

Comparative Study of the Effect of Three Different Interocclusal Recording Materials on Reproducibility of Horizontal Condylar Registrations in Two Different Semiadjustable Articulators: A Clinical Study

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ABSTRACT

Purpose: Simulation of jaw movements in an articulator requires one of the important condylar parameters, i.e. horizontal condylar inclination (HCI) to be registered in the patient and transferred to a mechanical device (articulator). The most popular and commonly used technique to determine horizontal condylar inclination (HCI) is by use of interocclusal records. Clinical studies comparing the effects of different interocclusal recording materials on reproducibility of protrusive settings in semiadjustable articulators have not been studied much. Hence, the present clinical study was conducted to comparatively assess the effects of three commonly used interocclusal recording materials; namely wax, polyvinylsiloxane, polyether in obtaining HCI values in two commonly used semiadjustable articulators; namely Hanau Wide-Vue (arcon) and Dentatus ARH type (non-arcon).

Materials and methods: One healthy female patient with intact dentition and no signs and symptoms of TMJ problems was selected for the study. With the help of a custom-made protrusive guide, 10 individual protrusive records for each of the interocclusal recording materials were made. These records were used for programming the two articulators and the respective HCI values were noted. The results obtained were tabulated and subjected to statistical analysis.

Results: The HCI values obtained using each of the interocclusal recording materials in both the semiadjustable articulators was found to be statistically significant. Among the materials polyether gave the highest values with less variability and wax gave low values with greater variation.

Conclusion: The results of this study indicate that HCI values vary both according to the type of interocclusal recording material employed and the articulator selected.

Keywords: Interocclusal recording material, Semiadjustable articulators, Horizontal condylar inclination.

INTRODUCTION

Diagnosis and treatment of a patient for a prosthetic rehabilitation requires that the clinician fabricate diagnostic casts, master casts and articulate them on an articulator.¹ Articulators have been devised to simulate mandibular movements to allow the fabrication of indirect restorations, which on insertion in the mouth can be properly integrated with normal masticatory function.²

It is necessary to record the maxillomandibular relationship and accurately transfer it to the articulator.¹ The facebow transfer the centric, lateral and protrusive jaw relation records together establish the simulation of mandibular function on the articulator.² Various types of facebows and adjustable articulators have been developed that varied in their accuracy in simulating the mandibular movements among which the

semiadjustable articulators are popularly used because of their simplicity in handling and programming in comparison to fully adjustable articulators.

The condylar inclinations provided in semiadjustable articulators are horizontal and lateral condylar inclinations. Horizontal condylar inclination (HCI) is usually obtained with protrusive interocclusal record and the lateral condylar inclination can be calculated either from horizontal condylar inclination using Hanau's formula or with individual lateral records.

The different techniques to record HCI have been discussed in the literature which includes interocclusal records, radiographic interpretation, extraoral recording devices like simplified mandibular motion analyzer (e.g. the mini recorder (Denar), quick set recorder (Whip Mix), mandibular motion

analyzer (Pandent)), pantography; mechanical and electronic (Denar) and light emitting diode (LED) mandibular tracing devices. The most popular technique for the determination of the horizontal condylar inclination is by the use of interocclusal record.³⁻⁵

The interocclusal records are used commonly because of their simplicity. The records should be an accurate and dimensionally stable representation of the interocclusal space that is subsequently transferred to an articulator. The different materials used as interocclusal recording medium are Plaster of Paris, wax, modeling compound, acrylic resin, zinc oxide paste and elastomers. These materials are used to obtain centric, protrusive and lateral interocclusal records. The protrusive interocclusal record is required for setting the horizontal condylar inclination in the articulator.^{6,7}

The degree of correlation of the accuracy of the records between patient and articulator depends on many factors like biological factors, properties of the materials and type of articulator. Comparative studies using interocclusal recording materials to record horizontal condylar inclination (HCI) have shown that selection of the material is an important factor to be considered. Most of the interocclusal recording materials were shown having varying degrees of reproducibility of condylar inclinations when used along with different semiadjustable articulators.⁸⁻¹⁰

The efficiency of different semiadjustable articulators, such as Whip Mix, Hanau 158 and Denar Mark II have been compared for reproducibility of condylar guidance registrations. Significant differences in HCI values between these articulators have been documented when wax protrusive records were used to program them.^{9,10} Most of the studies comparing the efficiency of interocclusal recording materials were done on the laboratory simulated models at MICP. Clinical studies comparing the effects of different interocclusal recording materials as to the levels of their accuracy and reproducibility of horizontal condylar registrations in semiadjustable articulators have not been studied adequately.

