DENTAL MEDICINE

A comparative evaluation of three dimensional accuracy of different types of interocclusal recording materials - an *in vitro* study

Aparna Dwivedi[1], Kavita Maru[2], Aakash Sharma[3]

1) Department of Prosthodontics and Crown & Bridge, College of Dental Sciences and Hospital, Rau, Indore, India

2) Department of Prosthodontics and Crown & Bridge, Sri Aurobindo College of Dentistry, Indore, India

3) Parasu Dental Hospital, Chennai (Tamil Nadu), India

Abstract

Introduction. The interocclusal registration materials record the occlusal relationship between the natural and /or artificial teeth for planning an occlusal rehabilitation in removable and fixed partial dentures.

Aim and objectives. The aim of this in vitro study was to evaluate and compare the accuracy and the three dimensional stability offered by three different types of interocclusal recording materials at storage time intervals of 1 hour and 24 hours.

Methods. Three commercially available interocclusal recording materials were used: Group I- Polyether bite registration paste (Ramitec), Group II- Polyvinylsiloxane bite registration material (Imprint), Group III- Bite registration wax (Maarc). The test was carried out using an epoxy resin model. A total of 30 samples were made with each group consisting of ten samples. Three dimensional measurements were carried out by using 3D-Coordinate measuring machine (CMM) at time intervals of 0-1 hour and 0-24 hours in X, Y and Z- axis.

Results. Twelve readings were obtained for three axes (4 readings for each sample at 1 axis) and the averages of these four values were noted for a particular axis (X/Y/Z). Statistical analysis was performed using analysis of variance (ANOVA) for comparison among the groups and then Tukey's honestly significant difference (HSD) tests was performed for comparison among groups at the 0.05 level of significance.

Conclusion. Polyvinylsiloxane was dimensionally the most stable material followed by polyether and finally bite registration wax. Dimensional accuracy and stability is influenced by both "material" and "time" factors.

Keywords: dental impression materials, dimensional accuracy, bite registration paste, epoxy resins, 3D- coordinate measuring machine

Background

Successful rehabilitation dentistry is a composite of many steps coming together in synergy and all have to be accurate. An often-overlooked and yet critical piece to a successful rehabilitation is the interocclusal registration. Capturing the tooth-to-tooth and arch-to-arch relationship accurately is extremely demanding. The interocclusal registration materials record the occlusal relationship between the natural and /or artificial teeth for planning occlusal rehabilitation and for construction of removable and fixed partial dentures. An interocclusal record is the registration of the positional relationship of the opposing teeth or the jaws to each other (GPT-8) [1]. The first interocclusal records were made by Phillip Pfaff in 1756 using natural waxes [2-4]. Since then, many materials and techniques have been developed for recording interocclusal relationship.

If the goal of restorative treatment is to maintain a patient's pretreatment intercuspation and vertical dimension of occlusion (VDO), then casts should be mounted in a manner that maintains

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Address for correspondence:
dr.aparna90.ad@gmail.com

the same tooth-to-tooth relationship that existed before treatment. For opposing casts to be held together in a stable and reproducible manner, both a tripod of vertical support and satisfactory horizontal stability between the two casts are required [5].

The physical properties like compression resistance, compressibility and surface hardness and behaviors of different recording materials have been evaluated in many studies [6-8], but most important are the dimensional changes caused due to delay in transferring materials to distant laboratories or mishandling of material or delay in articulation procedure or remounting of casts play a key role.

Dr. Ken Rudd [9] said it best: "Most laboratory technicians experience little difficulty in making a restoration that will fit the master cast. Fitting the restoration to the patient's mouth can become a problem for the dentist." Small errors will lead to significant intraoral adjustments.

Possible reasons are the three-dimensional change of the materials, inaccuracies, spring action cause articulated casts in an open relationship or the inability of the record to be totally seated on the occlusal surfaces because of their morphologic features; hence, the casts should be articulated to reproduce the settled position and this needs to be evaluated [10].

Hence, this study has been conducted with the aim of evaluating and comparing the accuracy and the three dimensional stability offered by three different types of interocclusal recording materials at storage time intervals of 1 hour and 24 hours.

