

Comparative Evaluation of Sagittal Condylar Guidance in Edentulous Subjects using Interocclusal Record and Radiograph Method Using Cone Beam Computed Tomography (CBCT) in Udaipur City Population – In Vivo Study

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Abstract

Aim: This in vivo study was conducted to compare sagittal condylar guidance angle measured (SCGA) using cone-beam computed tomography (CBCT) and interocclusal records in completely edentulous patients.

Materials and Methods: Based on the inclusion and exclusion criteria, 15 completely edentulous individuals were evaluated. Radiologically CBCT imaging were used to record SCGA.

Results: After recording, the CBCT of the patient SCGA was measured using the Frankfort horizontal reference line and mean curvature line. The most superior and most inferior points of the curvature were identified to determine the mean curvature line. SCGA was measured in the clinical method using interocclusal method in the same patients. Data obtained using both methods were subjected to statistical analysis.

The mean left and right SCGA using CBCT view was 34.67 and 34.53, respectively. The mean right and left SCGA using interocclusal records were 24.87 and 25.73 respectively. Intergroup comparison of condylar guidance of both sides where obtained results were statistically significant along with mean 9.66 and 8.93 respectively for Radiographic Right – Interocclusal Right and Radiographic Left – Interocclusal Left variables.

Conclusion: There was no significant difference in values of SCGA when evaluated using both techniques. Within the study's limitations, CBCT appears to be a viable alternative to traditional methods for recording.

Keywords: Cone beam computed tomography, Interocclusal records, Sagittal condylar guidance angle.

INTRODUCTION

The rehabilitation of completely edentulous patients presents a significant challenge for prosthodontists, as it requires the creation of complete denture prostheses that seamlessly integrate with the surrounding stomatognathic system¹. Achieving optimal esthetics, function, and phonetics in complete denture fabrication hinges upon recording an accurate maxillomandibular relationship. This entails establishing precise vertical dimension of occlusion (VDO) and centric relations (CR) through meticulous clinical skills. Any errors made during the recording of maxillomandibular jaw relation records can lead to discomfort and potential unwearability of the dentures, underscoring the critical nature of this aspect of prosthodontic treatment².

According to The Glossary of Prosthodontic Terms 9 (GPT-9), condylar guidance (CG) can be defined as mandibular guidance generated by the condyle and articular disc traversing the contour of the articular eminence (AE)³. According to the glossary of prosthodontic Terms 10 (GPT-10), Condylar guidance can be defined as the mechanical form located in the posterior region of an articulator that controls movement of its mobile member. The sagittal condylar guidance angle (SCGA) is determined by the condyle and articular disc traversing the contour of the glenoid fossa and the articular eminence⁴.

Various methods are employed for recording centric relations, categorized into static, graphic, functional, and cephalometric approaches. Functional methods, subdivided into intra-oral and extra-oral methods, are exemplified by techniques such as interocclusal protrusive wax records, Lucia jig, leaf gauge, and intraoral tracers. Among these, interocclusal wax

records and graphical methods are most commonly used, though they are prone to errors due to factors related to patient, operator, or equipment/material⁴. Protrusive or lateral interocclusal records used to record SCGA on an articulator and also records were originally used for the registration of condyle translation. In 1905 Christensen advocated the use of protrusive wax records to determine SCGA directly on an articulator and recommended a 4-mm to 5-mm mandible protrusion during recording. In contrast, Posselt and Craddock recommended a 6-mm protrusion for wax registrations. A protrusive record of 6-mm distance is obtained and used for programming of the semi-adjustable articulator based on which the condylar guidance is set⁵.

Recognizing the limitations and errors inherent in manual registration methods, alternative approaches utilizing radiographs have emerged. Radiographic methods offer advantages such as stable bony landmarks and reduced reliance on operator or patient neuromuscular control³. Cone beam computed tomography (CBCT), in particular, has gained popularity for its three-dimensional imaging capabilities, providing accurate multiplanar sections without superimposition⁶. Studies suggest that SCGA values obtained from various radiographic methods can be directly used in the programming of semi-adjustable articulators, potentially saving time and avoiding patient-sensitive clinical procedures⁷. Despite the advantages of radiographic techniques, challenges such as additional equipment costs and radiation exposure must be considered. Moreover, there remains a scarcity of evidence in the literature comparing sagittal condylar angle values obtained from different radiographic methods, highlighting the need for further research in this area⁸.

