

Comparison of Linear Dimensional Stability among Three Different Types of Interocclusal Recording Materials: An In-vitro Study

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ABSTRACT

Introduction: In routine dental practice, clinicians often face difficulty in selecting accurate interocclusal recording materials due to the introduction of numerous options in the market. Therefore, it is crucial to choose the appropriate material and use it correctly for the success of any prosthesis.

Aim: To evaluate and compare the linear dimensional stability of three different types of interocclusal recording materials: polyvinyl siloxane bite registration paste (orangebite), polyether bite registration paste (ramitec), and bite registration wax (aluminium filled).

Materials and Methods: An in-vitro study was conducted in the Department of Prosthodontics and Crown and Bridge, with microscopic evaluation performed at the Department of Oral and Maxillofacial Pathology and Microbiology at Maratha Mandal's NGH Institute of Dental Sciences and Research Centre, Belagavi, Karnataka, India in September 2020 for a period of four days. A stainless steel die was used to make impressions, and materials were manipulated according to the manufacturer's instructions.

A total of 30 samples (10 for each material) were created. Three minutes after the respective setting time of each material, discs were separated from the die. The distance between two parallel lines was measured using a stereomicroscope at different time intervals: one hour, 24 hours, 48 hours, and 72 hours. Statistical analysis was performed using Analysis of Variance (ANOVA) and the Mann-Whitney test.

Results: In the intragroup comparison of dimensional changes at different time intervals, all three materials showed statistically insignificant results ($p > 0.05$). However, statistically significant results ($p \leq 0.05$) were found when comparing the materials at different time points. Polyether bite registration material exhibited better dimensional stability than polyvinyl siloxane and bite registration wax at one hour, 24 hours, 48 hours, and 72 hours.

Conclusion: Polyether demonstrated superior dimensional stability compared to polyvinyl siloxane and bite registration wax. The dimensional stability was influenced by both the material used and the duration of time.

Keywords: Polyether, Prosthesis, Stereomicroscope, Time interval

INTRODUCTION

The success of any prosthetic rehabilitation treatment depends on the precise mounting of casts in an articulator. The most commonly used materials to record maxillomandibular relationships are direct interocclusal record materials [1]. There are two types of records: one for mounting casts or setting the articulator adjustments, and the other for checking the degree of occlusal or incisal tooth contacts. It is important to accurately record the patient's maxillomandibular relationship with interocclusal recording materials in order to create a harmonious occlusion [2]. There are different categories and designs of interocclusal records for the remaining vertical support and horizontal stability of the dentition [3].

The articulation of a patient's casts may be delayed for various reasons. Therefore, it is crucial to use dimensionally stable interocclusal recording materials to accurately represent the patient's maxillomandibular relationship [4]. The accuracy of the impression can be assessed by its dimensional stability over time, so dimensional stability should be considered when selecting an impression material [5].

In 1756, Phillip Pfaff introduced the first interocclusal registration, and since then, many materials and techniques have emerged. Interocclusal recording materials are essentially impression materials, but they have been improved for better handling characteristics when recording maxillomandibular relationships. Examples include impression plaster, zinc oxide eugenol, waxes, vinyl polysiloxane, and polyether [6]. In the present study, polyvinyl siloxane bite registration paste (orangebite), polyether bite registration paste

(ramitec), and bite registration wax (aluminium filled) were used to evaluate dimensional stability, as these materials are commonly used in day-to-day practice. The function and aesthetics of prosthetic treatments depend on this critical step of recording the maxillomandibular relationship. Therefore, interocclusal recording materials must be dimensionally stable, easy to manipulate, and cost-effective for effective use [7].

In a previous study by Begum S et al., the dimensional stability of polyvinyl siloxane and alginate as interocclusal recording materials was compared, and it was concluded that polyvinyl siloxane was a more dimensionally stable material than alginate [2]. However, newer commercially available materials need to be evaluated for their stability. Therefore, the present study was conducted to evaluate the linear dimensional stability of three types of interocclusal recording materials, which is time-dependent, providing clinicians with information regarding their usage in day-to-day practice.

