ORIGINAL RESEARCH

In Vitro Assessment of Dimensional Accuracy of Three Different Types of Interocclusal Recording Materials

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Abstract

Aim: The aim of the current study was to evaluate the dimensional accuracy of three various interocclusal recording materials.

Materials and methods: A total of 90 disc-shaped samples were prepared using polyether paste, wax, and polyvinyl siloxane material with the support of stainless steel die. For the purposes of this investigation, three frequently utilized interocclusal recording materials were chosen, and 30 samples from each material were prepared. Group I: Bite registration using polyether paste; Group II: Bite registration using wax; Group III: Bite registration using polyvinyl siloxane material. No samples were exposed to direct sunlight during storage and were kept at room temperature. Using a 10x universal measuring microscope, each sample disc was examined for the presence of horizontal and vertical lines inscripted in the die. For each of the samples, readings were taken at different time periods of 24, 48, and 72 hours.

Results: After 24 hours, the less dimensional changes were found in polyether paste group (0.11 ± 0.07) followed by polyvinyl siloxane material group (0.19 ± 0.04) and wax group (0.25 ± 0.12). After 48 hours, the less dimensional changes were found in polyether paste group (0.34 ± 0.02) followed by polyvinyl siloxane material group (0.42 ± 0.01) and wax group (0.94 ± 0.12). After 72 hours, the least dimensional changes were found in polyether paste group (0.46 ± 0.14) followed by polyvinyl siloxane material group (0.92 ± 0.03) and wax group (1.14 ± 0.09).

Conclusion: The present study concluded that both the material and time factors had an impact on dimensional stability. The most dimensionally stable group was the polyether paste group, which was followed by the polyvinyl siloxane and wax material groups.

Clinical significance: Interocclusal recording material records the occlusal connection between real or artificial teeth for occlusal rehabilitation planning and for creating removable and fixed dentures. The creation of a clinically acceptable prosthesis is dependent upon the accuracy of the patient's diagnostic or working casts and the interocclusal record.

Keywords: Accuracy, Bite registration dimensional stability, Interocclusal material.

The Journal of Contemporary Dental Practice (2023): 10.5005/jp-journals-10024-3574

Introduction

Humans have a complex system called the stomatognathic system that integrates the organs, tissues, and nerves needed for a wide range of activities like speaking, mastication, and deglutition. The stomatognathic system's overall pattern and structural foundation can be affected by the functions of occlusion. Establishing posterior occlusal contacts that stabilize the occlusion and providing anterior guidance that will offer a predictable amount of disocclusion during protrusive and lateral excursions are the two main objectives of any restorative treatment.[1]

In order to design occlusal rehabilitation and to create detachable and fixed partial dentures, interocclusal recording material registers the occlusal connection between natural or artificial teeth. An inaccuracy in the interocclusal arch registration results in an improper presentation of patients existing maxilla–mandibular relationship, leading to errors in the diagnosis and treatment and occlusal errors in the final prosthesis.[2]

The optimal interocclusal registration material must meet the following requirements: It must have minimal resistance prior to setting in order to prevent tooth or mandible displacement during closure. After setting, it ought to become rigid and experience little dimensional change. It should create an accurate record of the teeth's incisal and occlusal surfaces. It should be simple to control. It should be straightforward to verify and should not have any negative effects on the tissues engaged in the treatment.[3] The dependability of the mandibular position affected by the occlusal contacts, muscle action, or tissue changes within the joints, as well as the recording technique, all have an impact on the accuracy of an interocclusal record.[4]

Wax has gained wide acceptance for interocclusal record transfer; however, complete closure into wax is not easily achieved

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How to cite this article: Sonkesriya S, Subramanian D, Saha P, *et al*. *In Vitro* Assessment of Dimensional Accuracy of Three Different Types of Interocclusal Recording Materials. J Contemp Dent Pract 2023;24(12): 936–939.

Source of support: Nil

Conflict of interest: None

and rarely registers accurate incisal and occlusal forms of teeth. However, the newer materials polyvinyl siloxane and polyether are being used commonly due to their elastic properties and dimensional stability. These bite registration materials have the advantages of less rigidity with easy removal from undercuts. These elastomeric materials resemble the long-used imprint materials. Plasticizers and catalyst have been used as modifications to offer various handling properties.[5] It is still unclear, though, whether these changes to the parent impression materials have affected things like dimensional stability. Due to the paucity of studies examining dimensional stability over time. The current study was conducted to evaluate the dimensional accuracy of polyether paste, wax, and polyvinyl siloxane interocclusal recording materials.

Materials and Methods

Preparation of Samples

The present *in vitro* study was conducted in the Department of Prosthodontics, Government College of Dentistry, Indore, India, during the year of 2022–2023. A total of 90 disc-shaped samples were prepared using polyether paste, wax, and polyvinyl siloxane material with the support of stainless steel die. According to the ADA specification-19, die was a 38-mm diameter cylindrical stainless block with a 30-mm diameter step on the top surface. On the top of the imprint surface of the die, three horizontal and two vertical lines were scored. To make measuring easier, the vertical lines were designated as CD and C'D and the horizontal lines as X, Y, and Z. Two vertical lines were spaced 25 mm apart. Die contained a ring around its periphery that serves as a tray or a container for the interocclusal recording material and had a highly polished surface. For the purposes of this investigation, three commonly used interocclusal recording materials were chosen, and 30 samples from each material were prepared.

