A Clinical Study to Compare the Condylar Guidance Measured By the Conventional Method and CBCT

Dr. Swalpa Sharma, [1] Dr. Sudhir Meena, [2] Dr. Pooja Jain, [3] Dr. Soniya Joseph [4]

1. **Dr. Swalpa Sharma**
   Senior Lecturer, Department of Prosthodontics and crown & bridge, NIMS Dental College and Hospital, Jaipur, Rajasthan, India
2. **Dr. Sudhir Meena**
   Professor, Department of Prosthodontics and crown & bridge, Mahatma Gandhi Dental College and Hospital, Jaipur, Rajasthan, India
3. **Dr. Pooja Jain**
   Professor, Department of Prosthodontics and crown & bridge, Mahatma Gandhi Dental College and Hospital, Jaipur, Rajasthan, India
4. **Dr. Soniya Joseph**
   Private practitioner, MDS, Department of Prosthodontics and crown & bridge, Mahatma Gandhi Dental College and Hospital, Jaipur, Rajasthan, India

Abstract

Condylar guidance is the mandibular guidance generated by the condyle and articular disc traversing the contour of glenoid fossa. The angle formed by the path of the condyle, within the horizontal plane compared with the median plane is the Horizontal condylar guidance. Recording condylar guidance accurately is essential for the success of a prosthesis. The present clinical study was conducted to evaluate the relationship between sagittal condylar guidance obtained by cone beam computed tomography imaging modality and two different clinical methods through extraoral tracer at the time of jaw relation and interocclusal wax records at the time of try-in, and to compare difference between right and left condylar guidance angles within the same subject. Within the limitations of the study it was observed that the condylar guidance value/angle is influenced by the stage at which the record is made. The condylar guidance value/angle obtained from the radiographs was higher than those obtained during jaw relation and try-in. However, the mean condylar guidance values recorded during try-in were nearer to the mean condylar value recorded on radiograph.

Keywords: Horizontal condylar guidance, Sagittal condylar guidance, Cone beam computed tomography, Try in, Extraoral tracers.

INTRODUCTION

Prosthetic rehabilitation depends a lot on restoring what is lost, and every attempt is made to rehabilitate them back to natural function. A successful treatment not only depends on accurate findings, but also depends on exact replication and recording of these findings. Studies of the condylar mechanism and attempts to register mandibular movement date back to the late 18th century. The goal for such recording of movements is to re-establish the patient's occlusion and mandibular movement patterns as precisely as possible on articulator [1]

Mandible is the only part capable of independent motion in the Stomatognathic system. It is vital to simulate the similar mandibular movements on the articulator while fabricating a prosthesis. The mandibular movement can be titled as condylar movement. In restorative as well as prosthodontic treatment the mandibular movements recording become essential as they influence cusp angles and for making of complete denture to provide balanced occlusion in it.[2,3] 'Condylar guidance is the mandibular guidance generated by the condyle and articular disc traversing the contour of glenoid fossa.

It is also defined as the mechanical form located in the upper posterior region of an articulator that control movement of its mobile member (GPT-9).[4]'The angle formed by the path of the condyle, within the horizontal plane compared with the median plane is the Horizontal condylar guidance.

Difficulties faced while recording the protrusive and lateral interocclusal records are cumbersome as the record base in many instances becomes loose and unstable. The patient's inability to hold the mandible while these records were made due to the absence of periodontal proprioceptors, make such records erroneous and fallacious in many instances[5]Literatures[6-8] indicate the use of radiograph for recording the condylar guidance. Panoramic radiograph is used commonly for the diagnosis in completely edentulous patient. In Prosthodontic field, Cone Beam Computed Technology (CBCT) has brought revolution especially in area of maxillofacial imaging. Gilboa et al [8], studied dry human skulls and evaluated the outline of the articular eminence and the glenoid fossa of the temporal bone on panoramic radiographs and suggested to be of valuable aid in determining condylar guidance angle in semi-adjustable articulators. This study was done to compare the inclination of the condylar path obtained by panoramic radiograph and protrusive interocclusal records in completely edentulous patients.

Usually Horizontal condylar inclination (HCI) is obtained with protrusive interocclusal records [9]. The influence of condylar paths over the movements of the mandible can be registered by protrusive inter occlusal records. It facilitates the condylar guidances of the articulator to be set to an approximation of the paths of the condylar movements in patients [10].

