Assessment of preference of mixing techniques and duration of mixing and tray loading for two viscosities of vinyl polysiloxane material

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Statement of problem. Information regarding operators' preferences for different impression mixing techniques and duration of mixing and tray loading is limited.

Purpose. The purpose of this study was to assess operators' preferences, and the duration of mixing and tray loading using different mixing techniques.

Material and methods. Thirty dentists, 30 dental assistants, and 30 inexperienced dental students evaluated mixing heavy-body vinyl polysiloxane material (VPS) using electronic mixing compared to automixing, and extra-heavy-body material using electronic mixing compared to hand mixing. Participants rated their level of preference using a scale from 0 to 10 for ease of mixing, control of loading, quality of mixing, level of cleanliness, and overall rating. The duration of mixing and tray loading was also measured. Mean values were compared within participant groups using the paired *t* test (α=.05) and between groups using 1-way analysis of variance (ANOVA) (α=.05). Holm's procedure was used to adjust the level of significance for the multiple comparisons.

Results. The paired *t* test showed that mean values of level of preference for electronic mixing were significantly higher ($P<.001$ to .033) than those for automixing or hand mixing. The mean values of duration of mixing and tray loading with electronic mixing were significantly higher ($P<.001$ to .002) than those with automixing or hand mixing, except for students using heavy-body materials (P=.31). One-way ANOVA showed that there were no significant differences between the 3 participant groups in preference and duration of mixing and tray loading, both of heavy-body and extra-heavy-body VPS impression materials.

Conclusions. All participant groups preferred electronic mixing to automixing or hand mixing. Electronic mixing was significantly slower for all groups except for students using heavy-body materials. There was no significant difference between the 3 participant groups in the preference or duration of mixing and tray loading for the mixing techniques tested. (J Prosthet Dent 2007;97:12-7.)

CLINICAL IMPLICATIONS

All participant groups preferred electronic mixing to automixing or hand mixing, despite the fact that electronic mixing was slower. This study should assist clinicians in making decisions regarding impression mixing techniques.

Making a definitive impression is a critical step in producing biologically, mechanically, functionally, and esthetically acceptable restorations. The accuracy of definitive impressions significantly affects the quality of restorations in restorative dentistry.[1] The definitive impression should be accurate to fabricate restorations with ideal marginal fit, internal fit, interproximal contacts, and occlusal contacts.[2,3] Also, the impression material should reproduce the hard and soft tissue around prepared and adjacent teeth.[4-6] The working time for impression materials is also an important factor for dental practitioners[7] and may be influenced by mixing techniques.

Vinyl polysiloxane (VPS) impression materials are popular due to their favorable qualities, relative simplicity, and reliability.[8] Vinyl polysiloxane impression materials were introduced in the 1970s.[9] These materials have low dimensional change, low creep, relatively short setting time, and moderate to high tear resistance.[10] Also, compared with other types of impression materials, VPS impression materials demonstrate excellent accuracy, elastic recovery from undercuts,[11] and the fewest dimensional changes after multiple pours.[12-14] The original disadvantage of using VPS impression materials was their hydrophobic characteristic; however, hydrophilicity of these materials was facilitated by

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adding polyether carbosilane (PCS) surfactant.[15-18] Early generations of VPS impression materials released hydrogen gas after setting, which required a delay in the pouring of casts to avoid bubbles. This problem has been resolved by adding platinum or palladium to scavenge the gas, and this improvement has allowed the immediate pouring of casts without bubbles or voids.[19,20]

Factors that affect the quality of the definitive impression include tooth preparation design, soft tissue management, tray selection, impression material, and impression technique.[20] Previous studies have shown that mixing techniques have an effect on the quality of impressions.[21-28] Compared to hand mixing, both automixing and electronic mixing techniques enhance the quality of a definitive impression.[21] The latter 2 techniques have improved the accuracy of impressions and casts because of the resultant impression materials' superior physical properties, uniform mix, reduction of voids, and avoidance of contamination.[22-25] Also, automixing was considered to be more economical than hand mixing because it wastes one third less volume of material as compared to hand mixing.[26,27] Kugel et al[20] compared clinicians' preferences using an electronic mixing technique to automixing and hand mixing. More than two thirds of the clinicians reported that electronic mixing was easier to perform, faster to mix, and cleaner than automixing or hand mixing. However, most often the dental assistant, rather than the clinician, is responsible for handling and mixing the impression materials. In addition, the perceived ergonomic comfort of the efforts made by the operator when mixing and loading a complete-arch impression tray with high-viscosity materials may be a factor affecting selection of the mixing technique for impression materials.