Group I: Bite Registration Using Polyether Paste

For polyether bite (Ramitec 3M ESPE, AG Dental Products, Germany) the necessary quantities of equal lengths of pastes were dispensed on the mixing pad provided by the manufacturer. To get a uniform, streak-free mixture, these two pastes were combined for 45–50 seconds with a stainless steel mixing spatula. The mixture was then gathered on the mixing spatula and placed into a plastic syringe that was given by the manufacturer. Following careful spreading of the material across the die's surface, a glass plate covered in polyethylene sheet and a weight of 500 gm was set on top of the material. To imitate the situation of the mouth, the material was allowed to set for 4–5 minutes in a water bath that was thermostatically controlled.

Group II: Bite Registration Using Wax

Using a hydraulic syringe, samples for bite registration wax (Aluwax, Dental Products Co.) were prepared. The material was first softened in a warm water bath (40–45°C) for 5 minutes. Following careful spreading of the material across the die's surface, a glass plate covered in polyethylene sheet and a weight of 500 gm was set on top of the material. To replicate an oral condition, the substance was allowed to set for 4–5 minutes in a water bath that was thermostatically controlled.

Group III: Bite Registration Using Polyvinyl Siloxane Material

A cartridge comprising base and accelerator paste was used to deliver the polyvinyl siloxane bite (Jet Bite, Coltene Whaledent). An auto-mixing gun had a cartridge and mixing tip attached to it. The substance that the pistol shot out was distributed evenly across the die's surface. A glass plate with a polyethylene sheet covering it was put on the die, over which a weight of 500 gm was retained, and allowed to mimic for 4–5 minutes in a water bath with a thermostat.

Table 1: Evaluation of dimensional accuracy of three interocclusal recording materials after 24 hours

Interocclusal recording materials	*Mean ± SD*	*Std. error*	*F*	*p-value*
Group I: Polyether paste	0.11 ± 0.07	0.0395	4.838	0.001
Group II: Wax	0.25 ± 0.12	0.0042		
Group III: Polyvinyl siloxane	0.19 ± 0.04	0.0058		

Post hoc test: Polyether paste and wax ($p < 0.001$)

Evaluation of Dimensional Accuracy of Three Interocclusal Recording Materials

No samples were exposed to direct sunlight during storage and were kept at room temperature. The recording of horizontal and vertical lines inscribed in the die was assessed for each sample disc. Using a universal measuring microscope with a 10× magnification, the linear distance between the parallel lines was measured at six distinct intersecting fixed sites in order to evaluate the dimensional stability of each sample. For the sake of that specific sample's statistical analysis, the mean of these six different readings was taken into account. Each sample's mean spacing between the lines was compared to the stainless steel die's corresponding measured spacing. For each of the samples, readings were taken at different time periods of 24, 48, and 72 hours by a single investigator. The mathematical formula for calculating the percentage change in the dimension was used to calculate the change in the dimension.

$$\text{Dimensional change } \% = (X–Y)/X \times 100$$

where X is the standard distance (in mm) between lines A and B in the die and Y is an equivalent measurement at the sample.

Statistical Analysis

SPSS software version 20.0 was used to analyze the data. The results are given as mean ± SD. Intergroup comparisons were made using a one-way analysis of variance, and pair-wise comparisons of the accuracy and dimensional stability of the interocclusal recording materials were made using a Tukey HSD (*post hoc*) test. For statistical significance, a *p*-value of 0.05 or less was taken into consideration.

Results

Table 1 shows the dimensional accuracy of three interocclusal recording materials after 24 hours. The less dimensional changes were found in polyether paste group (0.11 ± 0.07) followed by polyvinyl siloxane material group (0.19 ± 0.04) and wax group (0.25 ± 0.12). *Post hoc* test shows that there was statistically significant difference between polyether paste and wax groups ($p < 0.001$).

Table 2 shows the dimensional accuracy of three interocclusal recording materials after 48 hours. The less dimensional changes were found in polyether paste group (0.34 ± 0.02) followed by polyvinyl siloxane material group (0.42 ± 0.01) and wax group (0.94 ± 0.12). *Post hoc* test shows that there was statistically significant

Table 2: Evaluation of dimensional accuracy of three interocclusal recording materials after 48 hours

Interocclusal recording materials	*Mean ± SD*	*Std. error*	*F*	*p-value*
Group I: Polyether paste	0.34 ± 0.02	0.0151	7.154	0.001
Group II: Wax	0.94 ± 0.12	0.0082		
Group III: Polyvinyl siloxane	0.42 ± 0.01	0.0032		

Post hoc test: Polyether paste and wax, polyvinyl siloxane and wax ($p < 0.001$)

Table 3: Evaluation of dimensional accuracy of three interocclusal recording materials after 72 hours

Interocclusal recording materials	*Mean ± SD*	*Std. error*	*F*	*p-value*
Group I: Polyether paste	0.46 ± 0.14	0.0290	9.736	0.001
Group II: Wax	1.14 ± 0.09	0.0237		
Group III: Polyvinyl siloxane	0.92 ± 0.03	0.0156		

Post hoc test: Polyether paste and wax, polyvinyl siloxane and wax, polyether paste and polyvinyl siloxane ($p < 0.001$)

difference between polyether paste and wax groups and polyvinyl siloxane and wax groups ($p < 0.001$).

