to dimensions of the gypsum working cast, but not for dimensions of the working die (*P*=.97). In general, differences relative to the master were small and of minor clinical significance considering marginal gaps of crowns smaller than 150 -100 µm are considered clinically acceptable.

Conclusions. VSE monophase impressions and VSE dual-viscosity impressions demonstrated acceptable accuracy for clinical use with immersion disinfection, since the results for VSE were comparable to the results for PE and VPS materials, and the differences as compared to the master model were small. (J Prosthet Dent 2010;103:228-239)

Clinical Implications

The overall accuracy of the new vinyl siloxanether, as well as the polyether and vinyl polysiloxane, was high with immersion disinfection. The clinical impact of detected differences is considered to be minor. To compensate for shorter working dies, additional die spacer can be applied to the occlusal surface of working dies.

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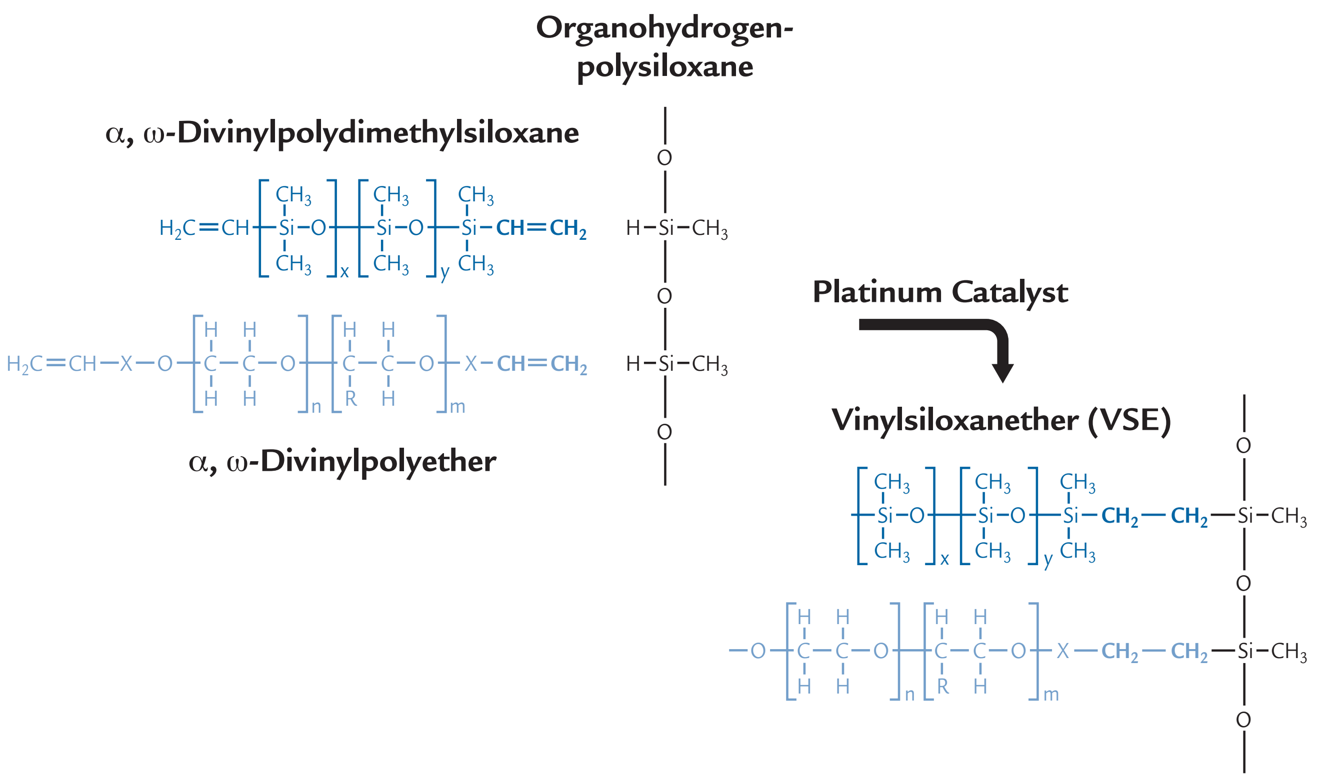
Impression making is an important step in the complex process of fabricating a well fitting indirect prosthetic restoration. Accuracy of the impression material, in terms of both dimensional accuracy and detail reproduction, is an essential prerequisite for a successful impression. Despite technical improvements in the field of computer-aided design/computer-aided manufacturing (CAD/CAM) systems and 3-dimensional (3-D) imaging procedures, the conventional impression process still has a role in transferring information from the patient to the dental laboratory.

Accuracy of the impression is influenced by a number of clinical parameters, such as periodontal status, oral hygiene, and location of the preparation finish lines.[1-3] The impression technique, impression tray, and properties of the impression material also contribute to the accuracy of the impression.[1,2,4-11] The significance of other clinical factors relative to accuracy, such as tooth mobility,[12] mandibular deformation during opening,[13,14] and factors related to laboratory processes, should also be considered when fabricating prosthetic restorations.[15,16] For instance, it was found in a clinical study that the mean cement thickness under crowns was between 109 and 310 μm.[17] Some authors define clinically acceptable values for the marginal gap of crowns to be smaller than 150 μm,[18] others, smaller than 100 μm.[19,20]

Common clinical techniques used in the impression process have also been investigated, and potential consequences have been reported. Variables that have been compared include monophase versus dual-phase materials,[1,4,5] 1-stage versus 2-stage impressions,[2] polyether versus vinyl polysiloxane materials,[4-6] fast-setting versus regular-setting materials,[6,7] stock versus custom impression trays,[8-10] stock versus dual-arch trays,[11,21] metal versus disposable plastic trays,[22,23] and methods of mixing impression materials.[24] The effects of disinfection on the accuracy of different impression materials have also been investigated.[4-7,24-27]

A number of impression materials are commercially available. Two widely used materials are vinyl polysiloxane (also called addition silicone) and polyether. The accuracy and dimensional stability of vinyl polysiloxane and polyether is well documented.[1,2,4-9,11,21-23,25-30] Recently, a new impression material, classified as a vinyl siloxanether by the manufacturer, has been made commercially available. This material has been purported by the manufacturer to possess good mechanical and flow properties, along with excellent wetting characteristics in the unset condition when applied to the prepared tooth, and also in the set condition. The chemical formulation as provided by the manufacturer is illustrated in Figure 1. Enhancement of hydrophilicity may influence the accuracy of impressions[30] and can result in improved flow[31-33] and finer detail[1] of impressions made on moist dentinal surfaces and in the area of the gingival sulcus. The accuracy of the new vinyl siloxanether has not been established, and is needed, given the new and novel formulation. The effect of disinfection on the new material must also be established.

