INTERNATIONAL JOURNAL OF CURRENT MEDICAL AND PHARMACEUTICAL RESEARCH
ISSN: 2395-6429, Impact Factor: 4.656
Available Online at www.journalcmpr.com
Volume 6; Issue 05(A); May 2020; Page No.5139-5145
DOI: http://dx.doi.org/10.24327/23956429.ijcmpr202005879

Research Article

TO COMPARE AND EVALUATE THE DIMENSIONAL STABILITY AND ACCURACY OF VARIOUS INTEROCCLUSAL RECORDING MATERIALS: AN IN VITRO STUDY

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ARTICLE INFO

Article History:
Received 6th February, 2020
Received in revised form 15th March, 2020
Accepted 12th April, 2020
Published online 28th May, 2020

Key words:
Interocclusal bite registration material, Stainless steel mold, Accuracy, Dimensional stability.

ABSTRACT

Aim: To compare and evaluate the accuracy and dimensional stability of aluwax (AW), zinc oxide eugenol (SB), bisacryl (LB), polyvinylsiloxane (DB and CB) and polyether(RT) as bite registration materials at different time intervals (on first day, third day and seventh day).
Materials and methods: A Stainless steel mold was made according to revised American dental association specification no.19 and 60 samples were prepared according to different manufacturers instructions. The samples were observed for accuracy and dimensional stability on day 1, day 3 and day 7 under Nikon Profile Projector. The data was collected and statistically analyzed.
Results: There was a statistically significant difference in accuracy scores among various groups ($p<0.001$). Highest mean accuracy score i.e. surface detail reproduction was shown by Superbite followed by Luxabite, Ramitec = DMG O bite, Cad bite with least accuracy score of Aluwax. Superbite was least dimensionally stable followed by Luxabite, Aluwax, Ramitec, DMG O bite with lowest mean difference in Cadbite suggesting it to be most dimensionally stable.
Conclusion: Zinc oxide eugenol bite registration paste (SB) was found to be most accurate Polyvinylsiloxane bite registration paste (CB) was found to be most dimensionally stable even after 7 days.

INTRODUCTION

Interocclusal registration materials have been used for recording the occlusal relationship between natural and/or artificial teeth, for planning occlusal rehabilitation and for construction of removable and fixed dental prosthesis.[1] The accuracy of the interocclusal record is not only affected by the operator's clinical ability and the technique followed, but also the type of material chosen.[2] Errors in diagnosis and treatment will result if the interarch registration is inaccurate as the mounted casts will not show the patient's existing maxillomandibular relationship.[3] A tripod of vertical support and horizontal stability between the two casts are required for a stable and reproducible opposing casts.[4] The first interocclusal registration was made by Phillip Ptaff in 1756 by natural waxes, since then many materials and techniques have been evolved for maxillomandibular registration procedures.[5] Plasticizers and catalyst have been added to provide different handling characteristics.[6] These include impression plaster, waxes, zinc oxide eugenol, acrylic resin, hydrocolloids, and newer ones include polyether and vinyl polysiloxane.[5] Dental waxes and zinc oxide eugenol impression pastes have been used till today because of their economic viability, less skill dependency, ease of manipulation and less time consumption. However, the use of elastomeric dental materials like Polyvinyl siloxane interocclusal materials has increased recently because of the ease of use of automixing cartridges and dimensional stability.[7]The interocclusal recording material

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should have certain basic ideal properties like: minimal initial resistance to closure before setting, dimensional stability after setting, resistance to compression after polymerization, ease of manipulation, absence of any adverse effects on the involved tissues, accurate recording of the incisal or occlusal surface of teeth and ease of verification.[8] Of all the properties of the interocclusal recording materials, most important is the dimensional changes which occurs due to delay in carrying materials to distant laboratories or delay in articulation or remounting of casts.[6] Therefore, dimensional stability is a very important property for interocclusal records so that any discrepancies between the maxillomandibular registration and mounting of casts can be avoided.[2] The present study is done to compare and evaluate the accuracy and dimensional stability of different bite registration materials i.e. aluwax, zinc oxide eugenol, bisacryl, polyvinylsiloxane and polyether at different time intervals.

