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Research Article

Comparative Evaluation Of Dimensional Stability Of Three Types Of Inter-Occlusal Record Materials: An In-Vitro Study

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ABSTRACT

A recording medium is necessary to register the patient's interarch relationship. If the interarch registration is inaccurate, the mounted casts will not show the patient's existing maxilla-mandibular relationship, and errors in occlusion will occur. Inter-occlusal record is made with an assumption that a repeatable position had been permanently reference. Many materials have been used for inter-occlusal recording such as: Dental plaster with modifiers, Waxes, Acrylic resins, Zinc oxide eugenol pastes, Non-eugenol paste, Modelling compound, Silicone elastomers and Polyether elastomers. These materials have their own advantages and disadvantages. Although, numerous studies have been done on Dimensional stability of the parent impression materials, there are only a few studies on Inter-occlusal registration as such.

In the above context, an In-Vitro study was designed with the following objective:

1) To evaluate the Dimensional Stability of three types of Inter-occlusal recording material namely Polyvinylsiloxane bite registration material, Bite registration wax, and Zinc oxide eugenol bite registration paste
2) To compare the dimensional stability of these materials at a pre-determined time interval.

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INTRODUCTION:

Precise articulation of patient's casts is a prerequisite for proper diagnosis and subsequent treatment planning. There are various methods of recording maxilla-mandibular relationships, namely, graphic, functional, cephalometric and direct interocclusal. The later is most commonly used because of their simplicity. [1] A recording medium is necessary to register the patient's interarch relationship. If the interarch registration is inaccurate, the mounted casts will not show the patient's existing maxilla-mandibular relationship, and errors in occlusion will occur.[2] Inter-occlusal record is made with an assumption that a repeatable position had been permanently reference. [3]

Dawson[4] has given criteria for accuracy in making interocclusal records which includes:

1. 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 intraorally
3. Accuracy of the jaw relation record should check in mouth and on casts.

Many materials have been used for inter-occlusal recording such as: Dental plaster with modifiers, Waxes, Acrylic resins, Zinc oxide eugenol pastes, Non-eugenol paste, Modelling compound, Silicone elastomers and Polyether elastomers. These materials have their own advantages and disadvantages. These recording materials are basically similar to impression materials and they are modified to give good handling characteristics. [5] Even though a record may appear to be fixed and accurate, it may still undergo dimensional changes which can only be evaluated microscopically. The inaccuracies attributed to the inter-occlusal record can be divided into three categories given below: [6]

1. Biologic characteristic of the stomatognathic system and by the dentist,
2. Manipulation of the Inter-occlusal material used, and
3. Properties of the Inter-occlusal material used.

However, other than above mentioned factors, the storage time period of the Inter-occlusal records taken also affects the dimensional stability. Although, numerous studies have been done on Dimensional stability of the parent impression materials, there are only a few studies on Inter-occlusal registration as such.

In the above context, an In-Vitro study was designed with the following objective:

- To evaluate the Dimensional Stability of three types of Inter-occlusal recording material namely
  - Polyvinylsiloxane bite registration material,
  - Bite registration wax, and
  - Zinc oxide eugenol bite registration paste
- To compare the dimensional stability of these materials at a time interval of 1hr, 24hrs, 48hrs and 72hrs.

  in a controlled laboratory environment.

MATERIALS:

1. Polyvinyl Siloxane Bite Registration Material. (Virtual CADBite, Ivoclar, USA) (Fig. 1)
2. Zinc Oxide Eugenol Bite Registration paste. (Superbite, Bosworth company, USA) (Fig. 2)
3. Bite Registration Wax – Hard. (Alumax, Yetti Dental corporation, Germany) (Fig. 3)

Figure 1

Figure 2

Figure 3

Figure 4

Instruments and equipment's

1. Stainless Steel Die.
2. Glass plate 4 x 4 inches.
3. Polyethylene sheet.
4. Stop clock.
5. 5 ml syringe.
6. Auto mixing dispensing gun.
7. Bard Parker handle and Blade No:15

8. 500 grams weighing stone
9. Spatula and glass slab
10. Optical Microscope with Micrometer provision.
11. Thermostat controlled water bath unit.
12.