In view with the above, the present clinical study was conducted to comparatively assess the effects of three commonly employed interocclusal recording materials namely, interocclusal wax, polyvinyl siloxanes, and polyether in obtaining the horizontal condylar inclination (HCI) values in two semiadjustable articulators; namely Hanau Wide-View and Dentatus ARH type.

OBJECTIVES

1. To compare the reproducibility of horizontal condylar inclination values obtained using three different interocclusal recording materials in Hanau Wide-View semiadjustable articulator.
2. To compare the reproducibility of horizontal condylar inclination values obtained using three different interocclusal recording materials in Dentatus semiadjustable articulator.

3. To compare the values of horizontal condylar inclination obtained with each of the three types of interocclusal recording material and the two different semiadjustable articulators

METHODOLOGY

This study was conducted in the Department of Prosthodontics of Ragas Dental College, Chennai after obtaining informed consent from the patient.

Selection of the Subject

For the present study, a female patient aged 26 years, with a full complement of dentition (excluding the third molars) fulfilling the following criteria was selected:

1. Angle's class I molar and incisal relations
2. Absence of crowded or malaligned teeth
3. Absence of decayed/missing/restored teeth
4. Good oral hygiene and periodontal status
5. Absence of signs and symptoms of temporomandibular joint disorder.

Articulators and Interocclusal Materials used

Hanau Wide-View no. 183-2 (arcon) and Dentatus ARH type (non-arcon) semiadjustable articulators were selected for the study. The interocclusal recording materials used in the study were wax (Aluwax Dental Products Co., Michigan, USA), polyvinyl siloxane (Jet Bite, Coltene/Whaledent, Ohio, USA) and, polyether (Ramitec, 3M ESPE Dental Products, Germany).

Obtaining Maxillary and Mandibular Casts

Maxillary and mandibular perforated dentulous stock tray were used for making impressions with polyvinyl siloxane impression material (Aquasil, Dentsply). The obtained impression was rinsed, dried, inspected and disinfected with 2% glutaraldehyde (Cidex) for 10 minutes. Surfactant spray was used on both impressions and cast poured with type IV dental stone (Ultrarock, Khalabhai Karson Pvt. Ltd., Mumbai, India). The set casts were then retrieved, inspected, trimmed and finished with round plaster bases formed by the inversion method. This method was repeated to obtain another pair of maxillary and mandibular casts from the same impression.

Relating the Casts to the Articulators

Facebow Records

Facebow transfer records were made to relate the maxillary casts to the Hanau Wide-View and Dentatus ARH semiadjustable articulators using Spring Bow and arbitrary facebow TYPE AEB respectively. For both, the orbitale was used as third point of reference.

Obtaining Interocclusal Record at Maximal Intercuspal Position

In the present study, the mandibular cast was mounted on to the maxillary cast at maximal intercuspal position using wax bite wafer technique. In this technique, the baseplate wax was softened, adapted to the mandibular arch and the patient was instructed to bite in maximal intercuspal position, cuts are made with the help of scissors between the lateral incisor and the canine on each side and which served as the orientation tabs. Obtained wax records was trimmed, the mild indentations in the wax were washed with zinc oxide eugenol paste.

Articulator Preparation

Before the facebows are attached to their respective articulators, the articulator settings were adjusted/‘zeroed’ in the following way:

- In Hanau articulator, the protrusive inclination of both the condylar guidances were adjusted to 30°, Bennett angles of both condylar guidances to 30° and the incisal guide to 0°.
- In Dentatus articulator the protrusive inclination of both the condylar guidances are adjusted to 40°, Bennet angle to 20° and the incisal guide to 0°.
- For both the articulators, the guidelines specified in the respective manuals were followed.