MATERIALS AND METHODS

The present study was carried out in Department of Prosthodontics including crown and bridge and implantology, Himachal Institute of Dental Sciences, Paonta Sahib. This study was conducted to evaluate the dimensional stability and accuracy of six interocclusal recording materials: Bite registration wax (Aluwax, Aluwax Dental Product Co, Michigan USA) Zinc oxide eugenol bite registration paste (Superbite, Bosworth Company, Skokie) Bisacryl bite registration paste (Luxabite, DMG America) Vinyl polysiloxane bite registration paste (Virtual Cadbite, Ivoclar Vivadent) Vinyl polysiloxane bite registration paste (DMG O'Bite) Polyether bite registration paste (Ramitec, 3M ESPE, AG Dental Products, Germany).(fig.1)

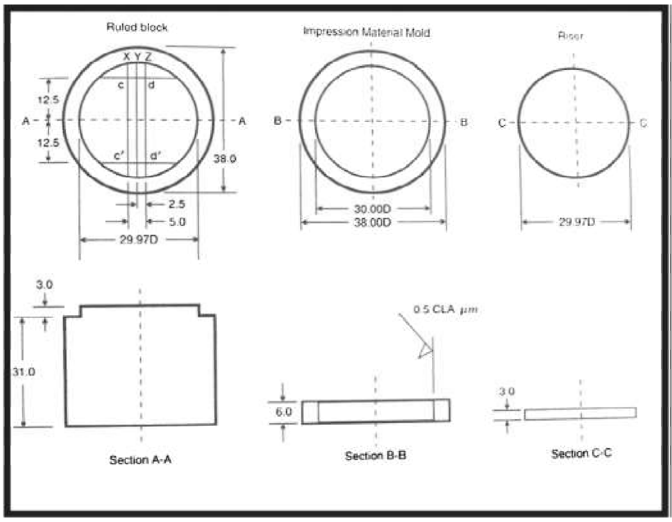
The materials and methods include: Preparation of Stainless steel mold with a riser (fig.2) followed by samples preparation (fig.3) and observations are made for scoring the samples for accuracy and dimensional stability.

Fig 2 Master die with riser

METHODOLOGY

Preparation of stainless steel mold

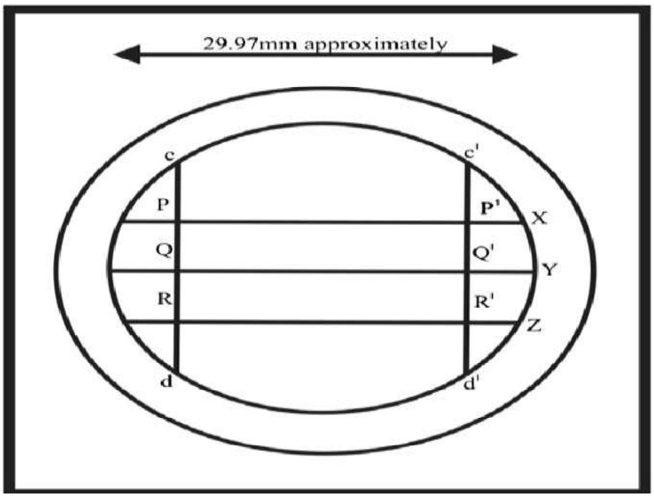
A mold was prepared according to revised American dental association specification no.19 for non-aqueous elastic dental impression materials. It consisted of a ruled block AA, test material mold BB, and a riser CC (Diag.1).



Diag 1 Section A-A : Ruled block

Section B-B: Impression material mold Section C-C: Riser (* all measurements in mm)

All parts were made up of stainless steel. The ruled block was having three horizontal lines of different widths; small Y -line (width-24µm), medium X-line (width-57µm) and a thick Z line (width -83µm). And two vertical lines CD and C'D' of 82µm each. The lines CD and C'D' were separated from each other by 25mm approx (24.740mm). The test material mold was a cylinder of inner diameter 30mm and depth of 6mm. The riser was a stainless disc of diameter 29.9mm and thickness of 3mm. (Diag.2)



Diag.2 **Line X: 50±8µm**
Line Y : 20±4µm
Line Z : 75±8µm
Line CD: 75±8µm
Line C'D': 75±8µm

Preparation of samples

The materials were divided into six groups of 10 samples each.(fig.3)