METHODOLOGY:

A. Fabrication of the Metal Master Die[7] (Fig. 4)

A stainless steel master die was fabricated similar to ADA specification No. 19. The master die consists of a ruled block and a mold ring.

B. Fabrication of the test specimens.

The individual materials were manipulated according to the manufacturer's instructions. All materials were conditioned at ambient room temperature for at least 24 hrs prior to the testing. Materials that were supplied in automixing cartridges namely Polyvinyl siloxane elastomeric material were dispensed through the cartridges and the materials supplied in tubes namely Zinc oxide eugenol bite registration paste was dispensed taking equal length of base and catalyst paste. The material was mixed with spatula in a glass slab to a streak free consistency as per the manufacturer's instruction. For the wax, the method was modified by submerging it at a 45 ^{0} C water bath for 5 minutes using a 5 ml syringe. After homogenous mixing, the materials were carried to the die. The die was inverted on to a 4 x 4 inches square glass plate covered with polyethylene sheet. Hand pressure was applied for 5 seconds to initially express the materials; this was followed by application of a 500gm weight to further eliminate excess materials. The mold, the stainless steel die and the weight were submerged in a 36 ± 1 ^{0}C water bath to simulate oral condition. Each assembly remained in the bath for the manufacturer's suggested setting time plus an additional 3 minutes to ensure polymerization of the material. Upon removal from the water bath, the mold assembly was removed from the stainless steel die and all excess material (flash) was trimmed by using a Bard Parker knife. The material was separated from the mold, the resulting specimens were in the form of a disk measuring 0.3 cm in thickness and 3 cm in diameter with 3 parallel lines on the surface. These three lines were named as A, B and C which are equally separated by a distance of 2.5 mm.

Group A	Polyvinyl siloxane (n=10)
Group B	Alumax (n=10)
Group C	Zinc oxide eugenol bite registration paste (n=10)

C. Measurement of the test samples (Fig. 5, 6, 7)

The distance between the parallel lines A and C was measured at five fixed points utilizing optical microscope with a provision of micrometer. The magnification used for the measurement was 10 X. The mean of the five readings was used for calculation in each sample. Readings were recorded for all the ten samples of each group at an interval of 1 hr, 24 hrs, 48 hrs and 72 hrs. The mean measurement of the distance AC in each sample was compared to the corresponding measurement of 5000.200 micron meter in the standard stainless steel die measured under the same optical microscope.

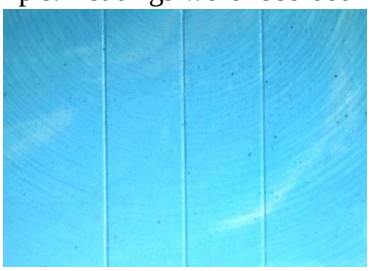

Figure 5

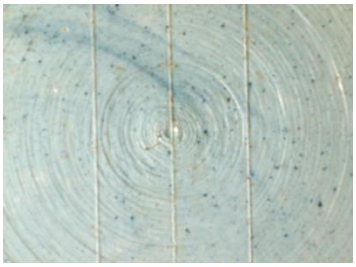

Figure 6

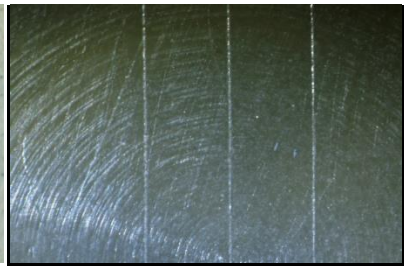

Figure 7

D. Evaluation of the dimensional change

The change in the Dimension is calculated by using the formula:

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

where X is the standard measurement (µm) of AC in the die, and

Y is the observed measurement (µm) of AC in the sample.

E. Statistical Analysis

Statistical analysis was performed using analysis of variance (ANOVA) and then Tukey honestly significantly different (HSD) tests for comparisons among groups at the 0.05 level significance.

