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ACCURACY OF CONE BEAM COMPUTED TOMOGRAPHY AND PANORAMIC IMAGING IN DETERMINING CONDYLAR RAMP IN COMPARISON TO INTEROCCLUSAL PROTRUSIVE RECORD

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Abstract

Aim: This study was conducted to determine the correlation between condylar ramp obtained by Cone Beam Computed Tomography (CBCT) and panoramic radiography and interocclusal protrusive record in dentulous subjects.

Methods: In these clinical study 28 dentulous patients with an average age of 13-43 years, who were referred to radiology center for taking CBCT and panoramic radiography, were evaluated. Protrusive interocclusal record was taken. Then the casts were transferred to a semi-adjustable articulator by using face bow in CR position. Condylar guidance was obtained by transferring the protrusive interocclusal record to articulator. In panoramic radiographs, the angle between the line tangential to the posterior slope of articular eminence and Frankfurt plan was obtained. On CBCT this angle was measured in the section with maximum depth of glenoid fossa. SPSS software was used for the statistical analysis. The agreement between methods was evaluated using ICC (absolute agreement) and Bland-Altman graphs.

Results: There was an acceptable agreement between values obtained by radiographic methods and interocclusal recording. The mean difference between the condylar guidance obtained using interocclusal recording and CBCT was $0.73 \pm 0.8^\circ$ for the right side and $0.48 \pm 0.1^\circ$ for the left side. These differences between interocclusal recording and

panoramic were $2.79\pm 0.30^\circ$ and $2.49\pm 0.9^\circ$ for right and left sides respectively. CBCT had a narrower Bland-Altman graph than panoramic radiography.

Conclusion: The results confirmed that CBCT and Panoramic can be used instead of interocclusal record for adjusting condylar guidance in articulator,if necessary. CBCT was more accurate than panoramic radiography.

Keyword: Cone beam computed tomography, panoramic radiography, mandibular condyle, articulator.

Introduction:

Outcome of complex prosthodontic procedures is depended on simulation of the condylar path of patient on an articulator. Condylar guidance by definition is the mandibular guidance generated by the condyle and articular disc traversing the contour of the glenoid fossa. The condylar guidance inclination in semi-adjustable articulators is set by two methods: protrusive and lateral interocclusal records. The aim of protrusive jaw relation is to set the condylar components of the articulator so that they will reproduce slope, which are similar to the patient's temporomandibular joint slope. The ultimate purpose is to fabricate a prosthesis without interferences(1, 2).

Varying inclinations have been reported with successive recordings, between operators, recording materials and between articulators. The condylar guidance varies from person to person and from one side to the other side. The outline of the articular eminence and the glenoid fossa of the temporal bone can be seen on radiographs. And despite the clinical records, there are stable bony landmarks on radiographs so these measurements can be even more accurate(3). Some studies evaluated the accuracy of different radiographic methods in comparison to interocclusal protrusive record. But there are controversies between them. So because cone beam computed tomography(CBCT) is an advanced modern technique that provides multiplanar sections without any superimposition(4, 5); with regard to the availability of panoramic, this study was conducted to evaluate the accuracy of CBCT and panoramic images in determining condylar guidance in comparison to interocclusal protrusive record.

Material and Methods:

In this clinical study 28 dentulous patients aged between 13-43 years, who were referred to radiology center for taking CBCT (FOV=9-12 inch) and panoramic radiography were selected according to the inclusion and exclusion criteria. Inclusion criteria included: having class II molar relation, 2-3 mm of overjet, 1-2 mm of overbite and having at least 3 posterior teeth in each quadrant. Exclusion criteria included: progressive periodontal disease, gross attritions, malformation, temporomandibular disorders (TMDs), poor neuromuscular control and having fixed or removable prosthesis. Then after taking consent they were referred to a prosthodontist.

Panoramic imaging: All radiographs were made in the same radiographic unit(SCARA II, Planmeca, Helsinki, Finland)with exposure factors proper for each patient. Then by usingRomexisviewer, the line tangential to the posterior slope of articular eminence (from the highest point of glenoid fossa to the lowest point of articular eminence) was drawnand the angle between this line and Frankfurt plan was obtained. This angle was recorded for both right and left sides (Fig 1).