1. Group 1- Bite registration wax (Aluwax-AW)
2. Group 2- Zinc oxide eugenol bite registration paste (Superbite- SB)
3. Group 3- Bisacryl bite registration paste (Luxabite-LB)
4. Group 4- Vinyl polysiloxane bite registration paste (Virtual Cadbite-CB)
5. Group 5- Vinyl polysiloxane bite registration paste (DMG O'Bite-DB)
6. Group 6- Polyether bite registration paste (Ramitec 3M ESPE-RT)

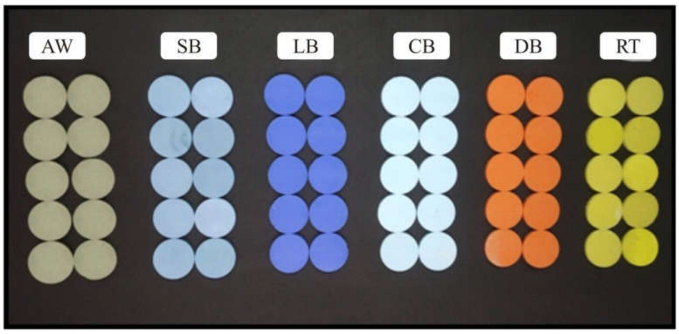


Fig 3 Different groups of bite registration samples

Altogether, a total of sixty samples were prepared. Individual materials were manipulated following the manufacturer's instructions and were loaded within their working time in the mold. The materials were spread on the surface of the die by taking precautions not to incorporate any air bubbles. A total force of 5.56N (weight of glass plate 67g + external weight 500g) was applied over them. The materials were allowed to set for recommended setting time in thermostatically controlled water bath (32 ± 1°C) to simulate mouth condition plus 3 minutes to ensure polymerization in case of elastomeric materials. After removal from the water bath, the material was separated from the die by using the disk (riser). The excess flash was trimmed using a Bard Parker knife

Thus prepared specimens obtained were of dimensions 30 mm in diameter, 3mm in thickness and had the lines X, Y, Z, CD and C´D´ lines on it. Similarly, all the 60 bite registration record samples were obtained (Fig. 3). In between days of observation, the samples were stored in air sealed containers at room temperature of 28 ± 2°C. (Fig. 4)

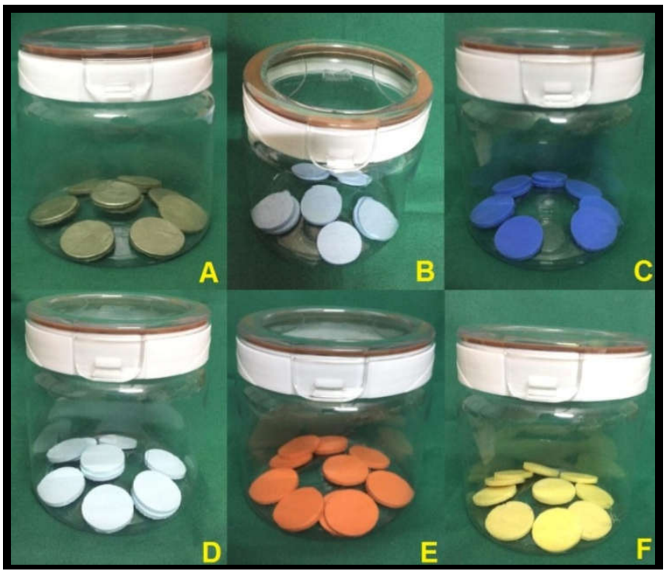


Fig 4 Storage of samples in air sealed containers

A)Aluwax (AW) B) Superbite (SB) C) Luxabite (LB)
D) Cadbite (CB) E) DMG O Bite (DB) F) Ramitec (RT)

Observation made for scoring the samples for accuracy

Accuracy of different interocclusal recording materials was determined by observing each sample under Nikon Profile Projector V-12(Fig.5) Observations for accuracy was made after obtaining the samples only on the day 1. Each sample was graded group wise according to line criteria.