RESULTS:

The Mean Percentage Dimensional change

	GROUP A	GROUP B	GROUP C
1 hour	0.08% (±0.07)	0.68% (±0.13)	0.16% (±0.11)
24 hours	0.14% (±0.09)	0.92% (±0.16)	0.32% (±0.13)
48 hours	0.26% (±0.09)	1.15% (±0.10)	0.41% (±0.15)
72 hours	0.38% (±0.13)	1.42% (±0.13)	0.53% (±0.16)

One-Way ANOVA test at 1 hour for all 3 group samples to calculate p – value.

	Sum of squares	Difference	Mean Square	Significance
Between Groups	2.123	2	1.061	2.1437E-12
Within Groups	0.336	27	0.012	
Total	2.458	29		*p<0.05*

Tukey-HSD procedure to identify the significant group at 5% level for 1 hour

Dependent variable	Sample – I	Sample – J	Significance
	A	B	5.1198E-09
		C	0.26144395
	B	C	5.2843E-09

Inference: Mean values of Group A is significantly lower than the mean values in Group B and Group C ($p<0.05$) and Group C is significantly lower than the mean value in Group B ($p<0.05$).

One-Way ANOVA test at 24 hours for all 3 Group samples to calculate p – value

	Sum of squares	Difference	Mean Square	Significance
Between Groups	3.336	2	1.668	1.02977E-12
Within Groups	0.496	27	0.018	
Total	3.832	29		*p<0.05*

Tukey-HSD procedure to identify the significant group at 5% level for 24 hours

Dependent variable	Sample – I	Sample – J	Significance
	A	B	5.1144E-09
		C	0.016498
	B	C	5.6357E-09

Inference: Mean values of Group A is significantly lower than the mean values in Group B and Group C ($p<0.05$) and Group C is significantly lower than the mean value in Group B ($p<0.05$).

One-Way ANOVA test at 48 hours for all 3 Group samples to calculate p – value

	Sum of squares	Difference	Mean Square	Significance
Between Groups	4.540	2	2.270	1.71652E-15
Within Groups	0.398	27	0.015	
Total	4.938	29		*p<0.05*

Tukey-HSD procedure to identify the significant group at 5% level for 48 hours

Dependent variable	Sample – I	Sample – J	Significance
	A	B	5.113E-09
		C	0.02668
	B	C	5.113E-09

Inference: Mean values of Group A is significantly lower than the mean values in Group B ($p<0.05$) and Group B is significantly lower than the mean value in Group C ($p<0.05$). However, there is no significant difference in mean values between Group A and Group C.

One-Way ANOVA test at 72 hours for all 3 Group samples to calculate p – value

	Sum of squares	Difference	Mean Square	Significance
Between Groups	6.320	2	3.160	1.6778E-15
Within Groups	0.553	27	0.020	
Total	6.873	29		*p<0.05*

Tukey-HSD procedure to identify the significant group at 5% level for 72 hours

Dependent variable	Sample – I	Sample - J	Significance
	A	B	5.113E-09
		C	0.06663
	B	C	5.133E-09

Inference: Mean values of Group A is significantly lower than the mean values in Group B and Group C ($p<0.05$) and Group C is significantly lower than the mean value in Group B ($p<0.05$).

