An Experimental Study on Particular Physical Properties of Several Interocclusal Recording Media. Part I: Consistency Prior to Setting

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Purpose: **To evaluate the consistency prior to the setting of 5 elastomeric interocclusal recording materials in comparison with a wax and a zinc oxide–eugenol paste. This property is related to the viscosity as well as to the working and setting times of these materials.**

Materials and Methods: **Testing of consistency was performed following a modification of the method described in ADA Specification No. 19, for elastomeric impression materials. Each one of the tested materials was mixed for 20 seconds and was then loaded into a 0.5 mL syringe. The material was syringed onto a 10 × 10 × 0.5 cm glass plate. A second 575 g glass plate was placed on top of the unset interocclusal registration material. A total of 10 samples were tested for each material. The surface area covered by the materials was measured with the help of a scanner and the use of appropriate computer software.**

Results: **One-way ANOVA revealed significant differences among the materials ($F = 889.493$, $p < 0.0005$). According to Tukey's honest significant difference test, all materials were significantly different ($p < 0.05$) from one another. All polyvinylsiloxanes occupied a smaller area than that of the polyether and of the zinc oxide–eugenol paste.**

Conclusions: **Zinc oxide–eugenol paste was the most fluid of all materials tested. Polyvinylsiloxanes displayed less flow properties than polyether.**

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INDEX WORDS: interocclusal recording media, bite registration materials, consistency

DIAGNOSIS and treatment of a patient for a prosthetic rehabilitation requires that the clinician fabricate diagnostic casts, as well as master casts, and articulate them on an articulator. For this reason it is necessary to record maxillomandibular relationship and accurately transfer it to the articulator. In some cases it is sufficient to record the maximum intercuspation of the patient, whereas in full mouth rehabilitation it is necessary to record the centric relation.

Correct interocclusal records give the clinician the opportunity to make only minimal adjustments to the restorations that were delivered from the laboratory and avoid unnecessary use of chair-time, or repetition of some clinical and technical stages. Possible errors in this essential clinical stage may be due to the biologic characteristics of the stomatognathic system, to faulty techniques of jaw manipulation, or to mishandling of the interocclusal recording medium by the clinician.

Many materials and techniques have been used for maxillomandibular registration procedures since the first interocclusal registration made in 1756 by Phillip Pfaff.[1]

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There is no material, however, that has all the properties of the "ideal" interocclusal registration medium. These properties have been described as having:[2]

1. Limited initial resistance to closure (in order to avoid the displacement of mobile teeth or of the mandible during record making);
2. Dimensional stability after setting;
3. Resistance to compression after polymerization;
4. Ease of manipulation;
5. Absence of any adverse effects on the tissues involved in the recording procedures;
6. Accurate recording of the incisal or occlusal surface of the teeth; and
7. Ease of verification.

Materials that have been proposed for interocclusal registration procedures include the following:[3-6]

a. Plaster
b. Modeling compound
c. Waxes
d. Acrylic resin
e. Zinc oxide–eugenol pastes

All the above-mentioned materials are inelastic. As a result, these materials display the following properties:

1. Increased initial resistance (with the exception of the plaster and zinc oxide–eugenol paste);
2. Dimensional instability;
3. Difficulty in manipulation; and
4. Difficulty in verification because of their brittle nature.

These materials have been used for many years. Wax is still the material of choice in many instances. Some elastomeric materials have been used for the same purpose. These include polyether and addition silicone interocclusal registration materials.[7]

Polyethers and addition silicones have been used for many years as impression materials and have gained popularity because of their excellent accuracy, dimensional stability, and quick recovery.[8-15] These impression materials have been modified with the addition of plasticizers and fillers in order to be used as interocclusal recording media. Catalysts have also been added in order to accelerate their polymerization reaction.[16,17]

There is a question, though, whether this modification of the "parent" material has changed the excellent properties that these materials possess. This paper is the first of 3 that examine 3 physical properties of some elastomeric interocclusal recording media in comparison with a wax and a zinc oxide–eugenol paste.

The purpose of this study was to evaluate the consistency of the elastomeric interocclusal recording materials. This property is related to the viscosity, as well as to the working and setting time. Examination of the consistency of the materials was chosen after correlating this property with the first desired properties of the registration materials: limited resistance before setting.

Materials and Methods

One polyether and four polyvinylsiloxane interocclusal registration materials were compared to a wax and a zinc oxide–eugenol paste used for the same purpose (Table 1). As consistency is related to the viscosity and working and setting time of the materials, these times are listed in Table 2. All materials were stored according to manufacturers' instructions.

