Evaluation of Vertical Accuracy of Interocclusal Records

Vassilis K. Vergos, DDS[a]
Aris-Petros D. Tripodakis, DDS, MS[b]

Purpose: The aim of this study was to evaluate four recording materials (polyether, polyvinyl siloxane, acrylic resin, and wax) for their ability to accurately record, maintain, and reproduce the vertical interocclusal relationship. **Materials and Methods:** A metallic apparatus was used to represent the opposing arches; its epoxy resin duplicate represented the working casts. The vertical discrepancies produced because of the presence of the records were measured both after repositioning them on the metal apparatus and after transferring them onto the casts. Two-way ANOVA was performed. **Results:** Closure through the interocclusal recording materials produced small vertical discrepancies ranging from 24 to 74 μm. When repositioned on the apparatus, the vertical discrepancies were greater. The lowest discrepancy was displayed by polyvinyl siloxane (101 μm) and polyether (107 μm), and the greatest was displayed by wax (168 μm). When records were transferred onto casts, the discrepancies were approximately 0.5 mm, without significant differences among materials. **Conclusion:** Closure through interocclusal recording materials and removal and repositioning of the records on the apparatus produced small vertical discrepancies with clinically insignificant differences between the materials tested. When records of all materials tested were transferred onto casts, vertical discrepancies of approximately 0.5 mm were found, which is of clinical concern. *Int J Prosthodont 2003;16:365–368.*

Direct interocclusal records are most commonly used to record maxillomandibular relationships because of their simplicity. The arches are brought into a relationship with or without tooth contact, and a space is created between the teeth. The recording material, which is initially soft, fills the spaces between teeth, hardens, and records the specific relationship of the arches. The hardened material is then transferred onto casts to be mounted on an articulator. According to Millstein and Hsu,[1] the "interocclusal record should be an accurate and dimensionally stable representation of an interocclusal space that is subsequently transferred to an articulator." Plaster, wax, zinc oxide–eugenol paste, autopolymerizing acrylic resin, condensation-type silicones, polyether, and polyvinyl siloxane (PVS) are materials clinically in use for this purpose.

Many studies have evaluated the physical properties and behavior of these materials.[2–7] The accuracy of an interocclusal record, however, is influenced not only by the material properties, but also by the recording technique, as well as the reliability of the mandibular position influenced by the occlusal contacts,[8] muscular action, or tissue changes within the joints.[9] Moreover, the accuracy of fit of the recording material on the study or working casts seems to be a critical factor in the whole procedure. Repositioning the record on casts could be a source of discrepancy,[5] probably because imprints of occlusal pits and fissures cannot accurately be repositioned onto occlusal surfaces of casts, which do not reproduce complete surface detail.[10] For this reason, a technique in which the contact surfaces of the record are kept as small as possible and involve

[a]*Instructor, Department of Fixed Prosthodontics, School of Dentistry, National and Kapodistrian University of Athens, Greece.*
[b]*Assistant Professor, Department of Fixed Prosthodontics, School of Dentistry, National and Kapodistrian University of Athens, Greece.*

Reprint requests: *Dr Vassilis K. Vergos, Protopapadaki 4, Athens 111 47, Greece. e-mail: vergosdent@yahoo.com*

This study was presented in part at the 17th Panhellinic Dental Congress, 29 October–1 November 1997, Rhodes, Greece.

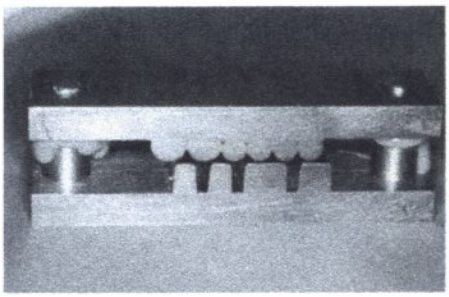

Fig 1 Metal apparatus consists of two separate members that simulate the maxilla and mandible.

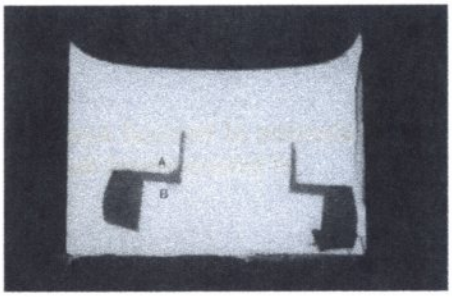

Fig 2 Cross-section of silicone ring (original magnification × 10). Lower part of the epoxy model represents cylinder of lower member and rings of upper member. Vertical distance *(A* to *B)* between two members that house silicone material represents thickness discrepancies to be measured.

only one cusp tip on each strategic tooth, three in total, has been suggested.[10] A previous study[11] showed that simple removal and repositioning or transferring of the record influences the relationship of the two members of a model apparatus or of the casts, respectively. The design of the experiment was such that repositioning of the record material as a source of vertical discrepancy was isolated.

