



ISSN: 0976-3031

Available Online at <http://www.recentscientific.com>

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 10, Issue, 07(F), pp. 33715-33720, July, 2019

**International Journal of
Recent Scientific
Research**

DOI: 10.24327/IJRSR

Research Article

CLINICO-RADIOGRAPHIC COMPARATIVE EVALUATION OF HORIZONTAL CONDYLAR GUIDANCE ANGLE BY INTEROCCLUSAL WAX RECORD, CBCT AND GOTHIC ARCH TRACING METHOD- AN IN VIVO STUDY

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DOI: <http://dx.doi.org/10.24327/ijrsr.2019.1007.3732>

ARTICLE INFO

Article History:

Received 6th April, 2019

Received in revised form 15th May, 2019

Accepted 12th June, 2019

Published online 28th July, 2019

Key Words:

HCGA, CBCT, Interocclusal wax record,
Gothic arch tracing

ABSTRACT

Background/Purpose: The aim of this study was to compare the horizontal condylar guidance angulation (HCGA) values obtained by using interocclusal wax record, cone beam computed tomography (CBCT) and Gothic arch tracing method in edentulous patients.

Materials and Method: A total of 15 (n=15) completely edentulous patients were selected for this study according to inclusion and exclusion criteria. Horizontal condylar guidance angulation (HCGA) was recorded for each patient by three methods: interocclusal wax record method, cone beam computerized tomography (CBCT) and Gothic arch tracing. Statistical analysis of comparison amongst three methods was evaluated by *Student t-test* and *Two-way ANOVA* at a significance level of 0.001 (p value < 0.001 significant).

Results: The mean difference of HCGA on right and left side from interocclusal wax record method was 26.80°±2.14° and 27.00°±2.13° respectively. The mean difference of HCGA on right and left side from CBCT method was 33.09°±4.65° and 33.81°±3.45° respectively. The mean difference of HCGA on right and left side from Gothic arch tracing method was 31.13°±2.90° and 31.10°±2.50° respectively.

Conclusions: There was significant difference in the values of HCGA when measured by 3 methods. Highest value of HCGA was obtained by CBCT method and lowest value was obtained by Interocclusal wax record method. On comparison of right and left horizontal condylar guidance angulation by these methods individually, no significant difference was found between right and left sides.

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INTRODUCTION

Occlusion is defined as the static relationship between the incising and masticating surfaces of the maxillary and mandibular teeth or tooth analogues (GPT 9). The study of occlusion and its relationship to masticatory system, has always been a topic of interest in dentistry. Success of complex prosthodontic procedures is enhanced by accurate simulation of the condylar path of patient on an articulator. It enables the clinician to estimate the correlation between the path traced by the condyle during mandibular movements and the morphology of the occlusal surfaces which in turn aids in restoring the occlusion without interferences.¹

Condylar guidance is defined as the mandibular guidance generated by the condyle and articular disc traversing the contour of the articular eminence, or the mechanical form

located in the posterior region of an articulator that controls movement of its mobile member (GPT 9). Accurate recording of condylar guidance will lead to harmonious tooth contacts with no occlusal interferences during mandibular movements. Accurate simulation of condylar path of patient on an articulator is important for the success of prosthodontic procedure. If condylar guidance is not recorded accurately, it will lead to occlusal interferences during mandibular movements. This may also increase chairside denture adjustment time, which can be frustrating for both the patient and the dentist.² The condylar guidance in a patient is governed by a number of factors and its accurate determination is very difficult.³

The condylar guidance inclination in semi adjustable articulator is set either by protrusive or lateral interocclusal records. The

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purpose of protrusive jaw relation is to set the condylar elements of the articulator so that they will reproduce condylar inclinations which are similar or comparable to that of patient's temporomandibular articulation. In clinical practice, the method most often used to determine the inclination of the sagittal path of the condyles consists of employing intra oral wax record and then programming the condylar guidance on the articulator.⁴ Some authors have also advocated gothic arch tracing as one of the method of recording condylar guidance.

