A COMPARATIVE STUDY OF HORIZONTAL CONDYLAR ANGLE VALUE OF THREE DIFFERENT CONCEPTS THROUGH COMPUTERISED DIGITAL CEPHALOMETRIC TRACING

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In partial fulfillment of the requirement for the degree of

MASTER OF DENTAL SURGERY

(BRANCH I)
(PROSTHODONTICS AND CROWN & BRIDGE)

2010-2013

CERTIFICATE

This is to certify that the dissertation titled **"A COMPARATIVE STUDY OF HORIZONTAL CONDYLAR ANGLE VALUE OF THREE DIFFERENT CONCEPTS THROUGH COMPUTERISED DIGITAL CEPHALOMETRIC TRACING "** is a bonafide record of work carried out by **Dr. Pallavi Vashisht**, during the period of 2010-2013. This dissertation is submitted in partial fulfillment, for the degree of **Master of Dental Surgery** awarded by **Tamil Nadu Dr. MGR Medical University, Chennai** in the branch of **Prosthodontics and Crown and Bridge (Branch-I)**.

It has not been submitted partially or fully for the award of any other degree or diploma.

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DECLARATION

I**, Dr**. **PALLAVI VASHISHT**, do hereby declare that the dissertation titled **"A COMPARATIVE STUDY OF HORIZONTAL CONDYLAR ANGLE VALUE OF THREE DIFFERENT CONCEPTS THROUGH COMPUTERISED DIGITAL CEPHALOMETRIC TRACING"** 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 this study in partial fulfillment of the requirements for the degree of **Master of Dental Surgery** in the specialty of **Prosthodontics and Crown & Bridge (Branch I)** during the course period 2010-2013 under the conceptualization and guidance of my dissertation Guide **Dr. C. THULASINGAM, M.D.S.**

I declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission from the Tamil Nadu Government Dental College & Hospital.

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Signature of the HOD

Signature of the Head of the Institution

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And

Dr. C. THULASINGAM MDS, aged 57 years working as **Professor and Head** in the Department of Prosthodontics at the college, having residence address at No. 10/35, VENKIER STREET, MINT.P.O, ChennaI-600079 (herein after referred to as the Principal investigator')

And

Dr. PALLAVI VASHISHT, aged 26 years currently studying as **Post Graduate Student** in the Department of Prosthodontics, Tamil Nadu Government Dental College and Hospital, Chennai-03 (herein after referred to as the 'PG Student and co-investigator').

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College represented by its **Principal** **PG Student**

Witnesses **Student Guide**

1.

2.

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I am extremely grateful to my esteemed guide **Dr. C. THULASINGAM,** M.D.S, Professor and Head, Department of Prosthodontics, Tamil Nadu Govt. Dental College and hospital, for his filial attitude, valuable guidance, encouragement, lending me his precious time and never ending patience without which this study would not have been possible. I also thank him for the valuable guidance he has given me throughout my post-graduation.

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ABSTRACT

BACKGROUND:

Condylar path is a path travelled by the mandibular condyle in the temporomandibular joint during various mandibular movements.

The condyle will descend along the slope of articular eminence when it will move from centric relation to perform excursive movements. The angle at which the condyle moves from a horizontal reference plane is called Horizontal condylar angle. This condylar path inclination must be determined in relation to a horizontal plane of reference.

AIM:

To evaluate the Horizontal Condylar angle value using Computerised Digital Cephalometric Tracing.

OBJECTIVES:

1) To assess the Horizontal Condylar angle established by FENN, SHILLINGBURG and FRANKFORT horizontal plane using Computerised Digital Cephalometric tracing.
2) To compare these values obtained, with that of clinically established Horizontal Condylar angle

METHODS:

This clinical study was performed on 30 dentate individuals and horizontal condylar angle was measured clinically from these subjects by using Semi-Adjustable Arcon type articulator and these values were compared with the three values obtained by lateral cephalogram to find out which value comes closest to clinically established horizontal condylar angle value.

RESULTS:

When both anterior and reference posterior reference points were used to trace the condylar path, it was observed that there was significant difference between the radiographic horizontal condylar angle values and clinically established horizontal condylar angle value.

When only posterior reference point was used to trace condylar path, there was no significant difference between the radiographic value of Ala-tragus line (camper's plane) and clinically established horizontal condylar angle value.

INTERPRETATION AND CONCLUSION:

Within the limitations of this study, it was concluded that the radiographic method can be used successfully as an adjunct to clinical methods of obtaining horizontal condylar inclination using Ala-tragus line (camper's plane).

INTRODUCTION

It is a well-accepted matter in the field of dentistry that three vital factors which influence the mandibular movements are namely, Incisal guidance, Condylar guidance and overall neuromuscular control. According to GPT-8[1], Condylar Guidance is defined as a mandibular guidance generated by the condyle and articular disc transversing the contour of the glenoid fossae. It depends on the steepness of articular eminence. It is the first factor of occlusion. It is obtained from the patient and cannot be changed.

Factors that show major impact on the occlusal morphology of posterior teeth are the protrusive condylar path inclination and mandibular lateral translation. The inclination of the condylar path during protrusive movement can vary from steep to shallow in different patients. Studies by Zamacona et al[2], Lundeen and Wirth[3], Woelfel et al[4], Hobo and Mochizuki[5], Preti et al[6], and dos Santos et al[7] found variations in condylar guidance angles ranging from 5 to 55◦, average angle being 30.4 degrees.

If the protrusive inclination is steep, the cusp height may be longer, with more pronounced anterior guidance. However, if the inclination is shallow, the cusp height must be shorter, with less pronounced anterior guidance. Therefore correct recording of condylar guidance and its accurate transfer to semi-adjustable articulator determines the success of restorative procedure.

Condylar inclination affects the angulation of the cusps of the teeth in both protrusive and lateral excursive movements[8]. A steep condylar inclination allows steeper inclines on the cusps of the teeth, while a less steep inclination demands a flatter occlusal surface with shallower cuspal inclination. If the articulator condylar path is set at a steeper angle than that which exists in the patient, the resulting restoration will have cusps that have overly steep inclines. A positive error exists and an occlusal interference may result during a protrusive excursion and/ or during a

lateral excursion at the time of mastication. Condylar path is a path traveled by the mandibular condyle in the temporomandibular joint during various mandibular movements.

The condyle will descend along the slope of articular eminence when it will move from centric relation to perform excursive movements. The angle at which the condyle moves from a horizontal reference plane is called Horizontal condylar angle.

There are three classes of records for transferring maxillomandibular relations from patient to articulator.(1) the method based on Christensen phenomenon in which the interocclusal records are made and then horizontal condylar angle is calculated in the articulator, commonly advocated in dentate individuals (2) A graphic method in which the condylar path is recorded on a flag with tracing paper by means of a facebow (pantographic tracing) and correct adaptation of recording is facilitated by an intraoral bearing device, and the articulator is programmed accordingly.

The angle of the condylar path is obtained by measuring the tangent to the functional portion of the tracing. Pantographic tracing method although quite accurate, is quite cumbersome to perform in clinical situations and not feasible in all the patients. Both orthopantogram and lateral cephalogram can be used to measure condylar angle radiographically, as the condyle transverses the slope of articular eminence during protrusion and radiograph made at edge to edge position of anterior teeth.

This condylar path inclination must be determined in relation to a horizontal plane of reference, but the values obtained cannot be directly compared to the inclinations measured in relation to Frankfurt plane or Axis-orbital plane. In the literature, there is no uniform consensus regarding the horizontal reference plane which is capable of accurately determining condylar guidance of patient.

H.R.B Fenn[9] recommends occlusal plane parallel to Ala-tragus line (Campers line) as horizontal reference plane whereas Shillingburg[10] recommends a plane formed by point 43mm above incisal edge of maxillary lateral incisor to superior margin of external auditory meatus to measure condylar angle.

The purpose of this study is to evaluate the horizontal condylar angle using Computerised Digital Cephalometric tracing and to assess the effectiveness of three different horizontal reference planes described by Fenn, Shillingburg and Frankfort horizontal plane and to compare it with clinically established condylar angle value.

AIM
AND
OBJECTIVES

Aim of the study:

To evaluate the Horizontal Condylar angle value using Computerised Digital Cephalometric Tracing.

Objectives of the study:

1) To assess the Horizontal Condylar angle established by FENN using Computerised Digital Cephalometric tracing.
2) To assess the Horizontal Condylar angle established by SHILLINGBURG using Computerised Digital Cephalometric tracing.
3) To assess the Horizontal Condylar angle established by FRANKFORT horizontal plane using Computerised Digital Cephalometric tracing.
4) To compare these values obtained, with that of clinically established Horizontal Condylar angle.

REVIEW OF LITERATURE

Boos R H[11] **(1951)** conducted a study to measure condylar angle by Roentgenograph. A metal form was devised which would fit onto an occlusion rim or onto natural teeth which may be present. Two steel rods, l/16 inch in diameter, are attached on either side of the metal form. The rods are arranged so that they may be placed at the side & of the face below the temporo mandibular joint. They are U-shaped with straight end segments. They are attached to the metal form so that they may be set at the Fox plane. The Fox plane extends from the tragus of the ear to the ala of the nose and provides an anatomic landmark on the face. The rod on the side of the head which is being x-rayed is placed in position on the Fox plane, and the opposite side is dropped down.

X ray was obtained, the developed film should show the steel rod as an opaque line, and the temporomandibular joint with the angle of the articular tubercle of the fossa. The measurement of the angle of the condylar path is made in degrees on the developed x-ray film. (Boos R H: condylar path by roentgenograph. J. Prosthet Dent 1951;1:387-92)

Cohen R[12] **(1956)** conducted a study to find out the effect on the condylar guidance when the shape of the anterior guidance is altered and when the vertical dimension is increased. Gnathograph and Gnathoscope was used to record and duplicate the paths of movement of the condyle. This experiment concluded that (1) within the range of opening of the vertical dimension used, there is no change in the paths of condylar movement regardless of the vertical dimension or the shape of the anterior guidance for the mandible (2) within the range of opening of the vertical dimension used, there is conclusive evidence of the existence of the hinge action of

the mandible. (Cohen R: The relationship of anterior guidance to condylar guidance in mandibular movement, J.Pros.Dent.1956;6:758-67)

Issacson D[13] **(1958)** conducted a study to record Bennett movement with a clinical instrument Gnathograph in 26 patients.. The stylus points attached to Gnathograph made tracing of various mandibular movements on the glass slides. Study demonstrated average Bennett angle ranges in age from 19 to 60 years was 12.33 degrees and range of bennett path angulation was zero degree to 35 degrees. (Issacson D: A clinical study of the Bennett movement J.Pros.Dent.1958;8:641-49)

Issacson D[14] **(1959)** designed a study to measure the angle and radius of the condyle path. He used orbital plane as horizontal reference plane. complete movements of mandible in sagittal plane were traced on glass slides by gnathograph styli and mounted on gnathoscope, and was adjusted to follow path of tracing. He concluded that the condyle path angle ranged from a minimum of 22 to a maximum of 53 degrees. The age and sex of patient had little bearing on the size of condyle path angle, which was determined as approx. 35 degrees. (Issacson D: A clinical study of condyle path, J. Pros. Dent.1959; 9:927-35).

Posselt U and Skytting B[15] **(1960)** conducted a study to (1) to assess any variations of sagittal condyle path inclination as obtained by graphic recording and (2) to compare them with the results obtained from the intraoral wax record method. He concluded that the error of the graphic method was found to be about twice that of the intraoral wax method. It is probable that the error is mainly caused by the difficulty in drawing a tangent to the curved condylar path rather than to the recording itself. (Possel and Skytting B: Registration of the condyle path inclination: variation using the Gysi technique, J.Pros.Dent.1960;10:243-47)

Olsson A and Posselt U[16] **(1961)** advocated condylar path inclination measured in relation to one horizontal reference plane cannot be compared directly to inclinations measured in relation to Frankfort plane or its near equivalent, the Axis orbital plane. He compared nasion sella line, Frankfort plane, campers line and occlusal line. Average angles between these planes were calculated on lateral cephalogram and ranked according to magnitude of variation. (Olsson A and Posselt U.: Relarionship of various skull reference lines, J. Pros.Den 1961;11:1045-4)

P**osselt U and Nevstedt P**[17] **(1961)** carried an investigation to determine the frequency of condyle path inclinations, with the error of measurement found with the dentatus articulator as a background in 101 patients. Protrusive bite registration was obtained and dentatus articulator was programmed to obtain condylar inclination and it varied between 0 and 60 degrees. The greatest frequency was around 40-50 degrees as related to Frankfort plane. (Posselt U and Nevstedt P: Registration of the condyle path inclination by intraoral wax records-its practical value,J.Pros.Den 1961;11:43-47)

Ismail YH and Bowman JF[18] **(1968**) conducted a study to compare the occlusion plane established prosthetically with the one that existed before extraction of the teeth in each subject. Lateral Cephalograms were taken for 20 subjects with their teeth in centric occlusion. Following extraction of teeth, denture construction was started using a standardized technique. The occlusal plane was tentatively determined. The height of the maxillary occlusion rim in the anterior region was placed 1-3mm below the resting upper lip and parallel to the Ala-tragus line posteriorly.

