Compare and Evaluation of Compression Resistance of Polyvinyl Siloxane and Aluwax as Interocclusal Recording Material

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ABSTRACT

Background: *Interocclusal recording materials are utilized to capture maxillomandibular relations, ensuring precise mounting of dental casts onto an articulator. Their ability to resist compression is vital to avoid deformation during recording and cast mounting, thus guaranteeing precise production of dental restorations. Polyvinyl siloxane (PVS) and Aluwax are two of the most frequently utilized materials for interocclusal recordings. This research sought to evaluate the compression resistance of polyvinyl siloxane and Aluwax used as interocclusal recording materials.* ***Methods:*** *This analytical cross-sectional in vitro study took place in the Department of Prosthodontics at Bangabandhu Sheikh Mujib Medical University in Dhaka, running from March 2019 to September 2021. Ninety samples were created following the guidelines provided by the manufacturers. Every specimen underwent compressive loads of 10 N and 50 N via a Universal Testing Machine. Dimensional alterations were assessed in millimeters using a digital caliper, and the compression strength was computed. The analysis of data was conducted with SPSS version 22, utilizing descriptive statistics and the unpaired t-test.* ***Results:*** *Mean dimensional changes for PVS were 0.1882 ± 0.0533 mm at 10 N and 0.3731 ± 0.0682 mm at 50 N, compared with 0.6486 ± 0.1189 mm and 1.1166 ± 0.1630 mm, respectively, for Aluwax. Compression resistance was significantly higher for PVS (0.812 ± 0.0555) than for Aluwax (0.542 ± 0.1058) (*$p < 0.00001$*).* ***Conclusion:*** *Polyvinylsiloxane material has greater compression resistance than aluwax as interocclusal recording material.*

Keywords: Polyvinyl Siloxane, Aluwax, Iterocclusal Recording Material, Compression Resistance

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INTRODUCTION

Recording maxillo-mandibular relationships is an important step in oral rehabilitation. This relationship is transferred to the articulator, so that the laboratory procedures done on the casts will correspond with the patient's mouth. Various methods of recording maxillo-mandibular relationships like graphic, functional, cephalometric, and direct interocclusal can be used [1]. The interocclusal recording material records the occlusal relationship between the natural and/or artificial teeth for planning the prosthesis for construction of removable and fixed partial dentures. This relationship transferred to the articulator should be accurate to determine the relation of maxilla and mandible. Interocclusal records are the maxilla mandibular records that are used to transfer interarch relationships from the mouth to an articulator. The ability of interocclusal recording material to resist compressive forces is critical because of the potential for these inaccuracies [2].

An accurate interocclusal record minimizes the need for intraoral adjustments during prosthesis insertion

[3]. Recording jaw relations in prosthodontics treatment aims at facilitating the adaptation of prosthesis to optimum level of comfort and function to the patient [4]. The accuracy of the interocclusal material is the crucial factor in the success of any type of prosthesis. An interocclusal recording medium is necessary to record the maxilla-mandible relationship accurately [5]. Diagnosis and treatment of a patient for prosthetic rehabilitation requires the clinician to fabricate diagnostic casts as well as master casts and articulate them on an articulator. For this reason, it is necessary to record maxilla-mandibular relationship and accurately transfer it to the articulator. An interocclusal record is a precise recording of a maxilla-mandibular position [1]. A compressive force is commonly exerted on the elastic recording material during this procedure and may cause inaccuracies during mounting of the casts and distortions during fabrication of the restorations [6].

Over the years, various materials and methods have been used to detect occlusal contacts. An ideal occlusal registration material should provide post polymerization dimensional stability, resistance to compression force after setting, accurate recording of incisal and occlusal surfaces of teeth, simple handling, biocompatibility with the tissues involved in the procedure and ease of verification [7,8]. The criteria for accurate interocclusal recording are no movement of teeth or displacement of the soft tissues by the recording material and proper seating of recording material on the cast as precisely as on the teeth intraorally. The accuracy of an interocclusal record is influenced not only by the material properties, but also by the recording technique, as well as the anatomic and physiologic characteristics of patient including reliability of the mandibular position influenced by the occlusal contacts, muscular action, or tissue changes within the joints [9].