The objective of this in vitro study



1 Chemical formulation of vinyl siloxanether (VSE), as provided by manufacturer.

was to assess the accuracy of disinfected vinyl siloxanether impressions and compare the accuracy to a common vinyl polysiloxane and a polyether impression system. Although not of clinical importance, nondisinfected controls were also evaluated to note the effect of immersion disinfection on the impression materials. The primary null hypothesis was that there would be no differences in the accuracy of gypsum casts and working dies among 4 impression systems, primarily for the disinfected condition. Accuracy was evaluated for several clinically important aspects, such as the distance between left first molar to central incisors, the distance between left first molar to right first molar, and height and cross-section dimensions of a working die. The secondary null hypothesis was that impression systems would not be affected by immersion disinfection.

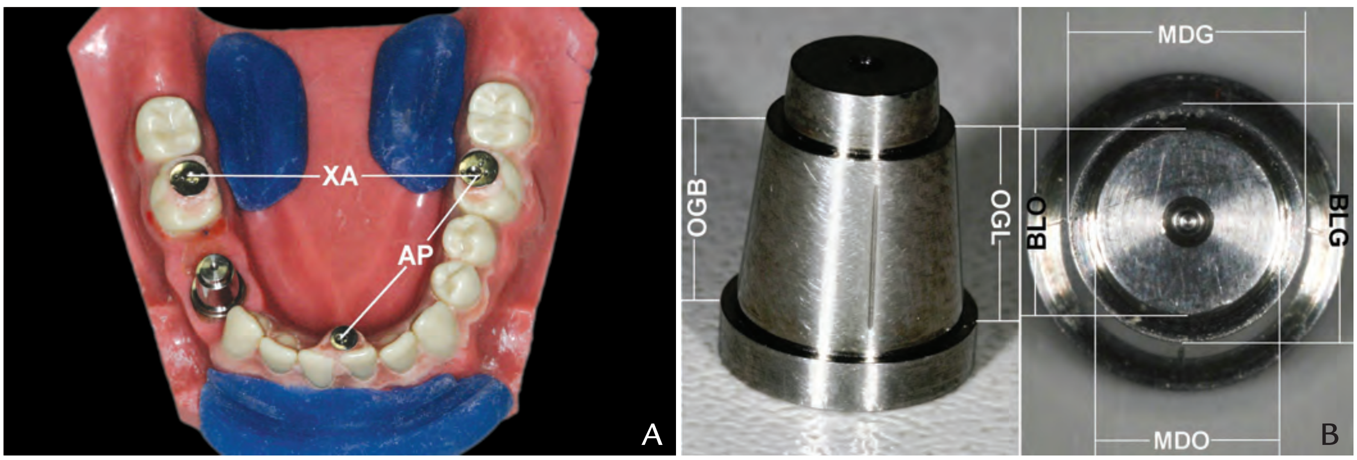
MATERIAL AND METHODS

The accuracy of 3 different types of impression material was assessed indirectly by measuring several clinically relevant dimensions on gypsum casts obtained from impressions of a master model. The master model, consisting of a mandibular arch of a typodont (model 1362; Columbia Dentoform Corp, Long Island City, NY) with some modifications, was similar to that used in previous studies.[5,6,26] The master model contained machined stainless steel inserts on the occlusal surface of both first molars and on the lingual surface of the central incisors. These metal elements provided reference points for measuring cross-arch and anteroposterior dimensions (Fig. 2, A). Additionally, the master model contained a removable, simulated stainless steel crown preparation in the position of the mandibular right first premolar. The crown preparation was machined with a 12-degree angle of convergence and with defined gingival and occlusal shoulder finish lines, which served as reference marks for measurement (Fig. 2, B).

The dimensions measured on the master model were (1) anteroposterior (AP), from left first molar to a point lingual of both central incisors, and (2) cross-arch (XA), from left first molar to right first molar. Individual measurements on the master model preparation and working dies were (3) mesiodistal (MDG) and (4) buccolingual (BLG) across the gingival shoulder of the master die; (5) mesiodistal (MDO) and (6) buccolingual (BLO) across the occlusal shoulder of the master die; and (7) the occlusogingival height of the master die on the lingual side (OGL) and (8) the buccal side (OGB).

The 3 types of impression materials evaluated in this study were the newly formulated vinyl siloxanether (VSE) (Identium; Kettenbach GmbH, Eschenburg, Germany), vinyl polysiloxane (VPS) (Aquasil Ultra; Dentsply Caulk, Milford, Del) and polyether (PE) (Impregum Penta; 3M ESPE, St. Paul, Minn). Two impression material combinations used the 1-step, dual-viscosity technique, and 2 used the 1-step monophase technique. All are listed in Table I, along with their ISO 4823-2000[34] viscosity designation, the impression technique used, the respective working and setting times, and batch numbers.

For each material, the recommended tray adhesive was used: Identium Adhesive (Kettenbach GmbH), Polyether Adhesive (3M ESPE), or Silfix (Dentsply Caulk). Metal, nonperforated stock trays with retentive rims (Ergolock 411 XL/1; Omnident GmbH, Rodgau, Germany) were used to make all impressions. To standardize the seating position and centering of the trays when making impressions, acrylic resin positioning devices (Individo Lux; VOCO GmbH, Cuxhaven, Germany) were fabricated, as shown in Figure 2, A. All impressions were



2 A, Occlusal view of modified typodont master model with simulated crown preparation. Illustrated are occlusal reference areas and anteroposterior (AP) and cross-arch (XA) dimensions measured on master model and on working casts. Blue acrylic positioning devices allow standardized seating of tray and similar thickness of impression material. B, Working die of simulated crown preparation in which occlusogingivobuccal (OGB) and occlusogingivolingual (OGL), buccolingual (BLO) and mesiodistal (MDO) at occlusal part of master die, and buccolingual (BLG) and mesiodistal (MDG) distances at gingival part of master die reference areas and distances are shown. Same dimensions were measured on gypsum working dies.