The TMJ can also be evaluated by various radiologic imaging techniques such as panoramic radiography, TMJ radiography, both open and closed mouth transcranial projections, linear tomography, computed tomography, and magnetic resonance imaging. The outline of the articular eminence of the temporal bone may be seen on a panoramic radiograph. If the panoramic radiographic image accurately represents the outline of the articular eminence, it may be used as an aid in setting the condylar guidance inclination on a semiadjustable articulator.⁴ Numerous studies that indicate the use of interocclusal wax record method, CBCT and gothic arch tracing as means of calculating HCGA are available, but there is a paucity of studies having direct comparison of these methods to the best of our knowledge. Due to the aforementioned concerns, there is a need for comparing the horizontal condylar guidance angulation (HCGA) values obtained by using interocclusal wax record, cone beam computed tomography (CBCT) and Gothic arch tracing method.

The null hypothesis stated that there was no difference in horizontal condylar guidance angulation (HCGA) values obtained by using interocclusal wax record, cone beam computed tomography (CBCT) and Gothic arch tracing method. The alternate hypothesis states that there was difference in horizontal condylar guidance angulation (HCGA) values obtained by using interocclusal wax record, cone beam computed tomography (CBCT) and Gothic arch tracing method.

Experimental Section

A total of 15 completely edentulous patients (n=15) were selected from outpatient Department of Prosthodontics according to the inclusion and exclusion criteria. This sample size was determined according to pilot study and previous studies in which sample size was 12 patients with similar parameters.³ Inclusion criteria included completely edentulous subjects in the age group of 45-70 years, Class I jaw relationship, well rounded ridges and minimum duration of 4 months after last tooth extraction. Exclusion criteria included subjects suffering from arthritis, osteoporosis, neurological disorder, Class II and class III jaw relationship, facial asymmetry, inadequate interocclusal space.

Before starting the study, ethical clearance was obtained from the institutional ethical board (ITS/CDSR/1/2018/070). Written consent was obtained from all the patients regarding procedure. For all subjects, HCGA was calculated using three methods: interocclusal wax record method, cone beam computerized tomography and Gothic arch tracing. Interocclusal wax record method and Gothic arch tracing method are considered to be clinical methods while CBCT is radiographic method of calculating the HCGA. For interocclusal wax record method

and Gothic arch tracing method maxillary and mandibular casts were mounted on semiadjustable articulator (Hanau wide vue) with the aid of facebow and centric relation record. (Fig 1)



Fig 1- Recording face bow in patient's mouth

Interocclusal wax record method

For interocclusal wax record method, centric and protrusive interocclusal records for all patients were made using aluwax (MDM Corp, Delhi, India) (Fig 2A, 2B).



Fig 2A- Interocclusal wax record method (Centric relation)

Fig 2B- Interocclusal wax record method (Protrusive relation)

3mm of maxillary rim was removed from the first premolar area distally till the end of the wax rim both on the right and left side. On the mandibular rim in the corresponding areas, two 'V' shaped notches on each side were made with the help of scalpel and blade. Surface was lubricated with vaseline before making records. Softened aluwax was placed on the maxillary occlusal rim in the areas from where modeling wax was removed. The aluwax was about 1.5 -2 mm above the original height of rim. Then mandibular occlusal rim was placed in the mouth and patients were assisted in retruding mandible by placing the right and left index fingers on the buccal flanges of the mandibular occlusion rim in both premolar region with thumb under patient's chin. Protrusive relations were recorded by adding wax on the mandibular occlusion rim. Record bases with softened aluwax were inserted in patient's mouth. The lower recording base was stabilized by index finger and thumb while patient was instructed to protrude the lower jaw. The patients were guided to protrude the mandible 6mm while keeping the midline of upper and lower occlusion rims coincident before closure.

Gothic arch tracing

For Gothic arch tracing method, extra-oral Gothic arch tracers (Hight tracers) were attached to the occlusal rims. The stylus was attached to the maxillary rim and the recording plate to mandibular rim. Stylus was retracted and training exercises were conducted with the patient. Then tracing plate was prepared to record the tracing of mandibular movements. A definite arrow point tracing with a sharp apex was accepted. (Fig 3)



Fig 3- Gothic arch tracing method

After obtaining arrow point tracing for each patient, tracing was preserved by securing transparent IOPA (Intraoral periapical) film on tracing with cyanoacrylate. A point was marked and perforated on IOPA film on tracing and another point was perforated 6mm from the apex of centric point on IOPA film. Gypsum product with anti-expansion (Type IV) solution was injected between rims in centric relation and centric relation record was obtained. (Fig 4)



