Accuracy of newly formulated fast-setting elastomeric impression materials

Chandur P.K. Wadhwani, DDS, MSD,[a] Glen H. Johnson, DDS, MS,[b] Xavier Lepe, DDS, MS,[c] and Ariel J. Raigrodski, DMD, MS[d]
School of Dentistry, University of Washington, Seattle, Wash

Statement of problem. Elastomeric impression materials have been reformulated to achieve a faster set. The accuracy of fast-setting elastomeric impression materials should be confirmed, particularly with respect to disinfection.

Purpose. The purpose of this study was to assess the accuracy of 2 types of fast-setting impression materials when disinfected with acid glutaraldehyde.

Material and methods. Impressions of the mandibular arch of a modified dentoform master model were made, from which gypsum working casts and dies were formed. Measurements of the master model and working casts included anteroposterior (AP) and cross-arch (CA) dimensions. A stainless steel circular crown preparation incorporated within the master model was measured in buccolingual (BL), mesiodistal (MD), and occlusogingival (OG) dimensions and compared to measurements from recovered gypsum dies. The impression materials examined were a fast-set vinyl polysiloxane (VPS-FS, Aquasil Ultra Fast Set), a fast-set polyether (PE-FS, Impregum Penta Soft Quick Step), and a regular-setting polyether as a control (PE, Impregum Penta). Disinfection involved immersion in 3.5% acid glutaraldehyde (Banicide Advanced) for 20 minutes, and nondisinfected impressions served as a control. Linear measurements were made with a measuring microscope. Statistical analysis utilized a 2-way and single-factor analysis of variance with pair-wise comparison of mean values when appropriate. Hypothesis testing was conducted at $\alpha=.05$

Results. No differences were shown between the disinfected and nondisinfected conditions for all locations. However, there were statistical differences among the 3 materials for AP, CA, MD, and OG dimensions. AP and CA dimensions of all working casts were larger than the master model. Impressions produced oval-shaped working dies for all impression materials. PE and PE-FS working dies were larger in all dimensions compared to the stainless steel preparation, whereas VPS-FS–generated working dies were reduced in OG and MD dimensions. Differences detected were small and may not be of clinical significance.

Conclusions. Impression material accuracy was unaffected by immersion disinfection. The working casts and dies were similar for PE and PE-FS. VPS-FS generated gypsum dies that were smaller in 2 of the 3 dimensions measured and may require additional die relief. Overall accuracy was acceptable for all 3 impression materials.

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CLINICAL IMPLICATIONS

The fast-setting elastomeric impression materials tested were shown to be as accurate as the regular setting material tested under conditions of immersion disinfection. When clinical circumstances permit their use, patients, practitioners, and dental office staff can benefit from the shorter setting times.

Impression materials are used to register or reproduce the form and relations of the teeth and the surrounding oral tissues.[1] A variety of dental impression materials currently exist, the majority of which originated for use in non–dental-related fields. One such group is the nonaqueous elastomeric impression materials, or elastomers, which were developed as an alternative to natural rubber during World War II. These materials have since been modified chemically and physically for use in dentistry. Initially, this group consisted exclusively of polysulfide impression materials. Subsequently, condensation-cured silicones were developed. Today, 2 of the most popular elastomers used in dental practice are the polyethers and addition-reaction silicones, or vinyl polysiloxanes.

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[a] Resident, Graduate Prosthodontics, Department of Restorative Dentistry; Private practice, Bellevue, Wash.

[b] Professor, Department of Restorative Dentistry.

[c] Associate Professor, Department of Restorative Dentistry.

[d] Associate Professor and Director of Graduate Prosthodontics, Department of Restorative Dentistry.

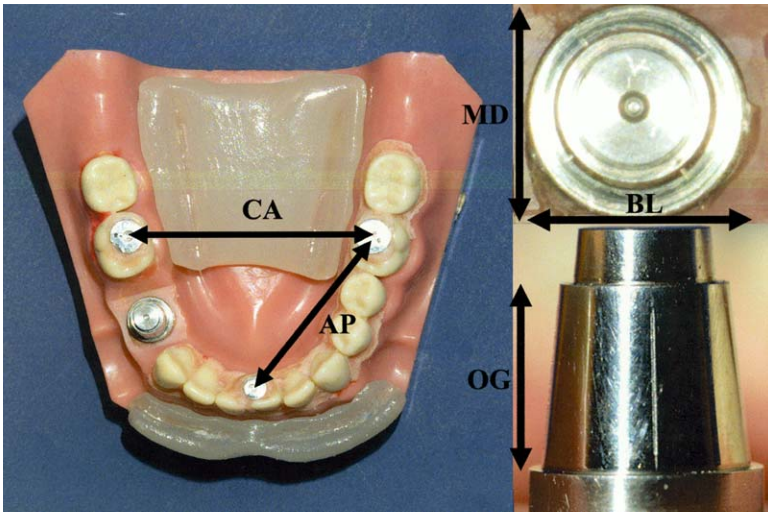

Fig. 1. *Left*, Occlusal view of master model showing AP and CA areas measured. Also shown, labial and lingual positioning index for impression tray. *Right*, Stainless steel complete crown preparation where MD, BL, and OG dimensions were assessed.

