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Comparison of Condylar Inclination Attained by Interocclusal Records, Graphic Tracer and Arcus Digma II and Their Effect on Bilateral Balanced Occlusion

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ABSTRACT

Purpose: Was to compare between the interocclusal record for protrusive movement, the tracing method and the electronic face bow (Arcus Digma) for recording horizontal condylar guidance and their effects on bilateral balanced occlusion. **Material and Methods:** Ten completely edentulous patients with an average age of 55 years old participated in this study. Each patient received upper and lower complete denture, artificial teeth were arranged according to balanced occlusion concept. The horizontal condylar angle was recorded during patient mandibular protrusion of 6mm using the following techniques; interocclusal record, tracer (quick set analyzer) and electronic face bow (Arcus Digma II). **Results**: The horizontal condylar guidance values of both right and left sides obtained from interocclusal record for protrusive movement, tracing method as well as electronic face bow (Arcus Digma II) showed no statistically significant differences (P>0.05) using ANOVA test (at 95% confidence interval). Arcus Digma II method recorded the centric relation at a more posterior position than other methods, However, it could not make any difference in clinical performance of the complete denture. Horizontal condylar guidance angle was approximately similar by the three techniques. **Conclusion:** Arcus Digma II seemed a reliable and promising method to be used in recording patient's horizontal condylar angle as an alternative to the interocclusal and tracer methods.

KEYWORDS

Condylar angle, Arcus Digma, Occlusion.

- Paper extracted from Doctor thesis titled "Comparison of Condylar Inclination Attained by Interocclusal Records, Graphic Tracer and Arcus Digma II and Their Effect on Bilateral Balanced Occlusion."

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INTRODUCTION

Success of complex prosthodontic procedures is improved by delicate simulation of condylar path of patient on articulator, it allows the clinicians to evaluate the correlation between the path traced by the condyle during mandibular movements and the morphology of the occlusal surfaces which assists in restoring the occlusion without interferences [1,2].

Mandibular movement is intricate and difficult to describe appropriately. The mandible moves relative to the maxilla by the effect of two influences, to start with locomotive forces which are provided by muscles under the effect of the neuromuscular control. Moreover, the temporomandibular joint as well as occlusal surfaces of the posterior teeth as a hard tissue guidance system. [3].

Bilateral balanced occlusion preserves the stability of complete dentures during the chewing and setting of artificial teeth in that occlusal arrangement decreases the active loading of supporting tissue and edentulous ridge [4]. It limits the tilting of the dentures and thus minimizes disruption of the peripheral seal and risk of instability and so it improves the masticatory function by offering more grinding surfaces in contact at each movement [5].

The aim of protrusive jaw relation is to set the condylar elements of the articulator so that they will reproduce inclinations, which are resemble or comparable to that of the patient's temporomandibular articulation. If condylar guidance is not recorded precisely, it will result in occlusal interferences during mandibular movements [6].

Intraoral recording method is the most frequently used technique. It is simple and quick, and more applicable procedure in regular clinical practice. The choice of material used for records, the method of recording as well as the skill of therapist are the main factor to achieve the accuracy of adjustment[7,8].

Extraoral graphic tracings are visible while the tracings are being made. Therefore, the patient can be guided and directed more intelligently during the mandibular movements. However, the method has limitations due to possible errors in the equipment used, clinician's capability, and in linear movement of the articular complex regardless of actual morphology of the condylar fossa [9].

Recently, such limitations could be avoided by using electronic face bow (Arcus digma II) system which records and analyses mandibular movement in three dimensions with ultrasonic electronic sensor to measure condylar guidance on a computer. Real-time reproduction of mandibular movement can be shown on the monitor, and condylar guidance can be identified [10].

MATERIAL AND METHODS

Ten completely edentulous patients participated in this clinical study design. All patients accepted this dental treatment and informed about the steps of this study and signed a written consent with Research Ethics Committee (REC) approval of faculty of dental medicine for girls was obtained with code (REC-PR-21-01).

The patients were selected to have their ridges covered with firm, thick and compressible mucosa, free from any signs of TMJ disorder. Patients with limited mouth opening or mandibular movement, muscle spasm or tenderness and mandibular deviation were excluded. Patient history and clinical examination for medical, dental, extra oral and intra oral were taken.