Testing of the consistency was performed following a modification of the method described in ADA Specification No. 19, for elastomeric impression materials.[18] Each of the tested materials was mixed for 20 seconds and a 0.5 mL syringe was filled with the material. The total time of mixing and filling of the syringe was never more than 25 seconds. The material was then syringed onto a 10 × 10 × 0.5 cm glass plate lubricated with Ricospray Silicone (3M, St. Paul, MN). A second

Table 1. Interocclusal Recording Materials Included in the Study

Brands	*Material Type*	*Batch*	*Manufacturers*
Ramitec	Polyether	B404/C392	ESPE, Seefeld, Germany
3M	Polyvinylsiloxane	6BGP1U1	3M, St. Paul, MN
Stat-BR	Polyvinylsiloxane	22739/4-1166	Kerr, Romulus, MI
Blu-Mousse	Polyvinylsiloxane	S 438	Parkell, Farmington, NY
Regisil 2X	Polyvinylsiloxane	980902	LD Caulk, Milford, DE
ZOE-SSW	Zinc oxide–eugenol	049436	SSWhite, Gloucester
Alminax	Wax	DW219204	Purton, Swindon

Table 2. Working and Setting Time of the Materials

Materials	*Working Time*	*Setting Time*
Ramitec	2 min	5 min
3M	30 sec	1 min
Stat-BR	30–45 sec	1 min 30 sec
Blu-Mousse	45 sec	2 min
Regisil 2X	30–60 sec	1 min 30 sec
ZOE-SSW	3 min	10 min
Alminax	N/A	N/A

lubricated glass plate, weighing 575 g, was placed on top of the unset interocclusal registration material. Each specimen was left to set at room temperature for the time suggested by the manufacturer, plus an additional 6 minutes.

For the wax (Alminax) the method was modified as follows: The wax was softened, according to manufacturer's instructions, submerged in a 45°C water bath (Dentek Inc., Buffalo, NY). Afterwards it was loaded into the syringe, and the syringe was placed again in the water bath for 5 minutes. The lubricated glass plates were placed in a 36 ± 1°C water bath (Dentek Inc.) for 2 minutes before syringing the wax.[19] The glass plates were placed into the water bath to simulate the wax contacting teeth at approximately oral temperature. After removing the glass plates from the water bath, the wax was immediately syringed onto the first glass plate, and the second plate was placed on top of it. The whole glass plates–wax system was cooled with airflow for 2 minutes to allow the glass plates to cool down.[19]

The method described for the testing of the elastomeric materials was also applied to the zinc oxide–eugenol paste. This was done in order to provide comparable results among all the materials included in this study.[20] Ten samples were tested for each material.[21,22]

Measurements and data collection were always performed by the same operator. Temperature and relative humidity were recorded throughout the experiment (21 ± 1°C, 50 ± 10%).

The surface area covered by the materials was recorded with a scanner (One scanner, Apple, Cupertino, CA) and accurately calculated in square centimeters with the use of Claris Draw (FileMaker, Santa Clara, CA) and Mini CAD 7.0 (Graphisoft Inc., San Francisco, CA) software. This software had the ability to measure surface area with a precision of 4 decimal places.

Results

The results of the descriptive statistics for the measurements of the consistency are depicted in Table 3 and Figure 1. All values are in square centimeters. One-way ANOVA revealed significant differences among the materials ($F = 889.493$, $p < 0.0005$) (Table 4). Tukey's honest significant difference (HSD) test was used to determine the significant differences between the materials (Table 5). All materials were significantly different ($p < 0.05$) from one another. Polyvinylsiloxanes occupied smaller areas than polyethers and the zinc oxide–eugenol paste. Regisil 2X and Stat BR occupied a larger area than the other addition silicones. The polyvinylsiloxane material 3M occupied the smallest area, while zinc oxide–eugenol paste covered the largest area of all materials tested.

Table 3. Descriptive Statistics for the Consistency of Different Interocclusal Registration Materials

Materials	*N*	*Mean*	*SD*	*Min*	*Max*
Ramitec	10	7.64	0.20	7.36	7.92
3M	10	3.87	0.18	3.50	4.16
StatBR	10	6.53	0.17	6.16	6.71
Blu-Mousse	10	5.49	0.18	5.23	5.80
Regisil	10	6.82	0.23	6.46	7.08
ZOE-SSW	10	9.31	0.25	9.00	9.66
Alminax	10	4.52	0.10	4.38	4.69

Measurements in square centimeters.

The results concerning the wax and the zinc oxide–eugenol paste are only of a comparative value to those of the elastomers.

Discussion

All the materials included in this study displayed statistically significant differences in their consistency characteristics. Polyether (Ramitec) occupied the largest area of all the elastomeric recording media. This implies that all polyvinylsiloxanes displayed reduced flow characteristics in comparison to the polyether.

In clinical practice it seems that the polyether will display less resistance during the interocclusal registration procedures. As a result, displacement of mobile teeth or of the mandible should be less frequent.