When considering the replication process of which impression making is a part, an understanding of the accuracy required of an impression material is essential. The significance of accuracy relative to clinical[2,3,4] and laboratory factors, such as those involved in the process of fabricating indirect restorations,[4,5,6,7] should also be understood. An exact dimensional replica, or 1-to-1 scale reproduction, may not be beneficial. Bailey et al[5] indicated that many of the steps involved in the process of fabricating cast restorations resulted in dimensional changes, and if some of these changes compensated for each other, it would be advantageous. Dental elastomeric impression materials are subject to several factors that can result in dimensional change. For example, the process of polymerization, which involves cross-linking of the polymer chains, can result in a reduction of spatial volume.[7] Polymerization reactions have been shown to continue for a considerable period of time, beyond the achievement of what is considered a final clinical set, and continue after removal of the impression from the mouth.[7-9] The effect of temperature as a variable has been demonstrated to alter the dimension, both during the setting phase and after the clinical set.[9] Accuracy is dependent on material volume used, or bulk,[10,11] as is the extent of undercuts encountered during the removal of the set material.[12] The conditions under which the materials are stored[13] and the requirement that the set impression material be disinfected are also factors demonstrated to affect the accuracy of casts.[13,14] Materials used to fabricate the replica or working cast may also be subject to changes in dimension, such as gypsum expansion with setting. Although accuracy is affected by many factors, it should be realized that the magnitude of some of these changes may not be clinically significant.[15]

Common clinical techniques involved with impression making have been extensively investigated, and potential consequences have been reported. Variables include the comparison of single-phase versus dual-phase materials,[15,16] stock versus custom impression trays,[17-21] bond to a supportive tray,[22-24] perforated or solid trays,[24] stock versus dual-arch tray,[25] and methods of mixing the impression materials.[26]

Although the polyether and vinyl polysiloxane (VPS) materials are chemically distinct, they have similar physical characteristics when set.[1] Many of these properties render the impression materials clinically useful. Numerous studies have indicated differing properties among and within elastomeric groups. For example, 2 recent studies have shown that polyethers exhibit useful clinical properties.[16,27] One investigation into the viscoelastic behavior of impression materials in a gingival sulcus simulation model reported that polyethers produce the greatest sulcular extension, suggesting a direct clinical benefit.[27] In another study, under moist surface conditions, better detail reproduction was produced by polyether than most VPS materials.[16] Such information provides the practitioner the information to judiciously select the material possessing properties that best suit the needs of the procedure being undertaken.

A potentially clinically useful change has been the production of a soft polyether with reduced stiffness when compared with the traditional material.[9] A recent modification has been the introduction of fast-setting versions of both VPS and soft polyether impression materials. These elastomers were specifically designed for use when making impressions of 1 to 2 prepared teeth. One study reported on patterns of clinical treatments,[28] finding those involving single crown restorations to be

Table I. Product combinations tested

Type	Product	Viscosity	Working/Setting time (min:sec)	Batch no.	Manufacturer
VPS	Aquasil Ultra LV Fast Set	Low	1:15/3:00	040415	Dentsply Caulk, Milford, Del
VPS	Aquasil Ultra Monophase Fast Set	Medium	1:15/3:00	040513	Dentsply Caulk
Polyether	Permadyne Garant LB	Low	2:00/5:30	C172844 B172358	3M ESPE, St. Paul, Minn
Polyether	Impregum Penta MB	Medium	2:30/6:00	C179957 B180108	3M ESPE
Polyether	Impregum Soft Quick Step LB	Low	1:00/4:00	B174999 C173527	3M ESPE
Polyether	Impregum Penta Soft Quick Step MB	Medium	1:00/4:00	B176018 C177575	3M ESPE

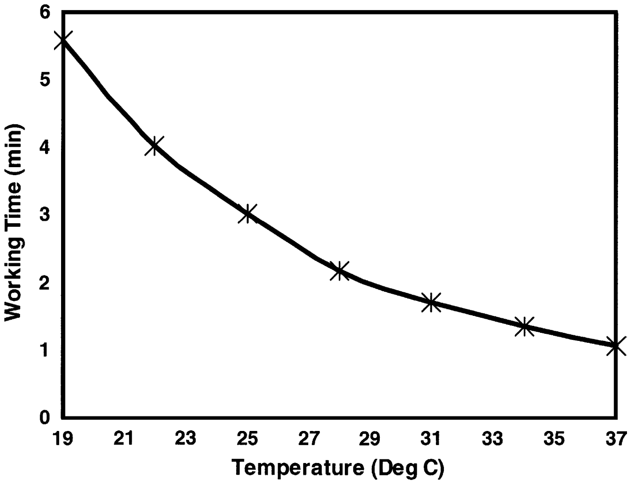

Fig. 2. Effect of ambient temperature on working time for VPS impression material (Courtesy of R. Hare, Dentsply Caulk).

extremely popular, accounting for 21% of the total costs from 1 dental insurance provider company. Time saving usually relates to reduced costs and increased patient comfort. Impression making is generally an uncomfortable procedure, and for some patients with a strong gag reflex, it presents a severe problem. Reducing the time the impression material remains intraorally is an improvement from the patient's perspective.

