A comparative study on the accuracies exhibited by four commonly used interocclusal registration materials

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Abstract:

Interocclusal records are an everyday necessity in routine prosthodontic practice. A number of materials have been advocated by several groups of workers over a length of time to be suitable for the purpose. In the present study, the accuracies exhibited by four commonly used interocclusal recording materials were compared when they were subjected to both the clinical and laboratory phases of jaw relation transfers. The four materials were Zinc oxide and eugenol impression paste, wax corrected with Zinc oxide and eugenol impression paste, Impression plaster and medium body hydrophilic Vinyl Polysiloxane impression material. The results revealed that Vinyl Polysiloxane impression material was the most accurate and clinically acceptable for the purpose. All other materials were found to have significant levels of variance from the control. All four materials exhibited statistically significant variances among the records produced by each one of them and at the various occlusal regions considered. Further scopes still exist to increase the domain of the study and include the other materials found to be suitable for making interocclusal registrations.

Key words: Interocclusal records; Articulation; Occlusion

Introduction:

For a variety of reasons, the majority of the restorations are prepared outside the oral cavity which afterwards is fitted in the mouth. This indirect fabrication of the prosthesis requires an accurate duplication of the jaw relations in the laboratory. Models prepared from the maxillary and mandibular arches have to be properly related to the articulator. This enables the dentist and the technician to properly study the occlusion in function and fabricate restorations.

When there is presence of teeth in occlusion on either side of the arches, the models are articulated in the maximum intercuspation position (ICP), by manual articulation. Complete dentures, full mouth rehabilitations and mounting of study models for diagnostic purposes need articulation in retruded contact position (RCP). For mounting of models in RCP, an interocclusal record is needed.

The maxillary model is fitted to the upper element of the articulator by a face-bow record that will orient it to the transverse horizontal axis. An interocclusal registration is required to record the occlusal relationships between natural and/or artificial teeth and relate the mandibular model to the already fixed maxillary one. If the interocclusal registration is incorrect, the mounted models will never reflect the actual maxillomandibular relationships of the patient. Thus errors in diagnosis, treatment planning and final restorations will result.

Several materials including wax, plaster of Paris, zinc-oxide and eugenol impression paste, acrylic resins and elastomers have been used so far for making interocclusal records with various degrees of successes. Studies conducted upon the relative accuracies of these materials for making interocclusal records have come out with conflicting results. While
some of the studies recommended wax as the most accurate for the purpose\textsuperscript{1,2,3} others advocated zinc oxide and eugenol impression paste\textsuperscript{4,5}. Still other studies suggested the correction of a wax record with a low viscosity material like zinc oxide and eugenol impression paste\textsuperscript{6,7}. Two studies recommended the use of self curing acrylic resin\textsuperscript{8,9}. Two studies indicated Plaster of Paris to be the best suited for the purpose\textsuperscript{10,11}, while two others found that the elastomers constantly resulted in the least amount of errors\textsuperscript{12,13}.

Thus, conflicting results have been put forward by several investigators working with the same materials at different times. Some of these studies dealt with the properties of these materials at controlled laboratory environments. In those cases, although the properties of the materials were correctly interpreted, there influence on the stomatognathic system was not considered. Other workers created in vitro clinical situations that completely avoided the influences of the actual clinical phase.

No single material presently used for the purpose is devoid of undesirable physical and chemical properties and can be accepted as ideal. The present study was conducted to evaluate the accuracies exhibited by four different interocclusal registration materials when they were subjected to both the clinical and laboratory phases of jaw relation transfer.

The occlusal contact pattern in ICP after mounting the models with each of these four materials was compared with the occlusal contact pattern in ICP in the subject’s mouth. The four materials subjected to test were Zinc Oxide and Eugenol impression paste [ZnOE] (Impression Paste, DPI), Modeling Wax (Y-Dent, MDM Corporation) corrected with ZnOE, Impression Plaster (Insta Accurate, Ramen Research) and Regular body hydrophilic Vinyl Polysiloxane impression material, (Reprosil, Dentsply).

