Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 09, pp.57681-57686, September, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

AN IN-VITRO STUDY TO COMPARE THE DIMENSIONAL STABILITY AND SURFACE HARDNESS OF ELASTOMERIC BITE REGISTRATION MATERIALS AT VARIOUS TIME INTERVALS

***,[1]Arjun N. Mithra, [2]Pranav V. Mody, [3]Mohamed Imran Zainvi and [4]Bhushan G. Wankhade**

[1]Senior lecturer, Department of Prosthodontics, V. S. Dental College and Hospital, Bengaluru, Karnataka, India
[2]Professor and Head, Department of Prosthodontics, K.V.G. Dental College and Hospital, Sullia, Karnataka, India
[3]Private Practitioner, St. Fathima Dental Clinic and Implant Center, Deharadun, Uttarkhand, India
[4]Senior lecturer, Department of Prosthodontics, V.Y.W.S. Dental College, Amravati, Maharashtra, India

ARTICLE INFO

Article History:
Received 05th June, 2017
Received in revised form
11th July, 2017
Accepted 15th August, 2017
Published online 30th September, 2017

Key words:

Interocclusal record,
Dimensional stability,
Surface hardness,
Time,
Vinyl Polysiloxane,
Polyether.

ABSTRACT

Introduction: Interocclusal records are essential to relate dental casts to an articulator. The advance of the polymer science introduced elastomeric interocclusal recording materials in the field of dentistry. But their properties are not completely understood.

Aim: To evaluate and compare the dimensional stability and surface hardness of two commercially available Vinyl Polysiloxane and Polyether elastomeric bite registration materials at various time intervals.

Materials and Methods: The materials tested were Imprint™ bite, Futar® D and Ramitec™. A total of 30 specimens were made, 10 each from three elastomeric bite registration materials. A travelling microscope was used to measure dimensional change and Shore-A durometer was used to measure surface hardness. The measurements were collected at the time intervals of 1, 24, 48 and 72 hours and mean values were taken for statistical analysis. Statistical analysis was performed by one-way ANOVA test and post hoc analysis by Bonferroni to compare the percentage of change over a period of time.

Results: Result showed that significant percentage of dimensional change was noted in all the three materials. Vinyl Polysiloxane showed significant dimensional change up to 48 hours. Polyether showed less dimensional change in the first 24 hours but later showed significant expansion. All the bite registration materials attained their maximum surface hardness in 48 hours. Vinyl Polysiloxane bite registration materials recorded the highest surface hardness.

Citation: Arjun N. Mithra, Pranav V. Mody, Mohamed Imran Zainvi and Bhushan G. Wankhade, 2017. "An In-vitro study to compare the dimensional stability and surface hardness of elastomeric bite registration materials at various time intervals", *International Journal of Current Research*, 9, (09), 57681-57686.

INTRODUCTION

Any dental restorative procedures require the transfer of tooth and jaw relationships to an articulator and interocclusal records are used to articulate mandibular cast to maxillary cast. (Berman, 1960; Shanahan, 1960) This enables us to study the status of the dentition and to construct dental restorations. (Cohn, 1963) Historically various materials have been used to make interocclusal records such as Waxes, Dental plaster, Zinc Oxide Eugenol impression paste etc. Wax alone or waxes combined with other materials were most commonly used for these purposes. However, since most waxes have not been specifically developed for these objectives, they are subject to distortion and do not store well at room temperatures after removal from the mouth. In addition, most techniques do not establish sufficient control of the accuracy and detail of the record. (Cohn, 1963; Lucia, 1964; Skurnik, 1969; Skurnik, 1969) The materials available to us are either thermoplastic or chemically set. The thermoplastic materials are predominantly waxes and chemically set materials are Zinc Oxide Eugenol and the recently developed and popular elastomerics. The thermoplastics should have some "body" in order to be manipulated. The chemically set materials require some time to undergo their chemical reaction before they set. (Skurnik, 1969) Considerable controversy exists regarding the accuracy, usefulness and manipulative skills required in obtaining accurate interocclusal records. (Millstein *et al*., 1971; Millstein *et al*., 1973; Lundeen, 1974) They should have the ability to maintain extreme accuracy even under varying conditions during storage and handling. Even though a record may appear to be dimensionally stable and accurate, it may still undergo dimensional change which can only be evaluated microscopically. (Millstein *et al*., 1975; Skurnik, 1977) Four specific jaw relation registration materials that have been using