Dental impressions are potential sources for cross-contamination and should be cleaned and disinfected with an EPA-registered hospital disinfectant with a tuberculocidal claim.[29] Immersion disinfection presents a challenge to some materials, as early studies reported that this method adversely affects the accuracy of polyether impression material.[14] Also, long-term immersion has been shown to alter accuracy of both polyether and VPS.[13] Polyether impression material has since been modified, and more recent studies have shown immersion disinfection to be an effective way of disinfecting polyether and VPS impression materials without the loss of accuracy, provided that immersion does not exceed the recommended time period.[13,15] The accuracy of polyether is well established in the literature,[13,15,16,30] and the effects of disinfection on the dimensional stability of impression materials have also been investigated.[13,14,25,31,32] The accuracy of the newly developed fast-setting materials has not been established, and is needed, given changes in formulation to achieve the faster set. The purpose of this study was to assess the accuracy of the faster-setting polyether and VPS impression materials under both disinfected and non-disinfected conditions and compare their accuracy to a regular setting polyether. Thus, the research hypotheses were that no differences existed in accuracy among the 3 impression materials, and secondly, that accuracy was unaffected by disinfection.

MATERIAL AND METHODS

The accuracy of 3 impression material types was evaluated indirectly through recovered gypsum casts from impressions made on a master model (Fig. 1). The master model was similar to that used in previous studies,[13,15] consisting of a dentoform mandibular arch (Model 1362; Columbia Dentoform, Long Island City, NY) with modifications. Three stainless steel inserts, 1 on each occlusal surface of the right and left first molars, and 1 on the lingual surface of the mandibular central incisor (Fig. 1), provided reference points for measuring cross-arch and anteroposterior dimensions. In addition, the master model contained a removable stainless steel complete crown preparation in the position of the mandibular right first premolar. The complete crown preparation was machined with a 12-degree angle of convergence, and had gingival and

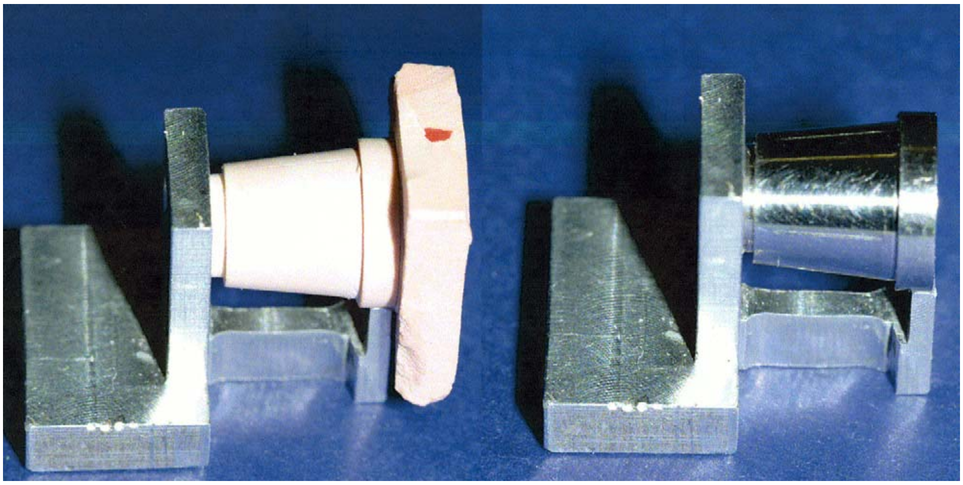

Fig. 3. Working die and stainless steel complete crown preparation on positioning device, which standardized and facilitated measurements of die dimensions.

occlusal shoulder finish lines, which served as reference marks (Fig. 1). Specifically, the cross-arch (CA) dimension was assessed by measuring the distance from the mandibular left first molar to the mandibular right first molar, the anteroposterior (AP) distance from mandibular left first molar to central incisor; the mesiodistal (MD) and buccolingual (BL) dimension across the gingival shoulder of the simulated complete crown preparation, and the occlusogingival (OG) measurement of the preparation from the gingival shoulder to the occlusal shoulder (Fig. 1). The same 5 dimensions were measured on gypsum working casts and dies retrieved from impressions of the master model.