A standardization of the subjects, technique of jaw relation recordings and manipulation of the materials were fixed. Young and healthy subjects below thirty years of age and without any periodontal disease or temporomandibular joint problems were selected. Jaw relations records were done in the retruded contact position with prefabricated trays from Hager & Werken. An acrylic resin jig as advocated by Lucia was used as an anterior deprogramming device. All the materials were manipulated by strictly following the manufacturer’s instructions. The interocclusal records were then used to mount the respective models in a Hanau H2 articulator.

The study hypothesis: Thus all the variables in the method of transferring an interocclusal record from the subject’s mouth to the articulator were standardized. The only variable remaining were the accuracies of the four registration materials in recording the interocclusal relationship from the subject’s mouth and then successfully transferring them to the articulator. These accuracies were then calculated to derive the results.

Materials and Methods

Forty six subjects, of which fourteen were females and thirty-two were males aged between 19 to 26 years with good oral hygiene and full complement of teeth were selected for this study from among the outdoor patients, students and interns of New Horizon Dental College & Research Institute, Bilaspur, Chattisgarh. The students and interns were selected as they were of the relatively younger age group and could be easily motivated to volunteer. All the subjects were free from periodontal diseases, temporomandibular joint problems and malocclusion. The four operators were divided into two groups. Each subject was dealt with any one of the groups of operators and evaluated by the other group at each step to reduce operator induced variability.

Irreversible hydrocolloid impression material (Zelgan, DPI) was used to make the primary impressions of both maxillary and mandibular arches of the subjects with suitable stock trays. Study models were poured with type IV die stone (Kalrock, Kalabhai).

Auto-polymerizing acrylic resin (Detrey Rapid Repair, DPI) was used to construct a Lucia jig\textsuperscript{14} on the maxillary central incisors. If the opposing teeth contact during interocclusal registration, the mandible may deviate causing inaccuracy of the result. This jig deprogrammed the influence of the posterior teeth by creating a platform on which the mandibular incisors contacted. Occlusal surface of the jig was made flat so that it did not influence the direction of the closure of the mandible, but only prevented the closure. Only a very gentle posterior inclination was provided so as to assist the subject in holding the mandible in position while the materials set. The mandible closed anteriorly over the jig in order to provide 1.5 to 2 mm of space posteriorly.

Preformed interocclusal registration frames (Hager & Werken) were selected for the interocclusal registrations. These autoclavable frames are made up of two interlocking parts capable of holding a disposable piece of tissue paper in between them. The subject was trained thoroughly at this stage to close his/her mandible in centric relation position with the jig in place (Figure-1). Once the centric relation position was correctly ascertained, the points of contact of the mandibular anterior teeth on the
occlusal surface of the jig were marked with a pencil. This enabled the operator to monitor and guide the subject’s mandible to centric relation position while making the interocclusal registrations. During making the registration, the subject was asked to close his/her eyes to minimize the natural prehensile reflex.

All the four materials put to test were used one by one to load the interocclusal registration trays and make the records while the subjects closed their mandibles in centric relation positions (Figure-2). The manufacturer recommended handling instructions of the respective materials were strictly adhered to. All excess materials flowing beyond the boundaries of the trays might interfere with the proper sitting of the records over the casts. They were trimmed off with a No. 11 Bard Parker knife (Figure-3). All the records were cleaned in gently running tap water and preserved in sealed dry containers. One of these interocclusal records was then used to orient the mandibular model to the already fixed maxillary model in the articulator (Figure-4). Once the mandibular cast was fixed to the articulator with Plaster of Paris, the records were removed. The articulator was then adjusted to close in ICP (Figure-4).
6). The teeth in the model were then painted with a die lubricating oil. A strip of modeling wax was cut to approximate the shape of the maxillary model. It was then softened uniformly in warm water and placed over the teeth in the mandibular model. The articulator was closed with pressure over this strip of wax so that the vertical rod touched uniformly with the incisal guide table.