Studies have shown that radiographic methods can record condylar guidance more accurately than other methods[11]. The inconvenience and radiation exposure concerns are said to be the main disadvantage for widespread usage of radiographic methods to estimate condylar guidance[12]. Additionally, there is little evidence in literature to suggest it in comparison with the prevalent methods. Lately, digital Cone Beam CT scans have made them safer, more accurate and comparatively cheaper resulting in their widespread application in many areas of dentistry. It can be argued that application of advanced imaging is unwarranted in Prosthodontics. The higher levels of safety, and ultimate patient benefit from advanced digital imaging suggests that time may be ripe for its introduction into prosthodontics.

However, evidence based adoption of digital CBCT scans for stomatognathic measurements [13] and calibration of the dental articulator's calls for definitive comparative studies in this area. The purpose of this study thus was to compare both right and left condylar guidance values obtained using Cone Beam CT scans, extra- oral tracer and interocclusal wax records in healthy adults. Null hypothesis is that, there is difference in mean condylar values between jaw relation and radiograph was found to be statistically significant (P\0.001). Similarly, the difference in mean condylar values between try-in and radiograph was found to be statistically significant (P\0.001)

METHODOLOGY

The present clinical study was conducted to evaluate the relationship between sagittal condylar guidance obtained by cone beam computed tomography imaging modality and two different clinical methods through extraoral tracer at the time of jaw relation and interocclusal wax records at the time of try-in, and to compare difference between right and left condylar guidance angles within the same subject. This study was conducted at Mahatma Gandhi Dental College and Hospital, Jaipur, in department of Prosthodontics &Crown & Bridge. Study participants were selected from inpatient and outpatient department of Mahatma Gandhi Dental College and Hospital. All the participants were well-informed about the purpose and methods of the study and signed the informed consent. The sample size selected for the study was 15 edentulous patient irrespective of gender.The study was done after obtaining approval from the Institutional Ethical Committee. Subjects that were included in the study were those who were willing for voluntary participation and signed consent, edentulous subjects with good general health and between the age of 50-70 years who had no signs and symptoms of temporomandibular disorder, facial asymmetry and congenital facial defect. Subjects with any

temporomandibular disorder or restricted mandibular movement and poor general health were excluded from the study.

RADIOGRAPHIC METHOD

Radiographic Parameters:

Frankfort's Horizontal reference plane

Posterior slope of articular eminence

Radiographic sagittal condylar Guidance Angle

CBCT of whole skull was recorded. Articular eminence and mandibular fossa was identified for both right and left sides. Tangent of the Posterior slope of the articular eminence was drawn in the digital image. A line joining the superior most point of the external auditory meatus (Porion) and Inferior most point in the margin of the orbit (Orbitale) was marked. The angles between these two lines represent the Radiographic condylar guidance. (Fig 15)

CLINICAL METHOD

Clinical Parameters:

Centric interocclusal record

Protrusive inter occlusal record

Sagittal condylar Guidance Angle

Primary and secondary impressions were made, a final cast was obtained, face bow transfer was done and jaw relation records were made, and extra oral tracing was thereafter carried out with the help of tracers attached to the rims. In Gothic arch tracing, when definite arrow point tracing with a sharp apex was made, the subjects were asked to retrude the mandible to the most retruded position i.e centric relation. The bite registration material was injected between the central bearing device and allowed to set. From the apex of the arrow point tracing the distance of 6 mm was measured on the protrusive tracing and was marked and then protrusive interocclusal records were made. (Fig 13)

PROGRAMMING THE ARTICULATOR

The horizontal condylar adjustments were made by releasing the locknuts. The protrusive records were seated on the mandibular cast and the maxillary cast was seated on the record. The maxillary articulator member was gently manipulated into position using precise fit of the maxillary split cast to determine the condylar guidance angulation. The condylar guidance values/angles were recorded for the right and left sides.

Try In

After ideal teeth arrangement the trial dentures were placed on the articulator and then a line was drawn on the first upper premolar and an another line drawn 6 mm posterior on the lower premolar so that when the upper member is retruded, the line will coincide. The horizontal relation of the upper to lower anterior teeth and the relationship of the lower and upper midlines were observed carefully. The locknuts were tightened in that position.