A simultaneous dual-viscosity single-step impression technique was used with medium-viscosity material for the tray and a low-viscosity material injected onto the complete crown preparation and occlusal reference points. The impression materials evaluated were (1) a regular-setting polyether (PE) (Impregum Penta MB) with its corresponding light-viscosity material (Permadyne Garant LB), (2) a fast-setting polyether (PE-FS) (Impregum Penta Soft Quick Step MB) with low-viscosity Impregum Soft Quick LB, and (3) a fast-setting vinyl polysiloxane (VPS-FS) material (Aquasil Ultra Monophase Fast Set) and low-viscosity material (Aquasil Ultra LV Fast Set). The materials, working times, setting times, and batch numbers are listed in Table I.

Thirty impressions were made, consisting of 10 impressions for each of the 3 impression material combinations, of which 5 were disinfected and 5 were not. Previous studies have demonstrated that the resulting sample size of 5 yielded an adequate power to detect statistically significant differences.[13,15] A large, mandibular, disposable plastic impression tray (President Disposable Impression Tray; Coltene Whaledent, Cuyahoga Falls, Ohio) was used for all impressions. This was a rigid, perforated tray with the ability to resist distortion expected during seating and removal of the tray.[33] To standardize the seating position and centering of the tray during impression making on the master model, positioning guides were constructed (Fig. 1) with light-polymerized acrylic resin material (Triad TruTray, VLC; Dentsply Intl, York, Pa).

The appropriate tray adhesive recommended by each manufacturer was applied to the internal surface of the trays and left to dry for 15 minutes.[22] All 3 low-viscosity materials were mixed using a static automix cartridge dispenser[1] and expressed directly into a 1.2-mL disposable syringe (Ultradent Products, South Jordan, Utah). This ensured that a standard volume of light-body material was used for injection around the stainless steel crown preparation and onto the occlusal reference points. Both polyether medium-bodied materials under investigation were dispensed using an automix dynamic mixing machine[1] (Pentamix II; 3M ESPE, St. Paul, Minn). The VPS medium-bodied tray material was mixed using the automix static cartridge system. In all cases, the first 3 cm of paste extruded from the mixing tip was discarded, ensuring that adequate mixing of material had occurred. To standardize the amount of medium-viscosity material used, it was first dispensed into the tray, then leveled to the height of the borders of the tray. The tray was then seated over the master model, centered according to the positioning guides, and left to set. The total time interval between the start of automixing the low-viscosity material, applying it on the reference areas, and finally, seating the tray loaded with medium-viscosity material on the master model, was 45 seconds.

Setting time can be considered an extension of working time, and both are temperature-dependent. All materials were mixed and allowed to set at a room temperature of 23°C. To determine an appropriate

Table II. Mean values and SDs (mm) for dimensions of master model evaluated

	Anterioposterior (AP)	Cross-arch (CA)	Occlusogingival (OG)	Buccolingual (BL)	Mesiodistal (MD)
Mean	33.903	42.808	6.208	7.939	7.940
SD	0.001	0.000	0.001	0.001	0.001

Table III. Two-factor ANOVA results for 5 dimensions

Source	Dependent variable	*df**	F	Significance
Impression	AP	2	19.967	.000
	CA	2	6.121	.007
	OG	2	26.499	.000
	BL	2	.519	.602
	MD	2	10.515	.001
Disinfection	AP	1	1.103	.304
	CA	1	.014	.907
	OG	1	.000	1.000
	BL	1	1.636	.213
	MD	1	2.561	.123
Impression × Disinfection	AP	2	.554	.582
	CA	2	1.623	.218
	OG	2	4.431	.023
	BL	2	.605	.554
	MD	2	1.399	.266

*Total *df*=24.

setting time for this temperature, a graph of ambient temperature and working time was used, as shown in Figure 2 (supplied by R. Hare, AAS, Senior Scientist, Division of Technical Research, Dentsply Caulk, written communication, July 2004). While 23°C corresponds to a working time 2.5 times longer than the working time for a simulated intraoral temperature of 33°C, 3 times the stated setting time was utilized to be certain adequate polymerization had occurred.

Once removed, the impression was visually inspected to determine that the reference marks were clearly reproduced, rinsed for 10 seconds under running water to simulate removal of saliva and other contaminants, and then air dried. The nondisinfected groups were allowed to remain in ambient air for 1 hour. Specimens within the disinfected group were immersed in 3.5% acid glutaraldehyde (Banicide Advanced; Pascal, Bellevue, Wash) for 20 minutes (Tentarelli V, Quality Control Manager, Pascal Dental; e-mail communication, May 26, 2004, indicating submission of testing information for CDC approval demonstrating high-level disinfection with 20 minutes of immersion using full-strength Banicide Advanced)[29] to simulate intermediate level disinfection, then rinsed under running water for 10 seconds, air dried, and left in ambient air for an additional 40 minutes to correspond to a time equivalent to that of the nondisinfected group.

To form the working casts, Type IV gypsum (Prima-Rock; Whip Mix, Louisville, Ky) in the form of 70-g packages was used. The gypsum was mixed with 14 mL of distilled water, first by hand for 15 seconds, and then vacuum-mixed for an additional 30 seconds (Combi-Mix; Whip Mix). The gypsum was vibrated into the impression, filled to the level of the tray borders, and the excess material utilized to provide mechanical retention. The cast was allowed to set at room temperature in air for 60 minutes.