Table 3 shows the dimensional accuracy of three interocclusal recording materials after 72 hours. The least dimensional changes was found in polyether paste group (0.46 ± 0.14) followed by polyvinyl siloxane material group (0.92 ± 0.03) and wax group (1.14 ± 0.09). *Post hoc* test shows that there was statistically significant difference between polyether paste and wax groups, polyvinyl siloxane and wax groups, and polyether paste and polyvinyl siloxane groups ($p < 0.001$).

The inference of the present study includes that the polyether paste group was dimensionally the most stable followed by polyvinyl siloxane material group and wax group.

Discussion

The main goals of occlusal rehabilitation are to attain the best levels of dental health, functional effectiveness, oral comfort, and esthetics. Making a prosthetic repair requires an appropriate transfer of the intraoral maxilla–mandibular connection to the articulator. An interocclusal record is required to connect the casts when the teeth do not provide vertical and horizontal support between the arches. For a good diagnosis and subsequent accurate therapy, precise articulation of the patient's casts is necessary. The material selected can have a significant impact on the interocclusal registration accuracy in addition to the operator's clinical skills and the technique used.[6]

Due to their affordability and simplicity of usage, waxes are the most popular interocclusal recording materials. The accuracy, utility, and manipulative abilities necessary to obtain correct interocclusal data are highly debatable. The accuracy of an interocclusal recording wax must be considered in terms of the many variables responsible for dimensional changes. The perfect replication of the original wax recording was never made, not even under the most controlled environments.[7]

Among all the materials evaluated in the current investigation, waxes showed the most significant dimensional changes. Similarly, studies by Pipko and Khassa[8] and Millstein and Clark[9] explained as the high coefficient of heat expansion of wax and the release of internal tensions that can cause wax distortion. According to a study by Anup and Ahila,[10] wax contains aluminium or copper particles with a flow rate of 2.5–22% at 37.5°. Hence they are susceptible to distortion.

Polyvinyl siloxane material displayed smaller dimensional changes than wax in the current investigation. After 24 hours, the polyvinyl siloxane findings showed a considerable shift in dimensional stability. This outcome is consistent with the conclusion reached by Michalakis et al.[3] After 24 hours, the three dimensionally stable elastomeric materials showed a 0.18% dimensional change. The extended polymerization duration of polyvinyl siloxane, which results in a sustained contraction period, may be the cause.

Comparing all of the materials utilized in this investigation, polyether showed the least dimensional change. The present study findings are consistent with those of Fattore et al.,[11] who demonstrated that polyether showed no dimensional change after 24 hours. According to Sunneta and Gangadhar,[12] and Dixon,[13] polyether gels by a polymerization reaction, this results in a volumetric shrinkage of the material of roughly 0.3%.

The majority of the issues with the prior materials was resolved when polyvinyl silicone and polyether compounds were used as interocclusal materials. These materials can be removed from the mouth and mounted in the articulator without breaking as they are elastic with a moderate amount of stiffness (elastic modulus). Due to the fact that they do not emit any byproducts during polymerization, these materials have exceptional dimensional stability. The standard die provided by ADA specification No. 19 was similar to the stainless steel die used in the current study. In contrast to a tooth surface with cusps and fossa, the surface of this die is smooth and glossy, making it simpler to assess dimensional changes. The diameter and angles of the flutes in the typical ADA dies are crucial for assessing the precision of the imprint materials. This study evaluated the distance between the vertical lines at different time intervals with different interocclusal recording materials.[14]

The recording material must not induce any tooth movement or soft tissue displacement, according to Dawson's requirements for accuracy in making interocclusal records. As precisely as it fits the teeth intraorally, the recording material must fit castings. It is important to inspect the casts and the mouth for accuracy of the jaw relation record.[15]

The limitation of this *in vitro* investigation was that it solely used linear measurement to determine dimensional stability. But dimensional errors in interocclusal registrations happen in all three dimensions in typical clinical practice. Additional clinical research will be required to take this into account.

Conclusion

The present study concluded that both material and time factors influenced dimensional stability. The polyether paste group was the most dimensionally stable, followed by the polyvinyl siloxane material group and the wax group. Every clinician should find a way to mount the patient's casts as soon as they are recorded and should refrain from choosing an option where the mounting will be done after a few days.

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