Aluwax was immersed in a water bath of 54 °C for 30 s and was placed on the lower trial denture. The upper member of the articulator was pressed into the warm wax. Then wax record was chilled thoroughly. Then the trial dentures were placed in patients mouth and the patient was trained to perform 6mm protrusive movement and then alu wax records were placed in patients mouth and the patient was asked to hold the jaw in these indentations. After satisfactory closure, wax records were cross checked by registering protrusive using O-bite registration paste. (Fig 14)

PROGRAMMING THE ARTICULATOR (Fig:15)

The trial dentures were placed on the articulator along with the interocclusal record and programming was done. The maxillary articular member was gently manipulated into position using precise fit of the maxillary split cast to determine the condylar guidance angulation. The condylar guidance values/angles were recorded.

Statistical Analysis

The data was coded and entered into Microsoft Excel spreadsheet. Analysis was done using SPSS version 20 (IBM SPSS Statistics Inc., Chicago, Illinois, USA) Windows software program. Descriptive statistics included computation of percentages, means and standard deviations. The data was checked for normality before statistical analysis using Shapiro–Wilk test. Quantitatively were analyzed using Mann–Whitney Utest. The analysis of variance (ANOVA) was used for quantitative data comparison of all clinical indicators. Level of significance was set at $P \leq 0.05$.

OBSERVATIONS & RESULTS

Fig 1 shows the insignificant statistical difference in the right and left condylar guidance with p value of 0.94

- Mean value of right condylar guidance with GROUP I came out to be 44.60 degrees +- 3.979.
- Mean value of left condylar guidance with GROUP I came out to be 44.47 degree +- 5.592.
- The condylar guidance measured in Sub group A shows higher mean value than Sub group B.

The bar graph comparing right and left condylar guidance in CBCT is represented on fig 2

Fig 3 shows the insignificant statistical difference in the right and left condylar guidance with p value of 0.06

- Mean value of right condylar guidance with Group II came out to be 22.33 degrees +- 3.773.
- Mean value of left condylar guidance with Group II came out to be 25.67degree +- 5.678.
- The condylar guidance measured in Sub group B shows higher mean value than Sub group A

The bar graph comparing right and left condylar guidance in Jaw Relation is represented in Fig 4

Fig 5 shows the insignificant statistical difference in the right and left condylar guidance with p value of 0.79

- Mean value of right condylar guidance with Try in came out to be 35.87 degrees +- 4.749.
- Mean value of left condylar guidance with Try in came out to be 36.33 degree +-5.192.
- The condylar guidance measured in Sub group B shows higher mean value than Sub group A.

The bar graph comparing right and left condylar guidance in Try in is represented in Fig 6

Fig 7 shows the significant statistical difference in the right condylar guidance between Group I, II, & III with p value of 0.001

- Mean value of condylar guidance with Group II came out to be 22.33 degrees +- 3.77.
- Mean value of condylar guidance with Group III came out to be 35.86 degree +-4.74.
- Mean value of condylar guidance with Group I came out to 44.6 degree +- 3.97.
- The condylar guidance measured in Group I shows higher mean value than the Group III and Group II.

The bar graph comparing right side mean condylar guidance between jaw relation, Try in and CBCT is represented in **Fig 8.**

In Fig 9, On applying post hoc Bonferroni test:

- On comparing Group II to Group III, there is a mean difference showing the significant difference in condylar guidance that is of 13.53 degree
- On comparing group Group II and Group I, there is a mean difference showing the significant difference in condylar guidance that is of 22.26 degree
- On comparing Group I and III, there is a mean difference showing the significant difference in condylar guidance that is of 8.733 degree

Fig 10 shows the significant statistical difference in the left condylar guidance between Group I,II and III with p value of 0.001

- Mean value of condylar guidance with Group II came out to be 25.66 degrees +-5.67.
- Mean value of condylar guidance with Group III came out to be 36.33 degree +-5.19.
- Mean value of condylar guidance with Group I came out to 44.46 degree +- 5.59.
- The condylar guidance measured in group I shows higher mean value than the Group II and III.