MATERIALS AND METHODS

An in-vitro study was conducted in the Department of Prosthodontics and Crown and Bridge, and the microscopic evaluation was performed in the Department of Oral and Maxillofacial Pathology and Microbiology at Maratha Mandal's NGH Institute of Dental Sciences and Research Centre, Belagavi, Karnataka, India, in September 2020, over a period of four days. The Institutional Review Board (IRB) granted clearance for the present in-vitro study (Letter number: 1401).

Inclusion criteria: Specimens that were 3 mm thick, had even colour, visible lines, and no voids were included in the study.

Exclusion criteria: Specimens with voids, uneven colour, and invisible lines were excluded from the study.

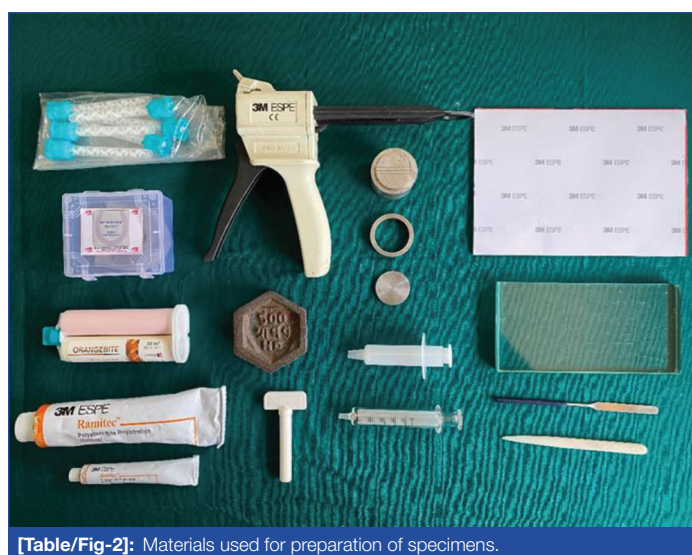
Sample size: For the present study, a total of 30 samples were selected, with 10 samples per group (group A, group B, and group C).

Study Procedure

The interocclusal recording materials used as test materials in the study as listed in [Table/Fig-1], and the armamentarium used for the study listed in [Table/Fig-2].

Test materials				
Groups	Number of specimens	Brand name	Type of material	Manufacturer
Group A	10	Orangebite	Polyvinyl siloxane bite registration Material	Medicept UK Ltd.
Group B	10	Ramitec	Polyether bite registration paste	3M ESPE (Germany)
Group C	10	Aluminium filled (Alu)	Bite registration wax	MP Sai Enterprise Pvt., Ltd., (Thane)

[Table/Fig-1]: Materials used for preparation of specimens.



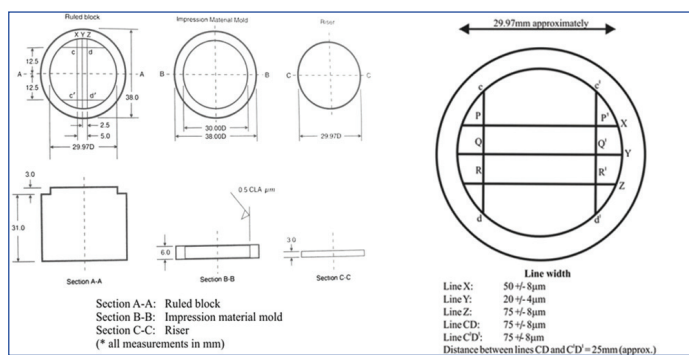
[Table/Fig-2]: Materials used for preparation of specimens.

The method used to compare the dimensional stability followed the testing methodology outlined in American Dental Association (ADA) specification no.19 for elastomeric impression materials.

