An *in vitro* study of the effect of different occlusal registration materials on the reproducibility of mounting casts

Original Article

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ABSTRACT

This study compared the recorded interocclusal relationships produced using commonly used materials, determining which material accurately provides records of the interocclusal relationship for remounting. Ten occlusal registration materials were used in this study. Maxillary and mandibular casts were mounted on an articulator in maximum intercuspation. The interocclusal relationship was recorded with each specimen under a constant weight. Remounting of the mandibular cast was accomplished with the interocclusal record. The record was removed and the interocclusal contact recorded using occlusal indicator wax. The penetration of contacts was counted. This process was repeated using three specimens for each of the 10 materials used and measured. A standard deviation analysis was done on the number of penetration contacts. Stone interocclusal records were the most accurate material for occlusal registration. Wax wafer interocclusal records were the least accurate material. **Clinical Application:** This study suggests that the choice of material used for occlusal registration should be based on the expected time interval between occlusal registration and mounting of casts. If the mounting is expected immediately following the interocclusal registration, bite stone is the material of choice for occlusal registration. When a delay is expected between occlusal registration and mounting of the casts, non-eugenol zinc oxide may be chosen as the registration material.

KEY WORDS: Occlusal registration, reproducibility

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INTRODUCTION

Numerous occlusal registration materials are available today for the purpose of recording interocclusal relationships. However, the accuracy of the recorded interocclusal relationship varies by material, storage time and storage media.

An accurate occlusal registration is necessary to mount dental casts. Even with meticulous clinical and technical procedures, occlusal adjustments are invariably required. To minimize the necessity of such adjustments, the chosen occlusal registration material should accurately capture the interocclusal relationship.

In previous studies it has been established that resistance to closure varies by occlusal registration material. In a study by Lassila[1] that compared five interocclusal recording materials, it was noted that elastomers, zinc oxide pastes and acrylic resin show low initial resistance to closure (0.112 to 0.135 pounds). However, there is a rapid increase in resistance with an increase in setting time in all materials except zinc oxide eugenol paste. The resistance to closure of acrylic resin was about 10 times higher after only 2 minutes. The resistance exhibited by wax at 60°C was about 1.574 pounds and almost doubled when the temperature was 5°C lower. In a study by Shanahan *et al.*,[2] three wax interocclusal records were made under different closing pressures by using the same cast in centric occlusion. Differences in the three interocclusal records indicated that the quality of the recorded interocclusal relationship is dependent on closing pressure. To eliminate such inconsistencies due

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to different closing pressures and resistance to closure, it is imperative to compare the occlusal relationships obtained from the different registration materials using a constant closing pressure.

Numerous studies have shown that storage time and media influence the structural properties of occlusal registration materials. This in turn impacts the ability of these materials to accurately record, and reproduce the interocclusal relationships.

Millstein *et al.*,[3] in their study concluded that both storage time and environment have an effect on the properties of waxes. Water storage of waxes produced the greatest change while air-cooling produced the least. Considerable vertical and rotational changes occurred when a test model was replaced in a previously formed wax registration. Exact reproduction of the original wax recordings was never achieved.

In a study done by Balthazar-Hart *et al.*,[4] accuracy and dimensional stability of four interocclusal recording materials was examined in a controlled laboratory environment. Eugenol-free zinc oxide paste exhibited dimensional stability throughout the 168-hour experimental period. A slight shrinkage was observed but was not statistically significant. This stable behavior allows eugenol-free zinc oxide paste to be used as an effective bite registration material and be stored indefinitely. Zinc oxide eugenol paste on the other hand was the least accurate of the materials tested, exhibiting an initial expansion at the end of the first hour. This expansion was followed by contraction and again by expansion.

In an experimental study to evaluate the linear dimensional change and accompanying weight change of several recording media done by Michalakis *et al.*,[5] it was shown that there was a statistically significant effect of material and time factors on linear changes. Wax presented the greatest linear changes of all materials tested at all time intervals. This is explained both by the great coefficient of thermal expansion of wax and distortion of this material due to release of internal stresses. Zinc oxide eugenol presented statistically significant differences when compared to addition silicones and polyether, at all time intervals. The linear changes of zinc oxide eugenol were always bigger than the linear changes of the elastomers. This, combined with the lengthy setting time and that it should always be used with a carrier, make zinc oxide eugenol a less attractive proposition in recording accurate interocclusal relationships.[6]

From the results of their studies, Michalakis *et al.*,[5] concluded that wax and zinc oxide eugenol are not reliable as interocclusal materials as they undergo dimensional changes with time. On the other hand, polyether and polyvinyl siloxanes undergo limited dimensional changes with time and may be more appropriate for registration of maxillomandibular relationships where storage time is expected between recording the relationship and mounting of the cast. In two studies, Eriksson *et al.*,[7,8] confirmed the accuracy in the use of polyvinyl siloxanes occlusal registration material with prolonged storage time.

In a study by Lassila[1] comparing the properties of five interocclusal recording materials it was noted that under room conditions, dimensional changes of rigid materials, acrylic resins and zinc oxide pastes during a storage period of 30 minutes to 72 hours remained below 0.3%. It was also shown that a tightly sealed plastic bag was superior to open containers in the storage of elastomers. Elastomers expanded considerably when stored in water.

The purpose of this study was to compare the recorded interocclusal relationships produced using ten commonly used materials to determine which material results in the most accurate recorded interocclusal relationship. To eliminate the impact of storage time and storage media, all the interocclusal records were mounted immediately after the interocclusal registration procedure.