Thus a wax record of occlusal contacts at ICP was obtained from the articulator after orienting the mandibular model at RCP with one of the interocclusal records. The same procedure was then repeated after removing and re-orienting the mandibular model with the interocclusal records made from the other three materials. The keys prepared at the base of the mandibular models were thoroughly lubricated with petroleum jelly to facilitate easy removal. Thus four wax records were obtained after orienting and mounting the mandibular model with the four different interocclusal records.

A similar wax record was also made from the subject’s mouth by training the subject to close his/her mandible in ICP over a strip of softened modeling wax. This record acted as the control with which the other four such records obtained from the articulator was compared. The comparisons were done after judging the indentations against a dental operating light (Figure VI). Three distinct types of indentations were noted:

- An indentation with little or no thinning of the wax readily recognized under a light source represented near occlusal contact (Score 1).
- An indentation with thinning of the wax readily recognized under a light source represented occlusal contact (Score 2).
- A perforation of the wax represented supra-contact (Score 3).

A chart was made where the records with various registration materials and that obtained from the subject’s mouth were evaluated against the position of each single tooth that comes into occlusion on either side of the jaws. Owing to the variability in position and time of eruptions the third molar regions were excluded from the study. The positions of the occlusal contact regions were denoted as:

- 2- Right second molar region
- 3- Right first molar region
- 4- Right second premolar region
- 5- Right first premolar region
- 12- Left first premolar region
- 13- Left second premolar region
- 14- Left first molar region
- 15- Left second molar region

These occlusal contact regions were placed in a horizontal disposition at the top of the chart. The occlusal records denoted as A-B-C-D-E in the order shown below were placed in a vertical disposition at the left side of the chart.

- Record from the subject’s mouth
- Record after mounting with ZnOE impression paste
- Record after mounting with Wax corrected with ZnOE impression paste
- Record after mounting with Impression Plaster
- Record after mounting with Hydrophilic Vinyl Polysiloxane impression material

At the right hand side of the chart, the total of the scores of the eight occlusal regions as was found with each interocclusal record and that from the subject’s mouth were calculated and compared. The mean of these total scores in each occlusal region obtained with the four interocclusal records were compared to that of the records taken from the
subjects’ mouths. The results obtained from the final evaluation of the data were subjected to statistical analysis.

To compare the results produced by the four interocclusal recording materials to that of the control, Fisher’s t-statistics were used (Table-1). This was done using the software G*Power, which is a free software. Analysis of variance (ANOVA) test, which can evaluate a two way classified data, was undertaken to analyze whether total of the average scores of the materials varied among each other and also whether they varied in the eight occlusal regions considered (Table 2). The software used was ezANOVA which is a free program for analyzing data.

Results & Analysis

Data collected from the 46 subjects was tabulated in a master chart. The sum total score of the control group was 845 at an average of 18.369. None of the materials recorded a single case where the total score was more than the control group. Vinyl Polysiloxane impression material was closest to the control group in 40 out of the 46 cases. It equaled the total score of the control group in 12 cases. It recorded a sum total score of 802 at an average of 17.434.

Impression plaster recorded the second best scores with a sum total of 780 at an average of 16.956. Wax corrected with ZnOE impression paste occupied the third position with a sum total score of 780 at an average of 15.521. ZnOE impression paste was furthest from the control group with a sum total score of 692 at an average of 15.043. For statistical analysis, the scores calculated for each occlusal region was found to be more representative in respect of the present study. So the average scores of each occlusal region of the control and the four variants were tabulated in Table-1.