The bar graph comparing left side mean condylar guidance between jaw relation, Try in and CBCT is represented in **Fig 11.**

In Fig 12, On applying post hoc Bonferroni test on right side:

- On comparing Group II to Group III, there is a mean difference showing the significant difference in condylar guidance that is of -10.66 degree
- On comparing Group II and Group I, there is a mean difference showing the significant difference in condylar guidance that is of -18.80* degree
- On comparing Group I and III, there is a mean difference showing the significant difference in condylar guidance that is of 8.133 degree

DISCUSSION

Successful prosthodontic procedure results most likely in cases where the condylar path of the patient is simulated accurately using an articulator. This can restore the effective shape of the occlusal surface resulting with trouble free restorations [14]. Therefore, usefulness of articulator is unaltering whether the

required restoration is removable or fixed, single unit or a complex restoration, for recording of this condylar guidance.

The face-bow transfer and the centric, lateral and protrusive jaw relation records together establish the simulation of the mandibular movements on the articulator [15,16]. However the degree of correlation between the patient and articulator depends on many factors including biological considerations and the properties of the material used during process of transferring the maxillomandibular relations from the patients to the articulators [17,18].

Various methods of recording condylar pathways are available, ranging from simple interocclusal method to recently available advanced methods such as pantronic, computerized jaw tracking devices which records precise condylar pathways. The choice of technique depends on the specific clinical needs of occlusal rehabilitation rather than an overriding concern for precise condylar pathways. Hence the simplest and the most convenient method which would suit the particular clinical situation should be chosen to serve the purpose.[19]Three general classes of records are used for transferring maxillomandibular relations from the patients to the articulator. It may be either directly by the hinge axis records and pantographic records to the articulator or indirectly by the interocclusal records [20] to the articulator or by radiographic methods [21].

This clinical study is oriented towards comparing two different clinical methods in reproducing sagittal condylar guidance angulations when programmed using protrusive record with the condylar guidance value obtained by Cone beam Computed Tomography. The left and right condylar guidance angles were measured of all subjects using three methods, Condylar guidance values from CBCT image, Condylar guidance values from extra oral Tracer Method, and Condylar guidance values from interocclusal Wax Records. The difference attained between the left and right measurements from all methods was statistically insignificant.

Weinberg[22] and Gilboa *et al*.[8]reported a high degree of correlation between articular eminences anatomically and radiographically and suggested that the inclination of the articular eminence in a panoramic image may coincide with the anatomic articular eminence. They also stated that compared to clinical methods, radiographic measurement has the advantage of using stable bony landmarks and ability of being standardized and repeatable.

Galagali *et al*.[23]also reported a correlation between the condylar guidance angles obtained by protrusive interocclusal records, panoramic radiograph, and the lateral cephalogram radiograph methods. They found that lateral cephalogram radiographs were more positively related than the panoramic radiograph, and the values of lateral cephalogram radiographs were closer to the interocclusal records on the articulator as separate radiographs for the left and right side were taken, making the amount and quality of image distortionless.

Studies conducted by Gheriani[24], Winstanley, Zamacona[25] reveled high variability in the values of right and left side. But graphic registration was done in their study and all the subjects considered by them were patients with tempomandibularjoint disorder.

Literature indicates the use of lateral cephalograms, panoramic radiograph,tomographs, digital CT scan used for recording condylar guidance [8,26.] WhenCephalometric technique was used to find out the condylar guidance values there was adifference in readings for the same patient even when a standardized procedure was followed [27]. Magnetic resonance imaging has also been used to find out the articulareminence morphology and inclination in the past. At recent days the advent of digital CBCT scans has ruled out these.

Davis Et Al [28] concluded digital imaging and Interactive computer processing have added benefits of high quality images, speed of application, direct analysis and as accurate as manual technique with high precision as the earlier.

In this study, condylar guidance values obtained from wax interocclusal record exhibited high level of significance when compared with CBCT, while extra-oral method revealed low significant difference. Also, there was no statistical significant difference found when right and left sides were compared from all three methods. In general, it could be derived from the present study that none of the clinical methods were recognized to be giving condylar guidance angle values comparable with the CBCT. Accounting the excellent accuracy, meticulousness and chemo-mechanical properties of procedures and materials, it is only obvious to imply

that Cone Beam computerized tomographical methods of determining condylar guidance values must be introduced into the clinical work flow. However, it is not recommended, on the basis of these results to invalidate the application of these techniques as clinical methods are more practical, economical and are dependable with each other. A few limitations of the study are the small sample size, the radiographic exposure could have been reduced by limiting the exposure to TMJ area, and that the articulator has a numerical scale with increments of 5 degree, and difficulty in distinguishing articular eminence from zygomatic arch.