Transfer of Facebow Records and Completion of Mounting

The two maxillary casts were mounted on to the upper members of the respective articulators using type II dental plaster (Khalabhai Karson Pvt. Ltd., Mumbai, India). Then the mandibular casts were articulated in maximum intercuspal position with the maxillary using the interocclusal record made at maximum intercuspal position.

Fabrication of the Protrusive Guide

In this study, a custom-made protrusive guide was fabricated prior to obtaining protrusive interocclusal record. The use of an anterior jig provides the desired amount of interocclusal space for the registration material and practically eliminates the risk of mandibular deviation due to muscle fatigue.^{1,7,8}

The jig was fabricated as follows:

Autopolymerizing clear acrylic resin (DPI – RR cold cure, Dental products India Ltd., Mumbai, India) was used to fabricate a custom-made anterior jig on a separate maxillary stone cast of the patient. Separating medium was applied on to the labial surface of the maxillary cast. The autopolymerizing acrylic resin was sprinkled on to the labial surface of the cast to cover the anterior teeth and the labial sulcus along with an extension 5 to 6 mm incisal to the two central incisors. After polymerization, the protrusive guide was retrieved from the model trimmed and adjusted in the patient’s mouth to guide

the mandibular anterior teeth repeatedly to the same protrusive edge-to-edge position. This position allowed 5 mm of anterior movement from the maximal intercuspal position to provide space for the registration material.^{8,11,12}

Making of Protrusive Interocclusal Records

The customized protrusive jig was inserted over the maxillary anterior teeth and the patient was trained to protrude the mandible as guided by the jig. The methodology adopted for obtaining the protrusive interocclusal recording with these three materials was done as per the manufacturer’s instruction.

Ten protrusive interocclusal records were made with each material and transferred to each of the articulators. In particular, two sets of 10 protrusive records each, for the two different articulators were made with interocclusal recording wax to avoid errors in programming due to distortion of wax. All records were trimmed of the excess material such that only the imprint of cusp tips remained on the trimmed record.

The semiadjustable articulators are programmed to obtain the readings for horizontal condylar inclination for both the right and the left side using the polyvinyl siloxane (Jet Bite, Coltene/Whaledent, Ohio, USA) and Polyether (Ramitec, 3M ESPE Dental Products, Germany) interocclusal records.

Thus, summing up the methodology, with each interocclusal recording material, 10 protrusive records were obtained. With these records, HCI values for each articulator was programmed (on right and left sides) and these values were noted. Therefore 30 records (from 3 materials) gave 60 HCI readings (right and left side) for each articulator. These values were subjected to statistical analysis and inferences drawn.

RESULTS

The interocclusal recording materials wax (Aluwax), polyvinyl siloxane (Jet Bite) and polyether (Ramitec) were assigned as three groups as mentioned below:

- G1 represents wax (Aluwax)
- G2 represents polyvinyl siloxane (Jetbite)
- G3 represents polyether (Ramitec) respectively

Tables 1 to 3 and Figures 1 to 3 show the basic data of the results obtained in this study of the HCI values in Hanau Wide-Vue and Dentatus ARH type semiadjustable articulators.

The results were subjected to statistical analysis.

The mean, standard deviation of Tables 1 to 3 were found and tabulated in Table 4 and Figure 4.

The results of Table 4 were further subjected to tests of significance namely.

Independent t-test, student-Newman-Keuls test, two tailed t-test followed by two-way analysis of variances to compare the reproducibility of HCI values using three different interocclusal recording materials in two different semiadjustable articulators.