Table I. Impression materials evaluated

Impression Systems Evaluated	Type of Material, Impression Technique	Manufacturer	ISO 4823-2000 Viscosity/Type	Impression Technique	Working/ Setting Time (min:s)	Batch No.
Identium Heavy	VSE Dual	Kettenbach GmbH	Heavy/1	single step dual viscosity	2:00/5:30	80721-06
Identium Light			Light/3		2:00/5:30	80011
Identium Medium Soft	VSE Mono	Kettenbach GmbH	Medium/2	single step monophase	2:00/5:30	80701-04
Impregum Penta Soft	PE Mono	3M ESPE	Medium/2	single step monophase	2:45/6:00	341220 332341
Aquasil Ultra Heavy Deca	VPS Dual	Dentsply Caulk	Medium/2	single step dual viscosity	2:30/5:00	0809151
Aquasil Ultra LV			Light/3		2:30/5:00	080901

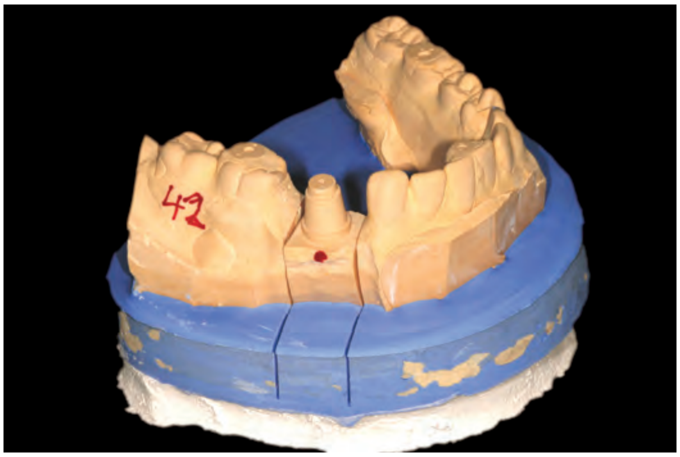
VSE: vinyl siloxanether; PE: polyether; VPS: vinyl polysiloxane

made by a single investigator.

The heavy-body and medium-body impression materials were mixed using automatic dispensing and mixing systems (for VSE: Plug & Press Dispenser; Kettenbach GmbH, and for VPS and PE: Pentamix 3; 3M ESPE). The light-body materials were dispensed and mixed by the recommended hand-mixing dispenser system. When the 1-step, dual-viscosity impression technique was used, the light-body material was injected around the master model preparation and onto the occlusal reference points of the master model. Thereafter, the tray, filled with heavy- or medium-body material, was placed onto the dental arch using the positioning device for alignment. The same procedure was used for the monophase or single-viscosity impression technique. All materials were mixed at room temperature (25°C) and placed within the working time recommended by the manufacturer (Table I). The impressions were allowed to polymerize approximately 3 times longer (15 minutes) than the time recommended by the manufacturer to ensure adequate polymerization occurred at room temperature.[6]

For each of the 4 impression systems evaluated, 16 impressions were made, of which 8 were disinfected by immersion and 8 were not. A solution containing potassium peroxomonosulfate, sodium benzoate, and tartaric acid (Silosept; Kettenbach GmbH) was used for disinfection. After the impressions were removed from the master model, they were rinsed for 10 seconds under running water to simulate saliva and blood removal, and then air dried. The nondisinfected impressions were left for 120 minutes before forming gypsum casts. The impressions within the disinfection group were immersed in disinfectant for 10 minutes, then rinsed again for 10 seconds under running water, air dried, and left in ambient air for an additional 110 minutes before cast fabrication.

Type IV gypsum (Tewerock; Kettenbach GmbH) was used to form the working casts and dies. The recommended ratio of 20 ml of distilled water to 100 g of powder was used, and the amount of gypsum was standardized by using prepackaged units of powder and a dosing system (DSW 2-1; Wassermann Dental Maschinen GmbH, Hamburg, Germany). The powder and water was first mixed by hand for 10 seconds, then vacuum mixed (Multivac 4; Degussa GmbH, Hanau, Germany) for an additional 30 seconds. The gypsum was vibrated into the impressions for the first pour and allowed to set for 60 minutes before the second pour of type IV gypsum was mixed and placed (Picodent S 120 base stone; Picodent, Wipperfürth, Germany). To allow for removal of the gypsum die, a stone-stone separator (Isofix 2000; Renfert GmbH, Hilzingen, Germany) was painted over the appropriate area of the working die. With boxing in place, the base was formed. The casts were



3 Example of gypsum working cast and removable die. Cast has been leveled with fast-setting gypsum so that all 3 reference points are in plane parallel to table top. This facilitates AP and XA measurement on measuring microscope. Dot on buccal surface of working die served as orientation reference point.

left in a vented environment at room temperature for 24 hours to dry after being removed from the impressions.

For ease of measurement of the XA and AP dimensions (Fig. 2, A), the master model and the casts were leveled with the aid of a plastic piece which rested on the 3 stainless steel reference points. A "bull's eye" bubble balance was placed on the plastic, and impression plaster (Snow White Plaster No. 2; Kerr Italia SpA, Salerno, Italy) was added to the base of the master cast to level the 3 occlusal reference points. An example of a leveled working cast with removable die is shown in Figure 3.

All measurements were made by 2 calibrated examiners using a measuring microscope (Measurescope MM-400; Nikon GmbH, Düsseldorf, Germany) capable of measuring to 1 µm. Calibration was ensured by measuring each dimension on the master model and on some working casts/working dies. These measurements allowed the 2 examiners to determine precise locations on the various reference points for making measurements. First, the XA and AP dimensions were measured on the master model (Fig. 2, A). Thereafter, the simulated stainless steel crown preparation (master die) was positioned on a stainless steel device to record MDG, BLG, MDO, BLO, OGL, and OGB dimensions (Fig. 2, B). Each dimension on the master model was measured 10 times to record the standard measurements at the start of the study, and again on completion of the study. The values obtained at the end of the study were used as standard values for the master model, to which all dimensions from gypsum models were compared. The same dimensions were measured on the 64 gypsum casts and gypsum dies, respectively, retrieved from impressions of the master model. Each dimension of a gypsum cast and die was measured 3 times and an average was taken. The measurements were made with the examiners blinded to the type of impression material and to the disinfection condition. Results were expressed as a difference in millimeters between the gypsum and master model dimensions.