Complete denture construction**;** For each patient primary and final impression for upper and lower ridges were made by conventional technique to produce final cast. Upper and lower trial denture bases, as well as modeling wax occlusion rims, were created on the master cast using Auto-polymerizing acrylic resin. Face-bow record was made using Hanau spring bow. The maxillary cast was mounted to (Hanu 96 H2) semi adjustable articulator, the upper member of the articulator is mounted using plaster of Paris. The centric relation record was recorded using interocclusal wax record. The wax

record that used for centric relation registration was separated from the lower record block and was kept in cold water. Mounting the mandibular cast; using centric relation record was carried out using plaster of Paris to attach the lower cast to the articulator's lower compartment.

Protrusive record registration; 3mm thickness of soft compound material was added to the lower record block. The patient was instructed to protrude the mandible 6mm and close his mouth. The compound used for protrusive relation registration was separated from the lower record block and was kept in cold water. The horizontal condylar guidance of the articulators was adjusted according to the protrusive record. The lateral condylar guidance of both sides obtained from Hanau equation L=H/8+12.

Semi anatomical teeth were used for teeth setting. Teeth were aligned to balanced articulation. Denture was waxed up, tried at the patient's mouth and processed into heat cured acrylic resin.

Clinical remounting: occlusal adjustment of the finished denture was done by using plaster index. Centric, protrusive and lateral records without teeth contact and any occlusal disharmony was eliminated.

Complete denture duplication: The complete denture for each patient was duplicated by conventional method for experimental work. The patient wears the duplicated denture for registrations of the horizontal condylar angles using three groups in measuring modality.

Techniques:

In this study, the interocclusal records method was used as control to compare between it and graphic tracing method and the electronic facebow Arcus Digma II in recording horizontal condylar angle.

a- The patient was asked to wear duplicated denture then right and left horizontal angles were recorded by using inter occlusal record of protrusive movement as mentioned before.

b- The graphic tracer method (whip mix).

- The graphic tracer was adjusted to the patient's axis orbital plane, then the hinge axis on both sides was drew on the card with a flexible ruler.

The head band was attached and the nasion part was adjusted on nasion of the patient. The bite fork of the Quick set recorder was attached to the lower record block fixed to the mandible by mandibular clamp. Apiece of graphic recording paper was attached to each flag. The patient was seated in an upright, comfort position with the jaw in the most retruded position.

The patient was instructed to move his jaw from the most retruded position to 6mm protrusive to record the horizontal condyle curve on the graphic paper in two sides as shown as (Fig. 1). The curve was magnified 10 times and calculated using a mathematical method. Four arbitrary points (1-4) were selected on each curve to include the whole curve. From points (2-4) horizontal lines were drawn (parallel to the axis-orbital plane) and from points (1-3) vertical lines were dropped into the horizontal lines. The slope of the angles (a, b and c) was calculated from the following equation:

Slope = Vertical distance ÷ horizontal distance

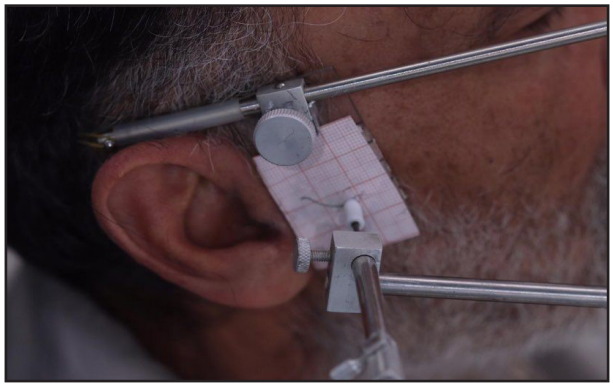

Figure (1) The graphic method trace.

The angles were calculated by reversing its slope using a scientific calculator (Casio, FX-82C, Japan). The mean of the three values for each

curve was calculated and the mean of the three curve angulations was considered as the condylar inclination of this side. The procedure was repeated to achieve the condylar inclination of the other side for each patient.

Electronic face bow (Arcus Digma II) shown as (Fig .2);

The lower denture was poured during the preparation stage to create a new cast to remain stable the lower denture. The lower denture was placed in the cast. Light cure acrylic resin was used to adjust the mandibular clutch to the lower denture. The light cure acrylic resin was molded into a festoon shape on the cervical area of the teeth. After shaping, the light cure acrylic was cured using a side bench light cure apparatus.

The upper and lower dentures were worn by the patient, with the lower denture having a fixed clutch. The Arcus Sevo face bow was attached to the patient's head with an ear plug, fixed to the ear, and the nasion component of the face bow was attached to the patient's nasion with a screw tightened. The lower clutch was interlocked with the projection of the Arcus Digma II transmitter by opening on the handle of clutch.