The aim of the present study was to evaluate four different recording materials for their ability to accurately record and reproduce interocclusal relationships. It was hypothesized that there would be no vertical discrepancies between the materials in the procedure of recording maxillomandibular relationships, or in reproducing them when transferred onto casts.

Materials and Methods

Four recording materials specially made for bite registration were tested: a polyether (Ramitec, ESPE/Premier), a metal-wax compound (Alminax, Whip-Mix), an autopolymerizing acrylic resin (Kallocryl CP-GM, Zahfabrig-Rot), and a PVS material (President Jet Bite, Coltene/Whaledent). The materials used were from the same batch for each material and were handled according to the manufacturer's directions.

The same metal apparatus employed in a previous study,[11] with two separate members that simulated the maxilla and mandible, was used (Fig 1). The upper member consisted of horizontal cylindric rods that, in cross-section, simulated the occlusal surfaces of maxillary molars and premolars. On the lower member, metal bars of trapezoid cross-sectional form with tapering proximal surfaces (3 degrees) simulated the occlusal surfaces of prepared mandibular molars and premolars. Machined vertical cylinders on each end of the lower member precisely fit into corresponding holes of the upper member to create a stable position for the two members.

In the closed position, the apparatus maintained 0.5 mm of interarch clearance. The vertical discrepancies between upper and lower members were measured by placing light-body PVS material (Extrude, Kerr) at the hole of the upper member. The members were then placed together, and a force of 1 kg was applied by a weight on the upper member to simulate a force of closure. This force was applied in all phases of the experiment. The polymerized silicone mass placed at the hole of the upper member formed a ring around the vertical cylinder of the hole of the lower member. The thickness of the cross-section of the ring at its horizontal middle area represented the vertical deviation of the members, interpreting the accuracy of the record between points A and B (Fig 2). To measure this thickness, the polymerized silicone rings were removed and invested in white epoxy resin (Epoxy Die, Ivoclar). The polymerized resin blocks were sectioned through the center of the rings with a microtome (Beuhler) under constant water irrigation. The distance between points A and B, representing the vertical deviation, was measured through a stereoscope (Olympia), which had a measuring device.

Acrylic resin custom trays (Ivolet, Ivoclar) were used to make impressions of the apparatus members in PVS (Extrude). The impressions were poured in green epoxy resin (Epoxy Die). Testing of the materials was accomplished in three phases. Initially, the members of the apparatus were occluded with the recording material in between (phase 1). The hardened recording material was removed and repositioned on the apparatus, and a second series of measurements were taken (phase 2). Finally, the records were transferred from the

apparatus onto the epoxy resin models, and a third series of measurements were taken (phase 3). The polyether, wax, and PVS materials were placed on the lower member as a mass. The acrylic resin was placed in small drops in three different points, forming a triangle, as has been suggested.[10]

For every phase and every material, six measurements were taken; 12 groups were formed. Each measurement was the mean of two width measurements taken in two diametrically opposite areas of the silicone ring. Because some measurements were much above average, and possibly created a lack of homogeneity of variance, a logarithmic transformation was completed before statistical analysis. This transformation spread out the observations with smaller values and compressed the larger values.[12] A two-way analysis of variance (ANOVA) was performed with two independent variables (phases, materials) to test for any interaction between them. The statistical significance level was placed at $P < .05$.

Results

Closure through the interocclusal recording materials tested produced vertical discrepancies ranging from 24 μm for PVS to 74 μm for wax. Although small, the differences between the materials were statistically significant (Table 1). When the records were repositioned on the apparatus, greater vertical discrepancies were found. The lowest discrepancy was displayed by PVS (101 μm) and polyether (107 μm), and the greatest was displayed by wax (168 μm). When the records were transferred onto the casts, the discrepancies were approximately 0.5 mm, without significant difference among materials.

The two-way ANOVA showed that materials in all phases influenced the measurements of the silicone ring thickness ($P < .001$). The measurements within groups in all cases did not differ significantly, confirming the reliability of the method ($P > .05$). Repositioning all records on the apparatus (phase 2) or transferring them to the casts (phase 3) produced significantly greater discrepancies. In pair-wise comparisons, all groups differed on a statistically significant level ($P < .05$), except for a few comparisons (Table 1).

Table 1 Means (Standard Deviations) of the Six Measurements of All Experimental Groups (in μm)*

Material	Phase 1	Phase 2	Phase 3
Polyether	30[a] (2)	107[g] (12)	475[h] (26)
Wax	74[b] (9)	168[i] (14)	545[j] (16)
Acrylic resin	57[c] (6)	133[g] (8)	511[h,j] (14)
Polyvinyl siloxane	24[d] (4)	101[e] (6)	476[h] (11)

*Different superscripted letters denote statistically significant differences ($P < .05$).

Discussion

Simple closure through an occlusal record has proven to be a cause of inaccuracies in recording jaw relations in vertical and horizontal dimensions.[1–7,11] The present findings showed an increasing influence from PVS to polyether, acrylic resin, and wax, probably because of different physical or chemical properties of these materials. However, the differences between these materials were probably clinically insignificant (< 0.1 mm). In a previous experiment,[11] the observed vertical discrepancies in recording maxillomandibular relations were not present upon simple closure through a polyether record, but they were present when the records were repositioned or transferred. This finding also was confirmed in the present study for all four recording materials tested.