BIBLIOGRAPHY

1. Dawson PE. Functional occlusion : from TMJ to smile design. Mosby; 2007.630.
2. Okeson JP. Management of Temporomandibular disorders and occlusion. 6th ed. St. Louis: Elsevier; 2008
3. Bhandari A, Manandhar A, Singh RK, Suwal P, Parajuli PK. A Comparative study to measure the horizontal condylar guidance obtained by protrusive interocclusal records and panoramic radiographic images in completely edentulous patients. JCMS Nepal. 2018;14(1):21-7.
4. The Glossary of Prosthodontics Terms. J Prosthet Dent. 2005;94:10-92. https://doi.org/10.1016/ j.prosdent.2005.03.013
5. Rahn AO, Heartwell CM. Textbook of complete dentures. 5th ed. Pennsylvania: Lea and Febiger; 1993.p.250-1, 298.
6. Boos RH.Condylar path by roentgenograph. J Prosthet Dent. 1951;1:387-92. https://doi.org/10.1016/0022-3913 (51)90022-4.
7. Katsavrias EG. The effect of mandibular protrusive (activator) appliances on articular eminence morphology. Angle Orthod. 2003;73:647-53. PMID: 14719728.
8. Gilboa I, Cardash HS, Kaffe I, Gross MD. Condylar guidance: correlation between articular morphology and panoramic radiographic images in dry human skulls. J Prosthet Dent. 2008;99:477-82. https://doi.org/10.1016/ S0022-3913(08)60112-2.
9. Zarb GA (George A, Bolender CL, Eckert SE. Prosthodontic treatment for edentulous patients : complete dentures and implant-supported prostheses.Mosby; 2004. 560 p.
10. Sheldon Winkler. Essentials Of Complete Denture Prosthodontics 3rd Edition
11. American Dental Association Council on Scientific affairs, The use of cone beam computed tomography in dentistry: an advisory statement from the American Dental Association Council on Scientific Affairs. The Journal of the American Dental association. 2012 Aug 1;143(8):899-902
12. Shreshta P, Jain V, Bhalla A, Pruthi G. A comparative study to measure the condylar guidance by the radiographic and clinical methods. J Adv Prosthodont. 2012;4(3):153.
13. The use of cone-beam computed tomography in dentistry: An advisory statement from the American Dental Association Council on Scientific Affairs. J Am Dent Assoc. 2012 Aug 1;143(8):899–902
14. Donegan SJ, Christensen L V. Sagittal condylar guidance as determined by protrusion records and wear facets of teeth. Int J Prosthodont ;4(5):469–72.
15. Swenson. Complete Dentures, 4th Edition, by Swenson, 1959 ,
16. 47. Sharry JJ. Complete denture prosthodontics. McGraw-Hill; 1974. 378 p.
17. Mullick SC, Stackhouse JA, Vincent GR. A study of interocclusal record materials. J Prosthet Dent. 1981 Sep 1;46(3):304–7.
18. 49. Campos AA, Nathanson D. Compressibility of two polyvinyl siloxane interocclusal record materials and its effect on mounted cast relationships. J Prosthet Dent. 1999 Oct;82(4):456–61.
19. Godavarthi AS, Sajjan MS, Raju AR, Rajeshkumar P, Premalatha A, Chava N. Correlation of condylar guidance determined by panoramic radiographs to one determined by conventional methods. Journal of international oral health: JIOH. 2015 Aug;7(8):123.
20. Rahn AO, Ivanhoe JR, Plummer KD, Dentistry & Oral Sciences Source. Textbook of Complete Dentures. McGraw-Hill Companies, The; 2009
21. Malone WFP, Koth DL, Cavazos E, Kaiser DA, Morgano SM, Tylman SD (Stanley D. Tylman's theory and practice of fixed prosthodontics. Ishiyako EuroAmerica; 2001. 461 p.
22. Weinberg LA. An evaluation of basic articulators and their concepts part I and II. J Prosthet Dent. 1963;13:645–63.
23. Galagali G, Kalekhan SM, Nidawani P, Naik J, Behera S. Comparative analysis of sagittal condylar guidance by protrusive interocclusal records with panoramic and lateral cephalogram radiographs in