- Preparation of mould:** A study mould was prepared according to the ADA specification no.19 [8]. It consisted of a ruled block (AA), a test material mould (BB), and a riser (CC). The study mould was made of stainless steel. The ruled block consisted of three horizontal lines of different widths: a small Y-line (24 μ m), a medium X-line (57 μ m), and a thick Z-line (83 μ m). It also had two vertical lines CD and C'D', each measuring 82 μ m. The distance between the lines CD and C'D' was 25 mm. The test mould was used to place the bite registration material and was a cylinder with an inner diameter of 30 mm and a depth of 6 mm. The riser, a stainless steel disc used to remove the samples, had a diameter of 29.9 mm and a thickness of 3 mm [Table/Fig-3].
- Manipulation of polyvinyl Siloxane bite registration material:** The polyvinylsiloxane bite registration material (orangebite) was supplied as base and accelerator paste. The material was carried in an automixing gun and uniformly spread over the surface of the die. A glass slab covered with a polyethylene sheet was placed on the die, and a weight of 500 grams was applied to set the material for 4-5 minutes in a thermostatically controlled water bath to simulate mouth conditions [Table/Fig-4] [8].
- Manipulation of polyether bite registration paste:** For the Polyether bite registration paste (ramitec), equal lengths of the



[Table/Fig-3]: Stainless steel die and ring fabricated according to ADA specification no. 19.



[Table/Fig-4]: Schematic diagram of block reproduction [8].

pastes were mixed together for 45 to 50 seconds on a mixing pad. The homogeneous mix was then spread on the surface of the die using a plastic syringe and a glass slab covered with a polyethylene sheet. A weight of 500 grams was placed over it, and the material was allowed to set for 4-5 minutes in a thermostatically controlled water bath to simulate mouth conditions [Table/Fig-4] [8].

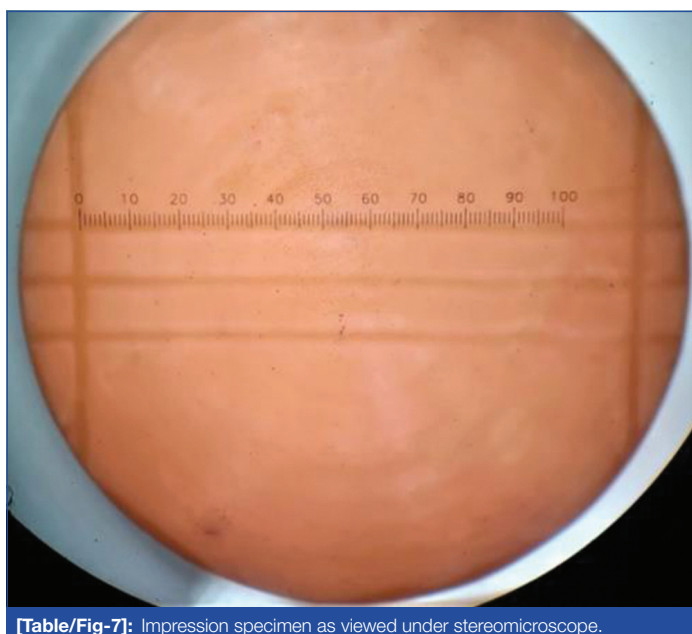
- Manipulation of bite registration wax:** The samples of bite registration wax were submerged in a 45°C water bath for five minutes using a 5 mL glass syringe. Then, the material was spread on the surface of the die, and a glass slab covered with a polyethylene sheet was placed over it. A weight of 500 g was placed on top. The material was allowed to set for 4-5 minutes in a thermostatically controlled water bath [Table/Fig-4] [8].
- Observation of samples for dimensional stability:** Using a stereomicroscope (Labomed -LB 340 Zoom stereo microscope with LED illumination) with 10X magnification, the distance between the lines CD and C1D1 was measured at three different points, PP1, QQ1, and RR1 (i.e., at the intersections of these lines with the lines XYZ) [Table/Fig-3,4,7]. Three readings were obtained, and the averages of these three values were recorded.



[Table/Fig-5]: Die assembly immersed in water bath.



[Table/Fig-6]: Impression specimens of all the three materials.



[Table/Fig-7]: Impression specimen as viewed under stereomicroscope.

Readings were recorded at different time intervals: one hour after removal of the material from the die, at 24 hours, at 48 hours, and at 72 hours, respectively, for each of the samples. Statistical analysis of all the readings was done to compare the dimensional stability of all three recording materials.