Table 1: HCI values for G1 in two different semiadjustable articulators

Sl.no	HCI in degrees			
	Hanau		Dentatus	
	Right	Left	Right	Left
1.	40	30	42	38
2.	38	26	41	40
3.	35	25	45	35
4.	33	33	42	33
5.	40	28	43	35
6.	35	25	35	40
7.	30	24	36	30
8.	38	20	42	28
9.	34	32	43	33
10.	28	35	45	38

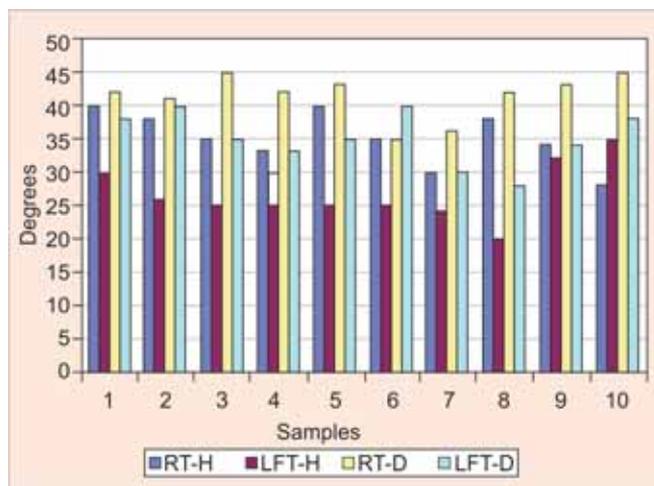


Fig. 1: HCI values for G1 in two different semiadjustable articulators

Table 2: HCI values for G2 in two different semiadjustable articulators

Sl.no	HCI in degrees			
	Hanau		Dentatus	
	Right	Left	Right	Left
1.	40	41	44	45
2.	39	37	45	45
3.	40	40	44	44
4.	38	37	43	43
5.	40	39	43	42
6.	39	37	43	42
7.	39	39	42	42
8.	38	38	44	44
9.	38	36	43	43
10.	39	38	45	44

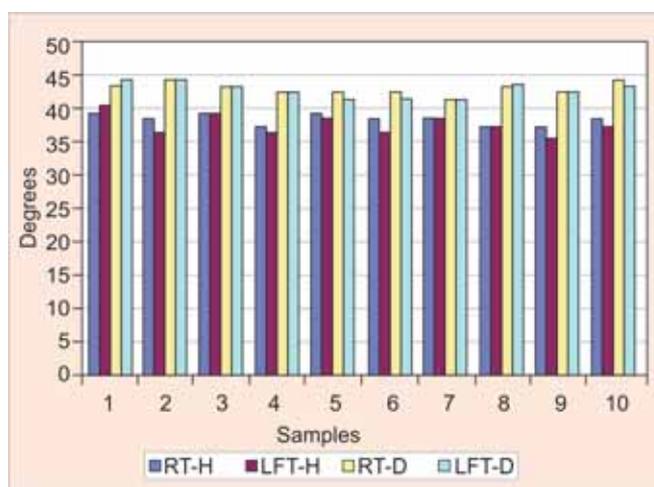


Fig. 2: HCI values for G2 in two different semiadjustable articulators

Table 3: HCI values for G3 in two different semiadjustable articulators

Sl.no	HCI in degrees			
	Hanau		Dentatus	
	Right	Left	Right	Left
1.	44	44	49	49
2.	44	42	52	51
3.	44	44	50	50
4.	43	41	50	51
5.	42	40	49	49
6.	43	41	51	50
7.	43	41	49	50
8.	42	42	50	51
9.	43	43	52	51
10.	42	40	52	52

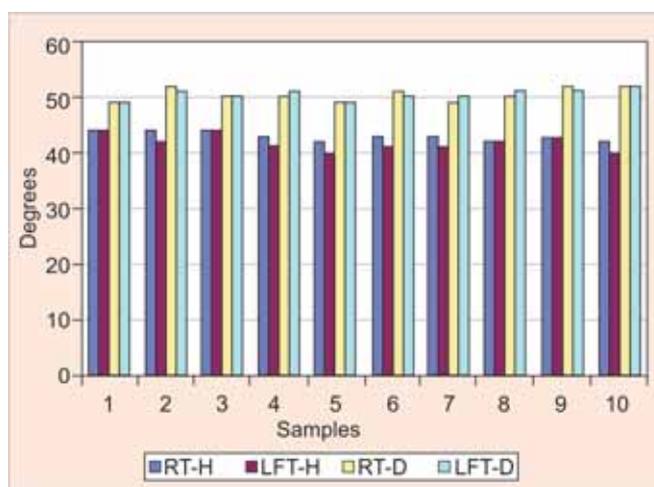


Fig. 3: HCI values for G3 in two different semiadjustable articulators

In the present study, $p \leq 0.001$ was considered as the level of significance. Independent t-test (Tables 5 to 7) was used to compare the means of HCI values obtained by using G1, G2, and G3 in two different semiadjustable articulators. Since the p-value was ≤ 0.01 , the HCI values using G1, G2, G3 on both the articulators were found to be statistically significant.