Methods

The present study was a comparative study conducted in the Department of Prosthodontics and Crown & Bridge.

Grouping the sample and construction of master model

Three commercially available interocclusal recording materials were used:

Group I- Polyether bite registration paste (Ramitec, 3M ESPE Dental Products, U.S.A),

Group II- Polyvinylsiloxane bite registration material (Imprint, 3M ESPE, Canada),

Group III- Bite registration wax (Aluminium filled) (Maarc, Mumbai). A total of 30 samples were made, each group consisting of ten samples.

The typodont models (Frasaco, ANA-4V DAF) were used, in which maxillary complete dentate and mandibular partially dentate model in which right mandibular quadrant was prepared having one tooth missing (right mandibular first molar) (Figure 1A and 1B).

For the experiment, the right mandibular second premolar and second molar in the model were prepared for a metal-ceramic complete coverage restoration. These models were duplicated with the help of duplicating material agar-agar (reversible hydrocolloid, BEGO WiroGel® C). Then, epoxy resin material was mixed and poured into the duplicated agar-agar impression. The epoxy resin models were allowed to set for 8 hours. The epoxy resin models were then retrieved from the agar-agar impression (Figure 2 and 3).

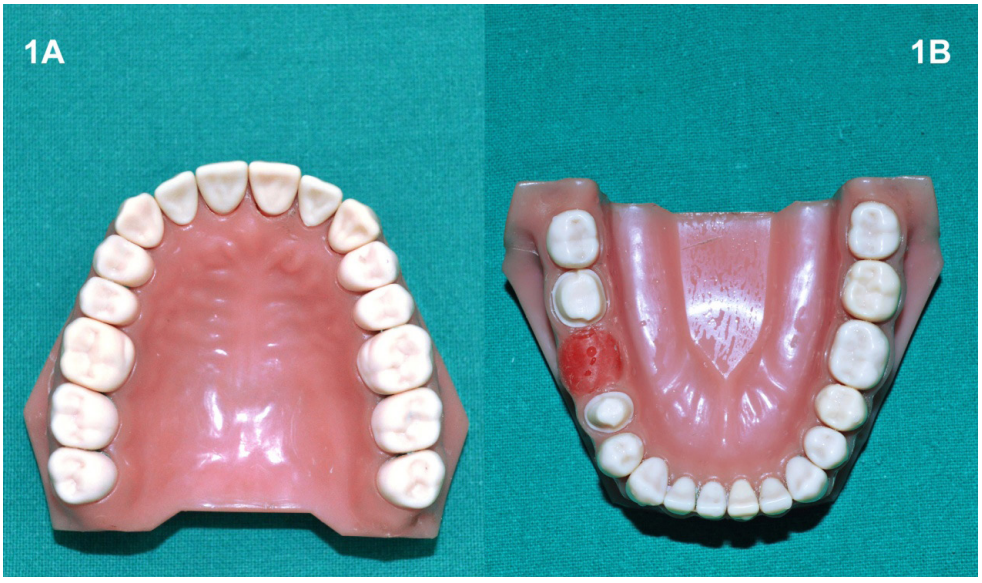

Figure 1. Typodont models A - Maxillary complete dentate B - Mandibular partially dentate model in which right mandibular quadrant was prepared having one tooth missing (right mandibular first molar).