The purpose of this study was to compare the preference and duration of mixing and tray loading with experienced dentists, experienced dental assistants, and inexperienced first-year dental students using different mixing techniques. This was accomplished using 3 mixing techniques for VPS impression materials of 2 different viscosities. The study compared an electronic mixing technique to an automixing technique for heavy-body (HB) VPS impression material, and an electronic mixing technique to a hand-mixing technique for extra-heavy-body (EHB) VPS material. The first null hypothesis was that there was no difference within each participant group in the preference and duration of mixing and tray loading of different mixing techniques. The second null hypothesis was that there was no difference between the 3 participant groups in the preference and the duration of mixing and tray loading for each mixing technique.

MATERIAL AND METHODS

Thirty experienced dentists (1-40 years of experience), 30 experienced dental assistants (1-40 years of experience), and 30 inexperienced first-year dental students from the University of Washington participated in this study. Participants were asked to use 3 different impression mixing techniques (Fig. 1), following which they evaluated these techniques using a questionnaire. Several comparisons were made in this study. For HB VPS impression material mixing, Imprint II Penta (Lot 237528; 3M ESPE, St. Paul, Minn) was mixed using a Pentamix 2 (3M ESPE) mixing device and compared to Imprint II Garant (Lot 20050531; 3M ESPE), which was mixed using a Garant mixing unit (3M ESPE). For EHB VPS impression material mixing, Imprint 3 Penta (Lot 193171; 3M ESPE) was mixed using the Pentamix 2 (3M ESPE) device and was compared to Express STD Putty (Lot 20060119; 3M ESPE), which was mixed using hand mixing.

Each participant in the study was asked to fill 3 complete-arch mandibular metal trays (Size L15, Rim-Lock; Dentsply Caulk, Milford, Del) with each impression material. All participants were assigned to perform tray filling for the HB material first, and then the EHB material. In each material group, the order of the mixing technique was randomly assigned and balanced to give equal sample sizes of each mixing order. Randomization assignments were generated by the biostatistician using randomly selected block sizes of 2 or 4 using the sample function of the statistical software (S-PLUS 2000 Professional Release 1; Insightful Corp, Seattle, Wash). Prior to commencing the mixing procedures, all participants were trained to use each mixing technique and the tray loading procedure with all provided impression materials.

A self-reported survey questionnaire was used to evaluate the mixing technique preference of the dentists, assistants, and inexperienced students. Participants rated their level of preference using a scale of 0 (not at all satisfied) to 10 (very satisfied) for 5 questions: ease of mixing, control of loading, quality of mixing, level of cleanliness, and overall rating. After completing 3 tray fills, participants evaluated the overall level of preference for each technique as low, medium, or high.

The duration of mixing and tray loading for each technique was recorded in seconds. The duration was measured from the start of mixing impression materials until the trays were completely filled. To standardize the volume of the hand-mixed EHB VPS impression material, scoops (3M ESPE) were used to measure equal amounts of base and catalyst. Twenty seconds was allowed for each participant to mix EHB putty by hand as recommended by the manufacturer. Participants wore vinyl gloves (Excel professional fit; Excel Gloves & Safety Supplies Inc, Fife, Wash) to mix EHB impression material because latex gloves may interfere with the setting of VPS materials.[28] The total duration of EHB hand mixing and tray loading was recorded for each participant.