Fig 4- Gothic arch tracing records

Again gypsum product was inserted between occlusal rims in patient's mouth and patient was instructed to drag the mandible from centric relation to protrusive relation i.e second point on IOPA film to obtain protrusive record. (Fig 4)

Adjusting the articulator for calculating HCGA for Intra-oral wax record and Gothic arch tracing

Horizontal condylar adjustment assembly was made free on the articulator by releasing the centric locknuts and proper oiling for all locknuts. Incisal guide pin was raised about half inch from the top of the guide table. Centric locknuts were secured with positive finger pressure. Centric relation plaster records or aluwax were kept to verify centric relation. Protrusive records were placed for both aluwax and plaster records and right and left calibrations of the horizontal condylar assembly of the articulator were adjusted making sure that there were no gaps between the notches on the cast and the split cast mounting. Horizontal condylar guidance angulation was recorded and locknuts were tightened on the articulator.

Cone beam conical tomography (CBCT) method

The scan was done for each patient with the CBCT unit (Newtom Giano, Italy) at 90 kV, 10mA, and 3.6 sec of exposure time at a resolution of 200 microns. Concession was provided for patients in CBCT because of thesis work. The

image analysis was done in the MPR mode and the axial window was manipulated to localize the widest dimension of the condylar head. At this level para-sagittal cross-sections were created following the long axis of the condyle. On the designated section two points were localized; superior most point on the porion (P) and the inferior most point of the articular eminence (E). Then a straight line joining these two points was drawn using the drawing toolbar. Then the highest point of the articular fossa (R) was marked and another line was drawn interesting the other line joining the point (R) to the inferior most point of the articular eminence (E). The angle at this intersection depicted the articular eminence inclination and was measured using the angle toolbar of the software. (Fig 5A, 5B)

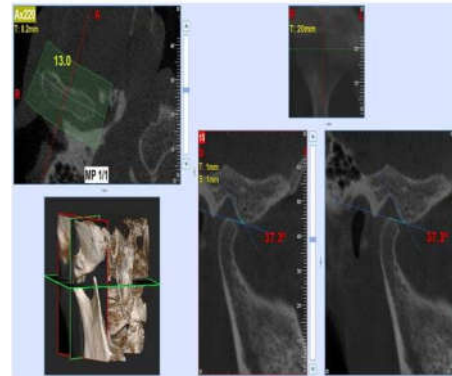


Fig 5A- CBCT evaluation on right side

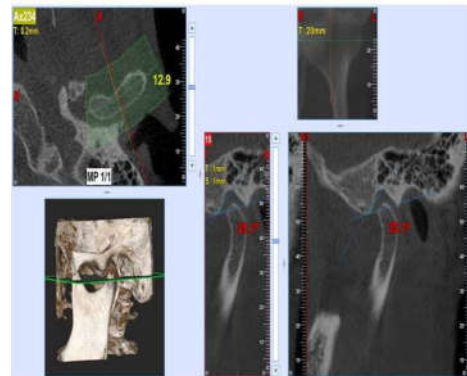
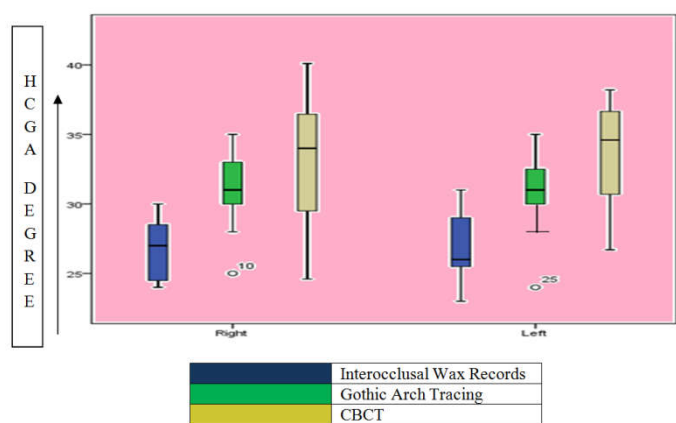