Still, consistency is related to the temperature of the environment and to the working and setting time of the materials. Working and setting times are in close relationship with the rapidity of the chemical reaction, which leads to the construction of polymer chains. A lengthy setting time is not a desired property for the registration of the maxillomandibular relations, because it can affect the precision due to possible movement of the mandible. This movement can occur because

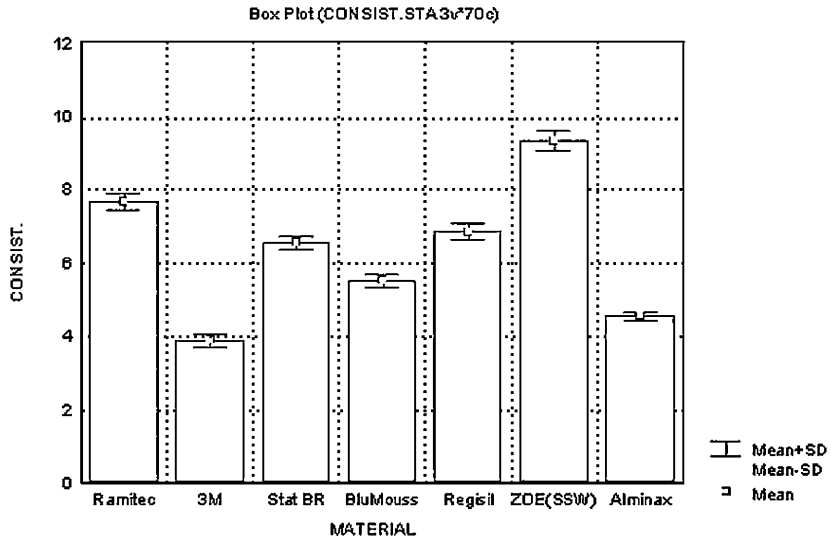

Figure 1. Mean percentages and standard deviations of the consistency of different interocclusal registration materials. (Consistency measured in square centimeters.)

of the patient's inability to maintain the mandible in one position due to muscle fatigue.

Even if the consistency characteristics of the polyether (Ramitec) seem to be satisfactory, they should be correlated to the lengthy setting time of 5 minutes, which is too long for these procedures. For this reason, other materials that combine good consistency characteristics with shorter setting times may be preferable. The fact that Ramitec presents almost the same setting time with the corresponding impression material (Impregum, ESPE, Seefeld, Germany) is a possible indication that the modification of the "parent" material was restricted only to the addition of plasticizers and fillers without the addition of catalysts, which would achieve a faster polymerization reaction.

Regisil 2X presents the best consistency characteristics in the polyvinylsiloxane group, followed by Stat BR. Their setting time is 1 minute 30 seconds, which is highly acceptable. Blu-Mousse has a setting time of 2 minutes, but it does not present consistency characteristics as good as the previous two addition silicones. This is probably related to the viscosity of this material. 3M occupied the smallest area of all the materials included in this study. This is related to both the high viscosity and the very fast construction of polymer chains and transition from the plastic to the elastic phase. The 1-minute setting time of 3M may be considered very short for the precise accomplishment of maxillomandibular registration procedures.

With the exception of 3M, elastomeric interocclusal recording media displayed better flow characteristics when compared to wax. As mentioned before, SS White zinc oxide–eugenol paste occupied the largest area of all the materials tested. The lengthy setting time in combination with the fact that this material should always be used with a carrier, are the major drawbacks for its use.

Table 4. One-Way ANOVA to Compare the Consistency of Different Interocclusal Registration Materials ($p = 0.05$)

Sources	*SS*	*df*	*MS*	*F*	*Sig*
Between the groups	208.83	6	34.80	889.49	0.000
Within the groups	2.46	63	3.913E-02		
Total	211.30	69			

Table 5. Tukey's HSD to Compare the Consistency of Various Interoclussal Recording Media ($p = 0.05$) (Values indicated are in square centimeters)

	N	*Subset*						
Material		1	2	3	4	5	6	7
3M	10	3.87						
Alminax	10		4.52					
Blu-Mousse	10			5.49				
StatBR	10				6.53			
Regisil	10					6.82		
Ramitec	10						7.64	
ZOE-SSW	10							9.31

The flow of the wax depends largely on the temperature, the applied force, and the duration of the force application. In order to have reliable results when using the wax, the clinician should always follow the manufacturer's instructions and keep in mind its limitations. The difficulties encountered in wax manipulation as well as the special instrumentation needed are the major disadvantages of this material, when compared to the new elastomeric bite registration media.

Consistency and working and setting times usually affect the choice of the interocclusal registration material to be used. However, it should be pointed out that the use of a resistant anterior stop, such as Lucia jig,[23] can significantly affect the choice of the material to be employed. Its use provides the desired amount of interocclusal space for the registration material and practically eliminates the risk of mandibular deviation due to muscle fatigue.

Finally it should be mentioned that both consistency and setting times are affected by the temperature, as has been shown by previous studies.[24,25] Therefore, there should be further research on the consistency characteristics of the materials in a temperature similar to that of the oral cavity.

Conclusions

One polyether and four polyvinylsiloxane interocclusal recording materials were compared to a wax and a zinc oxide–eugenol paste regarding their consistency characteristics. Given the limitations and methods of this study, the results were as follows:

1. Zinc oxide–eugenol paste exhibited the greatest flow characteristics of all materials tested.
2. Polyether (Ramitec) exhibited greater flow characteristics than the addition silicones.
3. Regisil 2X and Stat BR exhibited greater flow characteristics than the remainder of the addition silicone materials.
4. 3M exhibited the least flow characteristics of all interocclusal recording media tested.

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