# Evaluation of the accuracy of interocclusal records in relation to two recording techniques

**Aris-Petros Tripodakis, DDS, MS,[a] Vasilis K. Vergos, DDS,[b] and Andreas G. Tsoutsos, DDS[c]**
University of Athens, Dental School, Athens, Greece

**Purpose.** The accuracy of interocclusal records influences the relationship of the working casts and therefore the success of the prosthesis. The aims of this study were to determine the accuracy of the fit of interocclusal records on the working casts and to compare the accuracy between a classic and modified recording technique, which is described in this article.
**Methods.** The modified technique uses a metal apparatus that represents opposing arches. Bite registration polyether was used as the recording material and epoxy resin was used as the working cast material.
**Results.** The results indicated that the presence of the recording material produced vertical discrepancies on the interocclusal relationships of the casts. Repositioning or transferring of the records enhanced these discrepancies.
**Conclusions.** The proposed modified technique reduced the inaccuracies but did not completely eliminate them.(J Prosthet Dent 1997;77:141-6.)

**CLINICAL IMPLICATIONS**

*Interocclusal registration materials produce vertical discrepancies in the interocclusal relationship of mounted casts. The proposed technique reduces these discrepancies but does not eliminate them.*

Recording maxillomandibular relationships is an important step in oral rehabilitation. This relationship is transferred to the articulator, so laboratory procedures done on the casts will correspond with the patient's mouth. There are various methods of recording maxillomandibular relationships, namely, graphic, functional, cephalometric, and direct interocclusal.[1] Direct interocclusal records are used most commonly because of their simplicity. According to Dawson,[2] criteria for accuracy in making interocclusal records include the following points. (1) The recording material must not cause any movement of teeth or displacement of soft tissues. (2) The recording material must fit casts as accurately as it fits the teeth intraorally. (3) The accuracy of the jaw relation record should check in the mouth and on the casts.

Many studies have evaluated the physical properties and behaviors of different recording materials.[3-10] According to these studies, the materials in order of accuracy are as follows: polyether, zinc oxide eugenol paste, plaster, autopolymerizing acrylic resin, condensation type silicones, and wax. Recently, addition type silicones have been proposed as registration material to improve the accuracy of condensation type silicones.[11] Nevertheless, registration material is not the only parameter that influences the accuracy of an interocclusal record. Recording techniques have also been the cause of errors because many studies[10-15] have reported broad variation in accuracy without clarifying the specific influence of the individual parameters involved. In a study of the influence of the presence of the registration material during the mounting of the models on the articulator, Strohaver[12] found that the least variable of all methods was the one in which the casts were hand articulated in maximum intercuspation. However, Muller et al.[7-9] found the repositioning of the record as a source for discrepancies. The importance of this specific influence has not yet been examined.

When transferring records from dental arches to casts, the required accuracy of fit is not always achieved clinically. A possible reason is the dimensional change of the materials,[4-6] inaccuracies found in the casts, or the inability of the record to be totally seated on the occlusal surfaces because of their complicated morphologic features. It is possible that if the cast is poured directly in the record the potential error will be minimized. This possibility has led to modification of the classic jaw relation recording technique.[2] The modification is such that

Presented at the thirteenth Pan-Hellenic Dental Congress, Kalamata, Greece, October 1993.
This study has been approved and funded by the Biomedical Research Committee, Central Council of Health, Ministry of Health and Social Security grant No. 70/3/1174.
[a]Assistant Professor, Department of Fixed Prosthodontics.
[b]Private practice.
[c]Professor, Department of Fixed Prosthodontics.