Interocclusal recording materials are generally used in prosthetic dentistry to register jaw relationships for mounting dental casts on an articulator. These materials have a wide range of physical properties including viscosity, elasticity, and volumetric changes within the various material groups [10]. The basic requisites of an ideal interocclusal material include limited resistance before setting for mandibular closure, rigid or resilient after setting, minimal dimension changes after setting, accurate record of the incisal and occlusal surface of teeth, easy to manipulate and no adverse effects on the tissues involved in the recording procedure [11].

Wax, Zinc oxide eugenol paste, auto polymerizing acrylic resin, condensation type silicone, polyether and polyvinyl siloxane are clinically used material for bite recordingmaxillo-mandibular relationship. Recently composite resin based bisacryl was introduced as a recording material. Several studies have evaluated the hardness, compressive resistance, and dimensional stability of interocclusal recording material. However, the accuracy of the material is also influenced by other factor such as recording technique, and accuracy of fit of the record on the study or working cast which could affect vertical discrepancy [12]. The recording material, which is soft initially fills the spaces between teeth, hardens, and records the specific relationship of the arches. The set material is then transferred onto casts to be mounted on an articulator [1].

Polyvinyl siloxane bite registration materials are characterized by short working time, setting time, high stiffness, low percent strain in compression. Polyvinyl siloxane is an addition reactive silicone elastomer (addition silicone). It is a viscous liquid that quickly hardens (solidifies) into a rubbery solid that assumes the shape of the surface it lays on during curing. Packaging usually keeps the two component liquids in separate tubes until the moment they are mixed and applied. This is because it hardens (hardens) quickly when it is mixed. Polyvinyl siloxane is widely used in the dental field as an impression material. Aluwax bite registration wax is a sophisticated composite material which contains powdered aluminum, increasing the integrity of the compound while providing the heat retention properties needed for efficient modeling. It is available in multiple sizes and shapes. Aluwaxhas short setting time, well thermal property and is less expensive that used in daily dental practice [1].

The most desirable characteristic of the interocclusal registration materials is resistance to compression after polymerization. The material should be rigid enough to resist the distortion that might be caused from the weight of the dental casts, the components of the articulator, or other means used to stabilize the casts during the mounting procedure [13]. The resistance to compressive forces is very important because restorative errors occur due to the discrepancy between the intra-oral relationships of the teeth and the position of the teeth on the mounted working cast [14].

This in vitro study was conducted with the objective to evaluate the compression resistance of polyvinyl siloxane and aluwax as interocclusal recording materials when subjected to a compressive load. Each specimen was placed in the Universal Testing Machine exerting pressure 10N and 50N. This study was undertaken to evaluate and compare the polyvinyl siloxane and aluwax to a constant compressive load to find the best between them which can resist a constant compressive load and will give the least inaccuracies.

MATERIAL AND METHODS

Type of study: This was a cross sectional analytical study.

Place of study: This study was conducted in the Department of Prosthodontics, Bangabandhu

Sheikh Mujib Medical University, Dhaka, Bangladesh, and Bangladesh council of scientific and industrial research (BCSIR), Dhaka, Bangladesh.

Period of study: March 2019 to 30th September 2021

Study population

1. Aluwax as interocclusal recording material.
2. Polyvinyl siloxane as interocclusal recording material.

Study sample: Sample prepared of polyvinyl siloxane and aluwax with definite cylindrical dimension of 20mm width and 20mm length to select the study sample.

Sampling Technique: Purposive sampling technique was selected purposively from prepared sample of polyvinyl siloxane and aluwax.

Sample size: A total of 90 samples were included in the study.

The calculative value was 43. To compensate data inadequacy, irrelevancy and inconsistency the sample size 43 would be increased to 45 for each sample. So, the total sample size would be 90.

Study procedure

Armamentarium used for the study: The armamentarium used in this study included a Universal Testing Machine, a stainless-steel mould, a dispensing gun (Dentsply), a standard laboratory glass slab, hot water, a rubber bowl, Vaseline, and a digital slide caliper.

Tools used for the study:

Data collection sheet: Data was collected according to a data collection sheet.

Materials used for the study

1. Polyvinyl siloxane as interocclusal recording material.
2. Aluwax as interocclusal recording material.

Procedure:

Material collection: Polyvinyl siloxane is produced from GC company of Tokyo, Japan and aluwax produced from CE company of America were collected from the distributor of YUME company of Bangladesh.

Mold preparation: A 100 mm stainless steel cylindrical metal with 20 mm width diameter was collected from a hardware shop. Then the metal was cut to a dimension of 20 mm width and 20 mm length. The prepared cut metal than smoothened with finishing cutting instrument for making the mold.