To enable ease of separation of the gypsum working die, a stone separator (Super-Sep; KerrLab, Orange, Calif) was painted over the site. The cast was boxed and then a base was added using a Type III dental stone (Microstone; Whip Mix). This consisted of 70 g of stone mixed with 20 mL of water, initially incorporating the powder by hand spatulation, then vacuum-mixing for 30 seconds (Combi-Mix; Whip Mix). The base was allowed to bench set for 1 hour. The recovered gypsum cast with base was separated from the impression and left to set for 24 hours in ambient air.

To facilitate measurement in the AP and CA locations, the master model was leveled using a plastic piece that rested on the 3 stainless steel occlusal reference points, onto which a bull's eye circular level (Empire Level Mfg Corp, Mukwonago, Wis) was placed. Fast-set plaster (Mounting Stone; Whip Mix Corp) was added to the base of the master model to level the occlusal plane to the countertop. A similar technique was used to level the recovered gypsum casts. The AP and CA dimension measurements were made using a binocular measuring microscope (Nikon Measurescope 20; Nikon, Tokyo, Japan) capable of measuring to 0.001 mm. After these 2 measurements were recorded, the working die was sectioned and positioned on a custom fabricated stainless steel device, to assess the BL, MD, and OG dimensions (Fig. 3) with the same instrument.

Thirty casts containing the 5 reference dimensions were produced. Each dimension was measured 3 times, and an average was taken for each sample value. The master model and stainless steel complete crown preparation were measured on 3 separate occasions: at the start of the study, during the study, and on completion of the study. These repeated measurements allowed the examiner to confirm consistency of measurement. The

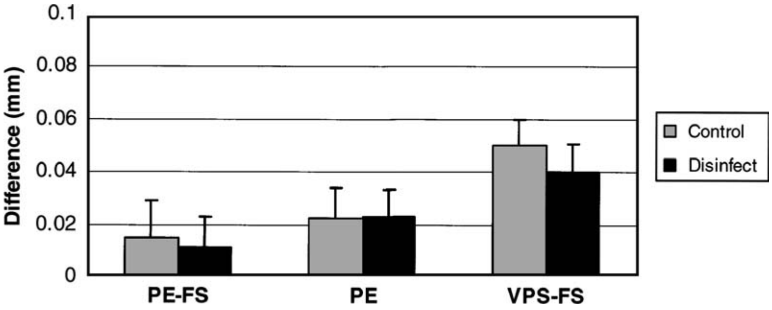

Fig. 4. Mean change for disinfected and nondisinfected condition in AP dimension compared to that of master model. *Vertical bars* indicate SDs.

Table IV. Mean differences between casts and master model

		AP	CA	BL	MD	OG disinfected	OG control
Impregum Soft Quick	Mean	0.013	0.063	0.019	0.009	0.009	0.007
(PE-FS)	SD	(0.012)	(0.013)	(0.009)	(0.010)	(0.006)	(0.005)
Impregum	Mean	0.022	0.082	0.016	0.012	0.013	0.007
(PE)	SD	(0.011)	(0.015)	(0.008)	(0.009)	(0.004)	(0.005)
Aquasil Ultra Fast Set	Mean	0.045	0.085	0.015	−0.006	−0.010	−0.002
(VPS-FS)	SD	(0.011)	(0.018)	(0.010)	(0.010)	(0.005)	(0.005)

Values shown are grand mean values for both disinfection conditions. Mean values for OG are shown separately for each condition given statistical interaction. *Bars* indicate mean values not shown to differ at α=.05. SDs are shown in parentheses.

values obtained at the end of the study were used as the values for the master model. All measurements were made by 1 examiner, blinded to the type of impression material that generated the working cast and working die, as well as to the disinfection condition.

A 2-factor analysis of variance (ANOVA) was used to analyze the data. The 2 factors were the type of impression material and disinfection condition. Given significant main effects and nonsignificant cross-product interactions, factor-level mean values were compared using the Student-Newman-Keuls procedure for multiple pairwise comparisons. Where main effects were significant for disinfection, no additional mean tests were needed since only 2 conditions existed. Where cross-product interactions existed, a single-factor ANOVA was conducted separately for disinfection and no disinfection. All hypothesis testing was conducted at α=.05.

RESULTS

The mean values for the 5 measurements (AP, CA, OG, BL, MD) on the master model are given in Table II. The SD recorded was 0.001 mm (1 μm) for the multiple readings of each dimension. The working casts and dies were compared to the respective dimensions of the master model.

The results for the 2-factor ANOVA are shown in Table III for all 5 dimensions. Results for the factor “impression material” indicated that a significant difference existed for all locations (P<.05) except BL (P=.602). Regarding the “disinfection condition,” no significant differences were detected for disinfected versus nondisinfected for any of the 5 locations. The Levene test for equal variances was not significant for all locations, satisfying this requirement for the ANOVA model. Cross-product interactions (impression × disinfection) were not significant for all locations, except OG. For this reason, a single-factor ANOVA was conducted separately for OG for the separate conditions, disinfected (P<.05) and nondisinfected (P>.05).