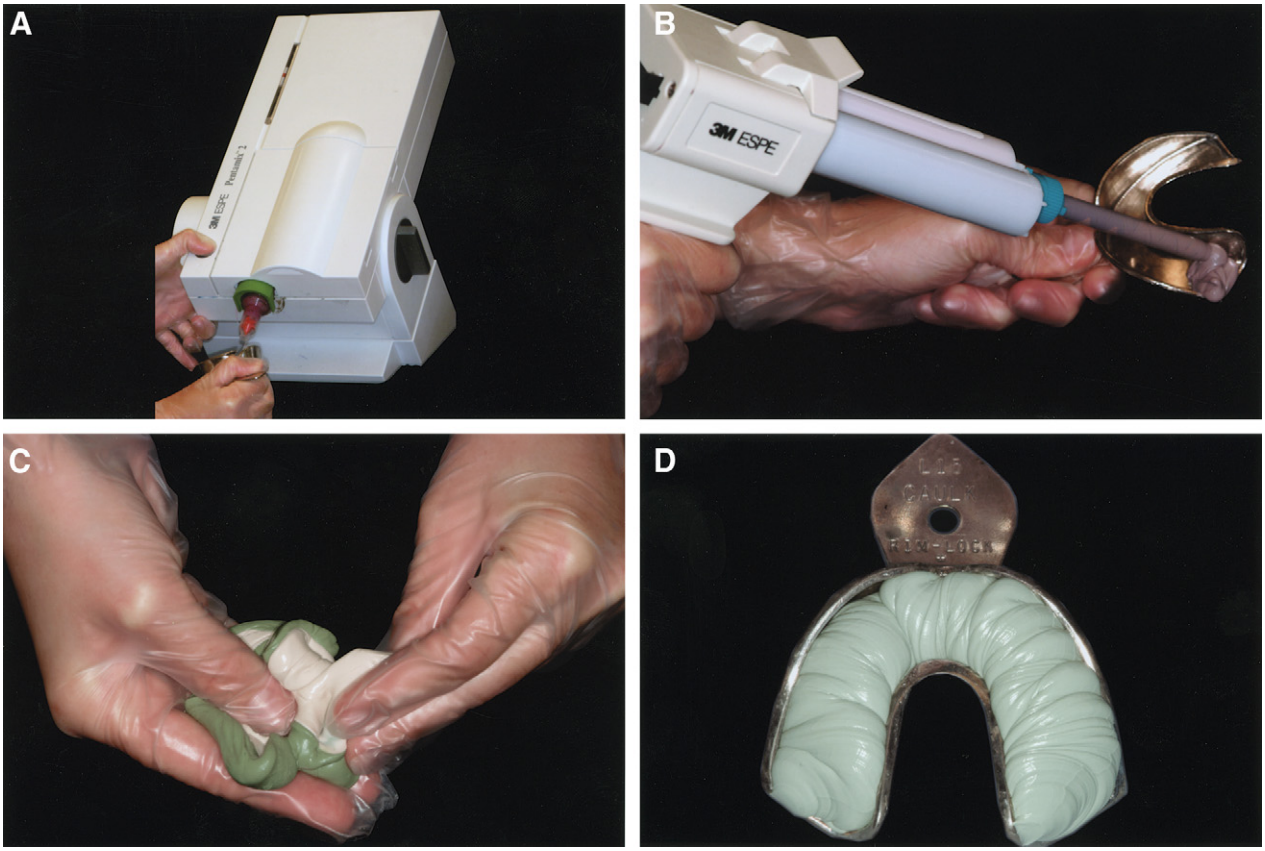

Fig. 1. Different mixing techniques. **A,** Electronic mixing. **B,** Automixing. **C,** Hand mixing. **D,** Mandibular metal rim-lock tray filled with impression material.