CBCT scans: The CBCT scans were obtained using New Tom 3G (Quantitative Radiology, Verona, Italy) with 0.2-0.4mm voxel size at 110 kVp and 3.79, 10.40 and 10.65 mAs for 9 and 12-inch FOVs, respectively. Axial sections were selected at the level of condylar head and inferior border of zygomatic arch. Then parasagittal sections perpendicular to condylar long axis were made (width=200 mm, thickness=1mm, step=2 mm). Measurements were done on a section adaptable to maximum depth of glenoid fossa. To determine the maximum depth of glenoid fossa, the line connected deepest point of glenoidfossa, perpendicularly; to the line connected two sides of glenoid fossa was drawn on the central section and two sections before and after. The section has the most distance, was selected as the maximum depth of glenoid fossa. On this section, the angle between the line tangential to the posterior slope of articular eminence and Frankfurt plan was obtained. This angle was obtained for both right and left sides (Fig2).

All measurements (CBCT and panoramic) were done by two separate observers to eliminate inter examiner errors. To eliminate intra examiner errors, the measurements were repeated 10 days later by each observer.

Interocclusalprotrusive record: Maxillary and mandibular casts were mounted on a semi-adjustable arcon articulator (Hanau, spring bow, Whip max, USA) with the aid of face bow (Hanau, spring bow, Whip max, USA) and centric relation (CR).Then Inter occlusal protrusive record was made in 5-6 mm protrusive movement by using anterior jig and polyvinylsiloxane was injected between occluding surface of the teeth, while paying attention to midline. The obtained protrusive record transferred to the articulator and the condylar guidance was determined. All stages were done by a single operator (Figs 3A-C).

Statistical analysis: SPSS software version 18 (Microsoft, IL, USA) was used for the statistical analysis. The agreement between methods was evaluated by using Inter Class Correlation (ICC) (absolute agreement) and Bland-Altman graphs.

Results:

To evaluate inter observers and intra observers agreement, ICC was calculated. Since this agreements were acceptable (ICC>0.75), we calculated the mean value of condylar guidance and this mean value was analyzed.

In the present study, values of condylar inclination of right and left sides obtained by protrusive record were $32.60\pm 3.08^\circ$ and $32.92\pm 3.16^\circ$ for right and left sides respectively. CBCT shows these values 33.49 ± 2.94 for right side and $33.94\pm 3.40^\circ$ for left side. Values obtained by Panoramic were $35.43\pm 3^\circ$ for right and $35.67\pm 3.36^\circ$ for left sides (Table 1).

Then to evaluate the agreement between different methods we used ICC, and Bland-Altman graphs. In these graphs, in spite of outlier instances, most cases showed the mean difference of 2 degrees. (Table 2 and Figs 4 to 7). Statistical results of present study indicated there is an acceptable agreement between condylar guidance obtained by interocclusal protrusive record and radiographic methods. CBCT also had narrower Bland-Altman graphs than panoramic, that indicates CBCT is more accurate than panoramic and correlation between CBCT and interocclusal protrusive record was more than panoramic and interocclusal protrusive record (Table 2 and Figs 4 to 7). In this study, the mean difference between the condylar guidance obtained using inter occlusal recording and CBCT were $0.73\pm 0.8^\circ$ for the right side and $0.48\pm 0.1^\circ$ for the left side. These differences between interocclusal recording and panoramic were $2.79\pm 0.30^\circ$ and $2.49\pm 0.9^\circ$ for right and left sides.

Table 1- Mean value of condylar ramp in clinic (protrusive method), Cone Beam CT and panoramic radiography (degree).

