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Comparative evaluation of linear dimensional change and resistance to the compressibility of three polyvinyl siloxane interocclusal recording materials: an *in-vitro* study

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ABSTRACT

Background: Simulation of patient's occlusion on an articulator marks the basis for initiating any prosthodontic treatment. An understanding of the inherent properties of materials used to record the maxillomandibular relationship becomes essential to minimise errors. The soft recording material initially fills the spaces between teeth, hardens, and records the specific relationship of the arches. Elastomers as interocclusal record materials have consistently yielded the least error among the materials studied.

Aim: To comparatively evaluate linear dimensional change and resistance to compression of three polyvinyl siloxane interocclusal recording materials after setting.

Materials and methods: Clonebite (Ultradent), Colorbite D (Zhermack) and Imprint bite (3M ESPE) were evaluated for linear dimensional changes using Travelling Microscope and resistance to compressibility using Universal Testing Machine.

Results: Maximum linear dimensional change was observed in Imprint bite along with the highest resistance to compressibility. The minimum linear dimensional change was seen in Colorbite D while the least resistance to compressibility was seen in Clonebite.

Conclusion: From the results of the present study, the immediate articulation of casts is recommended after the bite registration using the material tested. However, a delay up to 8 hours could be considered as acceptable for Clonebite and Colorbite D.

1. Introduction

The precise articulation of the patient's cast is a prerequisite for diagnosis and subsequent corrective treatment [1]. Interocclusal record is defined as "A registration of the positional relationship of the opposing teeth or arches; a record of the positional relationship of teeth or jaws to each other" [2]. It forms the prime connecting link between the mouth and an articulator. The first interocclusal registration was made in 1756 by Philip Pfaff [3]. Accurate interocclusal records minimize the need for intraoral adjustments during prosthesis delivery and thus, are essential in providing precisely fabricated restorations to reduce

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overall treatment time and cost [4].

There are various interocclusal recording materials viz. dental plaster with modifiers, modelling compound, waxes, acrylic resin, and zinc oxide eugenol paste. The accuracy of the fit of recording material on the study or working casts is a critical factor as repositioning the record on the cast could be a source of discrepancy. Elastomers as interocclusal record materials have consistently yielded the least error among the materials studied. These materials are easy to manipulate and offer little or no resistance to closure. They set to a consistency that makes them easy to trim without distortion, and accurately reproduce tooth details. Addition silicone and polyether impression materials were modified by adding plasticizers and catalysts in order to be used as interocclusal recording media [1].

Many studies have evaluated the physical properties and behaviour of these materials. A compressive force is usually exerted on the interocclusal recording materials during articulating procedures that may cause inaccuracy during mounting of casts and distortion during fabrication of restorations. The resistance of these materials to compressive forces is critical because any deformation during the recording and mounting process could result in inaccurate articulation of casts and faulty fabrication of restorations [5]. The linear dimensional accuracy is also accountable for errors after the material sets and during transfer of the records on the articulator. It becomes an important property of the interocclusal recording media in order to avoid any discrepancies between the maxillomandibular registration and mounting of the casts. The objective of this study was to evaluate the linear dimensional change at varying time intervals and resistance to compression of Clonebite (Ultradent), Colorbite D (Zhermack) and Imprint bite (3M ESPE) polyvinyl siloxane interocclusal recording material and to suggest the ideal time for articulation for Clonebite (Ultradent), Colorbite D (Zhermack), and Imprint bite (3M ESPE).

2. Materials and methods

Three commercially available addition polysiliconebased bite registration material. i.e., Clonebite (Ultradent) (Material A), Colorbite D (Zhermack) (Material B), and Imprint bite (3M ESPE) (Material C) with similar composition were selected. An apparatus (Universal testing machine) for the determination of strain in compression (Instron 3345-Screw driven 5 kN capacity) and Travelling Micrometer microscope (WeswoxOptik two-motion microscope, 10x Eyepiece, 0. 01 mm Vernier reading) for determination of linear dimensional change were used. All the experiments were conducted at 23°C and 75% humidity [6].

Maxillary and mandibular dentulous study models were mounted in maximum intercuspation on Hanau semi-adjustable articulator (Figure 1) using Kaldent mounting plaster type II [6]. The mounting was stabilized using non-latex number 19 rubber bands which exerted an even force of 25N on the articulator till the plaster set [5]. The bite was opened by 3mm anteriorly according to incisal pin guidance markings.

Sample preparation was done by injecting the interocclusal recording material using the automix technique on the occlusal surface of mandibular teeth and firmly closing the articulator till the incisal pin touched the incisal table (Figure 2). Each material was allowed to set according to the manufacturer's instructions. Left half (3rd quadrant) of the samples was used to assess the resistance to compressibility while the right half (4th quadrant) was used for assessing linear dimensional change.

