CLINICO-RADIOGRAPHIC ANALYSIS OF CONDYLAR GUIDANCE OBTAINED FROM CONE BEAM COMPUTER TOMOGRAPHY AND THREE DIFFERENT CLINICAL METHODS - A COMPARATIVE STUDY

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In partial fulfillment of the requirements for the degree

of

MASTER OF DENTAL SURGERY

(BRANCH – I)

(PROSTHODONTICS AND CROWN & BRIDGE)

2015 – 2018

CERTIFICATE

This is to certify that **Dr. JILL VADODARIA ,** Post Graduate student (2015 - 2018) in the Department of Prosthodontics and Crown and Bridge, has done this dissertation titled **"CLINICO-RADIOGRAPHIC ANALYSIS OF CONDYLAR GUIDANCE OBTAINED FROM CONE BEAM COMPUTER TOMOGRAPHY AND THREE DIFFERENT CLINICAL METHODS - A COMPARATIVE STUDY "** under my direct guidance and supervision in partial fulfillment of the regulations laid down by **The Tamil Nadu Dr. M.G.R. Medical University, Guindy, Chennai – 32** for **M.D.S.** in **Prosthodontics and Crown & Bridge (Branch I)** Degree Examination.

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DECLARATION

I, **Dr. JILL VADODARIA,** do hereby declare that the dissertation titled **"CLINICO-RADIOGRAPHIC ANALYSIS OF CONDYLAR GUIDANCE OBTAINED FROM CONE BEAM COMPUTER TOMOGRAPHY AND THREE DIFFERENT CLINICAL METHODS - A COMPARATIVE STUDY"** was done in the Department of Prosthodontics, Tamil Nadu Government Dental College & Hospital, Chennai 600 003. I have utilized the facilities provided in the Government Dental College for the study in partial fulfilment of the requirements for the degree of **Master of Dental Surgery** in the speciality of **Prosthodontics and Crown & Bridge (Branch I)** during the course period **2015-2018** under the conceptualization and guidance of my dissertation guide, **PROF. Dr. C. SABARIGIRINATHAN.MDS.,** and co-guided by **DR. M. RAJA KUMAR M.D.S.,** Associate Professor in Department of Prosthodontics Crown & Bridge

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I also declare that no part of this work will be published either in the print or electronic media except with those who have been actively involved in this dissertation work and I firmly affirm that the right to preserve or publish this work rests solely with the prior permission of the Principal, Tamil Nadu Government Dental College & Hospital, Chennai 600 003, but with the vested right that I shall be cited as the author(s).

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College represented by its Principal Guide

Witnesses PG Student

1.

2.

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LIST OF ABBREVIATIONS

SL No.	ABBREVIATION	EXPANSION
1	**CBCT**	Cone Beam Computed Tomography
2	**HCI**	Horizontal Condylar Inclination
3	**HCG**	Horizontal Condylar Guidance
4	**CR**	Centric Relation
5	**VDO**	Vertical Dimension at occlusion
6	**TMJ**	Temporomandibular joint
7	**DICOM**	Digital Imaging and Communication in Medicine
8	**SD**	Standard Deviation
9	**ANS**	Anterior Nasal Spine
10	**PNS**	Posterior Nasal Spine
11	**FH**	Frankfort Horizontal Plane

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CERTIFICATE – II

This is to certify that this dissertation work titled : **CLINICO-RADIOGRAPHIC ANALYSIS OF CONDYLAR GUIDANCE OBTAINED FROM CONE BEAM COMPUTER TOMOGRAPHY AND THREE DIFFERENT CLINICAL METHODS - A COMPARATIVE STUDY** of the candidate **Dr. JILL VADODARIA** with registration Number **2415-11006** for the award of **I** in the branch of **PROSTHODONTICS AND CROWN & BRIDGE**. I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows **1** percentage of plagiarism in the dissertation.

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ABSTRACT

Introduction: Condylar guidance is one of the most vital clinical procedures in rehabilitating patients especially with complex restoration. It will have a direct effect on function comfort aesthetics, and denture stability. The use of Cone Beam Computed Tomography still remains controversial. It is mainly due to cost, technique sensitivity and difficulty in availability. The present study was undertaken to is to evaluate correlation between Sagittal Condylar Guidance obtained by cone beam computed tomography imaging modality and three different clinical methods through interocclusal wax records, interocclusal jigs and intraoral tracer in dentulous subjects.

Keywords: Condylar Guidance, Cone Beam Computed Tomography, Intraoral tracer, interocclusal records, Wax record.

Aim: To evaluate correlation between Sagittal Condylar Guidance obtained by cone beam computed tomography imaging modality and three different clinical methods through interocclusal wax records, interocclusal jigs and intraoral tracer in dentulous subjects.

Materials and methods: 30 dentate subjects were selected as per predetermined criteria. . Cone Bean Computed Tomography was obtained for all the subjects. Tracings were performed digitally for all of these radiographs using DICOM software and condylar guidance angle was attained. Clinically, methods were employed with help of interocclusal wax, jig and intraoral tracer and record was obtained. These interocclusal records were transferred to articulator and condylar guidance angle values were attained.

Results: Statistical analysis was done using SPSS Version 23. The condylar guidance angle values obtained from the dentulous subjects was performed using independent sample-t-test to compare the different angles. To describe the data descriptive statistics the mean and standard deviation were used. Condylar guidance values obtained from wax interocclusal record and jig method exhibited high level of significance when compared with CBCT, while intra-oral method revealed lesser significant difference. And there was no statistical significant difference found when right and left sides were compared from all four methods.

Conclusion: The condylar Guidance angle values obtained from Right and Left side from radiographic as well as clinical method can be comparable to a limited degree only. Cone Beam Computed Tomography presents with highest mean condylar guidance values when compared with all three clinical methods. Condylar Guidance values obtained from all clinical methods are comparable with each other. It may be valuable to utilize CBCT scans for condylar measurements especially for complex oral rehabilitations. Still, further studies with much larger sample sizes are needed with Condylar Guidance angle values to confirm the present results.

INTRODUCTION

With immense technological advancement and multitudinous resources available there is pinnacle of achievement in all fields of development. In Prosthodontic field Cone Beam Computed Technology (CBCT) has brought revolution especially in area of maxillofacial imaging [1].

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 [2].

Condylar guidance by definition is mandibular guidance generated by the condyle and articular disc traversing the contour of the articular eminence or synonymously as the mechanical form located in the posterior region of an articulator that controls movement of its mobile member [3].During any procedure for restoration a prosthodontist has control over factors like cusp angulation, anterior guidance, compensating curves and plane of occlusion to a certain extent but condylar guidance is independent on its own; patient controlled factor [4]. Thus it is essential to establish an optimum occlusion that is in harmony with the patient's stomatognathic system [5].

The correlation between the path traced by the condyle during mandibular movements and the morphology of the occlusal surfaces has been studied by various investigators [6]. It is very important to establish precisely in patient during complete and fixed prosthodontic rehabilitation because it allows clinician to access the correlation between the path of condyle during mandibular movements and the morphology of occlusal surfaces. Thus it helps in restoring the occlusion without any interferences. If

error is present during recording of condylar guidance it will generate occlusal interferences during restoration procedure which is time consuming for dentist and patient [7 8 9].

In healthy dentate individuals, the occlusal anatomy of teeth functions in harmony with structures controlling the movement patterns of the mandible. These patterns are determined by the temporomandibular joint and the anterior teeth. The significance of the condylar guidance lies in how it influences posterior tooth morphology, both the vertical and horizontal components [10].

Horizontal condylar inclination (HCI) is usually obtained with protrusive interocclusal record [11]. A protrusive interocclusal record can register the influence of condylar paths over the movements of the mandible. It enables the condylar guidances of the articulator to be set to an approximation of the paths of the condylar movements in patients [12].

Condylar guidance can be recorded mainly by three methods: (1) Graphic registration (2) Intraoral or positional wax method (3) Radiographic method.

Extra oral methods are generally exemplified by Gysi and McCollum and mainly used in edentulous patients. The different materials used as interocclusal recording medium are Plaster of Paris, wax, modeling compound, acrylic resin, zinc oxide paste and elastomers [13 14]. Significant differences in Horizontal Condylar Inclination values between these articulators have been documented when wax protrusive records were used to program them [15 16]. Consecutive condylar guidance angles recorded showed variation between operator, between recording materials and between articulators [17].

The use of supplementary aids such as imaging may help in resolving above problems. Also Literature indicates the use of lateral cephalograms, panoramic radiograph, tomographs, digital CT scan used for recording condylar guidance [18 19]. In Earlier studies Cone Beam Computed Tomography was used to detect articular eminence and condyle morphology [20 21]

Studies have shown that radiographic methods can record condylar guidance more accurately than other methods [22]. The added expense, inconvenience and radiation exposure concerns are said to be the main deterrents for widespread usage of radiographic methods to estimate condylar guidance [23]. 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. Yet, the higher levels of safety, accuracy 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 [24] and calibration of the dental articulators calls for definitive comparative studies in this area. The purpose of this study thus was to compare condylar guidance values obtained using Cone Beam CT scans, interocclusal jigs, intra-oral tracer and interocclusal wax records in healthy adults.

AIM AND OBJECTIVES

AIM:

The aim of the study is to evaluate correlation between Sagittal Condylar Guidance obtained by cone beam computed tomography imaging modality and three different clinical methods through interocclusal wax records, interocclusal jigs and intraoral tracer in dentulous subjects.

OBJECTIVES:

1. To measure condylar guidance with CBCT with Frankfort Horizontal Plane as reference.
2. To compare the condylar guidance value obtained from CBCT and those obtained from Interocclusal Wax Records.
3. To compare the condylar guidance value obtained from CBCT and those obtained from Interocclusal jig Method.
4. To compare the condylar guidance value obtained from from CBCT and those obtained from intraoral tracer.
5. To Compare the Condylar guidance values obtained from different methods with each other.
6. To compare difference between right and left condylar guidance angles within the same subject.

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REVIEW OF LITERATURE

An exact reproduction of occlusal relation on the articulator during all stages of treatment for fabrication of prosthesis is utmost important. It depends on correct intraocclusal records transferred to articulator. Various materials and methods for recording these interocclusal records are mentioned in literature. The concept of recording condylar guidance is described ever since early 1900's in literature. Also, It is essential to obtain independent condylar measurements for each individuals

In 1951 **RALPH H. BOOS** [25] depicted a procedure to record condylar path by roentgen graph. This strategy allowed the central X-ray to be as near to the horizontal plane as possible. This was relied upon to obtain a picture of the angle of the joint without interference. This method included minimal measure of gear and can be utilized as a part of a normal dental office and remain as a column stone for our investigation.

RAYMOND COHEN [26] in 1956 conducted investigation to verify if the path of condylar movement was consistent or changes with degree of maxillomandibular opening or anterior guidance. The condylar guidance obtained was permanent and fixed. It was found out that only one tooth form functions best for individual once vertical and horizontal overlap of anterior teeth as well as plane of occlusion and compensating curve is established.

In 1959 **DANIEL ISSACSON ET AL** [27] made a clinical study of condylar path. It was found that every patient in unique and should have restorations according to their own condylar path. Older patients shouldn't be provided with cusp of a lesser angulation.

ARTHUR E. AULL [28] in 1965 investigated about the condylar determinants of occlusal patterns. It was determined that increase of steepness in eminences increases the requirement for steeper sloping cusps on the balancing side. An increase in laterotrusion requires shorter cusps and as the intercondylar distance is increased, the angle between the transverse path and oblique path of the cups will be more acute.

ROBERT J.ROTHSTEIN [29] in 1972 made a study on condylar guidance settings on articulators from protrusive records. He described the procedure for adjustment of the condylar elements on the articulator. This is an essential adjunct in the improvement of denture occlusion.

L. V. CHRISTENSEN, J. C. G. SLABBERT [30] in 1978 discussed the clinical concept of condylar guidance. They concluded there is no single and well defined sagittal condylar guidance present. Thus no single and well defined sagittal condylar guidance angle can be applicable to the adjustable articulator.

G.PRETI ET AL [31] in 1982 made a clinical study related to the graphic representation of the condylar path inclination. It was established from the study that the average sagittal condylar path values were not satisfactory when an extensive prosthodontic rehabilitation was required. Also, this study concluded that the sagittal condylar path values had a change of less than 5 degree in healthy patients and the disparity was greater than 5 degree for subjects with TMJ disturbances.

GHERIANI, WINSTANLEY RB. [32] in 1989 carried out study in 30 subjects to determine the accuracy of different methods of measuring condylar inclination from graphical recordings of the condylar paths. The results displayed variations in the values of the condylar angles and also variation between right and left sides within the same individual.

J.M.ZAMACONA OTADUY E, ARANDA E. [33] conducted study in 1992 of sagittal condylar path in edentulous patients. He concluded the inclination of the condylar path is variable for every individual. Also there is significant variation between the condylar inclination on the left and right sides and graphic registrations yield more accurate results compared to wax registrations.

In 1997 **T. OGAWA** [34] described the influence of anterior guidance and this condylar guidance on mandibular protrusive movement. It was concluded that the influence of the condylar path on the 1st and 2nd molar paths was twice as great in female as that in male subjects.

J. A. PAYNE [8] in 1997 conducted electronic pantographic assessment for condylar determinants in patients. He concluded high variability of condylar values suggesting the importance of determining the individual condylar determinants than counting on on average values.

Later in 2008 **GILBOA, CARDASH HS ET AL** [19] made a study in 25 dry human skulls on condylar guidance to determine the correlation between the articular morphology and panoramic radiographic images. There was a significant correlation

between the sagittal inclination of the anatomic articular eminence outline and the corresponding radiographic image for both the right and left sides. This made mark in studies with respect to use of radiographic techniques in assessing condylar guidance.

MRIDUL THAKUR ET AL [35] in 2012 evaluated static and functional methods for recording of centric Relation and Condylar Guidance. They concluded the dentures fabricated using the two different methods were comparable by the exactness of centric relation, retention, stability and condition of basal tissues as well as the level of satisfaction and chewing efficiency of the patient.

Also there were controversies in the **TYPE OF ARTICULATORS** to be used which would accurately duplicate the condylar path**.**

ULF POSSELT ET AL [36] in 1960 found out the variations in three instruments by recording the condyle path inclination using intraoral wax records. This study was done to find out the frequency of condyle path inclinations while using Dentatus articulator.

In 1963 **LAWRENCEA.WEINBERG ET AL** [37] made a study to find out the Arcon principle in the condylar mechanism of adjustable articulators. Condylar guidance is a result of the interaction of a condylar ball on an inclined plane. The Arcon principle reflects the physiological conditions more truly than the Non Arcon type articulator.

In 1998 **M. GROSS ET AL** [17] showed the effect of different recording materials on the reproducibility of condylar guidance in three semi-adjustable articulators. He

concluded, Denar Mark II gave the highest mean condylar guide registrations, followed by WhipMix, Hanau 158 and Denar Pantronic.

MUKESH KUMAR GOYAL ET AL [38] did a study in 2011 to compare the discrepancy in condylar guidance values between two commercially available Arcon and NonArcon articulators with the aid of cephalometric imaging. The mean difference in sagittal condylar guidance values obtained between Arcon and Cephalometric radiographs was insignificant but the mean difference between the sagittal condylar guidance values obtained between NonArcon and Cephalometric radiographs was significant.

PARANJAY PRAJAPATI ET AL [39] in 2013 conducted study on variation in condylar guidance values using three different anterior reference points in two articulator systems. They concluded orbitale as a best reference point for mounting of maxillary cast. Also whether use of arcon or non arcon does not make a significant difference in the values of horizontal condylar guidance.

As a first step of articulation, there comes **FACE BOW TRANSFER**.

LAWRENCEA.WEINBERG ET AL [40] in 1961 thus designated the association of the condylar motion and maxillary arch and estimated the effect of errors in face-bow transfer. Face-bow transfer by means of non-kinematic facebow transfer was found to be a critical step while fabricating restorations that will require minimal intraoral correction.

J. O. BAILEY [9] in 1984 illustrated the evaluation of third point of reference while mounting maxillary cast on Hanau articulator after facebow transfer. He concluded use of the middle groove on the incisal guide pin as a third point of reference positions the maxillary cast on the Hanau articulator as precisely as the orbital pointer does.

MANU RATHEE ET AL [41] in 2014 reported the significance of Face-Bow. They described in brief parts, types and uses of facebow. They concluded that failure to use facebow results in error in occlusion. So use of facebow should be essential part of prosthodontic treatment for the occlusal harmony as well as biological integrity of the restoration.

ADITI MISHRA, JAYANT PALASKAR [42] in 2014 conducted study to evaluate the effect of both direct and indirect face-bow transfer on the horizontal condylar guidance inclination values. They concluded values obtained from indirect face-bow transfers are unvaryingly higher than those obtained from direct transfers and are also nearer to the values attained from lateral cephalograms.

For relating casts to articulator, recording of **CENTRIC RELATION** is done in my study.

In 1952, **POSSELT** [18] conducted study regarding the movement of human mandible. He depicted that the movement of mandible in horizontal and sagittal plane is characteristic of individual but varies in different individual. Also it is possible for mandible to perform posterior hinge-opening and hinge-closing movements.

BARABAN DJ [43] in 1962 described technique for registering and transferring centric relation at determined vertical relation from the mouth to the articulator using plaster and wax records. He concluded, centric relation recorded at established vertical dimension by means of a plaster interocclusal record avoids the possibility of error which is present in techniques using an interocclusal wax record.

VICTOR O.LUCIA [44] in 1964 illustrated a technique to record centric relation by using centric relation jig and wax wafer. The significant variation between this procedure and other technique for creating anterior stops is that by modification of Duralay jig to train the patient for placing the mandible in the centric relation.(44) This was incorporated perfectly in our study.

In 1974 **J.K.HARCOURT** [45] conducted the study for accuracy of recording and transfer of prosthetic records. He discussed various material and methods required for centric relation records along with their limitations.

MARTIN F. LAND [46] in 2003 showed an anterior deprogramming device fabrication using a thermoplastic material. He states that use of an anterior programming device allows separation of the posterior teeth immediately prior to centric relation record fabrication. The resulting anterior stop acts as a fulcrum, allowing the directional force provided by the elevator muscles to seat the condyles in a superior position within the fossae.

KESHVAD ET AL [47] in 2001 made review of the literature on subject of centric relation. Centric relation is still regarded to be the final solution for any reorganization in occlusion. Though, its definition and concepts are constantly varying till date. This is a repeatable border position attained by bimanual mandibular manipulation. Though there were availability of numerous materials, because of the characteristic deficiencies in the material properties, the lack of operator's knowledge on the materials, difficult techniques and costly instruments, many studies started inclining towards radiographic techniques to overcome all these troubles.

There are various **MATERIALS AND METHODS** available for recording of the interoccusal space and thus guiding in programming of articulator.

