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ORIGINAL ARTICLE

Evaluation of Dimensional Stability, Accuracy and Surface Hardness of Interocclusal Recording Materials at Various Time Intervals: An In Vitro Study

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Abstract To evaluate and compare the dimensional stability, accuracy and surface hardness of three interocclusal recording materials at various time intervals. Polyvinylsiloxane, Zinc oxide eugenol, Aluwax were taken for this study. A stainless steel die of ADA specification no 19. was prepared. A total of ten samples were made with each group. The samples were measured using a travelling microscope of 10× magnification at 1, 24, 48 and 72 h time intervals. Five readings were taken for each sample, the mean was considered to measure the dimensional change, accuracy and surface hardness. The values obtained were statistically analysed by ANOVA and Tukey HSD-Honestly significant difference. Polyvinylsiloxane was the most dimensionally stable, accurate and had the highest surface hardness among the three inter-occlusal materials.

Keywords Dimensional stability · Accuracy · Hardness

Introduction

The success of any prosthetic rehabilitating treatment depends on several aspects related to the precise mounting of casts in the articulator [1]. Interocclusal recording materials are basically similar to impression materials but are modified to give good handling characteristics [2] however these alterations in the parent impression material resulted in altered properties which is unknown.

According to Warren and Capp, the basic principal approach should be to make the interocclusal record at the correct occlusal vertical dimension, choosing an accurate, dimensionally stable recording material, and selecting an appropriate method of mandibular guidance [3].

Many materials have been used for maxilla-mandibular registration procedures including wax, acrylic resin, zinc oxide eugenol pastes, modelling compound and plaster. Currently, elastomeric materials such as polyether and polyvinylsiloxane have been widely used for the same purpose. When elastomeric inter-occlusal recording materials are clinically used, flow characteristics of the mixed materials are necessary to reproduce a surface detail. But over clinically reasonable time periods, they must have solid like hardness to retain the shape and strength when dental casts are articulated. The viscoelasticity of dental materials is important in the selection of suitable materials for clinical applications [4].

Direct interocclusal records are most commonly used to record maxilla-mandibular relationships because of their simplicity. The arches are brought into a relationship with or without tooth contact, and a space is created between the teeth. The recording material, which is initially soft, fills the spaces between teeth, hardens, and records the specific relationship of the arches. The hardened material is then transferred on to casts to be mounted on an articulator [5].

The accuracy of an interocclusal record, however, is influenced not only by the material properties, but also by the recording technique, as well as the reliability of the mandibular position influenced by the occlusal contacts, muscular action, or tissue changes within the joints [2, 6]. Oral rehabilitation involves a sequence of steps that must be followed in a highly judicious manner. This study was

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conducted to evaluate and compare the dimensional stability, accuracy and surface hardness of polyvinylsiloxane, zinc oxide eugenol and Aluwax at 1, 24, 48.62 h intervals.

Materials and Method

A stainless steel master die was prepared according to ADA specification no 19. Polyvinylsiloxane, Zinc oxide eugenol and Aluwax were manipulated according to manufacturer's instructions and the specimens were prepared at room temperature. The die was covered with a 4 × 4 inches square glass slab. Hand pressure was applied over the glass slab for 5 s till the metal ring is seen; this was followed by application of a 500 g weight to further remove the excess material.

Then the mold, the stainless steel die and the weight were submerged in 36 ± 1°C water bath to simulate ambient temperature. Each assembly remained in the bath till the material sets plus an additional 3 min to ensure complete set of the material. Then the metal ring was removed from the stainless steel die and all the excess material (Flash) was removed by using a Bard parker knife no 15. The samples were stored at room temperature in a water proof container.

The prepared specimens were in the form of a disk measuring 0.3 cm in thickness and 3 cm in diameter with three parallel lines with a distance of 2.5 mm on the surface, these three lines were named as A, B and C. Then the ten samples were prepared with each material.

Measurement of the each samples were taken between the parallel lines A and C by means of travelling microscope with magnification of 10×. The distance between the two parallel reference lines A and C was measured at four fixed points. The mean of the four readings was taken for statistical analysis. Readings was recorded for all the ten samples of each group at an interval of 1, 24, 48, and 72 h. The mean of the distance between the lines A and C of each sample was compared to the corresponding measurement of 5000 × 200 µm in the standard stainless steel die measured under the travelling microscope.

The change in the dimension was calculated by the formula

$$\text{Dimensional change\%} = \frac{(X - Y)}{X \times 100}$$

where X is the standard measurement (µm) of A–C in the die. Y is the observed measurement (µm) of A–C in the sample.

The same specimens were used to evaluate the accuracy of interocclusal recording materials. For this the B line which measures 0.2 mm depth has been standardized and measured using light section microscope with magnification of 200×.