The connecting device is worn around the patient's neck to send the electronic waves of mandibular motion to the Arcus Digma II basic unit. During the work on the Arcus Digma II basic unit, fill in the information on the first page (date, doctor name and patient name). The green light for each sensor was examined on the screen to ensure that all sensors were connected. Open the "Measuring programs", choose the measuring option to calculate the angle, articulator, arbitrary axis.

After selecting the axis, the comment for the pointer was attached to the lower bow to determine the arbitrary location of the left and right condyle, as well as the infraorbital notch. as shown in (fig. 2).

The patient was instructed to slowly protrude and retrude the mandible. The patient was told to start by pressing the foot control, which would allow the device to start tracing the movement as shown (fig. 3). The device took the average of the right and left horizontal condylar angles after the patient repeated this movement three times.

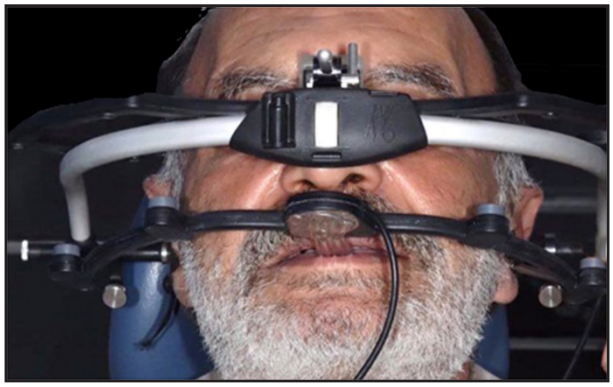

Figure (2) Electronic (Arcus Digma II) face bow

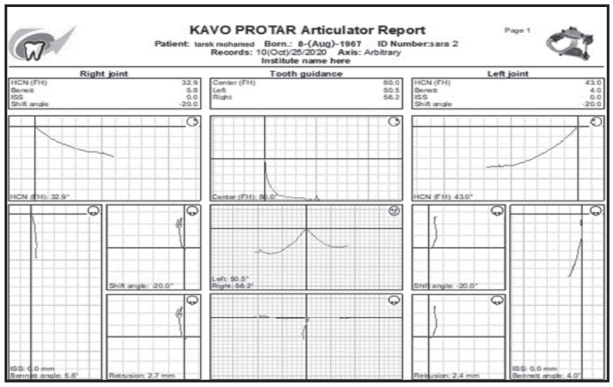

Figure (3) Recording curves by (Arcus Digma II).

The effect of horizontal condylar angles records on balanced occlusion.

The duplicate denture and occlusal adjustment were carried out to establish even bilateral occlusal contact at premolar and molar region in centric relation and to remove any interference in protrusive and lateral relations. The articulator was locked in centric relation. The maxillary and mandibular second molars were removed from both maxillary and mandibular dentures. One cm square metal plates with graphic paper were fixed in the lower second molar positions by Auto-polymerizing

acrylic resin. Metal tubes with internal diameters 0.44mm were fixed by Auto-polymerizing acrylic resin in place of maxillary second molars. The lateral guidance was adjusted according to Hanu's equation, horizontal guidance adjusted according to three methods technique (Protrusive interocclusal record, graphic tracing record, and electronic face bow). On balanced side record mesiodistal and buccolingual perpendicular lines and direct distance errors were measured by digital caliper. All data were collected, statistically analyzed to compare between the three methods and evaluate their effects on balanced occlusion.

Statistical analysis

Numerical data was explored for normality by checking the data distribution, calculating the mean and median values and using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data showed parametric distribution so; it was represented by mean and standard deviation (SD) values and was analyzed using ANOVA test. The significance level was set at $p \leq 0.05$ for all tests. Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 26 for Windows.

RESULTS

1- Horizontal guidance angle:

- ***Right side:***

The highest value was measured with electronic records (39.38±9.61) followed by tracing (36.17±5.46) while the lowest value was found with the interocclusal records (35.00±6.36). Results of repeated measures ANOVA revealed that there was no significant difference between three records (p=0.322).

- ***Left side:***

The highest value was measured with electronic record (37.78±11.91) followed by interocclusal (34.50±4.23) while the lowest value was found with the tracing records (32.75±3.60). Results of repeated measures ANOVA revealed that there was no significant difference between three records (p=0.488).

Mean, standard deviation (SD) values of horizontal guidance angle and results of ANOVA test were non-significant different between three methods and results of repeated measures ANOVA test was shown as (fig. 4).