Methods	Male		Female		Total	
	right	left	right	left	right	left
Protrusive record	32.52 ± 3.14	32.71 ± 3.05	32.85 ± 3.13	33.57 ± 3.64	32.60 ± 3.08	32.92 ± 3.16
CBCT	33.35 ± 2.92	33.84 ± 3.43	33.90 ± 3.21	34.22 ± 3.56	33.49 ± 2.94	33.94 ± 3.40
Panoramic	34.96 ± 2.89	35.34 ± 3.44	36.83 ± 3.09	36.62 ± 3.11	35.43 ± 30	35.67 ± 3.36

Table 2- Agreement between different methods by ICC.

Methods	Methods	ICC
Clinic right side	CBCT right side	0.91 (0.55-0.97)
	Panoramic right side	0.62 (0.50-0.88)
Clinic left side	CBCT left side	0.90 (0.53-0.97)
	Panoramic left side	0.66 (0.50-0.89)
CBCT right side	Panoramic right side	0.75 (0.50-0.93)
CBCT left side	Panoramic left side	0.80 (0.10-0.94)

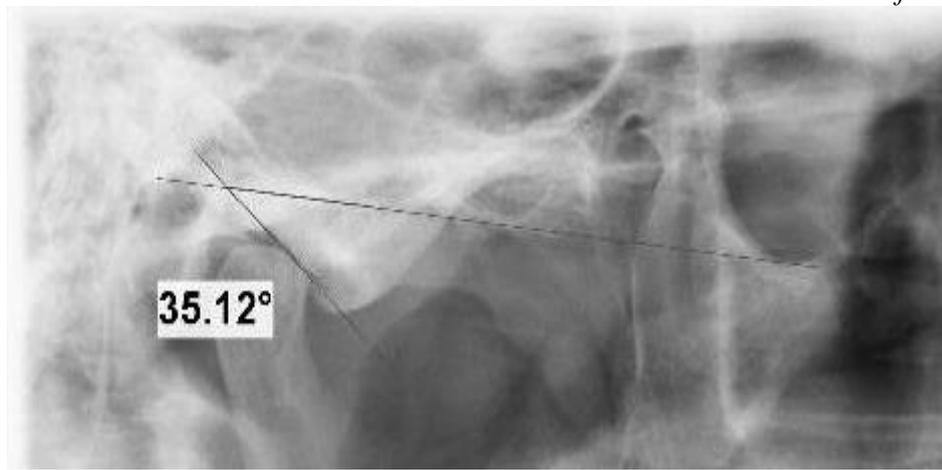


Figure 1. Determination of condylar guidance by panoramic radiography.