Student-Newman-Keuls test (Tables 8 and 9) was used to compare the means of HCI values obtained in Hanau Wide Vue semiadjustable articulator using G1, G2, G3. Since the p-value was ≤ 0.01 , the HCI values using three different interocclusal recording materials were found to be statistically significant. Two tailed t-test (Tables 8A and 9A) was used to

Table 4: Estimation of mean and standard deviation of HCI values for G1, G2, G3 in two different semiadjustable articulators

Bite registration materials	Articulators	Right		Left		Net mean
		Mean	SD	Mean	SD	
G1	Hanau	35.10	4.04	27.8	4.17	31.45
	Dentatus	41.40	3.37	35.00	4.08	38.20
G2	Hanau	39.00	0.82	38.20	1.55	38.60
	Dentatus	43.60	0.97	43.40	1.17	43.50
G3	Hanau	43.00	0.82	41.80	1.48	42.40
	Dentatus	50.40	1.26	50.40	0.97	50.40

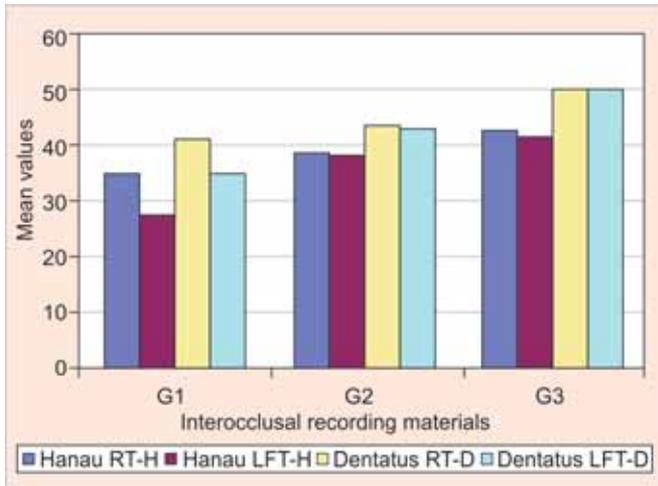


Fig. 4: Comparison of mean of HCI values obtained by using G1, G2, G3 in two different semiadjustable articulators of right and left sides

Table 5: Test of significance for comparison of mean of G1 in two different semiadjustable articulators

Articulators	Right side	Left side	Net mean
	Mean	Mean	
Hanau	35.10	27.80	31.45
Dentatus	41.40	35.00	38.20

p-value: 0.000**

Note: **Denotes statistically significant at 1% level

Table 6: t-test of significance for comparison of mean of G2 in two different semiadjustable articulators

Articulators	Right side	Left side	Net mean
	Mean	Mean	
Hanau	39.00	38.20	38.60
Dentatus	43.60	43.40	43.50

p-value: 0.000**

Note: **Denotes statistically significant at 1% level

compare the reproducibility of HCI values for each material (on both right and left sides). The p-value obtained using G2, G3 was not ≤ 0.01 hence was found to be statistically not significant whereas that of G1 was found to be statistically significant. Likewise, tests with Dentatus showed similar results.