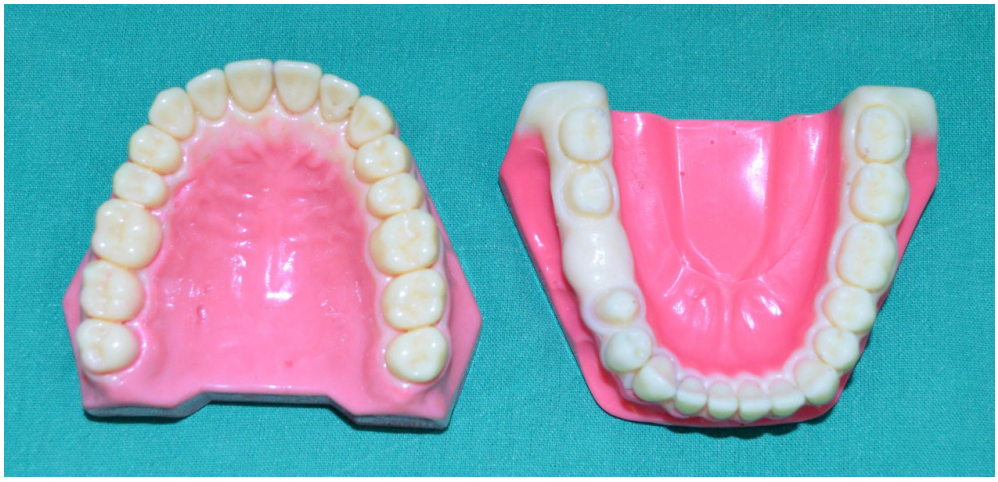

Figure 2. Epoxy resin models.

Figure 3. Epoxy resin models in maximum intercuspation.

The epoxy resin models were mounted according to the mounting protocol on a semi-adjustable articulator (Hanau Wide-vue articulator 8500 series- Whipmix 010885-000 USA) with the maximal intercuspal position determined manually. Then, the occlusal contacts were marked with articulating paper and adjusted in the conventional manner using diamond burs until the baseline occlusal relationship was established. As a result, all teeth had equal contacts with their antagonists, and the left side molars and premolars had at least two contacting points.

Eight steel rods of dimension 3mm*40mm were attached to the maxillary and mandibular epoxy resin models with the help of jig boring machine. The "x" (Dx) variation was measured in the lateral direction, "y" (Dy) variation was measured in the anteroposterior direction and "z" (Dz) variation was measured in the vertical direction. The articulator was placed on the platform which was connected to a movable 3-dimensional laser pointer, from which deviations from the settled positions of the master models in x, y and z directions were measured with a reading precision of 1 micron (0.001 mm).

Three dimensional measurements were carried out by using 3D-Coordinate measuring machine (CMM). The reading precision of Coordinate measuring machine is 1 micron (0.001 mm).

Interocclusal records

The epoxy resin models were mounted in a settled position and were not removed during record making. Ten records of each group were produced under the external weight of 1 kg (9.81N), which was applied constantly over the articulator. This closing force was chosen because the force required to compensate initial resistance of interocclusal material to closure varies between 0.5N to 13.8N [11].

Polyether bite registration paste was manipulated over the mixing pad according to the manufacturer's instructions. After the material was set, the material was not removed from the articulator and the second reading was carried out by CMM to verify the position which is similar to that of first reading (base line position) and no error was incorporated during record making. The record was removed to check, and trimming and finishing was done with the help of sharp 15 no. bard's parker blade. Records were stored in a sealed, dry polyethylene bag at room temperature for 1 hour and/or 24 hours and the readings were recorded (Figure 4).

Figure 4. Polyether bite registration record seated in place for testing.

The polyvinylsiloxane bite registration material was mixed with the help of automixing gun and the rest procedure is similar (Figure 5).

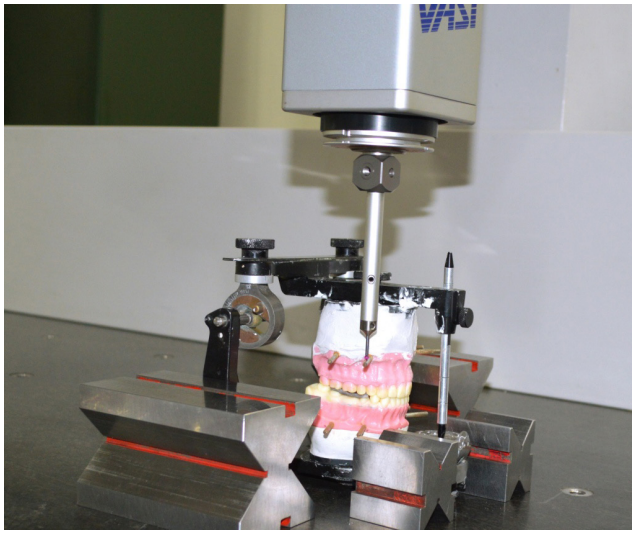

Figure 5. Polyvinylsiloxane bite registration record seated in place for testing.