This study aims to address this gap by comparing SCGA obtained from manual and CBCT methods, evaluating the potential of CBCT as an alternative aid for programming dental articulators. By elucidating the comparative efficacy of these methods, this research endeavours to contribute to the refinement of prosthodontic treatment protocols and enhance the quality of complete denture prostheses.

MATERIAL AND METHODOLOGY

MATERIALS

1. Plaster of paris
2. Die stone
3. Cold cure acrylic resin
4. Modelling wax
5. Petroleum Jelly
6. Sticky Wax

EQUIPMENT

1. Hanau wide view articulator
2. Whip mix Facebow.
3. Extra oral tracers
4. Rubber bowl & Spatula
5. Lacron Carver
6. Wax knife & Wax spatula
7. B.P blade
8. Diagnostic set
9. Cone beam computed tomography – Carestream & Carestream software

METHODOLOGY

A. SOURCE OF DATA

This In- vivo study will be conducted in the Department of prosthodontics, Pacific Dental College and Hospital, Debari, Udaipur.

B. STUDY DESIGN

An In Vivo study was conducted in department of crown and bridge and implantology, Pacific Dental college and hospital, Udaipur. The study is to evaluate and compare the two techniques, manual (interocclusal records) by centric and protrusive method and radiographic (CBCT) in determining the sagittal condylar guidance.

C. CRITERIA

INCLUSION CRITERIA

1. Healthy Completely edentulous patient
2. Clinically symmetric ridges

EXCLUSION CRITERIA

1. Temporomandibular or cranio cervical disorders
2. Any pathologic condition involving the oral soft or hard tissues
3. History of craniofacial trauma or surgery
4. Gross asymmetry of the face.

D. PROCEDURE

Informed consent will be obtained from all the participants prior to their participation. Each subject will be seated in a dental chair with the head upright supported by the head rest, so the F-H plane is parallel to the floor. Different measurements relevant to this study will be recorded by one operator. Each parameter will be measured and the average value will be computed and recorded.

FOR CBCT

Conventional steps in the fabrication of complete dentures were carried out till Try in. A CBCT image of the midfacial region of each individual was obtained in centric position. Using appropriate software, axial sections perpendicular to condylar long axis were made at the level of the head of the condyle and inferior border of the zygomatic arch. To determine the maximum depth of glenoid fossa, a perpendicular line connecting the deepest point of the glenoid fossa was drawn onto another line connecting the two sides of glenoid fossa on the central section and two sections before and after. The FHP was constructed after identifying the “porion” and “orbitale” and another second line was constructed along the posterior slope of AE, connecting the most concave (highest) point on the glenoid fossa and the most convex (lowest) point on the apical portion of AE. The condylar inclination angle for both the sides was obtained by measuring the angle between FHP and the second constructed line for each individual. Finally, condylar inclination values obtained by the radiographic methods will be evaluated (Fig1, Fig2).