Sample preparation of polyvinyl siloxane: A glass slab was placed on the laboratory table and separating media (Vaseline) was applied on the mold and glass slab. Collected polyvinyl siloxane was prepared for making the samples. Polyvinyl siloxane contained cartridge attached to the dispensing gun and inserted the material into the mold. After setting the material, samples were removed from the mold and observed any defect, surface roughness, irregularity. 45 samples were prepared by this procedure. Then the sample was ready to place on the universal testing machine for measuring the compression resistance.

Sample preparation of aluwax: A glass slab was placed on the laboratory table and separating media (Vaseline) was applied on the mold and glass slab. Collected aluwax was softened in hot water bath for 5 minutes and placed into a stainless-steel mold (20mm length×20mm width). Special precautions were taken not to overheat or underheat the material, which may hamper the properties of aluwax. Softened aluwax then put into the mold and waited for 3 minutes to set within the mold. After setting, aluwax was removed from the mold and observed any defect, surface roughness, irregularity.45 samples were prepared by these procedures. Then the samples were ready to place on the universal testing machine for measuring the compression resistance.

Preparation of universal testing machine: Universal testing machine which is situated in the Bangladesh Council of Scientific and industrial research (BCSIR) named Hounsfield. Dr. Md. Abdul Gafur, in BCSIR introduced the machine and instructed the procedure to measure the compression resistance of the samples. A 50N weight meter was placed in the meter compartment within the machine. Universal testing machine was ready to receive the prepared sample of aluwax and polyvinyl siloxane. A digital slide calipers were used to measure the linear dimensional change in mm.

Testing the samples: Each specimen was placed in the Universal Testing Machine and a force of 10N was exerted on each sample of polyvinyl siloxane and aluwax. The reading of the Universal Testing Machine recorded the dimensional changes in mm using a digital slide caliper in mm after 30 seconds. After the application of the first force, 60 seconds later, a second force of 50N was applied gradually. 30 seconds later the reading of the dimensional length changes of the specimen in Universal Testing Machine was recorded again. The differences between readings were recorded and subtracted from 1. This value was considered as the compression resistance of each material.

Measuring Compression resistance: The change in the dimensional length was calculated by using digital slide caliper. The change between 10N and 50N were measured for each sample. The difference between 10N and 50N was calculated. The compression resistance was calculated by using the mathematical formula: Compression resistance = [1 - (50N - 10N)]. The measured value ware inserted into the computer for statistics result of compression resistance of the specimen.

Statistical analysis: Data was collected through compression resistance analysis of each material. Computer based statistical analysis was carried out

using SPSS-22 (SPSS Inc.®, Chicago, Illinois, USA). Descriptive statistics and independent sample un pair t-tests were done to analyze the data. A P-value less than 0.05 will be considered statistically significant. The summarized data will be presented as percentages on table, graph, or diagram. Quality assurance strategy will be maintained.

Ethical consideration: Ethical clearance for the study was taken from the institutional review board of BSMMU prior to the commencement of the study. Before the research protocol was approved by the board, permission for the study was taken from the department of prosthodontics, BSMMU. Standard laboratory procedure was done at BCSIR.

RESULTS

In this cross-sectional analytical study, a total of 90 samples of two different interocclusal recording materials were fabricated and tested under the Universal Testing Machine by exerting certain amount of force on them.

Table 1 shows the linear dimensional changes of polyvinyl siloxane against 10N and 50N forces. The mean dimensional changes against 10N force were 0.1882 with a standard deviation of 0.0533; where, the minimum and maximum changes were 0.11mm and 0.32mm respectively. On the other hand, the dimensional changes were 0.3731 against 50N force with a standard deviation of 0.0682; where, the minimum and maximum changes were 0.26 and 0.51 respectively. The difference of the mean value by the force of 50N and 10N was 0.18171 (±0.0149)

Table 1: Distribution of dimensional length changes of polyvinyl siloxane with the force of 10N and 50N (n=45)

Force	Mean (mm)	SD (±)	Min (mm)	Max (mm)	Mean of Differences (mm)
10N	0.1882	0.0533	0.11	0.32	
50N	0.3731	0.0682	0.26	0.51	0.18171

N = Newton
SD = Standard deviation
Mm = Millimeter
Unpaired t-test was done

Table 2 shows the linear dimensional changes of aluwax against 10N and 50N forces. The mean dimensional changes against 10N force were 0.6486 with a standard deviation of ±0.1189; where, the minimum and maximum changes were 0.50mm and 0.89mm respectively. On the other hand, the dimensional changes were 1.1166 against 50N force with a standard deviation of ±0.1630$; where, the minimum and maximum changes were 0.84 and 1.38 respectively. The difference of the mean value by the force of 50N and 10N was 0.4688 (±0.0441).