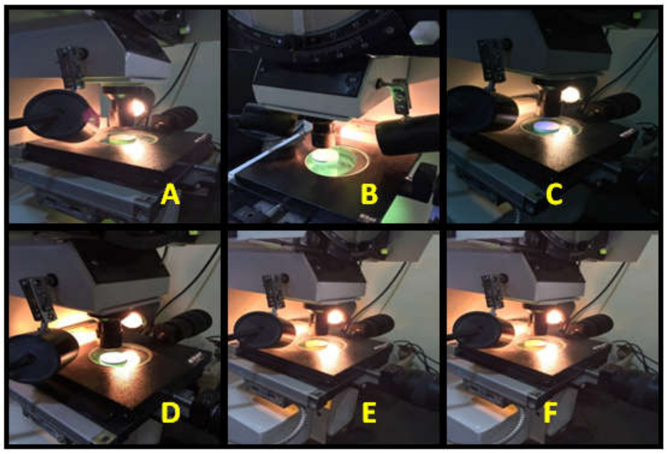


Fig 5 Samples observed under profile projector

A) Aluwax (AW) B) Superbite (SB) C) Luxabite (LB)
D) Cadbite (CB) E) Dmg O Bite (DB) F) Ramitec (RT)

Line criteria: Thinnest continous line produced by each material was observed by using Nikon Profile Projector V-12 with 50X magnification and the scores were noted.(Fig.6)

Score	Observation
0	No continous line
1	Continous thick line (Z-line)
2	Continous medium line (X-line)
3	Continous thin line (Y-line)

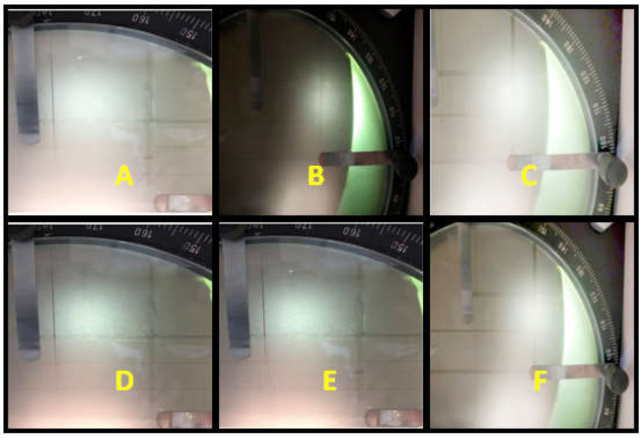


Fig 6 Magnified view of lines under 50X magnification

A) Aluwax (AW) B) Superbite (SB) C) Luxabite (LB)
D) Cadbite (CB) E) Dmg O Bite (DB) F) Ramitec (RT)

Observation of samples for dimensional stability

The distance between the lines, CD and C´D´ reproduced on the samples was measured at three different points PP´,QQ´ and RR´(i.e. at the intersections of these lines with the lines XYZ) by using Nikon Profile projector V-12 with 50X magnification. Three readings were obtained for each sample and the averages of these three values was noted. Likewise readings were made at different time intervals i.e.; on first day after removal of material from the die, on third day, on seventh day respectively for each of the samples. All the readings thus obtained were tabulated and subjected to statistical analysis for the comparison and correlation of accuracy and dimensional stability of six interocclusal recording materials. One way ANOVA was used for intergroup comparison and post-hoc Tukey's test for pairwise comparison of accuracy and dimensional stability of six interocclusal recording materials.

RESULTS

Table 1 and graph 1 shows the mean accuracy scores i.e. surface detail reproduction in various groups. Highest mean accuracy score i.e. surface detail reproduction was shown by SB followed by LB, RT = DB, CB with least accuracy score of AW. Multiple comparison with post-hoc Tukey's test (Table 2) shows significantly lower scores of AW with all experimental groups except CB. Hence found to be least accurate (lowest surface detail reproduction) among various groups evaluated in this study.

Highest mean value was shown by SB followed by RT, DB, CB, LB with least mean value of AW. Hence SB was most dimensionally stable and AW was least dimensionally stable on day 1. Observation on day 3 showed highest mean value of SB with least mean value of AW depicting the similar results as observed on day 1. On day 7, highest mean value was shown by DB followed by CB, RT, SB, LB with least mean value of AW. Hence DB was most dimensionally stable and AW was least dimensionally stable on day 7(Table 3)