In 1949 **F. W. CRADDOCK** [48] reported critical evaluation of series of wax records of jaw relations and articulator adjustments for evaluating accuracy of condylar guidance values. He Concluded use of intraoral wax records are considered unreliable and invalid.

MARTIN HENRY BERMAN [49] in 1960 did a study on accuracy and reliability of various different interocclusal records. He inferred from his study that material of choice was zinc oxide eugenol impression paste giving sharp and accurate details when it sets hard.

THOMAS E. SHANAHAN ET AL [50] in 1960 conducted a comparative study between the interocclusal records made from wax and autopolymerizing resin. It was evaluated that when the records were made from baseplate wax and impression waxes

during mounting of casts in articulator result was not very satisfactory while records made from autopolymerizing resin were more accurate.

HARRY SKURNIK [51] in 1969 reviewed various properties of interocclusal record materials along with their techniques of use. He reported High-quality wax is a useful material for registering interocclusal records. Zinc oxide and eugenol pastes and plaster are materials that are used for making interocclusal records but they were not considered as versatile as wax and acrylic resin might become material of choice in future.

GARRY ET AL [52] in 1984 did study on 16 patients to compare condylar control settings obtained from wax interocclusal records and simplified mandibular motion analysis. It was found that the wax interocclusal records produced a protrusive condylar pathway angle that averaged 17 degrees less than the Whip-Mix analyser and 6 degrees less than the Panadent analyser. Also, the protrusive condylar pathway recorded by the two analysers varied by an average of 11 degrees.

In 1984, [53] **LA DEANE FATTORE** conducted a study to determine the Clinical accuracy of waxes, zinc oxide-eugenol, and polyether impression materials for recording interarch relationship in relation to their magnitude and direction of distortion. He concluded wax was consistently unreliable while Polyether material was most accurate.

LASSILIA [54] 1986 conducted a study to compare the clinically important properties of six common types of recording materials to find the most suitable material. The materials used included silicone putty, polyether, zinc oxide eugenol paste, non eugenol

paste, acrylic resin and base plate wax. These materials were tested for resistance to closure, thermal expansion setting and dimensional changes when stored in different conditions. The highest degree of resistance was shown by silicone putty material, therefore this study found elastomers to be reliable recording material.

CURTIS [55] in 1989 compared protrusive settings on an articulator adjusted by a pantograph to protrusive setting recorded by two interocclusal recording materials, a polyvinyl siloxane (Regisil) and a laminated metalized wax (Coprawax). The author concluded that the pantographic recording of protrusive movement were slightly higher than Regisil interocclusal records but significantly higher than Coprawax.

J. MULLER [56] in 1990 conducted study of the accuracy of various recording materials. He concluded Due to different tooth preparations on contralateral sides of the test model, the interocclusal recording materials induced asymmetric three-dimensional deviations of the condyles. The least three-dimensional changes were recorded by plaster, polyether, and corrected Beauty wax.

VERGOS VK, TRIPODAKIS AP [57] in 2003 evaluated four recording materials; polyether, polyvinyl siloxane, acrylic resin, and wax for their ability to accurately record and reproduce the vertical interocclusal relationship. He concluded closure through interocclusal recording materials and removal and repositioning of the records on the apparatus produced small clinically insignificant vertical discrepancies. When records of all these materials were transferred onto casts, vertical discrepancies of approximately 0.5 mm were found which is of clinical concern.

JOSE DOS SANTOS JR ET AL [58] in 2003 did a pilot study to compare the condylar guidance setting acquired from a wax record and extra oral tracing. They concluded that condylar guidance values achieved using pantographic technique provided comparatively higher values than wax protrusive records.

V.V.NANDINI ET AL [59] in 2005 made a comparative evaluation between Hight tracer, Chandra tracer, Intra oral tracer, Functiograph and Check bite. It was derived that the articulator value of the horizontal condylar guidance angle gained by the five experimental methods were more than the Cephalometric value in the majority of subjects.

LAVANYA AJAY SHARMA ET AL [60] conducted a Comparative Study in 2011 of Effect of Three Interocclusal Recording Materials on Reproducibility of Horizontal Condylar Registrations Different Semi adjustable Articulators and concluded polyvinyl siloxane and polyether materials show minimum variability while wax exhibits wide variability.

KRISHNA PRASAD D ET AL [61] conducted a literature review in 2012 in which there is discussion about all interocclusal materials used till date. Various materials like zinc oxide eugenol, impression plaster, elastomers are described along with the techniques and proper methods of their utilization.

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PAVAN KUMAR TANNAMALA ET AL [62] in 2012 made a pilot study to compare the correlation between the protrusive interocclusal record and panoramic radiographic image on 10 patients. It was concluded that protrusive condylar guidance angles

obtained using panoramic radiographs may be useful in programming of semi adjustable articulators.

WC SCARFE, Z LI ET AL [1] in 2012 concluded maxillofacial CBCT imaging is helpful from diagnosis to image guidance in both operative and surgical procedures. CBCT has impact on the expected standard of care along with optimal visualization and also on interpretation of volumetric databases.

KRISHNA PRASAD D. ET AL [63] 2012 further conducted a clinico-radiographic analysis of the sagittal condylar guidance values obtained using panoramic radiographs and protrusive interocclusal records. There was a strong positive correlation between them. Panoramic radiographic tracings of sagittal condylar path guidance may be made relative to the Frankfort's horizontal reference plane and the resultant condylar guidance angles may be used to set the angle in semi-adjustable articulators.

PRAGYA SHRESTHA ET AL [23] in 2012 did a study to compare the condylar guidance values attained by clinical methods and with use of CT scan. The right and left side HCG values were almost the same and the CT scan showed higher CG values when compared with the clinical methods like intraoral tracer, wax and jig method.

JOSIP KRANJC, DENIS VOJVODIC [64] in 2012 measured articular-eminence inclination in relation to the Frankfurt horizontal plane with digital images of the skull's two lateral views by using AutoCAD computer software. They state that the articular-eminence inclination can be of different values depending on various methods of measurement.

RUWAIDA Z. ALSHALI ET AL [65] in 2013 compared the sagittal condylar guidance angle values between males and females. It was concluded that variation does not seem to be contributed to condylar asymmetry for gender or age differences in adult participants.

SHILPA SHETTY ET AL [22] in 2013 compared Condylar Guidance Value from Radiograph with Interocclusal Records made during recording of jaw relation and Try-in. They concluded condylar guidance values are influenced by stage at which the record is made. Also values acquired from the radiographs was greater than those obtained during jaw relation and try-in, and the mean condylar guidance values recorded during try-in were closer to the mean condylar value recorded on radiograph.

KHYATI SHAH ET AL [66] in 2014 correlated the sagittal condylar guidance with panoramic radiographs and conventional method in 24 completely edentulous patients. It was concluded that condylar guidance value was higher in radiographic method.

TORABI K. ET AL [67] in 2014 conducted clinical comparative study of Cadiax Compact II a mandibular motion recording device with intraoral records using wax and addition silicone. They reported Cadiax measurements had a stronger correlation with silicone records. Also the values of sagittal condylar inclination were higher with Cadiax than with intraoral records.

In 2015 **L.SO, R.DIAS, A. MERRISA ET AL,** [68] evaluated condylar position by CBCT after both static and dynamic registration in edentulous patients and concluded

dynamic registration as a reliable and accurate method to use, reproducing a physiologic condylar position.

RAGHUNATH PATIL ET AL [69] in 2015 made a clinico-radiographic analysis to determine the correlation between the sagittal condylar guidance obtained by gothic arch tracing an interocclusal record in edentulous patients and by means of panoramic radiographic tracing. Statistically the study didn't reveal any correlation but clinically the angles attained were similar.

Similarly**, DEVIPRASAD NOOJI ET AL** [70] in 2015 conducted study to find out the effect of the third point of reference on the protrusive condylar guidance angles using semi adjustable articulator. It was established within the confines of the study that Orbitale and inferior annular notches were more exact as anterior points of reference than the superior annular notch and Orbitale minus 7 mm reference points, for mounting the casts in Hanau Wide Vue articulator.

A SOWJANYA GODAVARTHI ET AL [71] in 2015 conducted a study to Correlate Condylar Guidance obtained with Panoramic Radiographs to one recorded Conventional Methods in twenty dentulous and edentulous subjects. The study concluded that OPG could be used as an alternative to clinical methods to overcome the disadvantages associated with conventional techniques.

GIRISH GALAGALI [72] in 2016 conducted a study to correlate between sagittal condylar guidance obtained by protrusive interocclusal records with panoramic and lateral cephalogram radiograph tracings in dentulous population. The study concluded

lateral cephalogram radiograph may be taken as an important tool to rely on for recording the sagittal condylar guidance angle.

V. VINUTHA KUMARI ET AL [73] in 2016 compared the HCG values obtained by radiographic and extra oral Gothic arch tracing method in edentulous subjects. They concluded statistically significant difference between the sagittal condylar guidance values achieved between right and left sides with extra oral Gothic arch tracing and OPG method.

W. LEE ET AL [74] in 2016 conducted study for noting three-dimensional positions of the nonworking side maxillary first molar at different condylar and incisal settings using a laser displacement sensor attached to motorized stages with biaxial freedom of movement. He concluded alteration from individual to average settings leads to positional difference in the maxillary first molar nonworking side movement. When the setting was lower than average vertical occlusal error occurred, which might grounds occlusal interference.

SWETA SINGH ET AL [75] in 2017 conducted study to correlate the HCG in subjects with Angle's Class I, Class II, and Class III malocclusion using both radiographic and clinical methods.

A significant difference in the HCG amongst three skeletal relationships was seen, Class II having a steeper angle than other two. The average value of HCG should not be used as it differs according to the skeletal relationship. Radiographic method can be used to yield consistent HCG; however, the protrusive method should be employed.

POULOMI M. ET AL [76] in 2017 conducted Meta-analysis for studies based on interocclusal records for recording of the condylar guidance. They concluded there is

heterogeneity in the condylar guidance values depending on materials used for interocclusal records, the type of articulators and the facebow technique.

DR.SMITA A. KHALIKAR ET AL [22] conducted study in 2017 to compare Condylar Guidance angulations attained from protrusive records and Orthopantomogram in edentulous subjects and concluded within the confines of the study both OPG and protrusive records may be used as a reliable guides for measuring condylar guidance angulation.

OH-KYUN KWON, SEUNG-WON YANG, AND JEE-HWAN KIM [77] in 2017 illustrated Correlation between sagittal condylar guidance angles acquired using radiographic images using Panoramic and CBCT imaging and protrusive occlusal record methods. The radiographic measurements were 5 - 9 degree more than those made using the protrusive occlusal record by 8 - 9 degrees for panoramic measurements and higher by 5 - 6 degrees for CBCT measurements. Thus, CBCT images are considered to be reasonable for clinical applications.

Similarly in 2017 **FATEMAH SALAMI ET AL** [78] conducted study to determine the correlation between condylar guidance obtained by Cone Beam Computed Tomography (CBCT) and panoramic radiography with interocclusal protrusive record in dentulous subjects. The results established that CBCT and Panoramic could be used as an alternative of interocclusal record for adjusting condylar guidance. CBCT was however more accurate than panoramic radiography.

MATERIALS AND METHODOLOGY

STUDY DESIGN:

The present clinical study was conducted to evaluate the relationship between Sagittal Condylar Guidance obtained by cone beam computed tomography imaging modality and three different clinical methods through interocclusal wax records, interocclusal jigs and intraoral tracer. This study was performed in the department of Prosthodontics, Tamilnadu Government Dental College and Hospital, Chennai.

ETHICAL COMMITTEE APPROVAL:

The study was done after obtaining approval from the Institutional Ethical Committee.

MATERIALS:

1. Irreversible hydrocolloid impression material ALGITEX, DPI Mumbai
2. Dental stone Kalstone Kalabhai Karson Mumbai, India
3. Alu Wax , MAARC
4. Zinc oxide eugenol Paste DPI Mumbai, India
5. Auto polymerising resin DPI Mumbai, India
6. Polyvinyl siloxane Putty, Light body Aquasil, Dentsply, Germany
7. Bite registration paste Jet Bite , Coltene WhaleDent
8. Low fusing compound, DPI

INSTRUMENTS UTILIZED FOR EXAMINATION:

1. Mouth mirror
2. Straight explorer
3. Probe
4. Kidney tray
5. Surgical disposable gloves
6. Surgical three layered mask

INSTRUMENTS FOR MAKING IMPRESSION AND CAST FOR DENTULOUS PATIENTS

1. Dentulous stock trays.

2. Rubber bowl and spatula

FOR CONE BEAM COMPUTED TOMOGRAPHY:

1. CBCT unit
2. Laptop with software installed for 3D programming.

INSTRUMENTS USED FOR FACE BOW RECORD, INTEROCCLUSAL RECORD AND TRANSFER TO ARTICULATOR

1. Face bow units.

2. Semi adjustable articulator (Hanau Wide Vi

3. Intra Oral Tracer Bio Tracer, Delta

SUBJECT SELECTION:

Study participants were selected from the dental students and outpatient section of Tamilnadu Government Dental College and Hospital. All the participants were well-versed about the purpose and methods of the study and signed the informed consent.

GENDER:

Both male and female patients

SAMPLE SIZE:

Total number of subjects: 30

GROUPING OF SAMPLES:

Condylar guidance values from CBCT image: GROUP I

Condylar guidance values from Wax Records: GROUP A

Condylar guidance values from Jig Method: GROUP B

Condylar guidance values from Intraoral Tracer Method: GROUP C

Condylar guidance values from Right Side: GROUP 1

Condylar guidance values from Left Side: GROUP 2

INCLUSION CRITERIA:

• Subjects willing for voluntary participation and signed consent
• Dentulous subjects with minimum 26 intact maxillary and mandibular teeth
• Good general health
• Subjects age between 24-40
• No sign and symptoms of temporomandibular disorder, facial asymmetry and congenital facial defect.

EXCLUSION CRITERIA:

• Subjects with any temporomandibular disorder.
• Subjects with restricted mandibular movement.
• Subjects with gross attrition, abrasion or erosion of teeth
• Pregnant and lactating patients
• Poor general Health

Radiographic parameters:

- Frankfurt's Horizontal reference plane
- Posterior slope of articular eminence
- Radiographic sagittal condylar Guidance Angle

Clinical parameters:

- Centric interocclusal record
- Protrusive inter occlusal record
- Sagittal condylar Guidance Angle

RADIOGRAPHIC METHOD:

1. CBCT of whole skull was recorded with the patient's mandible in protrusive position.

2. Articular eminence and mandibular fossa was identified for both right and left sides.

3. Tangent of the Posterior slope of the articular eminence was drawn in the digital image.

4. 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.

5. The angles between these two lines represent the Radiographic condylar guidance.

CLINICAL METHOD:

- **MAKING OF IMPRESSION & OBTAINING CASTS**

Maxillary and mandibular perforated dentulous stock tray were used for making impressions. Impression was made with alginate with impression material (Aquasil, Dentsply). The resulting impression was rinsed, dried, inspected and disinfected using 2% glutaraldehyde (Cidex) for 10 minutes. Surfactant spray was used on both impressions and cast poured with type IV dental stone (Ultrarock, Khalabhai Karson Pvt. Ltd., Mumbai, 1ndia). The set casts were then retrieved,

inspected, trimmed and finished. Plaster bases were than formed also trimmed and finished.

1) INTEROCCLUSAL WAX RECORD METHOD:

The patient is trained to move the mandible forward till the teeth are in edge to edge relationship. A two-sheet thick Alu wax rim is adapted to the maxillary arch. Patient is then asked to do the movement as practiced before. This record was then transferred to articulator (HANAU™ Wide-Vue Articulator). Protrusive relation was assessed and reconfirmed prior to setting of the sagittal condylar inclinations and locknuts were tightened with the help of hand pressure. In all the cases, articulator was programmed by a single operator only.

2) INTER OCCLUSAL RECORD WITH LUCIA JIG :

A Lucia jig was prepared with clear autopolymerising acrylic resin to record the centric position. The palatal surface of the jig was trimmed to a flat surface according to Dr.Peter Neff to allow condylar movement upwads without any distalizing effect. It is used to interrupt the reflex action of muscles as well as train the patient close in centric relation position. The principal function of the jig is deprogramming of the individual's habitual closure. The jig is inserted in place and a carbon paper was inserted between the jig and the lower incisors. The individual was asked to move right, left, forward, backward in order to free jaw movements. The jig was removed and there would be a Gothic arch traced on the jig. The tails of the Gothic arch was trimmed off and the apex was slowly trimmed into a flat area eliminating any inclined plane effect. The mandible was trained to retruded position and the jig was trimmed just to produce disocclusion. The procedure was completed and the position was confirmed again. Bite registration addition silicone paste was syringed on to the

occlusal surfaces of mandibular teeth and was guided to close in a rehearsed position. A centric record was obtained to relate the mandibular cast to the maxillary cast and a protrusive record obtained at edge to edge position for programming the articulator.

3) INTRA-ORAL TRACER:

An intra-oral tracer consisting of central bearing point and plate will be used to record the centric relation and the eccentric path followed by mandible during protrusive movements.

An intra-oral tracer is attached to the acrylic plate and the Gothic arch tracing will be obtained. Protrusive record will be recorded at 6 mm of protrusion. This record will be used to adjust the articulator and thereby condylar inclination angles will be obtained.

PROGRAMMING OF THE ARTICULATOR:

For determining the condylar guidance the condylar locks of the articulator were loosened and the protrusive record was placed on the mandibular cast. The maxillary cast was seated into the indentations and the two parts were held firmly together and the condylar guidance on both sides of the articulator reading was noted at the pointer modified in the articulator for one degree readings. This step was repeated thrice to get at least two coincident readings. The condylar screws were tightened and the condylar readings on both sides were recorded and tabulated.

STATISTICAL ANALYSIS:

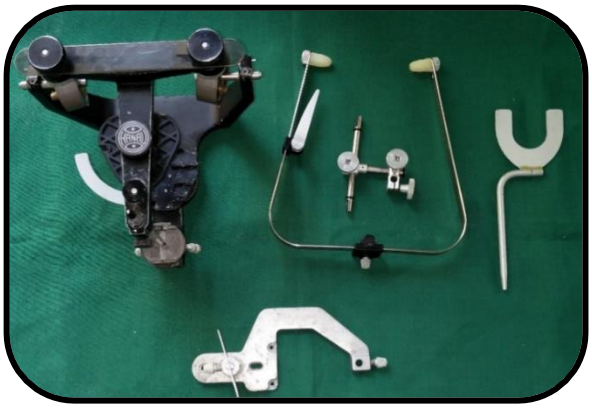
Statistical analysis was carried out using statistical software SPSS version 23. The quantitative data obtained was subjected to Paired t test and Independent t test. Paired t test was done to compare the values on both sides. Intergroup comparison of condylar guidance angle between all methods amongst each other was carried out with Independent t-test and Pearson's correlation test to compare the right and left sides and to correlate the different methods used to measure the horizontal condylar guidance values.