He told camper's line is a anthropologic measurement projected to the living head as a line passing from the ala of the nose to the centre of the tragus of the external auditory meatus. During try in,the occlusal plane was modified anteriorly to

fulfill esthetic requirements and posteriorly middle third of retromolar pad was used as reference point for orienting the occlusal surface of second molars. After the complete dentures were placed, another set of lateral cephalogram were made. (Ismail YH and Bowman JF: Position of occlusal plane in the natural and artificial teeth. J Pros.Dent 1968;20:407-11)

Pipko D[19] **(1969)** conducted a study on 10 subjects to check the validity of the concept of curvilinear condylar path movement. The condylar path curvature was recorded by a radiographic method, by the Ney technique, by pantographic tracings and by the electronic methods of instrumentation. He concluded that condylar path movement recordings are more curvilinear than rectilinear in nature, and positive correlation exists among the methods used for determining the specific condylar radius path curvature. (Pipko D: Evaluation of validity of condylar path curvature. J. Pros.Den 1969;21:626-38)

Lee R[20] **(1969)** conducted a study to obtain a scientifically accurate and practical method of duplicating jaw movements. A new method and apparatus was designed to record right lateral, left lateral and protrusive movements. All jaw movements were recorded directly from the patient in the form of engravings in solid plastic. The paths of these points are represented by groves in the plastic blocks at the tips of their respective recording styli. These engravings were related to hinge axis. (Lee R: Jaw movements engraved in solid plastic for articulator controls,Part I. Recording apparatus J.Pros.Dent 1969;22:209-24)

Corbett et al[21] **(1971)** designed a study to determine the relationship between the form of articular eminence and their corresponding condylar paths. A lateral cephalogram showing the relation of the condylar head to articular eminence at selected protrusive positions was taken,and compared with gnathologic recordings of

the movement of the condyles in mandibular protrusions. He concluded that gnathologically recorded protrusive condylar paths and radiographically derived protrusive condylar paths were found to be same and in protrusion, the condylar head of mandible follows closely the anatomical form of the articular eminence. (Corbett et al: The relation of the condylar path to the articular eminence in mandibular protrusion, J.Pros. Den1971;41:286-92)

Rothstein R[22] **(1972)** described prerequisites of interocclusal protrusive record and method to adjust the condylar elements on the articulator using this protrusive interocclusal records. (Rothstein R: Condylar guidance settings on articulator from protrusive records. J.Pros.Den 1972;28:334-36)

Ingervall B[23] **(1972**) studied the movements of the mandibular condyles in the sagittal plane and the inclinations of the condyle path with a roentgencephalometric method in children aged 7 and 10 years and in adults.. In both children and adults, the condyles moved,on the average, forwards and downwards from intercuspal position to postural position. The inferior movement was positively correlated with the inclination of the condyle path recorded between intercuspal position and 5mm protruded position. The inferior movement of the condyle from intercuspal position to protruded position and to maximal opening increased as did the inclination of the condyle path with age.

No correlation was found between the inclination of the condyle path and the inclination of the incisal path in children or in adults. No correlation was found between the inclination of the condyle path and the number of tooth contacts on the working and non working sides. (Ingervall B: range of sagittal movement of the mandibular condyles and inclination of the condyle path in children and adults. Acta odont scand 1972;30:67-87)

Spartley MH [24]**(1980)** in his article demonstrated that it runs from the center of the Ala to the center of the tragus. (Spartley MH: A simplified technique for determining the occlusal plane in full denture construction. J Oral Rehab 1980;7:31-33)

Preti G,Scotti R, Bruscagin C and Carossa S[6]**(1982)** conducted a research to study the statistical investigation of the angular values of the condylar sagittal pathway obtained with the Graphic record method and to verify its repeatability. Gerber's graphic registration instrument was used to obtain protrusive graphic registration and a tangent is drawn to each tracing to express the angular value of condylar sagittal pathway in 309 subjects. He concluded that the data when was subjected to statistical analysis gave median angular value of the sagittal pathway equals to 33 degrees and showed a greater median value dispersion. A low error index was obtained in tracing the tangent to the CSP tracing with Gerber registration method. (Preti G,Scotti R, Bruscagin C and Carossa S: A clinical study of graphic registration of the condyle path inclination. J.Pros.Dent 1982;48:461-66)

Fattore et al[25] **(1984)** conducted a study to determine the clinical accuracy of waxes, zinc oxide-eugenol, and polyether dental materials for recording interarch relationships. Interocclusal records of 31 patients were placed on an arcon articulator with an arbitrary face-bow to measure the magnitude and direction of distortion. He concluded that 1) Polyether interocclusal recording medium without a carrier was the most accurate. 2) Polyether and zinc oxide-eugenol pastes with carriers were the next most accurate recording mediums, but they required a disciplined technique. 3) Recording waxes were consistently unreliable. 4) Distortion occurred more frequently in a vertical direction, followed by an anteroposterior direction. (Fattore et al: clinical evaluation of accuracy of interocclusal recording material. J.Prosthet Dent 1984;51:152-57)

El-Gheriani AS and Winstanley RB[26] (1989) carried out study to determine the accuracy of different methods of measuring condylar inclinations from graphical recordings of condylar paths. Thirty subjects made protrusive mandibular movements while condylar inclination was recorded on a graph paper card. This method proved to be too variable. The spline curve fitting technique was shown to be accurate, but its use clinically may prove complex. The mathematical method was more practical and overcame variability of the tangent method. (El-Gheriani AS and Winstanley RB: Graphic tracings of condylar paths and measurements of condylar angles. J. Pros. Dent1989;61:77-87)

Muller J, Gotz G, Horz W and Kraft E[27] (1990) conducted a study to determine the three-dimensional errors in mounting casts affected by the interocclusal recording materials. Eight materials and/or combinations of two different materials were selected for this study (1) impression plaster, (2) Palavit G self-curing resin, (3) Palavit G resin combined with Temp-Bond zinc oxide-eugenol paste, (4) Beauty pink (X-hard) wax, (5) Beauty pink wax combined with Temp Bond material, (6) impression compound, (7) impression compound combined with Temp Bond material, and (8) polyether. The results indicated that all the materials induced asymmetric deviations of the condyles after each storage period. Impression plaster was the most accurate and dimensionally stable material; polyether was the second most accurate material, but it must be used within 6 hours. (Muller J,Gotz G,Horz W and Kraft E: Study of the accuracy of different recording materials. J Prosthet Dent 1990;83:41-6.)

Muller J,Gotz G,Horz W and Kraft E[28] (1990) conducted a study to analyze the accuracy of transferring jaw relations with recording materials and the derived casts. A specific measuring system was designed to determine three-dimensional deviations of the condyles of an articulator. Four interocclusal recording materials were analyzed after various storage periods. Recording materials used were plaster,

compound, wax and zinc oxide and eugenol. He concluded that the greatest three-dimensional deviations were evident in plaster recordings. Impression compound was the most accurate of the materials tested, but deviations to 300 pm need review. (Muller J,Gotz G,Horz W and Kraft E: An experimental study on the influence of the derived casts on the accuracy of different recording materials. Part 1: Plaster, impression compound, and wax. (J Prosthet Dent1990;63:263-9.1)

Zamacona J, Otaduy Eand Aranda E[2](1992) studied 55 patients making three graphic registrations of the protrusive condylar movement on each side. Three examiners independently used tangential method to measure the angulation relative to the Camper's plane. Range of inclination of condylar path varied from 10 to 62 degrees on the left side, with a mean of 35.75 degrees, while on right side, it was from 23 to 55 degrees,with a mean of 36.6 degrees. He recommended tangential method of measuring inclination on graphic records. (Zamacona J,Otaduy Eand Aranda E: Syudy of the sagittal condylar path in edentulous patients. J.Pros.Dent1992;68:314-17)

Ogawa T, Koyano K and Suetsugu T[29] (1997) conducted a study to reveal the influence of the incisal and condylar guidance on mandibular protrusive movement. The protrusive movements were measured on 54 young adults using a three-dimensional mandibular movements analyzing system. The inclinations of the sagittal path on the incisor, canine, first molar, second molar and condylar points were calculated, and multiple regression analysis was performed to evaluate the influence of the incisal and condylar path on the path of each tooth quantitatively.

The influence of the incisal path on any tooth path was consistently greater than that of the condylar path. The condylar path had a greater influence on the paths of posterior teeth than on the paths of anterior teeth, especially in the female subjects.

(Ogawa T, Koyano K and Suetsugu T: The influence of anterior guidance and condylar guidance on mandibular protrusive movement Journal of oral rehabilitation 1997;24;303-09)

Rudolph, Sinclair, and Coggins[30] **(1998)** Computerized cephalometric analysis currently requires manual identification of landmark locations. This process is time-consuming and limited in accuracy. The purpose of this study was to develop and test a novel method for automatic computer identification of cephalometric landmarks. Spatial spectroscopy (SS) is a computerized method that identifies image structure on the basis of a convolution of the image with a set of filters followed by a decision method using statistical pattern recognition techniques. By this method, characteristic features are used to recognize anatomic structures.

This study compared manual identification on a computer monitor and the SS automatic method for landmark identification on minimum resolution images. Fifteen landmarks were selected on a set of 14 test images. The results showed no statistical difference in mean landmark identification errors between manual identification on the computer display and automatic identification using SS. We conclude that SS shows potential for the automatic detection of landmarks, which is an important step in the development of a completely automatic cephalometric analysis. (Rudolph, Sinclair, and Coggins: Automatic computerized radiographic identification of cephalometric landmarks. (Am J Orthod Dentofacial Ortho1998;113:173-9)

Chen, Chen, Chang, Chen[31] **(2000**) conducted a study to assess landmark identification on digital images in comparison with those obtained from original radiographs. Ten cephalometric radiographs were selected randomly. Seven orthodontic residents identified 19 cephalometric landmarks on both the original radiographs and the digital images. He concluded that In our computerized digital

cephalometric analysis, the differences of landmark location between original cephalometric radiographs and their digital counterparts were statistically significant.

The reliability of landmark identification in digital images was comparable to that in original radiographs except for the points Po, Ar, PNS, and UM. These landmarks with significant lower reliability in digital images should be scrutinized more carefully when we take potential advantages of the use of digital cephalometry. (CHEN, CHEN, CHANG, CHEN: Comparison of Landmark Identification in Traditional Versus Computer-Aided Digital Cephalometry. Angle Orthodontist 2000;50:387-92)

Perillo et al[32] **(2000)** Identification of craniofacial landmarks, particularly condylar anatomy, on the lateral cephalometric radiograph is erratic. They conducted a study to to evaluate the identification of condylion and other cephalometric landmarks commonly used, or thought to be easily identifiable. A lateral cephalograph was taken on each of 34 adult subjects. Five examiners, three orthodontists, a dental radiologist and a second-year orthodontic resident rated the condyle, along with sella (S), nasion (Na), point A (A), infradentale (I), pogonion (Pog) and menton (Me) as identifiable, non-identifiable and interpreted. The left condyle, subject to less magnification than the right condyle because it is closer to the film, was more identifiable than the right condyle, which had the highest rating as non-identifiable. (Perrilo et al: Effect of landmark identification on cephalometric measurements: guidelines for cephalometric analyses. Clin Orthod Res 3, 2000:29–36)

Dos Santos J, Nelson S and Nowlin T[7] **(2003**) conducted a study to compare the condylar inclinations angles found by the use of the wax protrusive record in a Hanau articulator with those found by use of the Whip-Mix Protrusive tracing quick-set recorder in ten patients. He concluded that measurement of the extraoral tracing of the sagittal protrusive condylar path gave higher values with less variation than the

intraoral wax protrusive method. (Dos Santos J,Nelson S and Nowlin T: Comparison of condylar guidance setting obtained from a wax record versus an extraoral tracing: A pilot study. J Pros Dent 2003;89:54-9)

Kucukkeles N, Ozkan H, Demirkaya A and Cilingirturk A[33] (2003) conducted a study to compare measurements between mechanical and computerized axiographs in recording the rotational and translation movements of the mandible in 31 subjects. A single operator obtained 3 separate axiographic tracings of right and left condylar paths for each subject, using repeated opening, closing, protrusive and retrusive movements. Data were collected for both the mechanical and computerized axiographs. He used axio-orbital plane as horizontal reference plane. He concluded that data from the manual and the computerized axiographs are compatible with each other. (Kucukkeles N, Ozkan H, Demirkaya A and Cilingirturk A: compatibility of mechanical and computerized axiographs:A pilot study.J.Pros.Dent 2005;94:190-4)

Chen, Chen, Yao, Chang[34](2004) conducted a study to explore the effects of differences in landmark identification on the values of cephalometric measurements on digitized cephalograms in comparison with those obtained from original radiographs. Ten cephalometric radiographs were randomly selected from orthodontic patients' records. Seven orthodontic residents identified 19 cephalometric landmarks on the original radiographs and digitized images. Twenty-seven cephalometric measurements were computed with a customized computer aided program. To assess the concordance between cephalometric measurements derived from landmarks identified on the original radiographs and those from digitized counterparts, the values of 27 cephalometric measurements were compared to quantify the absolute value of measurement difference and the interobserver errors between these two methods.

He concluded that the measurement differences between the original cephalograms and the digitized images are statistically significant but clinically acceptable. The interobserver errors for cephalometric measurements on our digitized cephalometric images are generally comparable with those on the original radiographs. The results of our study substantiated the benefits of digital cephalometry in terms of the reliability of cephalometric analysis. (CHEN, CHEN, YAO, CHANG: The Effects of Differences in Landmark Identification on the Cephalometric Measurements in Traditional Versus Digitized Cephalometry. Angle Orthod 2004;74:155–161)

Matsumura H, Tsukiyama Y and koyano K[35] (2006) investigated the sagittal condylar path during protrusive and lateral excursions by analysing the actually measured jaw movement data and re-evaluated the setting of the sagittal condylar path inclination in consideration of Fischer's angle. Protrusive and lateral excursions of 10 healthy subjects were measured using a three-dimensional mandibular movement analysing system. Condylar path inclinations at the hinge-axis point and the corresponding external point laterally extending from the condyle were evaluated in the sagittal plane. Fischer's angle was defined as the difference between the sagittal condylar inclinations during protrusive and lateral excursions on the non-working side, by keeping the corresponding horizontal distance from the intercuspal position (ICP) equivalent at the incisal point.