2.1 Testing the samples for linear dimensional change

Two fixed reference points were marked on the dentulous study models (buccal cusp tip of 1st premolar and mesiobuccal cusp tip of 1st molar) by applying a drop of composite resin on the cusp tips. The distance between the reference points marked on the interocclusal record was measured on the travelling microscope immediately after the material had set and it was noted as 'L'. This reading was measured on the travelling microscope. Subsequent readings were recorded at time intervals of 1 hour, 8 hours and 24 hours. The values were noted as 'Time 1', 'Time 2', and 'Time 3' respectively (n=40).

The linear dimensional change of the materials was assessed by using the following formula [7];

Linear dimensional change= L-(Time1/Time 2/Time3)

2.2 Testing the samples for resistance to compression

Three fixed reference points on the samples, i. e. centre of the incisal edge of the maxillary central incisor (21), the buccal cusp tip of 1st maxillary premolar (24) and mesiobuccal cusp tip of maxillary 1st molar (26) were marked where the minimum thickness of the specimen was 1mm in posterior teeth and 3mm in anterior teeth [7] and were subjected to a load of 20N [6] after the

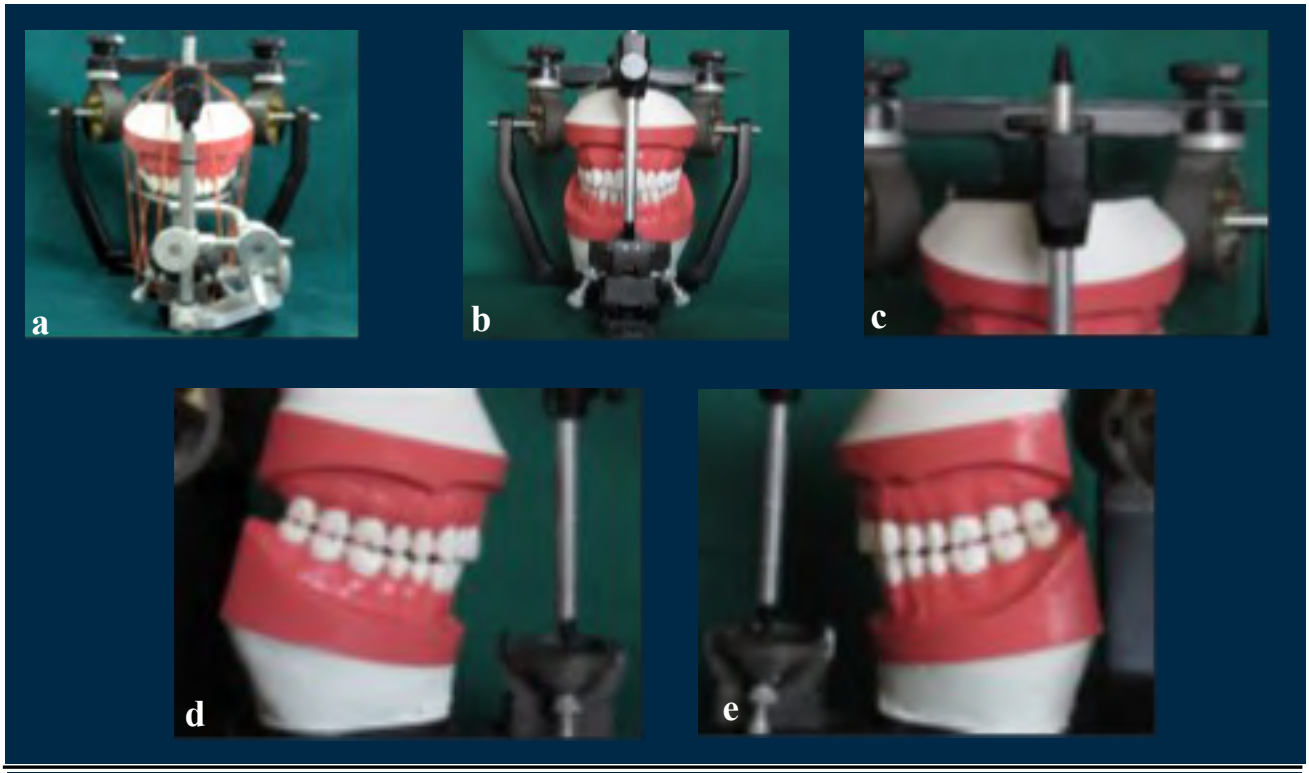

Figure 1. a-e. Mounting of maxillary and mandibular models on a semi adjustable articulator and raising the bite.