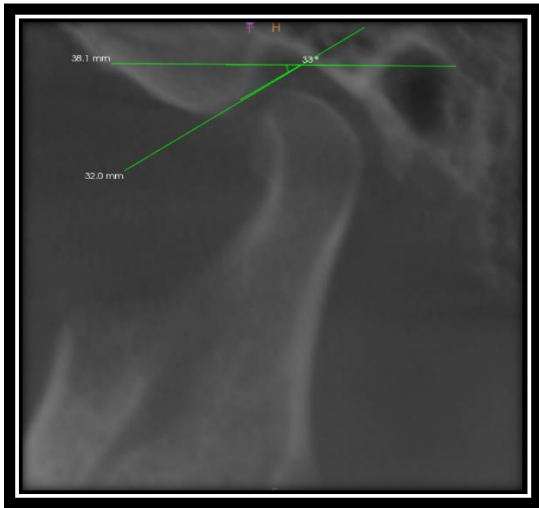


Fig: 1

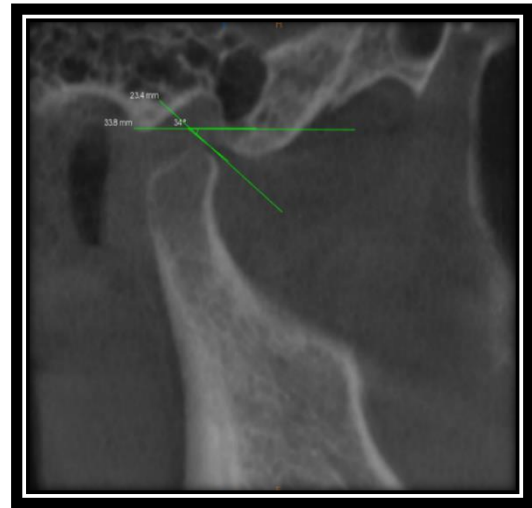


Fig: 2

For Manual method

Conventional steps in the fabrication of complete dentures were carried out till jaw relation. Facebow registrations were accomplished using the standard technique, and maxillary cast was mounted along with split cast using indirect technique (Fig3). After tentative jaw relation, mandibular cast was mounted to articulator using centric relation record(Fig: 4). The intraoral tracers were attached to the occlusion rims. Center-bearing plate on maxillary occlusal rim and center bearing point on mandibular occlusal rim were attached. The patient was guided about various movements that needed to be performed and after adequate training, the patients were able to give a definitive arrow point tracing with acceptable sharp apex. The arrow point tracing was secured by attaching transparent film of the same size on the recording plate. The transparent film was perforated 6 mm from the apex of centric point and the patient

was guided to hold the stylus in this protrusion point. Type II dental plaster and Type IV Dental stone in the ratio of 2:1 was mixed and was placed in-between the rims and centric and protrusive records were obtained (Fig:4). This protrusive record was used to program the articulator (Fig: 5). The centric locknuts of the Hanau Wide Vue semi-adjustable articulator were released, incisal guide pin raised approximately half inch from the guide table. The protrusive record was placed and right and left side calibrations of horizontal condylar assembly were adjusted till the complete seating of the protrusive record without any gaps between the notches on the cast and split cast mounting. After tightening the locknuts, the protrusive relation record was then removed. Thus, horizontal condylar inclinations on both sides of the articulator were set. The right and left SCG value on articulator were tabulated for all the patients.

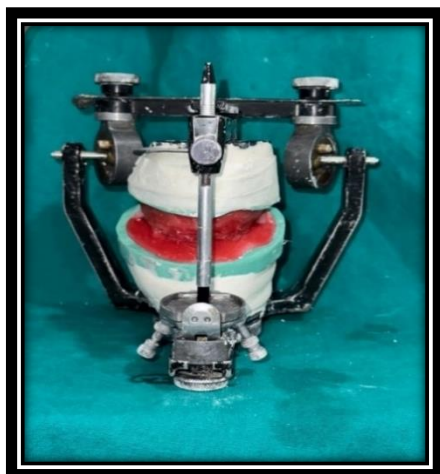


Fig: 3

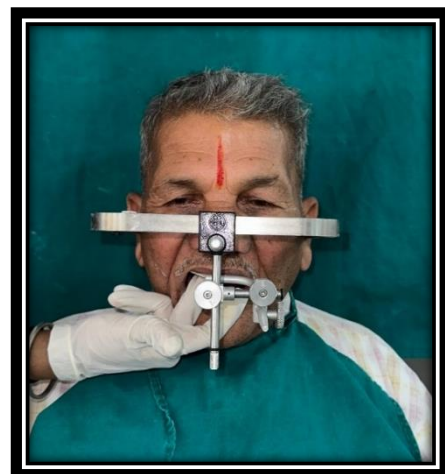


Fig: 4



Fig: 5



Fig: 6

E. Grouping of samples

15 subjects were selected, including all the inclusion and exclusion criteria. In all 15 subjects we had measure SCGA using protrusive inter occlusal records and using CBCT.