Analysis was performed at three different magnitudes of excursions, where the incisal point was located at 1, 3 and 5 mm away from the ICP. He concluded that The sagittal condylar path inclination was significantly different at the 1-, 3- and 5-mm eccentric mandibular positions from ICP, but not different between the reference point in the centre of the condyle and the corresponding external point laterally extended from the condyle and Fischer's angle was significantly different across the

different magnitudes of excursions, but not different between the two condylar reference points. (Matsumura H, Tsukiyama Y and koyano K: Analysis of sagittal condylar path inclination in consideration of Fischer's angle. Journal of Oral Rehabilitation 2006 33; 514–519)

Gilboa et al[36] **(2008)** conducted a study to determine the correlation between the anatomic shape of the articular eminence and the corresponding panoramic image in dry skulls. Two metal wires were adapted and fixed to the inner and outer surfaces of the articular eminences in 25 human skulls. The inner (thicker) wire was fixed to the middle of the most concave aspect of the articular eminence in an anterior-posterior direction. The outer (thinner) wire was attached to the inferior aspect of the zygomatic arch adjacent to the articular eminence. Panoramic radiographic images were recorded. Impressions were made of the condylar fossae in 25 human dry skulls. Tracings of the incline of the articular eminence on the panoramic radiographs and the impression sections were compared. He concluded that the panoramic radiographic image of the sagittal inclination of the articular eminence consistently replicated the eminence inclinations in the 25 human skulls evaluated. (Gilboa I,Cardash HS,Kaffe I,Gross MD.Condylar guidance:correlation between articular morphology and panoramic radiographic images in dry human skulls. J.Pros.Dent 2008;99:477-82)

Roden-Johnson, English, and Gallerano[37] **(2008)** conducted a study (1) to investigate the variations of landmark identification between film and digital cephalometric tracings, (2) to compare the ability of Quick Ceph 2000(Quick Ceph Systems, Inc, San Diego, Calif) to measure the linear and angular measurements with the hand-traced method, and (3) to compare Quick Ceph 2000 superimpositions to the hand-traced method of superimpositions that are currently accepted by the American Board of Orthodontics. They concluded that there was no difference in the identification of cephalometric landmarks made manually vs digitally with Quick

Ceph 2000 and there was no difference in the regional superimpositions of the mandible, the maxilla, and the cranial base, manually vs digitally with Quick Ceph 2000. (Roden-Johnson, English, and Gallerano: Comparison of hand-traced and computerized cephalograms: Landmark identification, measurement, and superimposition accuracy. (Am J Orthod Dentofacial Orthop 2008;133:556-64)

Yu, Nahm, and Baek[38] **(2008)** conducted a study to compare the reliability of landmark identification with hard-copied film images vs monitor-displayed images from digital lateral cephalograms in 50 orthodontic patients. Identification and digitization of the cephalometric landmarks were performed 3 times at 2-week intervals by 2 observers. The 2 methods of landmark identification were the hard-copied film-based method (HFM) and the monitor-displayed method (MDM) and concluded that there were no statistically significant differences in landmark identification between the 2 methods. (Yu, Nahm, and Baek: Reliability of landmark identification on monitor-displayed lateral cephalometric images. Am J Orthod Dentofacial Orthop 2008;133:790)

Zoghby A,Re J and Perez C[39] **(2009)** conducted a study to find a correlation between the mean Functional Incisal path of the maxillary anterior teeth and the Functional Condylar Path. The tracing of multiple cuts of silicone of maxillary anterior block which were analyzed by an odontometry software program and a mechanical axiography to register the protrusive path bilaterally was performed for 50 dental students. He concluded that the functional incisal path is superior by 9.52 degree as compared to the functional condylar path. (Zoghby A,Re J and Perez C. Functional harmony between the sagittal condylar path inclination and the anterior guidance inclination. J.Stomat.Occ.Med. 2009; 2: 131–136)

Huja, Grubaugh, Rummel, Fields, Beck[40] **(2009)** conducted a study to determine the ability to produce comparable superimpositions using hand tracing and digital methods and to determine if a difference existed between the best-fit cranial base superimposition and S-N superimpositions using the digital method. Sixty-four initial (T1) and final (T2) cephalometric film radiographs were obtained. Cranial base and regional superimpositions were completed independently for each pair of radiographs by either hand tracing and digital methods. They concluded that there are no differences between cranial base and regional superimpositions produced by Dolphin Imaging version 10 and those completed by hand when using the described methods and provides support for transition from hand to digital superimposition methods. (Huja, Grubaugh, Rummel, Fields, Beck: Comparison of Hand-Traced and Computer-Based Cephalometric Superimpositions. Angle Orthod. 2009;79:428–435)

AL quran et al[41] **(2011)** conducted a study to determining the most reliable Ala-tragus line as a guide for the orientation of the occlusal plane in complete denture patients by use of cephalometric landmarks on dentate volunteers. Analysis was made for prosthodontically related craniofacial reference lines and angles of lateral cephalometric radiographs taken for 47 dentate adults. Variables were determined and data were analyzed using SPSS. He concluded that the superior border of the tragus with the inferior border of the Ala of the nose was most accurate in orienting the occlusal plane. (AL quran et al: The Position of the Occlusal Plane in Natural and Artificial Dentitions as Related to Other Craniofacial Planes. J. Prosthodon 2011:19;601-05)

Goyal MK and Goyal S[42] **(2011)** conducted a study to compare evaluation of sagittal condylar values of arcon and non-arcon articulators with cephalometric readings and to determine the amount of discrepancy in sagittal condylar guidance

values between arcon and non-arcon articulators using same protrusive record in twenty subjects.

He concluded that the mean difference in the sagittal condylar guidance values obtained from non arcon and arcon articulators show a low level of reproducibility, and no significant difference found in mean sagittal condylar values obtained from Arcon articulator and cephalometric tracings indicates replication of sagittal condylar guidance value from image of articular eminence. (Goyal MK and Goyal S. A comparative study to evaluate the discrepancy in condylar guidance values between two commercially available arcon and non-arcon articulators: a clinical study IJDR,22;2011)

Hue O[43] **(2011)** conducted a study to determine the condylar form, incline, and movement characteristics during protrusive movement in fully edentulous complete denture wearers. The study included 60 complete denture wearers (aged 58 to 74 years), who received a new set of complete dentures for this study. The patients did not present signs of muscular or articular pain. Protrusive movements were recorded by a SAM electronic axiography system.

He concluded that during protrusive movement in completely edentulous patients, the condylar path patterns were different than conventionally described patterns. In particular, the sinusoidal form was frequently found, and the incline of the condylar slope was low. These factors need to be taken into account during the final occlusal selective grinding for new sets of complete dentures. (Hue O : Condylar Paths during Protrusion in Edentulous Patients Analysis with Electronic Axiography. J. Prosthodon 2011; 20:294-98)

Tannamala P V, Pulagam M, Pottem S and Swapna B[44] **(2012)** conducted a study to compare the sagittal condylar angles set in the Hanau articulator by use of a method of obtaining an intraoral protrusive record to those angles found using a

panoramic radiographic image in ten patients. A panoramic radiographic image of each patient was made with the Frankfurt horizontal plane parallels to the floor of the mouth. He concluded that radiographic values were on average 4 degree greater than the values obtained by protrusive interocclusal record method and the protrusive condylar guidance angles obtained by panoramic radiograph may be used in programming semi-adjustable articulators. (Tannamala P V, Pulagam M, Pottem S and Swapna B: Condylar guidance :correlation between protrusive interocclusal record and Panoramic radiographic image: A pilot study JOP 2012 ;181-84)

References from Text books

Schillingburg H T, Hobo S, Whitsell L D, Jacobi R and Brackett S E[10]: Fundamentals of Fixed Prosthodontics, Third edition. Page 20

The inclination of condylar path during protrusion movement can vary from steep to shallow in different patients. It forms an average angle of 30.4 degrees with the horizontal reference plane (43mm above the maxillary central incisor edge).

Fenn H.R.B, Liddelow K.P and Gimson A.P[9] :Clinical Dental Prosthetics Page 270

By condylar path is meant, the path taken by the head of the condyle when moving up and down the articular eminence. The angle which this makes with the occlusal plane is known as Condylar Angle.

Fenn H.R.B, Liddelow K.P and Gimson A.P[9]: Clinical Dental Prosthetics Page 243-44

When recording the occlusion in the patient's mouth, the occlusal surface of the record blocks are trimmed parallel to the occlusal plane, which is a horizontal plane parallel to the Nasoauricular line which is line joining the lower border of the ala of nose to the external auditory meatus.

Boucher CO[45]: Complete denture prosthodontics—state of the art. J Prosthet Dent 1975;34:372-383

Basker RM, Davenport JC, Tomlin HR[46]: Prosthetic Treatment of the Edentulous Patient (ed 1). London, Macmillan, 1976

Grant AA, Johnson W[47]: An Introduction to Removable Denture Prosthetics. Edinburgh, Churchill Livingstone, 1983

Neill DJ, Naim RI[48]: Complete Denture Prosthetics. Bristol, John Wright Sons, 1975

Among seven of the most famous prosthodontic textbooks, only Boucher's provides a definition., Two other textbooks recommend the concept without defining it, while Basker et al, Grant and Johnson, and Neill and Naim provide only pictorial representation, illustrating Camper's line as extending to a point, not at the superior border, but at the center of the tragus of the ear.

Winkler S[49]: Essentials of Complete Denture Prosthodontics, Second edition, page 140-41

After forming the occlusal rim with prescribed vertical heights, the plane of occlusion is modified until it is parallel with a line projected from the Ala of nose to the superior edge of the tragus of ear (camper's line). When viewed from the front, the occlusal plane should also be parallel to the interpupillary line. The relationship of the interpupillary line, Camper's line and the occlusal plane is also shown in a pictorial diagram.

MATERIALS AND METHODS

STUDY DESIGN:

This clinical study was performed in dentate individuals to compare values of horizontal condylar angle in relation to three different horizontal planes described in the literature. Horizontal condylar angle was measured clinically from dentulous subjects by using Semi-Adjustable Arcon type articulator and these values were compared with the three values obtained by lateral cephalogram to find out which value comes closest to clinically established horizontal condylar angle value. This study was performed from June 2012 to November 2012 in the Department of Prosthodontics, Tamil Nadu Government Dental College and Hospital, Chennai.

ETHICAL COMMITTEE APPROVAL:

The study was conducted with the approval from the institutional ethical committee.

The following materials and equipments were used to conduct the study.

S.No	NAME (commercial name)	FORM OF THE MATERIAL	MANUFACTURER DETAILS
1.	Vignette chromatic alginate impression material	Irreversible hydrocolloid impression material	Dentsply, India
2.	Jabbar trays	Stock tray	Jabbar & co,India
3.	Kalstone	Type III Dental stone	Kalabhai, India
4.	White gold	Type II Dental plaster	Asian chemicals, India
5.	Professional face bow		Bio art, Brazil
6.	Samit super Tracing Sticks	Green Stick Compound	Samit, India

7.	A7 Plus Articulator	Semi Adjustable Arcon Articulator	Bio Art , Brazil
8.	Konark ever bright dental stainless steel wire	Stainless steel orthodontic wires, 23 gauge	Khokhar, india
9.	Cellotape		Premier
10.	Multimark 1513	Black marker pen	Faber-castell
11.	Camlin scale	Scale 15cms	Camlin limited, Mumbai
12.	Kodak Digital Panoramic and Cephalogram system		
13.	DICOM viewer 2.1.7		Medsynaptics Pvt. Ltd. , Pune, India

ARMAMENTARIUM FOR CLINICAL EXAMINATION:

1. Kidney Tray
2. Mouth mirror
3. Periodontal probe
4. Cheek retractor
5. Disposable gloves and mask

ARMAMENTARIUM FOR OBTAINING IMPRESSIONS:

1. Alginate (Vignette chromatic)
2. Maxillary and Mandibular stock trays
3. Type III Dental stone (Kalstone)
4. Rubber bowl and Spatula
5. Disposable gloves and Mask

ARMAMENTARIUM FOR FACE BOW TRANSFER:

1. Bio-Art Professional face bow
2. Green stick Impression Compound
3. Rubber bowl

ARMAMENTARIUM FOR FACE BOW MOUNTING:

1. Bio-Art Arcon Semi-adjustable Articulator
2. Accessories for mounting
3. Type II Dental Plaster
4. Rubber bowl and spatula
5. Cotton

ARMAMENTARIUM FOR JAW RELATION REGISTRATION:

1. Green Stick Impression Compound
2. Rubber bowl

ARMAMENTARIUM FOR OBTAINING LATERAL CDEPHALOGRAM:

1. Protrusive registered bite
2. Two straight 21 gauge orthodontic wires
3. Cellotape
4. Ruler
5. Permanent Marker Pen

ARMAMENTARIUM FOR COMPUTERISED DIGITAL CEPHALOMETRIC TRACING:

1. Computer

2. Digital Lateral Cephalogram
3. DICOM Software

METHODOLOGY

1. SUBJECT SELECTION
2. PREPARATION OF STUDY MODELS
3. FACE BOW TRANSFER
4. MOUNTING OF MAXILLARY CAST ON SEMIADJUSTABLE ARTICULATOR
5. CENTRIC JAW RELATION REGISTRATION
6. MOUNTING OF MANDIBULAR CAST ON SEMIADJUSTABLE ARTICULATOR
7. OBTAINING PROTRUSIVE AND RIGHT LATERAL AND LEFT LATERAL BITES
8. PROGRAMMING THE SEMI ADJUSTABLE ARTICULATOR TO OBTAIN RIGHT AND LEFT SIDE CONDYLAR ANGLE VALUE
9. OBTAINING LATERAL CEPHALOGRAM OF PATIENT
10. COMPUTERISED DIGITAL CEPHALOMETRIC TRACING TO OBTAIN VALUES RADIOGRAPHICALLY

SUBJECT SELECTION

Study participants were selected from the undergraduate dental students of Tamil Nadu Government Dental College and Hospital with the age group of 20-27 years of age and both male and females subjects were included in the study. All the patients were informed about the purpose and methods of the study and signed the written consensus.

The **inclusion criteria** for entry in the trial were:

(a) Class I molar and canine relation

(b) Average horizontal and vertical overlap

(c) Minimal spacing or crowding of anterior teeth

(d) No prosthesis with minimum or no occlusal restorations

(e) No history of orthodontic treatment

The **exclusion criteria** for entry in trial were:

a) Class II or III relation

b) Any missing teeth

c) Traumatic occlusion of anterior teeth

d) TMJ clicking,crepitation,tenderness

e) Parafunctional habits

SAMPLE SIZE

Study was designed with sample size of 30.

PREPARATION OF STUDY MODELS

Maxillary and mandibular arch impressions were recorded with irreversible hydrocolloid and casts poured with type III dental stone and bases were formed with type II plaster.

FACE BOW REGISTRATION

Bio-art Professional face bow was used in this study. Three points are made on the fork, one frontal point, in the exact center of the fork, and two points at the back, one at each semi-arch of the fork. Bite fork is positioned such that the midline of the

fork handle is aligned with the midline of the maxilla and placed on the upper arch, it was held up firmly in place until the registration material hardens. Individual was made to sit in reclined position in the chair to reduce the induction of tensions on the fork set and face-bow. Individual was asked to keep the fork in the same position by supporting the thumbs against the maxilla. The face bow was taken to the patient and the bite fork assembly was introduced into the fork handle, assuring the wing nut is upside down. The face-bow earpieces were carefully inserted into the patient's external auditory meatus.