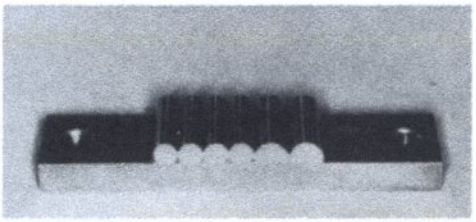

**Fig. 1.** Upper member of apparatus.

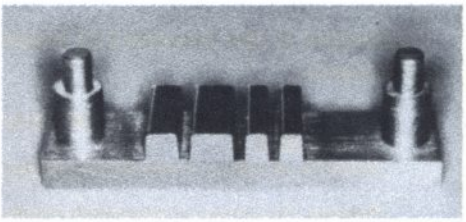

**Fig. 2.** Lower member of apparatus.

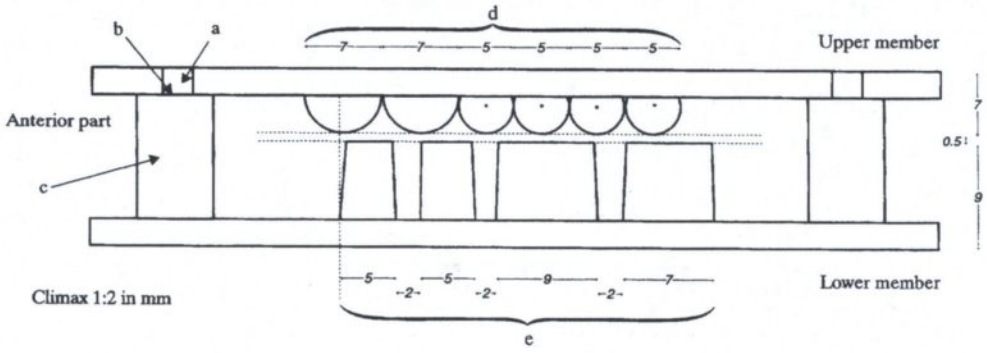


**Fig. 3.** Dimensions of apparatus.

after the polymerization of the record material the patient is asked to open. If the record stays in contact with one jaw, an irreversible hydrocolloid impression is made and incorporates the record. A cast in direct contact with the record is then poured in this impression.

This new cast-record system is used for the reproduction of the jaw relation on the articulator. Therefore the aims of this study were to determine the specific influence of the record's transfer from the mouth to the casts on the accuracy of the recorded jaw relation as a result of inadequate fit of the record and to compare the classic technique with the one suggested in this report.

## MATERIAL AND METHODS

A metal apparatus was used that consisted of two separate members that simulated the maxillae and mandible (Figs. 1 and 2). Small cylinders (a) machined (b) on large flanged cylinders (c) provided a precise fit to holes in the opposing member. The flanges acted as positive vertical stops. The upper member consisted of contacting horizontal cylindric rods (d) that simulated the occlusal surfaces of maxillary molars and premolars, two rods for the molars and one for the premolars. On the lower member, metal bars *(e)* of cross-sectional trapezoid form with tapering proximal surfaces (3 degrees), simulated the occlusal surface of prepared molars 7 and 9 mm wide and premolars 5 mm wide (Fig. 3).[16] At the closed position the apparatus maintained 0.5 mm of interarch clearance to minimize the volume of the recording material and therefore reduce the potential volumetric error.

Measurements of vertical discrepancies were made between upper and lower members of the apparatus. Light body additional silicone (Extrude, batch No. 1-1262, Kerr Mfg. Co., Romulus, Mich.) was placed in holes. The members of the apparatus were occluded and force of 1 kg was applied in all phases. The polymerized silicone rings were removed from the pins and mounted in white epoxy resin (Epoxy-Die batch No. 401138, Ivoclar, Schaan, Liechtenstein). Formed resin tubes were sectioned approximately through the middle of the rings with a microtome (Beuhler Ltd., Lake Bluff, Ill.) under constant water irrigation. The thickness of the cross-section of the rings, measured through a stereoscope (Olympia), represented the vertical deviation of the members of the apparatus interpreting the accuracy of the record (Fig. 4). The recording material used in this study was polyether record material (Ramitec, batch No. W268, Espe–Premier, Seefeld, Germany), which in many studies was shown to be extremely accurate.[5,6,9,17-19]

The experiment was conducted in three phases: (1) evaluation of fit of the record on metal apparatus, (2) evaluation of record accuracy achieved by the classic recording technique, and (3) evaluation of record accuracy achieved by the modified technique. Eight groups

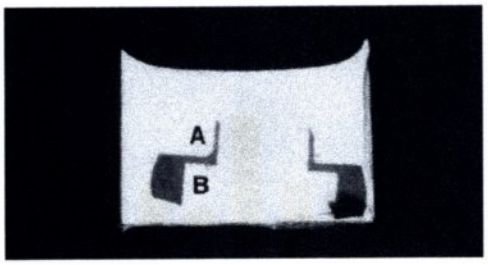


**Fig. 4.** Cross-section of silicone ring (original magnification ×10). Lower part of epoxy die material represents cylinder of lower member and rings of upper member. Vertical distance *(a to b)* between two members that houses silicone material represents thickness discrepancies to be measured.