RESULTS

Table 1: Descriptive statistics for different methods

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Radiographic Right	15	30	41	34.53	3.270
Radiographic Left	15	31	42	34.67	2.845
Interocclusal Right	15	20	30	24.87	3.681
Interocclusal Left	15	20	31	25.73	3.634

Table 2: Intergroup comparison of condylar guidance of both sides

Variables	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Radiographic Right – Interocclusal Right	9.667	4.419	1.141	7.220	12.114	8.473	14	.000*
Radiographic Left – Interocclusal Left	8.933	4.267	1.102	6.570	11.296	8.108	14	.000*

Data were given as mean±SD and the significant difference between the groups was assessed by using *t*-test. df: Degree of freedom, SD: Standard deviation.

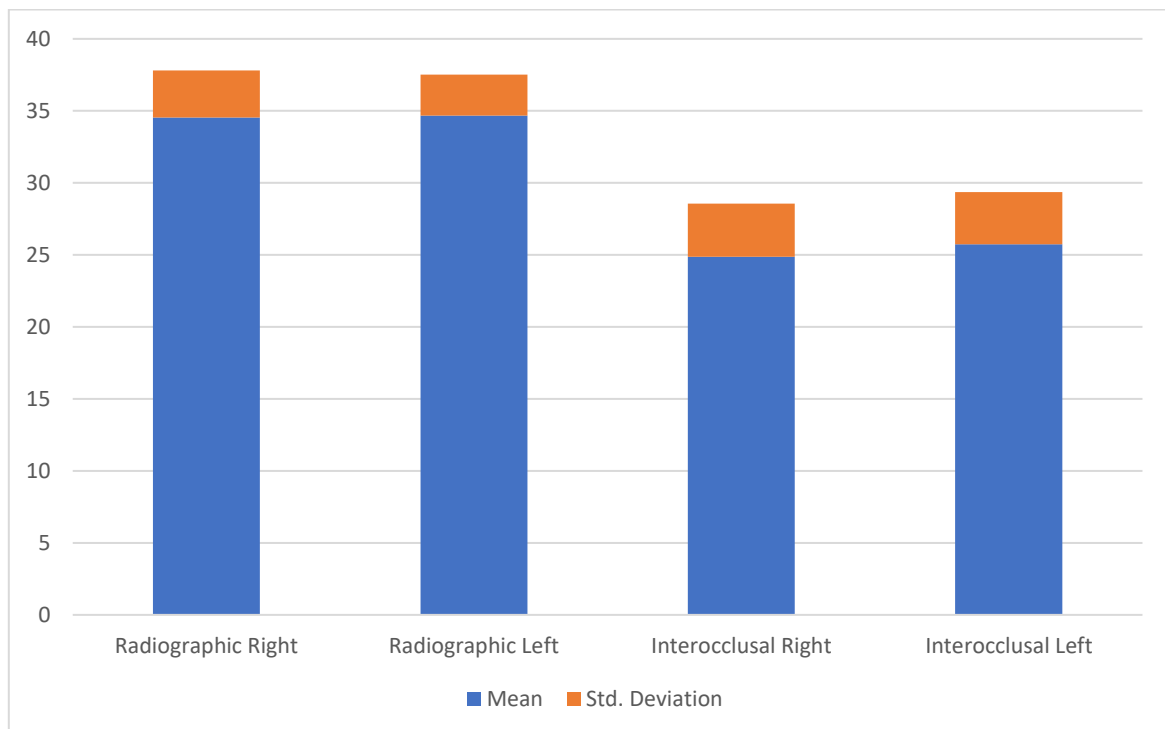
Table 3: Correlation between condylar guidance of different methods

Correlations					
		Radiographic Right	Radiographic Left	Interocclusal Right	Interocclusal Left
Radiographic Right	Pearson Correlation	1	.196	.926**	.187
	Sig. (2-tailed)		.483	.000	.504
	N	15	15	15	15
Radiographic Left	Pearson Correlation	.150	1	.173	.926**
	Sig. (2-tailed)	.594		.538	.000
	N	15	15	15	15
Interocclusal Right	Pearson Correlation	.196	.173	1	.899**
	Sig. (2-tailed)	.483	.538		.000
	N	15	15	15	15
Interocclusal Left	Pearson Correlation	.187	.150	.899**	1
	Sig. (2-tailed)	.504	.594	.000	
	N	15	15	15	15