The nasion relator was placed on the face-bow cross bar and centered on patient nose. The fork fixator assembly was pushed forward, sliding it on the fork handle until it is as close as possible to the lips, without touching them. First the double articulated nut of the fork was tightened followed by the horizontal slide bar nut. Patient was asked to remove his thumbs from the bite fork and it was checked if the fork and facebow are stable and immobilized. The wing nut of the nosepiece was loosened to remove the face bow and nasion relator assembly removed from the face bow. Then, the central wing nut of the facebow was loosened, cross bar was held and patient was told to open mouth slowly, removing the whole set carefully.

MOUNTING OF MAXILLARY CAST ON SEMIADJUSTABLE ARTICULATOR

As study was planned to be carried out on Bio-Art Arcon Semi-adjustable articulator (Model A7 plus), to facilitate the mounting of the casts, condylar guidance angle was adjusted at 30 degrees and the Bennett angle at 0 degree as recommended by the manufacturers. The upper part of the central lock was pushed back until the "click" sound is heard. Bio-art Professional facebow was used in this study. The main

feature of this model is the Jig Transfer Assembly for mounting the casts on the articulator. This assembly is placed in the lower member of the articulator through the jig assembly lower base thus eliminating the need for the face bow frame while transferring the patient's registration onto the articulator and providing quick mounting of the cast.

Incisal guide table was removed from the lower member of the articulator and lower base transfer was inserted, assuring that the guide pin is properly touching the end of the slot. The Jig Transfer Assembly was removed from the face bow and connected to the jig transfer lower base and wing nut was fastened. The upper member support was inserted on the jig transfer connection rod, supporting the upper member and assuring the parallelism between the upper and lower members of the articulator. Upper cast was placed on the fork registration and the upper member of the articulator was lifted and plaster placed on the upper mounting plate and some on the top of upper cast. Upper member was closed and articulation of upper cast was completed.

CENTRIC JAW RELATION REGISTRATION

Green stick compound was used to record the centric jaw relation, the compound was taken and placed in a bowl of warm water. It was formed into a shape of U shaped arch and placed on mandibular teeth of patient. Then the patient's mandible was manipulated in centric relation by bimanual manipulation method. Material was left in patient's mouth for adequate time for proper cooling. Occlusal record was evaluated for distortion and repeated if needed.

MOUNTING OF MANDIBULAR CAST ON SEMI-ADJUSTABLE ARTICULATOR

The incisal guide in the upper member of the articulator is placed with its rounded tip pointing downward so that the upper and lower members are kept parallel i.e. when the incisal pin is on zero marking. Articulator is turned upside down and lower cast affirmed upon the interocclusal register that was placed in the mounted mandibular cast. A small amount of plaster was placed on the lower part of mandibular cast and a small amount on the mounting plate of the lower member of articulator to fill in the gap between them. After the plaster hardens, articulator is turned back to its correct position and finishing touches given to plaster.

OBTAINING PROTRUSIVE AND RIGHT AND LEFT LATERAL JAW RELATIONS REGISTRATIONS

Green stick compound was taken and placed in a bowl of warm water. It was formed into a shape of U and placed on mandibular teeth of patient. Patient was asked to bring his/her incisors edge to edge relation and the protrusive bite was registered. It was allowed to cool, removed and examined.

Then again green stick impression compound was molded in U shape and placed on mandibular teeth and patient was asked to move towards right lateral side. Material was allowed to cool down and then inspected. It was repeated in a similar way for left lateral position. Thus three jaw relations were obtained.

1. Protrusive
2. Left lateral
3. Right lateral

PROGRAMMING THE SEMI ADJUSTABLE ARTICULATOR TO OBTAIN RIGHT AND LEFT SIDE CONDYLAR ANGLE VALUE

Before mounting of the casts, condylar guidance was adjusted to 30 degree and Bennett angle at zero degree as recommended by manufacturers in instruction manual. For programming of the articulator, upper member was required to be separated completely from the lower member. Before proceeding with it, condylar guidance screw was loosened to allow free movement of condylar guidance assembly and angle was brought down to zero degree. Then Stablilizing elastic band was removed from stabilizing elastic band pin on both right and left sides. Central lock of upper frame was released to let free condylar element on both sides. Now upper member was lifted from the lower member and kept aside.

Protrusive bite was placed on the mandibular teeth and checked for proper adaptation on teeth. Now the upper member of articulator was placed gently over this protrusive record so that the maxillary teeth fit into the indentations on the protrusive record. It was noticed at this stage that the condylar element should not be touching the superior wall of the condylar guidance assembly after placing protrusive record. At this stage, the condylar guide assembly was rotated gently towards the increasing angulation till the condylar element touches the superior wall of the condylar guide assembly. The point where contact would be established is recorded as the condylar guidance value (Horizontal condylar angle value) obtained for that patient on that side. Similar procedure was repeated for the opposite side.

OBTAINING LATERAL CEPHALOGRAM OF THE PATIENT

Before taking lateral cephalogram for the patient, ruler was taken and kept at incisal edge of lateral incisor of maxilla up towards the nose and a point was marked 43mm above on infraorbital area below medial surface of eye with a marker pen.

23 gauge orthodontic wire was cut into two pieces according to the length required and straightened.

a) First segment of wire was placed connecting two points, one at 43mm above from the incisal edge of lateral incisor to a point posteriorly at superior margin of tragus of ear. Wire was fastened to skin with cellotape at these two points.
b) Second segment of wire was placed connecting lower margin of Ala of nose to posterior margin of tragus of ear, and wire was fastened with cello tape at these two points.

The position of these two wires was evaluated again for their proper position on respective points. Protrusive record previously recorded in green stick compound, was used to program the articulator was again placed in patient's mouth and lateral cephalogram was taken

Digital lateral cephalometric image was obtained using Kodak 8000C unit with standardized radiographic parameters (78kv/12mA/1sec) following the manufacturers's instructions and guidelines. Obtained images were saved using Kodak Dental imaging software program.

COMPUTERISED DIGITAL CEPHALOMETRIC TRACING TO OBTAIN VALUES RADIOGRAPHICALLY

Radio graphically obtained lateral cephalogram was traced using computerised DICOM (Digital imaging and Communication in Medicine) software. This software has features of performing tracing digitally. It allowed Zoom in for better visualisation of landmarks, Inversion of image, to draw lines and measure angle between these drawn lines and the horizontal plane.

a) Tracings were made for Frankfort horizontal plane by identifying the orbitale and porion by display of white hairline cursor controlled by a graphic mouse
b) Orthodontic wires would be seen radio opaque line running from marked landmarks on patients face. Line was drawn following these radiographic lines for both shillingburg plane and Ala tragus plane by display of white hairline cursor controlled by a graphic mouse
c) Slope of the articular eminence was traced by connecting posterior slope of articular eminence with the point obtained by edge to edge incisors relation due to protrusive bite placed in patients' mouth.

Horizontal Condylar angle was measured for these three different horizontal reference planes in relation to articular eminence.

1. Frankfort horizontal reference plane and slope of Articular eminence
2. Horizontal reference plane described by shillingburg and slope of Articular eminence
3. Ala-tragus plane and slope of Articular eminence.

Thus three values of condylar angle value were obtained in degrees radiographically.

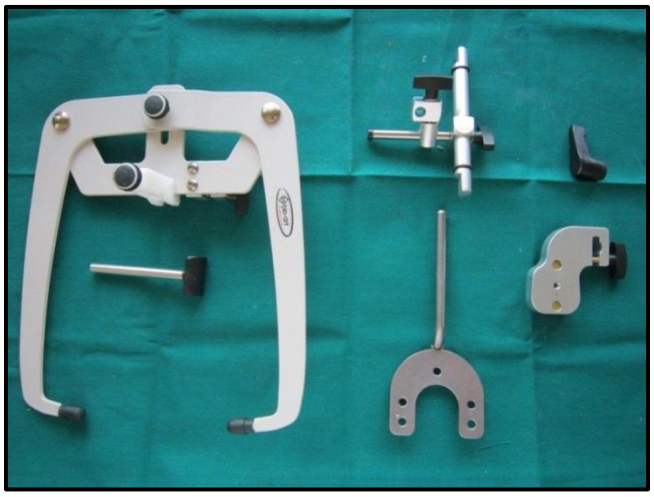
METHODS OF STATISTICAL ANALYSIS:

The value of condylar angle obtained from articulator after Facebow transfer was compared with condylar angle values obtained from lateral cephalogram with three reference planes using Paired t test.

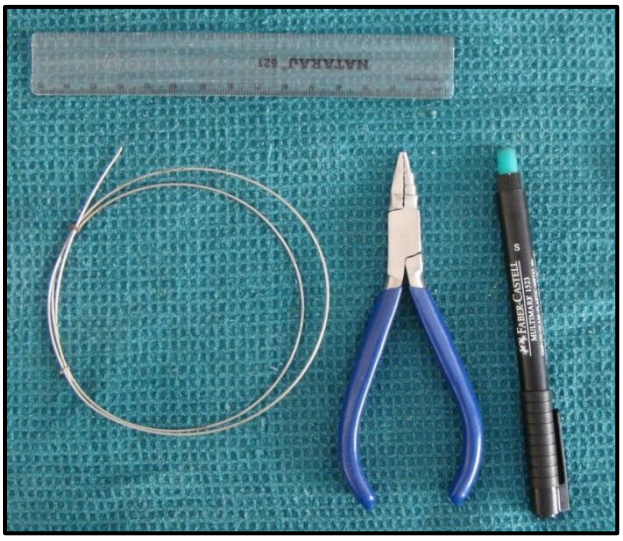
ARMAMENTARIUM

ARMAMENTARIUM FOR EXAMINATION

ARMAMENTARUIM FOR IMPRESSION MAKING

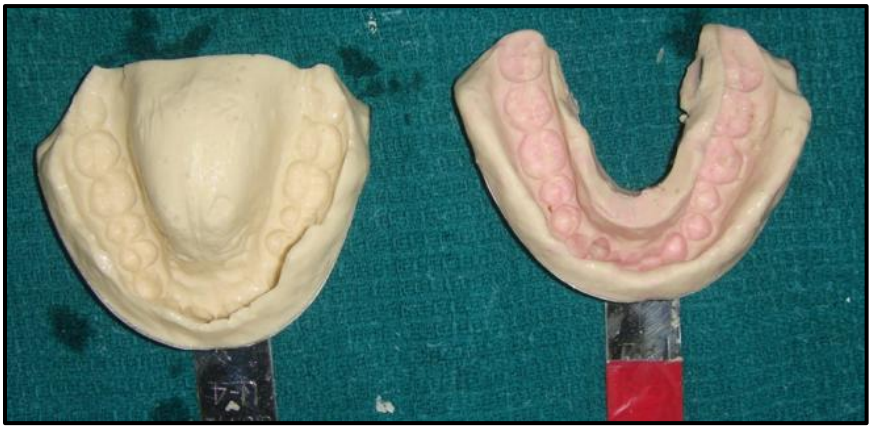


BIO-ART PROFESSIONAL FACE BOW
NASION RELATOR
BITE FORK
TRANSFER JIG ASSEMBLY

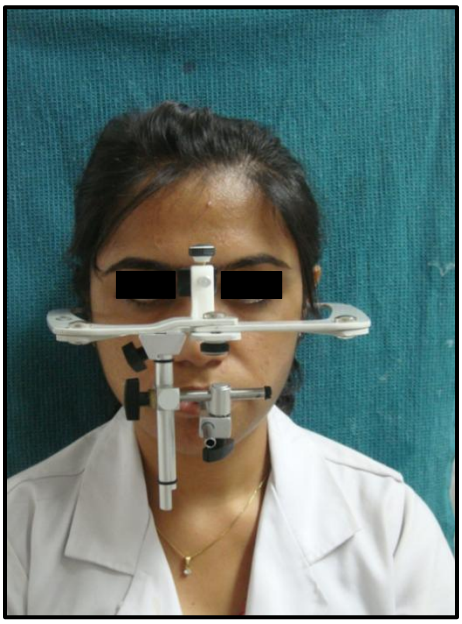


ARMAMENTARIUM FOR MARKINGS ON FACE BEFORE LATERAL CEPHALOGRAM

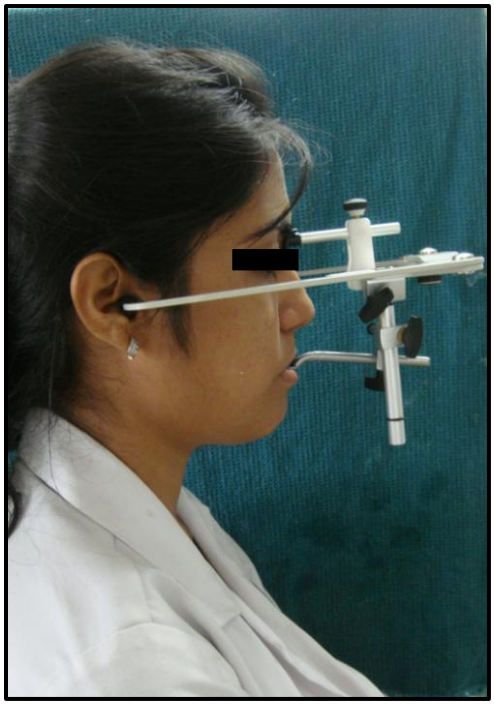
PROCEDURE



UPPER AND LOWER ALGINATE IMPRESSIONS



BIO-ART FACE BOW TRANSFER (FRONTAL VIEW)



BIO-ART FACE BOW TRANSFER (LATERAL VIEW)