******Corresponding author:* **Arjun N. Mithra,**
Senior lecturer, Department of Prosthodontics, V. S. Dental College and Hospital, Bengaluru, Karnataka, India.

recent years are Zinc Oxide Eugenol paste, Eugenol free Zinc Oxide paste, Silicone elastomer, and Polyether elastomer. While these recording materials are basically similar to impression materials, they have been modified to give them different handling characteristics. (Balthazar-Hart *et al*., 1981) Polyether has been suggested as being more dimensionally stable when compared with its predecessors and Vinyl Polysiloxane have recently claimed even superior accuracy and stability over Polyether. (Lacy *et al*., 1981) Considering the introduction of these materials and current usage in dental practice, it is absolutely necessary to study the material properties before using them clinically.

MATERIALS AND METHODS

In this study, a stainless steel die was prepared according to the ANSI/ADA specifications no 19 [Fig.1]. (Revised American dental association specification no. 19 for non-aqueous, elastomeric dental impression materials, 1977) Vinyl Polysiloxane bite registration paste (Group 1 & Group 2) and Polyether bite registration paste (Group 3) [Table: 1] were manipulated according to manufacturer's instructions [Table: 2]. Specimens were prepared at room temperature. Metal ring was placed over the mold and material was manipulated and placed in the mold. Then the die was covered with a 4 x 4 inch square glass plate. Hand pressure was applied over the glass plate for 5 seconds until the metal ring was seen; this was followed by application of a 500 g weight to further remove excess material. Then the stainless steel die with bite registration material, glass slab and weight were submerged in a water bath with temperature of 36 ± 10C to simulate ambient temperature. Complete assembly remained in water bath till the material was set plus an additional 3 min to ensure complete set of the material. Once the material was set, the metal ring was removed from the stainless steel die and all the excess material was removed by using a Bard parker blade no: 15. The sample was stored at room temperature in a water proof container. The prepared specimen was in the form of a disk measuring 3mm in thickness and 30mm in diameter. 30 samples comprising of 10 samples from 3 different materials were obtained [Fig. 2, Fig. 3 and Fig. 4] [Table: 3].

Testing the samples

To measure dimensional stability

Measurements from each sample were taken between the parallel lines A and C by means of travelling microscope (Mitutoyo, Japan) [Fig. 5] with magnification of 10 X. The microscope had least count of 0.01 mm. The distance between two parallel lines A and C was measured at four fixed points. The mean of two readings was taken for statistical analysis. Measurements were made for all the samples of each group at an interval of 1, 24, 48 and 72 hours.

The change in dimension was calculated using the following formula:

Dimensional change % = (X' – Y') / X' x100

Where

X' = standard measurement (mm) of X and Z line in the die
Y' = observed measurement (mm) of A and C line in the sample

To measure the surface hardness

The same specimens were used to evaluate the surface hardness using Shore - A Durometer (RSK Co., Taiwan) [Fig. 6]. For testing, the depth indicator was set to zero. A light force was applied with the index finger to the indenter for 3 seconds and the unit was lowered on the sample until the presser was in full contact. The hardness value was displayed on the Durometer. Four readings were taken on four different sites of the specimen and mean value was taken for statistical analysis. Surface hardness was measured for all the samples of each group at an interval of 1, 24, 48 and 72 hours. Mean value was taken for statistical analysis. For each dimension one way ANOVA analysis was used to assess the significance of the difference among the 3 groups. Subsequent pair-wise comparisons were performed by using post hoc analysis by Bonferroni test.