Table 7: Test of significance for comparison of mean of G3 in two different semiadjustable articulators

Articulators	Right side	Left side	Net mean
	Mean	Mean	
Hanau	43.00	41.80	42.40
Dentatus	50.40	50.40	50.40

p-value: 0.000**

Note: **Denotes statistically significant at 1% level

Table 8: Test of significance for comparison of mean of G1, G2, G3 in Hanau Wide-Vue semiadjustable articulator

Bite registration materials	Right side	Left side	Net mean
	Mean	Mean	
G1	35.10	27.80	31.45
G2	39.00	38.20	38.46
G3	43.00	41.80	42.40

p-value: 0.000**

Note: **Denotes statistically significant at 1% level

Table 8A: Test of significance for comparison of means of HCI values obtained using G1, G2, G3 in Hanau Wide-Vue no. 183-2 semi-adjustable articulator of both right and left sides

Groups	Sig. (2-tailed) p-value
G1	0.00**
G2	0.166*
G3	0.035*

Note: *Denotes statistically not significant, **Denotes statistically significant at 1% level

Table 9: Test of significance for comparison of means of G1, G2, G3 in Dentatus ARH type semiadjustable articulator

Bite registration materials	Right side	Left side	Net mean
	Mean	Mean	
G1	41.40	35.00	38.20
G2	43.60	43.40	43.50
G3	50.40	50.40	50.40

p-value: 0.000**

Note: **Denotes statistically significant at 1% level

Table 9A: Test of significance for comparison of means of HCI values obtained using G1, G2, G3 in Dentatus ARH type semiadjustable articulator of both right and left sides

Groups	Sig.(2-tailed) p-value
G1	0.00**
G2	0.682*
G3	1.000*

Note: *Denotes statistically not significant, **Denotes statistically significant

Table 10: Two-way Anova test for comparison of mean of HCI values obtained by using G1, G2, G3 in two different semiadjustable articulators

Bite registration materials	Articulators			
	Hanau		Dentatus	
	Right	Left	Right	Left
G1	35.10	27.80	41.40	35.00
G2	39.00	38.20	43.60	43.40
G3	43.00	41.80	50.40	50.40

p-value: 0.000**

Note: **Denotes statistically significant at 1% level

Two-way analysis of variance (Table 10) was done to compare the interactions of each of the interocclusal recording materials with two semiadjustable articulators in determination of HCI values. Since, the p-value was ≤ 0.001 it was found to be statistically significant.

DISCUSSION

In this study, a single subject, aged 26 years, with a full complement of dentition, with Angle’s class I molar relation and absence of signs and symptoms of temporomandibular joint disorders was selected. This was done to overcome any bias in registering HCI values as influenced by anatomy of the joints, and, teeth position and contacts, if multiple subjects are employed in the study. Models obtained were articulated at maximal intercuspal position (MICP) via bite registration records. Though centric relation records are commonly used, articulation at MICP is recommended when more than three interocclusal points of contact (i.e. two posterior and one anterior interdigitation) are available.¹³

A custom-made protrusive guide fabricated helped to achieve the desired amount of interocclusal space for the recording material and practically eliminated the risk of mandibular deviation due to muscle fatigue. The amount of protrusion has direct influence on the amount of separation between the posterior teeth and on somatognathic apparatus. A minimum of 5 mm anterior movement along the protrusive pathway is recommended to measure the HCI value and the same was employed in this study.¹⁴⁻¹⁷

A total of 30 (3 × 10) records obtained were used to program each articulator, hence, gave 60 HCI values. In

particular, two sets of protrusive records for the two different articulators were made with wax to avoid errors in programming due to distortion of the wax. The records were used immediately to program the articulator to reduce the time dependant distortion which has been observed in previous studies. The results obtained were tabulated and subjected to statistical analysis.

Table 5 showed the mean HCI values for Aluwax was 35.10 (right side) and 27.80 (left side) on Hanau (arcon), and 41.40 (right side) and 38.20 (left side) on Dentatus (non-arcon). The mean inclination for Dentatus was higher than mean of Hanau by 7 to 8°. Comparison by independent t-test (p-value ≤ 0.01) showed the HCI values obtained using Aluwax on both the articulators to be statistically significant.

The mean HCI values using polyvinyl siloxane in Dentatus were higher than mean of Hanau by 5 to 6°. Also, the mean HCI values using polyether were higher in Dentatus than Hanau by 8 to 9°. Since the p-value in Table 6, 7 were ≤ 0.01 , the HCI values obtained using polyvinyl siloxane and polyether on both the articulators were found to be statistically significant.