Overall results are provided in Table IV. Factor-level mean values are supplied where cross-product interactions were not significant (AP, CA, BL, MD), and individual mean values are supplied for OG for each disinfection condition for which the cross-product interaction was significant. Bars connect mean values not shown to differ at α=.05. Figures 4 and 5 provide the AP and CA mean differences from the master model, respectively, for the control and disinfected condition. Figures 6 and 7 provide mean differences for the individual working die, which simulates a crown preparation. The BL and MD dimension differences are shown on the same graph to demonstrate the shape as it might deviate from the round stainless steel crown preparation. The percent of dimension change was calculated as: $\Delta L = 100\ (L_m - L_{c)} / L_m$, where L represents the linear dimension, L_m represents the master model dimension,

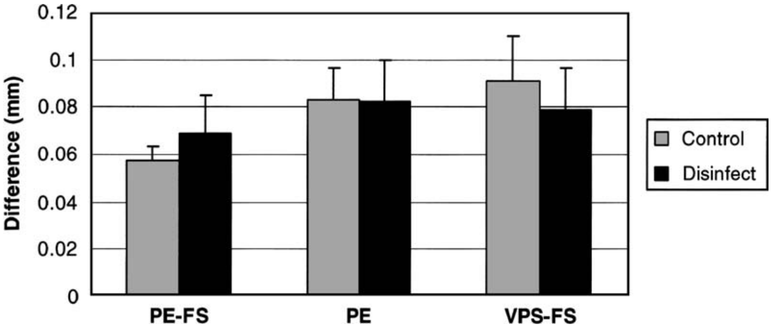

Fig. 5. Mean change for disinfected and nondisinfected condition in CA dimension compared to that of master model. *Vertical bars* indicate SDs.

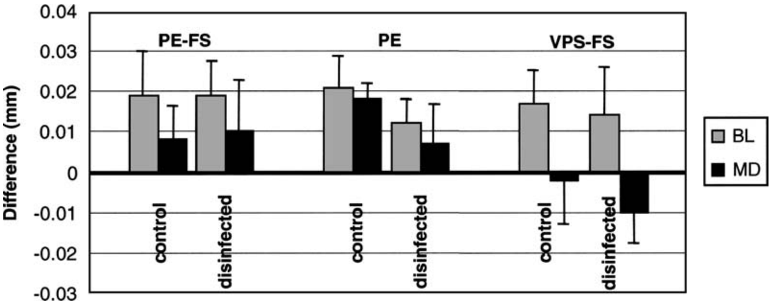

Fig. 6. Mean change for disinfected and nondisinfected condition, in MD and BL dimensions of working die compared to that of stainless steel complete crown preparation. *Vertical bars* indicate SDs.

and L_c represents the cast dimension, and is given in parentheses.

In the AP dimension, all working casts were larger than the master model (Fig. 4). The mean AP dimensional changes compared to the master model, with corresponding percentages, were as follows: casts formed from the PE-FS increased in the AP dimension by 0.013 mm (0.038%), those from the PE increased by 0.022 mm (0.065%), and those from the VPS-FS increased by 0.045 mm (0.133%). Significant differences between working casts from the VPS-FS and the 2 polyethers (PE and PE-FS) were detected ($P<.05$) as shown in Table IV.

The CA measurements of the working casts were also larger when compared to the master model, as shown in Figure 5. The mean difference in dimension for the working casts formed was 0.063 mm (0.147%) for the PE-FS, 0.082 mm (0.191%) for the PE, and 0.085 mm (0.199%) for the VPS-FS. Statistically significant differences between the PE-FS and the 2 other materials (PE and VPS-FS) were detected ($P<.05$), as shown in Table IV.

The stainless steel crown preparation dimensions for the BL and MD were nearly the same (Table II), indicating a nearly circular cross-section. The working die showed a distinct deviation from this form (Table IV and Fig. 6), becoming ovoid. The BL dimensional changes were nearly the same for all 3 materials, with an increase in dimension ranging from 0.015 mm (0.188 %) to 0.019 mm (0.239 %). No significant differences were detected among the 3 materials (P=.602), as shown in Table IV. In the MD dimension, the working casts from the PE and the PE-FS increased by 0.012 mm (0.150%) and 0.009 mm (0.113%), respectively. In contrast, the VPS-FS working casts were smaller when compared to the stainless steel preparation by 0.006 mm (−0.076%). Statistical analysis showed a significant difference between the VPS-FS and the 2 polyethers (PE and PE-FS) ($P<.05$), as shown in Table IV.