Figure 2. Samples prepared with interocclusal materials.

material had set. The strain at this load was recorded as 'X'. The load was brought back to Zero Newtons. Sixty seconds after the application of the first load, the samples were again subjected to a load of 20N [1,7,8]. The strain at this load was recorded as 'Y'. The change in strain in compression was computed as follows;

Change in Strain in compression= (Y-X)/100

2.3 Statistical analysis

Data were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS v 21.0, IBM). Comparison of numerical values between the groups was done using one-way ANOVA test, followed by Post Hoc Tukey's test for pair wise comparisons. For all the statistical tests, $p<0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving power to the study as 80%.

3. Results

3.1 Linear dimensional change

Intergroup comparison at 0 hours showed a mean linear dimensional change of Clonebite and Imprint bite to be similar, i.e. 1.32±0.025 and 1.33±0.040 whereas that of Colorbite D to be 1.30±0.35. A comparison at 1 hour, 8 hours and 24 hours showed similar results.

Although significant differences in linear dimensional changes were observed among the materials, the intragroup comparison did not show any statistically significant changes (Table 1).

Linear dimensional change of Clonebite with Colorbite and Imprint bite showed a statistically significant difference at 0 hours. The difference in linear dimensional change between Colorbite D and Imprint bite was not statistically significant. At 1 hour, 8 hours and 24 hours, the comparison between Clonebite, Colorbite D and Imprint bite showed statistically non-significant results (Table 2).

Significant differences in linear dimensional changes were observed between Colorbite D and Imprint bite in the 1st hour. No statistically significant differences were observed between 0-8 hours. All groups showed a statistically significant difference between 0-24 hours; dimensional change of Imprint bite being the highest followed by Clonebite and Colorbite D.

3.2 Resistance to compressibility

Intergroup comparison of at various time intervals and resistance to compressibility at incisor, premolar and molar regions of all three materials showed statistically significant results (Table 3).

In the incisor region, Clonebite and Imprint bite showed a statistically significant difference, with Imprint bite showing higher resistance to compressibility than Clonebite. In premolar region, Clonebite and Imprint bite, as well as Colorbite D and Imprint bite, showed statistically significant differences, with Imprint bite being most resistant to compression in both cases. Results obtained for the molar region were similar to those obtained for the premolar region. Clonebite and Imprint bite, as well as Colorbite D and Imprint bite, showed statistically significant differences in resistance to compression. Imprint bite showed the highest resistance to compression.

4. Discussion

The present study was conducted with a null hypothesis that linear dimensional change and resistance to compression after the setting of three polyvinyl siloxane interocclusal recording materials are not time-dependent entities and do not influence the time of

Table 1: The linear dimensional change in interocclusal materials at different time intervals (Post Hoc analysis - Pair wise comparison)

Time	Groups		Mean Difference	Standard Error	Significance
0 hours	A	B	0.02625*	0.00758	0.002*
	A	C	0.00455	0.00758	0.820#
	B	C	0.03080*	0.00758	0.000*
1 hours	A	B	0.03150	0.02351	0.376#
	A	C	0.01225	0.02351	0.861#
	B	C	0.01925	0.02351	0.692#
8 hours	A	B	0.00950	0.04285	0.973#
	A	C	0.04125	0.04285	0.602#
	B	C	0.05075	0.04285	0.465#
24 hours	A	B	0.01200	0.05045	0.969#
	A	C	0.01575	0.05045	0.948#
	B	C	0.00375	0.05045	0.997#

* Significant difference between the groups.
# No significant difference between the groups.

Table 2. The linear dimensional change in interocclusal materials at different time intervals (Post Hoc analysis - Inter group comparison)

Time	Groups		Mean Difference	Standard Error	Significance
Difference 0-1 hrs	A	B	0.01975	0.00958	0.103#
	A	C	0.01655	0.00958	0.200#
	B	C	0.03630*	0.00958	0.001**
Difference 0-8 hrs	A	B	0.01675	0.01133	0.305#
	A	C	0.01167	0.01133	0.559#
	B	C	0.02842*	0.01133	0.036#
Difference 0-24 hrs	A	B	0.03725*	0.01353	0.019*
	A	C	0.06450*	0.01353	0.000**
	B	C	0.10175*	0.01353	0.000**

* Significant difference between the groups.
# No significant difference between the groups.