Fig 5B- CBCT evaluation on left side

Statistical Analysis

The data was recorded from these subjects; this data was represented as mean ± standard deviation. The analysis had been carried out using SPSS version 20 IBM corp. Ltd (New York) the statistical test applied was student "t test" to compare between two groups. The comparisons among three different methods were done using repeated measure analysis (Two-way ANOVA) followed by post hoc comparison by Bon Ferroni method. (Graph 1)



Graph I Difference in HCGA of right and left side using three methods

RESULTS

A total of 15 subjects were chosen for the study by following strict inclusion and exclusion criteria. Horizontal condylar guidance angulation was obtained of these subjects using Interocclusal wax records, CBCT and Gothic arch tracing.

The mean difference of HCGA on right and left side from interocclusal wax record method was $26.80 \pm 2.14^\circ$ and $27.00 \pm 2.13^\circ$ respectively. The mean difference of HCGA on right and left side from CBCT method was $33.09 \pm 4.65^\circ$ and $33.81 \pm 3.45^\circ$ respectively. The mean difference of HCGA on right and left side from Gothic arch tracing method was $31.13 \pm 2.90^\circ$ and $31.10 \pm 2.50^\circ$ respectively. (Table I)

Table 1 Comparison of horizontal condylar guidance angulation obtained with Interocclusal wax records, Gothic arch tracing and CBCT

	Interocclusal wax records	Gothic arch tracing	CBCT	P value
Right	26.80±2.14	31.13±2.90	33.09±4.65	<0.001
Left	27.00±2.23	31.10±2.50	33.81±3.45	<0.001
Average	26.90±2.19	31.12±2.61	33.45±4.04	<0.001

It was found that the HCGA in Interocclusal wax records method, CBCT method and Gothic arch tracing method showed insignificant results with $p < 0.001$ on right and left side. (Table II)

Table II Comparison of Horizontal condylar guidance angulation of all three methods

	RIGHT	LEFT	P VALUE
Interocclusal wax records	26.80 ±2.14	27.8±2.30	0.81
Gothic arch tracing	31.31 ±2.83	31.10±2.49	0.97
CBCT	33.09± 4.65	33.81 ± 3.45	0.63

On comparing these methods with each other, Interocclusal wax record to CBCT showed a significant difference of $6.55 \pm 0.53^\circ$ with $p < 0.001$. Further post hoc comparison revealed that from Interocclusal wax record to gothic arch tracing, there was a significant difference of $4.22^\circ \pm 0.28^\circ$ with $p < 0.001$. On comparison of Gothic arch tracing with CBCT there was a significant difference of $2.33^\circ \pm 0.44^\circ$ with $p < 0.001$. (Table III)

Table III Comparison between methods

Comparison Between Methods	Mean Difference	Std. Error	P value
Interocclusal wax records and CBCT	6.55	.529	<.001
Interocclusal wax records and Gothic arch tracing	4.22	.281	<.001
Gothic arch tracing and CBCT	2.33	.441	<.001

It was evaluated that there was highly significant difference in Horizontal condylar guidance angulation (HCGA) by Interocclusal wax record method and CBCT as compared to CBCT and Gothic arch tracing method.

DISCUSSION

Horizontal condylar guidance angle can be measured by various methods. The direct interocclusal record is the oldest method for recording horizontal condylar guidance angulation. Factors that influence interocclusal check records are the thickness and equalization of pressure which depends upon the uniform consistency of the recording material.

Various authors advocated the use of interocclusal wax record method. Godavarthi AS *et al*⁵ used bite registration paste, Millestein *et al*⁶ used white pink baseplate wax and compared it with hygienic extra tough baseplate wax, whereas Prasad *et al*⁷ used Aluwax.

The graphic method records tracing of mandibular movements in horizontal plane as an arrow point tracing. Shrestha P *et al*², Nair C *et al*⁸ Kumari VV⁹ used arrow tracing method for mandibular movements.

Some investigators have used radiographic methods including OPG and CBCT. It is observed that there are very few studies available using CBCT for determination of horizontal condylar guidance angulation. Veloso L *et al*¹⁰ and Shrestha P *et al*² used CBCT for calculating horizontal condylar guidance angulation.