ORIENTATION OF MAXILLARY CAST ON ARTICULATOR

MAXILLARY CAST MOUNTED TO ARTICULATOR

CENTRIC JAW RELATION REGISTRATION

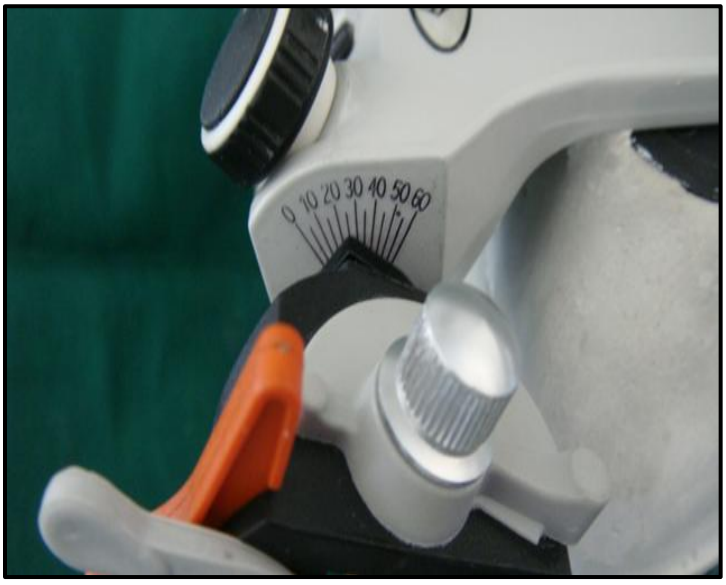
CONDYLAR GUIDANCE SET AT 30 DEGREE

MOUNTING OF MANDIBULAR CAST

ARTICULATED UPPER AND LOWER CAST IN ARCON ARTICULATOR

PROTRUSIVE EDGE TO EDGE INTEROCCLUSAL RECORD

PROGRAMMING OF ARTICULATOR



CONDYLAR ANGLE OBTAINED AFTER PROGRAMMING
25 DEGREES

RADIOGRAPHIC STAGE

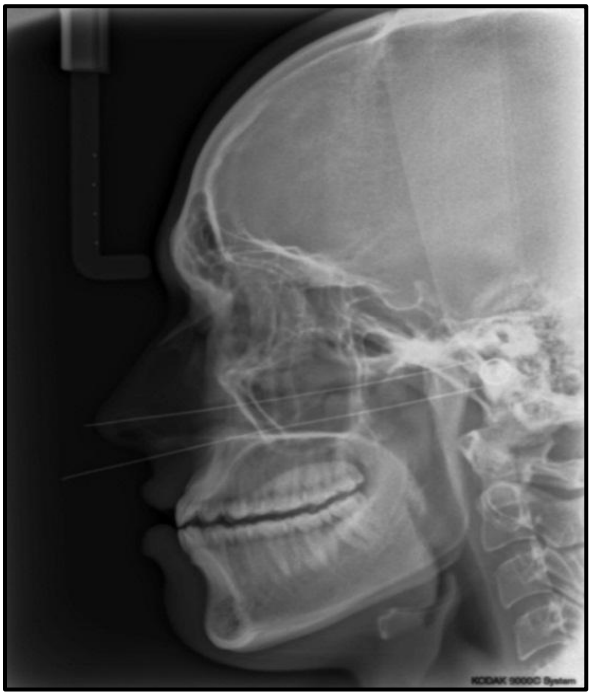
A POINT 43 mm MARKED ABOVE FROM INCISAL EDGE OF LATERAL INCISOR ON PATIENT SKIN

23 GAUGE ORTHODONTIC WIRE PLACED FROM

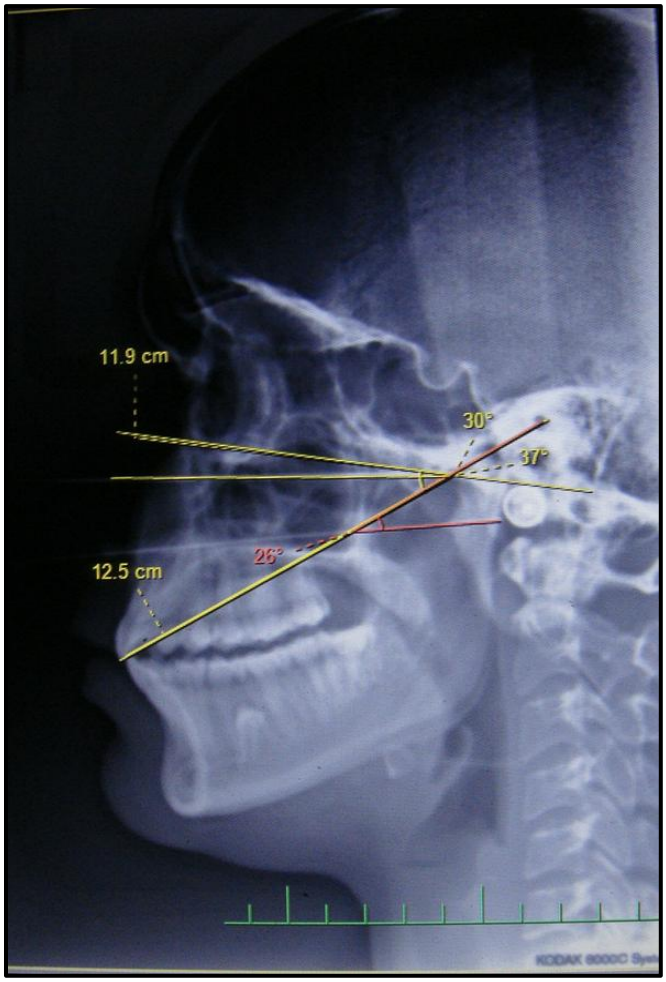
a) LOWER BORDER OF ALA OF NOSE TO MIDDLE OF TRAGUS

b) A POINT 43 MM FROM LATERAL INCISOR EDGE ABOVE ON PATIENT SKIN TO SUPERIOR PART OF TRAGUS

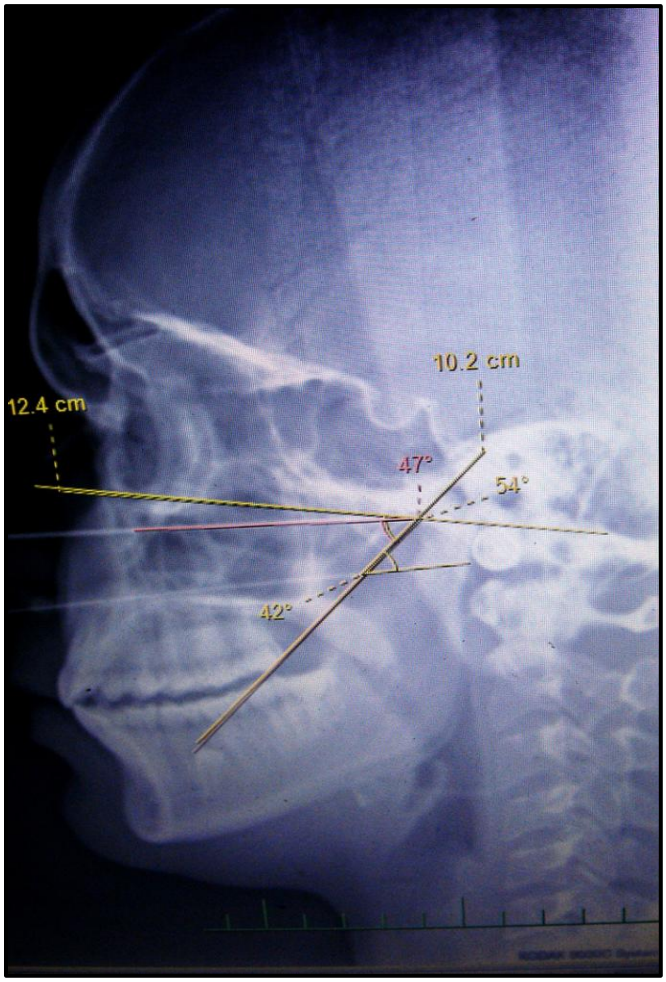
LATERAL CEPHALOGRAM OBTAINED



LATERAL CEPHALOGRAM WITH RADIOPAQUE ORTHODONTIC WIRES



VALUES OF HORIZONTAL CONDYLAR ANGLE WITH THREE DIFFERENT PLANES ON LATERAL CEPHALOGRAM BY USING POSTERIOR SLOPE OF ARTICULAR EMINENCE AND CONTACTING INCISAL EDGES(ANTERIOR AND POSTERIOR REFERENCE) TO DRAW CONDYLAR PATH



VALUES OF HORIZONTAL CONDYLAR ANGLE WITH THREE DIFFERENT PLANES ON LATERAL CEPHALOGRAM BY USING POSTERIOR SLOPE OF ARTICULAR EMINENCE (POSTERIOR REFERENCE) TO DRAW CONDYLAR PATH

RESULTS

This clinical study was performed in dentate individuals to compare values of horizontal condylar angle in relation to three different horizontal planes described in the literature. Horizontal condylar angle was measured clinically from dentulous subjects by using Semi-Adjustable Arcon type articulator and these values were compared with the three values obtained by lateral cephalogram to find out which value comes closest to clinically achieved horizontal condylar angle value. Three horizontal planes selected were

1. Frankfort horizontal plane
2. Ala-tragus plane
3. Plane described by Shillingburg.

The basic data of the results obtained in this study are shown in the appendix I and II.

STATISTICAL ANALYSIS OF RESULTS

The collected data was analysed with SPSS 16.0 version. To describe about the data descriptive statistics mean, S.D were used. To find the significance difference between the bivariate samples paired samples t-test test was used .In the above statistical tools the probability value P=.05 is considered as significant level.

Table 1 shows the descriptive statistics of the variables with Minimum, Maximum, Mean and Standard deviation of clinically obtained horizontal condylar angle value with three different radiographically obtained values.

Descriptive Statistics				
	Minimum	Maximum	Mean	Std. Deviation
RCOHCAV	24	44	36.47	3.902
RWSHRP	21	38	29.67	4.180
RWATP	17	30	22.67	3.880
RWFHP	22	38	28.50	3.739
LCOHCAV	25	44	36.30	4.300
LWSHRP	21	38	29.67	4.180
LWATP	17	30	22.67	3.880
LWFHP	22	38	28.50	3.739

Table 2 shows the correlation between the comparing paired groups of clinically obtained horizontal condylar angle value with all the three radiographic values respectively

TABLE 2			
Paired Samples Correlations			
		Correlation	Sig.
Pair 1	RCOHCAV & RWSHRP	.348	.059
Pair 2	RCOHCAV & RWATP	.370	.044
Pair 3	RCOHCAV & RWFHP	.494	.006
Pair 4	LCOHCAV & LWSHRP	.142	.454
Pair 5	LCOHCAV & LWATP	.165	.383
Pair 6	LCOHCAV & LWFHP	.306	.101

Table 3 Shows the paired t-test comparison between the Clinically obtained horizontal condylar angle value in right and left side with all the three radiographically obtained values respectively and it was obtained that all the radiographic values are significantly different with Clinically obtained horizontal condylar angle value at P = .000 level.

TABLE 3

Paired Samples Test

		t-Values	P-value
Pair 1	RCOHCAV - RWSHRP	8.063	.000
Pair 2	RCOHCAV - RWATP	17.312	.000
Pair 3	RCOHCAV - RWFHP	11.346	.000
Pair 4	LCOHCAV - LWSHRP	6.540	.000
Pair 5	LCOHCAV - LWATP	14.103	.000
Pair 6	LCOHCAV - LWFHP	8.977	.000

The results shown above were obtained when the condylar path on lateral cephalogram was drawn as a tangent to posterior slope of articular eminence and joining the contacting incisal edges of maxillary and mandibular incisors during protrusive relation interocclusal record obtained by asking patient to close in edge to edge relation. In our study, both anterior and posterior point for tracing condylar path is fixed to increase the accuracy of tracing the condylar path.

But, many of the literature available on radiographic method of obtaining horizontal condylar inclination, to determine condylar path, a line was drawn tangent to posterior slope of articular eminence without anterior reference point. So, it was decided to obtain the results by this method as well and subject the readings to statistical analysis to study the effect of this variation on our results and to view both results obtained to provide better insight into the study.

When the data obtained with this method was subjected to statistical analysis, following results were obtained.

Table 4 shows the descriptive statistics of the variables with Minimum, Maximum, Mean and Standard deviation of clinically obtained horizontal condylar angle value with three different radiographically obtained values.

TABLE 4

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
RCOHCAV	24	44	36.47	3.902
RWSHRP	21	38	29.67	4.180
RWATP	17	30	22.67	3.880
RWFHP	22	38	28.50	3.739
LCOHCAV	25	44	36.30	4.300
LWSHRP	21	38	29.67	4.180
LWATP	17	30	22.67	3.880
LWFHP	22	38	28.50	3.739

Table 5 shows the correlation between the comparing paired groups of clinically obtained horizontal condylar angle value with all the three radiographic values respectively.

TABLE 5

Paired Samples Correlations

		Correlation	Sig.
Pair 1	RCOHCAV - RGSHRP	.168	.375
Pair 2	RCOHCAV - RGATP	.366	.047
Pair 3	RCOHCAV - RGFHP	-.068	.723
Pair 4	LCOHCAV - LGSHRP	-.117	.539
Pair 5	LCOHCAV - LGATP	.188	.319
Pair 6	LCOHCAV-LGFHP	-.128	.499

Table 6 Shows the paired t-test comparison between the Clinically obtained horizontal condylar angle value in right and left side with the three radiographic values respectively and it was obtained that all the radiographic values are significantly different with Clinically obtained horizontal condylar angle value at P = .000 level, except Ala- Tragus plane in right & left side with Clinically obtained horizontal condylar angle value which is close to it.

TABLE 6

Paired Samples Test

		t-Values	P-value
Pair 1	RCOHCAV - RGSHRP	-4.039	.000
Pair 2	RCOHCAV - RGATP	.868	0.392*
Pair 3	RCOHCAV - RGFHP	-8.803	.000
Pair 4	LCOHCAV - LGSHRP	-3.423	.002
Pair 5	LCOHCAV - LGATP	.614	0.544*
Pair 6	LCOHCAV - LGFHP	-8.181	.000

* NO SIGNIFICANT DIFFERENCE

INTERPRETATION OF RESULTS

Paired sample t-test was used for analysis of data in this study.

Table 1 shows the descriptive statistics of the variables with Minimum, Maximum, Mean and Standard deviation. Maximum and minimum value in degrees for right side clinically obtained horizontal condylar angle value (RCOHCAV) was determined i.e. 24 degree minimum and 44 degree maximum and standard deviation was found to be 3.902. Similarly, for left side clinically obtained horizontal condylar angle value (LCOHCAV) was determined i.e. 25 degree minimum and 44 degree maximum, standard deviation was found to be 4.300. Standard deviation and mean for Shillingburg horizontal reference plane (RWSHRP and LWSHRP) was found to be 4.180 and 29.67 respectively. Standard deviation and mean for Ala-Tragus plane (RWATP and LWATP) was found to be 3.880 and 22.67 respectively.