**Table I.** Groups at the three phases

| Group | Description |
|---|---|
| A | Metal apparatus without record |
| B | Metal apparatus with record |
| C | Metal apparatus with repositioning of record |
| D | Epoxy models without record |
| E | Epoxy models with record |
| F | Epoxy models with repositioning of record |
| G | Modified technique in metal apparatus |
| H | Modified technique in epoxy models |

of measurements were formed, three for phase 1, three for phase 2, and two for phase 3 (Table I). The experiment was repeated five times for each group.

### Evaluation of fit on the record on metal apparatus (control)

Initially the members of the apparatus were occluded with no recording material superimposed and the width of the silicone rings was measured to form control group A. The same measurements were made after placing recording material between the members of the apparatus and formed control group B (Fig. 5). For group C the upper member of the apparatus was separated from the lower and the record was removed and repositioned. The width of new silicone rings was measured.

### Evaluation of record accuracy achieved by the classic recording technique

Acrylic resin custom trays were made from Ivolet (batch No. 342162, Ivoclar) material for the two members of the apparatus. Impressions were made with additional silicone (Extrude, batch #1-1262, Kerr Mfg. Co.), and green epoxy resin models were poured (Epoxy Die batch No. 401137, Ivoclar) to present the least amount of dimensional change. The entire sequence of phase 1 was repeated on resin models, and groups D, E, and F were produced (Table I). In group D no recording material was used (Fig. 6, *A*). For group E recording material was placed between the members of the epoxy apparatus, and in group F the record made on the metal apparatus in group C was used (Fig. 6, *B*). Group F corresponded to the classic recording technique.

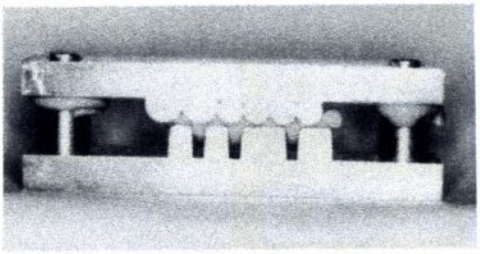

**Fig. 5.** Group B: metal apparatus with record and silicone rings in place.

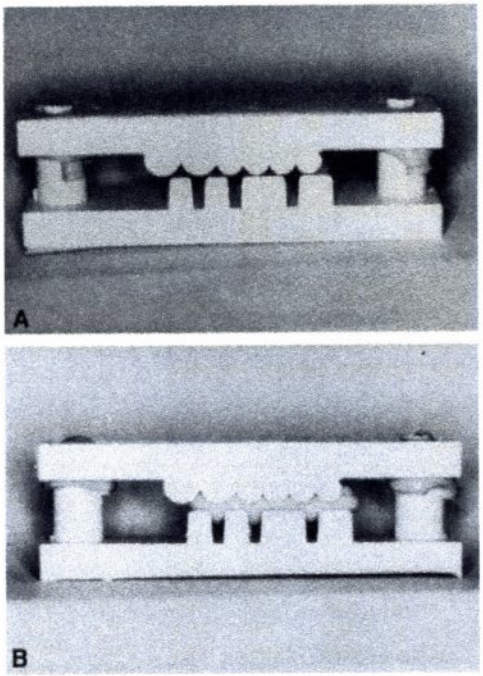


**Fig. 6. A,** Group D: epoxy models without record and silicone rings in place. **B,** Group F: epoxy models with repositioned record and silicone rings in place.

### Evaluation of record accuracy achieved by the modified technique

New custom trays and impressions for both members of the apparatus were made as was done in phase 2, and epoxy models of the lower member were poured. For