Here, X represents the standard measurement (μm) of CD and C'D' in the die, and Y represents the observed measurement (μm) of CD and C'D' in the sample [8]. The dimensional change was calculated using the formula: Dimensional change $\% = (X - Y) / X \times 100$ [8]. Linear

dimensional change was measured in the present study. The time intervals were selected according to the time taken to transport interocclusal recording materials to distant laboratories or the delay in articulation or remounting of the casts. All the specimens were stored in sealed dry polyethylene bags at room temperature.

STATISTICAL ANALYSIS

The results were obtained, and sample size estimation was done using OpenEPI software version 2.3.1. Statistical analysis was performed using Kruskal-Wallis and ANOVA for the overall comparison of dimensional stability, and the Mann-Whitney test was used for comparisons between each of the two groups. A probability value of less than 0.05 was considered statistically significant.

RESULTS

The mean distance between the lines of all samples was highest in polyvinyl siloxane, as shown in [Table/Fig-8]. The dimensional change in percentage for all the samples is depicted in [Table/Fig-9]. Intragroup comparison of dimensional changes at different time intervals showed statistically insignificant results ($p > 0.05$) for all three materials. Statistically significant results ($p \leq 0.05$) were found between all the materials when compared at different time points [Table/Fig-10].

Dimensional stability was compared between the three interocclusal recording materials at different time intervals. Statistically significant results ($p \leq 0.05$) were found between polyether and bite registration wax, as well as between polyvinyl siloxane and bite registration wax

Materials	Sample no.	Dimensional stability: mean distance between lines (mm)			
		1 hour	24 hours	48 hours	72 hours
Polyvinyl siloxane	1.	24.837	24.813	24.787	24.774
	2.	24.571	24.564	24.454	24.464
	3.	24.387	24.390	24.371	24.370
	4.	24.451	24.450	24.445	24.439
	5.	24.819	24.820	24.806	24.815
	6.	24.664	24.657	24.648	24.640
	7.	24.626	24.612	24.609	24.601
	8.	24.537	24.536	24.435	24.430
	9.	24.727	24.720	24.707	24.686
	10.	24.731	24.716	24.696	24.690
Polyether	1.	24.791	24.689	24.675	24.681
	2.	24.851	24.858	24.854	24.848
	3.	24.750	24.741	24.746	24.738
	4.	24.626	24.619	24.623	24.628
	5.	24.796	24.784	24.787	24.779
	6.	24.578	24.570	24.566	24.550
	7.	24.750	24.732	24.692	24.704
	8.	24.796	24.780	24.758	24.774
	9.	24.730	24.677	24.680	24.660
	10.	24.580	24.530	24.582	24.575
Alu wax	1.	24.398	24.387	24.350	24.347
	2.	24.451	24.419	24.399	24.375
	3.	24.264	24.284	24.268	24.247
	4.	24.613	24.602	24.588	24.571
	5.	24.626	24.618	24.630	24.613
	6.	24.287	24.251	24.235	24.213
	7.	24.264	24.260	24.257	24.245
	8.	24.387	24.359	24.338	24.321
	9.	24.596	24.575	24.558	24.540
	10.	24.451	24.438	24.429	24.390

[Table/Fig-8]: Average data of mean distance between the lines.

at different time intervals, with a higher mean score observed at 24 hours (p=0.0257) [Table/Fig-11].