RESULTS

Percentage of Dimensional change

Comparison of change between various groups for dimensional stability at different time intervals by Post hoc analysis by Bonferroni test [Table: 4] [graph 1] showed significant difference between the time period of 1 hour (hr) – 24 hours (hrs) between group 1 & group 2 and highly significant difference between the group 1 & group 3 and group 2 & group 3. Between the time period 1 hr – 48 hrs, no significant difference was seen between group 1 & group 2 but highly significant difference was seen between group 1 & group 3 and group 2 & group 3. Between the time period 1 hr – 72 hrs, no significant difference between group 1 & group 2, highly significant difference between group 1 & group 3 and group 2 & group 3. Between the time period 24 hrs – 48 hrs, no significant difference between group 1 & group 2, highly significant difference between group 1 & group 3 and group 2 & group 3. Between the time period 24 hrs – 72 hrs, no significant difference between group 1 & group 2, highly significant difference between group 1 & group 3 and group 2 & group 3. Between the time period 48 hrs – 72 hrs, no significant difference between group 1 & group 2, highly significant difference between group 1 & group 3 and group 2 & group 3.

Change in Surface hardness:

Multiple comparisons within the groups for surface hardness at various time intervals [Table: 5] [Graph: 3] showed high significant difference in group 1 material between 1 hr and 24 hrs, 48 hrs & 72 hrs and also high significant difference between 24 hrs & 48 hrs and 24 hrs & 72 hrs. No significant difference between 48 hrs & 72 hrs. In group 2 high significant differences between 1 hr and 2 4hrs, 48 hrs & 72 hrs and also high significant difference between 24 hrs & 48 hrs and 24 hrs & 72 hrs. No significant difference between 48 hrs & 72 hrs. In group 3 high significant differences between 1 hr and 24 hrs, 48 hrs & 72 hrs and 24 hrs & 72 hrs, significant difference between 24 hrs & 48 hrs and no significant difference between 48 hrs & 72 hrs.

DISCUSSION

During oral rehabilitation of the patient, articulation of the casts is necessary to simulate the patient's maxillo-mandibular relation which enables the dentist and the technician to study

Table 1. List of materials used in the study

S.No.	Material	Trade name	Manufacturer	Batch no.
1	Vinyl Polysiloxane bite registration material (Group 1)	Imprint™ bite	3M Deutschland GmbH, Germany	LOT 507557 2015 - 02
2	Vinyl Polysiloxane bite registration material (Group 2)	Futar® D	Kettenbach GmbH & Co, Germany	LOT 112211 2014 - 07
3	Polyether bite registration material (Group 3)	Ramitec™	3M Deutschland GmbH, Germany	LOT 506034 2015 - 02

Table 2. Manufacturer's recommendation for Bite registration materials (≤ - lesser than or equal to, ≥ - greater than or equal to)

Material Trade name	Mixing system	Storage temperature	Mixing time	Working time	Setting time
Imprint™ bite (Group 1)	Auto mix Base/catalyst paste - cartridge	15-25^{0}C	20 sec		1 min from start of mixing
Futar® D (Group 2)	Auto mix Base/catalyst paste - cartridge	18-25^{0}C	≤ 30 sec at 23^{0}C		≥ 1 min 30 sec at 35^{0}C
Ramitec™ (Group 3)	Manual mixing Base/catalyst paste - Tube	18-25^{0}C	30 sec	2 min from start of mixing	5 min from start of mixing

Table 3. Study samples

Material	Vinyl Polysiloxane bite registration material	Vinyl Polysiloxane bite registration material	Polyether bite registration material
Trade name	Imprint™ bite (Group 1)	Futar® D (Group 2)	Ramitec™ (Group 3)
No. of specimen	10	10	10

Table 4. Comparison of change between various groups for dimensional stability over period of time by post hoc analysis by Bonferroni test (Sig – significant, HS – highly significant and NS – not significant)

			p	
1hr – 24 hrs	Group 1	Group 2	0.041	Sig
		Group 3	0.000	HS
	Group 2	Group 3	0.001	HS
1 hr – 48 hrs	Group 1	Group 2	0.072	NS
		Group 3	0.000	HS
	Group 2	Group 3	0.000	HS
1 hr – 72 hrs	Group 1	Group 2	0.084	NS
		Group 3	0.000	HS
	Group 2	Group 3	0.000	HS
24 hrs – 48 hrs	Group 1	Group 2	1.000	NS
		Group 3	0.000	HS
	Group 2	Group 3	0.000	HS
24 hrs – 72 hrs	Group 1	Group 2	1.000	NS
		Group 3	0.000	HS
	Group 2	Group 3	0.000	HS
48 hrs – 72 hrs	Group 1	Group 2	1.000	NS
		Group 3	0.000	HS
	Group 2	Group 3	0.000	HS