Table 2: Distribution of dimensional length changes of aluwax with the force of 10N and 50N (n=45)

Force	Mean (mm)	SD (±)	Min (mm)	Max (mm)	Mean of Differences (mm)
10N	0.6486	0.1189	0.50	0.89	
50N	1.1166	0.1630	0.84	1.38	0.4688

N = Newton SD± = Standard deviation Mm = Millimeter Unpaired t-test was done

Table 3 shows the comparison of dimensional length changes between aluwax and polyvinyl siloxane against 10N and 50N forces. The difference of mean dimensional length changes of polyvinyl siloxane against 10N and 50N force were 0.1871 and aluwax were 0.4688 respectively. The t value was 16.6078. The value was statistically significant (p<0.00001).

Table 3: Comparison of dimensional length change of polyvinyl siloxane and aluwax with the force of 10N and 50N (n=90)

Materials	Mean (mm)	SD (±)	t	P
Polyvinyl siloxane	0.1871	0.0555	16.6078	<.00001
Aluwax	0.4688	0.0993		

N = Newton SD±= Standard deviation Mm = Millimeter p = probability value Unpaired t-test was done

Table 4 shows the comparison of compression resistance between aluwax and polyvinyl siloxane. The mean compression resistance of aluwax (0.542\0.1058) and the mean compression resistance of polyvinyl siloxane was (0.812±0.0555). The t value was 15.1978 of aluwax and polyvinyl siloxane. These observations show statistically significant difference in compression resistance (p<0.00001) which shows greater compression resistance of polyvinyl siloxane than aluwax against 10N and 50N force.

Table 4: Comparison of compression resistance between polyvinyl siloxane and aluwax (n=90)

Materials	Mean (mm) SD (±)	Min-Max (mm)	t	p
Polyvinyl siloxane	0.812 0.0555	0.68-0.89	15.1978	<.00001
Aluwax	0.542 0.1058	0.41-0.88		

N = Newton SD±= Standard deviation Mm = Millimeter p = probability value Unpaired t-test was done

DISCUSSION

The accuracy of the interocclusal material is the crucial factor in the success of any type of prosthesis. The basic requisites of an ideal interocclusal material includes limited resistance before setting for mandibular closure, minimal dimension changes after setting, accurate record of the incisal and occlusal surface of teeth and easy to manipulate [15]. Different materials are introduced for interocclusal registration with different properties. The two most commonly materials used as occlusal records are aluwax and recently introduced polyvinyl siloxane. The dimensional length change against 10N and 50N were assessed and compression resistances were evaluated in this study.

In this present study, polyvinyl siloxane bite registration material showed greater compression resistance (0.812±0.0555) in comparison to aluwax (0.542±0.1058). These observations show statistically significant difference in compression resistance ($p<0.00001$). Observations of this present study were in correlation with the several previous studies.

In this present study aluwax showed more dimensional changes. Mean a dimensional change of aluwax against 50N force were 1.116 and for polyvinyl Siloxane was 0.373 respectively. The mean liner dimensional changes against 10N and 50N forces were more in aluwax when compared to polyvinyl siloxane material ($p<0.00001$) (Table 3). Similar observation was reported by Anup et al., (2011). They also found more dimensional change in aluwax (0.58±0.08) to polyvinyl siloxane (0.23±0.11). The result of this present study was similar to their observation [16].

In this present study, polyvinyl siloxane bite registration material showed greater compression resistance. Global study showed similar result in their study. They found that, polyvinyl siloxane showed the least dimensional change (minimum 0.019 mm and maximum 0.026 mm) than aluwax (minimum 0.023 mm maximum 0.032 mm). Their observations were also commensurate to our findings, as we also found more dimensional changes in aluwax[1].