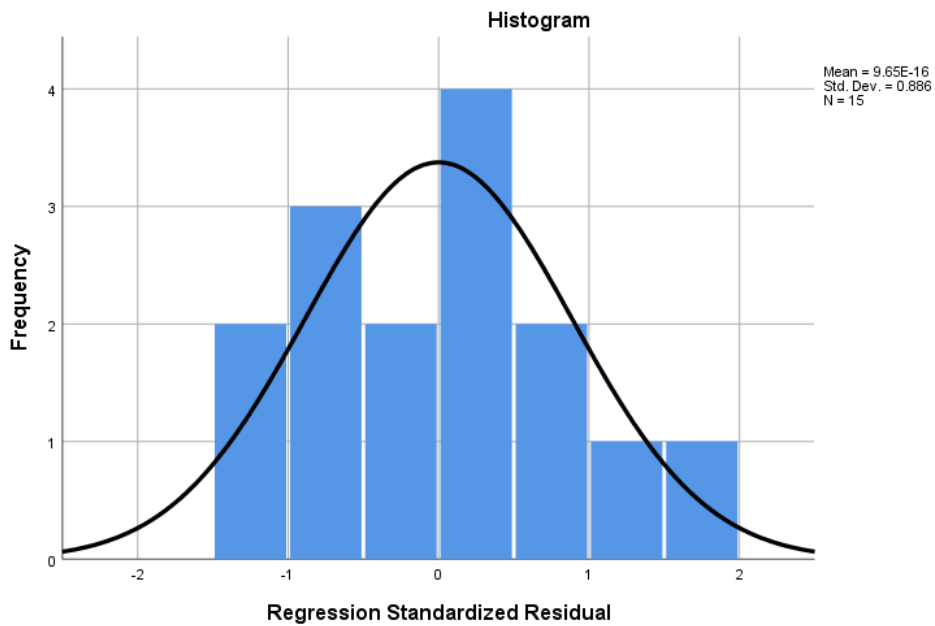
****.** Correlation is significant at the 0.01 level (2-tailed).

Pearson's "r" coefficient correlation test applied.

Graph 1: Showing mean and standard deviation of different condylar guidance angles



Graph 2: Showing correlations between different condylar guidance



DISCUSSION

The Cone Beam Computed Tomography (CBCT) scan is a cornerstone in modern dentistry, providing clinicians with unparalleled insights into the maxillomandibular region. Its ability to produce accurate images of the maxilla, mandible, and surrounding structures makes it indispensable for various diagnostic and treatment planning purposes. One of its notable applications lies in measuring the curvature of the glenoid fossa, a critical parameter for understanding condylar guidance—the mandibular guidance generated by the condyle and articular disc within the glenoid fossa.

Precise recording of condylar guidance is essential to prevent occlusal interferences during mandibular movements, thereby reducing the need for chair-side prosthesis adjustments, which can be time-consuming and frustrating for both patients and clinicians. Traditionally, both intraoral and extraoral methods have been utilized to determine sagittal condylar guidance angles (SCGAs), crucial for programming articulators to reproduce the patient's temporomandibular articulation accurately.

A literature search found that there were few studies available using CBCT panoramic views and CBCT cross-sectional views for the determination of SCGA. We intended to evaluate which CBCT view is better and closer to the routinely suggested method of extra oral gothic arch tracing method (EGTM). Studies by Schmitter⁹ Shrestha¹⁰, Prasad¹¹

found that SCGA measurement using the graphic method had lower reproducibility, which the authors attributed to variations among instruments, operators, etc.

Prasad and Mawani reported that SCGAs obtained radiographically are higher than those obtained from graphic records methods, our study showed similar results. Kwon et al. compared SCGA measured using a panoramic technique and two CBCT sectional views. They observed that SCGA differed significantly among the three methods which are in accordance with study done by R. Vijaya Kumar, et al. They also found a correlation between SCGA obtained using CBCT sectional views and protrusive occlusal record which is in agreement with our data obtained from this study¹².