Multiple comparison (Table 4) with post-hoc Tukey's test shows significantly lower scores of AW with all experimental groups. AW was found to be the most inferior material on day 1.Also showed statistically significant difference between RT and CB, RT and LB, CB and SB, DB and SB, DB and LB and SB and LB. On Day 3 multiple comparison with post-hoc Tukey's test (Table 5) shows that there was a statistically significant difference in the dimensional stability between AW and RT, AW and CB, AW and DB, AW and SB, AW and LB, RT and LB , CB and SB (p=0.018), DB and LB (p<0.001), and SB and LB (p<0.001). Other differences were not statistically significant (p>0.05). Multiple comparison with post-hoc Tukey's test (Table 6) on day 7 showed that there was a statistically significant difference in the dimensional stability between AW and RT, AW and CB, AW and DB, AW and SB, RT and LB, CB and SB, CB and LB , DB and SB , DB and LB , and SB and LB . Other differences were not statistically significant (p>0.05). Table 7 and graph 2 shows highest mean difference of distance between reference lines in SB from day 1 to day 7 showing maximum shrinkage suggesting it to be least dimensionally stable followed by LB, AW, RT, DB with lowest mean difference in CB suggesting it to be most dimensionally stable.

Table 1 Mean Accuracy Scores

	N	Mean	Std. Deviation	95% Confidence Interval for Mean		Min.	Max.
				Lower Bound	Upper Bound		
Aluwax	10	.8000	.78881	.2357	1.3643	.00	2.00
Superbite	10	2.6000	.69921	2.0998	3.1002	1.00	3.00
Luxabite	10	2.5000	.70711	1.9942	3.0058	1.00	3.00
Cadbite	10	1.9000	1.1005	1.1127	2.6873	0.00	3.00
DMG O Bite	10	2.4000	.84327	1.7968	3.0032	1.00	3.00
Ramitec	10	2.4000	.84327	1.7968	3.0032	1.00	3.00
Total	60	2.1000	1.02014	1.8365	2.3635	.00	3.00

Table 2 Post-hoc tukey's HSD multiple comparisons

Group	Group	Mean Difference	p-value	95% Confidence Interval	
				Lower Bound	Upper Bound
Aluwax	Superbite	-1.80000*	**<.001***	-2.9113	-.6887
Aluwax	Luxabite	-1.70000*	**<.001***	-2.8113	-.5887
Aluwax	Cadbite	-1.10000	.054	-2.2113	.0113
Aluwax	DMG O Bite	-1.60000*	**.001***	-2.7113	-.4887
Aluwax	Ramitec	-1.60000*	**.001***	-2.7113	-.4887
Superbite	Luxabite	.10000	1.000	-1.0113	1.2113
Cadbite	Superbite	-.70000	.437	-1.8113	.4113
Cadbite	Luxabite	-.60000	.605	-1.7113	.5113
Cadbite	DMG O Bite	-.50000	.768	-1.6113	.6113
DMG O Bite	Superbite	-.20000	.995	-1.3113	.9113
DMG O Bite	Luxabite	-.10000	1.000	-1.2113	1.0113
Ramitec	Superbite	-.20000	.995	-1.3113	.9113
Ramitec	Luxabite	-.10000	1.000	-1.2113	1.0113
Ramitec	Cadbite	.50000	.768	-.6113	1.6113
Ramitec	DMG O Bite	.00000	1.000	-1.1113	1.1113

*Statistically significant (Tukey's test)

Table 3 Mean dimensional stability scores

Groups	N	Mean (day 1)	Mean (day 3)	Mean (day 7)
Aluwax	10	24.6662	24.6271	24.6148
Superbite	10	24.7773	24.7439	24.6811
Luxabite	10	24.7059	24.6715	24.6398
Cadbite	10	24.7217	24.7178	24.7140
DMG O Bite	10	24.7329	24.7232	24.7169
Ramitec	10	24.7536	24.7254	24.7032
Total	60	24.7263	24.7015	24.6783