For standardization of procedure in CBCT, superior most point on the porion and the inferior most point of the articular eminence were marked. A straight line joining these two points was drawn using the drawing toolbar. The highest point of the articular fossa was marked. Another line was drawn joining the highest point of the fossa to the inferior most point of the articular eminence intersecting the first line. The angle at this intersection depicted the articular eminence inclination and was measured using the angle toolbar of the software. The same standardized protocol was used for all the patients.

In the present study there is insignificant difference in right and left HCGA which was in accordance with other studies. According to Shetty S *et al*¹¹ mean value of horizontal condylar guidance on right side was 24° and on left side was 21.67° by using interocclusal wax record method. The difference between right and left condylar guidance was insignificant. Godavarthi *et al*⁵ showed the condylar guidance angle 38.62° and 38.05° for right and left side respectively which was also statistically insignificant. Shah K *et al*¹² found a mean of 30.42° and 32.38° for right and left respectively using Gothic arch tracing method giving insignificant results, Shetty S *et al*¹¹ obtained a mean 12.73° and 13.47° right and left respectively showing insignificant difference.

El-Gheriani and Winstanley¹³ and Zamacona *et al*¹ have reported significant variation between the left and right condylar guidance values. The difference with Zamacona's results can be attributed to the heterogeneity of the sample who had selected a mix of partially edentulous and completely edentulous subjects where as in the present study; the sample was more homogenous, consisting of only completely edentulous subjects. It must also be noted that the above mentioned study employed only the graphic method. The disagreement with results from El-Gheriani and Winstanley, on the other hand, may be due to the fact that all the subjects in their study were those who were referred for treatment of TMJ disorders as compared to healthy subjects which were employed in the present study (no TMJ anomalies).

Studies done using CBCT by Shrestha P *et al*³ obtained a mean 43.83 ° and 42.42 ° for right and left respectively, which was in agreement with our results showing statistically insignificant difference on right and left sides.

In the present study horizontal condylar guidance values obtained from CBCT scan were greater than those obtained from clinical methods. Brewka¹⁴ in 1981 stated that radiographic methods and clinical methods were in disagreement. Christensen and Slabbert¹⁵ in a 1978 review has stated among the clinical methods, values obtained from the Gothic arch tracing exhibited high level of association with CBCT than those obtained from interocclusal wax record method. One important reason for the inconsistency of intra oral methods may be due to different material used, sagittal condylar angle changes with the amount of protrusion, and that intra-oral record represents only one point along the condylar path.

The values in Gothic arch tracing were close to the values obtained by CBCT. These findings suggested that Gothic arch tracing and CBCT provide almost similar value and can be clinically useful in determining horizontal condylar guidance angulation. These results leads to believe that CBCT can be preferred alternative to interocclusal wax records and Gothic arch tracing for accurate Horizontal condylar guidance angulation measurement with minimum discomfort and wastage of time for the patients. Moreover, Gothic arch tracing is more dependent on patient maneuver and it is time taking, cumbersome procedure especially for geriatric patients.

The result of present study leads to rejection of null hypothesis that there was no significant difference in horizontal condylar guidance angulation obtained using interocclusal wax records, Gothic arch tracing and CBCT.

CONCLUSION

Within the limits of this study the following conclusions were drawn:-

1. There was a significant difference in the values of horizontal condylar guidance angulation when measured by 3 methods i.e., interocclusal wax records, Gothic arch tracing and CBCT.
2. Highest value of horizontal condylar guidance angulation was obtained by CBCT, lowest was obtained by interocclusal wax records.
3. On comparison of subjects right and left iorizontal condylar guidance angulation by these methods

individually, no significant difference was found between right and left sides.

4. The values obtained by Gothic arch tracing method were closer to values obtained with CBCT than Interocclusal wax records.

In future if the accessibility of CBCT is improved, this can be a preferred alternative to interocclusal wax records and Gothic arch tracing for recording the accurate horizontal condylar guidance angulation.

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How to cite this article:

Silvi Jerath et al.2019, Clinico-Radiographic Comparative Evaluation of Horizontal Condylar Guidance angle by Interocclusal Wax Record, CBCT and Gothic Arch Tracing Method- an in Vivo Study. *Int J Recent Sci Res*. 10(07), pp. 33715-33720.
DOI: <http://dx.doi.org/10.24327/ijrsr.2019.1007.3732>