Materials	Sample no.	Dimensional change in %			
		1 hour	24 hours	48 hours	72 hours
Polyvinyl siloxane	1.	0.0163	0.0187	0.0213	0.0226
	2.	0.0429	0.0436	0.0546	0.0536
	3.	0.0613	0.061	0.0629	0.063
	4.	0.0549	0.055	0.0555	0.0561
	5.	0.0181	0.018	0.0194	0.0185
	6.	0.0336	0.0343	0.0352	0.036
	7.	0.0374	0.0388	0.0391	0.0399
	8.	0.0463	0.0464	0.0565	0.057
	9.	0.0273	0.028	0.0293	0.0314
	10.	0.0269	0.0284	0.0304	0.031
Polyether	1.	0.0209	0.0311	0.0325	0.0319
	2.	0.0149	0.0142	0.0146	0.0152
	3.	0.025	0.0259	0.0254	0.0262
	4.	0.0374	0.0381	0.0377	0.0372
	5.	0.0204	0.0216	0.0213	0.0221
	6.	0.0422	0.043	0.0434	0.045
	7.	0.025	0.0268	0.0308	0.0296
	8.	0.0204	0.022	0.0242	0.0226
	9.	0.027	0.0323	0.032	0.034
	10.	0.042	0.047	0.0418	0.0425
Alu wax	1.	0.0602	0.0613	0.065	0.0653
	2.	0.0549	0.0581	0.0601	0.0625
	3.	0.0736	0.0716	0.0732	0.0753
	4.	0.0387	0.0398	0.0412	0.0429
	5.	0.0374	0.0382	0.037	0.0387
	6.	0.0713	0.0749	0.0765	0.0787
	7.	0.0736	0.074	0.0743	0.0755
	8.	0.0613	0.0641	0.0662	0.0679
	9.	0.0404	0.0425	0.0442	0.046
	10.	0.0549	0.0562	0.0571	0.061

[Table/Fig-9]: Dimensional change in percentage.

Hours	1 hour	24 hours	48 hours	72 hours	p-value
Materials	Mean±SD				
Polyvinyl siloxane	24.63±0.14	24.62±0.14	24.59±0.15	24.43±0.16	F=0.4346 p=0.9329
Polyether	24.72±0.09	24.55±0.10	24.64±0.08	24.81±0.08	F=1.0638 p=0.7858
Bite registration wax	24.43±0.14	24.45±0.14	24.46±0.14	24.49±0.15	F=0.4843 p=0.9223
ANOVA	F=12.9422 p=0.0015	F=10.6400 p=0.0048	F=11.7387 p=0.0028	F=13.0099 p=0.0014	

[Table/Fig-10]: Comparison of the distance between horizontal lines (dimensional stability) at different time intervals using Analysis of Variance (ANOVA). p≤0.05 -significant (S), p≤0.001 -highly significant (HS), p>0.05- Not Significant (NS)

Materials	1 hour	24 hours	48 hours	72 hours
Polyether-polyvinylsiloxane	0.1498 (NS)	0.3472 (NS)	0.2584 (NS)	0.4965 (NS)
Polyether-bite registration wax	0.0011 (S)	0.0022 (S)	0.0011 (S)	0.0005 (S)
Polyvinylsiloxane-bite registration wax	0.0139 (S)	0.0257 (S)	0.0257 (S)	0.0114 (S)

[Table/Fig-11]: Comparison of dimensional stability at different hours by using Mann-Whitney test. p≤0.05 -significant(S), p≤0.001, HS: Highly significant; p>0.05 NS: Not significant

Based on the results of the present study, polyether bite registration material demonstrates greater dimensional stability than polyvinyl siloxane and alu wax.

DISCUSSION

Different interocclusal recording materials have been introduced in the market, which has put clinicians in confusion about which materials to use in their day-to-day practice. Recording precise records and transferring them to the articulator for the fabrication of satisfactory prostheses has become challenging for dentists. Hence, an in-vitro study was conducted to evaluate the linear dimensional stability of three different types of interocclusal recording materials: polyether, alu wax, and polyvinyl siloxane. Among these materials, polyether was found to be an excellent material compared to the others used in this study. Due to its complete polymerisation and composition, polyether material exhibited the best accuracy and dimensional stability at different intervals when analysed. The storage and manipulation of materials depend on geographical factors [8].