Table 3. Resistance to compressibility at incisor, premolar and molar regions of interocclusal materials (Post-Hoc analysis - Pairwise analysis)

Tooth region	Groups		Mean Difference	Standard Error	Significance
Incisor	A	B	7.47450	7.68091	0.595#
	A	C	20.46175*	7.68091	0.024*
	B	C	12.98725	7.68091	0.213#
Premolar	A	B	2.02500	7.29009	0.958#
	A	C	23.36450*	7.29009	0.005**
	B	C	21.33950*	7.29009	0.011*
Molar	A	B	4.47525	6.86386	0.792#
	A	C	26.29175*	6.86386	0.001**
	B	C	21.81650*	6.86386	0.005**

* Significant difference between the groups.
# No significant difference between the groups.

articulation of casts. The above materials were selected for the present study as they are based on polyvinyl siloxane composition, which is widely used in regular clinical practice due to their accurate for registration of the bite and consistent clinical performance.

Michalakis et al. [1] in 2004 stated that both 'material' and 'time' individually as well as in combination, affect the linear dimensional changes. In the present study, Colorbite D showed minimum linear dimensional change indicting comparably higher dimensional stability in

the horizontal plane after setting. Imprint bite, on the other hand, showed maximum distortion within the first hour, indicating least horizontal dimensional stability. Vassilis V. and Tripodakis [9] in 2003 conducted a study in which four bite registration materials were tested. PVS displayed the lowest discrepancy among the tested. When the records were transferred onto the casts, the discrepancies were approximately 0.5 mm, without significant difference among materials. In the present study, statistical differences were obtained in the 1st and 24th hour, indicating variability in the distortion of the materials is time-dependent in spite of same base filler material composition. Tejo S.K. et al. [8] in 2012 conducted a study to assess the dimensional stability of 3 PVS interocclusal recording materials at an interval of 24, 48 and 72 hours. They concluded that Polyvinylsiloxane interocclusal records must be articulated within 24 hours. The present study further shortened this time interval indicating that articulation of casts was done immediately for Imprint bite; however, a delay of up to 8 hours is acceptable for Colorbite D and Clonebite. Breeding L.G., Dixon D. L [5] in 1992, studied the compression resistance of four interocclusal recording materials. Results of one-way ANOVA indicated that there was a significant difference in compressive resistance among the materials of each thickness.

The present study simulates the bite as it is obtained in the patient's mouth, unlike the study as mentioned above, thus reducing the errors in the readings caused due to greater thicknesses which eventually lead to a higher degree in compressibility of the materials. Significantly high resistance to compressibility in incisor, premolar and molar areas was shown by Imprint bite as compared to the other materials. Michalakis et al. [1] in 2004 studied and evaluated the resistance to compressibility after setting of various interocclusal registration materials. The materials used were one polyether bite registration material, four polyvinyl siloxane bite registration materials and one zinc oxide eugenol paste. The test revealed that compared to the rest of the interocclusal materials that were tested, Blu Mousse recorded the highest resistance to compression. Regisil polyvinyl siloxane was the least resistant to compression. In the present study, a force of 20 N was applied and was kept constant throughout the study as compared to a 30 N force applied in this study, which is more than the normal force exerted in the oral cavity during mandibular closure [5]. Out of the three materials tested in the present study, Imprint bite showed the highest resistance to compression in all the three regions, i.e. incisor, premolar and molar regions that were tested indicating highest dimensional stability in the vertical plane. Clonebite showed maximum distortion, indicating a higher incidence of causing vertical discrepancies during articulation procedures. Studies showing testing of these materials have time and again been conducted using a standard steel cylinder method to provide a uniform thickness to the material as per Revised American Dental Association Specification No. 19 For Non-Aqueous, Elastomeric Dental Impression Materials. Such a situation does not exist in the oral cavity, where the bite thickness ranges from 1-3mm.

The present study compared three different polyvinyl siloxane materials of a similar composition for the linear dimensional changes and resistance to compression after setting. Certain limitations were encountered during the same. The properties that were tested in the study are influenced by various other factors like weight changes in the materials, consistency prior to setting etc. The 'Time' factor needed to be further considered as well. Larger sample size should be incorporated for testing. Correlation of dimensional changes occurring in all planes must be made and quantified to get the precise effect of dimensional change occurring along each axis on accuracy in articulation of casts.

5. Conclusion

Within the limitations of this study, the following conclusions were drawn;

a. Colorbite D showed minimum linear dimensional change out of the three materials tested while Imprint bite showed the most indicating that it is most susceptible to distortion in the horizontal plane while stabilising the bite during mounting of casts. Least resistance to compression was shown by Clonebite indicating highest rebound of material in the vertical plane during articulation of casts. Imprint bite showed the least rebound indicating least discrepancies in vertical plane post articulation of casts.
b. The ideal time of articulation of casts for Clonebite, Colorbite D and Imprint bite is ideally immediately when the bite is recorded, i.e. within the 1st hour. However, a delay of up to 8 hours can be considered as acceptable for Clonebite and Colorbite D. A delay in articulation beyond this time should be avoided.

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