Fig. 1 Polyvinylsiloxane

Fig. 2 Zinc-oxide eugenol

Fig. 3 Aluwax

The same specimens were used to evaluate the surface hardness of interocclusal recording materials using Shore hardness tester (shore A-round model, Mumbai-India). For testing of the specimens the depth indicator was set to zero. A light force was applied with the index finger to the indenter for 3 s and the unit was lowered on the sample

Fig. 4 Master die

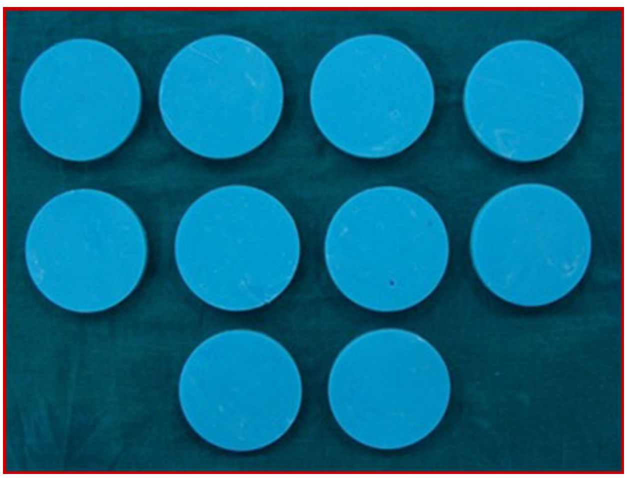

Fig. 5 Samples

Fig. 6 Thermostat

until the presser foot is in full contact. The hardness value was displayed on the hardness tester. Four reading were taken on four different sites of the specimen and mean value was taken for statistical analysis.

Fig. 7 Travelling microscope

Fig. 8 Light section microscope

Fig. 9 Shore hardness tester

Table 1 Comparison of dimensional change of three interocclusal record materials at various time intervals

Duration (h)	Group	Mean ± SD	P value		Significant groups[a]
			I vs. II, III	II vs. III	
1	I	0.23 ± 0.11	0.0001	0.004	I vs. II, III
	II	0.44 ± 0.06			II vs. III
	III	0.58 ± 0.08			
24	I	0.49 ± 0.06	0.0001	0.0001	I vs. II, III
	II	0.61 ± 0.08			II vs. III
	III	0.94 ± 0.08			
48	I	0.67 ± 0.09	0.0001	0.0001	I vs. III
	II	0.77 ± 0.12			II vs. III
	III	1.23 ± 0.08			
72	I	0.79 ± 0.08	0.0001	0.0001	I vs. II, III
	II	1.05 ± 0.06			II vs. III
	III	1.46 ± 0.10			

[a] is significant among groups

Table 2 Comparison of accuracy of three interocclusal record materials at various time intervals

Duration	Group	Mean ± SD	P value		Significant t groups[a]
			I vs. II, III	II vs. III	
1 h	I	0.19 ± 0.001	0.0001	0.0001	I vs. II, III
	II	0.18 ± 0.001			II vs. III
	III	0.17 ± 0.002			
24 h	I	0.19 ± 0.001	0.0001	0.0001	I vs. II, III
	II	0.18 ± 0.002			II vs. III
	III	0.16 ± 0.002			
48 h	I	0.19 ± 0.002	0.0001	0.0001	I vs. II, III
	II	0.18 ± 0.002			II vs. III
	III	0.16 ± 0.002			
72 h	I	0.19 ± 0.002	0.0001	0.0001	I vs. II, III
	II	0.18 ± 0.002			II vs. III
	III	0.16 ± 0.003			

[a] is significant among groups

Results

Statistical analysis was performed using one way analysis of variance (ANOVA) and multiple range tests (Tukey HSD-Honestly significant difference). The mean dimensional change, accuracy and surface hardness at various time intervals are shown in Tables and Figs. 1, 2, 3, 4, 5, 6, 7, 8, and 9.

Table 1 shows the mean dimensional change of interocclusal record material in Group I is lesser than Group II and Group III. Also, the mean dimensional change in Group II is lesser than Group III at 1, 24, 48, 72 h interval. On statistical analysis the *P* value is <0.0001 which is significant at 5% level, so the results were found to be significant.

Table 3 Comparison of surface hardness of three interocclusal record materials at various time intervals

Duration	Group	Mean ± SD	P value		Significant groups[a]
			I vs. II, III	II vs. III	
1 h	I	3.69 ± 0.06	0.0001	0.0001	I vs. II, III
	II	3.10 ± 0.07			II vs. III
	III	2.10 ± 0.14			
24 h	I	3.67 ± 0.04	0.0001	0.0001	I vs. II, III
	II	3.33 ± 0.15			II vs. III
	III	2.12 ± 0.15			
48 h	I	3.71 ± 0.05	0.0001	0.0001	I vs. II, III
	II	3.31 ± 0.14			II vs. III
	III	2.09 ± 0.12			
72 h	I	3.70 ± 0.05	0.0001	0.0001	I vs. II, III
	II	3.39 ± 0.12			II vs. III
	III	2.34 ± 0.13			

Group I: Polyvinyl siloxane, Group II Zinc oxide eugenol, Group III: Aluwax *P* value is <0.0001 which is significant at 5% level

[a] is significant among groups

Table 2 shows the mean accuracy of interocclusal record material in Group I is higher than Group II and Group III. Also, the mean accuracy in Group II is higher than Group III at 1, 24, 48, 72 h's interval. On statistical analysis the *P* value is <0.0001 which is significant at 5% level. Hence, the results were found to be significant.