1. Armamentarium for Examination

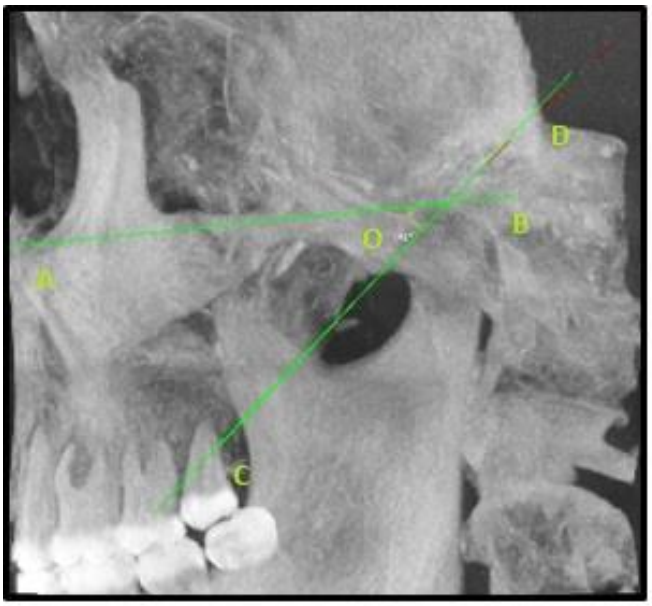
2. Armamentarium for Making Impression

3. Armamentarium for making Interocclusal Record

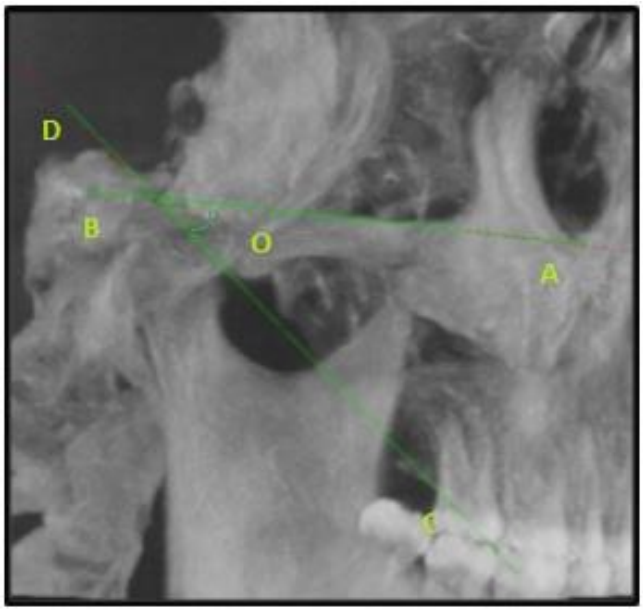
4. Armamentarium for Facebow transfer and Articulation



5. Recording of CBCT



5. A Left Side



5. B Right Side

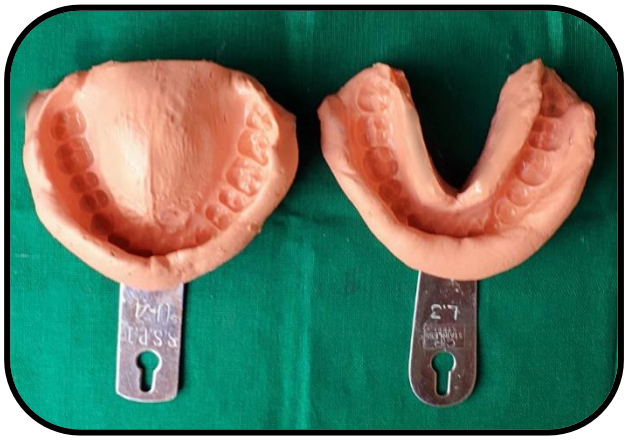
CBCT Analysis

AB: FRANKFORT'S HORIZONTAL PLANE (FHP)

CD: LINE ALONG THE SLOP OF POSTERIOR ARTICULAR EMINENCE

AOD: CONDYLAR GUIDANCE ANGLE

6. Preliminary Impression



7. Preliminary Cast

8. Recording of Face-Bow

9. Face-Bow Transfer

10. Articulation

11. Centric Relation Position

11. A Right Lateral View

11. B Frontal View

11. C Left Lateral View

12 Alu Wax Interocclusal Protrusive Record

12. A Frontal View

12. B Right Lateral View

12. C Left Lateral View

13 Protrusive Record with Jig Method

13.A Guiding of mandible with the jig

13. B Frontal View of record

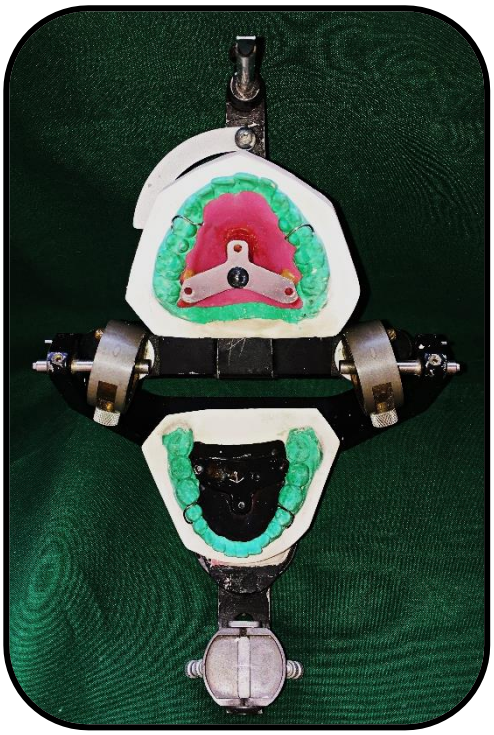
13. C Right Lateral View

13.D Left Lateral View

14 Protrusive Record With Intraoral Tracer Method

14.A Attachment Of Tracer

14.B Intraoral tracing



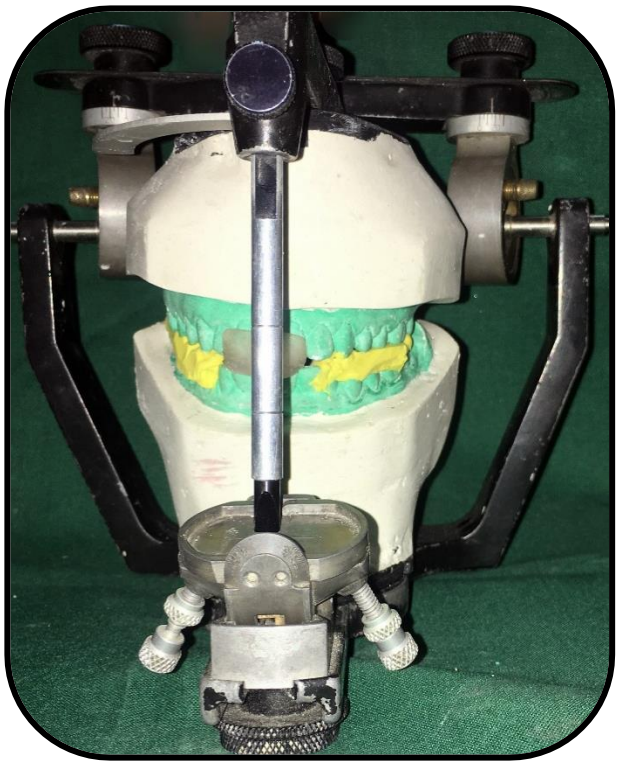
14. C Frontal View of record

14. D Right Lateral View

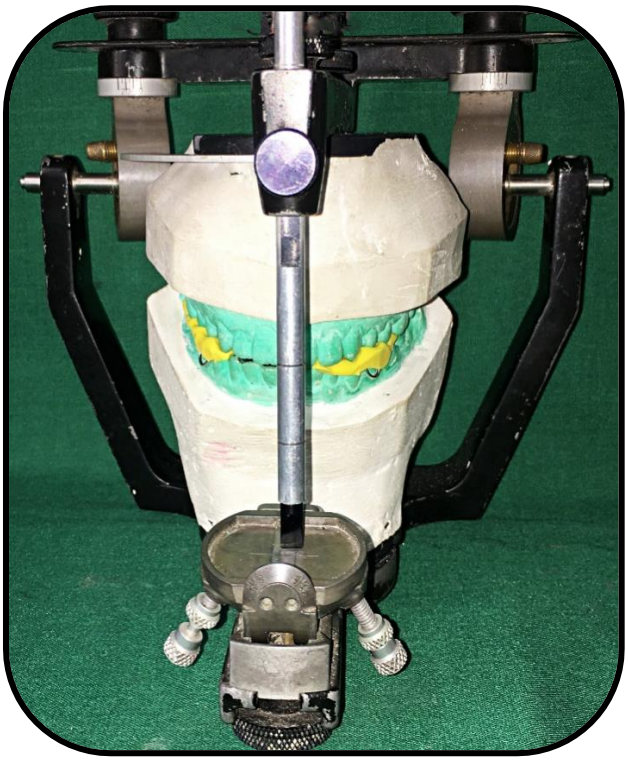
14. E Left Lateral View

15 Transfer of Record to the Semiadjustable Articulator

15.A Wax Record Transfer



15. B Jig Record Transfer



15. C Intraoral Record Transfer

16. Programming of the Articulator

16. A Wax Record

16.B Jig Record

16.C Intraoral Tracer Record

RESULTS

The following results were obtained from this study which evaluated the correlation between Sagittal Condylar Guidance obtained by cone beam computed tomography imaging modality and three different clinical methods through interocclusal wax records, interocclusal jigs and intraoral tracer in dentulous subjects.

Each group consisted of 30 samples. This was further evaluated for both right and left sides. Each group had 10 samples. After grouping clinical methods were evaluated through programming of articulator. Cone Beam CT was obtained and evaluation of the Horizontal Condylar Guidance angle was done digitally by connecting anatomic landmarks using Philips DICOM software.

Statistical analysis was done using SPSS Version 23. The condylar guidance angle values obtained from the dentulous subjects was performed using independent sample-t-test to compare the different angles. . To describe the data descriptive statistics the mean and standard deviation were used.

The mean and standard deviation of various condylar guidance angles for all subjects with both radiographic and three different clinical methods are shown in the following tables with bar diagrams. The basic data of the results obtained in this study are shown in appendix I, II and III.

TABLE 1: Comparison of Right and Left Condylar Guidance Angle Values Obtained from all different methods.

Method Groups	N	Group 1		Group 2		Mean Difference	P value
		Mean	SD	Mean	SD		
Group I	30	39.63	1.96	40.50	2.70	-.867	0.230 NS
Group A	30	27.43	2.61	28.75	3.01	-1.32000	0.086 NS
Group B	30	28.93	2.72	29.69	3.36	-.7600	0.317 NS
Group C	30	30.77	3.38	31.14	4.17	-.3630	0.706 NS

TABLE 2: Pearson correlation for comparison between different methods on right side.

Comparison Groups		Pearson correlation	P value
Group I	Group A	.084	0.659 NS
	Group B	.169	0.371 NS
	Group C	.337	0.068 NS
Group A	Group B	.122	0.522 NS
	Group C	.370*	0.044*
Group B	Group C	.478	0.008*

TABLE 3: Pearson correlation for comparison between different methods on Left side.

Comparison Groups		Pearson correlation	P value
Group I	Group A	.106	0.576 NS
	Group B	.018	0.925 NS
	Group C	.066	0.727 NS
Group A	Group B	0.379*	0.047*
	Group C	.101	.595
Group B	Group C	.047	0.804 NS

TABLE 4: Inter group comparison of Condylar Guidance angle between CBCT and Wax Methods by Independent T test

Side Groups	Method Groups	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	P value
Group 1	Group I	39.63	1.96	1.96	0.36	12.03	<0.001**
	Group A	27.60	2.68	2.68	0.49		
Group 2	Group I	40.50	2.70	2.70	0.49	11.74	<0.001**
	Group A	28.75	3.01	3.01	0.55		

**_highly significant (p<0.001)

TABLE 5: Inter group comparison of Condylar Guidance angle between CBCT and Jig Methods by Independent T test

Side Groups	Method Groups	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	P value
Group 1	Group I	30	39.63	1.9561	.3571	10.70	<0.001**
	Group B	30	28.93	2.7207	.4967		
Group 2	Group I	30	40.50	2.70057	.49306	10.81	<0.001**
	Group B	30	29.69	3.36029	.61350		

**_highly significant (p<0.001)

TABLE 6: Inter group comparison of Condylar Guidance angle between CBCT and Intra-Oral Tracer Methods by Independent T test

Side Groups	Method Group	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	P value
Group 1	Group I	30	39.63	1.96	0.36	8.86	<0.001**
	Group C	30	30.77	3.38	0.62		
Group 2	Group I	30	40.50	2.70	0.49	9.36	<0.001**
	Group C	30	31.14	4.17	0.76		

**_highly significant (p<0.001)

TABLE 7: Inter group comparison of Condylar Guidance angle between Wax and Jig Methods by Independent T test

Side Group	Method Group	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	P value
Group 1	Group A	30	27.60	2.68	0.49	-1.33	0.065 NS
	Group B	30	28.93	2.72	0.50		
Group 2	Group A	30	28.75	3.01	0.55	-0.93	0.262 NS
	Group B	30	29.69	3.36	0.61		

NS- Not significant (p>0.05), *-Statistically significant (p<0.05)

TABLE 8: Inter group comparison of Condylar Guidance angle between Wax and Intra-Oral Tracer Methods by Independent T test

Side Group	Methodi Group	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	P value
Group 1	Group A	30	27.60	2.68	0.49	-3.17	0.001*
	Group C	30	30.77	3.38	0.62		
Group 2	Group A	30	28.75	3.01	0.55	-2.38	0.014*
	Group C	30	31.14	4.17	0.76		

NS- Not significant (p>0.05), **-Highly significant (p<0.001)

TABLE 9: Inter group comparison of Condylar Guidance angle between Jig and Intra-Oral Tracer Methods by Independent T test

Side	Group	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	P value
Group 1	Group B	30	28.93	2.72	0.50	-1.85	0.422 NS
	Group C	30	30.77	3.38	0.62		
Group 2	Group B	30	29.69	3.36	0.61	-1.45	0.282 NS
	Group C	30	31.14	4.17	0.76		

NS- Not significant (p>0.05), *-Statistically significant (p<0.05)

INTERPRETATION OF RESULTS

The mean condylar guidance angle values was obtained from 30 subjects by CBCT and all three clinical methods with wax, lucia-jig and with Intra oral tracer on both right and left were compared by descriptive statistics and to calculate P values independent T tests were applied.

Formulation of Hypothesis:

Null Hypothesis: H_0 = There is no difference in condylar guidance angle when various groups are compared,

Alternate Hypothesis H_a = There is difference in condylar guidance angle when various groups are compared

P value < 0.05 is considered as statistically significant.

If P value < 0.05 we can reject the null hypothesis and consider the alternate hypothesis.

TABLE 1:

The above table shows the mean condylar guidance angles in various methods. In Group I, the mean condylar guidance angle on Group 1 was 39.63 ± 1.96 and on Group 2 was 40.50 ± 2.70 In group A, on Group 1 was 27.44 ± 3.06 and on Group 2 was 28.75 ± 3.01 in Group B on Group 1 was 29.18 ± 2.70 and on Group 2 was 29.69 ± 3.36 and in Group C on Group 1 was 31.24 ± 4.37 and on Group 2 was 30.32 ± 4.69

Paired t test was done to compare the values on both sides. There is no statistically significant difference present between the values on both sides. (p>0.05)

TABLE 2:

The above table shows the correlation between different methods in measuring the condylar guidance angle values on right side. There is no statistically significant correlation present between Group I and various other methods. There is significant positive correlation present between Group B and Group D (p=0.044) and Group C and Group D (p=0.008)

TABLE 3:

The above table shows the correlation between various methods in measuring the condylar guidance angle on left side. There is no statistically significant correlation present between Group I and various other methods. There is significant positive correlation present between Group A and Group B (p=0.047)

TABLE 4:

The above table shows the intergroup comparison of condylar guidance angle obtained between Group I and Group A. The mean value of the difference between the condylar guidance values obtained using Group A were compared with the values obtained with Group I on the right side was found to be **12.03** and difference between them was found to be highly significant with the P value of **<0.001**. On the left side was found to be **11.74** and difference between them was found to be highly significant with the P value <**0.001**. The comparison between the same two groups, using averages of the values on the right and left side was found to be – **0.72** and difference between them was found to be insignificant with the P value of **0.086.** Concluding, there is statistically high significant difference between the condylar guidance values between Group I and Group A with lower values in Group A.

TABLE 5:

The above table shows the intergroup comparison of condylar guidance angle between Group I and Group B. The mean value of the difference between the condylar guidance values obtained using Group B were compared with the values obtained with Group I on the right side was found to be **10.70** and difference between them was found to be highly significant with the P value of **<0.001**. On the left side was found to be **10.81** and difference between them was found to be highly significant with the P value <**0.001**. The comparison between the same two groups, using averages of the values on the right and left side was found to be – **0.76** and difference between them was found to be insignificant with the P value of **0.317**. Thus, there is statistically significant difference between the condylar guidance values between both groups with lower values in Group B method.

TABLE 6:

The above table shows the intergroup comparison of condylar guidance angle between Group I and Group C. The mean value of the difference between the condylar guidance values obtained using Group C were compared with the values obtained with Group I on the right side was found to be **8.86** and difference between them was found to be highly significant with the P value of **< 0.001**. On the left side was found to be **9.36** and difference between them was found to be highly significant with the P value < **0.001**. The comparison between the same two groups of Group C using averages of the values on the right and left side was found to be – **0.36** and difference between them was found to be insignificant with the P value of **0.706** There is statistically significant difference between the condylar guidance values between both groups with lower values in Group C method.

TABLE 7:

The above table shows the intergroup comparison of condylar guidance angle between Group A and Group B. The mean value of the difference between the condylar guidance values obtained using Group A were compared with the values obtained with Group B on the right side was found to be **-1.33** and difference between them was found to be highly significant with the P value of **0.065**. On the left side was found to be **– 0.93** and difference between them was found to be non-significant with the P value **0.262.** Therefore, there is no statistically significant difference between the condylar guidance values between both groups ($p>0.05$)

TABLE 8:

The above table shows the intergroup comparison of condylar guidance angle between Group A and Group C. The mean value of the difference between the condylar guidance values obtained using Group A were compared with the values obtained with Group C on the right side was found to be **– 3.17** and difference between them was found to be highly significant with the P value of **0.001**. On the left side was found to be **– 2.38** and difference between them was found to be significant with the P value of **0.014**. Thus, there is statistically significant difference between the condylar guidance values between both groups in Group 1 and Group 2 with lower values in Group A ($p<0.05$).

