An Experimental Study on Particular Physical Properties of Several Interocclusal Recording Media. Part III: Resistance to Compression After Setting

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Purpose: The purpose of this study was to evaluate the resistance to compression after setting of several elastomeric interocclusal recording materials.

Materials and Methods: Testing of the resistance to compression after setting was performed following a modification of the method described in specification No. 19 (4.3.6) of the A.D.A., for the elastomeric impression materials—1 cylindrical stainless steel mold with an internal diameter of 20 mm and a height of 20 mm was constructed. Mixing of the interocclusal registration media was conducted according to manufacturers' instructions, and the materials were injected into the mold. Two subsequent loads, one of 100 g/cm^2 and a second of 1000 g/cm^2 were exerted on each sample. The deformation of each was calculated using a vertical traveling micrometer microscope with an accuracy of $\pm$ 0.001 mm.

Results: One-way ANOVA revealed significant differences among the materials ($F = 331.58$, $p < 0.0005$). Tukey's HSD ($p < 0.05$) test was used to determine the significant differences between the materials.

Conclusions: Polyvinylsiloxane Blu Mousse displayed the greatest resistance to compression, as compared to other elastomeric interocclusal recording materials tested.

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INDEX WORDS: bite registration materials, interocclusal recording media, resistance to compression

ONE OF the most desirable characteristics of the interocclusal registration materials is resistance to compression after polymerization; the material should be rigid enough to resist the distortion that might be caused from the weight of the dental casts, the components of the articulator, or other means used to stabilize the casts during the mounting procedure.

Previous authors[1] have stated that a disadvantage of using an elastomeric interocclusal registration material is the lack of sufficient rigidity when the dental casts are articulated. Hence, an alteration in the relationship of the casts may result if the material is not used properly.

In Parts I and II of this study, the consistency, and linear and weight changes of 1 polyether and 4 polyvinylsiloxane interocclusal registration materials were studied in relation to those of 1 zinc oxide–eugenol paste and 1 wax interocclusal registration material.

In this part of the study, the resistance to compression after setting was determined for the same materials.

Materials and Methods

The materials used for Part III are listed in Table 1. All materials were stored according to manufacturers'

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Table 1. Interocclusal Registration Materials Included in the Study

Brand	*Material Type*	*Batch*	*Manufacturer*
Ramitec	Polyether	B404/C392	ESPE, Seefeld, Germany
3M*	Polyvinylsiloxane	6BGP1U1	3M-ESPE, St. Paul, MN
Stat-BR	Polyvinylsiloxane	22739 /4–1166	Kerr, Romulus, MI
Blu-Mousse	Polyvinylsiloxane	S438	Parkell, Farmington, NY
Regisil 2X	Polyvinylsiloxane	980902	LD Caulk, Milford, DE
ZOE-SSW	Zinc oxide–eugenol	049436	SSWhite, Gloucester
Alminax	Wax	DW219204	Purton, Swindon

*This product is not yet commercially available.

instructions. Testing of the resistance to compression after setting was performed following a modification of the method described in A.D.A. specification No. 19 (4.3.6)[2] for the elastomeric impression materials. One cylindrical stainless steel mold with an internal diameter of 20 mm and a height of 20 mm was constructed (Fig 1).

The method described for the testing of the elastomeric materials was also applied for the testing of the wax and the zinc oxide–eugenol paste. This was done in order to compare the results of all the materials included in this study.[3]

The walls of the stainless steel mold were lubricated with a separating medium (Rikospray Silicone, 3M, St. Paul, MN) before the injection of the materials, to facilitate the materials' removal from the mold. Interocclusal registration materials were mixed according to the manufacturers' instructions and were then injected into the mold, which was resting on a glass plate. A second glass plate was placed on top of it, and hand pressure was applied for 5 seconds to initially express material; this was followed by application of a 0.5 kg weight to further eliminate excess material.

For the wax, the method was modified by softening it submerged in a 45°C water bath (Dentek Inc, Buffalo, NY). Afterwards, a 10 ml syringe was filled with the wax and was placed in the water bath for 5 minutes. After this period, the wax was injected into the mold, which was standing on the glass plate. The procedure followed as previously described for the rest of the tested materials.

The stainless steel mold, the glass plates, and the weight were submerged in a 36 ± 1°C water bath (Dentek Inc) to simulate mouth conditions. Each assembly remained in the bath for the manufacturer's suggested setting time plus an additional 3 minutes.[4] Six minutes after its removal from the water bath and from the mold, each specimen was placed in an instrument exerting pressure on it (Seger, Tonindustrie, Berlin West und Goslar, Germany) (Fig 2), and a force of 100 g/cm^2 was exerted on each sample. Thirty seconds later the

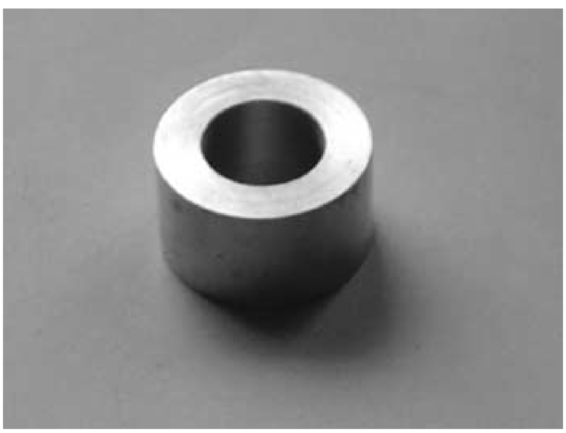

Figure 1. The stainless steel mold used for the fabrication of the samples of the interocclusal registration materials tested.