Bite registration wax (aluminium filled) was softened uniformly in a water bath at a temperature of (45 ± 2°C) for 5 minutes before record making. Wax exhibits some resistance to closure to make an imprint in the wax. Therefore, a constant force of 1 kg was applied on the articulator with the help of the external weight during making the wax records to ensure that the record caused no initial vertical discrepancies. However, initial vertical discrepancies of wax records might be a clinical problem but also the resistance to closure required to make an imprint in wax can be as advantage when the creation of a positional space is desired. As a result, the thickness of the wax records was standardized by raising the incisal pin 1 mm. Records were stored in chilled water for 1 hour and/or 24 hours (Figure 6).

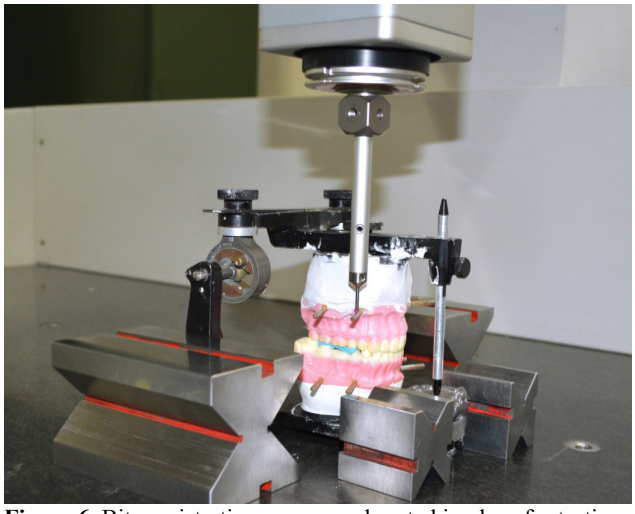

Figure 6. Bite registration wax record seated in place for testing

Evaluation of dimensional change of different samples

The 3D-CMM started the calibration by using laser probe, this laser probe was touched to the 2 condylar shafts of the articulator and 1 point was located over the flat surface, so that a 2D-line can be established and top view was established by taking a highest point on the incisal guide pin, so that X, Y and Z axis can be established in a single plane. Then, the four reference points were taken with the help of attached steel rods i.e. 2 on the right side and 2 on the left side by using a probe that is positioned manually by an operator. Then, the deviation was measured with the help of these four reference points- point 1, point 2, point 3 and point 4. Four readings were obtained at one axis for each sample, so 12 readings were obtained for three axes and the averages of these four values were noted for a particular axis (X/Y/Z). Likewise, these readings were made at different time intervals i.e.; base line reading was taken without the manipulation of material, at 0 hour without removal of the manipulated material from the master models, at 1 hour after removal of the material from the master models and articulation procedure and at 24 hours after mounting procedure of the master model.

All the readings thus obtained, were tabulated and subjected to a statistical analysis for the comparison of dimensional accuracy and stability of three interocclusal recording materials. Three types of deviations of the maxillary cast could then be calculated according to the following formulas:

Dx= [1/4(DXpoint 1+ DXpoint 2+ DXpoint 3+ DXpoint 4)]

Dy= [1/4(DYpoint 1+ DYpoint 2+ DYpoint 3+ DYpoint 4)]

Dx= [1/4(DZpoint 1+ DZpoint 2+ DZpoint 3+ DZpoint 4)]

Where; lateral = (Dx), anteroposterior = (Dy), vertical = (Dz)

Statistical analysis was performed using analysis of variance (ANOVA) for comparison among the groups and then Tukey's honestly significant difference (HSD) tests was performed for comparison among groups at the 0.05 level of significance.

Results

The aim of our study was to determine the time dependent three dimensional accuracy and stability of different types of interocclusal recording materials. Calculated data (by use of absolute values) for each of the interocclusal recording material groups are shown in Figure 7.

The statistical analysis was done to compare mean dimensional changes of all the interocclusal recording materials - Polyether, Polyvinylsiloxane and Bite registration wax at 0-1 hour and 0-24 hours in X, Y and Z-axis and to compare mean difference between the groups (Polyether, Polyvinylsiloxane and bite registration wax) at 0-1 hour and 0-24 hours in X, Y and Z- axis (Table I).