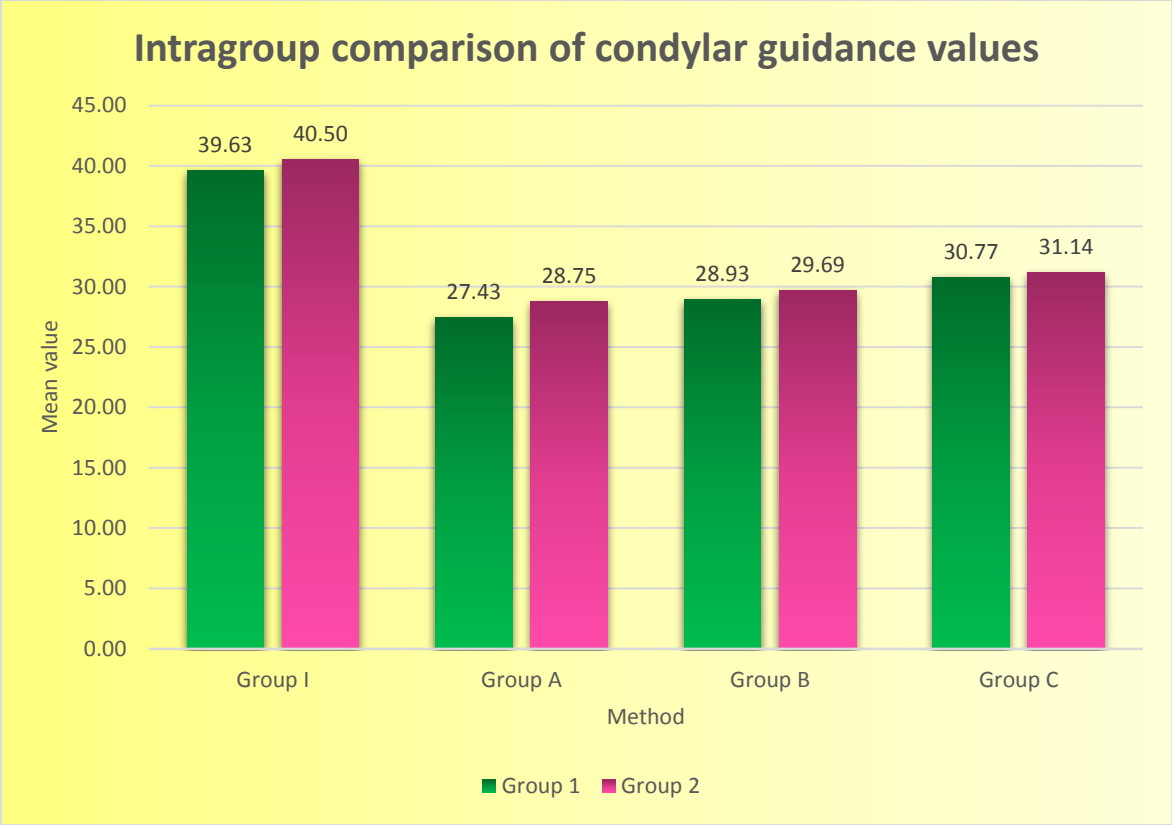
TABLE 9:

The above table shows the intergroup comparison of condylar guidance angle between Group B and Group C The mean value of the difference between the condylar guidance values obtained using Group B were compared with the values obtained with Group C

on the right side was found to be **– 1.85** and difference between them was found to be highly significant with the P value of **0.422**. On the left side was found to be **-1.45** and difference between them was found to be highly significant with the P value **0.282**.Therefore, there is no statistically significant difference between the condylar guidance values between both groups.

Figure – 1:

Comparison of Mean Condylar Guidance Angle values between Right and Left side obtained from different methods.



X-axis-Method, Y- axis- Condylar guidance angles

Figure – 2:

Comparison of Mean Condylar Guidance Angle values on Right and Left side obtained by CBCT & Wax record Methods.

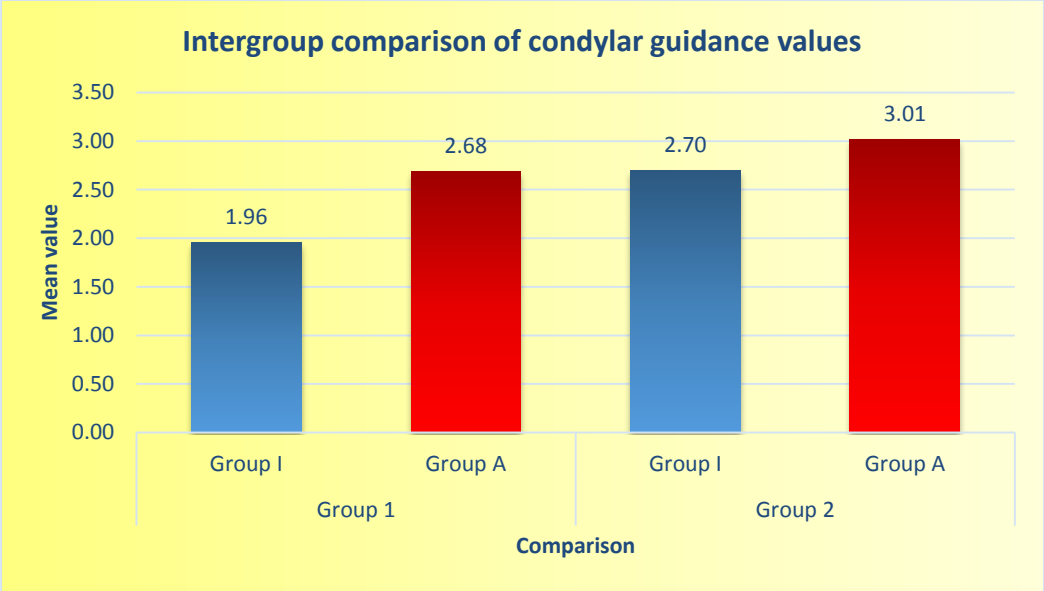


Figure – 3:

Comparison of Mean Condylar Guidance Angle values on Right and Left side obtained by CBCT & Jig record Methods.

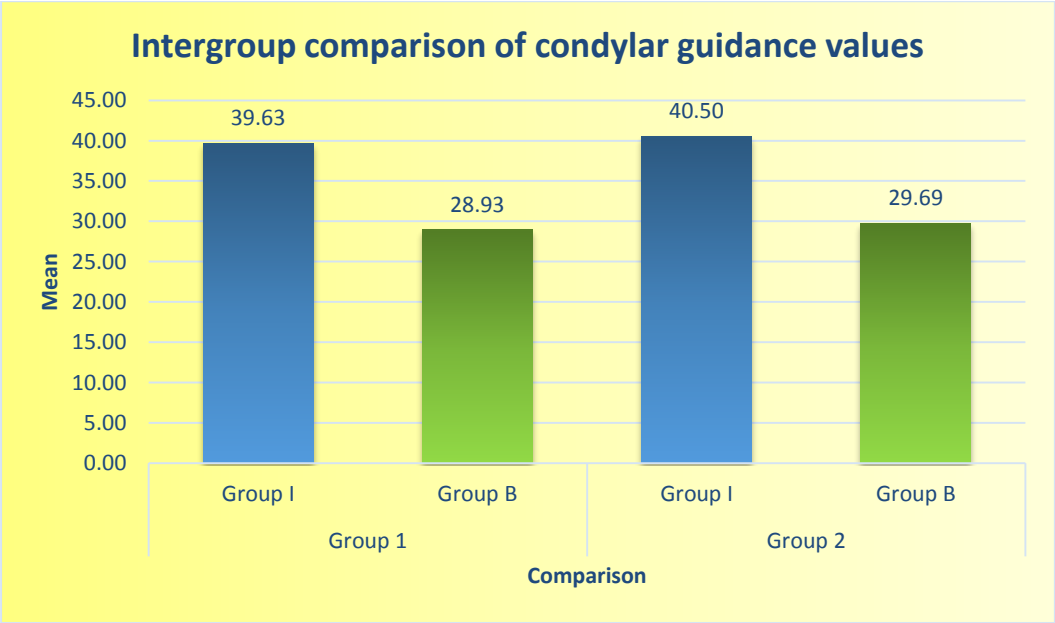


Figure – 4:

Comparison of Mean Condylar Guidance Angle values on Right and Left side obtained by CBCT & Intra-Oral Tracer record Methods.

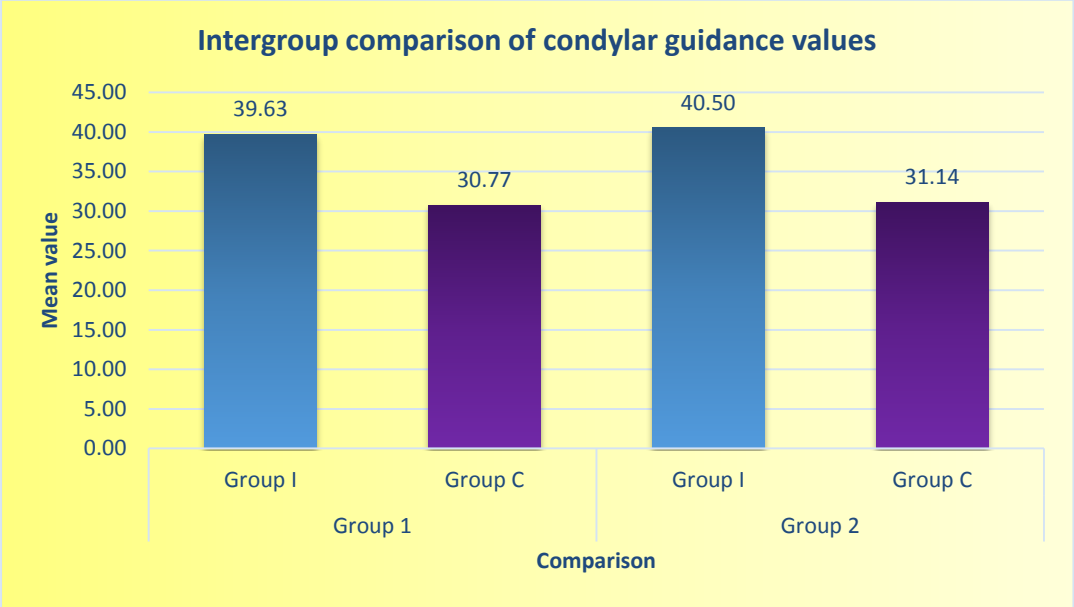


Figure – 5:

Comparison of Mean Condylar Guidance Angle values on Right and Left side obtained by Wax record & Jig record Methods.

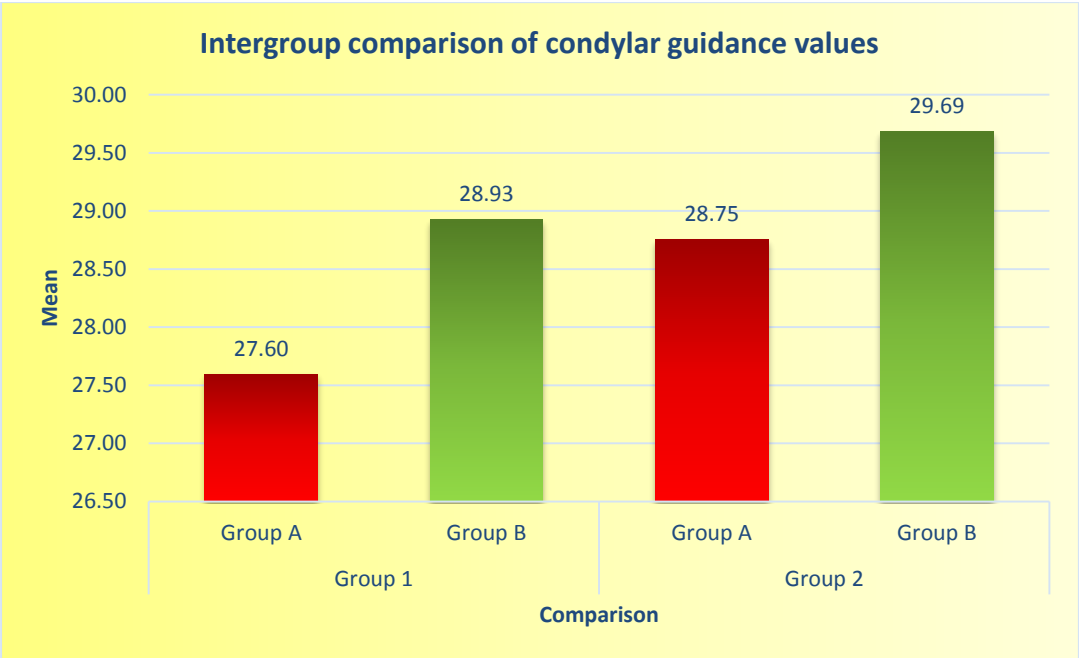


Figure – 6

Comparison of Mean Condylar Guidance Angle values on Right and Left side obtained by Wax record & Intra-Oral Tracer record Methods.

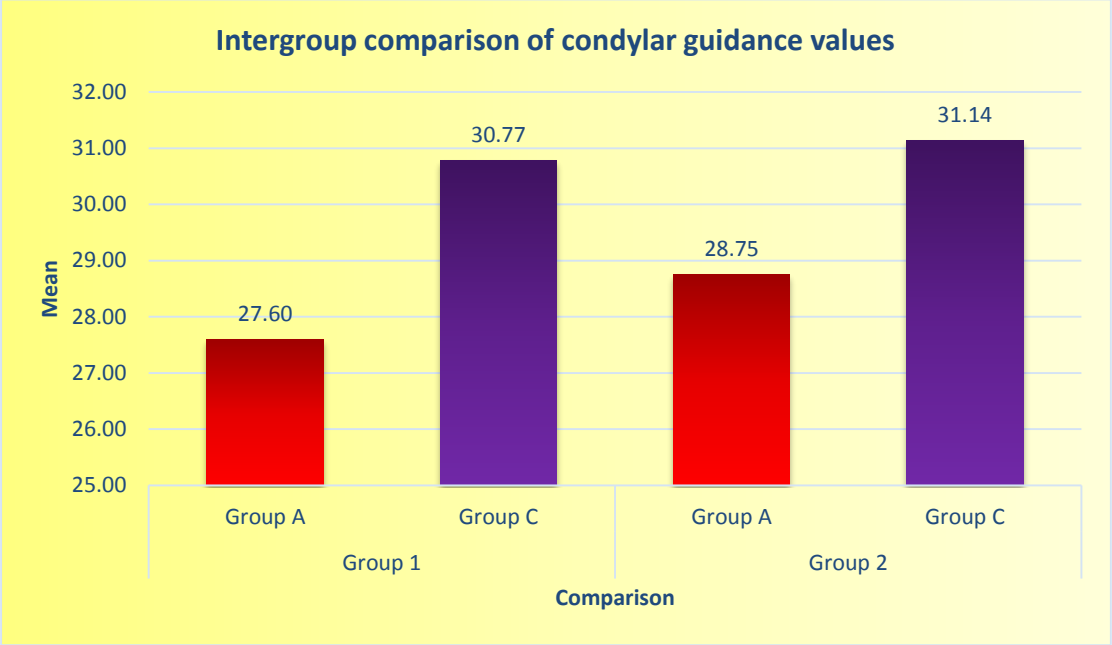
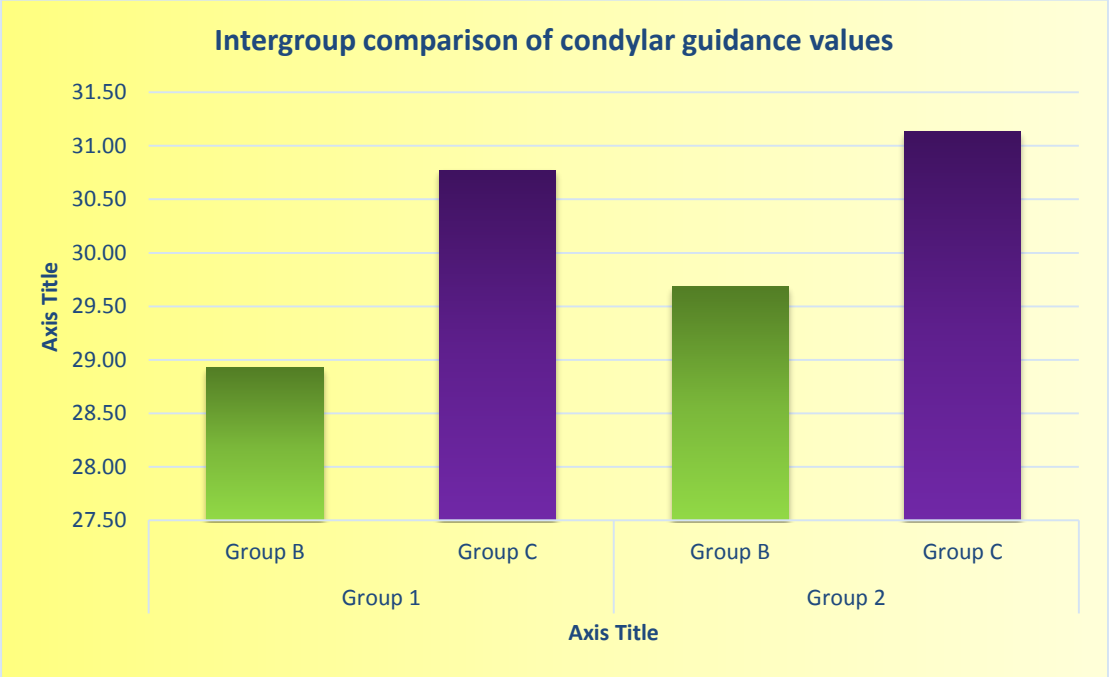


Figure – 7:

Comparison of Mean Condylar Guidance Angle values on Right and Left side obtained by Jig record & Intra-Oral Tracer record Methods.



DISCUSSION

The successful prosthodontic procedure results most likely in cases when 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 [79]. Therefore, usefulness of articulator is unfaltering whether the required restoration is removable or fixed, single unit or a complex restoration, for recording of this condylar guidance.

The ideal goal of an articulator is to fabricate the restoration that can be inserted into the mouth without the need for chair side occlusal adjustments [80]. The face-bow transfer and the centric, lateral and protrusive jaw relation records together establish the simulation of the mandibular movements on the articulator [81 82]. 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 [83 84] .

If articulator settings do not match the patient's individual parameters, the developed cusps in the restoration maybe of inaccurate occlusal morphology thus hampering the function [85].