Table 2 shows the correlation between the comparing paired groups of Clinically obtained horizontal condylar angle value in right and left side with all the three x-rays values respectively. Correlation value obtained by comparing right side clinically obtained horizontal condylar angle with right side Shillingburg horizontal reference plane was found to be 0.348, with right side Ala- tragus plane was 0.370, and with right side Frankfurt horizontal plane was 0.494. Similarly, when left side clinically obtained horizontal condylar angle value was compared with left side Shillingburg horizontal reference plane, correlation was found to be 0.142, with left side Ala-tragus plane, correlation was 0.165 and with left side Frankfurt horizontal plane, correlation was 0.306.

Table 3 shows the paired t-test comparison between the clinically obtained horizontal condylar angle value in right and left side with all the three x-rays values respectively. First pair shows that t value of 8.063 and P value 0.000 was obtained

when right side clinically obtained horizontal condylar guidance value was paired with right side Shillingburg horizontal reference plane, P value of 0.000 when paired with right side Ala-tragus plane and P value of 0.000 when paired with right side Frankfurt horizontal plane.

Similarly, when left side clinically obtained horizontal condylar angle value was paired with left side Shillingburg horizontal reference plane, P value of 0.000 was found, with left side Ala-tragus plane, P value of 0.000 and P value of 0.000 was obtained with left side Frankfurt horizontal reference plane.

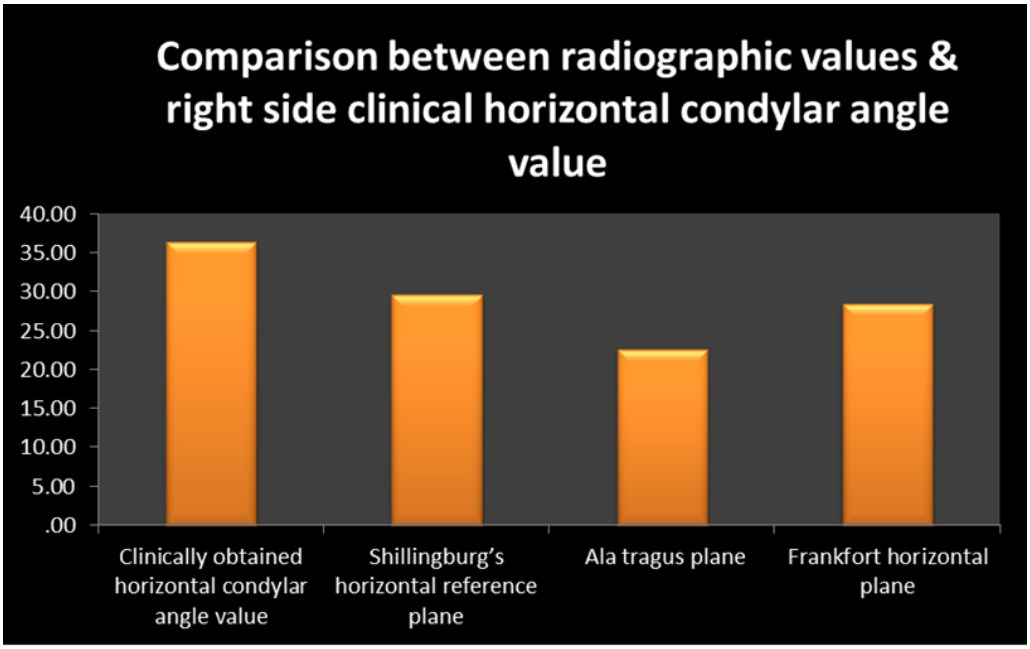
Table 3 reveals that the x-rays values of three different horizontal reference planes are highly significantly different with right and left side of Clinically obtained horizontal condylar angle value at P = .000 level.

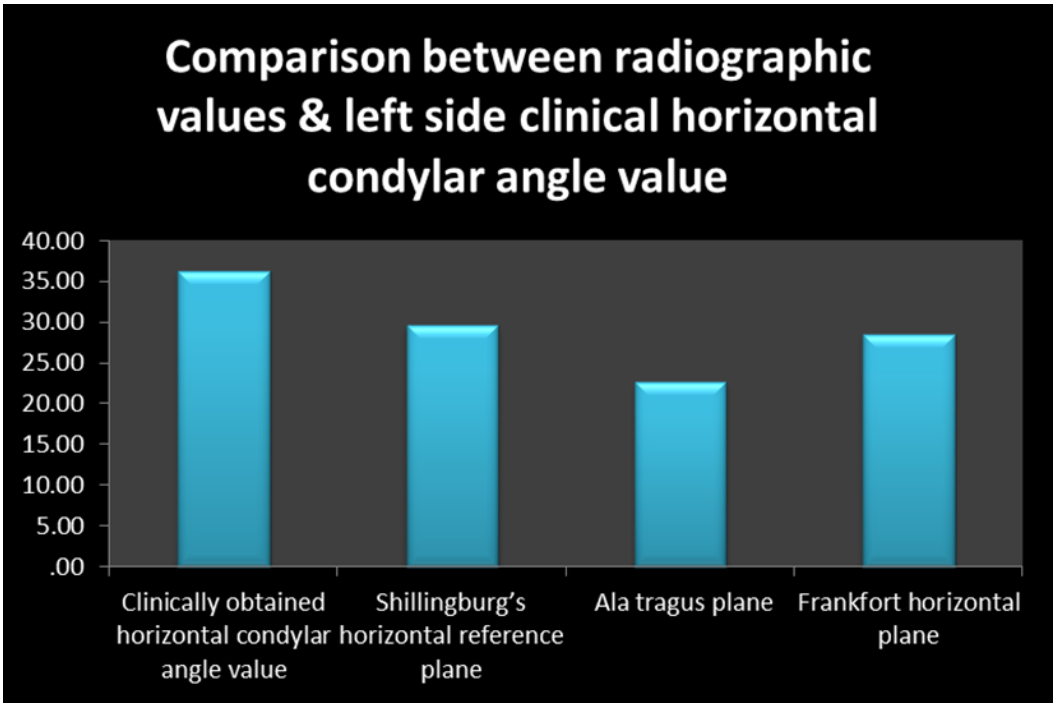
The results obtained when condylar path was traced by standardization of both anterior and posterior point are interpreted above. But when we used only posterior point to trace condylar path, results obtained were different from the one stated above. It was observed that the P-value between right side clinically obtained horizontal condylar angle value and right side Ala-tragus plane was 0.392 i.e. there is no significant difference between these two values.

Similarly, the P-value between left side clinically obtained horizontal condylar angle value and left side Ala-tragus plane was 0.544 i.e. there is no significant difference between these two values.

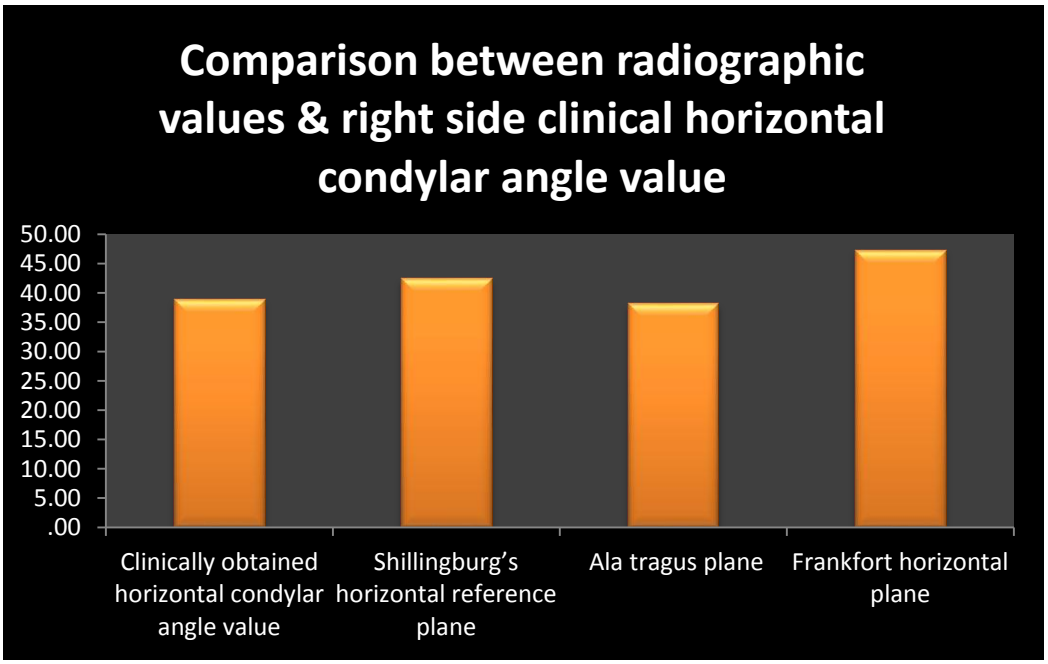
But when two other planes, Shillingburg horizontal reference plane and Frankfort horizontal reference plane were compared with right and left side clinically obtained horizontal condylar angle value, P value was 0.000 i.e. significant difference existed between these similar to the results obtained before.

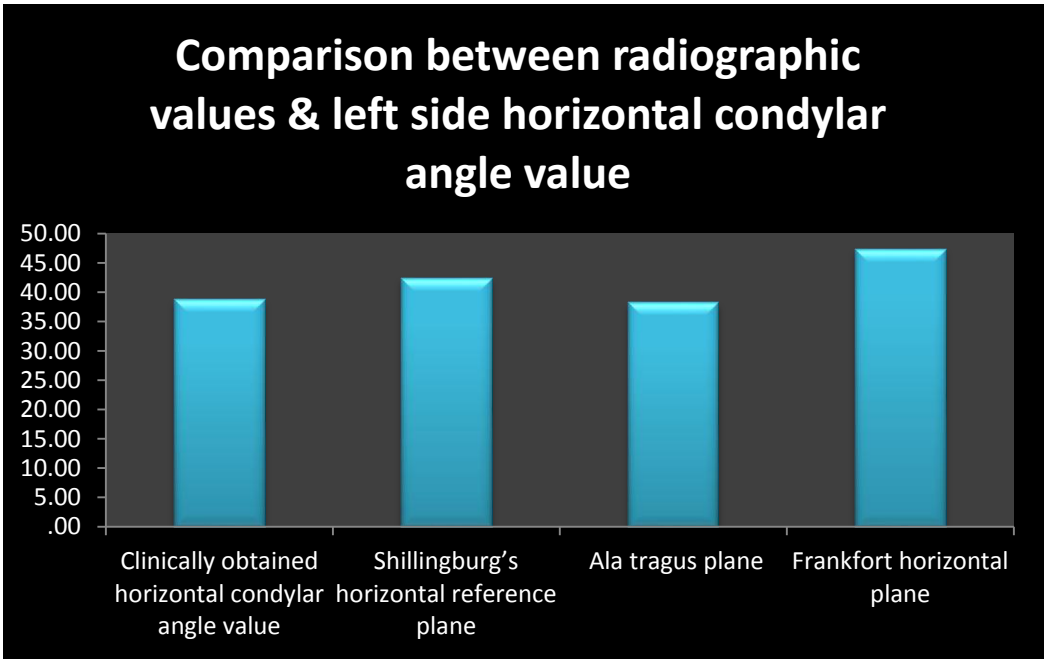
The bar diagrammatic representation of results obtained is shown below.





The bar diagramatic representation of the results obtained are shown below.





DISCUSSION

The determination of values of condylar pathway continues to attract the attention of numerous authors. Three ways of recording the slope of the condylar path have been proposed: 1) The Radiographic method 2) The Intraoral or positional wax record method 3) The Graphic registration method. All three methods have been executed by various authors and it was analyzed in the literature.

Pipko D J (1969) used Lateral Cephalogram radiographs to measure condylar path curvature. Radiographs were made in centric occlusion, 5 mm protrusive position, 10 mm protrusive position and mouth wide open. Tracing was done for cephalograms and value obtained was compared with the clinical value obtained by using protrusograph, pantographic tracing, and Ney articulator. It can be seen in literature that radiographic method to obtain horizontal condylar angle is in use since long. (Pipko D: Evaluation of validity of condylar path curvature. J. Pros.Den 1969;21:626-38)

In our study, we preferred digital lateral cephalogram because it offers several advantages compared with the conventional radiograph, such as easy image manipulation, computed analysis, storage, recovery and transmission of images, reduced radiation dose, reduced time and no need for film development. Image obtained was converted into DICOM format (Digital Imaging and Communications in Medicine) as JPEG image.

This DICOM software was provided by the digital centre and the tracing for lateral cephalogram was done on computer screen itself with the help of software. This software provides options for image inversion, image magnification and allows drawing lines connecting various landmarks and measurements of angles between

these lines. The angles formed by three reference planes used in our study with respect to condylar path were measured for thirty patients.

According to **Sandler**, direct digitization of the radiographs is more reproducible, particularly with angular measurements, when compared with hand instruments on tracings, digitization of tracings, and direct digitization of the radiographs on the monitor. (Sandler PJ. Reproducibility of cephalometric measurements. Br J Orthod 1988;15:105-10).

The method used for radiographic evaluation of condylar inclination in this study has also been employed in recent studies by **Goyal and Goyal (2011).** In this investigation, Author used Digital Lateral Cephalogram to obtain sagittal condylar inclination with respect to Frankfort plane as horizontal reference plane. The condylar path was marked as a tangent to the posterior slope of articular eminence. (Goyal MK and Goyal S. A comparative study to evaluate the discrepancy in condylar guidance values between two commercially available arcon and non-arcon articulators: a clinical study IJDR,22;2011)

Similarly, one more recent study done by **Tannamala et al (2012)** also used Panoramic Radiograph to measure sagittal condylar inclination with respect to Frankfort horizontal plane. (Tannamala P V, Pulagam M, Pottem S and Swapna B: Condylar guidance: correlation between protrusive interocclusal record and Panoramic radiographic image: A pilot study JOP 2012 ;181-84).

Both these studies drew condylar path as tangent to posterior slope of articular eminence without using anterior point. Only one plane i.e. Frankfort horizontal plane was used in these two studies.