The influence of the presence of the registration material during mounting of models on an articulator has been successfully eliminated when casts are hand articulated in maximum intercuspation.[13] Another study confirmed this finding, especially when many teeth are in contact.[14] Even when using a precise recording material to obtain a very accurate record, it is difficult to make it fit precisely on the casts upon repositioning. A similar explanation[10] was based on the assumption that an extremely precise recording material would never be able to fit to a less precise cast. However, the present study showed that simple removal and repositioning of the record is a source of inaccuracies. When repositioned on the apparatus, all records created statistically significant discrepancies of around 0.1 mm, which is estimated to be clinically insignificant. These inaccuracies were found to be lower when using PVS and increased in the order of polyether, acrylic resin, and wax. This is in agreement with other studies[6] rating polyether better than acrylic resin, while wax has been shown to be the worst. The increased accuracy of PVS versus polyether also has been confirmed,[7] while no differences were observed in other studies.[1]

When records were transferred onto precision working casts, as usually takes place in clinical practice, previously observed differences among the materials were not found. All materials were equally inaccurate. This led to the conclusion that the inaccuracy obtained by transferring the records onto casts occurs independent of the recording material and because of the procedure itself. The clinical relevance of this inaccuracy is related

to the magnitude of the discrepancies of approximately 0.5 mm. Clinically, such discrepancy is almost always present when a fixed prosthesis constructed on an articulator is first transferred for intraoral trial and immediately calls for vertical occlusal adjustment. Thus, the recording procedure is inaccurate and urges modification and improvement. Such an improvement would possibly result if transferring of the records onto casts could be eliminated, as previously proposed by two of the authors.[11] The introduced method, which limited transferring of the record to only one of the working casts, reduced the inaccuracies singnificantly.

Conclusions

Under the limitations of this study, the following conclusions were drawn:

- Simple closure through an interroclusal record produced vertical discrepancies in the procedure of recording maxillomandibular relationships. These inaccuracies were aggravated when transferring the records onto casts.
- The order in producing minimum vertical errors during simple closure related to different materials was PVS, polyether, acrylic resin, and wax, in a magnitude of less than 0.1 mm, which is estimated to be clinically insignificant.
- Records of all materials tested, when transferred on casts, produced equal inaccuracies of approximately 0.5 mm, which is estimated to be clinically significant.

Acknowledgment

This study was approved and partially funded by the Biomedical Research Committee, Central Council of Health, Ministry of Health and Social Security, Greece (grant No. 70/3/1174).

References

1. Millstein PL, Hsu CC. Differential accuracy of elastomeric recording materials and associated weight change. J Prosthet Dent 1994;71:400–403.
2. Lassila V, Mc Cabe JF. Properties of interocclusal registration materials. J Prosthet Dent 1985;53:100–104.
3. Lassila V. Comparison of five interocclusal recording materials. J Prosthet Dent 1986;55:215–218.
4. Muller J, Gotz G, Horz N, Kraft E. Study of the accuracy of different recording materials. J Prosthet Dent 1990;63:41–46.
5. Muller J, Gotz G, Horz N, Kraft E. An experimental study on the influence of the derived casts on the accuracy of different recording materials. Part I: Plaster, impression compound and wax. J Prosthet Dent 1990;63:263–269.
6. Muller J, Gotz G, Horz N, Kraft E. An experimental study on the influence of the derived casts on the accuracy of different recording materials. Part II: Polyether, acrylic resin and corrected wax wafer. J Prosthet Dent 1990;63:389–395.
7. Chai J, Tan E, Pang IC. A study of the surface hardness and dimensional stability of several intermaxillary registration materials. Int J Prosthodont 1994;7:538–542.
8. Berry DC, Singh BP. Daily variations in occlusal contacts. J Prosthet Dent 1983;50:386–391.
9. Lundeen HC. Centric relation records: The effect of muscle action. J Prosthet Dent 1974;31:244–253.
10. Wiskott HWA, Nicholls JI. A fixed prosthodontic centric relation registration technique using resin copings. Int J Prosthodont 1989;2:447–452.
11. Tripodakis AP, Vergos VK, Tsoutsos AG . Evaluation of the accuracy of interocclusal records in relation to two recording techniques. J Prosthet Dent 1997;77:141–146.
12. Dawson-Saunders B, Trapp RG. Estimating and comparing means. In: Basic and Clinical Biostatistics. New York: Prentice Hall, 1990:99–123.
13. Strohaver RA. A comparison of articulator mountings made with centric relation and myocentric position records. J Prosthet Dent 1972;28:379–390.
14. Walls AWG, Wassell RW, Steele JG. A comparison of two methods for locating the intercuspal position (ICP) whilst mounting casts on an articulator. J Oral Rehabil 1991;18:43–48.