Table 4 Multiple comparisons on day 1

Group	Group	Mean Difference	p-value	95% Confidence Interval	
				Lower Bound	Upper Bound
Aluwax	Superbite	-.11110*	<.001*	-.1362	-.0860
Aluwax	Luxabite	-.03970*	<.001*	-.0648	-.0146
Aluwax	Cadbite	-.05550*	<.001*	-.0806	-.0304
Aluwax	DMG O Bite	-.06670*	<.001*	-.0918	-.0416
Aluwax	Ramitec	-.08740*	<.001*	-.1125	-.0623
Superbite	Luxabite	.07140*	<.001*	.0463	.0965
Cadbite	Superbite	-.05560*	<.001*	-.0807	-.0305
Cadbite	Luxabite	.01580	.437	-.0093	.0409
Cadbite	DMG O Bite	-.01120	.773	-.0363	.0139
DMG O Bite	Superbite	-.04440*	<.001*	-.0695	-.0193
DMG O Bite	Luxabite	.02700*	.028*	.0019	.0521
Ramitec	Superbite	-.02370	.074	-.0488	.0014
Ramitec	Luxabite	.04770*	<.001*	.0226	.0728
Ramitec	DMG O Bite	.02070	.162	-.0044	.0458

*Statistically significant (Tukey's test)

Table 5 Multiple comparisons on day 5

	Day 1	Day 7	Mean Difference	p-value
Aluwax	24.6662	24.6148	.05140	**<.001***
Superbite	24.7773	24.6811	.09620	**<.001***
Luxabite	24.7059	24.6398	.06610	**<.001***
Cadbite	24.7217	24.7140	.0077	.446
Dmg o bite	24.7329	24.7169	.01600	**<.001***
Ramitec	24.7536	24.7032	.5040	**<.001***

*Statistically significant (Tukey's test)

Table 6 Multiple comparisons on day 7

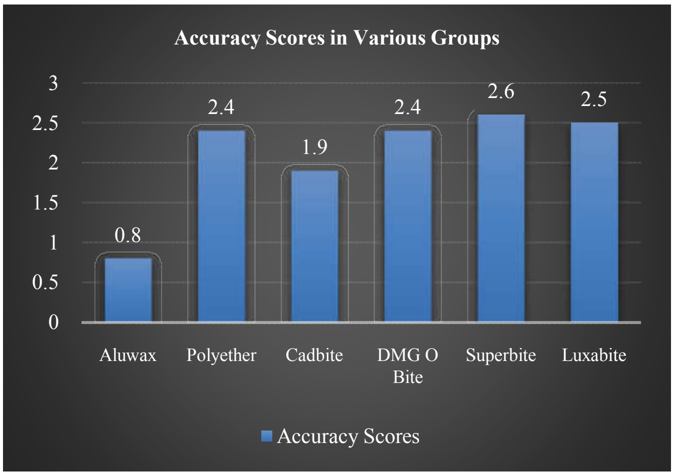
Group	Group	Mean Difference	p-value	95% Confidence Interval	
				Lower Bound	Upper Bound
Aluwax	Superbite	-.11680*	<.001*	-.1398	-.0938
Aluwax	Luxabite	-.04440*	<.001*	-.0674	-.0214
Aluwax	Cadbite	-.09070*	<.001*	-.1137	-.0677
Aluwax	DMG O Bite	-.09610*	<.001*	-.1191	-.0731
Aluwax	Ramitec	-.09830*	<.001*	-.1213	-.0753
Superbite	Luxabite	.07240*	<.001*	.0494	.0954
Cadbite	Superbite	-.02610*	.018*	-.0491	-.0031
Cadbite	DMG O Bite	-.00540	.982	-.0284	.0176
Cadbite	Luxabite	.04630*	<.001*	.0233	.0693
DMG O Bite	Superbite	-.02070	.101	-.0437	.0023
DMG O Bite	Luxabite	.05170*	<.001*	.0287	.0747
Ramitec	Cadbite	.00760	.924	-.0154	.0306
Ramitec	DMG O Bite	.00220	1.000	-.0208	.0252
Ramitec	Superbite	-.01850	.184	-.0415	.0045
Ramitec	Luxabite	.05390*	<.001*	.0309	.0769

*Statistically significant (Tukey's test)

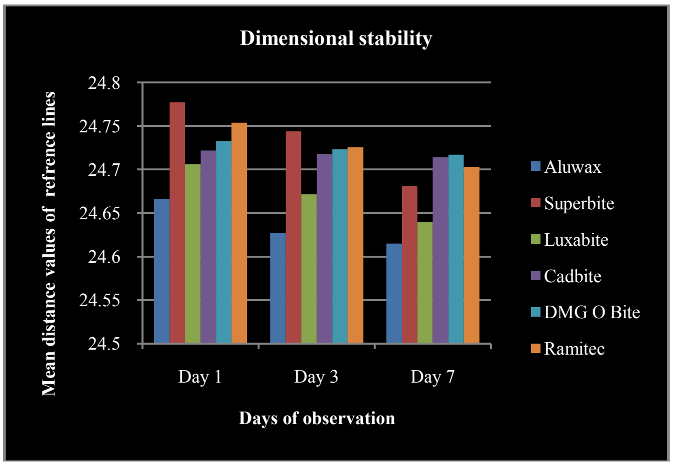
Table 7 Paired sample t-test between day 1 to day 7 for mean distance values