Previous studies using the same methodology demonstrated that a sample size of 5 was adequate to detect clinically relevant differences.[5,6,26] For a recent accuracy study,[35] also with a sample size of 5, the 95% confidence interval with respect to the mean was ±0.007 mm for anterio-posterior and cross-arch dimensions, ±0.005 mm for mesiodistal and buccolingual dimensions, and ±0.010 mm for occlusogingival dimensions. These confidence intervals are adequate to detect differences in cross-arch and working die dimensions that are clinically important. In addition, the buccolingual data from this recent study[35] was used to prospectively estimate sample size for the present study. Results indicated that a sample size of 7 or 8 would yield a power of 80% to detect a buccolingual difference of 0.01 mm with a difference in population means of 0.007.

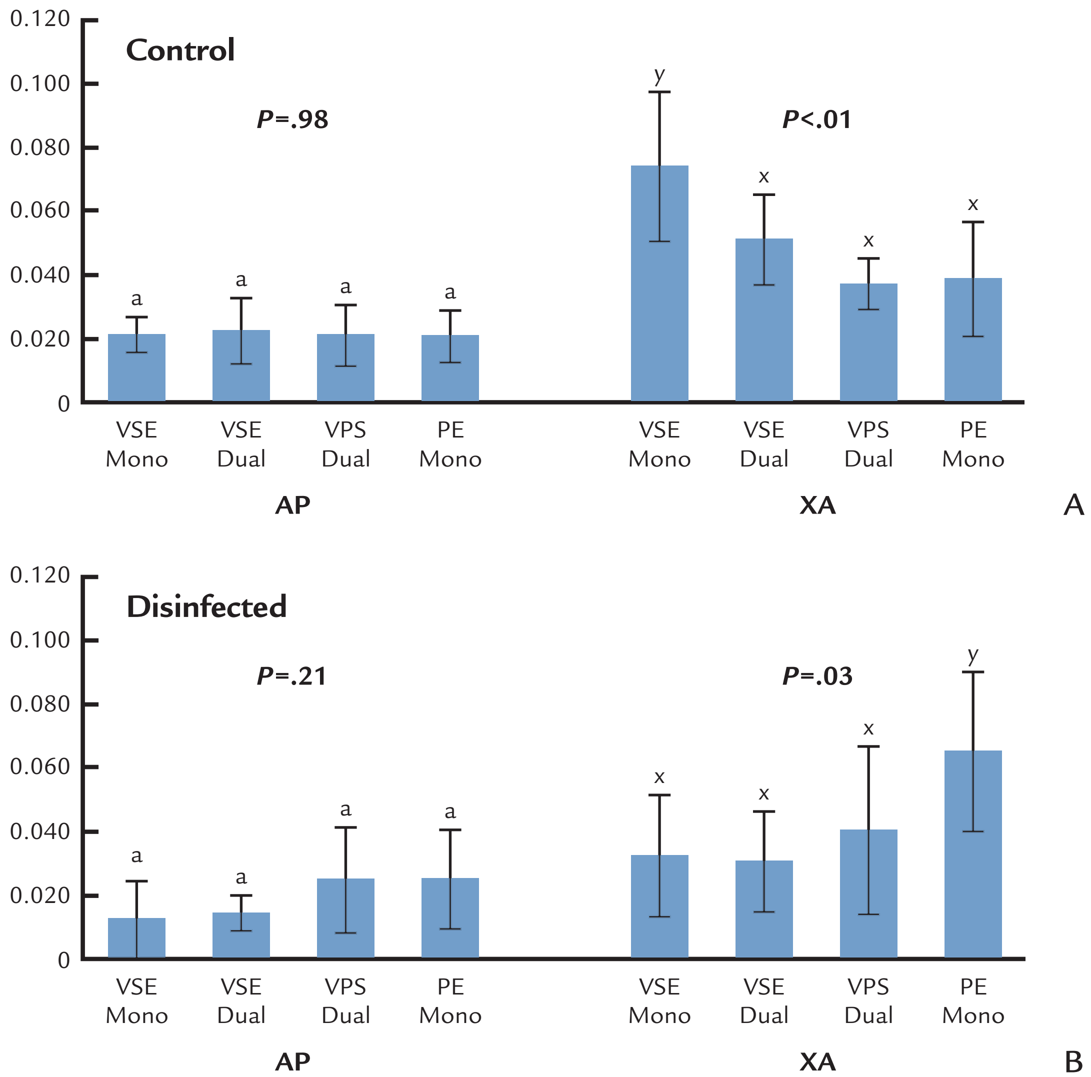
Using statistical software (SPSS 16.0; SPSS, Inc, Chicago, Ill), a general linear model (GLM) statistical approach (MANOVA) was used for the 4 impression systems and 2 disinfection conditions (control and immersion), but for sets of independent variables (dimensions) which were logically related based on clinical understanding. Therefore, the multivariate GLM analysis was conducted separately for the 2 master cast dimensions (XA and AP) and for the 6 working die dimensions. When the difference among impression systems was significant (Wilks' lambda test) and when the requirement for equal variances was met (Levene's test), the Student-Newman-Keul's method was used to test for differences among means. If this initial analysis exhibited significant main effects but also significant impression-disinfection cross-product interactions, a multivariate GLM analysis was used for each disinfection condition to test for significant differences among the 4 impression systems. To determine the degree to which the independent variables within a set were correlated, a Pearson's correlation test was carried out. All hypothesis testing was conducted at α=.05.

RESULTS

The dimensions of the master model and simulated preparation, plus standard deviations of the 10 measurements, are shown in Table II. The results of the initial GLM analysis indicated that for the gypsum cast dimensions (XA, AP), differences were