The accuracy with which certain mandibular movements are simulated depends also on the contour of condylar path and adjustability of the articulator. The study conducted by **POSSELT** [7] concluded that individual registration of condyle path must be

recorded as mean value requires adjustments of 20 – 40 degrees that will affect the restoration inadvertently [18].

The condylar elements of the articulator glide in a slot, which can be adjusted to provide a rectilinear simulation of the curvilinear condylar path.(86) The sagittal condylar guidance inclination, which is programmed with the protrusive interocclusal record, is measured in degrees, relative to the third point of reference. This angle is relative measure and not an absolute value, which is related to the angle of the eminence of the temporomandibular joint [79]. Condylar guidance on articulators achieved through programming is an approximate duplication of the condylar path of the patients [87].

There are some prerequisites which need to be achieved prior obtaining of protrusive interocclusal including, complete stability of the recording bases, a systematic face bow transfer, tentative jaw relation and a good centric relation record [88] .

According to **WEINBERG** [89] the several anterior point of reference points of reference used in different face-bows may change the occlusal plane by ±16mm and this has no effect on centric occlusion. Thus the chances of the error made by face-bow registration could be eliminated in the study.

Moreover in agreement with **GONZALEZ AND KINGERY** [90] the axis orbital plane is the minimum variable and most reliable and best for face-bow registration as it is easy to find and reproducible . Thereby, in our case orbitale is the reference point corresponding to the face bow.

In our case Lucia jig [44] was used to guide the mandible in centric relation position and it was obtained with the Jet bite (polyvinyl siloxane) material because the elastomers as interocclusal recording materials consistently yielded least errors among the different materials studied and are found to be reliable recording materials [91] .

The objective of a good centric relation record is to relate the mandible to the maxillae such that there could be no fulcrum on the teeth or periodontal ligament but only in the temporomandibular joints. This is a mechanical necessity which has biologic dependability. Centric relation is still the final solution for a reorganized approach in occlusion.

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[92] to the articulator or by radiographic methods [93.]

Also, comparative studies of sagittal condylar inclination values determined using intraoral protrusive interocclusal records to those using various extra oral methods of tracing the condylar path concluded that extra oral tracing methods gave higher values with less variation than the intraoral methods. Among the extra oral methods, studies showed that electronic pantography provided measurements more accurate and reproducible [94 95].

This clinical study is oriented towards comparing three 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.

All the cases were selected in the age group of 20 to 40 years. This age group was selected as the craniofacial growth is accomplished by this age.

The left and right condylar guidance angles were measured of all subjects using these four methods. The difference attained between the left and right measurements from all methods was statistically insignificant. Conversely, there is evidence in the literature disagreeing to the results of this study [96] .

Studies conducted by **GHERIANI** [32]**, WINSTANLEY, ZAMACONA**[33] 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 tempo-mandibular joint disorder. But Cases with a full complement of dentition, with Angle's class I molar relation and absence of signs and symptoms of temporomandibular joint disorders were selected in our study.

CRADDOCK [48] believed that it was important to keep the distance of protrusion the same because the sagittal condylar angle changes with the amount of protrusion. Also he believed that it is essential to maintain same amount of protrusion as Condylar Guidance varies with amount of protrusion. So the amount of protrusion was kept same in the present study.

Literature indicates the use of lateral cephalograms, panoramic radiograph, tomographs, digital CT scan used for recording condylar guidance [19] [58]. When Cephalometric technique was used to find out the condylar guidance values there was a difference in readings for the same patient even when a standardized procedure was

followed [17]. Magnetic resonance imaging has also been used to find out the articular eminence morphology and inclination in the past. At recent days the advent of digital CBCT scans has ruled out these.

DAVIS ET AL [97] 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.

The use of conventional radiographic techniques, such as orthopantography (OPG) and computerized tomography (CT), may indicate whether the condyle is in the CR position. CT provides three-dimensional images but with high radiation, whereas OPG overcomes the radiation exposure, but limited to bi-dimensional images. Evaluating the condylar position by cone beam computed tomography (CBCT) has become an essential tool to obtain three-dimensional images. The capture of the area of interest with rapid scan time (10–70 s) minimizes the exposure of adjacent structures, while exposing the patient to low radiation doses in comparison with conventional CT.

Perhaps the most important advantage of CBCT is that it provides unique images demonstrating features in 3D [98] that intraoral, panoramic, and Cephalometric images cannot. Cursor driven measurement algorithms provide the clinician with an interactive capability of real time dimensional assessment. On screen measurements provide dimensions free from distortion and magnification. [99].

CBCT consists of extra benefits like great picture quality, utilizing a smaller field of view shorter check time, compatibility with other radiographic arrangements for picture export and simplicity of establishment of minimal units in a general clinical setting. These preferences of CBCT could be used to discover the condylar position amid dynamic registration in edentulous and dentulous patients and precisely find the position of condyle.

Among the other radiographic techniques in use today CBCT is gaining increasing popularity in assessing normal condylar morphology [100]. craniofacial anomalies, and mandibular condyle bone lesions [101] in the field of implantology and for endodontic applications. There are some limitations of the radiographic method concerning distortion, head and reference plane orientation and difficulty in distinguishing the articular eminence outline from the zygomatic arch. The protrusive occlusal record and CBCT imaging method were found to be comparable in this study.

However **BREWKA,** compared condylar guidance values obtained by pantographic tracings with lateral cephalograms and stated that radiographic method and clinical method yield highly diverse value [102]

Also, **CHRISTENSEN AND SLABBERT** [30] in a 1978 review has stated that "no radio graphically determined sagittal condylar guidance angle coincided with that obtained with the use of intra-oral records. The radio graphically determined angle showed a greater mean value than that determined by intra-oral records."

According to **MIRIAN AIKO NAKANE MATSUMOTO ET AL** [103] there was a definite correlation between depth of glenoid fossa and inclination of the posterior slope of

the articular eminence. This reliability in radiographic landmarks is a useful parameter used in our study.

KRISHNA PRASAD D [63]**,** put forward that panoramic radiographic tracings maybe used to set sagittal condylar guidance values. This study is in accordance with our study where CBCT was used to obtain the same value.

After maxillary cast were mounted using facebow and mandibular cast was mounted with the help of centric relation record, Protrusive record was attained with the help of three different methods. Despite accurate registration methods, chances of error arise during laboratory procedures because of instability of materials and changes during their setting or polymerization [45].

S. C. MULLIK [83] in 1981 conducted investigation regarding several interocclusal materials. He concluded Aluwax was the most variable and unreliable of all materials. Superbite constantly lead to open cast relationships. While, the five elastomers reliably resulted in the least amount of errors.

Here, in first method protrusive record was obtained using Alu-Wax. The advantage of this wax is that it is dimensionally stable, does not shrink or distort easily. When it is heated at 55°C it turns in to soft less than 1 minute. This wax adapts well to details and sets by water or room temperature around 27°C. Patient was asked to bite on Alu-wax bite registration material on edge to edge relation. It was than reinforced with zinc-oxide eugenol paste for accurate details and record was made [104].

The reliability of wax records for protrusive jaw relation has been questioned as condylar guidance adjusted according to three separate records will yield three different results [48]. Moreover, if the patient moves the jaw laterally in protrusive movement, the registration of the condyle path will be changed [25]. The values on the right side, left side and the average of both sides were compared.

In second clinical method a custom-made jig was fabricated to guide the mandible prior to obtaining protrusive interocclusal record. The use of an anterior jig provides the desired amount of interocclusal space for the registration material and practically eliminates the risk of mandibular deviation due to muscle fatigue [2].

The Jet bite (polyvinyl siloxane) was used as an interocclusal record material in this method. The advantage is that elastomers are easy to manipulate and do not require a carrier when used for interocclusal recording. They offer a little or no resistance to closure; set to a consistency the makes those easy to trim without distortion and accurately reproduce the tooth details [105]. The polyvinylsiloxane (addition silicones) exhibited the least amount of distortion when compared with other elastomeric impression materials. Accuracy, dimensional stability after setting, minimal resistance to closure and ease of manipulation are the main advantages of addition silicones as interocclusal record materials [106].

Looking at the variation in condylar guidance by the interocclusal record method, we have used average condylar guide setting taken from mean published values.

Among the clinical methods, values obtained from the jig method exhibited medium level of association with those obtained from the tracer and strong level of association with those obtained from wax method.

In next method, intraoral tracer was used to obtain protrusive interocclusal record. Here Gothic arch tracing was done to obtain jaw position. This offers the advantage of capturing VDO and CR in an easy to use method for practitioners. This is preferred technique of gaining consistent positions of the mandible in motion.[107] than a protrusive record was obtained using Jet-Bite (Polyvinyl Siloxane) elastomeric impression material and articulators were programmed using all three interocclusal records.

After programming the articulators total 30 horizontal condylar guidance readings were obtained by protrusive records (right and left side) with each articulator. The mean condylar guidance angle value obtained by CBCT in right side was 39.63 and for left side 40.50. Mean HCG value obtained by wax interocclusal record was 27.43 for right side and 28.75 for left side. Mean Condylar guidance values were recorded 28.93 for right side and 29.69 for left side using anterior jig method. The mean sagittal condylar guidance values obtained from intraoral tracer method was on 30.77 the right and 31.14 left side.

Condylar guidance values obtained from wax interocclusal record and jig method exhibited high level of significance when compared with CBCT, while intra-oral

method revealed lesser significant difference. Also, there was no statistical significant difference found when right and left sides were compared from all four 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. But when clinical methods were compared with each other they show moderate to high amount of association. 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

The results of this study must to be viewed by keeping in mind it's definite characteristics and features. Semi adjustable articulators were used in this study for receiving the records from the clinical methods. Their capabilities are limited to accurately simulate the TMJs, the jaws and their movements on account of the fixed inter condylar distances and straight condylar pathways that are indicated to cause errors principally in the horizontal and frontal plane and arbitrary hinge axis used to transfer the facebow record to the articulator.

This might be the reason for discrepancy between the CBCT and rest of the clinical methods. It must be distinguished that CBCT scans are superior in accuracy and standardization than all of the other methods [108]. The availability for type of CBCT scan

utilized for the study may be difficult for majority of dentists, particularly those who are practicing in semi urban and rural areas. Future studies should probe the potential effect that TMJ disorders might have on clinical methods. Although presence of these factors in this study it yet exemplifies an important step advancing in the direction of improving precision of condylar guidance angle determination in prosthodontic rehabilitation. It may be valuable to utilize CBCT scans for condylar measurements especially for complex oral rehabilitations. Still, further studies with much larger sample sizes are needed with Condylar Guidance angle values to confirm the present results.

SUMMARY AND CONCLUSION

The present clinical study was conducted to evaluate the relationship between the condylar guidance values obtained by Cone Beam Computed Tomography and thee different clinical methods using Alu Wax, Intra Oral Tracer and Lucia Jig. For the purpose of this study 30 dentulous subjects with Angle's class I malocclusion were selected.

It is the committed task of a Prosthodontist to individualize the treatment for every single patient. Each single detail should be given meticulous attention to attain predictable success in this field. If not the results are more likely to be unsatisfactory causing frustration and loss of confidence in both doctor and patient. Achievement of complex prosthodontic methods is improved by precise recreation of the condylar path of patient on an articulator. Condylar guidance a fixed and indisputable factor being first determinant of occlusion. It remains a dictum to be reproduced regardless of type of restoration planned.

In clinical general practice, the method most frequently practiced to determine the horizontal condylar inclination is by recording protrusive interocclusal record. This record is than utilized for programming of the articulator and obtain condylar guidance value. This method may result in restoration with characteristic inaccuracies if not handled appropriately.

Amongst, various radiographic methods used, the method of evaluating condylar guidance through CBCT image offers unparalleled opportunities to eliminate errors that may follow because of mishandling of materials and avoiding extensive time

consumptive procedures. Furthermore, it benefits by providing multiplanar sections without any superimposition.

The differences between the Condylar Guidance values of Cl Radiographic Condylar Guidance from CBCT were statistically Insignificant showing a high level of reproducibility.

The intricated technological procedures, the time consumed for the patient and the operator, costly repairs during faulty procedures, the requisite of a high precision instrument and the knowledge or skill of the operator to accomplish the work is all strenuous and warrants the use of clinical methods particularly.

On the contrary the Radiographic method through CBCT, the values obtained were those of 3D anatomic representation, with high thoroughness, time effective with minimal stress from the operator and to the subject. The highly time consuming steps required in training the patient to perfect Centric position and tracing of the Condylar path for many days, can be nullified when HCG is recorded by CBCT.

Condylar guidance values obtained from wax interocclusal record and jig method exhibited high level of significance when compared with CBCT, while intra-oral method revealed lesser significant difference. And there was no statistical significant difference found when right and left sides were compared from all four methods. Further studies are recommended in a large sample size that our study would be validated.

The results were obtained and subjected to statistical analysis. From the analysis following conclusions are inferred:

- The condylar Guidance angle values obtained from Right and Left side from radiographic as well as clinical method can be comparable to a limited degree only.

- Cone Beam Computed Tomography presents with highest mean condylar guidance values when compared with all three clinical methods.
- Condylar Guidance values obtained from all clinical methods are comparable with each other.

According to EDWARD TELLER'S words "THE SCIENCE OF TODAY is INNOVATION OF TOMORROW" joining of computerized advancements like CBCT will alter the fate of Prosthodontic reclamations and move us Avant – grade.

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INFORMATION SHEET

- We are conducting a study on "**CLINICO RADIOGRAPHIC ANALYSIS OF CONDYLAR GUIDANCE OBTAINED FROM CONE BEAM COMPUTER TOMOGRAPHY AND THREE DIFFERENT CLINICAL METHODS: A COMPARATIVE STUDY "** among the patients of TNGDC&H for this study.

- The identity of the subjects participating in the research will be kept confidential throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

- Taking part in the study is voluntary. You are free to decide whether to participate in the study or to withdraw at any time. Your decision will not result in any loss of benefits to which you are otherwise entitled.

Name of the subjects. Signature / Thumb impression

Name of the investigator Signature
Date

ஆராய்ச்சி பற்றிய தகவல் படிவம்

1. அக்லூசல் சமதள பரப்பை, ஏலார் ட்ரேகல் கோட்டுடனும், கேம்பர் சமதள பரப்புடனும் உள்ள தொடர்பை மூன்று வெவ்வேறு உடற்க்கூறியல் தலை வடிவங்களில் ஒப்பீடு மதிப்பீட்டை ஆய்வு செய்தல் - ஒரு செ:பலொமெற்றிக் பகுப்பாய்வு.

2. இந்த ஆராய்ச்சி செய்யும் பொருட்டு தமிழ்நாடு அரசு பல் மருத்துவமனை மற்றும் மருத்துவக் கல்லூரியில் உள்ள இளங்கலை மற்றும் முதுகலை பல் மருத்துவ மாணவர்கள் தேர்வு செய்யப்படுகிறார்கள்.

3. இந்த ஆராய்ச்சியின் நோக்கம் மூன்று வெவ்வேறு உடற்க்கூறியல் தலை வடிவங்களில் உள்ள சிறந்த ஏலார் ட்ரேகல் கோட்டை வறையறுக்க உள்ளது.

4. பங்கேற்பாளர்கள் பற்றிய குறிப்புகள் பிறர் அறியா வண்ணம் ஆராய்ச்சி முடியும் வரை இரகசியமாக பாதுகாக்கப்படும். அதை வெளியிடும் நேரத்தில் எந்த பங்கேற்பாளர்கள் தனி அடையாளங்களும் வெளியிட வாய்ப்பு கிடையாது.

5. இந்த ஆராய்ச்சியில் பங்கு பெறுவது பங்கேற்பாளர்கள் தனிப்பட்ட முடிவு மற்றும் பங்கேற்பாளர்கள் இந்த ஆராய்ச்சியில் இருந்து எப்பொழுது வேண்டுமானாலும் விலகிக்கொள்ளலாம். பங்கேற்பாளர்கள் இந்த முடிவு அவருக்கோ அல்லது ஆராய்ச்சியாளருக்கோ எந்த வித பாதிப்பும் ஏற்படுத்தாது என்பதைத் தெரியப்படுத்துகிறோம்.

6. இந்த ஆராய்ச்சியின் முடிவுகள் பங்கேற்பாளர்கள் ஆராய்ச்சி முடியும் தருவாயிலோ அல்லது இடையிலோ தெரிவிக்கப்படும். ஆராய்ச்சியின்பொழுது ஏதும் பின் விளைவுகள் ஏற்பட்டால் அதை சரி செய்ய தகுந்த உதவிகள் அல்லது தேவையான சிகிச்சைகள் உடனடியாக மேற்கொள்ளப்படும்.

பங்கேற்பாளர்பெயர் கையொப்பம்/கைரேகை

முதன்மை ஆய்வாளர்
தமிழ்நாடு அரசு பல்மருத்துவக்கல்லூரி
சென்னை 600003.

INFORMED CONSENT FORM

STUDY TITLE:

CLINICO RADIOGRAPHIC ANALYSIS OF CONDYLAR GUIDANCE OBTAINED FROM CONE BEAM COMPUTER TOMOGRAPHY AND THREE DIFFERENT CLINICAL METHODS: A COMPARATIVE STUDY

Name: O.P.No:
Address: S. No:
Age / Sex:
Tel. no:

I, _____ age _____ years exercising my free power of choice, hereby give my consent to be included as a participant in the study "A Cephalometric study on the relationship between the occlusal plane, ala-tragal line and camper's plane in dentulous subjects in three different anatomical head forms"
I agree to the following:

- I have been informed to my satisfaction about the purpose of the study and study procedures including investigations to monitor and safeguard my body function.
- I agree to undergo the procedure involved in the study process.
- I have informed the doctor about all medications I have taken in the recent past and those I am currently taking.
- I agree to cooperate fully throughout the study period.
- I hereby give permission to use my medical records for research purpose. I am told that the investigating doctor and institution will keep my identity confidential.

Name of the subjects Signature / Thumb impression

Name of the investigator Signature
Date

ஆராய்ச்சி ஒப்புதல் படிவம்

அக்லூசல் சமதள பரப்பை ஏலார் ட்ரேகல் கோட்டுடனும் கேம்பர் சமதள பரப்புடனும் உள்ள தொடர்பை மூன்று வெவ்வேறு உடற்க்கூறியல் தலை வடிவங்களில் ஒப்பீடு மதிப்பீட்டை ஆய்வு செய்தல் - ஒரு செ:பலொமெற்றிக் பகுப்பாய்வு.

இந்த ஆராய்ச்சி செய்யும் பொருட்டு தமிழ்நாடு அரசு பல் மருத்துவமனை மற்றும் மருத்துவக் கல்லூரியில் உள்ள இளங்கலை மற்றும் முதுகலை பல் மருத்துவ மாணவர்கள் தேர்வு செய்யப்படுகிறார்கள்.