dentulous population: A clinico-radiographic study. The Journal of the Indian Prosthodontic Society. 2016 Apr;16(2):148.
24. el-Gheriani AS, Winstanley RB. Graphic tracings of condylar paths and measurements of condylar angles. J Prosthet Dent. 1989 Jan;61(1):77–87.
25. 57. Zamacona JM, Otaduy E, Aranda E. Study of the sagittal condylar path in edentulous patients. J Prosthet Dent. 1992;68(2):314–7.
26. Dos Santos J, Nelson S, Nowlin T. Comparison of condylar guidance setting obtained from a wax record versus an extraoral tracing: a pilot study. The Journal of prosthetic dentistry. 2003 Jan 31; 89(1):54-9
27. Gross M, Nemcovsky C, Friedlander LD. Comparative study of condylar settings of three semiadjustable articulators. Int J Prosthodont;3(2):135–41.
28. Davis DN, Mackay F. Reliability of cephalometric analysis using manual and interactive computer methods. Br J Orthod. 1991 May;18(2):105–9.

FIGURES AND LEGENDS

Fig 1: GROUP I: CBCT (Mann–Whitney U-test)

	Mean	Std. Deviation	Minimum	Maximum	P value
Right (Subgroup A)	44.60	3.979	40	53	0.94
Left (Subgroup B)	44.47	5.592	33	56	
Total	44.53	4.769	33	56	

Fig 2

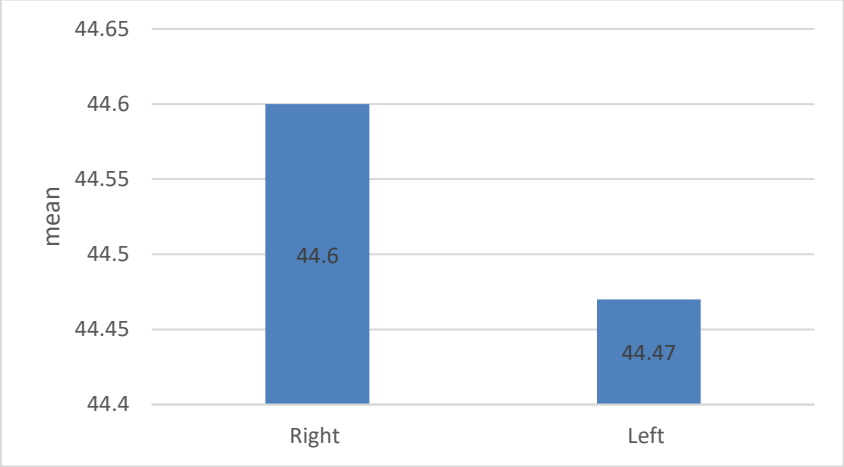


Fig 3

	Mean	Std. Deviation	Minimum	Maximum	P value
Right	22.33	3.773	15	28	0.06
Left	25.67	5.678	15	35	
Total	24.00	5.031	15	35	

Fig 4

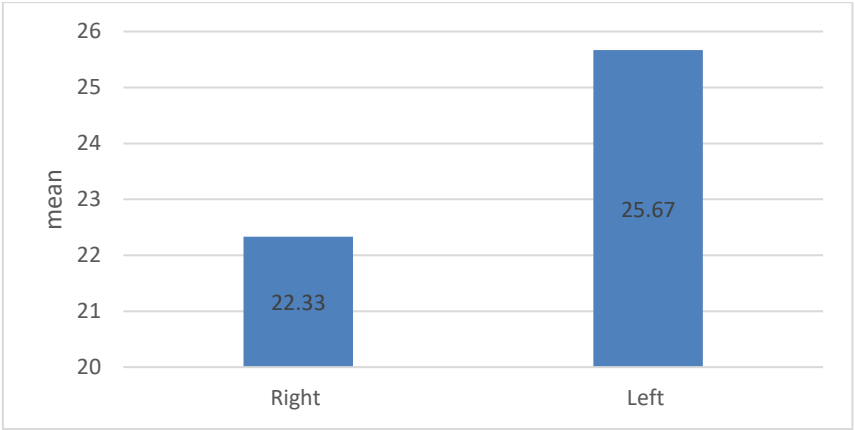


Fig 5: GROUP III: Try in (Mann–Whitney U-test)