Table 5. Multiple comparisons within the groups for surface hardness at various time intervals (Sig – significant, HS – highly significant and NS – not significant)

Group			p	
Group 1	@ 1 hour	@ 24 hours	0.000	HS
		@ 48 hours	0.000	HS
		@ 72 hours	0.000	HS
	@ 24 hours	@ 48 hours	0.001	HS
		@72 hours	0.000	HS
	@ 48 hours	@ 72 hours	0.064	NS
Group 2	@ 1 hour	@ 24 hours	0.000	HS
		@ 48 hours	0.000	HS
		@ 72 hours	0.000	HS
	@ 24 hours	@ 48 hours	0.001	HS
		@72 hours	0.000	HS
	@ 48 hours	@ 72 hours	0.221	NS
Group 3	@ 1 hour	@ 24 hours	0.000	HS
		@ 48 hours	0.000	HS
		@ 72 hours	0.000	HS
	@ 24 hours	@ 48 hours	0.015	Sig
		@72 hours	0.000	HS
	@ 48 hours	@ 72 hours	0.090	NS

the dentition in static as well as in function and to fabricate the restoration. (Cohn, 1963) When the teeth do not offer vertical and horizontal stability between the arches, an interocclusal record is mandatory to relate the casts. Precise articulation of the patient's casts is a prerequisite for proper diagnosis and subsequent accurate treatment. (Lucia, 1964) Many authors have explained the use and manipulation skills of several interocclusal recording materials like Hi-Fi Wax, (Skurnik, 1969) Tenax wax, Alu wax, Zinc Oxide Eugenol paste with Jones frame, Dental plaster, (Skurnik, 1969) Acrylic resin

wafers, modelling compound (Skurnik, 1977) and Polyether elastomeric bite registration materials (Balthazar-Hart *et al*., 1981). Waxes have been used as interoccluasl recording material since a very long time.