Another result show that linear dimensions changes of various interocclusal recording materials to find out the longest possible dimensionally stable interocclusal recording material. They found dimensional changes in aluwax from as early as 1 hour, which relatively increased significantly. They also showed that polyvinyl siloxane showed the least dimensional changes at all observed intervals. Their result was compatible to the observations of this present study [17].

Polyvinyl siloxane has been reported that less linear dimensional changes in the horizontal plane than polyether material [18].

Previous studies have reported that aluwax presented the greatest dimensional changes over time with respect to the other materials. From the previous studies we can concluded that polyvinyl siloxane had the least dimensional change and aluwax had more dimensional change than other materials. Thus, the above observations on dimensional changes were also unanimous to our observations. Present study also showed similar observation about these materials [19].

Previous studies comparing the compression resistance of different materials. They found that Polyvinyl siloxane material has greater resistance to compression as compared to wax materials. They also found that Polyvinyl siloxane showed less compression distance value (0.025) than was (0.027) under 1000g/cm2 pressure. All the above observations resembled our observations that polyvinyl siloxane showed greater compression resistance than other interocclusal materials [20].

Similar to the present study, previous investigations have evaluated the compression resistance of several bite registration materials using Universal Testing Machine. In their study they also found that, polyvinyl siloxane showed greater resistance to compression than the other interocclusal recording materials ($p<0.0001$). In this present study we also found that polyvinyl siloxane showed greater resistance to compression to Aluwax. Our result is also similar to their findings[1].

Previous in vitro studies evaluating the compression resistance of different interocclusal recording materials. They found polyvinyl siloxane interocclusal recording material exhibited the greatest resistance to compression than the other materials at thicknesses of 2, 5 and 10 mm. This result also supports the result of the present study, as we found that polyvinyl siloxane interocclusal material exhibited the greater resistance than aluwax[2].

Previous studies have demonstrated that Polyvinyl siloxane was more dimensionally stable when compared to zinc oxide eugenol, and aluwax and likewise, Polyvinyl siloxane was reported more accurate as it has more compression resistance. Their findings are commensurate with our findings [16].

Observation of this present study were also in correlation with the global studies, showed that polyvinyl siloxane displayed the greatest resistance to compression as compared to other interocclusal recording materials, such as waxes and zinc oxide-eugenol paste. This result also support the result of the present study, as we found that, polyvinyl siloxane interocclusal material exhibited the greater resistance than aluwax[13,14].

Another study showed that polyvinyl siloxane bite registration material had greater resistance to compression than other materials. Their observations were also relevant to the findings of the present study [3].

Global observation has also shown that aluwax showed less compression resistance than polyvinyl siloxane bite registration material. The result of this study also showed that polyvinyl siloxane had greater compression resistance than aluwax also [9,21].

It is necessary to record the maxillomandibular relationship and accurately transfer it to the articulator. One of the most desirable characteristics of the interocclusal registration material is resistance to compression after polymerization. The material should be rigid enough to resist the distortion that might be caused by the weight of the dental casts, the components of the articulator, or other means used to stabilize the casts during the mounting procedure. The ability of an interocclusal registration material to resist compressive forces is very important because any discrepancy between the intraoral relationships of the teeth and the position of the teeth on the mounted working casts will result in restorative errors.

In this present study, aluwax showed a decrease in compression resistance when compared to polyvinyl siloxane. The reason for the greater compression resistance of polyvinyl siloxane bite registration material may be because of its low dimensional change. Therefore, if polyvinyl siloxane bite registration materials are used for mounting working casts in the fabrication of the prostheses, the casts should be secured in a record in such a manner that ensures complete seating but exerts a minimal compressive force.

CONCLUSION

Based on the result of the present study, Polyvinyl siloxane interocclusal recording material showed greater compression resistance than aluwax against the force of 10N and 50N.

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AUTHORS CONTRIBUTIONS

Abu Hena Helal Uddin Ahmed managed the patients, conceptualized the work, initiated the study with fabrication of prostheses and analyzed the data and formulated results SM Omar Faruk designed the study and developed the data collection tools and initiated the manuscript writing. Nilay Chakrovorty designed the study and developed the data collection tools and initiated the manuscript writing. Syeda Mahmuda Akhter managed the patients of this study, collected data, arranged them in data sheet and finalized the manuscript writing. Faisal Solaiman designed the study and developed the data collection tools and initiated the manuscript writing. Muhammad Mahfuzur Rahman contributed in methodology, interpreted the results, reviewed the literatures and finally revised the manuscript critically.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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