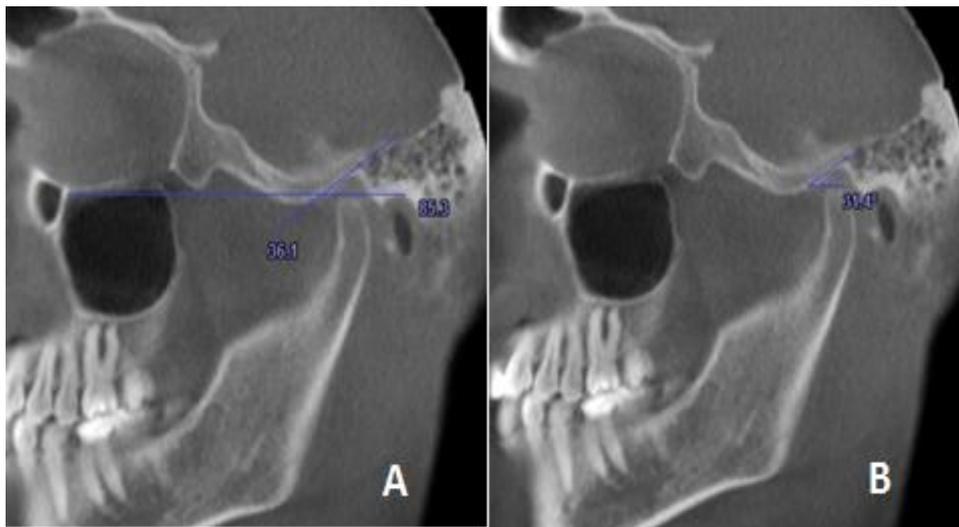


Figure 2. A and B. Determination of condylar guidance by CBCT

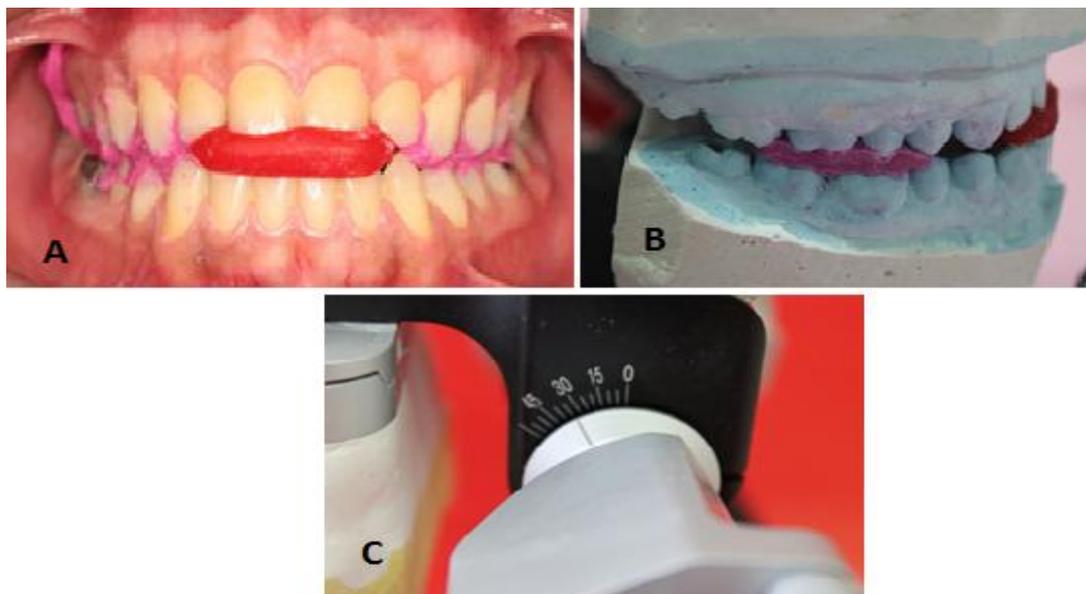


Figure 3.A. Inter occlusal protrusive record by using anterior jig and polyvinyl siloxane was injected between occluding surface of the teeth. B. Obtained protrusive record transferred to the articulator. C. Condylar guidance was determined.

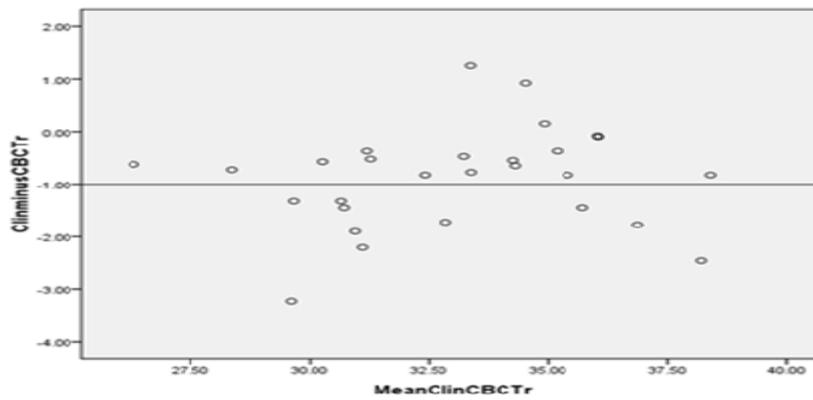


Figure 4.Bland-Altman graph for protrusive record and CBCT (right side).