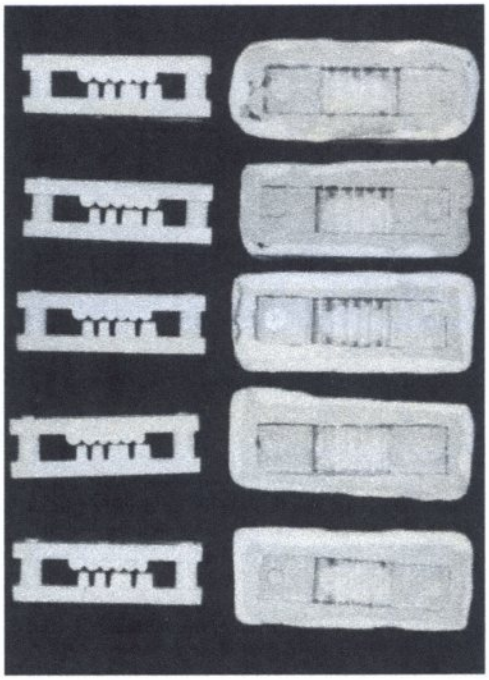

**Fig. 7.** Modified technique, five series.

**Table II.** Mean value of silicone ring thickness (in micrometers)

| | Series of Measurements | | | | |
|---|---|---|---|---|---|
| Groups | 1 | 2 | 3 | 4 | 5 |
| A | 22.5 | 28.5 | 18.5 | 27.5 | 18.5 |
| B | 26.5 | 29.0 | 30.5 | 32.0 | 33.5 |
| C | 118.0 | 108.5 | 98.5 | 93.0 | 122.5 |
| D | 22.5 | 17.0 | 30.0 | 17.5 | 16.5 |
| E | 28.0 | 29.0 | 27.0 | 31.0 | 30.0 |
| F | 430.0 | 480.0 | 118.0 | 512.5 | 480.0 |
| G | 37.0 | 42.5 | 31.0 | 59.5 | 42.0 |
| H | 85.0 | 175.0 | 145.0 | 135.0 | 139.0 |

the upper member models, a record was made on the metal apparatus and the upper member bearing the record was separated from the lower one. An impression of the upper member record assembly was made and the recording material was incorporated in the impression. Therefore impression of occlusal surfaces of the "teeth" was presented by the recording material (Fig. 7). An epoxy resin model was poured, with the record being transferred to it. This model was positioned on the lower member of the apparatus and measurements were made to form group G (Table I). The procedure was repeated with the model–record assembly being

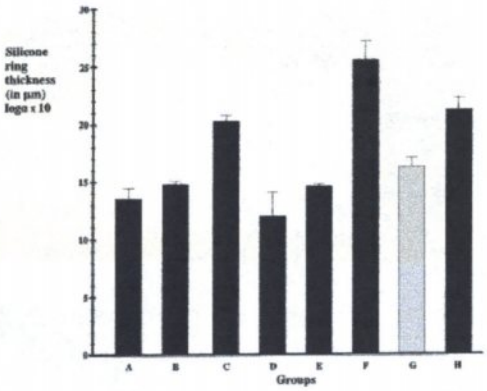


**Fig. 8.** Graphic representation of mean values and SDs for each group when silicone ring thickness is compared.

**Table III.** Mean, SD, and SEM

| Group | Mean | SD | SEM |
|---|---|---|---|
| A | 23.10 | 4.77 | 2.13 |
| B | 30.30 | 2.70 | 1.21 |
| C | 108.10 | 12.50 | 5.59 |
| D | 20.70 | 5.72 | 2.56 |
| E | 29.00 | 1.58 | 0.70 |
| F | 404.10 | 162.63 | 72.73 |
| G | 42.40 | 10.62 | 4.75 |
| H | 135.80 | 32.45 | 14.51 |

transferred on the epoxy model of the lower member, forming group H (Table I). Because of the apparent lack of homogeneity of variance that appeared in the data (Tables II and III), the logarithmic transformation was completed before the statistical analysis.[20]

Means, SDs, and SEs of the transformed data were calculated for all groups (Table IV). Bar graphs of all groups are presented in Figure 8. Comparisons between mean widths of silicone rings were made with two-sample *t*-tests for independent group samples. Because of the number of multiple tests being conducted, a Bonferroni correction was used to reduce the risk of type I errors. For eight experimental groups, 28 two-sample tests were possible. Therefore it was necessary for the two-tailed *p* values that resulted from any test to be less than 0.05 of 28 or 0.0017. Levene's test for equality of variances was taken into account to perform the appropriate *t*-test, assuming equal or unequal variances. All tests were performed with statistical software (SPSS for Windows, version 6.0, SPSS Inc.).

## RESULTS

Results from two-sample *t*-tests for independent groups are presented in Table V. Only comparisons lead-

**Table IV.** Means, SDs, and SEs of logarithmic transformation

| Group | *n* | Mean | SD | SEM |
|---|---|---|---|---|
| A | 5 | 1.3561 | 0.0902 | 0.0403 |
| B | 5 | 1.4802 | 0.0395 | 0.0177 |
| C | 5 | 2.0315 | 0.0507 | 0.0227 |
| D | 5 | 1.3041 | 0.1106 | 0.0494 |
| E | 5 | 1.4619 | 0.0237 | 0.0106 |
| F | 5 | 2.5555 | 0.2720 | 0.1220 |
| G | 5 | 1.6171 | 0.1039 | 0.0464 |
| H | 5 | 2.1214 | 0.1160 | 0.0519 |