MATERIALS AND METHODS

Ten occlusal registration materials were used in this study, namely, zinc oxide eugenol bite registration paste, red stick impression compound, bite wafers, Swiss wax, base plate wax, bite registration material, Futar D Occlusion, bite stone, light-cured resin, and self-cure resin. The processes and manufacturers used to prepare and use the individual materials are summarized in Table 1.

Maxillary and mandibular casts were mounted on an articulator in maximum intercuspation with the incisal guide pin set at zero. This was followed by setting the incisal guide pin at 2 notches above zero. The interocclusal relationship was recorded with all specimens with a weight of 50 pounds to eliminate material consistency resistance and uniform pressure so as not to distort the records when placed on the upper arm of the articulator. The mandibular cast was then removed. The incisal guide pin setting was changed to zero and remounting of the mandibular cast was accomplished with the new interocclusal record. The mandibular cast was remounted immediately after recording the interocclusal relationship to eliminate any errors on account of time and storage media dependent dimensional changes in the specimen. The specimen

Table 1: Materials and preparation methods used in this study

Materials and manufacturer	Preparation methods
Bite wafers (Aluwax, Aluwax Dental Products Co., Grand Rapids, Mich)	Softening in a hot water bath at 54°C
Base plate wax (Truwax, Dentsply International Inc., York, PA)	Softening in a hot water bath at 61°C
Swiss wax (Bite Wax, Blue Dolphin Products, Morgan Hills, Cal)	Softening in a hot water bath at 61°C
Red stick impression (Impression Compound, Kerr Compound Corp., Romulus, Mich)	Softening in a hot water bath at 65°C
Zinc oxide eugenol (Superbite, H.B. Bosworth Co., bite registration paste Skokie, Ill)	Equal parts of base and catalyst were mixed
Bite registration material (Regisil Rigid, Dentsply International Inc., York, PA)	Dispensing gun, setting time 4 minutes
Futar D Occlusion (Futar D Occlusion, Roydent, Rochester Hills, Mich)	Dispensing gun, setting time 4 minutes
Self cure resin (G C Pattern Resin, GC America Ind., III)	Autopolymerizing resin-powder and liquid were used at a ratio of 3 to 1 by volume
Triad Provisional (Dentsply, International, York, PA) light activated resin	Strips activated by curing light 3 minutes
Bite stone (WhipMix, Louisville, Ken)	Bite stone was mixed with water to a consistency loaded in the syringe

was removed and the interocclusal relationship was recorded on occlusal indicator wax in the re-mounted setting with the incisal guide pin not touching the table. The number of penetration contacts through the occlusal indicator wax was counted. This process was repeated using three specimens for each of the 10 materials used for the study. Before the second procedure the mandibular cast was again remounted on maximum intercuspation with the incisal guide pin set at zero as a base line. The readings so obtained have been summarized in Table 2.

RESULTS

Based on the analysis as captured in Table 3, it can be inferred that bite stone, with a mean average error of measurement at 0.753, is the most accurate material for occlusal registration. Bite wafers, with a mean average error of measurement at 2.401, are the least accurate material, under the experimental conditions.

DISCUSSION

A treatment plan necessitates the evaluation of a patient's existing dental jaw relationship. For this purpose, a material that can replicate accurate interocclusal relationships and details is necessary. This study shows that bite stone most accurately reproduces interocclusal relationships. The use of bite wafers on the other hand results in a less accurate reproduction of interocclusal relationships.

Table 2: Readings of penetration contact numbers (Right and left sides)

Materials	Trial 1		Trial 2		Trial 3	
	Right	Left	Right	Left	Right	Left
Aluwax	1	3	7	6	7	5
Base plate wax	5	6	6	4	6	5
Swiss wax	3	5	3	5	5	4
Red stick compound	4	6	5	6	4	5
Zinc oxide eugenol bite	4	6	4	5	4	5
Regisil rigid	6	7	6	5	5	7
Futar d occlusion	4	7	4	5	5	4
GC pattern resin	9	8	6	6	6	6
Triad provisional material	10	6	4	5	6	6
Functional stone	5	5	4	5	6	6

Table 3: Data of contacts calculation results contact numbers

Materials	Trial 1		Trial 2		Trial 3		Mean average
	Right	Left	Right	Left	Right	Left	
Aluwax	1	3	7	6	7	5	2.401
Base plate wax	5	6	6	4	6	5	0.816
Swiss wax	3	5	3	5	5	4	0.983
Compound	4	6	5	6	4	5	0.894
Zoe paste	4	6	4	5	4	5	0.816
Regisil	6	7	6	5	5	7	0.894
Futal d occlusion	4	7	4	5	5	4	1.169
GC resin	9	8	6	6	6	6	1.329
Triad	10	6	4	5	6	6	2.041
Functional stone	5	5	4	5	6	6	0.753

In this study a controlled occlusal force of 50 pounds was used to record the interocclusal relationship. However, in a clinical setting, patients may apply varying force when they close straight down onto the occlusal registration material. Additionally a patient's closing style may introduce alignment errors that could impact the accuracy of the occlusal registration on account of deviation of the mandible upon closure. However, *in vitro*, the articulator is closed in a straight vertical direction.

The present study has limited the impact of storage time and storage media on the accuracy of the recorded occlusal relationship through immediate re-mounting of the mandibular cast after recording the initial interocclusal relationship. In clinical situations, storage and shipping of the occlusal registration to a dental laboratory may result in a delay between the capturing of the occlusal relationship and the mounting of the cast on the articulator, with inherent error. This methodology was not included in other related studies. The values obtained in this study were unexpected.

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