Similarly in the present study when Intergroup comparison of condylar guidance of both sides SCG values obtained were found to be statistically significant for both Radiographic Right – Interocclusal Right as well as radiographic left and interocclusal left.

The sagittal condylar guidance angle is a critical factor in individualizing an articulator. Failure to properly record this angle may result in additional time spent on intraoral occlusal modifications. The correlation between posterior (joint-related) and anterior determinants has been controversial.

Christensen and Slabbert¹³ reported that SCGAs obtained radiographically are higher than those

obtained from intraoral records. However, if the difference between two methods is consistent, a clinically applicable SCGA can be obtained by adjusting the value measured using radiographic images. There were strong correlations between the SCGAs measured radiographically and using the protrusive occlusal record. Therefore, measuring the SCGA using radiographic images might indeed be a useful method. Previous studies found that intraoral methods of SCGA measurement have lower levels of reproducibility, which is attributable to variations between the instruments and operators.

Similarly in the present study all the variables relating to radiographic images of left or right were found to be statistically significant which is in correlation with the study done by Christensen and Slabbert, where the only difference is among usage of methodology in both the studies.

Panoramic radiography and CBCT are now widely used in diagnoses. CBCT was used to determine the relationships between protrusive occlusal record and radiographic measurements.

If SCGA measurements can be applied to the virtual articulator setting in a CAD-CAM process, this would greatly increase their clinical application. The protrusive occlusal record and CBCT imaging method were found to be comparable in this study.

In a study done by TA Naqash et al (2021)¹⁴, SCGA values obtained from Pantographic tracing (PT) were found to be closer to the SCGA values obtained from protrusive record than that from CBCT. The results are similar to the preliminary study conducted by Torabi et al, SCGA values obtained from PT (Cadiax®) are 2° higher than silicone intraoral records and statistically significant for all measurements. According to the literature, an error within 3.4° in the condylar setting seems acceptable for clinical use.

SCGA using CBCT images and pantographic tracings might indeed be a useful method. However, the value was low for PR indicating inconsistency. The present study is in agreement with the previous studies showing intraoral methods (PR) of recording SCGAs have a lower level of reproducibility and are subject to variation of instrument, operator, and occlusal records. PR technique for measuring SCGAs, regardless of the material used, is inconsistent and lacks precision; results from the

previous studies have reported significant differences between instruments and also between consecutive registrations for the same patients. Gross et al. have reported that Hanau consistently gave the lowest SCGA values and Whip Mix the highest, in the same patient.

The problem with the Protrusive technique is that the SCGA values change with the degree of protrusion and represent only one point along the condylar path. Semi-adjustable articulators are unable to reconstruct the condylar movements adequately because of their fixed inter-condylar distance and straight condylar pathway.

Several reports on the condylar mechanism and efforts to register mandibular movements date back to the late 18th century. The goal of registering the condylar path is to recreate the patient's occlusion as exactly as possible on the articulator, and is therefore essential for successful prosthodontic rehabilitation. As this study was done using radiographs whereas majority of the study done till date are under CBCT or CT or by any other reliable means is used as methodology, this study holds very high accuracy level which is nearly equal to other scanning techniques and can be a reliable method of caring it out on radiographs.

CONCLUSION

This study compared the SCGA values obtained by CBCT cross-section view with that of values obtained using extraoral Gothic arch tracing method using a protrusive record of 6 mm. A significant difference between the SCGA values between the two groups was observed. However, no statistically significant difference was found between the right and left sides within the group. No statistically significant difference was seen in the SCGA values neither in the graphic tracing method groups nor with the CBCT methods. Based on the findings of this clinical study, the following conclusions were drawn:

1. The right and left SCG angle values obtained from both the PIR and CBCT methods were comparable with no significant difference ($P > .05$).
2. There was no significant difference between the right and left side SCG angle values obtained from CBCT and PIR methods.

3. With increasing age, SCG angle values obtained from both the methods tend to decrease.
4. CBCT scans, with advantages over other radiographic and clinical techniques, can be used to determine SCG to program

semiadjustable and fully adjustable dental articulators.

In conclusion, within the study's limitations, CBCT appears to be a viable alternative to traditional methods for recording.

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