Table 3 shows the mean surface hardness of interocclusal record material in Group I is higher than Group II and Group III. Also, the mean surface hardness in Group II is higher than Group III at 1, 24, 48, 72 h interval. On statistical analysis *P* value is <0.0001 which is significant at 5% level the results were found to be significant.

Discussion

An accurate transfer of the intraoral maxilla-mandibular relationship to the articulator is essential for the fabrication of a prosthetic restoration [7]. When the teeth do not offer vertical and horizontal stability between the arches; an interocclusal record is needed to relate the casts. Precise articulation of a patient's casts is a prerequisite for proper diagnosis and subsequent correct treatment. Apart from the operator's clinical ability and the technique followed, the chosen material can critically affect the accuracy of the interocclusal registration [8].

According to Dawson [9] criteria for accuracy in making interocclusal records are

(1) The recording material must not cause any movement of teeth or displacement of soft tissues.
(2) The recording material must fit casts as accurately as it fits the teeth intra-orally.
(3) The accuracy of the jaw relation record should check in the mouth and on the casts.

The linear dimensional change, accuracy and surface hardness of the interocclusal record materials were measured over time in this study. The above mentioned time intervals were based on the time required to carry the interocclusal record material to distant laboratory or the delay in the articulation of the cast in the laboratory [10]. Several factors contribute to the dimensional changes of the material used for interocclusal recording. The major factors being the loss of volatile substance over time [1]. The results showed that there is existence of correlation between the linear change and the weight loss due to volatiles [11].

Wax has gained wide acceptance for interocclusal record transfer, however complete closure into wax is not easily achieved and rarely registers accurate incisal and occlusal forms of teeth [12]. Studies showed that waxes contain aluminium or copper particles have flow rate of 2.5–22% at 37.5°C. So that they are susceptible to distortion upon removal from the mouth [13].

Zinc oxide eugenol paste is a reliable interocclusal recording material, however it dehydrates cracks and sticks to the teeth or the portions of the record can be lost through breakage. Zinc oxide eugenol record once used for mounting is rarely used also is advisable to use minimum amount of zinc oxide eugenol to avoid excess flash [14].

Polyvinylsiloxane is an accurate interocclusal recording material. However there is a "spring" to this elastomeric that can cause articulated casts to "open" in the centric closure position, also decided amount of friction in seating a stone model into these records polyvinylsiloxane presented the least linear changes of all the material tested. Polyvinylsiloxane was found to be the most accurate of all the material tested, at all time intervals followed by Zinc oxide eugenol and Aluwax respectively.

Polyvinyl siloxane possessed the highest hardness value among the three materials tested, at all time intervals followed by Zinc oxide eugenol and Aluwax respectively.

Wax showed the greatest linear changes of all the material tested in this study. This was attributed to the greater coefficient of thermal expansion and distortion due to the stress release [13]. The zinc oxide eugenol undergoes setting by chelation reaction. The by products of this reaction may undergo evaporation and this may contribute to their dimensional change. However, the eugenols free zinc oxide paste showed less dimensional change when compared to eugenol containing paste. In case of the polyvinylsiloxane, the excellent dimensional stability was attributed to the fact that it set by addition reaction. Hence there is no by products and loss of volatiles [11].

Indirectly made prostheses such as crowns and fixed partial dentures should be placed in the mouth without occlusal adjustments. To achieve this goal, an accurate interocclusal recording material with good dimensional stability is required.

Conclusion

1. Dimensional stability, accuracy and surface hardness of three interocclusal record materials are influenced by time factor.
2. Polyvinylsiloxane was more dimensionally stable when compared to zinc oxide eugenol, and Aluwax. Zinc oxide eugenol showed less dimensional change compared to Aluwax at 1, 24, 48, and 72 h.
3. Dimensional change and accuracy of polyvinyl siloxane material were statistically significant at 5% level but clinically insignificant.
4. The accuracy of polyvinylsiloxane was more compared to zinc oxide eugenol and Aluwax. Zinc oxide eugenol showed better accuracy than Aluwax at 1, 24, 48, and 72 h.
5. The surface hardness of polyvinylsiloxane was more compared to zinc oxide eugenol and aluwax. There was minimal change in the hardness of zinc oxide eugenol and aluwax after 48 h. The surface hardness of polyvinyl siloxane remains the same after 24 h.

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