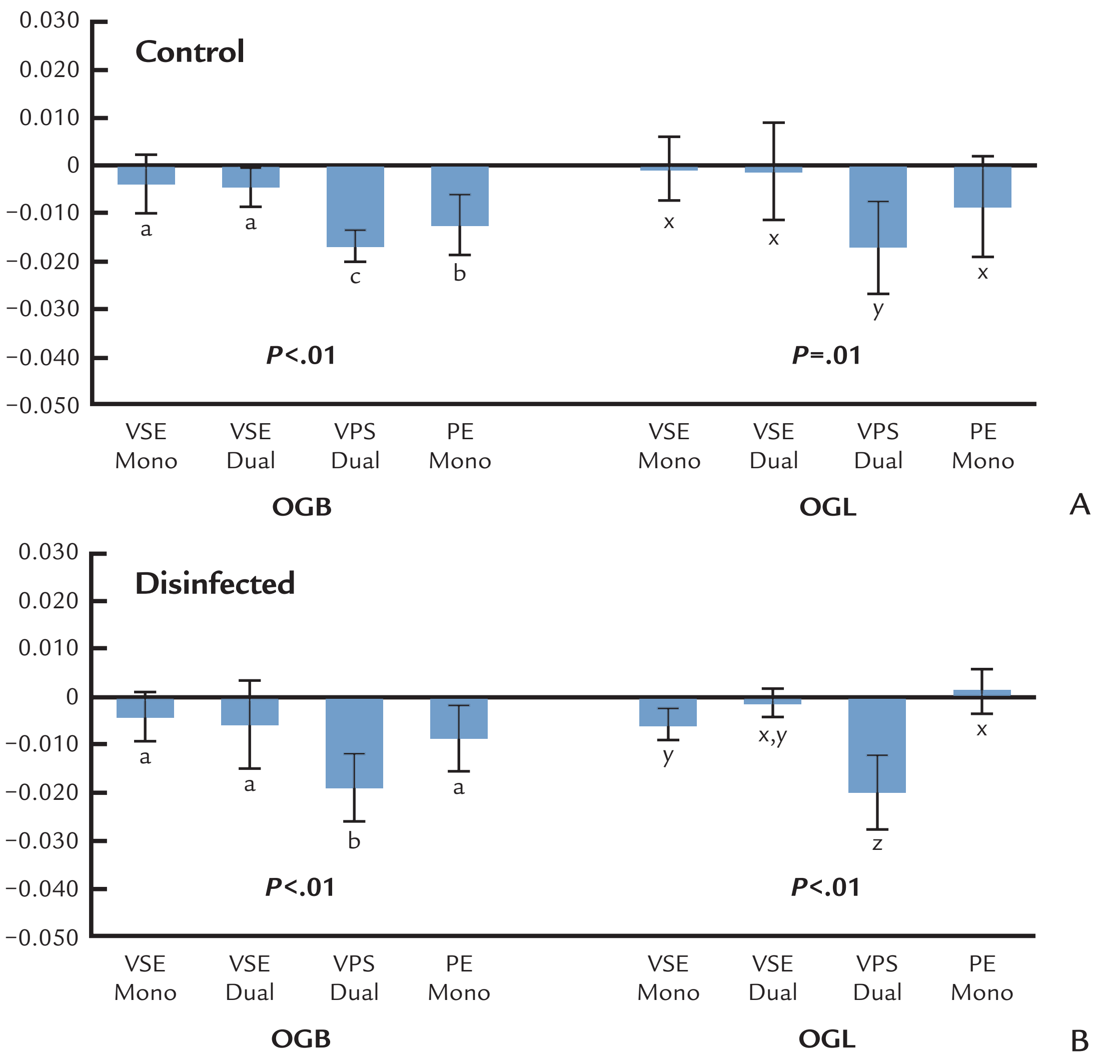
Table II. Dimensions (mm) of master model and master die with simulated preparation; means and SDs (n=10)

	AP	XA	OGB	OGL	MDO	BLO	MDG	BLG
Mean	33.918	43.134	6.226	6.228	5.816	5.816	7.945	7.945
(SD)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)

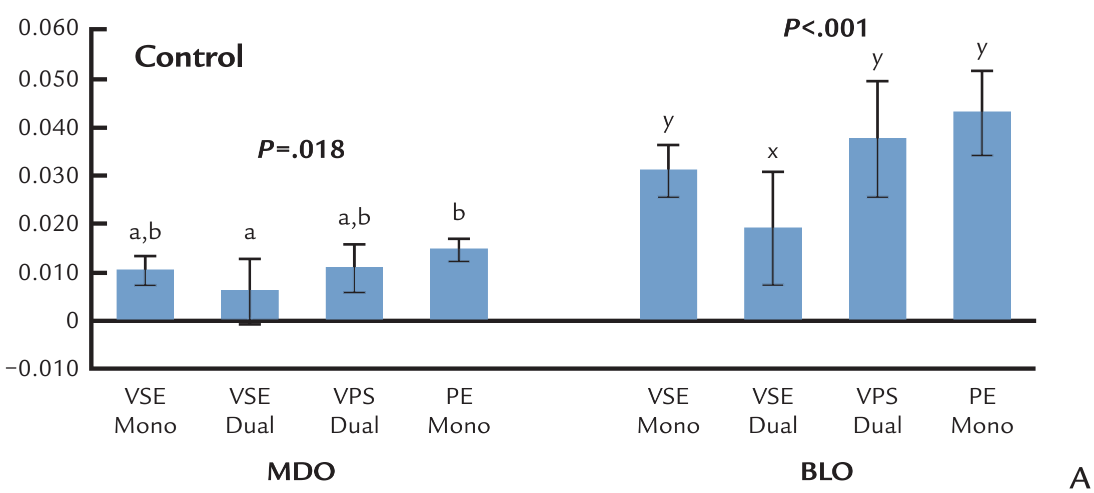


4 A, Differences (mm) in AP and XA dimensions between master cast and gypsum cast in control group without disinfection (mean and standard deviation from n=8; groups with different letters showed significant differences at $P<.05$). B, Differences (mm) in AP and XA dimensions between master cast and gypsum cast with disinfection (mean and standard deviation from n=8; groups with different letters showed significant differences at $P<.05$).