The data were analyzed using statistical software (SPSS 12.0; SPSS Inc, Chicago, Ill). The level of preference was summarized by the average rating of the 3 tray fillings, and then compared within and between participant groups separately for each feature. The preference scores were summarized by mean values and SDs. Preference scores were compared within each participant group by a paired *t* test, and 1-way analysis of variance (ANOVA) was used to compare the level of preference between 3 participant groups (dentists, dental assistants, and inexperienced dental students). The duration of mixing and tray loading was recorded, and the average of the 3 tray fillings was used for the analysis. Mean values and SDs were calculated and compared within groups using a paired *t* test, and between participant groups using 1-way ANOVA. An alpha level of .05 was used for all statistical testing. To reduce the probability of a type I error due to the multiple comparisons, Holm's procedure was used to determine the statistical significance and maintain an alpha level of .05 for each within-group comparison consisting of 6 tests (5 preference ratings and duration), and for each between-group comparison consisting of 6 tests.[29,30]

RESULTS

Table I lists mean values and SDs of the level of preference (5 questions in the survey) and the duration of mixing and tray loading of the HB impression material. All dentists, dental assistants, and inexperienced students preferred the electronic mixing technique to the automixing technique when comparing the level of preference. A comparison of the overall level of preference after 3 trials revealed that 97% of dentists, 87% of assistants, and 90% of inexperienced students rated the electronic mixing technique as "High" (highly preferable), whereas only 50% of dentists, 13% of assistants, and 27% of inexperienced students rated the automixing technique as "High" (Table II).

Table III lists mean values and SDs of the level of preference and the duration of mixing and tray loading of EHB impression material. All 3 participant groups preferred the electronic mixing technique to the hand-mixing technique. The overall level of preference after 3 trials demonstrated that 80% of dentists, 70% of assistants, and 86% of inexperienced students rated the electronic mixing technique as "High," whereas 13% of dentists, 3% of assistants, and 3% of inexperienced

Table I. Mean value (SD) within each group of level of preference (scale from 0 to 10) and duration of mixing and tray loading (in seconds) with HB

	Dentists			Dental assistants			Inexperienced dental students			Between groups	
	Electronic mixing	Automixing	P*	Electronic mixing	Automixing	P*	Electronic mixing	Automixing	P*	F†	P†
Ease of mixing	9.7 (0.6)	7.3 (1.3)	<.001	9.8 (0.5)	6.5 (2.4)	<.001	9.8 (0.5)	6.9 (1.7)	<.001	0.3	1.0
Control of loading	8.8 (1.3)	7.9 (1.3)	.033	8.8 (1.4)	6.8 (2.1)	<.001	8.3 (1.7)	6.9 (1.8)	.010	1.4	1.0
Quality of mixing	9.4 (0.7)	8.5 (1.3)	.002	9.4 (0.7)	8.4 (1.4)	.001	9.5 (0.7)	8.4 (1.5)	.001	0.4	1.0
Level of cleanliness	9.5 (0.6)	8.4 (1.2)	<.001	9.5 (0.7)	8.1 (1.9)	.001	9.3 (0.9)	7.6 (1.1)	<.001	1.1	1.0
Overall rating	9.3 (0.6)	8.0 (0.9)	<.001	9.4 (0.8)	7.0 (2.0)	<.001	9.1 (1.0)	7.3 (1.1)	<.001	1.1	1.0
Duration	28.4 (2.6)	25.1 (4.9)	.002	28.2 (1.6)	23.8 (5.7)	.001	29.4 (2.7)	28.1 (5.9)	.31	2.4	.56

*Within group comparisons: paired *t* test, *P* value adjusted for multiple tests (Holm's procedure).
†Between group comparisons: 1-way ANOVA (degrees of freedom 2 and 87), *P* value adjusted for multiple tests (Holm's procedure).

Table II. Percentage (frequency) of overall level of preference after 3 trials with HB

	Dentists		Dental assistants		Inexperienced dental students	
	Electronic mixing	Automixing	Electronic mixing	Automixing	Electronic mixing	Automixing
High	97% (29)	50% (15)	87% (26)	13% (4)	90% (27)	27% (8)
Medium	3% (1)	50% (15)	13% (4)	63% (19)	10% (3)	63% (19)
Low	0% (0)	0% (0)	0% (0)	23% (7)	0% (0)	10% (3)

Table III. Mean (SD) within each group of level of preference (scale from 0 to 10) and duration of mixing and tray loading (in seconds) with EHB