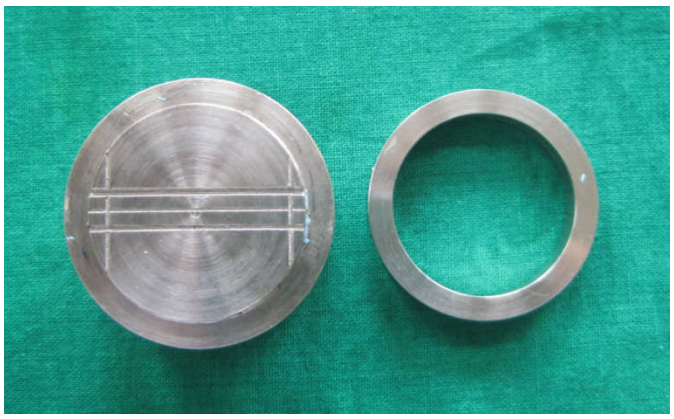


Figure 1. Stainless steel metal die

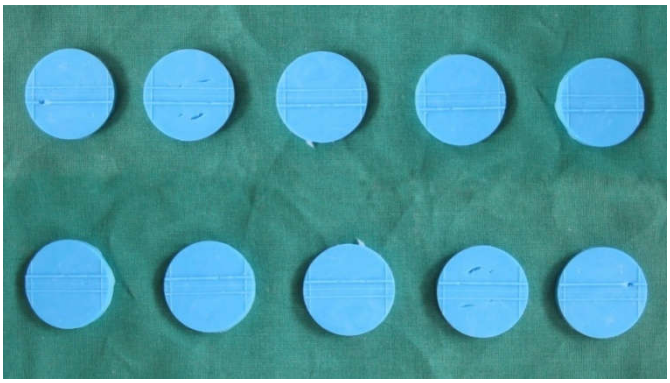


Figure 2. Imprint™ Bite (group 1) 10 specimens

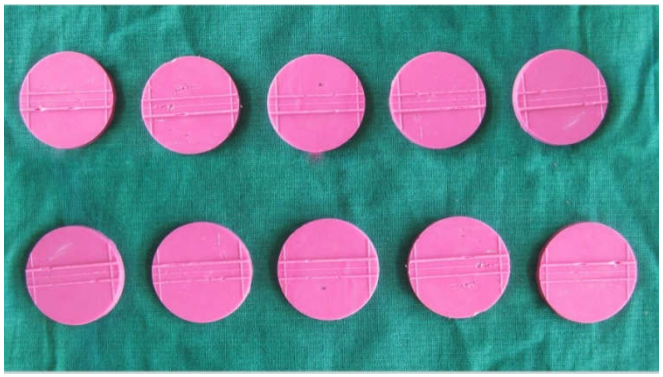
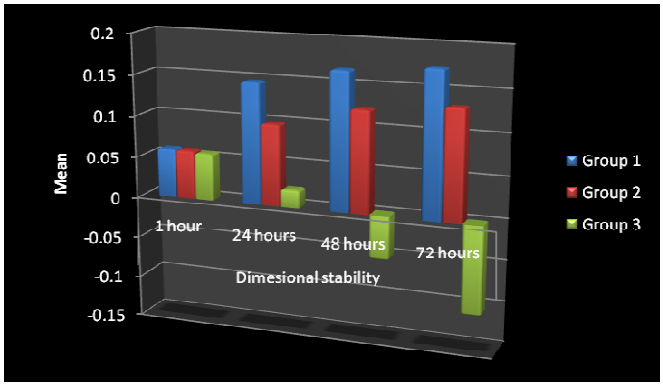


Figure 3. Futar® D (group 2) 10 specimens

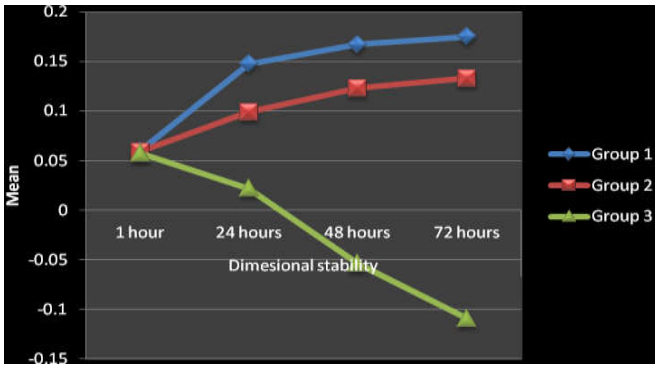
Figure 4. Ramitec™ (group 3) 10 specimens

Figure 5. Travelling microscope (Mitutoyo, Japan)

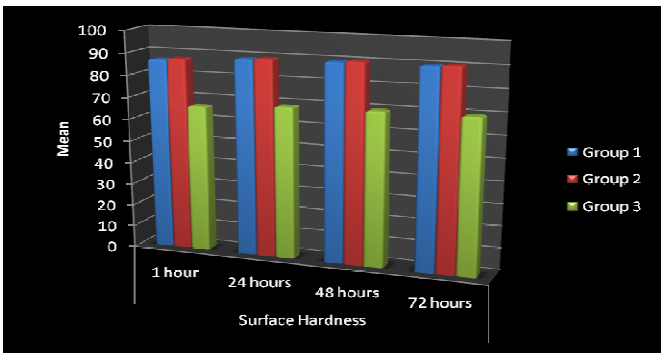
Figure 6. Shore - A Durometer (RSK Co., Taiwan)



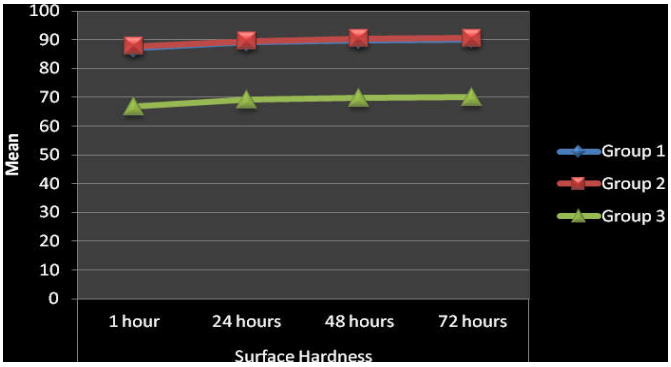
Graph 1. Percent deviation of mean of percentage dimension change of the 3 group of material at 1, 24, 48 and 72 hours