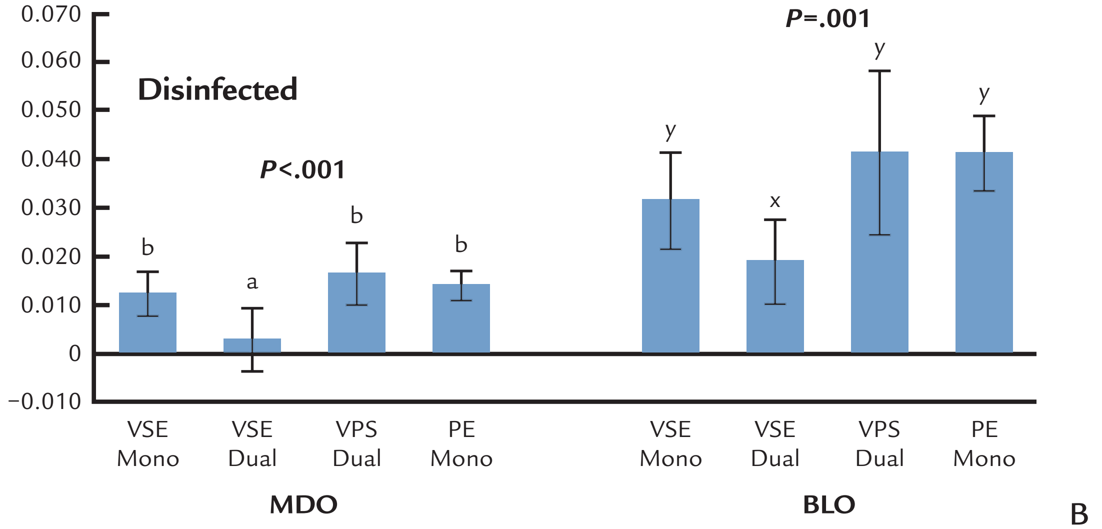
significant among the 4 impression systems ($P=.03$) and not significant for disinfection status ($P=.21$); however, the cross-product interaction was significant ($P<.01$). The result was similar for the working die dimensions, for which differences among impression systems were significant ($P<.01$) and not significant for disinfection status ($P=.97$). For this latter grouping of independent variables, the cross-product interaction term was not significant ($P=.37$). The results of the multivariate GLM for each disinfectant condition showed that there were significant differences among the 4 impression systems for the 2 master cast dimensions (AP, XA), whether disinfected ($P=.02$) or not ($P=.02$). Similarly, the Wilks' test for the 6 working die dimensions indicated significant differences existed among the impression materials for the disinfected ($P<.01$) and control ($P<.01$) states. The P values for the independent variables (such as AP and XA) for each disinfectant condition are provided in Figures 4-7, along with indications of means not shown to differ using the Student-



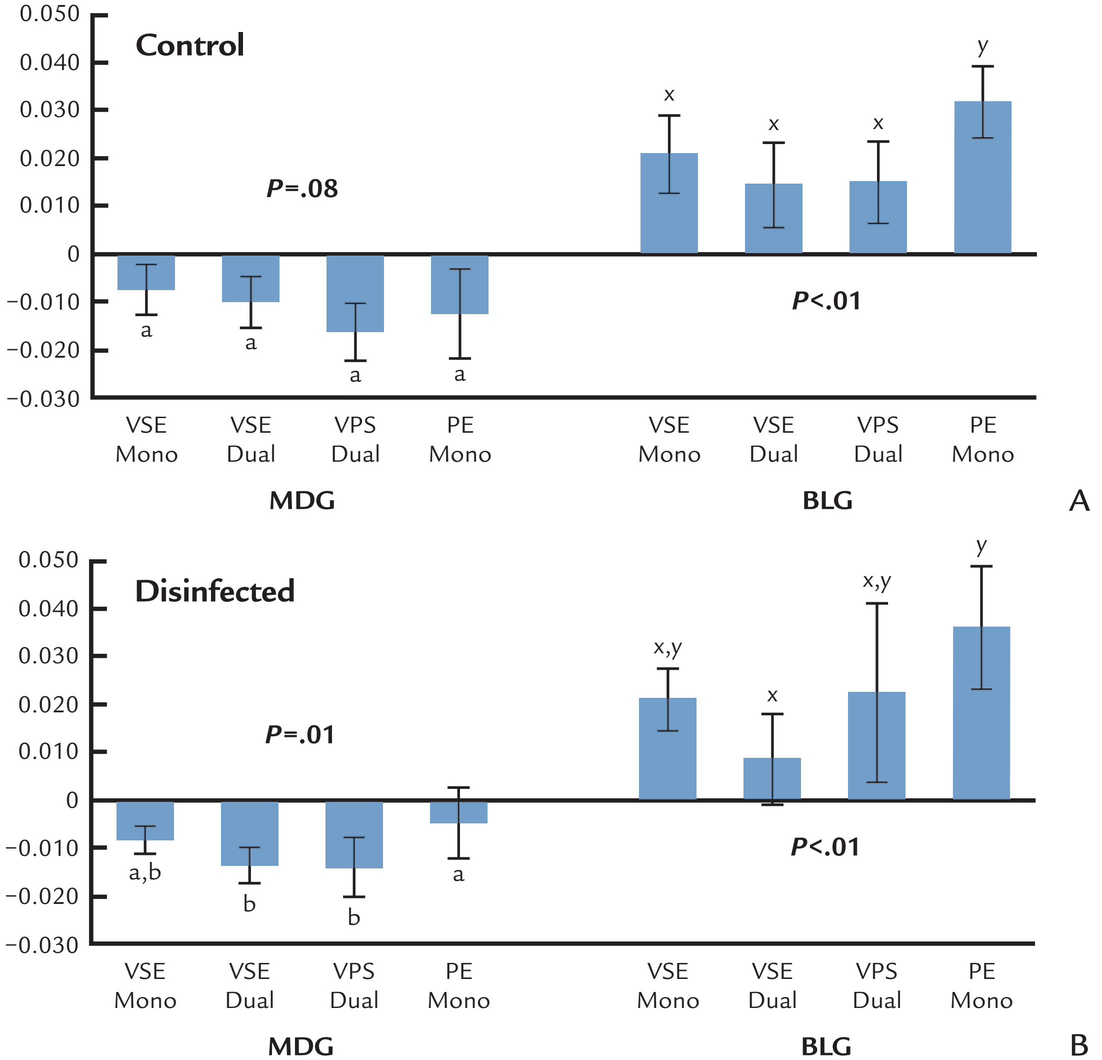
5 A, Differences (mm) in OGB and OGL dimensions between master die and gypsum die in control group without disinfection (mean and standard deviation from n=8; groups with different letters showed significant differences at *P*<.05). B, Differences in OGB (mm) and OGL dimensions between master die and gypsum die with disinfection (mean and standard deviation from n=8; groups with different letters showed significant differences at *P*<.05).



6 A, Differences (mm) in MDO and BLO dimensions between master die and gypsum die in control group without disinfection (mean and standard deviation from n=8; groups with different letters showed significant differences at *P*<.05).



6 *continued* (2 of 2) B, Differences (mm) in MDO and BLO dimensions between master die and gypsum die with disinfection (mean and standard deviation from n=8; groups with different letters showed significant differences at $P<.05$).