HCI values obtained with each of the three interocclusal recording materials were higher in Dentatus compared to that HCI values obtained in Hanau irrespective of the materials used. This can be attributed to the basic differences in the machining of the two articulators. Relevant literature shows that when teeth are closed on a non-arcon articulator, the condylar inclination becomes less steep and the angle changes between the open and closed positions of the non-arcon articulator.^{13,18} This could be one of the factors responsible for these differences.

The use of semiadjustable articulators using interarch records has shown low level of reproducibility and was subject to variables of occlusal registrations and instruments. High levels of inconsistency in condylar guidance settings between materials and instruments have been reported.¹⁹ Differences between the protrusive condylar guidance registrations obtained from the interocclusal records and those obtained from pantographic tracings have been demonstrated.²⁰ While the instruments being programmed with interocclusal records were set to static positions, pantographs presumably recorded not only specific jaw positions but also the entire range of excursive jaw movements.⁶

Earlier studies^{7,8} conducted to compare and evaluate the recording range and efficiency of three arcon semiadjustable articulators; namely, Denar Mark 11, Hanau 158 and Whip Mix using interocclusal records showed that semiadjustable articulators using interocclusal records have a low level of reproducibility compared to that of pantographic readings and was subject to variables of instrument, operator and interocclusal records. Also, comparative studies of sagittal condylar inclination values determined using intraoral protrusive interocclusal records to those using various extraoral methods of tracing the condylar path concluded that extraoral tracing methods gave higher values with less variation than

the intraoral methods. Among the extraoral methods, studies showed that electronic pantography provided measurements more accurate and reproducible.^{3,5,16,20-25}

The mean HCI values for wax, polyvinyl siloxane, polyether were 35.10, 39.00, 43.00 (right side) and 27.80, 38.20, 41.80 (left side) respectively on Hanau Wide-Vue semiadjustable articulator. The mean HCI values for wax, polyvinyl siloxane, polyether were 41.40, 43.60, 50.40 (right side) and 35.00, 43.40, 50.40 (left side) respectively on Dentatus ARH type semiadjustable articulator. Since the p-value (≤ 0.01) in Tables 8 and 9, the HCI values obtained using three materials on both the articulators were found to be statistically significant. In Tables 8A and 9A the p-value obtained using wax was found to be statistically significant and thus found to be highly variable and unreliable as interocclusal recording material.

Previous laboratory and clinical studies describe Aluwax as least reliable due to their high coefficient of thermal expansion, high resistance to closure and the thermoplastic nature of the material.²⁶⁻²⁸ Literature shows protrusive condylar guidance registration using waxes show greater variation with ranges up to 10° between articulators.^{19,29-31}

Another comparative study found that protrusive condylar pathway recorded with the wax interocclusal records averaged 17° less than Whip Mix analyzer and 6° less than the Panadent analyzer.³¹ Among the materials studied, elastomers as interocclusal recording materials consistently yielded least errors and was found to be reliable recording material.^{12,29,32,33} Also polyvinyl siloxane exhibited the greatest resistance to compression,^{15,34,35} and polyether and polyvinyl siloxane produced lowest vertical discrepancy in mounted casts with greatest by wax.^{29,36-39} The results of this study were in concurrence with observations of previous studies that interocclusal recording wax was the least reliable of the three materials used.

Future studies with inclusion of other parameters like the use of fully adjustable articulators with extraoral recording devices, number of patients, HCI recorded at different levels of protrusion can pave way for more predictable results.

CONCLUSION

The following were the levels of reproducibility of HCI values in two semiadjustable articulators within the three different interocclusal recording materials:

1. Polyether and polyvinyl siloxanes interocclusal recording materials exhibited very minimal variation in HCI values in both the articulators.
2. Wax exhibited wide variation in HCI values for both the articulators.

Comparative evaluation of the mean HCI values obtained using three different interocclusal recording materials in two different semiadjustable articulators revealed that irrespective of the recording material employed; a significant difference in HCI values exists between two different semiadjustable articulators.

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