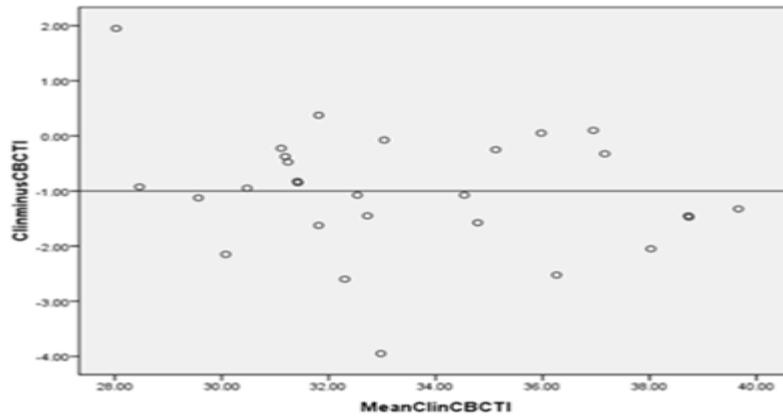


Figure 5.Bland-Altman graph for protrusive record and CBCT (left side).

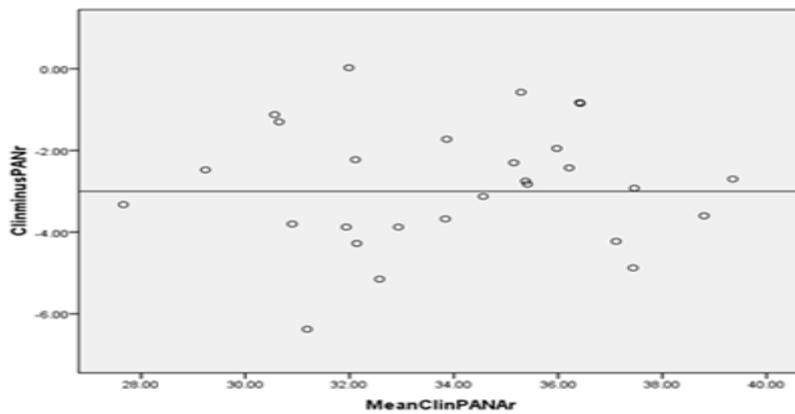


Figure 6.Bland-Altman graph for protrusive record and panoramic (right side).

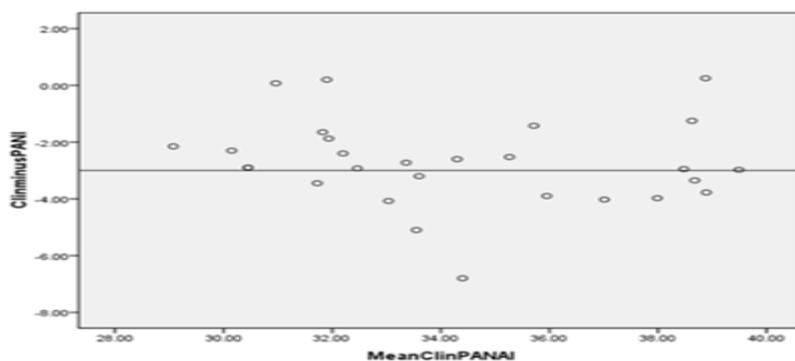


Figure 7.Bland-Altman graph for protrusive record and panoramic (left side).

Discussion:

Patient's occlusion free from interfaces is so important for prosthodontic rehabilitation. Two factors control 3-dimensional mandibular movements including rotation and translation movements. The posterior controlling factor is the condylar path in the TMJ and anterior teeth act as anterior controlling factor(6). To simulate the condylar path on an articulator, protrusive and interocclusal records are needed. Adjustment of articulator's condylar guidance with a greater degree than that of patient, result in lateral and protrusive interferences. Whereas, adjustment of articulator's condylar guidance with a lesser degree, indicate interferences that are not really present; so measurement of condylar guidance in each patient is important(6).Clinically, there are two methods in order to determining condylar guidance:

- 1- The method based on disocclusion upon protrusion (Christensen phenomenon), which includes intraoral recording and calculating the angle while programming on the articulator.
- 2- A graphic method in which the condylar path is recorded on a card by means of a face bow. The angle of the path is obtained by measuring the angle formed by the tangent drawn to the functional portion of the tracing. This method makes it possible to obtain the complete tracing of the condylar path rather than merely determining a point along the condylar path as represented by the intraocclusal method(7, 8).