7 A, Differences (mm) in MDG and BLG dimensions between master die and gypsum die in control group without disinfection (mean and standard deviation from n=8; groups with different letters showed significant differences at $P<.05$). B, Differences (mm) in MDG and BLG dimensions between master die and gypsum die with disinfection (mean and standard deviation from n=8; groups with different letters showed significant differences at $P<.05$).

Table III. Pearson's correlation coefficient (r) for working die and cast dimensions, for 4 impression materials combined, but for disinfected state only (n=32). Positive correlation exists as r approaches +1. Boxes within table distinguish correlation coefficients for working die height (OGB, OGL) and diameters (MDO, BLO, MDG, BLG) and working cast distances (AP, XA) to highlight independent variables which were thought, a priori, to be closely related

	OGB	OGL	MDO	BLO	MDG	BLG	AP	XA
OGB	1	0.53**	−0.38*	−0.53**	0.33	−0.21		
OGL	0.53**	1	−0.37*	−0.29	0.33	0.14		
MDO	−0.38*	−0.37*	1	0.74**	0.17	0.55**		
BLO	−0.53**	−0.29	0.74**	1	0.03	0.73**		
MDG	0.33	0.33	0.17	0.03	1	0.12		
BLG	−0.23	0.14	0.55**	0.73**	0.12	1		
AP							1	0.61**
XA							0.61**	1

* Correlation significant at .05 level (2 tailed)
** Correlation significant at .01 level (2 tailed)

Newman-Keul's test. Levene's test for equal variances was not significant for any test.

The results for correlation of independent variables (the 8 measured dimensions) for the disinfected condition are given in Table III. The results were similar for the nondisinfected control. The occlusogingival height (OGB and OGL) as well as the 2 occlusal diameters (MDO and BLO) are highly correlated (r=0.53, 0.74, respectively), indicating little distortion of these 2 aspects of the working die compared to the master. The 2 gingival diameters (MDG, BLG) are not well correlated, however (r=0.12), indicating that the working dies are somewhat distorted at the gingival of the simulated tooth preparation. BLG is well correlated with MDO and BLO (r=0.55, 0.73, respectively) whereas MDG does not correlate well (r=0.17, 0.03, respectively). The AP and XA dimensions were highly correlated in the disinfected state (r=0.61).

The mean deviation of gypsum casts in comparison to the master model (in mm) for dimensions AP and XA is shown in Figure 4, A, for the control and in Figure 4, B, for the disinfected condition. In general, the AP and XA dimensions of gypsums casts were larger than the master for the disinfected condition and control. For the control group, the cross-arch dimension (XA) for VSE Mono was statistically wider than that for casts from the other 3 impression systems (Fig. 4, A). In contrast, the XA dimension of casts made from disinfected PE Mono impressions was larger than that for the other impression systems (Fig. 4, B).

The height of the gypsum dies (dimensions OGB and OGL) for the control and disinfected groups was generally shorter than the height of the simulated prepared crown of the master (Fig. 5, A, and B). Gypsum dies formed from nondisinfected VPS Dual and PE Mono impressions were significantly shorter than the working dies from the 2 VSE groups (Fig. 5, A). With disinfection, the height of the gypsum dies made from VPS Dual was significantly shorter than that of the working dies made from PE and VSE Dual impressions (Fig. 5, B).

The dimensions of MDO, BLO, MDG, and BLG of the master model crown preparation were perfectly circular in horizontal cross sections (Table II), while the gypsum dies, whether disinfected or not, were somewhat larger than the master mesiodistally, and larger yet in the buccolingual dimension, resulting in an irregular or oval profile (Fig. 6, A and B). Near the occlusal, the MDO and BLO dimensions of gypsum dies formed from VSE Dual impressions, for both disinfection conditions, exhibited the smallest difference compared to the master die. For the disinfected state, the mean difference of VSE Dual for MDO and BLO was statistically smaller than the means for the other impression groups (Fig. 6, A and B).

Whether disinfected or not, the MDG dimension at the gingival level of the working die was, in general, smaller than the master, and the BLG was larger than the master (Fig. 7, A and B). Thus, the working gypsum die was oval in shape compared to the circular master, but also smaller than the master in the mesiodistal dimension.

The GLM result, when testing for the difference between the disinfected and control condition, was significant for the interdental dimensions of the gypsum working cast (Wilks' lambda, $P=.03$) and not significant for dimensions of the working die (Wilks' lambda, $P=.97$). Of the 4 impression systems, only VSE Mono differed significantly from the control ($P<.01$), and this was for the XA dimension and not the AP dimension (Fig. 4, A and B). The interdental cast dimensions from disinfected VSE Mono impressions were closer to the dimensions of the master model (more accurate) than those from the nondisinfected control. Upon visual examination of the associated pairs of graphs in Figures 4 through 7, there are only minor differences between the control and disinfected state.

DISCUSSION

The primary null hypothesis was that there would be no differences in accuracy of working casts and dies, among the 4 impression systems, in comparison to the master, for the disinfected condition. This hypothesis was rejected since there were statistically significant differences among the 4 systems. The secondary null hypothesis was that impression systems would not be affected by immersion disinfection. This hypothesis was rejected for the cast dimensions (AP, XA), but was accepted for the dimensions of the working die. In most situations, the differences detected were small in magnitude and of minor clinical significance, in light of other factors such as tooth mobility,[12] mandibular deformation during opening,[13,14] potential inaccuracies during laboratory processes,[15,16] and the clinically accepted values for marginal gaps of crowns (150-100 µm).[17-20]

It should be mentioned that the impression materials examined possess different surface properties. Because of its chemical basis, polyether possesses a high degree of wettability and, therefore, is well suited for the moist environment that exists intraorally.[33] In contrast, vinyl polysiloxane is hydrophobic, due to its molecular chemistry; however, it is known for its superior elastic recovery.[33] To improve wetting characteristics of vinyl polysiloxane materials, surfactants have been added by manufacturers. Most commonly, these surfactants consist of an oligoether or polyether substructure as the hydrophilic component.[33] As a result, a reduction in surface tension and, therefore, greater hydrophilicity of these hydrophilized vinyl polysiloxane materials is observed.[33] According to information provided by the manufacturer, the platinum-initiated vinyl siloxanether consists of a copolymer of α,ω-divinyl polydimethylsiloxane and α,ω-divinyl polyether crosslinked by an organohydrogen polysiloxane (Fig. 1). The composition is intended to incorporate the natural hydrophilicity of conventional polyether materials along with the desirable properties of vinyl polysiloxane materials, such as elastic recovery and tear resistance. To further improve the wetting characteristics and flowability, a surface tension eraser (STES) and wetting conditioner surfactant (WCS) have been incorporated into the vinyl siloxanether, per the manufacturer.