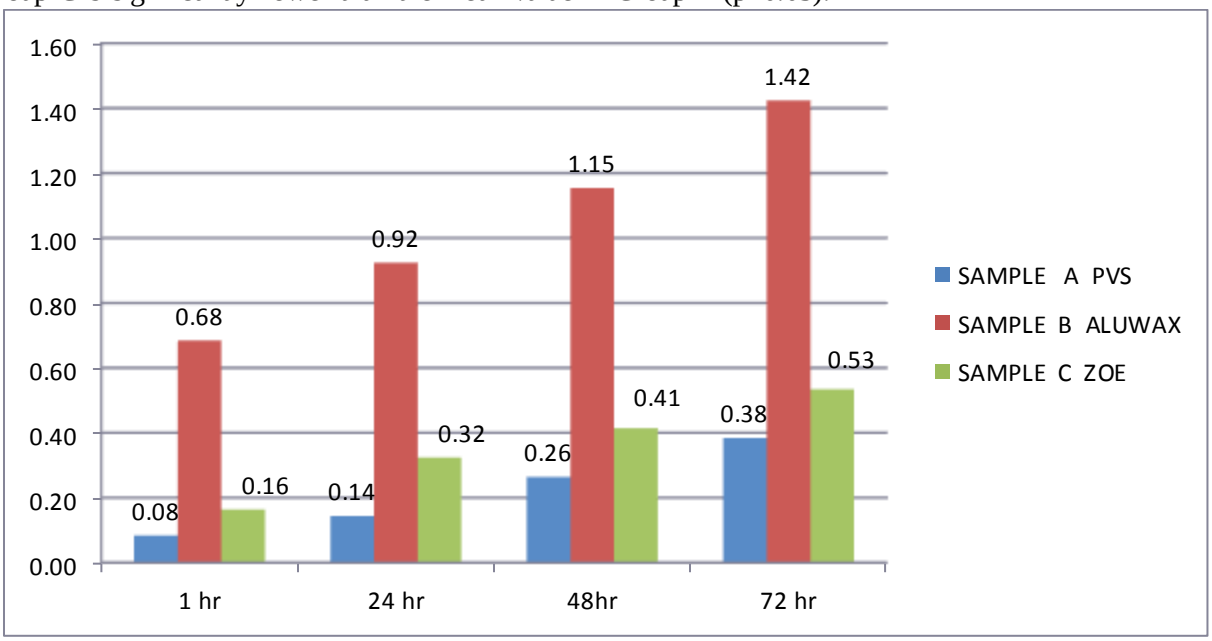

Fig 8: Comparison of Dimensional Change at various time intervals between Group A, B and C

DISCUSSION:

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 maxilla-mandibular relationship and accurately transfers it to the articulator. The centric relation record is the most important and the most difficult maxilla-mandibular relation record to make.[8] It is defined as *"a maxilla-mandibular relationship in which the condyle articulates with the thinnest avascular portion of their respective disks, with the complex and the anterior-superior position against the shapes of the articular eminences. This position is independent of tooth contact and clinically discernible when the mandible is directed superiorly and anteriorly. It is restricted to a purely rotational movement about transverse horizontal axis."*[9]

There are three requisites for making such record:

1. To record the horizontal relation of the mandible to the maxilla
2. To apply equal vertical pressure, and
3. To keep the completed record in a condition where it will not distort until the casts have been mounted.

Correct inter-occlusal records give the clinician the opportunity to make only minimal adjustments to the restorations that were delivered from the laboratory. Many materials and techniques have been used for maxilla-mandibular registration procedures since the first Interocclusal registration made in 1756 by Philip Pfaff. Interocclusal records were also known as *mush, biscuit or squash bite*.[10]

The ideal properties of an Interocclusal material should have, are:[11]

- Limited initial resistance to closure. (To avoid displacement of mandible during record making)
- Dimensional stability after setting
- Resistance to compression after polymerization
- Ease of manipulation
- Absence of adverse effects on the tissues
- Accurate recording of the incisal or occlusal surface of the teeth
- Ease of verification.

The inter-occlusal materials are chemically similar to the parent materials that have been used successfully for many years. Modifications have been made by adding plasticizers and catalysts to provide different handling characteristics; however, it remains unknown whether these modifications in the parent impression materials have altered their excellent accuracy, compressive strength, working time and dimensional stability. Out of this dimensional stability is of utmost importance as it ensures a more accurate representation of the patient's maxilla-mandibular relation. It also is a convenient parameter in visualizing the level of shrinkage activity at a given time interval. Delayed articulation of a patient casts can occur for various reasons like transport to the laboratory from a distant phase. Therefore, the dimensional stability of interocclusal recording materials over time is of utmost importance. [3]

In case of the Polyvinyl Siloxane, 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. However, the minimal of the dimensional change observed may be due to loss of hydrogen gas produced because of presence of scavengers or loss of water gained by added surfactants to make material hydrophilic. This finding was in favour of studies made by Eames W.B, Wallace S, Suway and Rogers L. in 1979[12] and of Millstein in 1975[13]. Even Mullick et al in 1981[14] stated that elastomeric materials were easy to manipulate, offered little or no resistance to closure or distortion while trimming compared to ZnOE or dental wax.