The results obtained were as follows:

1. The mean deviation of polyether was found to be statistically non significant at 1 hour as well as at 24 hours in X-axis (lateral) but shows statistically significant deviation at 1 hour and at 24 hours in Y-axis (anterior-posterior) and at 1 hour in Z-axis (vertical), but there was no statistically significant change at 24 hours in Z-axis (vertical).

2. The mean deviation of polyvinylsiloxane was found to be statistically non significant at 1 hour as well as 24 hours in X-axis (lateral) but shows statistically significant deviation at 1 hour as well as at 24 hours in Y-axis (anterior-posterior) and Z-axis (vertical).

3. The mean deviation of bite registration wax was found to be statistically significant at 1 hour as well at 24 hours in X-axis (lateral) but shows no statistically significant deviation at 1 hour as well as at 24 hours in Y-axis (anterior-posterior) but statistically significant deviation was seen at 1 hour as well as at 24 hours in Z-axis (vertical).

4. In X-axis (lateral), when comparison of mean deviation among the groups was done, statistically non significant deviation was seen at 0 hour in X-axis (lateral); at 1 hour as well as at 24 hours, the comparison between polyether-polyvinylsiloxane shows statistically non significant deviation in X-axis (lateral), but polyether-bite registration wax and polyvinylsiloxane-bite registration wax shows statistically significant deviation at 1 hour as well as at 24 hours in X-axis (lateral).

5. In Y-axis (anterior-posterior), when comparison of mean deviation among the groups was done, statistically non significant deviation was seen at 0 hour in Y-axis (anterior-posterior); at 1 hour as well as at 24 hours, the comparison between polyvinylsiloxane-bite registration wax shows statistically non significant deviation in Y-axis (anterior-posterior), but polyether-polyvinylsiloxane and polyether-bite registration wax shows statistically significant deviation at 1 hour as well as at 24 hours in Y-axis (anterior-posterior).

6. In Z-axis (vertical), when comparison of mean deviation among the groups was done, statistically non significant deviation was seen at 0 hour in Z-axis (vertical); at 1 hour the comparison between polyether-polyvinylsiloxane shows statistically non significant deviation in Z-axis (vertical), but polyether-polyvinylsiloxane, polyether-bite registration wax and polyvinylsiloxane-bite registration wax shows statistically significant deviation at 1 hour as well as at 24 hours in Z-axis (vertical) (Figure 7).

Table I. Comparison of the mean difference of all the interocclusal recording materials (Polyether, Polyvinylsiloxane and Bite registration wax) at 0 to 1 hour and 0 to 24 hours in X-axis, Y-axis and Z-axis.

Time Interval	Materials	Difference [Mean±SD] At X-axis	Difference [Mean±SD] At Y-axis	Difference [Mean±SD] At Z-axis
0 – 1 Hour	Polyether	0.006±0.009	0.359±0.341	0.128±0.067
	Polyvinylsiloxane	0.138±0.425	0.123±0.757	0.112±0.084
	Bite registration wax	0.027±0.010	0.011±0.35	0.984±0.088
0 – 24 Hours	Polyether	0.002±0.004	0.326±0.169	0.097±0.259
	Polyvinylsiloxane	0.138±0.433	0.119±0.093	0.190±0.108
	Bite registration wax	0.03±0.014	0.061±0.158	1.01±0.265

Significant. SD: Standard Deviation

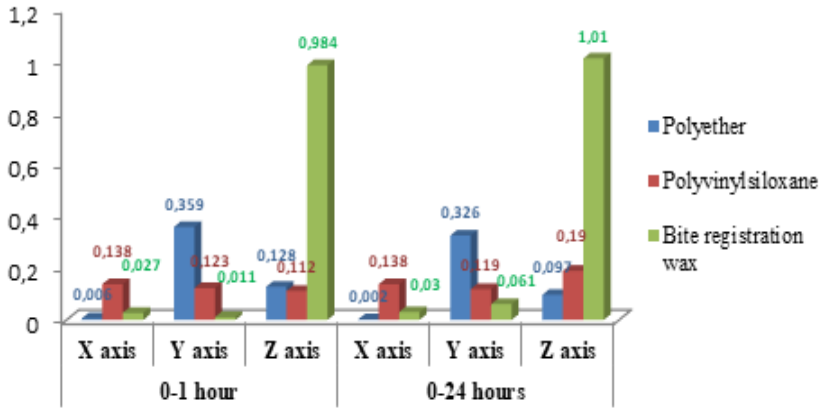

Figure 7. Comparison of mean difference of all the interocclusal recording materials (Polyether, Polyvinylsiloxane and Bite registration wax) at 0-1 and 0-24 hours in X, Y and Z-axis.