Graph 2. Mean and Standard Deviation for dimension change of the 3 group of material at 1, 24, 48 and 72 hours



Graph 3. Percent deviation of mean surface hardness of the 3 group of material at 1, 24, 48 and 72 hours



Graph 4. Mean and standard deviation for surface hardness of the 3 group of material at 1, 24, 48 and 72 hours

However they have many limitations. Being thermoplastic, they are easily subjected to dimensional change at varying room temperature. (Skurnik, 1969; Millstein *et al*., 1971) For improved dimensional stability, waxes should be reinforced with a metal screen or cloth matrix and zinc oxide eugenol paste. (Cohn, 1963) In various studies, exact reproduction of the original wax recording was never achieved even under highly controlled conditions. (Millstein *et al*., 1971; Millstein *et al*., 1973) Zinc oxide eugenol registration paste is simple to use, offers no resistance to closure and storage is not a problem but it must have sufficient body. Plaster is the most exacting material but its use is more complicated than the use of wax or zinc oxide eugenol paste. (Skurnik, 1969) Considerable controversy exists regarding the accuracy, usefulness and manipulative skills required in obtaining accurate inter-occlusal records. (Millstein *et al*., 1971) Variations in the interocclusal records may occur in the vertical, antero-posterior, or medio-lateral position. So it should have qualities to maintain extreme accuracy even under varying conditions of storage and handling. Although the record may appear to be accurate to the naked eye, it may undergo dimensional change which can only be evaluated microscopically. (Millstein *et al*., 1975) Recently Vinyl Polysiloxane elastomeric bite registration materials have been introduced in the market. Basically these materials are similar to Impression materials; they have been modified to give them different handling characteristics. (Balthazar-Hart *et al*., 1981) Elastomeric bite registration materials, introduced in the last decades, show superior properties than the conventional materials in handling characteristics, surface detail reproduction, dimensional stability and hardness. (Fattore *et al*., 1984)

Occlusal record inaccuracies can be caused by many factors but the basic nature of the recording material and its properties affects the most. Other factors are the storage temperature, polymerization shrinkage, chemical reaction, stress and mechanical manipulation occurs during the procedures. (Mullick *et al*., 1981) The evaluation period of 1 hr, 24 hrs, 48 hrs and 72 hrs very critical, this time intervals were based on the time required to carry the inter-occlusal records to distant laboratories or delay in the articulation of the casts in the laboratory. The study revealed that significant greatest shrinkage rate of all the materials appeared within the first 24 hrs after the manufacturer's specified setting time [Graph: 2]. Group 1 and group 2 (Vinyl Polysiloxane) showed greatest shrinkage in the first 24 hrs. Significant shrinkage was seen up to 48 hrs. After 48 hrs, no significant dimensional change was seen corresponding to the study conducted by Michalakis *et al*. (2004) In general, the excellent dimensional stability of Vinyl Polysiloxane was attributed to the fact that it set by addition reaction. Hence there were no by-products and loss of volatiles as stated by Millstein *et al*. (1994) Group 3 (Polyether) showed initial shrinkage up to first 24 hrs followed by significant expansion of the material up to 72 hrs and showed least linear change compared to group 1 and group 2 (Vinyl Polysiloxane) up to 24 hrs. Polyether sets by polymerization; hence an initial shrinkage is seen due to polymerization shrinkage. However, polyether is hydrophilic, resulting in absorption of water and expansion of the material. This leads to subsequent expansion after initial shrinkage. This expansion occurs after 24 hrs. Lassila and McCabe have confirmed the same shrinkage and expansion patterns. (Lassila and McCabe, 1985) Muller suggests that Polyether interocclusal records must be used within 24 hrs for realibility. (Muller *et al*., 1991) Both the groups of Vinyl Polysiloxane bite registration material (group 1 and group 2) show same hardness [Graph: 4]. Polyether (group 3) showed lesser values as compared to Vinyl Polysiloxane bite registration material. The significant increase in the surface hardness was noticed in all the 3 materials up to first 48 hrs as mentioned by the Hatzi *et al*, (2012) later no significant change in the hardness of the material was seen. Hardness of the bite registration material at setting time is critical, as it can ensure distortion free inter-occlusal recordings. Hard, highly filled inter-occlusal recording materials are expected to exhibit less vertical discrepancies due to reduced setting shrinkage and high resistance to deformation ensuring more accurate fit on stone models.