Group	Group	Mean Difference	p-value	95% Confidence Interval	
				Lower Bound	Upper Bound
Aluwax	Superbite	-.06630*	<.001*	-.0955	-.0371
Aluwax	Luxabite	-.02500	.133	-.0542	.0042
Aluwax	Cadbite	-.09920*	<.001*	-.1284	-.0700
Aluwax	DMG O Bite	-.10210*	<.001*	-.1313	-.0729
Aluwax	Ramitec	-.08840*	<.001*	-.1176	-.0592
Superbite	Luxabite	.04130*	.001*	.0121	.0705
Cadbite	Superbite	.03290*	.019*	.0037	.0621
Cadbite	Luxabite	.07420*	<.001*	.0450	.1034
Cadbite	DMG O Bite	-.00290	1.000	-.0321	.0263
DMG O Bite	Superbite	.03580*	.008*	.0066	.0650
DMG O Bite	Luxabite	.07710*	<.001*	.0479	.1063
Ramitec	Superbite	.02210	.238	-.0071	.0513
Ramitec	Luxabite	.06340*	<.001*	.0342	.0926
Ramitec	Cadbite	-.01080	.882	-.0400	.0184
Ramitec	DMG O Bite	-.01370	.735	-.0429	.0155

*Statistically significant (Paired sample t-test)



Graph 1 Accuracy scores in various groups



Graph 2 Comparison of Dimensional stability

DISCUSSION

Optimum oral health, functional efficiency, oral comfort and aesthetics are the basic objectives of occlusal rehabilitation.[9] A clinically acceptable prosthesis should be in harmony with the existing stomatognathic system.[6] For this precise articulation it requires clinician's knowledge of recording the patient's existing jaw relationship and a reliable material that can record and replicate the accurate interocclusal relationships.[10]

According to GPT 9, Interocclusal record can be defined as the registration of the positional relationship of the opposing teeth or arches, a record of the positional relationship of the teeth or jaws to each other. The introduction of different interocclusal recording materials with different physical and handling properties had put clinicians in dilemma regarding the choice of material to be used for precise recording and transfer of accurate existing records for articulation of patient's working or diagnostic casts in the fabrication of good satisfactory prosthesis.[6] Much work has not been done to judge the accuracy (surface detail reproduction) and dimensional stability, thus the present in vitro study was conducted to evaluate the accuracy (surface detail reproduction) and dimensional stability of commercially available interocclusal recording materials on 1st day, 3rd day and 7th day. In this study total of 60 samples were made and divided into six groups.

Statistical analysis of accuracy (surface detail reproduction) and dimensional stability was done between the various time intervals from the specimens obtained from stainless steel die of each bite registration material. The results were subjected to one-way ANOVA analysis to assess the significance of the difference among groups.[11,12] Multiple comparisons were done using Tukey's post-hoc test. The level of significance for the present study was fixed at a p-value of less than 0.05.

Highest mean accuracy score i.e surface detail reproduction was shown by SB followed by LB, RT = DB, CB with least accuracy score of AW (Table 1 and graph 1)

The possible reason for this is the high viscous nature of wax leading to low surface detail reproduction (accuracy). This is in agreement with study performed by Muller *et al* (1990)[13], Fattore *et al* (1984)[14], Gurav SV, Khanna TS (2015)[5]

Aluwax consists of low viscosity wax with impregnated aluminium particles to evenly disperse the heat and to avoid excessive cooling contraction.[5] The reason for its versatility is its easy manipulation and when softened, it softens uniformly and remains soft for an adequate working time. But it is dimensionally inaccurate interocclusal recording material as it has high coefficient of thermal expansion and high resistance to closure which lead to inaccuracies while registration is made. Distortion of wax is also very common due to release of internal stresses, thus, leading to inaccuracies in the record. Therefore, it has been classified as most inaccurate material among the interocclusal records studied.[15,16,17] Zinc oxide eugenol is shown to reproduce accurate surface details mainly because of its low initial viscosity coupled with its pseudo elastic nature, which allows fine detail reproduction. Moreover, Zinc oxide Eugenol offers minimal resistance to closure of mandible thus allowing a more accurate interocclusal relationship record to be formed.