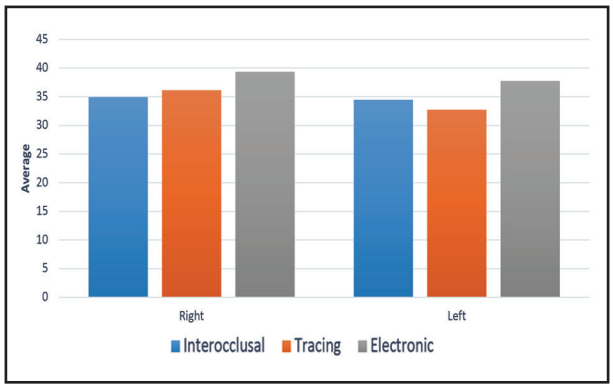

Figure (4) Bar chart showing average horizontal guidance angle

Balanced contact measurements with different horizontal condylar path inclination records:

Mean, Standard deviation (SD) values of balanced contact measurements with different horizontal condylar path inclination records and results of repeated measures ANOVA were presented in table (1) and (fig .5)

A- Right side:

- ***Mesiodistal:***

The highest value was measured with interocclusal record (2.20±0.37) and electronic (2.20±0.51) records, while the lowest value was found with the graphic tracing record (2.00±0.55). Results of repeated measures ANOVA revealed that there was no significant difference between three records (p=0.464).

- ***Buccolingual:***

The highest value was measured with the electronic record (1.68±0.38) followed by interocclusal record (1.65±0.41), while the lowest value was found with the graphic tracing record (1.63±0.29). Results of repeated measures ANOVA revealed that there was no significant difference between three records (p=0.688).

- ***Direct:***

The highest value was measured with the electronic record (2.38±0.43) followed by inter occlusal record (2.22±0.35), while the lowest value was found with the graphic tracer record (2.14±0.50). Results of repeated measures ANOVA revealed that there was no significant difference between three records (p=0.153).

B-Left side:

- ***Mesiodistal:***

The highest value was measured with the graphic tracer record (2.19±0.63) while the lowest value was found in interocclusal record (2.03±0.34) and electronic (2.03±0.56) records, Results of repeated measures ANOVA revealed that there was no significant difference between three records (p=0.442).

- ***Buccolingual:***

The highest value was measured with the interocclusal record (1.81±0.64) followed by the electronic record (1.64±0.34), while the lowest value was found with the graphic tracer record (1.47±0.39). Results of repeated measures ANOVA revealed that there was no significant difference between three records (p=0.097).

- ***Direct:***

The highest value was measured with the electronic record (2.36±0.48) followed by graphic tracer record (2.31±0.38), while the lowest value was found with interocclusal record (2.30±0.58). Results of repeated measures ANOVA revealed that there was no significant difference between three records (p= 0.881).

Table (1) *Mean, Standard deviation (SD) values of balanced contact measurements with different horizontal condylar path inclination recorded by ANOVA test.*

Side	Measurements	Horizontal path inclination records (mean±SD)			P-value
		Inter occlusal	Graphic tracer	Electronic	
Right	Mesiodistal	2.20±0.37	2.00±0.55	2.20±0.51	0.464ns
	Buccolingual	1.65±0.41	1.63±0.29	1.68±0.38	0.688ns
	Direct	2.22±0.35	2.14±0.50	2.38±0.43	0.153ns
Left	Mesiodistal	2.03±0.34	2.19±0.63	2.03±0.56	0.442ns
	Buccolingual	1.81±0.64	1.47±0.39	1.64±0.34	0.097ns
	Direct	2.30±0.58	2.31±0.38	2.36±0.48	0.881ns

**; significant (p ≤ 0.05) ns; non-significant (p >0.05)*

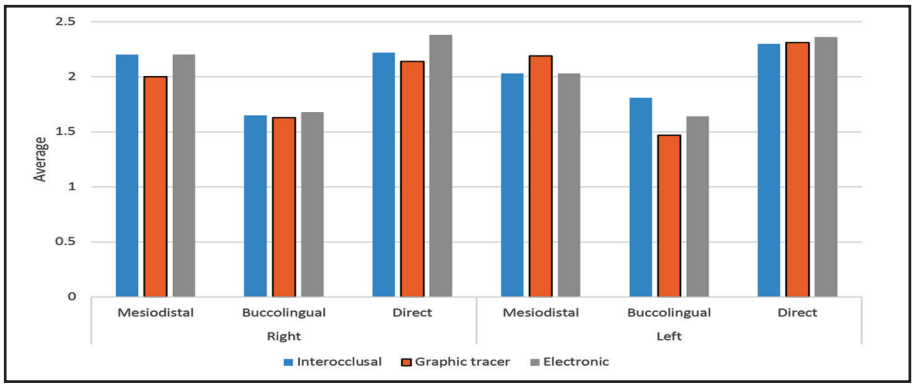

Figure (5)
Bar chart showing average balanced contact measurements with different horizontal condylar path inclination records.