### Table –1: Comparative evaluation of the accuracies exhibited by interocclusal records made from the four interocclusal recording media in respect to the control group: Fisher’s t-statistics

|    | 2   | 3   | 4   | 5   | 12  | 13  | 14  | 15  | TOTAL | t-value | t0.025,14 | t0.005,14 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-------|---------|-----------|
| A  | 2.282 | 2.326 | 2.217 | 2.173 | 2.130 | 2.304 | 2.543 | 2.391 | 18.366 | 2.15 | 2.98 |
| B  | 1.586 | 1.956 | 2   | 2.130 | 2.086 | 1.934 | 1.891 | 1.413 | 14.996 | 4.21 |
| C  | 1.804 | 1.956 | 2.043 | 2.173 | 2.130 | 2.108 | 1.760 | 1.543 | 15.517 | 3.95 |
| D  | 2.152 | 2.195 | 2.130 | 2.130 | 2.043 | 2.152 | 2.195 | 1.956 | 16.953 | 3.54 |

### Table-2: Variations between the records produced by the four interocclusal recording media: ANOVA

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Sum of squares</th>
<th>Degrees freedom</th>
<th>Mean squares</th>
<th>F-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed</td>
<td>Tabulated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between the four</td>
<td>0.52</td>
<td>3</td>
<td>0.17</td>
<td>8.5</td>
</tr>
<tr>
<td>materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between the eight</td>
<td>0.48</td>
<td>7</td>
<td>0.07</td>
<td>3.5</td>
</tr>
<tr>
<td>regions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>0.37</td>
<td>21</td>
<td>0.02</td>
<td>--</td>
</tr>
<tr>
<td>Total</td>
<td>1.38</td>
<td>31</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

The total of the average scores at different occlusal regions of each of these materials put to test were compared with that of the control group. All other materials except vinyl Polysiloxane impression material, type-I, showed statistically significant difference with the control group at 5% (P=0.05) and 1% (P= 0.01) levels of significance.
In case of vinyl Polysiloxane impression material, the calculated t value was 2.24. From the t-table, it was found that $t_{0.05,14} = 2.15$ (when $P = 0.05$) and $t_{0.01,14} = 2.98$ (when $P = 0.01$). Since the calculated t-value (2.24) is less than the t-value at 1% (2.98) level of significance, it is concluded that the total of the average scores with this material did not differ significantly with the control group at 1% level of significance and only marginally differed with the control group at 5% (2.15) level of significance.

The t-values of the totals of the average scores at different occlusal regions of all other materials varied widely than that of the control group both at 1% and 5% levels of significance. The calculated t-values for ZnOE impression material was 4.21, while that of Wax corrected with ZnOE impression material was 3.95 and that of Impression Plaster was 3.54, all much higher than that calculated from the t-table at both at 1% (2.15) and at 5% (2.98) levels of significance.

To evaluate whether the totals of the average scores at different occlusal regions of these four materials varied among themselves or not, they were subjected to the ANOVA test (Table-2). Since the observed value of F ($F=8.5$) for different interocclusal registration material was found to be larger than the corresponding tabulated value $F_{0.05,3,21} = 3.10$, it was found to be significant at 5% level of significance.

**Discussion**

Some of the earlier studies dealt with the properties of these materials at controlled laboratory environments. In those cases, although the properties of the materials were correctly interpreted, their influence on the stomatognathic system was not considered. Other workers created in vitro clinical situations that completely avoided the influences of the actual clinical phase. No study was ever conducted with these materials involving both the clinical and laboratory phases of jaw relation transfer.

In the present study, the four materials used have been the most widely used materials for making interocclusal records. Moreover, the four materials selected represent the diverse spectrum of the interocclusal registration materials. This is the reason why the other elastomeric materials were not included in the present study. Wax is still the most common material in day to day practice for its versatile nature. Since earlier studies have proved its inaccuracy in providing an acceptable result, the wax records were corrected with ZnOE impression paste as advocated in many studies and text books.