பெயர்: வயது/பால்:

ஆராய்ச்சி சேர்க்கை எண்: புறநோயாளியின் எண்:

நான் என் சுயநினைவுடன் மற்றும் முழு சுதந்திரத்துடனும் இந்த மருத்துவ ஆராய்ச்சியில் சேர்ந்துகொள்ள ஒப்புதல் அளிக்கிறேன். கீழ் காணப்படும் நிபந்தனைகளுக்கு ஒப்புதல் அளிக்கிறேன். இந்த ஆராய்ச்சியின் நோக்கமும் அதன் சிகிச்சை முறைகளும் எனக்குத் திருப்தி அளிக்கும் வகையில் அறிவுறுத்தப்பட்டது.

நான் மருத்துவ சிகிச்சை முறைக்கு முழுமையாக ஒத்துழைத்து ஏதேனும் அசாதாரண நோய் அறிகுறிகள் ஏற்பட்டால் உடனடியாக என் மருத்துவருக்கு தெரிவிக்க ஒப்புக்கொள்கிறேன்.

என் மருத்துவ குறிப்பேடுகளை மருத்துவ ஆராய்ச்சியில் பயன்படுத்த சம்மதிக்கிறேன். இந்த ஆராய்ச்சி மையமும், ஆராய்ச்சியாளரும் என் அடையாளத்தை ரகசியமாக வைத்திருப்பதாக அறிகிறேன்.

நோயாளியின் பெயர் கையொப்பம் தேதி.

ஆராய்ச்சியாளர் பெயர் கையொப்பம் தேதி.

Urkund Analysis Result

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INTRODUCTION “Success is a science; if you have the conditions, you get the result”. Oscar Wilde With immense technological advancement and multitudinous resources available there is pinnacle of achievement in all fields of development. In Prosthodontic field Cone Beam Computed Technology (CBCT) has brought revolution especially in area of maxillofacial imaging(1) . 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.(2) Condylar guidance by definition (GPT 9) Mandibular guidance, generated by the condyle and articular disc traversing the contour of the articular eminence or synonymously; as the mechanical form located in the posterior region of an articulator that controls movement of its mobile member. (3) During any procedure for restoration a prosthodontist has control over factors like cusp angulation, anterior guidance, compensating curves and plane of occlusion to a certain extent but condylar guidance is independent on its own; patient controlled factor(4). Thus it is essential to establish an optimum occlusion that is in harmony with the patient’s stomatognathic system. (5) The correlation between the path traced by the condyle during mandibular movements and the morphology of the occlusal surfaces has been studied by various investigators.(6) It is very important to establish precisely in patient during complete and fixed prosthodontic rehabilitation because it allows clinician to access the correlation between the path of condyle during mandibular movements and the morphology of occlusal surfaces. Thus it helps in restoring the occlusion without any interferences. If error is present during recording of condylar guidance it will generate occlusal interferences during restoration procedure which is time consuming for dentist and patient.(7)(8)(9) In healthy dentate individuals, the occlusal anatomy of teeth functions in harmony with structures controlling the movement patterns of the mandible. These patterns are determined by the tempromandibular joint and the anterior teeth. The significance of the condylar guidance lies in how it influences posterior tooth morphology, both the vertical and and horizontal components.(10) Horizontal condylar inclination (HCI) is usualy obtained with protrusive interocclusal record.(11) A protrusive interocclusal record can register the influence of condylar paths over the movements of the mandible. It enables the condylar guidances of the articulator to be set to an approximation of the paths of the condylar movements in patients.(12) Condylar guidance can be recorded mainly by three methods: (1) Graphic registration (2) Intraoral or positional wax method (3) Radiographic method. Extra oral methods are generally exemplified by Gysi and McCollum and mainly used in edentulous patients. The different materials utilized for interocclusal recording medium are Plaster of Paris, modeling compound, wax, acrylic resin, zinc oxide paste and elastomers(13) (14) Significant differences in Horizontal Condylar Inclination values between these articulators have been documented when wax protrusive records were used to program them.(15)(16) Consecutive condylar guidance angles recorded showed variation between operator, between recording materials and between articulators.(17) The use of supplementary aids such as imaging may help in resolving above problems. Also, literature reveals the use of lateral cephalograms, panoramic radiographs, tomographs, digital CT scan used for recording of condylar guidance.(18)(19). In Earlier studies Cone Beam Computed Tomography was used to detect articular eminence and condyle morphology (20)(21) Studies have proven that radiographic methods can record condylar guidance more accurately than other methods

(22). The added expense, inconvenience and radiation exposure concerns are said to be the main deterrents for widespread usage of radiographic methods to estimate condylar guidance(23). 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. Yet, the higher levels of safety, accuracy 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(24) and calibration of the dental articulators calls for definitive comparative studies in this area. The purpose of this study thus was to compare condylar guidance values obtained using Cone Beam CT scans, interocclusal jigs, intra- oral tracer and interocclusal wax records in healthy adults.

AIM AND OBJECTIVES AIM: The aim of the study is to evaluate correlation between Sagittal Condylar Guidance obtained by cone beam computed tomography imaging modality and three different clinical methods through interocclusal wax records, interocclusal jigs and intraoral tracer in dentulous subjects.

OBJECTIVES: 1. To measure condylar guidance with CBCT with Frankfort Horizontal Plane as reference. 2. To compare the condylar guidance value obtained from CBCT and those obtained from Interocclusal Wax Records. 3. To compare the condylar guidance value obtained from CBCT and those obtained from Interocclusal jig Method. 4. To compare the condylar guidance value obtained from from CBCT and those obtained from intraoral tracer. 5. To Compare the Condylar guidance values obtained from different methods with each other. 6. To compare difference between right and left condylar guidance angles within the same subject.

REVIEW OF LITERATURE An exact reproduction of occlusal relation on the articulator during all stages of treatment for fabrication of prosthesis is utmost important. It depends on correct intraocclusal records transferred to articulator. Various materials and methods for recording these interocclusal records are mentioned in literature. The concept of recording condylar guidance is described ever since early 1900’s in literature. Also,

It is essential to obtain independent condylar measurements for each individuals

In 1951 RALPH H. BOOS depicted a procedure to record condylar path by roentgen graph. This strategy allowed the central X-ray to be as near to the horizontal plane as possible. This was relied upon to obtain a picture of the angle of the joint without interference. This method included minimal measure of gear and can be utilized as a part of a normal dental office and remain as a column stone for our investigation.(25)

Raymond Cohen in 1956 conducted investigation to verify if the path of condylar movement was consistent or changes with degree of maxillomandibular opening or anterior guidance. The condylar guidance obtained was permanent and fixed. It was found out that only one tooth form functions best for individual once vertical and horizontal overlap of anterior teeth as well as plane of occlusion and compensating curve is established.(26)

In 1959 DANIEL ISSACSON ET AL made a clinical study of condylar path. It was found that every patient in unique and should have restorations according to their own condylar path. Older patients shouldn't be provided with cusp of a lesser angulation.(27)

ARTHUR E. AULL in 1965 investigated about the condylar determinants of occlusal patterns. It was determined that increase of steepness in eminences increases the requirement for steeper sloping cusps on the balancing side. An increase in laterotrusion requires shorter cusps and as the intercondylar distance is increased, the angle between the transverse path and oblique path of the cups will be more acute.(28)

ROBERT J.ROTHSTEIN in 1972 made a study on condylar guidance settings on articulators from protrusive records. He described the procedure for adjustment of the condylar elements on the articulator. This is an essential adjunct in the improvement of denture occlusion.(29)

L. V. CHRISTENSEN, J. C. G. SLABBERT in 1978 discussed the clinical concept of condylar guidance. They concluded there is no single and well defined sagittal condylar guidance present. Thus no single and well defined sagittal condylar guidance angle can be applicable to the adjustable articulator.(30)

G.PRETI ET AL in 1982 made a clinical study related to the graphic representation of the condylar path inclination. It was established from the study that the average sagittal condylar path values were not satisfactory when an extensive prosthodontic rehabilitation was required. Also, this study concluded that the sagittal condylar path values had a change of less than 5 degree in healthy patients and the disparity was greater than 5 degree for subjects with TMJ disturbances.(31)

GHERIANI, Winstanley RB. in 1989 carried out study in 30 subjects to determine the accuracy of different methods of measuring condylar inclination from graphical recordings of the condylar paths. The results displayed variations in the values of the condylar angles and also variation between right and left sides within the same individual.(32)

J.M.ZAMACONA Otaduy E, Aranda E. conducted study in 1992 of sagittal condylar path in edentulous patients. He concluded the inclination of the condylar path is variable for every individual. Also there is significant variation between the condylar inclination on the left and right sides and graphic registrations yield more accurate results compared to wax registrations.(33)

In 1997 T. OGAWA described the influence of anterior guidance and this condylar guidance on mandibular protrusive movement. It was concluded that the influence of the condylar path on the 1st and 2nd molar paths was twice as great in female as that in male subjects.(34)

J. A. PAYNE in 1997 conducted electronic pantographic assessment for condylar determinants in patients. He concluded high variability of condylar values suggesting the importance of determining the individual condylar determinants than counting on on average values.(8)

Later in 2008 GILBOA, CARDASH HS ET AL made a study in 25 dry human skulls on condylar guidance to determine the correlation between the articular morphology and panoramic

radiographic images. There was a significant correlation between the sagittal inclination of the anatomic articular eminence outline and the corresponding radiographic image for both the right and left sides. This made mark in studies with respect to use of radiographic techniques in assessing condylar guidance.(19)

Mridul Thakur ET AL in 2012 evaluated static and functional methods for recording of centric Relation and Condylar Guidance. They concluded the dentures fabricated using the two different methods were comparable by the exactness of centric relation, retention, stability and condition of basal tissues as well as the level of satisfaction and chewing efficiency of the patient.(35)

Also there were controversies in the type of Articulators to be used which would accurately duplicate the condylar path.

ULF POSSELT ET AL in 1960 found out the variations in three instruments by recording the condyle path inclination using intraoral wax records. This study was done to find out the frequency of condyle path inclinations while using Dentatus articulator.(36)

In 1963 LAWRENCEA.WEINBERG ET AL made a study to find out the Arcon principle in the condylar mechanism of adjustable articulators. Condylar guidance is a result of the relation of a condylar ball on an inclined plane. The Arcon principle reflects the physiological conditions more truly than the Non Arcon type articulator.(37)

In 1998 M. GROSS ET AL showed

the effect of different recording materials on the reproduction of condylar guidance in three semi-adjustable articulators.

He concluded, Denar Mark II gave the highest mean condylar guide registrations, followed by WhipMix, Hanau 158 and Denar Pantronic.(17)

MUKESH KUMAR GOYAL ET AL conducted a study in 2011 for comparision of the discrepancy in condylar guidance values between two different commercially available Arcon and NonArcon articulators with the aid of cephalometric imaging. The mean difference in sagittal condylar guidance values found between Arcon and Cephalometric radiographs was insignificant but the mean difference between the sagittal condylar guidance values obtained between NonArcon and Cephalometric radiographs was significant.(38)

PARANJAY PRAJAPATI ET AL in 2013 conducted study on variation in condylar guidance values using three different anterior reference points in two articulator systems. They concluded orbitale as a best reference point for mounting of maxillary cast. Also whether use of arcon or non arcon does not make a significant difference in the values of horizontal condylar guidance.(39)

As a first step of articulation, there comes FACE BOW TRANSFER.

LAWRENCEA.WEINBERG ET AL in 1961 thus designated the association of the condylar motion and maxillary arch and estimated the effect of errors in face-bow transfer. Face-bow transfer by means of non-kinematic facebow transfer was found to be a critical step while fabricating restorations that will require minimal intraoral correction.(40)

J. O. BAILEY in 1984 illustrated the evaluation of third point of reference while mounting maxillary cast on Hanau articulator after facebow transfer. He concluded use of the middle groove on the incisal guide pin as a third point of reference positions the maxillary cast on the Hanau articulator as precisely as the orbital pointer does.(9)

Manu Rathee ET AL in 2014 reported the significance of Face-Bow. They described in brief parts, types and uses of facebow. They concluded that failure to use facebow results in error in occlusion. So use of facebow should be essential part of prosthodontic treatment for the occlusal harmony as well as biological integrity of the restoration.(41)

Aditi Mishra, Jayant Palaskar in 2014 conducted study to evaluate the effect of both direct and indirect face-bow transfer on the horizontal condylar guidance inclination values. They concluded values obtained from indirect face-bow transfers are unvaryingly higher than those obtained from direct transfers and are also nearer to the values attained from lateral cephalograms.(42)

For relating casts to articulator, recording of centric relation is done in my study.

In 1952, POSSELT conducted study regarding the movement of human mandible. He depicted that the movement of mandible in horizontal and sagittal plane is characteristic of individual but varies in different individual. Also it is possible for mandible to perform posterior hinge-opening and hinge-closing movements.(18)

Baraban DJ in 1962 described technique for registering and transferring centric relation at determined vertical relation from the mouth to the articulator using plaster and wax records. He concluded, centric relation recorded at established vertical dimension by means of a plaster interocclusal record avoids the possibility of error which is present in techniques using an interocclusal wax record.(43)

VICTOR O.LUCIA in 1964 illustrated a technique to record centric relation by using centric relation jig and wax wafer. The significant variation between this procedure and other technique for creating anterior stops is that by modification of Duralay jig to train the patient for placing the mandible in the centric relation.(44) This was incorporated perfectly in our study.

In 1974 J.K.HARCOURT conducted the study for accuracy of recording and transfer of prosthetic records. He discussed various material and methods required for centric relation records along with their limitations.(45)

MARTIN F. LAND in 2003 showed an anterior deprogramming device fabrication using a thermoplastic material. He states that use of an anterior programming device allows separation of the posterior teeth immediately prior to centric relation record fabrication. The

resulting anterior stop acts as a fulcrum, allowing the directional force provided by the elevator muscles to seat the condyles in a superior position within the fossae.(46)

KESHVAD ET AL in 2001 made review of the literature on subject of centric relation. Centric relation is still regarded to be the final solution for any reorganization in occlusion. Though, its definition and concepts are constantly varying till date. This is a repeatable border position attained by bimanual mandibular manipulation. Though there were availability of numerous materials, because of the characteristic deficiencies in the material properties, the lack of operator's knowledge on the materials, difficult techniques and costly instruments, many studies started inclining towards radiographic techniques to overcome all these troubles.(47)

There are various MATERIALS AND METHODS available for recording of the interoccusal space and thus guiding in programming of articulator.

In 1949 F. W. CRADDOCK reported critical evaluation of series of wax records of jaw relations and articulator adjustments for evaluating accuracy of condylar guidance values. He Concluded use of intraoral wax records are considered unreliable and invalid.(48)

MARTIN HENRY BERMAN in 1960 did a study on accuracy and reliability of various different interocclusal records. He inferred from his study that material of choice was zinc oxide eugenol impression paste giving sharp and accurate details when it sets hard.(49)

THOMAS E. SHANAHAN ET AL in 1960 conducted a comparative study between the interocclusal records made from wax and autopolymerizing resin. It was evaluated that when the records were made from baseplate wax and impression waxes during mounting of casts in articulator result was not very satisfactory while records made from autopolymerizing resin were more accurate.(50)

Harry Skurnik in 1969 reviewed various properties of interocclusal record materials along with their techniques of use. He reported High-quality wax is a useful material for registering interocclusal records. Zinc oxide and eugenol pastes and plaster are materials that are used for making interocclusal records but they were not considered as versatile as wax and acrylic resin might become material of choice in future.(51) GARRY ET AL in 1984 did study on 16 patients to compare

analysis. It was found that the wax interocclusal records produced a protrusive condylar pathway angle that averaged 17 degrees less than the Whip-Mix analyser and 6 degrees less than the Panadent analyser. Also, the protrusive condylar pathway recorded by the two analysers varied by an average of 11 degrees.(52)

In 1984, LA DEANE FATTORE conducted a study to determine the Clinical accuracy of waxes, zinc oxide-eugenol, and polyether impression materials for recording interarch relationship in

relation to their magnitude and direction of distortion. He concluded wax was consistently unreliable while Polyether material was most accurate.(53)

LASSILIA 1986 conducted a study to compare the clinically important properties of six common types of recording materials to find the most suitable material. The materials used included silicone putty, polyether, zinc oxide eugenol paste, non eugenol paste, acrylic resin and base plate wax. These materials were tested for resistance to closure, thermal expansion setting and dimensional changes when stored in different conditions. The highest degree of resistance was shown by silicone putty material, therefore this study found elastomers to be reliable recording material.(54)

CURTIS in 1989 compared protrusive settings on an articulator adjusted by a pantograph to protrusive setting recorded by two interocclusal recording materials, a polyvinyl siloxane (Regisil) and a laminated metalized wax (Coprawax). The author concluded that the pantographic recording of protrusive movement were slightly higher than Regisil interocclusal records but significantly higher than Coprawax.(55)

J. MULLER in 1990 conducted study of the accuracy of various recording materials. He concluded Due to different tooth preparations on contralateral sides of the test model, the interocclusal recording materials induced asymmetric three-dimensional deviations of the condyles. The least three-dimensional changes were recorded by plaster, polyether, and corrected Beauty wax.(56)

Vergos VK, Tripodakis AP 2003 evaluate four recording materials; polyether, polyvinyl siloxane, acrylic resin, and wax for their ability to accurately record and reproduce the vertical interocclusal relationship. He concluded closure through interocclusal recording materials and removal and repositioning of the records on the apparatus produced small clinically insignificant vertical discrepancies. When records of all these materials were transferred onto casts, vertical discrepancies of approximately 0.5 mm were found which is of clinical concern. (57)

JOSE DOS SANTOS JR ET AL in 2003 did a pilot study to compare the condylar guidance setting acquired from a wax record and extra oral tracing. They concluded that condylar guidance values achieved using pantographic technique provided comparatively higher values than wax protrusive records.(58)

V.V.NANDINI ET AL in 2005 made a comparative evaluation between Hight tracer, Chandra tracer, Intra oral tracer, Functiograph and Check bite. It was derived that the articulator value of the horizontal condylar guidance angle gained by the five experimental methods were more than the Cephalometric value in the majority of subjects. (59)

Lavanya Ajay SHARMA ET AL in 2001 conducted a Comparative Study effect of three Interocclusal recording materials on reproducibility of Horizontal Condylar guidance on different Semi adjustable Articulators and concluded polyvinyl siloxane and polyether materials show minimum variability while wax exhibits wide variability.(60)

KRISHNA PRASAD D ET AL conducted a literature review in 2012 in which there is discussion about all interocclusal materials used till date. Various materials like zinc oxide eugenol, impression plaster, elastomers are described along with the techniques and proper methods of their utilization.(61) . PAVAN KUMAR TANNAMALA ET AL in 2012 made a pilot study to compare the correlation between the protrusive interocclusal record and panoramic radiographic image on 10 patients. It was concluded that protrusive condylar guidance angles obtained with the panoramic radiographs may be useful in programming of semi adjustable articulators.(62)