	Dentists			Dental assistants			Inexperienced dental students			Between groups	
	Electronic mixing	Hand mixing	P*	Electronic mixing	Hand mixing	P*	Electronic mixing	Hand mixing	P*	F†	P†
Ease of mixing	9.3 (1.0)	5.9 (1.9)	<.001	9.1 (1.3)	5.8 (2.4)	<.001	9.7 (.6)	5.6 (1.7)	<.001	1.3	.53
Control of loading	8.8 (1.1)	6.9 (1.7)	<.001	8.8 (1.1)	7.8 (1.7)	.014	8.7 (1.1)	7.6 (1.8)	.011	3.8	.13
Quality of mixing	9.3 (.9)	6.2 (2.1)	<.001	9.4 (1.2)	5.6 (2.1)	<.001	9.6 (.6)	5.5 (1.9)	<.001	0.1	.89
Level of cleanliness	9.3 (0.9)	6.4 (1.7)	<.001	9.4 (.6)	6.0 (2.2)	<.001	9.4 (.7)	5.9 (1.9)	<.001	2.2	.35
Overall rating	9.2 (.9)	6.3 (1.8)	<.001	8.9 (1.5)	5.9 (2.1)	<.001	9.2 (.8)	6.3 (1.4)	<.001	3.6	.13
Duration	35.0 (3.8)	32.2 (3.0)	.002	34.8 (2.7)	30.8 (3.1)	<.001	36.8 (3.4)	31.6 (2.8)	<.001	4.9	.06

*Within group comparisons: paired *t* test, *P* value adjusted for multiple tests (Holm's procedure).
†Between group comparisons: 1-way ANOVA (degrees of freedom 2 and 87), *P* value adjusted for multiple tests (Holm's procedure).

Table IV. Percentage (frequency) of overall level of preference after 3 trials with EHB

	Dentists		Dental assistants		Inexperienced dental students	
	Electronic mixing	Hand mixing	Electronic mixing	Hand mixing	Electronic mixing	Hand mixing
High	80% (24)	13% (4)	70% (21)	3% (1)	87% (26)	3% (1)
Medium	20% (6)	50% (15)	23% (7)	60% (18)	13% (4)	67% (20)
Low	0% (0)	37% (11)	7% (2)	37% (11)	0% (0)	30% (9)

students rated the hand-mixing technique as "High" (Table IV).

A comparison of the duration of mixing and tray loading, for the HB material, revealed that dentists (P=.002) and dental assistants (P=.001) were significantly slower with the electronic mixing technique than the automixing technique; however, inexperienced students (P=.31) showed no significant difference between the electronic mixing technique and the automixing technique (Table I). For the EHB material, all 3 participant groups were significantly slower with the electronic mixing technique than the hand-mixing technique (P<.001 to .002; Table III).

When using the HB impression material, both with the electronic mixing technique and the automixing technique, there were no significant differences in the

level of preference or duration of mixing and tray loading between the dentist, assistant, and inexperienced student groups ($P>.05$; Table I). When using EHB impression material, both with the electronic mixing technique and the hand-mixing technique, there were no significant differences in the level of preference or duration of mixing and tray loading between the 3 participant groups ($P>.05$; Table III).

DISCUSSION

The first null hypothesis, that there was no difference within each participant group in preference or duration of mixing and tray loading of the different mixing techniques, was rejected, except for the duration of mixing and tray loading for the inexperienced students group using HB VPS. The second null hypothesis, that there was no difference between the 3 participant groups in the preference and duration, was accepted for both preference and duration of mixing and tray loading. The authors compared participants' level of preference using both a quantitative (numerical) rating (0 to 10) and a qualitative rating (high, medium, low) in this study. The analysis of the quantitative ratings and descriptive results of the qualitative ratings showed similar results regarding the level of satisfaction.

In a survey study there are unavoidable limitations, including the subjectivity of answering a qualitative questionnaire. Other limitations in this study included the participation by different operators, different experience levels within the dentist and the dental assistant groups, and different experience levels using specific mixing techniques. The automixing technique was only available for the HB VPS impression material, and the hand-mixing technique was only available for the EHB VPS impression material.