	Mean	Std. Deviation	Minimum	Maximum	P value
Right	35.87	4.749	30	45	0.79
Left	36.33	5.192	30	45	
Total	36.10	4.894	30	45	

Fig 6

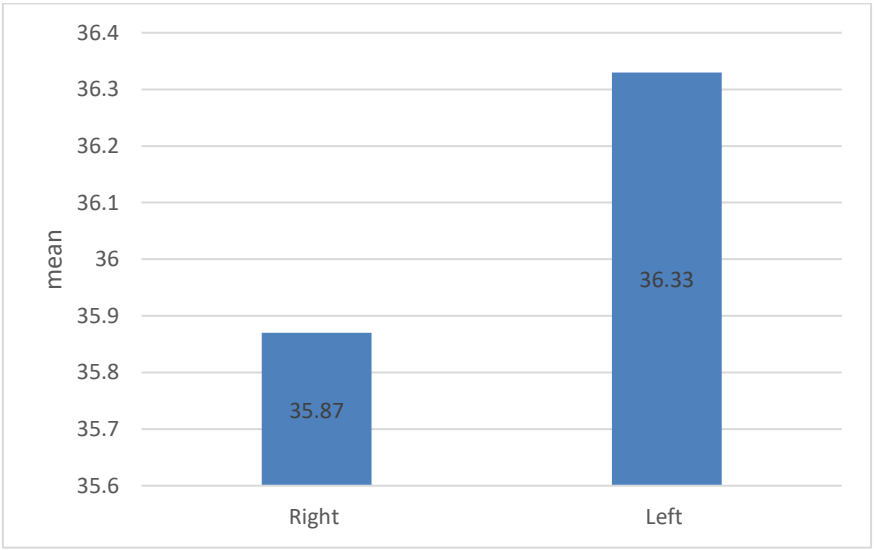


Fig 7: Inter-Group comparison of right side (ONE WAY ANOVA test)

	Mean	Std. Deviation	Minimum	Maximum	P value
Jaw relation (Group II)	22.33	3.77	15.00	28.00	0.001 (S)
Try in (Group III)	35.86	4.74	30.00	45.00	
CBCT (Group I)	44.6	3.97	40.00	53.00	
Total	34.26	10.12	15.00	53.00	

Fig 8

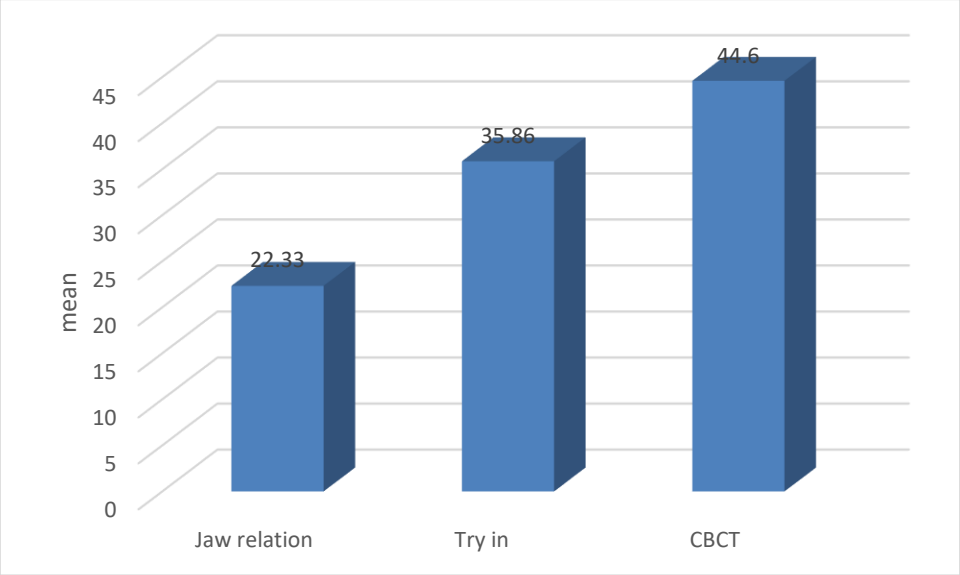


Fig 9: Intra-Group comparison of right side (post hoc Bonferroni test)