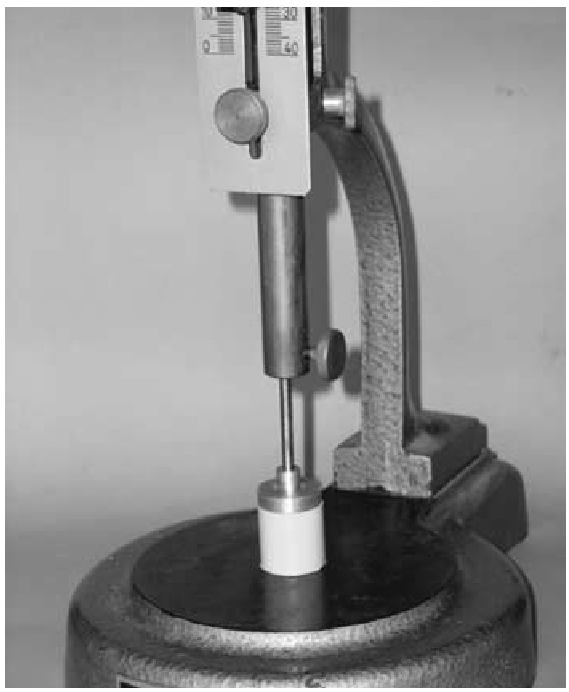

Figure 2. The testing instrument used to exert pressure on the specimens of the interocclusal registration materials.

Table 2. Descriptive Statistics for the Resistance to Compression

Material	*N*	*Mean*	*SD*	*Min*	*Max*
Ramitec	10	2.2100×10^{-2}	9.9443×10^{-4}	0.021	0.024
3M	10	2.2800×10^{-2}	1.2293×10^{-3}	0.021	0.025
Stat-BR	10	2.1200×10^{-2}	1.3984×10^{-3}	0.020	0.024
Blu-Mousse	10	1.2600×10^{-2}	1.0750×10^{-3}	0.011	0.014
Regisil 2X	10	2.8400×10^{-2}	1.0750×10^{-3}	0.027	0.030
ZOE-SSW	10	3.4900×10^{-2}	1.2867×10^{-3}	0.033	0.036
Alminax	10	2.5700×10^{-2}	1.2517×10^{-3}	0.024	0.027

reading of the pressing instrument was recorded using a vertical traveling micrometer microscope (Griffin Ltd., London, England) with an accuracy of $\pm$ 0.001 mm. This value was marked as reading "A." Sixty seconds after the application of the first force (100 g/cm^2), a second force of 1000 g/cm^2 was applied gradually during an interval of 10 seconds. Thirty seconds later the reading of the instrument exerting pressure on the specimen was recorded again. This value was marked as reading "B." The difference between readings "A" and "B" recorded the compression to resistance of each material. Ten samples of each material were constructed.[5,6]

Measurements and collection of the data were always performed by the same operator.

Temperature and relative humidity were recorded each day throughout the experiment (21 $\pm$ 1°C, 50 $\pm$ 10%).

Results

The results of the descriptive statistics for the measurements of the compression to resistance are depicted in Table 2 and Figure 3. One-way ANOVA revealed the significant differences among the materials tested ($F = 331.58$, $p < 0.0005$) (Table 3). Tukey's Honest Significant Difference ($p < 0.05$) test was used to determine the significant differences between the materials (Table 4). This test revealed that, compared to the rest of the interocclusal recording media tested, Blu Mousse polyvinylsiloxane interocclusal registration material had the greatest resistance to compression. Polyvinylsiloxanes Stat BR, 3M, and Ramitec (polyether) did not present any statistically significant differences. Regisil