When selecting impression materials, dentists as well as assistants may be a part of the selection process. The dentist selects the impression material, and the dental assistant may participate in selecting the desired mixing technique since the assistant generally mixes the impression material and may have different mixing technique preferences compared to dentists.

Comments made by participants regarding each of the mixing techniques were considered. For the electronic mixing technique, operators perceived that it was slow compared to other techniques. Although the electronic mixing technique was significantly slower than the other 2 mixing techniques, the differences of the duration of mixing and tray loading ranged from approximately 3 to 5 seconds. It seemed to the authors that because the participants only "pressed the buttons" to operate the electronic mixing machine and the other techniques required more physical effort to mix the impression materials, the effort involved may affect the perception of mixing time. Two thirds of the respondents in a study performed by Kugel et al[20] rated the electronic mixing technique (Pentamix; 3M ESPE) as faster than the automixing technique or the hand-mixing technique, which is in contrast to the findings of the current study. Other comments made by participants regarding the electronic mixing technique were that the electronic mixing unit was "too big" and that "it was difficult to predict when the supply of impression material would be emptied." Using the automixing technique, some participants' hands became fatigued after repeated performances.

Measuring and comparing the duration of mixing and tray loading of different mixing techniques should be clarified. Mixing and tray loading for the electronic mixing and the automixing techniques were performed simultaneously. In contrast, the duration of mixing and loading of the hand-mixing technique was comprised of a 20-second fixed mixing time plus an additional tray loading time. The duration of mixing and loading of the hand-mixing technique was therefore dependent on tray loading time.

Using the hand-mixing technique, participants had difficulty achieving homogeneous mixtures during the 20 seconds of mixing time recommended by the manufacturer. The authors opted to use the fixed 20-second mixing time instead of using a variable mixing time that allowed participants to mix until homogeneous mixtures were attained. The authors preferred to follow the manufacturer's recommendation and evaluate whether participants could achieve homogeneous mixtures in 20 seconds.

The results of the study showed that there was no statistically significant difference in quality of mixing (homogeneity) between experienced groups (dentists and assistant) and the inexperienced group (first-year dental students) for the hand-mixing technique. However, the authors observed that inexperienced participants had more difficulty in achieving homogenous mixtures than experienced participants. Thus, the hand-mixing technique with EHB impression material could be more technique-sensitive and result in more difficulty achieving homogeneity than the electronic mixing technique.

EHB impression material has been available only with the hand-mixing technique. The EHB impression material used in this study with the electronic mixing technique is the first commercially available EHB material with an alternative mixing technique. The results of this study showed that all 3 participant groups preferred mixing EHB impression material using the electronic mixing technique compared to the hand-mixing technique in terms of ease of mixing, control of loading, quality of mixing, and cleanliness. Use of the electronic mixing technique made it easier to facilitate equal mixing ratios between base and catalyst, providing better quality of mix. The electronic mixing technique could reduce potential contamination and facilitate more reliable

working and setting times for definitive impressions as compared to the hand-mixing technique. Since the perception of the study participants was that the electronic mixing was slower, further studies should evaluate the parameters evaluated in this study with a faster electronic mixing unit. A larger sample size of participants divided into subgroups based on duration of clinical experience may assist in further determining trends in participants' preferences. Based on the preference of the study participants to use electronic mixing, a comparison of different commercially available electronic mixers would be of value to determine if different electronic mixers perform equally.

CONCLUSIONS

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

1. Regardless of the impression material viscosity, dentists, dental assistants, and inexperienced first-year dental students significantly preferred the electronic mixing technique to the automixing and hand-mixing techniques.
2. The duration of mixing and tray loading using electronic mixing was significantly slower than other mixing techniques except when the inexperienced first-year dental students mixed HB VPS impression material. Inexperienced first-year dental students showed no significant difference in duration of mixing and tray loading between the electronic mixing technique and the automixing technique with HB VPS impression material.
3. There were no significant differences in preference of mixing techniques and duration of mixing and tray loading using both HB and EHB VPS impression materials when comparing the 3 participant groups.

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