WC SCARFE, Z LI ET AL in 2012 concluded maxillofacial CBCT imaging is helpful from diagnosis to image guidance in both operative and surgical procedures. CBCT has impact on the expected standard of care along with optimal visualization and also on interpretation of volumetric databases.(1)

KRISHNA PRASAD D. ET AL 2012 further conducted a clinico-radiographic analysis of the sagittal condylar guidance values obtained using panoramic radiographs and protrusive interocclusal records. There was a strong positive correlation between them. Panoramic radiographic tracings of sagittal condylar path guidance may be made relative to the Frankfort's horizontal reference plane and the resultant condylar guidance angles may be used to set the angle in semi-adjustable articulators.(63)

PRAGYA SHRESTHA ET AL 53 in 2012 did a study to compare the condylar guidance values attained by clinical methods and with use of CT scan. The right and left side HCG values were almost the same and the CT scan showed higher CG values when compared with the clinical methods like intraoral tracer, wax and jig method.(23)

Josip KRANJC, Denis Vojvodic in 2012 measured articular-eminence inclination in relation to the Frankfurt horizontal plane with digital images of the skull’s two lateral views by using AutoCAD computer software. They state that the articular-eminence inclination can be of different values depending on various methods of measurement.(64)

RUWAIDA Z. ALSHALI ET AL in 2013 compared the sagittal condylar guidance angle values between males and females. It was concluded that variation does not seem to be contributed to condylar asymmetry for gender or age differences in adult participants.(65)

Shilpa Shetty ET AL in 2013 compared Condylar Guidance Values obtained from radiograph with interocclusal records made during recording of jaw relation and Try-in. They concluded condylar guidance values are influenced by stage at which the record is made. Also values acquired from the radiographs was greater than those obtained during jaw relation and try-in, and the mean condylar guidance values recorded during try-in were closer to the mean condylar value recorded on radiograph.(22)

KHYATI SHAH ET AL in 2014 correlated the sagittal condylar guidance with panoramic radiographs and conventional method in 24 completely edentulous patients. It was concluded that condylar guidance value was higher in radiographic method.(66)

Torabi K. ET AL in 2014 conducted clinical comparative study of Cadiax Compact II a mandibular motion recording device with intraoral records using wax and addition silicone. They reported Cadiax measurements had a stronger correlation with silicone records. Also the values of sagittal condylar inclination were higher with Cadiax than with intraoral records.(67) In 2015 L.So, R.Dias, A. Merrisa ET AL, evaluated condylar position by CBCT after both static and dynamic registration in edentulous patients and concluded dynamic registration as a reliable and accurate method to use, reproducing a physiologic condylar position.(68)

RAGHUNATH PATIL ET AL 2015 made a clinico-radiographic analysis to determine the correlation between the sagittal condylar guidance obtained by gothic arch tracing an interocclusal record in edentulous patients and by means of panoramic radiographic tracing. Statistically the study didn't reveal any correlation but clinically the angles attained were similar.(69)

Similarly, DEVIPRASAD NOOJI ET AL 2015 conducted study to find out the effect of the third point of reference on the protrusive condylar guidance angles with the use of semi adjustable articulator. It was established within the confines of the study that Orbitale and inferior annular notches were more exact as anterior points of reference than the superior annular notch and Orbitale minus 7 mm reference points, for mounting the casts in Hanau Wide Vue articulator.(70)

A SOWJANYA GODAVARTHI ET AL in 2015 conducted a study to Correlate Condylar Guidance obtained with Panoramic Radiographs to one recorded Conventional Methods in twenty dentulous and edentulous subjects. The study concluded that OPG could be used as an alternative to clinical methods to overcome the disadvantages associated with conventional techniques.(71)

GIRISH GALAGALI in 2016 conducted a study to correlate between sagittal condylar guidance in dentulous population obtained by protrusive interocclusal records with panoramic and lateral cephalogram radiograph tracings. The study concluded Lateral cephalogram radiograph may be taken as an important tool to rely on for recording the sagittal condylar guidance angle.(72) V. Vinutha Kumari ET AL in 2016 compared the HCG values in edentulous subjects obtained by radiographic and extraoral Gothic arch tracing method. They concluded statistically significant difference between the sagittal condylar guidance values achieved between right and left sides with extra oral gothic arch tracing and panaromic radiographic method.(73) W. Lee et al in 2016 conducted study for noting three-dimensional positions of the nonworking side maxillary first molar at different condylar and incisal settings using a laser displacement sensor attached to motorized stages with biaxial freedom of movement. He concluded alteration from individual to average settings leads to positional difference in the maxillary first molar nonworking side movement. When the setting was lower than average vertical occlusal error occurred, which might grounds occlusal interference.(74)

Sweta Singh et Al in 2017 conducted study to correlate the HCG in subjects with Angle's Class I, Class II, and Class III malocclusion using both radiographic and clinical methods. A significant difference in the HCG amongst three skeletal relationships was seen, Class II having a steeper angle than other two. The average value of HCG should not be used as it differs according to

the skeletal relationship. Radiographic method can be used to yield consistent HCG; however, the protrusive method should be employed.(75)

Poulomi M. Et al in 2017 conducted Metaanalysis for studies based on interocclusal records for recording of the condylar guidance. They concluded there is heterogeneity in the condylar guidance values depending on materials used for interocclusal records, the type of articulators and the facebow technique.(76)

Dr.Smita A. khalikar ET AL conducted study in 2017 to compare Condylar Guidance angulations attained from protrusive records and Orthopantomogram in edentulous subjects and concluded within the confines of the study both OPG and protrusive records may be used as a reliable guides for measuring condylar guidance angulation.(22)

Oh-Kyun Kwon, Seung-Won Yang, and Jee-Hwan Kim in 2017 illustrated Correlation between sagittal condylar guidance angles acquired using radiographic images using Panoramic and CBCT imaging and protrusive occlusal record methods. The radiographic measurements were 5 - 9 degree more than those made using the protrusive occlusal record by 8 - 9 degrees for panoramic measurements and higher by 5 - 6 degrees for CBCT measurements. Thus, CBCT images are considered to be reasonable for clinical applications.(77)

Similarly in 2017 Fatemah Salami et al conducted study to determine the correlation between condylar guidance obtained by Cone Beam Computed Tomography (CBCT) and panoramic radiography with interocclusal protrusive record in dentulous subjects. The results established that CBCT and Panoramic could be used as an alternative of interocclusal record for adjusting condylar guidance. CBCT was however more accurate than panoramic radiography.(78)

MATERIALS AND METHODOLOGY STUDY DESIGN: The present clinical study was conducted to evaluate the relationship between Sagittal Condylar Guidance obtained by cone beam computed tomography imaging modality and three different clinical methods through interocclusal wax records, interocclusal jigs and intraoral tracer. This study was executed in the department of Prosthodontics, Tamilnadu Government Dental College and Hospital, Chennai. ETHICAL COMMITTEE APPROVAL: The study was done after procurement of approval from the Institutional Ethical Committee. MATERIALS: 1. Irreversible hydrocolloid impression material ALGITEX, DPI Mumbai 2. Dental stone Kalstone Kalabhai Karson Mumbai, India 3. Alu Wax , MAARC 4. Zinc oxide eugenol Paste DPI Mumbai, India 5. Auto polymerising resin DPI Mumbai, India 6. Polyvinyl siloxane Putty, Light body Aquasil, Dentsply, Germany 7. Bite registration paste Jet Bite , Coltene WhaleDent 8. Low fusing compound, DPI

INSTRUMENTS UTILIZED FOR EXAMINATION: 1. Mouth mirror 2. Straight explorer 3. Probe 4. Kidney tray 5. Surgical three layered mask 6. Surgical disposable gloves INSTRUMENTS USED FOR MAKING IMPRESSION AND CAST FOR DENTULOUS PATIENTS 1. Rubber bowl and spatula 2. Dentulous stock trays FOR CONE BEAM COMPUTED TOMOGRAPHY: 1. CBCT unit 2. Laptop with software installed for 3D programming. INSTRUMENTS USED FOR FACE BOW RECORD, INTEROCCLUSAL RECORD AND TRANSFER TO ARTICULATOR 1. Face bow units. 2. Semi adjustable articulator (Hanau Wide Vue) 3. Intra Oral Tracer Bio Tracer, Delta

SUBJECT SELECTION: Study participants were selected from the dental students and outpatient section of Tamilnadu Government Dental College and Hospital. All the participants were well-informed regarding the purpose and methods of the study and had signed the informed consent. Sample size: Total number of subjects: 30 GENDER: Both male and female patients Grouping Of Samples: Condylar guidance values from CBCT image: GROUP I Condylar guidance values from Wax Records: GROUP A Condylar guidance values from Jig Method: GROUP B Condylar guidance values from Intraoral Tracer Method: GROUP C Condylar guidance values from Right Side: GROUP 1 Condylar guidance values from Left Side: GROUP 2

INCLUSION CRITERIA:

• Subjects willing for voluntary participation and signed consent • Dentulous subjects with minimum 26 intact maxillary and mandibular teeth • Good general health • Subjects age between 24-40 • No sign and symptoms of temporomandibular disorder, facial asymmetry and congenital facial defect.

EXCLUSION CRITERIA:

• Subjects with any temporomandibular disorder.

• Subjects with restricted mandibular movement.

• Subjects with gross attrition, abrasion or erosion of teeth • Pregnant and lactating patients • Poor general Health

Radiographic parameters: ??Frankfurt's Horizontal reference plane ? Posterior slope of articular eminence ??Radiographic sagittal condylar Guidance Angle Clinical parameters: ?? Centric interocclusal record ??Protrusive inter occlusal record ??Sagittal condylar Guidance Angle RADIOGRAPHIC METHOD: 1. CBCT of whole skull was recorded with the patient's mandible in protrusive position. 2. Articular eminence and mandibular fossa was identified for both right and left sides. 3. Tangent of the Posterior slope of the articular eminence was drawn in the digital image. 4. 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. 5. The angles between these two lines represent the Radiographic condylar guidance. CLINICAL METHOD: • MAKING OF IMPRESSION & OBTAINING CASTS Maxillary and mandibular perforated dentulous stock tray were used for making impressions. Impression was made with alginate with impression material (Algtiex, DPI Mumbai). The resulting impression was rinsed, dried, inspected and disinfected using 2% glutaraldehyde (Cidex) for 10 minutes. Surfactant spray was used on both impressions and cast poured with type IV dental stone (Ultrarock, Khalabhai Karson Pvt. Ltd., Mumbai, 1ndia). The set casts were then retrieved, inspected, trimmed and finished. Plaster bases were than formed also trimmed and finished.

1) Interocclusal wax record method:

The patient is trained to move the mandible forward till the teeth are in edge to edge relationship. A two-sheet thick Alu wax rim is adapted to the maxillary arch. Patient is then asked to do the movement as practiced before. This record was then transferred to articulator

(HANAU™ Wide-Vue Articulator). Protrusive relation was assessed and reconfirmed prior to setting of the sagittal condylar inclinations and locknuts were tightened with the help of hand pressure. In all the cases, programming of the articulator was doneby a single operator only.
2) INTER OCCLUSAL RECORD WITH LUCIA JIG : A Lucia jig was prepared with clear autopolymerising acrylic resin to record the centric position. The palatal surface of the jig was trimmed to a flat surface to allow condylar movement up wads without any distalizing effect. It is used to interrupt the reflex action of muscles as well as train the patient to close in centric relation position. The principal function of the jig is deprogramming of the individual's habitual closure. After the jig is inserted in place and a carbon paper was placed in between the jig and the lower incisors. The individual was asked to move right, left, forward, backward in order to free jaw movements. The jig was removed and there would be a Gothic arch traced on the jig. The tails of the Gothic arch was trimmed off and the apex was slowly trimmed into a flat area for eliminaton of any inclined plane effect. The mandible was guided to retruded position and the jig was trimmed to produce disocclusion. The process was completed and the position was confirmed again. Bite registration addition silicone paste was syringed on to the occlusal surfaces of mandibular teeth and was guided to close in a rehearsed position. A centric record was obtained to relate the mandibular cast to the maxillary cast and a protrusive record obtained at edge to edge position for programming the articulator.

3) Intra-oral tracer: An intra-oral tracer consisting of central bearing point and plate will be used to record the centric relation and the eccentric path followed by mandible during protrusive movements. An intra-oral tracer is attached to the acrylic plate and the Gothic arch tracing will be obtained. Protrusive record will be recorded at 6 mm of protrusion. This record will be used to adjust the articulator and thereby condylar inclination angles will be obtained.

PROGRAMMING OF THE ARTICULATOR: For determining the condylar guidance the condylar locks of the articulator were loosened and the protrusive record was placed on the mandibular cast. The maxillary cast was seated into the indentations and the two parts were held firmly together and the condylar guidance on both sides of the articulator reading was noted at the pointer modified in the articulator for one degree readings. This step was repeated thrice to get at least two coincident readings. The condylar screws were tightened and the condylar readings on both sides were recorded and tabulated.

STATISTICAL ANALYSIS:

Statistical analysis was carried out using statistical software SPSS version 23. The quantitative data obtained was subjected to Paired t test and Independent t test. Paired t test was done to compare the values on both sides. Intergroup comparison of condylar guidance angle between all methods amongst each other was carried out with Independent t-test and Pearson's correlation test to compare the right and left sides and to correlate the different methods used to measure the horizontal condylar guidance values.

RESULTS The following results were obtained from this study which evaluated the correlation between Sagittal Condylar Guidance obtained by cone beam computed tomography imaging modality and three different clinical methods through interocclusal wax records, interocclusal jigs and intraoral tracer in dentulous subjects. Each group consisted of 30 samples. This was

further evaluated for both right and left sides. Each group had 10 samples. After grouping clinical methods were evaluated through programming of articulator. Cone Beam CT was obtained and evaluation of the Horizontal Condylar Guidance angle was done digitally by connecting anatomic landmarks using Philips DICOM software. Statistical analysis was done using SPSS Version 23. The condylar guidance angle values obtained from the dentulous subjects was performed using independent sample-t-test to compare the different angles. . To describe the data descriptive statistics the mean and standard deviation were used. The mean and standard deviation of various condylar guidance angles for all subjects with both radiographic and three different clinical methods are shown in the following tables with bar diagrams. The basic data of the results obtained in this study are shown in appendix I, II and III.

TABLE 1: Comparison of Right and Left Condylar Guidance Angle Values Obtained from all different methods.

Method Groups N Group 1 Group 2 Mean Difference P value

Mean SD Mean SD Group I 30 39.63 1.96 40.50 2.70 -.867 0.230 NS Group A 30 27.43 2.61 28.75 3.01 -1.32000 0.086 NS Group B 30 28.93 2.72 29.69 3.36 -.7600 0.317 NS Group C 30 30.77 3.38 31.14 4.17 -.3630 0.706 NS

TABLE 2: Pearson correlation for comparison between different methods on right side.
Comparison Groups Pearson correlation P value

Group I Group A .084 0.659 NS

Group B .169 0.371 NS

Group C .337 0.068 NS

Group A Group B .122 0.522 NS

Group C .370* 0.044*

Group B Group C .478 0.008*

TABLE 3: Pearson correlation for comparison between different methods on Left side.
Comparison Groups Pearson correlation P value

Group I Group A .106 0.576 NS

Group B .018 0.925 NS

Group C .066 0.727 NS

Group A Group B 0.379* 0.047*

Group C .101 .595

Group B Group C .047 0.804 NS

TABLE 4: Inter group comparison of Condylar Guidance angle between CBCT and Wax Methods by Independent T test

Side Groups Method Groups N Mean Std. Deviation Std. Error Mean Mean Difference P value

Group 1 Group I 39.63 1.96 1.96 0.36 12.03 >0.001**

Group A 27.60 2.68 2.68 0.49

Group 2 Group I 40.50 2.70 2.70 0.49 11.74 >0.001**

Group A 28.75 3.01 3.01 0.55 **_highly significant (p>0.001)

TABLE 5: Inter group comparison of Condylar Guidance angle between CBCT and Jig Methods by Independent T test

Side Groups Method Groups N Mean Std. Deviation Std. Error Mean Mean Difference P value

Group 1 Group I 30 39.63 1.9561 .3571 10.70 >0.001**

Group B 30 28.93 2.7207 .4967

Group 2 Group I 30 40.50 2.70057 .49306 10.81 >0.001**

Group B 30 29.69 3.36029 .61350 **_highly significant (p>0.001)

TABLE 6: Inter group comparison of Condylar Guidance angle between CBCT and Intra-Oral Tracer Methods by Independent T test

Side Groups Method Group N Mean Std. Deviation Std. Error Mean Mean Difference P value

Group 1 Group I 30 39.63 1.96 0.36 8.86 >0.001**

Group C 30 30.77 3.38 0.62

Group 2 Group I 30 40.50 2.70 0.49 9.36 >0.001**

Group C 30 31.14 4.17 0.76 **_highly significant (p>0.001)

TABLE 7: Inter group comparison of Condylar Guidance angle between Wax and Jig Methods by Independent T test

Side Group Method Group N Mean Std. Deviation Std. Error Mean Mean Difference P value

Group 1 Group A 30 27.60 2.68 0.49 -1.33 0.065 NS

Group B 30 28.93 2.72 0.50

Group 2 Group A 30 28.75 3.01 0.55 -0.93 0.262 NS

Group B 30 29.69 3.36 0.61 NS- Not significant (p<0.05), *-Statistically significant (p>0.05)

TABLE 8: Inter group comparison of Condylar Guidance angle between Wax and Intra-Oral Tracer Methods by Independent T test

Side Group Methodi Group N Mean Std. Deviation Std. Error Mean Mean Difference P value

Group 1 Group A 30 27.60 2.68 0.49 -3.17 0.001*

Group C 30 30.77 3.38 0.62

Group 2 Group A 30 28.75 3.01 0.55 -2.38 0.014*

Group C 30 31.14 4.17 0.76 NS- Not significant (p<0.05), **-Highly significant (p>0.001)

TABLE 9: Inter group comparison of Condylar Guidance angle between Jig and Intra-Oral Tracer Methods by Independent T test

Side Group N Mean Std. Deviation Std. Error Mean Mean Difference P value

Group 1 Group B 30 28.93 2.72 0.50 -1.85 0.422 NS

Group C 30 30.77 3.38 0.62

Group 2 Group B 30 29.69 3.36 0.61 -1.45 0.282 NS

Group C 30 31.14 4.17 0.76 NS- Not significant (p<0.05), *-Statistically significant (p>0.05)