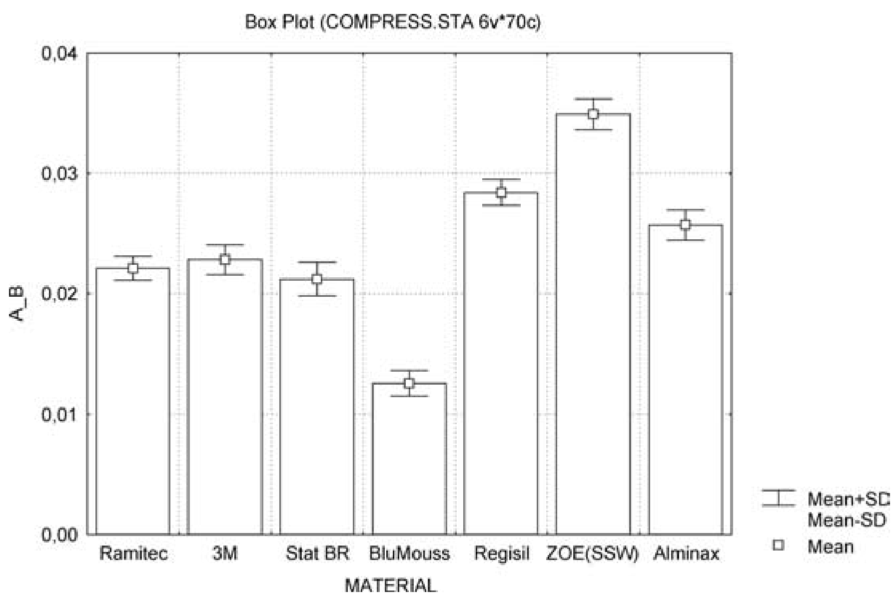

Figure 3. Mean percentages and standard deviations of resistance to compression of interocclusal registration materials. Measurement units are in millimeters.

Table 3. One-Way ANOVA for the Evaluation of the Resistance to Compression ($p = 0.05$)

Source	*SS*	*df*	*MS*	*F*	*Sig*
Between the groups	2.839×10^{-3}	6	4.732×10^{-4}	331.58	0.000
Within the groups	8.990×10^{-5}	63	1.427×10^{-6}		
Total	2.929×10^{-3}	69			

polyvinylsiloxane was the material with the least resistance to compression.

It should be noted that the results concerning the wax (Alminax) and the zinc oxide–eugenol paste were only of a comparative value to those of the elastomers.

Discussion

The resistance to compression after setting is a very desirable property for interocclusal recording media.[7] Maxillomandibular relationships that were registered correctly in the patient can be erroneously transferred in the mounting procedures because of the compressibility of the materials. If a material is compressible, it can be distorted by faulty manipulation by the operator or by the weight of the cast to be mounted.[8] The clinicians should choose interocclusal registration materials that display the least possible elastic or plastic distortion due to compression from a load. Of all the materials tested, Blu Mousse (polyvinylsiloxane) presented the greatest resistance to compression.

Breeding and Dixon[9] reported that usually a No. 19 rubber band is used for stabilization of the casts during the mounting procedures. The force this rubber band exerts on the casts and the interocclusal registration material, which is in between, is 25 N. In another study Campos and Nathanson exerted a force of 9.80 N (1 kgf) to test the compressibility of 2 interocclusal recording media.[10] The stress applied in this study was 30.80 N, which is more than the force usually exerted.

All the interocclusal recording media tested displayed elastic or plastic deformation under the stress applied; however, it should be mentioned that in clinical practice, the thickness of the materials is never 20 mm. It ranges between 2 and 4 mm, depending on whether occlusal clearance was provided to one or both arches.[11,12] Since it has been shown that thicker elastomeric interocclusal registration media are generally more compressible,[9] it should be noted that further research is needed in order to evaluate the compressibility of interocclusal registration materials in thicknesses similar to those of simulated clinical conditions.

Another point of interest is the ongoing polymerization reaction of the elastomeric materials, even after 30 minutes.[13-16] This continued setting process may result in increased surface hardness as shown by Chai et al[17] and may affect the resistance to compression as well. Another study should be conducted to evaluate how much time after the maxillomandibular registration procedure the articulation of the casts should take place, also taking into account the dimensional stability of the materials.

Conclusions

One polyether and 4 polyvinylsiloxane interocclusal recording materials were tested in comparison to a wax and a zinc oxide–eugenol paste for

Table 4. Tukey's HSD to Compare the Resistance to Compression of Various Interoclussal Recording Media ($p = 0.05$)

		Subset				
Material	*N*	*1*	*2*	*3*	*4*	*5*
Blu-Mousse	10	1.2600×10^{-2}				
Stat-BR	10		2.1200×10^{-2}			
Ramitec	10		2.2100×10^{-2}			
3M	10		2.2800×10^{-2}			
Alminax	10			2.5700×10^{-2}		
Regisil	10				2.8400×10^{-2}	
ZOE-SSW	10					3.4900×10^{-2}

their resistance to compression, in a controlled laboratory environment. The results are as follows:

1. Polyvinylsiloxane Blu Mousse displayed the greatest resistance to compression, when compared to other elastomers, a zinc oxide–eugenol paste, and a wax.
2. Elastomeric interocclusal registration materials, with the exception of Regisil 2X (addition reaction silicone), displayed greater resistance to compression than zinc oxide–eugenol paste and wax.
3. The material with the least resistance to compression after setting was zinc oxide-eugenol paste followed by Rigisil 2X polyvinyl-siloxane.

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