On day 1, SB was found to be most dimensionally stable and AW was least dimensionally stable.(Table 3) The possible reason for this is that wax has high coefficient of thermal expansion and distortion due to stress release and high resistance to closure which lead to inaccuracies while registration is made. Studies have shown that waxes contain aluminium or copper particles due to which they have a flow rate of 2.5-22% and are susceptible to distortion.[18] This is in agreement with other studies performed by Shrunik (1969)[19], Millstein *et al* (1971)[15], Shanahan (1960)[20], VergosVk *et al* (2003)[21], Michalakis *et al* (2004)[2], Karthikeyan *et al* (2007)[22], Ghazal M (2008)[23], Pipko *et al* (2009)[24], Assif *et al* (1988)[25], Anup G (2011)[18], Gupta S (2013)[26] which reported waxes to be the most inferior material.

Waxes was found to be least dimensionally stable on day 3 also. (Table 3) However, multiple comparison showed significantly lower scores of RT with CB samples.(Table 5) The possible reason might be due to absorption of water from the water bath by hydrophilic polyether during the polymerization process and simultaneous more leaching of the water soluble plasticizers.[2] This is in agreement with the study conducted by Michalakis *et al* in 2004 . The excellent dimensional stability of polyvinylsiloxane is attributed to the fact that it sets by addition polymerization reaction. Therefore, no byproducts and no loss of volatiles occur in addition silicones.[18]Multiple comparison also showed significantly lower scores. The possible reason could be inherent property of polymerization shrinkage of bisacryl.

Day 7 results (table 3) were consistent with the studies performed by Vergos *et al* in 2003[21], Millstein *et al* in 1994[27] and Dua *et al*[9].

SB showed maximum shrinkage from day 1 to day 7, suggesting it to be least dimensionally stable followed by LB, AW, RT, DB with lowest mean difference in CB suggesting it to be most dimensionally stable. (Table 7 and graph 2) This result seems to be in accordance with the study conducted by some researchers, who showed that ZnOE undergoes continuous contraction over a period of 72 hours.[6] This could be explained by the fact that water formed during chelation reaction evaporates leading to weight loss and contraction over the period of time thus contributing to dimensional change.[6]

The excellent dimensional stability of polyvinylsiloxane is attributed to the fact that it sets by addition polymerization reaction. Therefore, no byproducts and no loss of volatiles occur in addition silicones.[18]This is an agreement with the studies performed by Mullick *et al* in 1981[28], Chai *et al* 1994[7], Millstein *et al* in 1981[29], Balthazar-Hart *et al* in 1981[30], Breeding *et al* in 1994[31], Anup S *et al* in 2011[18], Dua *et al* in 2007[9], Ghazal *et al* in 2008[24], Gupta S *et al* 2013[27] and Saha A *et al* 2011[32] compared the various interocclusal recording materials with polyvinylsiloxane and found polyvinylsiloxane to be dimensionally most stable than other interocclusal recording material.

CONCLUSION

Within the limitations of the study, Zinc oxide eugenol bite registration paste (SB) was found to be most accurate (surface detail reproduction). Interocclusal recording material which was followed by bisacryl (LB), polyether (RT), polyvinylsiloxane (DB and CB), and AW respectively whereas polyvinylsiloxane bite registration paste (CB) was found to be most dimensionally stable even after 7 days followed by polyvinylsiloxane (DB), polyether (RT), AW, bisacryl (LB), zinc oxide eugenol (SB) respectively**.** No correlation exists between the accuracy and dimensional stability of the six tested interocclusal recording materials.

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How to cite this article:

Dr. Nitin Sethi *et al* (2020)' To Compare and Evaluate the Dimensional Stability and Accuracy of Various Interocclusal Recording Materials: An in Vitro Study', *International Journal of Current Medical and Pharmaceutical Research,* 06(05), pp 5139-5145.

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