Tannamala et al reported clinically obtained value of Horizontal Condylar Inclination to be 32.80 and **Goyal and Goyal** reported 32.75 on right side and 34.75

on left side as measured on Arcon articulator. Our study shows results being very close to values obtained by these studies, with the clinically obtained mean Horizontal Condylar Angle value being 36.47 on right side and 36.30 on left side.

Although the clinical values in our study were in accordance with the studies mentioned above, variation was noticeable between the radiographic values obtained taking Frankfort horizontal plane as reference plane**. Tannamala et al** found Panoramic Radiographic mean value of sagittal condylar guidance to be 36.50 on right side and 35.50 on left side. **Goyal and Goyal** found Lateral Cephalogram mean sagittal condylar guidance value of 36.05. The mean sagittal condylar angle value in our study measured on Lateral Cephalogram with respect to Frankfort horizontal plane was significantly different from these values.

Both these studies in order to mark condylar path during protrusion, drew a tangent to posterior slope of articular eminence, but the anterior point to draw this tangent was not fixed and described, which can lead in obtaining higher values due to discrepancy in drawing this tangent line. In our study, condylar path was drawn on lateral cephalogram by fixing the anterior and posterior points. Posterior point was fixed as slope of articular eminence and anterior point as the contacting incisal edges of maxillary and mandibular incisors during protrusive relation and interocclusal record was obtained. This explains slightly higher mean radiographic value obtained in these two studies with respect to Frankfort horizontal plane.

Zamacona J, Otaduy E and Aranda E (1992) studied 55 edentulous patients making three graphic registrations of the protrusive condylar movement on each side. Tangential method to measure the angulation relative to the Camper's plane was used. Range of inclination of condylar path varied from 10 to 62 degrees on the left side,

with a mean of 35.75 degrees, while on right side, it was from 23 to 55 degrees, with a mean of 36.6 degrees. (Zamacona J,Otaduy Eand Aranda E: Syudy of the sagittal condylar path in edentulous patients. J.Pros.Dent1992;68:314-17)

The values obtained in our study for clinically obtained mean horizontal condylar inclination value being 36.47 for right side and 36.30 for left side are in accordance with this study.

Preti G, Scotti R, Bruscagin C and Carossa S (1982) conducted a research to study the statistical investigation of the angular values of the condylar sagittal pathway obtained with the Graphic record method and to verify its repeatability. He found that although there was a large variation between right and left sides, the average was 33 degree. Our results obtained were in accordance with this study. (Preti G, Scotti R, Bruscagin C and Carossa S: A clinical study of graphic registration of the condyle path inclination. J.Pros.Dent 1982;48:461-66)

Posselt U and Skytting B (1960) gave a mean of 36.3 degree of condylar path inclination measured by graphic records. Our study also gave same mean of 36.47 on right side and 36.30 on left side of clinically obtained horizontal condylar inclination. (Posselt U and Skytting B: Registration of the condyle path inclination: variation using the Gysi technique, J.Pros.Dent.1960;10:243-47)

Issacson D (1959) studied 36 patients and found the condylar path angle to be between 22 degrees and 53 degrees,with an average of 35.64 degrees. In our study also, it was noticed that condylar path inclination falls between 24 degree and 44 degree, with a mean value of 36.47 for right side and 36.30 for left side. (Issacson D: A clinical study of condyle path, J. Pros. Dent.1959; 9:927-35)

Olsson and Posselt (1961) described that the condyle path inclination must be determined in relation to the cranial plane or a line of reference. In order to compare condyle path inclinations as measured in relation to various planes, the average angle between these planes, especially in their projections on the sagittal plane, should be determined. He compared Frankfort horizontal plane and camper's plane by radiograph and found a mean of 17 degree. (Olsson A and Posselt U.: Relarionship of various skull reference lines, J. Pros.Den 1961; 11:1045-4).

According to **Downs (1948**), the angle varies from +1.5 degree to+ 14 degree between the Camper's and Frankfort horizontal plane whereas according to Olsson and Posselt, there is no such variation, the angle being a constant +10 degrees. The values presented in our study are similar to those of down, with variation between these planes by +6 degrees, slightly lesser than those of Olsson and Posselt. (Downs WB. Variations in facial relationships: their significance in treatment and prognosis. Am J Orthod 1948;34:812-49.

All the studies cited above support the values of clinically obtained horizontal condylar angle of our study. Although the value of clinically obtained horizontal condylar inclination obtained by this study is in accordance with the previous studies mentioned in the literature, but no study could be found comparing the different horizontal reference planes on radiograph with the clinical value. So, to compare the values obtained by this study, limited literature was available.

According to the results of this study, on comparing correlation between horizontal condylar inclination values obtained with the Frankfort horizontal plane, plane described by Shillingburg and the Camper's plane (Ala-tragus line) plane with that of the horizontal condylar angle obtained by clinical methods, statistically no

correlation could be obtained in the present study. All the radiographic values were highly significantly different with right and left side of clinically obtained horizontal condylar angle value at P = .000 level.

When observing the results obtained using the line tangent to posterior slope of articular eminence alone to draw condylar path, for many individuals, this track is not passing through the contacting incisal edges of maxillary and mandibular anterior teeth in protrusion. On the contrary, they pass through premolars and in some cases, through molars of mandible. This led to the opening up of the horizontal condylar angle of three different horizontal reference planes employed in the study and showing greater values.

The results of this values obtained showed that the horizontal condylar angle values obtained using Ala-tragus line as a horizontal reference plane was found to be close to the clinically obtained horizontal condylar angle values with P- value of 0.392 for right side and 0.544 for left side.

Thus, it was observed that the horizontal condylar path does not pass through the contacting incisal edges of maxillary and mandibular anterior teeth at all the times though it occurred in some individuals and therefore giving rise to variation in horizontal condylar angle value obtained between clinical values and radiographic values.

But it is always possible to create error while drawing the tangent line with posterior slope of articular eminence, due to difficulties in locating this landmark accurately in the radiograph. **Gilboa et al** stated that two radio-opaque lines are consistently apparent on the radiographs in the region of the temporal bone. One depicts the outline of the articular eminence and fossa, the second, the inferior border

of the zygomatic arch. These lines often intersect and can be confusing. The outline of the articular eminence was generally lighter and more superior, with the heavier, more inferior line representing the inferior border of the zygomatic arch. (Gilboa I,Cardash HS,Kaffe I,Gross MD.Condylar guidance: Correlation between articular morphology and panoramic radiographic images in dry human skulls. J.Pros.Dent 2008;99:477-82)

It was noticed that the angles obtained on the radiographs with respect to three different planes showed greater mean values when compared to value obtained clinically due to 7-12 % magnification generally produced when radiographs are employed.

L.V Christensen and J.C.G Slabbert (1978) in his review paper on the concept of sagittal condylar guidance stated that, based on anatomical studies of the temporomandibular joint of macerated human skulls, Angel (1948) described that the sagittal condylar guidance coincided more or less with the height and slope of the posterior surface of the articular tubercle. In children, Angel found that this slope created an angle of 20 degree relative to the Frankfort horizontal plane, and in adults, it was about 40 degree.

Christensen believed that no valid conclusions should be drawn from such skulls regarding the sagittal and the other in vivo movements of the mandibular condyles since there is total absence of all extra- and intra-articular soft tissues e.g. fibrocartilage, disc, capsule, ligament and muscle in macerated skulls.

L.V Christensen and J.C.G Slabbert (1978) described that various angles measured on lateral cephalographs of the human temporomandibular joint are believed to be related or identical with the sagittal condylar guidance angle, and were measured relative to different horizontal planes. Some of these angles were

constructed by tracing the eminence slope of **Angel (1948)**, or by the tangent to the posterior bony surface of the articular tubercle. The measurements revealed that no radiographically determined sagittal condylar guidance angle coincided with that obtained with the use of intra- oral records.

He pointed out that, the radiographically determined angles showed greater mean value than that determined by intra-oral records. Moreover, an individual exhibiting an extremely large difference between the inclinations of the sagittal condylar guidance of the right and left side as determined by intra-oral records, showed almost identical values for the two sides when radiographic measurements were made. He stated that determination of the sagittal condylar guidance angle, as measured on radiographs of the temporomandibular joint cannot be compared with the sagittal condylar guidance angle obtained with the use of intra-oral records. (L.V Christensen and J.C.G Slabbert: The concept of the sagittal condylar guidance: biological fact or fallacy? Journal of oral rehabilitation 1978:5;1-7)

Thus, it was observed that by changing the method of tracing the condylar path by using only posterior slope of articular eminence, the results obtained were quite different as compared to the condylar path traced using both anterior and posterior reference points. We used same protrusive jaw relation record in which maxillary and mandibular incisors were contacting each other to obtain clinical horizontal condylar angle value and the same record was used to obtain lateral cephalograms. Standardization is must for any study to decrease the errors in obtaining accurate results.

On observation of the results of this study by using two different methods to measure the horizontal condylar angle radiographically, there was a gross difference in the values when two reference points (anterior and posterior) were used to draw the

horizontal condylar path. Such type of gross variation in the values of clinically obtained horizontal condylar angle with radiographic values was not noticed when posterior reference point (posterior slope of articular eminence) alone is considered to draw the horizontal condylar path.

Within the limitation of this study, it may be stated that variations between the values of clinical method and radiographic method is inevitable. Secondly, it was quite interesting to see that the horizontal condylar path is not all the times passing through the contacting incisal edges of maxillary and mandibular incisors in protrusion. Moreover, chances of errors also have to be taken into account when posterior reference point alone is used to trace the horizontal condylar path in the radiographic method.

SUMMARY AND CONCLUSION

Condylar guidance is the posterior determinant of occlusion which cannot be modified and changed by the dentist. It depends on the anatomical structure of the temporomandibular joints for a particular patient. Accurate recording and reproduction of condylar guidance on semi-adjustable articulator is of paramount importance to achieve and reproduce the mandibular movements more accurately. Various methods are described in literature even though these values are arbitrary only with minimum errors to record horizontal condylar inclination and their accuracy has been evaluated. Radiographic method to record horizontal condylar inclination is an easy method of recording the horizontal condylar angle by both dentists as well as for patient. Moreover, these values are accepted more accurate than the clinically established values in semi-adjustable articulator.

The present study was performed to evaluate the horizontal condylar angle using Computerised Digital Cephalometric tracing and to assess the effectiveness of three different horizontal reference planes described by Fenn, Shillingburg and Frankfort horizontal plane to compare it with clinically established horizontal condylar angle value.

This study was performed on thirty dentulous subjects, and clinical horizontal condylar angle value was obtained after face bow transfer and programming the semi-adjustable articulator with protrusive jaw relation record. Lateral cephalogram was obtained and computerized digital cephalometric tracing was done for three different horizontal reference planes. The results obtained were statistically analyzed.

Within the limitations of the present study and from the observation of the results of the study, the following conclusions were drawn:

1. The mean value of clinically obtained horizontal condylar angle and that of radiographic method using Ala-tragus line (Camper's plane) was not shown very significantly different on both right and left sides when condylar path was traced using only the posterior slope of articular eminence (posterior reference).
2. The mean value of clinically obtained horizontal condylar angle was significantly different from that of radiographic method using both Shillingburg's horizontal reference plane and Frankfort horizontal reference plane on both right and left sides when condylar path was traced using only the posterior slope of articular eminence.
3. The mean value of clinically obtained horizontal condylar angle value was significantly different from all the three planes established on radiograph on both right and left side when condylar path was traced from posterior slope of articular eminence to contacting incisal edges of maxillary and mandibular anterior teeth (anterior reference).
4. The significant difference between the clinically established horizontal condylar angle values with that of radiographic method was observed when two reference points (anterior and posterior) were used instead of posterior reference point alone. This variation indicated that the horizontal condylar path (track) not always passes through the contacting incisal edges even though it do occur in some individuals.

The results of this study demonstrated that the radiographic method can be used successfully as an adjunct to clinical methods of obtaining horizontal condylar inclination using Ala-tragus plane, but it is necessary to correlate these two values by the prosthodontist based on his judgement and expertise before proceeding with the programming of the articulator.

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APPENDICES

INFORMATION SHEET

- We are conducting a study on "A comparative study of Horizontal condylar angle value of three different concepts through computerized Digital Cephalometric tracing" among patients attending T.N.G.D.C. & H, Chennai. We are selecting patients for this study.

- The identity of the patients 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.

- The results of the special study may be intimated to you at the end of the study period or during the study.

Name of the patient Signature/Thumb impression

Name of the investigator Signature Date

INFORMED CONSENT FORM

Title of work:

A COMPARATIVE STUDY OF HORIZONTAL CONDYLAR ANGLE VALUE OF THREE DIFFERENT CONCEPTS THROUGH COMPUTERISED DIGITAL CEPHALOMETRIC TRACING

Name: OP No:

Address: Case No:

Age:

Sex:

I, ……. exercising my free power of choice, hereby give my consent to be included as a participant in the clinical study. I agree the following:

- I have been informed to my satisfaction about the purpose of the study, nature of the treatment and study procedure.
- I understand that dentist may stop my participation from clinical study for any reason. I am also aware of my right to opt out of study at any time during the clinical study duration without any reason

I hereby give my permission to use my records for research purpose and I am told that study institution and dentist will keep my identity confidential.

Name of the patient Signature and Date

<u>சுய ஒப்புதல் படிவம்</u>

ஆய்வு செய்யப்படும் தலைப்பு

இடைபட்ட காண்டைலார் கோண மதிப்பு பற்றி கணினி எண்முறை ஷெ:பெலோமெட்ரிக் தடமறிவதை பயன்படுத்தி ஒரு ஒப்பிட்டு ஆய்வு

ஆராய்ச்சி நிலையம் : அரசு பல் மருத்துவக்கல்லூரி
சென்னை - 600 003.

பங்கு பெறுபவரின் பெயர் :

பங்கு பெறுபவரின் எண் :

பங்கு பெறுபவரின் பிறந்த தேதி : ...../...../.....
தேதி மாதம் வருடம்

இப்படிப்பு சம்பந்தமாக நான் மேலே கூறப்பட்ட தகவல் படிவத்தை முழுமையாக படித்துப் பார்த்தேன் என்று உறுதி கூறுகிறேன்.