With respect to the OG, a cross-product interaction (material × disinfection condition) existed for this dimension. A single-factor ANOVA for the disinfected condition showed a significant difference between the VPS-FS and the 2 polyethers ($P<.05$), as shown in Table IV. Working dies generated from the VPS-FS reduced in dimension by 0.010 mm (−0.161%) when compared to the stainless steel preparation. Working dies from the PE-FS material were larger in the OG dimension by 0.009 mm (0.145%), and those from the PE, by 0.013 mm (0.209%), as shown in Figure 5. For the nondisinfected control, no statistical differences were detected, as indicated in Table IV. The mean values for the PE and the PE-FS working dies were the same, at 0.007 mm (0.112 %) larger than the stainless steel crown

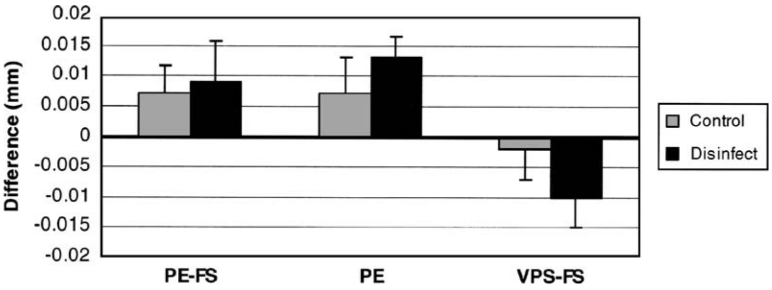

Fig. 7. Mean change for disinfected and nondisinfected condition in OG dimension compared to that of stainless steel complete crown preparation. *Vertical bars* indicate SDs.

preparation; the VPS-FS working dies were 0.002 mm (−0.032%) smaller.

DISCUSSION

The research hypotheses for this study were that no differences existed in accuracy of replica casts recovered from the 3 impression materials for the disinfected and nondisinfected samples. There were significant differences among the impression materials, while no differences between the disinfected and nondisinfected conditions were observed. To simplify presentation, the data were pooled to create grand mean values for the disinfected and nondisinfected conditions combined, except for the OG dimension, for which a cross-product interaction existed.

Since the materials were reformulated chemically to achieve a faster set, it was requisite to confirm accuracy with disinfection. No differences between disinfected and nondisinfected conditions were seen; thus, disinfection of the fast-setting materials is not a limitation. This result is consistent with recent studies of regular setting materials.[13,15] The disinfectant used had a higher concentration (3.5% acid glutaraldehyde) than that used in a previous study.[15] This reduced the immersion time necessary to attain the intermediate level of disinfection required by the Centers for Disease Control and Prevention (CDC).[29]

In all cases, the gypsum working casts formed were larger than the master model (Fig. 4) in both the AP and the CA dimensions (Figs. 4 and 5). For the AP dimension, the PE-FS and PE casts were more accurate than the VPS-FS working casts (Table IV). For the CA dimensional change, working casts were also larger than the master model in all cases. The PE-FS was more accurate than either the PE or VPS-FS (Table IV). Overall, the PE-FS casts demonstrated the least amount of dimensional change; the VPS-FS demonstrated the most.

Two previous studies[13,15] investigated a traditional polyether using the same model system with similar reference points as the current study, allowing some comparisons to be made. One study[15] using a custom impression tray reported working casts that were larger than the master model. The values recorded for the AP (0.007 mm) and the CA (0.020 mm) dimensions were more similar to the master when compared to the current study, in which the AP dimension increased 0.022 mm and the CA increased 0.082 mm for the PE. The second study[13] used a prefabricated stock tray different than the one used in the current study, and noted the AP dimension increased by 0.037 mm and the CA by 0.137 mm larger than the master model.

These differences in accuracy among the 3 studies may be attributed in part to the type of tray used.[10,17-19,25] Custom trays are more intimately adapted to the master model, requiring less impression material when compared to stock impression trays.[11,12] Stock trays differ in design and physical properties, thus affecting accuracy.[22-25] The current study used a more rigid, perforated plastic tray in contrast to the solid plastic tray chosen in one of the comparison studies.[13] An improvement in accuracy is expected when a rigid tray is used, since it is able to resist the distortion forces that can cause plastic deformation when the impression tray is seated and removed.[33] Another factor that may account for the improved accuracy seen in this study was the retention of the impression material in the tray.[22,23] The use of a perforated tray to improve mechanical retention has also been shown to improve the accuracy of casts.[24] However, in comparing the current study to those cited,[13,15] a degree of caution must be used, since the polyether material and mixing technique used were not identical.