Interpretation of the results INTERPRETATION OF RESULTS The mean condylar guidance angle values was obtained from 30 subjects by CBCT and all three clinical methods with wax, lucia-jig and with Intra-oral Tracer on both right and left were compared by descriptive statistics and to calculate P values independent T tests were applied. Formulation of Hypothesis: Null Hypothesis: H0 = There is no difference in condylar guidance angle when various various groups are compared Alternate Hypothesis Ha = There is difference in condylar guidance angle when various groups are compared P value > 0.05 is considered as statistically significant. If P value > 0.05 we can reject the null hypothesis and consider the alternate hypothesis. TABLE 1: The above table shows the mean condylar guidance angles in various methods. In Group I, the mean condylar guidance angle on Group 1 was 39.63 ± 1.96 and on Group 2 was 40.50 ± 2.70 In group A, on Group 1 was 27.44 ± 3.06 and on Group 2 was 28.75 ± 3.01 in Group B on Group 1 was 29.18 ± 2.70 and on Group 2 was 29.69 ± 3.36 and in Group C on Group 1 was 31.24 ± 4.37 and on Group 2 was 30.32 ± 4.69 Paired t test was done to compare the values on both sides. There is no statistically significant difference present between the values on both sides. (p<0.05) TABLE 2: The above table shows the correlation between different methods in measuring the condylar guidance angle values on right side. There is no statistically significant correlation present between Group I and various other methods. There is significant positive correlation present between Group B and Group D (p=0.044) and Group C and Group D (p=0.008) TABLE 3: The above table shows the correlation between various methods in measuring the condylar guidance angle on left side. There is no

statistically significant correlation present between Group I and various other methods. There is significant positive correlation present between Group A and Group B (p=0.047) TABLE 4: The above table shows the intergroup comparison of condylar guidance angle obtained between Group I and Group A. The mean value of the difference between the condylar guidance values obtained using Group A were compared with the values obtained with Group I on the right side was found to be 12.03 and difference between them was found to be highly significant with the P value of >0.001. On the left side was found to be 11.74 and difference between them was found to be highly significant with the P value >0.001. The comparison between the same two groups, using averages of the values on the right and left side was found to be – 0.72 and difference between them was found to be insignificant with the P value of 0.086. Concluding, there is statistically high significant difference between the condylar guidance values between Group I and Group A with lower values in Group A. TABLE 5: The above table shows the intergroup comparison of condylar guidance angle between Group I and Group B. The mean value of the difference between the condylar guidance values obtained using Group B were compared with the values obtained with Group I on the right side was found to be 10.70 and difference between them was found to be highly significant with the P value of >0.001. On the left side was found to be 10.81 and difference between them was found to be highly significant with the P value >0.001. The comparison between the same two groups, using averages of the values on the right and left side was found to be – 0.76 and difference between them was found to be insignificant with the P value of 0.317. Thus, there is statistically significant difference between the condylar guidance values between both groups with lower values in Group B method. TABLE 6: The above table shows the intergroup comparison of condylar guidance angle between Group I and Group C. The mean value of the difference between the condylar guidance values obtained using Group C were compared with the values obtained with Group I on the right side was found to be 8.86 and difference between them was found to be highly significant with the P value of > 0.001. On the left side was found to be 9.36 and difference between them was found to be highly significant with the P value > 0.001. The comparison between the same two groups of Group C using averages of the values on the right and left side was found to be – 0.36 and difference between them was found to be insignificant with the P value of 0.706 There is statistically significant difference between the condylar guidance values between both groups with lower values in Group C method. TABLE 7:

The above table shows the intergroup comparison of condylar guidance angle between Group A and Group B. The mean value of the difference between the condylar guidance values obtained using Group A were compared with the values obtained with Group B on the right side was found to be -1.33 and difference between them was found to be highly significant with the P value of 0.065. On the left side was found to be – 0.93 and difference between them was found to be non-significant with the P value 0.262. Therefore, there is no statistically significant difference between the condylar guidance values between both groups ($p<0.05$) TABLE 8: The above table shows the intergroup comparison of condylar guidance angle between Group A and Group C. The mean value of the difference between the condylar guidance values obtained using Group A were compared with the values obtained with Group C on the right side was found to be – 3.17 and difference between them was found to be highly significant with the P value of 0.001. On the left side was found to be – 2.38 and

difference between them was found to be significant with the P value of 0.014. Thus, there is statistically significant difference between the condylar guidance values between both groups in Group 1 and Group 2 with lower values in Group A ($p>0.05$). TABLE 9: The above table shows the intergroup comparison of condylar guidance angle between Group B and Group C The mean value of the difference between the condylar guidance values obtained using Group B were compared with the values obtained with Group C on the right side was found to be –1.85 and difference between them was found to be highly significant with the P value of 0.422. On the left side was found to be -1.45 and difference between them was found to be highly significant with the P value 0.282.Therefore, there is no statistically significant difference between the condylar guidance values between both groups.

DISCUSSION

The successful prosthodontic procedure results most likely in cases when 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.(79) Therefore, usefulness of articulator is unfaltering whether the required restoration is removable or fixed, single unit or a complex restoration, for recording of this condylar guidance.

The ideal goal of an articulator is to fabricate the restoration that can be inserted into the mouth without the need for chair side occlusal adjustments.(80) The face-bow transfer and the centric, lateral and protrusive jaw relation records together establish the simulation of the mandibular movements on the articulator.(81) (82)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.(83)(84)

If articulator settings do not match the patient's individual parameters, the developed cusps in the restoration maybe of inaccurate occlusal morphology thus hampering the function.(85)

The accuracy with which certain mandibular movements are simulated depends also on the contour of condylar path and adjustability of the articulator. The study conducted by POSSELT concluded that individual registration of condyle path must be recorded as mean value requires adjustments of 20 – 40 degrees that will affect the restoration inadvertently.(7)(18)

The condylar elements of the articulator glide in a slot, which can be adjusted to provide a rectilinear simulation of the curvilinear condylar path.(86) The sagittal condylar guidance inclination, which is programmed with the protrusive interocclusal record, is measured in degrees, relative to the third point of reference. This angle is relative measure and not an absolute value, which is related to the angle of the eminence of the temporomandibular joint.(79) Condylar guidance on articulators achieved through programming is an approximate duplication of the condylar path of the patients.(87)

There are some prerequisites which need to be achieved prior obtaining of protrusive interocclusal including, complete stability of the recording bases, a systematic face bow transfer, tentative jaw relation and a good centric relation record.(88)

According to Weinberg the several anterior point of reference used in various face-bows may change the occlusal plane by ±16mm and this has no effect on centric occlusion.Thus the chances of the error made by face-bow registration could be eliminated in the study.(89)

Moreover in agreement with Gonzalez and Kingery the axis orbital plane is the minimum variable and most reliable and best for face-bow registration as it is easy to find and reproducible.(90) Thereby, in our case orbitale is the reference point corresponding to the face bow.

In our case Lucia jig(44) was used for guiding of the mandible in centric relation position and it was obtained with the Jet bite (polyvinyl siloxane) material because the elastomers as interocclusal recording materials consistently yielded least errors among the different materials studied and are found to be reliable recording materials.(91)

The objective of a good centric relation record is to relate the mandible to the maxillae such that there could be no fulcrum on the teeth or periodontal ligament but only in the temporomandibular joints. This is a mechanical necessity which has biologic dependability. Centric relation is still the final solution for a reorganized approach in occlusion.

Records are used for transferring maxillomandibular relations from the patients to the articulator are of three general classes. It may be either directly by the hinge axis records and pantographic records to the articulator or indirectly by the interocclusal records(92) transferred to the articulator or by radiographic methods.(93)

Also, comparative studies of sagittal condylar inclination values determined using intraoral protrusive interocclusal records to those using various extra oral methods of tracing the condylar path concluded that extra oral tracing methods gave higher values with less variation than the intraoral methods. Among the extra oral methods, studies showed that electronic pantography provided measurements more accurate and reproducible.(94)(95)

This clinical study is oriented(37)(remove) towards comparing three 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. All the cases were selected in the age group of 20 to 40 years. This age group was selected as the craniofacial growth is accomplished by this age.

The left and right condylar guidance angles were measured of all subjects using these four methods. The difference attained between the left and right measurements from all methods was statistically insignificant. Conversely, there is evidence in the literature disagreeing to the results of this study.(96)

Studies conducted by GHERIANI,(32) Winstanley, ZAMACONA (33)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 tempo-mandibular joint disorder. But Cases with a full complement of dentition, with Angle’s class I molar relation and absence of signs and symptoms of temporomandibular joint disorders were selected in our study.

Craddock(48) believed that it was important to keep the distance of protrusion the same because the sagittal condylar angle changes with the amount of protrusion. Also he believed that it is essential to maintain same amount of protrusion as Condylar Guidance varies with amount of protrusion. So the amount of protrusion was kept same in the present study.

Literature indicates the use of lateral cephalograms, panoramic radiograph, tomographs, digital CT scan used for recording condylar guidance.(58)(19) When Cephalometric technique was used to find out the condylar guidance values there was a difference in readings for the same patient even when a standardized procedure was followed (17). Magnetic resonance imaging has also been used to find out the articular eminence morphology and inclination in the past. At recent days the advent of digital CBCT scans has ruled out these.

DAVIS ET AL(97) 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 than the earlier.

The use of conventional radiographic techniques, such as orthopantography (OPG) and computerized tomography (CT), may indicate whether the condyle is in the CR position. CT provides three-dimensional images but with high radiation, whereas OPG overcomes the radiation exposure, but limited to bi-dimensional images. Evaluating the condylar position by cone beam computed tomography (CBCT) has become an essential tool to obtain three-dimensional images. The capture of the area of interest with rapid scan time minimizes the exposure of adjacent structures, while exposing the patient to low radiation doses in comparison with conventional CT.

Perhaps the most important advantage of CBCT is that it provides unique images demonstrating features in 3D(98) that intraoral, panoramic, and Cephalometric images cannot. Cursor driven measurement algorithms provide the clinician with an interactive capability of real time dimensional assessment. On screen measurements provide dimensions free from distortion and magnification 20,50.(99)

CBCT consists of extra benefits like great picture quality, utilizing a smaller field of view shorter check time, compatibility with other radiographic arrangements for picture export and simplicity of establishment of minimal units in a general clinical setting. These preferences of CBCT could be used to discover the condylar position amid dynamic registration in edentulous and dentulous patients and precisely find the position of condyle.

Among the other radiographic techniques in use today CBCT is gaining increasing popularity in assessing normal condylar morphology,(100) craniofacial anomalies, and mandibular condyle bone lesions(101) in the field of implantology and for endodontic applications. There are some limitations of the radiographic method concerning distortion, head and reference plane orientation and difficulty in distinguishing the articular eminence outline from the zygomatic arch. The protrusive occlusal record and CBCT imaging method were found to be comparable in this study. However BREWKA, compared condylar guidance values obtained by pantographic tracings with lateral cephalograms and stated that radiographic method and clinical method yield highly diverse value.(102)

Also, Christensen and Slabbert(30) in a 1978 review has stated that "no radio graphically determined sagittal condylar guidance angle coincided with that obtained with the use of intra-oral records. The radio graphically determined angle showed a greater mean value than that determined by intra-oral records."

According to MIRIAN AIKO NAKANE MATSUMOTO ET AL there was a definite correlation between depth of glenoid fossa and inclination of the posterior slope of the articular eminence.(103) This reliability in radiographic landmarks is a useful parameter used in our study.

KRISHNA PRASAD D,(63) put forward that panoramic radiographic tracings maybe used to set sagittal condylar guidance values. This study is in accordance with our study where CBCT was used to obtain the same value.

After maxillary cast were mounted using facebow and mandibular cast was mounted with the help of centric relation record, Protrusive record was attained with the help of three different methods. Despite accurate registration methods, chances of error arise during laboratory procedures because of instability of materials and changes during their setting or polymerization.(45)

S. C. MULLIK in 1981 conducted investigation regarding several interocclusal materials. He concluded Aluwax was the most variable and unreliable of all materials. Superbite constantly lead to open cast relationships. While, the five elastomers reliably resulted in the least amount of errors.(83)

Here, in first method protrusive record was obtained using Alu-Wax. The advantage of this wax is that it is dimensionally stable, does not shrink or distort easily. When it is heated at 55° C it turns in to soft less than 1 minute. This wax adapts well to details and sets by water or room temperature around 27°C. Patient was asked to bite on Alu-wax bite registration material on edge to edge relation. It was than reinforced with zinc-oxide eugenol paste for accurate details and record was made.(104) The reliability of wax records for protrusive jaw relation has been questioned as condylar guidance adjusted according to three separate records will yield three different results.(48) Moreover, if the patient moves the jaw laterally in protrusive movement, the registration of the condyle path will be changed.(25) . The values on the right side, left side and the average of both sides were compared.

In second clinical method a custom-made jig was fabricated to guide the mandible prior to obtaining protrusive interocclusal record. The use of an anterior jig provides the desired amount of interocclusal space for the registration material and practically eliminates the risk of mandibular deviation due to muscle fatigue.(2)

The Jet bite (polyvinyl siloxane) was used as an interocclusal record material in this method. The advantage is that elastomers are easy to manipulate and do not require a carrier when used for interocclusal recording. They offer a little or no resistance to closure; set to a consistency the makes those easy to trim without distortion and accurately reproduce the tooth details.(105) The polyvinylsiloxane (addition silicones) exhibited the least amount of

distortion when compared with other elastomeric impression materials. Accuracy, dimensional stability after setting, minimal resistance to closure and ease of manipulation are the main advantages of addition silicones as interocclusal record materials.(106)

Looking at the variation in condylar guidance by the interocclusal record method, we have used average condylar guide setting taken from mean published values.

Among the clinical methods, values obtained from the jig method exhibited medium level of association with those obtained from the tracer and strong level of association with those obtained from wax method.

In next method, Intraoral tracer was used to obtain protrusive interocclusal record. Here Gothic arch tracing was done to obtain jaw position. This offers the advantage of capturing VDO and CR in an easy to use method for practitioners. This is preferred technique of gaining consistent positions of the mandible in motion. (107) than a protrusive record was obtained using Jet-Bite (Polyvinyl Siloxane) elastomeric impression material and articulators were programmed using all three interocclusal records.

After programming the articulators total 30 horizontal condylar guidance readings were obtained by protrusive records (right and left side) with each articulator. The mean condylar guidance angle value obtained by CBCT in right side was 39.63 and for left side 40.50. Mean HCG value obtained by wax interocclusal record was 27.43 for right side and 28.75 for left side. Mean Condylar guidance values were recorded 28.93 for right side and 29.69 for left side using anterior jig method. The mean sagittal condylar guidance values obtained from intraoral tracer method was on 30.77 the right and 31.14 left side.

Condylar guidance values obtained from wax interocclusal record and jig method exhibited high level of significance when compared with CBCT, while intra-oral method revealed lesser significant difference. Also, there was no statistical significant difference found when right and left sides were compared from all four 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. But when clinical methods were compared with each other they show moderate to high amount of association. 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

The results of this study must to be viewed by keeping in mind it's definite characteristics and features. Semi adjustable articulators were used in this study for receiving the records from the clinical methods. Their capabilities are limited to accurately simulate the TMJs, the jaws and their movements on account of the fixed inter condylar distances and straight condylar

pathways that are indicated to cause errors principally in the horizontal and frontal plane and arbitrary hinge axis used to transfer the facebow record to the articulator.

This might be the reason for discrepancy between the CBCT and rest of the clinical methods. It must be distinguished that CBCT scans are superior in accuracy and standardization than all of the other methods.(108) The availability for type of CBCT scan utilized for the study may be difficult for majority of dentists, particularly those who are practicing in semi urban and rural areas. Future studies should probe the potential effect that TMJ disorders might have on clinical methods. Although presence of these factors in this study it yet exemplifies an important step advancing in the direction of improving precision of condylar guidance angle determination in prosthodontic rehabilitation. It may be valuable to utilize CBCT scans for condylar measurements especially for complex oral rehabilitations. Still, further studies with much larger sample sizes are needed with Condylar Guidance angle values to confirm the present results.

SUMMARY AND CONCLUSION

This present clinical study was conducted to evaluate the relationship between the condylar guidance values obtained by Cone Beam Computed Tomography and thee different clinical methods using Alu Wax, Intra Oral Tracer and Lucia Jig. 30 dentulous subjects with Angle's class I malocclusion were selected for this study. It is the committed task of a Prosthodontist to individualize the treatment for every single patient. Each single detail should be given meticulous attention to attain predictable success in this field. If not the results are more likely to be unsatisfactory causing frustration and loss of confidence in both doctor and patient. Achievement of complex prosthodontic methods is improved by precise recreation of the condylar path of patient on an articulator. Condylar guidance a fixed and indisputable factor being first determinant of occlusion. It remains a dictum to be reproduced regardless of type of restoration planned. In clinical general practice, the method most frequently practiced to determine the horizontal condylar inclination is by recording protrusive interocclusal record. This record is than utilized for programming of the articulator and obtain condylar guidance value. This method may result in restoration with characteristic inaccuracies if not handled appropriately. Amongst, various radiographic methods used, the method of evaluating condylar guidance through CBCT image offers unparalleled opportunities to eliminate errors that may follow because of mishandling of materials and avoiding extensive time consumptive procedures. Furthermore, it benefits by providing multiplanar sections without any superimposition. The differences between the Condylar Guidance values of Cl Radiographic Condylar Guidance from CBCT were statistically Insignificant showing a high level of reproducibility. The intricated technological procedures, the time consumed for the patient and the operator, costly repairs during faulty procedures, the requisite of a high precision instrument and the knowledge or skill of the operator to accomplish the work is all strenuous and warrants the use of clinical methods particularly. On the contrary the Radiographic method through CBCT, the values obtained were those of 3D anatomic representation, with high thoroughness, time effective with minimal stress from the operator and to the subject. The highly time consuming steps required in training the patient to perfect Centric position and tracing of the Condylar path for many days, can be nullified when HCG is recorded by

CBCT. Condylar guidance values obtained from wax interocclusal record and jig method exhibited high level of significance when compared with CBCT, while intra-oral method revealed lesser significant difference. And there was no statistical significant difference found when right and left sides were compared from all four methods. Further studies are recommended in a large sample size that our study would be validated. The results were obtained and subjected to statistical analysis. From the analysis following conclusions are inferred: • The condylar Guidance angle values obtained from Right and Left side from radiographic as well as clinical method can be comparable to a limited degree only. • Cone Beam Computed Tomography presents with highest mean condylar guidance values when compared with all three clinical methods. • Condylar Guidance values obtained from all clinical methods are comparable with each other. As per EDWARD TELLER'S words "THE SCIENCE OF TODAY IS TECHNOLOGY OF TOMORROW" incorporation of digital technologies like CBCT will revolutionize the future of Prosthodontic restorations and move us Avant - garde

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