நான் இது தொடர்பான அனைத்து கேள்விகளுக்கும் நிறைவான பதில்கள் பெறப்பட்டேன்.

இந்த ஆய்வின் எனது பங்கு தன்னிச்சையானது என்றும் எந்த நேரத்திலும் இந்த ஆய்வில் இருந்து சட்ட உரிமைகள் பாதிக்கப்படாமல் விலகிக் கொள்ள சம்மதிக்கிறேன்.

மருத்துவ ஆய்வு அதிகாரிகள், எனது சிகிச்சை தொடர்பான பதிவேடுகளை பார்வையிடவும் எந்த நேரத்திலும், ஆய்வில் இருந்து நான் விலகினாலும் பார்வையிட சம்மதிக்கிறேன். எனது அடையாள குறிப்புகள் மூன்றாவது நபருக்கு தெரிவிக்கப்படமாட்டாது என்று புரிந்து கொண்டேன்.

இந்த ஆய்வு அறிக்கைகளை பயன்படுத்தவும், வெளியிடவும், நான் சம்மதிக்கிறேன். ஆய்வாளர் எனது மருத்துவக் குறிப்புகளை வெளியிட தடையாக இருக்க மாட்டேன் என உண்மையாக சம்மதிக்கிறேன்.

பங்கேற்பவரின் கையொப்பம் ..... இடம் ..... தேதி
கட்டை விரல் ரேகை

பங்கேற்பவரின் பெயர் மற்றும் விலாசம் .....
ஆய்வாளரின் கையொப்பம்..... இடம் ..... தேதி
ஆய்வாளரின் பெயர் .....

INSTITUTIONAL ETHICAL COMMITTEE

Tamil Nadu Government Dental College and Hospital, Chennai - 3
Telephone No. 044 2534 0343
Fax 044 2530 0681

Ref.No.0430/ DE/ 2010 Date: 29.11.2012

Title of the work: "A comparative study of Horizontal Condylar angle value of two different concepts through Computerized Digital Cephalometric tracing'

Principal investigator: **Dr.Pallavi Vashisht,**
III Year MDS

Department : Prothodontics and crown and bridge,
Tamil Nadu Government Dental College and Hospital, Chennai - 3

The request for an approval from the Institutional Ethical Committee (IEC) considered on the IEC meeting held on **26-07-2012** at the Principal's Chambers Tamil Nadu Government Dental College and Hospital, Chennai – 3 and subsequent to your modification letter dated 29.11.2012, You are

"Advised to proceed with the study"

The Members of the Committee, the secretary and the Chairman are pleased to approve the proposed work mentioned above , submitted by the principal investigator.

The principal investigator and their team are directed to adhere the guidelines given below:

1 .You should get detailed informed consent from the patients / participants and maintain confidentiality

2. you should carry out the work without detrimental to regular activities as well as without extra expenditure to the Institution or Government.

3 You should inform the IEC in case of any change of study procedure , site and investigation or guide.

4. You should not deviate from the area of work for which you have applied for ethical clearance

5. You should inform the IEC immediately in case of any adverse events or serious adverse reactions. You should abide to the rules and regulations of the institution (s)

6. You should complete the work within the specific period and if any extension of time is required, you should apply for permission again and do the work.

7 .You should submit the summary of the work to the ethical committee on completion of the work.

8. You should not claim funds from the Institution while doing the work or on completion.

9.You should understand that the members of IEC have the right to monitor the work with prior intimation

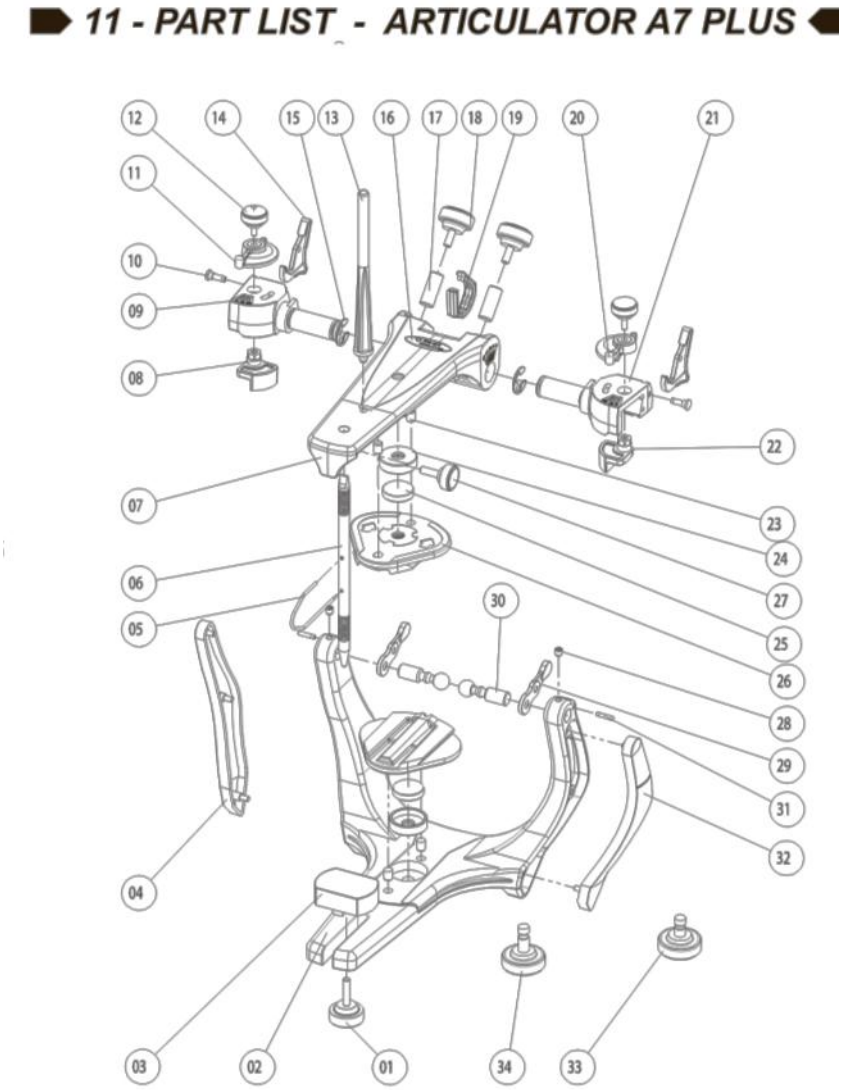
10. Your work should be carried out under the direct supervision of your Guide / Professor.

S Jayachand 29/11/12
SECRETARY

29/11/12
CHAIRMAN

APPENDIX I

PARTS OF BIO-ART SEMIADJUSTABLE ARCON ARTICULATOR



Item	Qty	Code	Description
1	1	SCRE0078	INCISAL TABLE SCREW
2	1	FRAM0731	LOWER FRAME A7
3	1	FMES0063	INCISAL TABLE STANDARD (POLYCARBONATE)
4	1	FTAP0761	FINISHING COVER OF RIGHT COLUMN
5	1	FAGU0753	OCCLUSAL PLAN INDICATOR
6	1	FPIN0750	INCISAL PIN WITH HOLE
7	1	FRAM0740	UPPER FRAME A7 PLUS
8	1	SALH0075	BENNETT ANGLE ADJUSTING DEVICE (RIGHT)
9	1	SGUI0073	CONDYLAR GUIDE (RIGHT)
10	2	FPIN0744	STABILIZING SILICONE BAND PIN
11	1	FPOS0759	POSITION INDICATOR OF BENNETT ANGLE ADJUSTING DEVICE (RIGHT)
12	2	SCRE0099	SCREW TO FIX THE BENNETT ANGLE ADJUSTING DEVICE
13	1	CPIN1197	UPPER FRAME SUPPORT PIN
14	2	FTRA0765	LOCK OF UPPER FRAME
15	2	CANE0319	CONDYLAR GUIDE O-RING
16	1	CETQ1113	MODEL IDENTIFICATION LABEL
17	2	FFIX0766	CONDYLAR GUIDE FIXER
18	2	SCRE0008	CONDYLAR GUIDE SCREW
19	1	FTAP0764	PULLEY FINISHING COVER
20	1	FPOS0758	POSITION INDICATOR OF BENNETT ANGLE ADJUSTING DEVICE (LEFT)
21	1	SGUI0072	CONDYLAR GUIDE (LEFT)
22	1	SALH0074	BENNETT ANGLE ADJUSTING DEVICE (LEFT)
23	4	FPIG0076	MOUNTING PLATE GUIDE PIN
24	2	FCAN0755	MAGNETIC FITTING
25	2	CIMA1118	RAIL MOUNTING PLATE MAGNETIC
26	2	SPLA0079	RAIL MOUNTING PLATE
27	1	SCRE0011	INCISAL PIN SCREW
28	2	CPAR1119	CONDYLAR ELEMENT SCREW
29	2	CMOL1100	STABILIZING SILICONE BAND
30	2	FECD0734	CONDYLAR ELEMENT
31	2	FPIG0788	FACE BOW'S GUIDE PIN
32	1	FTAP0760	FINISHING COVER OF LEFT COLUMN
33	1	SCRE0082	MOUNTING PLATE SCREW (LOWER FRAME)
34	1	SCRE0010	MOUNTING PLATE SCREW (UPPER FRAME)

APPENDIX II

S.No	Clinically obtained horizontal condylar angle value	Radiographic value with Shillingburg's horizontal reference plane	Radiographic value with Ala tragus plane	Radiographic value with Frankfort horizontal plane
1.	R- 35 degree L-34 degree	36 degree	26 degree	37 degree
2.	R-38 degree L-36 degree	27 degree	18 degree	26 degree
3.	R-38 degree L-40 degree	21 degree	17 degree	29 degree
4.	R-35 degree L-33 degree	34 degree	28 degree	26 degree
5.	R- 38 degree L- 32 degree	28 degree	22 degree	26 degree
6.	R-36 degree L-34 degree	28 degree	25 degree	29 degree
7.	R-24 degree L-25 degree	27 degree	24 degree	25 degree
8.	R- 39 degree L- 36 degree	24 degree	26 degree	27 degree
9.	R- 38 degree L- 40 degree	34 degree	26 degree	24 degree
10.	R- 40 degree L- 43 degree	30 degree	22 degree	32 degree
11.	R- 34 degree L- 32 degree	26 degree	18 degree	29 degree
12.	R-34 degree L-36 degree	25 degree	18 degree	27 degree
13.	R-38 degree L- 40 degree	23 degree	20 degree	25 degree
14.	R- 36 degree L-38 degree	25 degree	17 degree	24 degree
15.	R - 32 degree L -34 degree	29 degree	24 degree	26 degree
16.	R - 38 degree L -42 degree	34 degree	26 degree	30 degree
17.	R - 34 degree L -30 degree	32 degree	24 degree	30 degree
18.	R - 36 degree L - 32 degree	34 degree	20 degree	25 degree

19.	R - 40 degree L - 38 degree	34 degree	26 degree	30 degree
20.	R - 35 degree L - 38 degree	30 degree	20 degree	26 degree
21.	R - 42 degree L - 44 degree	32 degree	26 degree	34 degree
22.	R- 38 degree L- 36 degree	29 degree	24 degree	30 degree
23.	R- 32 degree L -36 degree	3o degree	19 degree	26 degree
24.	R - 42 degree L - 44 degree	35 degree	30 degree	38 degree
25.	R- 40 degree L- 36 degree	32 degree	24 degree	30 degree
26.	R-38 degree L- 34 degree	32 degree	27 degree	30 degree
27.	R- 44 degree L- 40 degree	38 degree	28 degree	32 degree
28.	R- 32 degree L- 36 degree	26 degree	18 degree	28 degree
29.	R- 32 degree L- 38 degree	27 degree	20 degree	22 degree
30.	R- 36 degree L- 32 degree	28 degree	17 degree	32 degree

APPENDIX III

S.No	Clinically obtained horizontal condylar angle value	Radiographic value of shillingburgs horizontal reference plane	Radiographic value of Ala-Tragus plane	Radiographic value of Frankfort horizontal plane
1.	R- 35 degree L-34 degree	36 degree	32 degree	37 degree
2.	R-38 degree L-36 degree	42 degree	34 degree	47 degree
3.	R-38 degree L-40 degree	34 degree	30 degree	45 degree
4.	R-35 degree L-33 degree	52 degree	45 degree	56 degree
5.	R- 38 degree L- 32 degree	47 degree	40 degree	52 degree
6.	R-36 degree L-34 degree	35 degree	32 degree	43 degree
7.	R-24 degree L-25 degree	45 degree	40 degree	52 degree
8.	R- 39 degree L- 36 degree	40 degree	39 degree	47 degree
9.	R- 38 degree L- 40 degree	44 degree	39 degree	52 degree
10.	R- 40 degree L- 43 degree	44 degree	43 degree	46 degree
11.	R- 34 degree L- 32 degree	45 degree	36 degree	50 degree
12.	R-34 degree L-36 degree	41 degree	34 degree	49 degree
13.	R-38 degree L- 40 degree	37 degree	32 degree	44 degree
14.	R- 36 degree L-38 degree	46 degree	39 degree	53 degree
15.	R -32 degree L -34 degree	49 degree	45 degree	57 degree
16.	R -38 degree L -42 degree	34 degree	36 degree	44 degree

17.	R -34 degree L -30 degree	44 degree	40 degree	50 degree
18.	R -36 degree L 32 degree	48 degree	44 degree	50 degree
19.	R 40 degree L -38 degree	40 degree	38degree	44 degree
20.	R -35 degree L -38 degree	42 degree	36 degree	44 degree
21.	R -42 degree L -44 degree	44 degree	38 degree	46degree
22.	R- 38 degree L- 36 degree	43 degree	40 degree	46 degree
23.	R- 32 degree L -36 degree	44 degree	40degree	46 degree
24.	R -42 degree L -44 degree	43 degree	40 degree	46 degree
25.	R- 40 degree L- 36 degree	45 degree	42 degree	48 degree
26.	R-38 degree L- 34 degree	45 degree	43 degree	46 degree
27.	R- 44 degree L- 40 degree	38 degree	36 degree	45 degree
28.	R- 32 degree L- 36 degree	39 degree	37degree	43 degree
29.	R- 32 degree L- 38 degree	41 degree	38 degree	47 degree
30.	R- 36 degree L- 32 degree	44 degree	40 degree	48 degree

PHOTOGRAPHS