Discussion

Oral rehabilitation involves a sequence of steps that must be followed in a highly circumspect manner. Interocclusal records have become the most popular method of transfer of maxillo-mandibular relations from the mouth to the articulator. Stable and accurate interocclusal records can be made in clinical situations using several techniques and materials [11].

Comparative studies of interocclusal record materials have shown that the selection of the record material is an important factor to be considered during the transfer procedure [12-21]. If the selected material is dimensionally unstable, the mounted casts will not reproduce the recorded maxillo-mandibular relationship on the articulator [22]. Walls [23] demonstrated the problems of inaccuracy in the transfer of maxillo-mandibular relations from the mouth to a semi-adjustable articulator. Even if the registration of the material is accurate but due to their inherent properties, the casts may not orient to the same settled position [24,25]. The final evaluation of any prosthesis depends upon an accurate duplication of the jaw relations in the laboratory. This relationship is not the simple matter of mandibular opening and closing. It is a complex relationship which exists in three dimensions. Variations may occur in the vertical, anteroposterior, or mediolateral position. In addition, the vertical variation may be dissimilar on the two sides [26]. Hence, the study was designed to compare and evaluate the three dimensional accuracy and stability of interocclusal recording materials-polyether, polyvinylsiloxane and bite registration wax, so that actual movements of the mounted casts in 3 dimensions can be calculated instead of calculating them indirectly, e.g., by measuring condylar movements [27,28]. The three dimensional accuracy and stability of the interocclusal recording materials over storage time intervals of 1 hour and 24 hours was measured in this study. The time intervals used in the study were selected considering the time taken to carry interocclusal recording materials to distant laboratories or delay in articulation or remounting of the casts. When comparison was done between the groups, there was a statistically significant deviation in X-axis (lateral) between polyether – bite registration wax and polyvinylsiloxane – bite registration wax at 1 hour as well as at 24 hours but no deviation was seen in polyether-polyvinylsiloxane. Hence, polyether and polyvinylsiloxane proved to be better in reproducibility of the details in X-axis (lateral). In Y-axis (anterior-posterior), there was a significant deviation between polyether-polyvinylsiloxane and polyether-bite registration wax at 1 hour as well as 24 hours but no deviation was seen in polyvinylsiloxane-bite registration wax. The materials which are more dimensionally accurate in Y-axis (anterior-posterior) are arranged in descending order - Polyvinylsiloxane > Bite registration wax > Polyether.

In Z-axis (vertical), statistically no significant change was seen in polyether-polyvinylsiloxane at 0-1 hour and at 0-24 hours, polyether-polyvinylsiloxane, polyether-bite registration wax and polyvinylsiloxane-bite registration wax showed significant changes.

Polyvinylsiloxane and polyether were dimensionally the most stable material and bite registration wax was the unstable material in comparison to the other groups in Z-axis (vertical).

Conclusion

Within the limitations of this study, it was concluded that among the three interocclusal recording materials tested for their three dimensional accuracy and stability over a different time intervals, Polyvinylsiloxane

was found to be more accurate interocclusal recording material and, followed by Polyether and Bite registration wax. Polyvinylsiloxane and Polyether were found to be the more dimensionally stable than Bite registration wax. Simple closure through an interocclusal record produced discrepancies in all the three directions in the procedure of recording maxillomandibular relationships. These inaccuracies were aggravated when transferring the records onto casts. Thus, the ideal time for articulation based on the type of interocclusal records used is 24-48 hours for polyether, <24 hours for polyvinylsiloxane and 1 hour for bite registration wax records.

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