The results of the present study are comparable to the results of similar past studies of polyether and vinyl polysiloxane impressions, in which the dimensions AP and XA were shown to be larger compared to the master model, and the dimensional changes of the working dies are also comparable.[5,6,26] Given the newly formulated vinyl siloxanether impression material, with claims of its low contact angles in the unset (representing the hydrophilicity to the prepared tooth and gingival tissues) and set conditions (representing the hydrophilicity to fluid gypsum), it is important to discuss how accuracy might be affected when the impressions are disinfected by immersion. Thus, the discussion will focus primarily on the disinfected impression, since disinfection is a clinical necessity.

The differences between the master model and the working casts for the anteroposterior dimension (AP) were small: a 0.012-mm to 0.025-mm difference was found overall, compared to the master model, according a maximal percentage error of 0.07%. These values are within the range of normal tooth mobility. For example, in a clinical study, single posterior teeth have been shown to move an average of 0.084 mm with wedging.[12] Thus, working casts with any of the impression systems investigated appear to provide enough accuracy between abutments for long-span fixed partial dentures, for example.

The cross-arch dimension (XA) of the working casts with disinfection was 0.031 mm to 0.065 mm larger than the master model. This finding is consistent with past studies in which the XA dimension was larger, whereas the AP dimension was relatively unaltered.[6,11] However, these differences were small compared to other factors influencing the accuracy of impressions, such as mobility of the teeth and torsion of the mandible during opening. For instance, the mandible was found to contract in the XA dimension by an average of 0.29 mm during protrusive opening,[13] and, in an older study, by an average of 0.78 mm during maximum opening.[14] Thus, it is unlikely that the differences observed for the XA dimension have any clinical impact on the fit of long-span fixed prostheses. Nevertheless, it can be recommended that short-span multi-unit restorations should be used when planning mandibular complete arch fixed restorations, in particular, on implant abutments, to avoid framework distortion and misfit.

Some studies addressed the dimensional changes of the working dies and concluded that a slight enlargement (0.04 mm) of the working die (height and diameter) would be helpful to facilitate cementation.[15,16] In the present study, the gypsum dies were shorter than the master crown preparation, in the range of 0.001 and -0.020 mm

(OGB and OGL). The same tendency was shown in past studies in which gypsum dies were shorter in the occlusogingival dimension.[6,11,26] These differences are small and unlikely to be of clinical significance. However, dental laboratory technicians should provide additional die spacer on the occlusal surface of working dies to compensate for slightly shorter working dies.

The MDO and MDG dimensions were close to the master die dimensions (differences between -0.014 and 0.016 mm) and were highly correlated (Table III). The BLO and BLG dimensions showed slightly larger differences from the master (between 0.009 and 0.041 mm). This result is consistent with findings of other studies.[6,7] An explanation for this finding is that there is more impression material buccal and lingual to the preparation compared to mesial and distal. Thus, polymerization shrinkage may be greater buccolingually. Another explanation is that impression material will shrink toward the walls of the tray where the adhesive is placed.

The fact that the MDG dimension was poorly correlated with the 3 other cross-sectional dimensions (Table III) and was smaller than the master (Fig. 7, A and B) may be explained by the fact that polymerization shrinkage of impression material between the teeth in the gingival area is free or unrestrained. The unrestrained MDG dimension could become smaller in response to the buccolingual dimension (BLG) becoming larger during polymerization, given the adhesion to tray borders. The MDO dimension is also smaller than the BLO, but not smaller than the master. In this situation, the tray with adhesive near the occlusal of the preparation may control the magnitude of shrinkage.

Some values showed large standard deviations in relation to the mean. During fabrication of the casts and their measurement, several sources of error may occur. For instance, there is more impression material buccal and lingual to the preparation compared to mesial and distal. These errors could combine and result in larger discrepancies, or could cancel each other out, resulting in fewer discrepancies. This may have an influence on the characteristics of the standard deviations.

For the XA dimension of vinyl siloxanether (VSE Mono), a significant difference between disinfected and nondisinfected conditions was found. In this case, the XA dimension was more accurate (closer dimensionally to the master) with disinfection, and the mean XA difference of 42 μm from the master is small in magnitude and of no clinical significance. In general, reasons for dimensional changes after disinfection could be water absorption with consequential swelling or chemical interactions between the impression material and disinfection solution. Such effects are evident in the behavior of materials susceptible to a wet environment, like polyether.[25,26] In this context, it should be considered that in the present study, the disinfection solution was the same for all materials. Thus, using the disinfection solution recommended by the manufacturer for the polyether examined could produce different results.

Limitations of this study include the following. The impressions were made from a modified typodont with plastic teeth, and the simulated crown preparation was made of stainless steel, the surface of which differs from dentin. These conditions differ from those of teeth in the natural oral environment, since soft tissue was not present, nor was saliva or sulcular fluid, and the intraoral temperature would be different. Also, this study used stock, sterilizable, full-arch metal impression trays, whereas, in some regions, disposable full-arch and dual-arch plastic trays are used. Finally, this study only examined accuracy of gypsum casts for the newly formulated vinyl siloxanether impression material. There is also a need to examine the biological, rheological, and wetting properties of this new material, to further ascertain equivalence with polyether and vinyl polysiloxane, and to lend additional support for clinical acceptability.

CONCLUSIONS

Considering the limitations of this in vitro study, it was shown that vinyl siloxanether monophase impressions and vinyl siloxanether dual-viscosity impressions display acceptable accuracy for clinical use with immersion disinfection, since the results for vinyl siloxanether were comparable to the results for representative polyether and vinyl polysiloxane materials. Although some statistically significant differences were observed among the 4 impression systems, the clinical impact of these differences is minor, considering the overall accuracy of casts was high. The effect of disinfection of the impressions by immersion (compared to the control) had no negative effects. There was a significant difference in 1 situation (1 material, 1 cast dimension), but this was not clinically significant since the master cast became more accurate with immersion disinfection.

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