ing to meaningful discussion and conclusions were selected, whereas the others were omitted. Group A (metal apparatus without record) did not differ from group D (epoxy models without record), which confirmed the reliability of the fabrication of the epoxy models ($p > 0.05$) (Table V). Group A (metal apparatus without record) did not differ from group B (metal apparatus with record) ($p > 0.05$). In the same manner, group D (epoxy models without record) did not differ from the group E (epoxy models with record) (Table V). These comparisons were made to evaluate the effect of the simple and direct introduction of the record material. Group B (metal apparatus with record) differed from the group C (metal apparatus with repositioning of the record) and even more from group F (epoxy models with repositioning of the record) at a statistically significant level ($p < 0.0017$) (Table V).

These comparisons were made to evaluate the influence of the repositioning of the record; group B was considered to be the control group. Group B differed from group H (modified technique in the epoxy models) but was not statistically significantly different from group F ($p > 0.0017$) (Table V). These comparisons were made to evaluate the efficacy of the modified recording technique, again with group B as the control. Although group G represented an additional control for the modified method, comparisons were not made with this group but with the original control group B to avoid confusion. In group F one abnormal value (118 μm) existed and it was inflating the SD and lowering the mean of this group. When this value was set aside, groups F and H were also found to differ at a statistical significant level ($p < 0.0017$).

## DISCUSSION

Closure through an occlusal record has proved to be a major cause of inaccuracies in recording jaw relations in a vertical and horizontal dimension, as shown in several studies.[3,7-9,17-19,21] The simple and direct introduction of the record material in this study did not create vertical discrepancies both in the control group (metal apparatus) and the test groups (models) at a statistically significant level. However transferring the record from the dental arch on to the models had not been evaluated as a possible cause of inaccuracies. Muller et al.[8] reported that removal and repositioning of the record eventually caused discrepancies. When these discrepancies were identified to be greater than 40 μm, they were excluded from the experiment, and thus this parameter was eliminated from the study. Breeding et al.[11] observed the same discrepancies that were attributed to the recording material. The materials used in that study were polyvinyl siloxane, thermoplastic resin, and acrylic resin.

**Table V.** Two-sample *t*-test for independent groups

| Pairs of comparing groups | *t* Value | df | Two-tailed significance |
|---|---|---|---|
| A-D | 0.82 | 8 | 0.438 |
| A-B | -2.82 | 8 | 0.023 |
| D-E | -3.12 | 4.37 | 0.032 |
| B-C | -19.18 | 8 | 0.000* |
| B-F | -8.76 | 8 | 0.000* |
| B-H | -11.70 | 8 | 0.000* |
| F-H | 3.29 | 8 | 0.011* |

Note that in comparison D-E *t*-test was performed assuming unequal variances as shown by Levene's test and therefore resulted in noninteger degrees of freedom.

*$p < 0.0017$.

In this study simple removal and repositioning of the record proved to influence the relationship of the two members of the apparatus. On the other hand, transferring the record from the apparatus to the models proved to be a source of serious discrepancies.

Discrepancies of 108.1 μm were observed in group C (metal apparatus with repositioning of the record) and 404.1 μm in group F (epoxy models with repositioning of the record). The high value combined with the large SD of group F are indicative of the great inaccuracies involved in the procedure of transferring the occlusal records from the dental arches on the models that represent the most commonly used clinical procedure during prosthetic treatment. This finding might explain the almost always present need for intraoral vertical selective grinding of the prosthesis constructed on casts mounted on articulators by means of such records. In a study of condyle deviations in a three-dimensional apparatus, Muller et al.[9] also found deviations in all directions. These deviations were attributed to errors induced by the impression and model materials.[22] The design of this study with the same apparatus, record material, and epoxy models for each measurement eliminated the induction of errors caused by these parameters. Therefore the deviations were restricted only to the ones caused by recording and mounting procedures and not to the materials.