Many earlier studies advocated the use of ZnOE impression paste as it was accurate, offered the least resistance to closure owing to its fluidity, adhered to the tray, was extremely soft and set hard enough to mount the models accurately. In the present study, ZnOE impression paste was found to be the least accurate of all the four materials put to test. Similar results were found in several other studies as well. The main disadvantage of ZnOE impression paste is its tendency to stick to the surface of the teeth and a long setting time during which registration errors can be introduced. It is inelastic in nature and inaccuracies might result from forcibly pulling it from the undercut areas. Some studies indicated that it constantly resulted in open cast relationships. Although wax is the most versatile and widely used material for making interocclusal registrations, it was not included in the present study. It has been proved to be unacceptable by most of the previous investigators. It was found to be an inaccurate and unstable material that offered resistance to closure thereby resulting in deviation of the mandible during interocclusal registrations.

Some investigators suggested that the correction of wax registrations with a more free flowing material like ZnOE impression material produced more accurate results. This combination when included in this study produced the third best result and was found to be unacceptable by the statistical analysis. This was probably due to the inelastic natures of both the materials and the effect of the underlying wax that may cause deviation of the mandible during closure. The volumetric shrinkage of ZnOE impression paste was negligible in this case as it was confined within the limits of the already set wax. This was probably the reason why this combination exhibited better results than ZnOE impression paste alone.

Impression plaster has been found to be acceptable for interocclusal registrations by many investigators in the past. They found that the material was accurate, rigid after setting and do not distort with extended storage. Impression Plaster came out with the second best results in the present study, although it had statistically significant differences with the recordings of the control group.

Impression plasters are messy material having a long setting time that might have contributed to the inaccuracies of the records. It is inelastic and brittle in nature and prone to result in fractures of important areas of the records during retrieval from undercut areas, or during the mounting of models. One study even suggested that the accuracy of the tooth imprints in the recordings may surpass that of the models thereby resulting in improper sitting of the models.

In the present study, Hydrophilic Vinyl Polysiloxane impression material was found to be...
most acceptable for making interocclusal registrations. Similar results were advocated by many other studies. It was very close to the control group at 5% level of significance and was found to have no difference with the control group at 1% level of significance. Many other studies have come out with similar results. Elastomeric materials are free flowing, elastic in nature and more dimensionally stable. Addition reaction silicones were used in this study as condensation silicones were proved to be of less dimensional stability.

The four materials considered in the present study have shown distinctly different and statistically significant variance from each other in the ANOVA test. In the various studies found in the literature where the workers went for a comparative evaluation of two or more materials, no two materials yielded the same levels of accuracy. This is probably due to the wide variance in the properties and handling characteristics of the materials.

In the present study, where both the clinical and laboratory phases of jaw relation transfers were considered, Hydrophilic Vinyl Polysiloxane impression material was found to be most clinically acceptable as an interocclusal recording medium while all other materials were rendered unsuitable for the purpose with a distinctly different variance in accuracies noted between all four materials considered.

Summary and Conclusions

The present study was undertaken to evaluate the accuracies exhibited by four commonly used interocclusal registration materials when they were used to articulate dentate models at the RCP, incorporating both the clinical and laboratory phases of jaw relation transfer. The four materials put to test were Zinc Oxide and Eugenol impression paste, wax records corrected with Zinc Oxide and Eugenol impression paste, Impression Plaster and Hydrophilic Vinyl Polysiloxane impression material, type-I. Based on the available data, the following conclusions may be derived:

Hydrophilic Vinyl Polysiloxane impression material, type-I was found to be the most accurate of the four and clinically acceptable while all other materials tried were rendered unsuitable for the purpose. The second best results much ahead of the other two, but was not found to be clinically acceptable.

The other two materials were found to be clinically unacceptable, with Zinc Oxide and Eugenol impression material being the least accurate one. The four materials considered were also found to yield distinctly different interocclusal registrations as a whole and at the different occlusal regions considered with statistically significant levels of variance among themselves (Table-2).

There is further scope of evaluating the accuracies exhibited by some other materials advocated for the purpose following similar materials and methods. These include Eugenol free Zinc Oxide impression paste, Acrylic Resin and Polyether. All the materials tested may be subjected to different storage periods to evaluate the effects of extended storage on the accuracies of these materials.

Bibliography


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