Conclusion

Within the limitation of this study, it can be concluded that Vinyl Polysiloxane bite registration paste is more

dimensionally stable over a period of time and recorded higher surface hardness compared to Polyether bite registration paste

1. All three elastomeric bite registration materials showed greatest dimensional change in the first 24 hrs of storage.
2. Vinyl Polysiloxane bite registration paste showed continuous shrinkage although the shrinkage was not clinically significant after 24 hrs.
3. Polyether bite registration paste showed least shrinkage in the first 24 hrs but exhibited expansion after 24 hrs leading to significant amount of dimensional change. This expansion is contributed to hydrophilicity due to which absorption of water takes place.
4. Vinyl Polysiloxane bite registration paste recorded greater surface hardness than Polyether.
5. Vinyl Polysiloxane bite registration paste and Polyether bite registration paste attained maximum surface hardness in the first 24 hrs.

REFERENCES

Balthazar-Hart Y, Sandrik JL, Malone WFP, Mazur B, Hart T. 1981. Accuracy and dimensional stability of four interocclusal recording materials. *J Prosthet Dent*., 45:586-91.

Berman MH. 1960. Accurate interocclusal records. *J Prosthet Dent*., 10:620-30.

Cohn LA. 1963. Two techniques for interocclusal records. *J Prosthet Dent*., 13:438-43.

Fattore LD, Malone WF, Sandrik JL, Mazur B, Hart T. 1984. Clinical evaluation of the accuracy of interocclusal recording materials. *J Prosthet Dent*., 51:152-57.

Hatzi P, Tzakis M, Eliades G. 2012. Setting characteristics of vinyl-polysiloxane interocclusal recording materials. *Dental Materials,* 28:783-91

Lacy AM, Fukuni H, Bellman T, Jendresen MD. 1981. Time-dependent accuracy of elastomer impression materials Part II. *J Prosthet Dent*., 45 :329-33.

Lassila V, McCabe JF. 1985. Properties of interocclusal registration materials. *J Prosthet Dent*., 53:100-04.

Lucia VO. 1964. A technique for recording centric relation. *J Prosth Dent*., 14:492-05.

Lundeen HC. 1974. Centric relation records: the effect of muscle action. *J Prosthet Dent*., 31:244-53.

Michalakis KX, Pissiotis A, Anastasiadou V, Kapari D. 2004. An experimental study on particular physical properties of several interocclusal recording media. Part II: Linear dimensional change and accompanying weight change. *J Prosthodont*, 13:150-59.

Millstein PL, Clark RE, Kronman JH. 1973. Determination of the accuracy of wax interocclusal registration Part II. *J Prosthet Dent*., 29:40-45.

Millstein PL, Clark RE, Myerson RL. 1975. Differential accuracy of silicone body interocclusal records and associated weight loss due to volatiles. *J Prosthet Dent*., 33:649-54.

Millstein PL, Hsu CC. 1994. Differential accuracy of elastomeric recording materials associated weight change. *J Prosthet Dent*., 71:400-03.

Millstein PL, Kronman JH, Clark RE. 1971. Determination of the accuracy of wax interocclusal registration. *J Prosthet Dent*., 25:189-96.

Muller J, Gotz G, Bruckner G, Kraft E. 1991. An experimental study of vertical deviations induced by different interocclusal recording materials. *J Prosthet Dent*., 65:43-50.

Mullick SC, Stackhouse JA, Vincent GR. 1981. A study of interocclusal record materials. *J Prosthet Dent*., 46:304-07.

Revised American dental association specification no. 19 for non-aqueous, elastomeric dental impression materials. JADA (April) 1977; 94:733-41.

Shanahan TEJ. 1960. Interocclusal records. *J Prosthet Dent*., 10:842-8.

Skurnik H. 1969. Accurate interocclusal records. *J Prosthet Dent*., 21:154-65.

Skurnik H. 1969. Functional interach relationship recorded in wax. *J Prosthet Dent*., 21:283-99.

Skurnik H. 1977. Resin registration for interocclusal records. *J Prosthet Dent.,* 37:164-72.

****