Optimum oral health, functional efficiency, and aesthetics are the objectives of occlusal rehabilitation. The interocclusal relationship of mounted dental casts represents the opposing dental arches. Various methods, such as graphic, functional, cephalometric, and direct interocclusal recordings, are used to record interocclusal relationships. Direct interocclusal records are the most commonly used method due to its simplicity [9,10]. Articulation of the patient's working casts is crucial for the successful fabrication of the prosthesis during the restorative phase of dental treatment. The accuracy of interocclusal registration and the final restoration are affected by the operator's skills, the technique used, and the selected material [6]. Dimensional stability is a vital property for interocclusal recording media for maxilla-mandibular registration and mounting of the casts [4]. An accurate bite registration record should be obtained with minimal closing force. The bite registration material should flow easily at a specific temperature. The medium should not cause any strain during mastication and should resist mandibular closure. The recording material should set to maintain a sharp, easily readable record of the relative position of the opposing teeth [11]. Bite waxes or corrective waxes tend to distort when withdrawn from undercut areas. Therefore, these waxes are limited to edentulous conditions or occlusal surface areas. They are soft at mouth temperature, registering the details of soft tissues, and rigid at room temperature [12]. Polyether impression material is an elastic type material with good accuracy and thixotropic properties, providing excellent surface detail. It has moderate tear strength, shorter working time, and setting times, which may limit its use [13]. Silicones are highly accurate and dimensionally stable materials with negligible weight change. However, they have a minimum working time and require sufficient record space. A major disadvantage of silicones is their resistance to compression when set, which can make seating plaster casts difficult [14].

A study conducted by Karthikeyan K and Annapurni H compared the dimensional stability of three types of interocclusal recording materials: Polyvinylsiloxane (Virtual), Zinc oxide eugenol paste (Superbite), and Bite registration wax (Alumax) at various time intervals [15]. The study concluded that polyvinylsiloxane (Virtual) was the most dimensionally stable material compared to others.

In another recent study by Arya S and Priya N the accuracy and dimensional stability of three interocclusal recording materials, namely bite registration wax, bis-acrylic, and polyvinylsiloxane, were compared. Polyvinylsiloxane was found to be the most accurate and dimensionally stable material, followed by the others [16]. Similar studies have been compared and tabulated in [Table/Fig-12] [1,2,6,8].

S. No.	Author's name and year	Place of study	Sample size	Materials considered	Parameters compared	Conclusion
1.	Anup G et al., 2011 [1]	SRM Dental College, Ramapuram, Chennai-89, India	10	Polyvinyl siloxane, Zinc oxide eugenol and Alu wax	Dimensional stability, accuracy and surface hardness	Polyvinylsiloxane was the most dimensionally stable, accurate and had the highest surface hardness
2.	Begum S et al., 2016 [2]	Dhaka Dental College Hospital, Dhaka	10	Polyvinyl siloxane and alginate	Dimensional stability	Polyvinyl siloxane was dimensionally stable. Dimensional stability was influenced by material and the time factors
3.	Michalakos KX et al., 2003 [4]	Aristotle University, Thessaloniki, Greece	10	Polyether, polyvinyl siloxane, zinc oxide eugenol and alu wax	Linear dimensional change and accompanying weight change	Ramitec (polyether) had the less linear change at all time intervals
4.	Tejo SK et al., 2012 [8]	Saraswati Dhanwantari Dental College and Hospital, Parbhani	10	Polyether, polyvinyl siloxane and zinc oxide eugenol bite registration paste	Dimensional stability	Polyether was found to be more dimensionally stable interocclusal recording material
5.	Present study	Maratha Mandal's N.G.H Institute of Dental Sciences and Research Centre, Belagavi	10	Polyvinyl siloxane, zinc oxide eugenol and alu wax	Dimensional stability	Polyether had less distortion with good dimensional stability

[Table/Fig-12]: Comparison of different similar studies [1,2,6,8].

Limitation(s)

The present study was not carried out in the patient's mouth; hence, the actual results may differ from the in-vivo findings.

CONCLUSION(S)

It was concluded that among the four interocclusal recording materials tested for their linear dimensional stability, polyether was found to be the most accurate, followed by polyvinyl siloxane and alu wax, respectively, at one hour, 24 hours, 48 hours, and 72 hours. The dimensional stability was dependent on both the material factor and the time factor. Future studies with a large sample size in actual patients' mouths should be conducted for more accurate findings.

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