The present study indicated there is an acceptable agreement between condylar guidance obtained by interocclusalprotrusive record and radiographic methods. CBCT is more accurate than panoramic. In the other word, correlation between CBCT and inter occlusalprotrusive record was more than panoramic and interocclusalprotrusive record. CBCT also had narrower Bland-Altman graphs than panoramicperhaps this matter is because of superimposition of zygomatic arch and skull base on articular eminence that obliterate the bone details on panoramic. But CBCT can eliminates superimpositions so articular eminence and glenoid fossa are clearly seen(1).

In this study, the mean difference between the condylar guidance obtained using inter occlusal recording and CBCT were $0.73\pm 0.8^\circ$ for the right side and $0.48\pm 0.1^\circ$ for the left side. These differences between interocclusal recording and panoramic were $2.79\pm 0.30^\circ$ and $2.49\pm 0.9^\circ$ for right and left sides. Shahidiet al. compared the condylar inclination attained by interocclusal records and transcranial radiography. She concluded transcranial radiography canbe used for adjusting condylar guidance of articulators; however, the values obtained from radiographs were almost 10 degrees higherbut this was clinically acceptable. This difference may be result from the amount of protrusive movement(6). InShahidi's study the protrusive records were registered in edge to edge relation. Since the patients had class I relation(1-2 mm over jet) it means1-2 mm protrusive movement. The condylar guidance in dentulous subjects can be

influenced by their amounts of overjet and overbite. So the obtained condylar guidance get space from the mean values in 5-6 mm protrusive movements(6). Although transcranial radiographies have low radiation dose, superimposition in this method reduces its accuracy but CBCT is more accurate because of eliminating superimpositions.

In the other hand, Shereshta et al. compared condylar guidance obtained by CT and clinical methods. Condylar guidance obtained by CT was about 10 degrees more than articulator, although statistically it wasn't significant. Semi adjustable articulator couldn't reconstruct the condylar movements because of fixed intercondylar distance and the straight condylar pathway. These cause a lot of errors in horizontal and frontal plans. The other factor in this study was using wax that doesn't have dimensional stability. These factors are main causes of differences between CT and protrusive recording in articulator. The main result of this study was that CT is a very accurate method for determining condylar guidance in prosthodontic reconstruction treatments. Nowadays CBCT is a good alternative method in dentistry. In present study, we use CBCT instead of CT in order to determining condylar guidance because it is less expensive, more available and has lower dose. This study showed high agreement between values obtained by CBCT and semi adjustable articulator. We use polyvinyl siloxane that has acceptable dimensional stability, instead of wax. This study also recommends using CBCT in prosthodontic reconstructions(9).

In Shetty et al. study on edentulous patients the differences between panoramic and clinical methods were both statistically and clinically significant. Perhaps the record base movement during condylar guidance registration caused some mistakes(10). Godavarthi et al. studied on two groups of dentulous and edentulous patients and evaluated the correlation between condylar guidance determined by panoramic and conventional method. The difference was statistically significant in dentulous group and was not statistically significant in edentulous group. Although he concluded that panoramic radiography can be used as an alternative(11) method only in edentulous patient but differences in both groups were less than 10 degrees. So clinically these differences are acceptable in both groups(3).

Prasad and Tannamala, both them used panoramic and concluded that condylar guidance obtained by panoramic is reliable and could be used in semi adjustable articulators. This confirmed our results, Although CBCT was more accurate(11, 12).

Godavarthi et al. mentioned that some limitations and manual errors could happen during programming the articulator using protrusive interocclusal records. He compared three different methods and concluded that for

recording protrusive excursion the electronic pantography had least errors. So this study recommends using fully adjustable articulators(3).

It seems that however the CBCT has adequate accuracy but further studies are required on other radiographic methods.

Conclusion:

The results confirmed that CBCT and Panoramic can be used instead of interocclusal record for adjusting condylar guidance in articulator, if necessary. CBCT was more accurate than panoramic radiography.

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