The maximum increase in the AP dimension was 0.045 mm, and in the CA dimension, 0.085 mm. These values should be interpreted in terms of the physiological changes that are known to occur during the impression making procedure. For example, as the mandible is opened, it flexes and can produce a cross-arch distortion of up to 0.400 mm between the first molars.[4] Tooth movement can cause anterior-posterior changes during impression making. For instance, single posterior teeth have been shown to move an average of 0.084 mm when acted on by a wedge.[3] Clinically, the magnitude of such changes would affect the outcome of CA or AP dimensions, compared to the dimensionally smaller changes with the impression procedure. It has been suggested that fabricating removable partial dentures on an enlarged cast may be beneficial, as it may partially compensate for casting shrinkage of the metal alloy.[13]

For all 3 of the materials tested, the BL increase ranged from 0.015 mm to 0.019 mm, or 15 to 19 μm. The MD increases for PE and PE-FS working dies were 0.009 mm (9 μm) and 0.012 mm (12 μm), respectively. The VPS-FS die recorded an MD dimension that was 0.006 mm (6 μm) smaller than the stainless steel complete crown preparation. The working dies differed in shape when compared with the stainless steel complete crown preparation, which was round in the cross-section. In all instances, the distortion resulted in the working dies being larger in the BL dimension when compared to the MD dimensions. This ovoid form was most pronounced in the VPS-FS working dies, for which the mean value for the MD dimension was smaller than the stainless steel preparation (Table IV and Fig. 6). The behavior of the impression material within the tray that gives rise to such a change in form requires some explanation. The PE and PE-FS working dies recorded increased dimensions in both BL and MD, with the BL dimension being the larger of the two. Polymerization shrinkage occurs on setting, and if unrestricted, can be considered to occur freely in all directions and ultimately toward the center of mass, as occurs with the ANSI/ADA/ISO test standard.[8] This situation occurs in areas where the setting material is not restrained by the tray, as in the interproximal regions. The resultant effect would be a die larger in the MD dimension compared to the stainless steel crown preparation. In contrast, with the use of a tray adhesive and mechanical tray retention, the impression material polymerization shrinkage would be directed toward the tray walls, thus exaggerating the BL dimension of the resultant die.

Describing the more pronounced reduction in the MD dimension seen with the VPS-FS is more challenging. In the previous explanation, shrinkage in the BL direction is considered to have little effect on the interproximal dimension. However, it is possible that in the case of the VPS-FS, the interproximal material was affected by shrinkage in the BL direction, being stretched much like stretching a rubber band, with the resultant working die being smaller in the MD dimension.

Clinically, a larger diameter working die would be advantageous for a complete crown restoration because the resulting crown would be more likely to seat completely.[5] Optimum crown seating has been determined to occur when a uniform 0.040 mm (40 μm) of axial space exists between the casting and the tooth.[6] This implies that if no other dimensional changes occur, an additional 0.025 mm (25 μm), or 2 layers of die spacer,[13] would be nearly optimal for working dies formed from either PE or PE-FS. However, if the VPS-FS were used to make an impression, the recovered gypsum working die would require 4 layers of die spacer in the MD dimension, and 2 in the BL dimension.

For the OG, the gypsum die was shown to be larger in the case of the PE and PE-FS working dies compared to the stainless steel crown preparation. Again, restricted polymerization shrinkage toward the tray may explain why a larger die was produced. The VPS-FS generated dies were smaller than the stainless steel preparation. This trend is similar to that reported previously,[15,25] although different VPS impression materials were used. The magnitude of change seen in the OG dimension ranged from 0.010 mm (10 μm) smaller to 0.013 mm (13 μm) larger than the stainless steel crown preparation. It is unlikely these differences would be of clinical significance[6]; however, for all 3 materials it would be desirable to use die spacer or some other form of relief in the occlusogingival to allow space for the luting agent.

One limitation of this study lies with differences in making impressions in vivo compared to in vitro. For example, the use of plastic teeth and tissues could affect distortion by their adherence to the impression materials. Also, no moisture equivalent to saliva was used, and there was no way to simulate the biofilm that exists on oral surfaces and comes into contact with the impression material. Impression cord and haemostatic agents are often used when making impressions, and their effects were not assessed. The measuring system used was linear, and so did not account for rotational changes in the shape of the gypsum working casts or dies. The graph used to estimate the setting time of the 3 materials at room temperature was for a VPS material. It was assumed that the polyether followed a similar pattern.

CONCLUSIONS

Within the limitations of this study the following conclusions were drawn:

1. All 3 impression materials evaluated demonstrated sufficient accuracy to enable use in the fabrication of complete crowns.
2. Immersion disinfection of the impressions for 20 minutes in 3.5% acid glutaraldehyde did not adversely affect the accuracy of any of the 3 impression materials.
3. The working casts and working dies from regular and fast-setting polyether demonstrated an increase in all dimensions when compared to the master model and stainless steel complete crown preparation. The working casts from the fast-set VPS were larger than the master model, whereas working dies showed a reduction in mesiodistal dimension and height compared to the stainless steel complete crown preparation.
4. The new fast-setting polyether and VPS materials demonstrated dimensional accuracy equivalent to a traditional polyether.

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Reprint requests to:
Dr Glen H. Johnson
Department of Restorative Dentistry
1959 NE Pacific St
Box 357456
University of Washington
Seattle, WA 98195-7456
Fax: 206-543-7783.
E-mail: gjohnson@u.washington.edu

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