Zinc Oxide Eugenol undergoes setting by chelation reaction. This acid-base reaction gives rise to salt and water: the water evaporates and this may contribute to their dimensional change. The study is in favour of Mullik[14] who stated that Superbite disqualified because of its extreme variability and clinical use of which leads to many casting in hyperocclusion. Berman[15] and Muller[16] favoured zinc oxide eugenol as compared to wax because material mixes to true fluid consistency, offers no resistance to closure, sets hard and is sharp and easily read. However, the eugenol free zinc oxide paste showed less dimensional change when compared to that of the one with the eugenol in

the study by Bahthazar - Hart Y et al. [2] Studies not in favour are of Skurnik[17] who stated that ZnOE can be used as interocclusal record material but it is not as versatile as wax.

Wax showed the greatest linear changes of all the material tested in this study. This was attributed to the greater co-efficient of thermal expansion and distortion due to internal stress release. However, inadequate cooling, abrupt withdrawal and tackiness caused increased distortion. Also, different seating forces in different sections of wax would lead to dimensional instability. The storage in cold water showed maximum distortion of wax inter-occlusal record as compared to room temperature or storage in tape water. This is in accordance to the study made by Millstein PL and Clark RE in 1983[18]. The above mentioned finding is in favour to study made by Millstein PL, Clark RE, and Kronman JH in 1971[19]. It concluded that accuracy of inter-occlusal wax must be considered in terms of many variables responsible for horizontal displacement. Even under highly controlled conditions of this study, exact reproduction or stability of wax records were never achieved. Even Shanahan[20] supported the later statement from his experiments. The studies not in favour to the obtained results are of Skurnik[17] reviewing that high quality wax is a useful and versatile material for registering interocclusal records. It provides resistance to closure but that resistance is apparently not sufficient enough to trigger proprioceptive receptors in the periodontal ligament to an extent that mandible is guided away from centric relation. Zinc oxide eugenol is not as versatile as wax. Certain situations negate their use. Cohn[21] stated that wax is rigid at room temperature and will snap in two if bent. It has comparatively little flow at room or mouth temperature, so, distortion will not occur accidently. Even Trappozano[22] quoted "Wax checkbite method is the technique of preference in recording and checking centric. Correctly used, its accuracy is far greater than is possibly obtained by other methods". An experimental study by Muller J proved that recordings made by wax with additional correction of the teeth imprints create only small vertical and horizontal deviation. Hence the material must be considered suitable for clinical use within short storage period of 30minutes. It showed the lowest vertical deviation at the occlusal surface followed by polyether.

Thus, the result of this study is concluded as following:

- Group A (polyvinyl siloxane) presented the smallest linear change among all the material tested, at all time intervals followed by Group C (zinc oxide eugenol) and Group B (Aluwax) respectively.

The result of this study was in accordance with those of Michalakis KX et al. who found that volumetric contraction of elastomers after polymerization was not clinically significant compared to Zinc oxide eugenol and Bite registration wax and K. Karthikeyan[23]. Lassila[24] stated that wax is difficult to use because its resistance to closure is very high even at temperatures near its melting point. Zinc oxide eugenol was difficult to store as it is susceptible to changes in relative humidity. Elastomeric materials, he said, remain stable for a long time, and their contraction due to volatility is slight if they are stored in tightly sealed plastic bags.

CONCLUSION:

Thus, the clinical implications of this study are as follow:

- Dimensional stability is influenced by both *"material"* factor and *"time"* factor. Dimensional stability decreases as the time factor increases.
- The errors in articulation will be induced by these inter-occlusal recording materials as time elapses.
- Selection of an Inter-occlusal recording materials with these facts in mind will yield a very good result.

Thus to conclude, when trading into the boundaries of the subject such as interocclusal records, it is natural for one to feel intimidated and scared for one does not know what to expect and what secrets it holds in its womb; but none is as dark and scary as the secrets of ignorance about the subject. One realizes that the more they differed regarding the procedure to be followed the more were they unified with regard to its importance. To quote Christensen who said, *"...accurate interocclusal record was of particular importance.... small errors in relating. The working*

casts may cause frustrations with occlusal adjustment and this result in the alteration of the occlusal anatomy and even ruining an otherwise acceptable prosthesis."

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