		Mean Difference	P value
Jaw Relation (Group II)	Try in	-13.53333*	.000 (S)
	CBCT	-22.26667*	.000 (S)
Try in (Group III)	Jaw relation	13.53333*	.000 (S)
	CBCT	-8.73333*	.000 (S)
CBCT (Group I)	Jaw relation	22.26667*	.000 (S)
	Try in	8.73333*	.000 (S)

Fig 10: Inter-Group comparison of left side (One Way ANOVA)

	Mean	Std. Deviation	Minimum	Maximum	P value
Jaw relation	25.66	5.67	15.00	35.00	0.001 (S)
Try in	36.33	5.19	30.00	45.00	
CBCT	44.46	5.59	33.00	56.00	
Total	35.48	9.45	15.00	56.00	

Fig 11

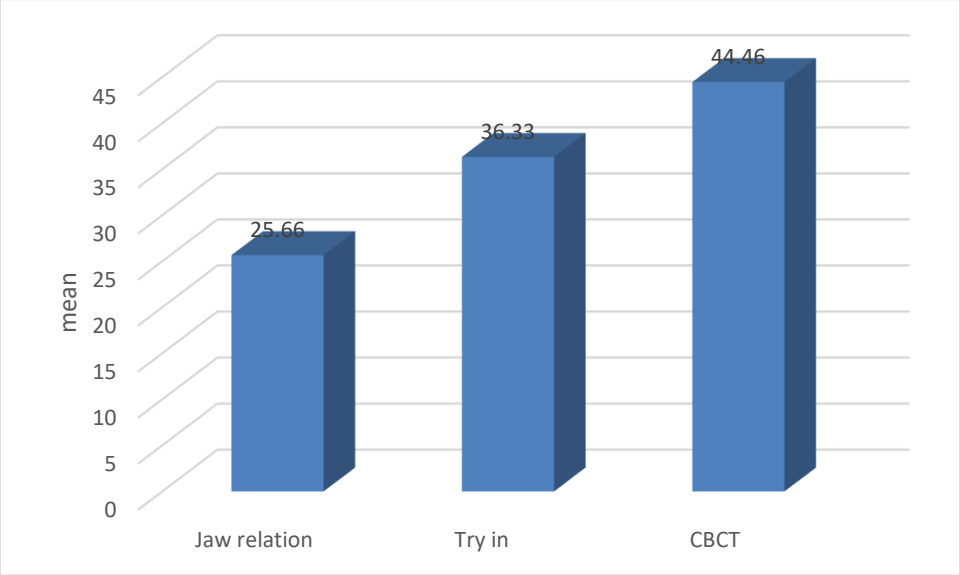


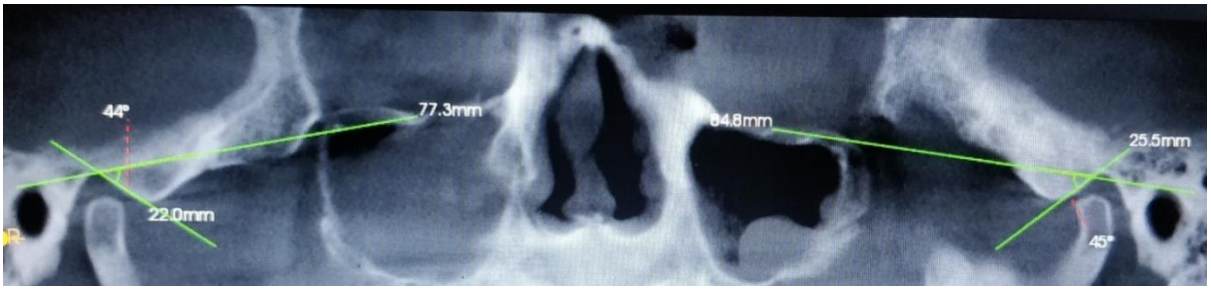
Fig 12: Intra-Group comparison of left side (post hoc Bonferroni test)

		Mean Difference	P value
Jaw relation (Group II)	Try in	-10.66667*	.000 (S)
	CBCT	-18.80000*	.000 (S)
Try in (Group III)	Jaw relation	10.66667*	.000 (S)
	CBCT	-8.13333*	.001 (S)
CBCT (Group I)	Jaw relation	18.80000*	.000 (S)
	Try in	8.13333*	.001 (S)

Fig 13

Fig 14

Fig 15


44°
77.3mm
84.8mm
25.5mm
22.0mm
45°