It became evident that the accuracy achieved by transferring the occlusal records was not reliable. Therefore a technique that would partly or totally eliminate this cause of inaccuracies could be valuable in clinical practice. In phase 3 of this study such a method was evalu-

ated. The record was incorporated in the impression material and was used for the construction of the opposing cast (unprepared teeth with simulated occlusal surfaces with cusps and fossae). Therefore the need for transferring by repositioning the record on this model was eliminated. On the other hand, transferring the record on the working model that contained the simulated prepared teeth still had to take place. However, considering that the morphologic features of the prepared occlusal surfaces are simpler, it was expected that the possibility for errors would be minor. The results demonstrated that the inaccuracy was greatly reduced although not completely eliminated, because the deviations were limited to these caused by the repositioning of the record on the prepared teeth. Group H (modified technique on the epoxy models) represented the application of this technique. The results showed also an improvement of the fit (mean value 135.8 μm and low SD 32.45 μm) in comparison with the one achieved by the classic technique (group F, mean value 404.1 μm, SD 162.63 μm). If repositioning on the prepared teeth could be eliminated, these values would eventually improve even more. However, the recording material used in this study has proved to be one of the most accurate. Nevertheless, recently produced recording materials of addition type silicones that present even higher accuracy should also be considered.

## CONCLUSIONS

The following conclusions were drawn from this study.

1. The observed vertical discrepancies in recording maxillomandibular relations are caused by the interference of the interocclusal records.

2. Repositioning or transferring the records aggravated these inaccuracies.

3. The modified technique that limits transferring of the record only on the working cast reduced the inaccuracies but did not completely eliminate them.

The authors would like to acknowledge the support of Ivoclar-Liechtenstein for providing the epoxy die material.

## REFERENCES

1. Myers ML. Centric relation records—historical review. J Prosthet Dent 1982;47:141-5.
2. Dawson PE. Evaluation, diagnosis and treatment of occlusal problems. St. Louis: Mosby, 1989:47-55.
3. Millstein PL, Clark RE. Determination of the accuracy of laminated wax interocclusal records. J Prosthet Dent 1983;50:327-31.
4. Balthazar-Hart Y, Sandrick JL, Malone WF, Mazur B, Hart T. Accuracy and dimensional stability of four interocclusal recording materials. J Prosthet Dent 1981;45:586-91.
5. Lassila Y. Comparison of five interocclusal recording materials. J Prosthet Dent 1986;55:215-8.
6. Lassila V, McCabe JF. Properties of interocclusal registration materials. J Prosthet Dent 1985;53:100-4.
7. Muller J, Gotz G, Horz W, Kraft E. Study of the accuracy of different recording materials. J Prosthet Dent 1990;63:41-6.
8. 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, I: plaster, impression compound, and wax. J Prosthet Dent 1990;63:263-9.
9. 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, II: polyester, acrylic resin, and corrected wax wafer. J Prosthet Dent 1990;63:389-95.
10. Balthazar YM, Ziebert GJ, Donegan SJ. Effect of interocclusal records on transverse axis position. J Prosthet Dent 1984;52:804-9.
11. Breeding LC, Dixon DL, Kinderknecht KE. Accuracy of three interocclusal recording materials used to mount a working cast. J Prosthet Dent 1994;71:265-70.
12. Strohaver RA. Comparison of articulator mountings made with centric relation and myocentric position records. J Prosthet Dent 1972;28:379-90.
13. Kantor ME, Silverman SI, Garfinkel L. Centric relation recording techniques—a comparative investigation. J Prosthet Dent 1972;28:593-600.
14. Lundeen HC. Centric relation records: the effect of muscle action. J Prosthet Dent 1974;31:244-53.
15. Simon RL, Nicholls JI. Variability of passively recorded centric relation. J Prosthet Dent 1980;44:21-6.
16. Wheeler RC. Dental anatomy, physiology and occlusion. 5th ed. Philadelphia: Saunders, 1974.
17. Assif D, Himel R, Grajower Y. A new electromechanical device to measure the accuracy of interocclusal records. J Prosthet Dent 1988;59:672-6.
18. La Deane Fattore, Malone WF, Sandrik JL, Mazur B, Hart T. Clinical evaluation of the accuracy of interocclusal recording materials. J Prosthet Dent 1984;51:152-7.
19. Hansen PA, Huff TL, Trebilcock CE. Centric interocclusal record analyzer. J Prosthet Dent 1985;54:851-3.
20. Dawson-Saunders B, Trapp RG: basic and clinical biostatistics. New York: Prentice-Hall, 1990.
21. Mullick SC, Stackhouse JA, Vincent GR. A study of interocclusal record materials. J Prosthet Dent 1981;46:304-7.
22. Odman PA, Jemt TM. Accuracy of impression materials in semiclinical model. Dent Mater 1988;4:64-7.

*Reprint requests to:*
Dr. Aris-Petros Tripodakis
92, Vas. Sophias Avenue
115 28 Athens
GREECE


0022-3913/97/$5.00 + 0. **10/1/78669**