DISCUSSION

In the present study, there is a comparison between different methods interocclusal wax, graphic tracer method (quick set analyzer) and electronic face bow (Arcus Digma II) to determine the horizontal condylar guidance and evaluate their effect on bilateral balanced occlusion. All the patients were selected to have normal jaw relationship and assessed clinically to have normal temporomandibular joint, because the relationship has not been established between occlusion and temporomandibular disorder (TMD), which can influence the protrusive movement of the mandible.

The balanced occlusion is described as the occlusal contacts between maxillary and mandibular teeth initially in maximum intercuspation and their continuous contacts during movements from this position along specific working, balancing and protrusive guidance pathways developed on the occlusal surface of the teeth. It is considered an ideal occlusion for complete dentures. The purpose of providing balanced occlusion is to permit stabilization of the dentures as the mandible moves into eccentric positions.[11]

In this study, statistically insignificant differences for the tested variables were found, which could have been expected in respect to limitation of selected sample and its age range. This study revealed insignificant difference between the three methods and there is no difference between right and left side and insignificant difference in their effect on balanced occlusion.

The result of this study is agreed with previous studies which based on the fact that there is a bilateral symmetry of the right and left sagittal condylar guidance on both sides by using protrusive interocclusal records in patient free from any TMJ disorders [12].

In the present study, the interocclusal record method was utilized to adjust condylar guidance due to its simplicity, so it is usually provided in daily clinical practice. In counter opinion, other study demonstrated that the clinical results of this method could be affected by the thickness of the material used during registration by using check bite and it was revealed that when the thickness of wax is 3 mm the maximum of 0.312 mm error can be occurred [13].

On the other hand, recent study reported that interocclusal method to record condylar guidance angle have lower level of reproducibility and are subjected to variations of the operator skills, instruments, and depend on the type and thickness of the material used [14].

In this study, there is no significant difference between interocclusal record and extraoral tracer, in counter of apparent other study which reported that the sagittal condylar angle recorded by intraoral bite

registration materials would be less than extraoral tracer average which comes in agreement other researches [15]. The extraoral tracings are visible while the tracings are being made. Therefore, the patient can be guided and directed more intelligently during the mandibular movements. Graphic tracer records the whole condylar pathway, and show the mean measurement according to the amount of condylar travers [16].

This comes in agree with a review of the literature on the average values of condylar path inclination have shown large variations, that might be came as a result of the different study sample sizes, different measurement methods for the condylar inclination according to different referential planes [17].

In counter of this study, when comparing the average values of horizontal condylar inclination recorded by means of protrusive interocclusal record and extraoral tracer. Statistical analysis showed that a match between these two methods, but it was insufficient in order to be reliably used for dental articulator programming in clinical conditions. The values of condylar path inclination obtained based on protrusive eccentric record, showed a high variance in relation to the values obtained with extra oral tracer. In conclusion, they recommend using a extraoral tracer in relation to protrusive records with the aim of individualized adjustable dental articulator programming [12].

This study selects to use Arcus Digma system as it might be allowing more accurate and quick processes for clinicians and technicians using electronic sensor which aid in condylar guidance measurements in the similar manner with the pantograph. However, there still are limitations in inconvenience clinical error production, and lack of enough data. More researches are required in order to overcome such limitations to produce a new one, reliable method [18].

The accuracy of Arcus Digma II revealed that it is an upgraded model, has increased number of ultrasonic sensors and thus can measure condylar guidance quicker than Arcus Digma I system. However, the increased weight of the sensors pulled the face bow downward constantly which will result in some difficulty in the measurements. Also, there is insignificant difference was found in measured data compared to Arcus Digma I system, so more researches are needed to determine the accuracy in measurements [19].

In agree with this study, that condylar movement in the sagittal direction is uniform; indeed, there was an insignificant difference between both left and right sides of the measured condylar inclination, their measurements were carried out with Arcus Digma II device, and the test group was almost identical as in this study [18].

CONCLUSION

Arcus Digma II seemed a reliable in interchangeability and promising to be used in horizontal condylar angle as interocclusal record and tracer so it can be used as alternative technique for them.

RECOMMENDATION

Arcus Digma II seemed a reliable in interchangeability and promising to be used in horizontal condylar angle as interocclusal record and tracer so it can be used as alternative technique for them. Further study of Arcus Digma II in complete denture to evaluate its effect on different occlusal schemes.

CONFLICT OF INTEREST

None declared

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