GEOMETRICAL ANALYSIS OF OCCLUSAL PLANE USING FRANKFORT HORIZONTAL PLANE - A CEPHALOMETRIC COMPARATIVE STUDY

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CERTIFICATE

This is to certify that this dissertation titled **"Geometrical Analysis of Occlusal Plane Using Frankfort Horizontal Plane – A Cephalometric Comparative Study"** is a bonafide record of work done by **Dr. Neha Sood** under my guidance during his postgraduate period between 2008- 2011. This Dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY**, in Partial fulfilment of requirements for the Degree of **Master of Dental Surgery in Prosthodontics and Crown & Bridge (Branch 1).**

It has not been submitted (partial or full) for the award of any other degree or diploma.

GUIDE

Dr. C. SABARIGIRINATHAN, M.D.S.

Senior civil Surgeon
Associate Professor
Department of Prosthodontics
Tamilnadu Government Dental College & Hospital , Chennai - 03

HEAD OF THE DEPARTMENT

Dr. C. THULASINGAM, M.D.S.

Professor & Head
Department of Prosthodontics
Tamilnadu Government Dental & College & Hospital, Chennai – 03

PRINCIPAL

Dr.K.S.G.A.NASSER, M.D.S.
TamilNadu Government Dental College & Hospital
Chennai – 600 003

DECLARATION

I, **Dr. Neha Sood**, do hereby declare that the dissertation titled "**Geometrical Analysis of Occlusal Plane Using Frankfort Horizontal Plane – A Cephalometric Comparative Study"** was done in the Department of Prosthodontics, Tamil Nadu Government Dental College & Hospital, Chennai - 600 003. I have utilized the facilities provided in the Government Dental College for this study in partial fulfillment of the requirements for the degree of **Master of Dental Surgery** in the speciality of **Prosthodontics and Crown & Bridge (Branch I)** during the course period 2008-2011 under the conceptualization and guidance of my dissertation Guide **Dr. C. Sabarigirinathan, 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.

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

Signature of the PG Student Signature of the HOD

Signature of the Head of the Institution

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LIST OF ABBREVIATIONS

S No	Abbreviation	Expansion
1	ANOVA	Analysis of Variance
2	HIP	Hamular notch-Incisive Papilla plane
3	kVp	Kilo Voltage Potential
4	OP	Occlusal Plane
5	FH	Frankfort Horizontal plane
6	AT	Ala-Tragus line
7	mA	Milliamperes
8	mm	Millimeters

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Introduction

"The occlusion of the teeth is the most potent factor in determining the stability in the new position." This was written by Kingsley in the nineteenth century and will always hold true.

Complete Denture Prosthetics is the dental specialty, which places the greatest number of important factors in the control of the operator. Here the Operator is concerned with the shape, size, and relative position of the ridges; the positioning of the artificial teeth in relation to the ridges; the arrangement of the anterior teeth for esthetics; the determination of the incisal guidance angle; condylar function and the combined influence of the incisal guidance angle and condylar function on the orientation of the plane of occlusion and the curve of Spee.

All these factors must be carefully considered in order to provide dentures that function successfully. One can, without going into detail, appreciate the modifications of tooth form and size required by alterations in condylar function, the incisal guidance angle, the Curve of Spee, and the orientation of the plane of occlusion. The interrelation of these various factors is conspicuously apparent. The more guides there are to these factors, the simpler the task. Various methods of recording mandibular function, vertical dimension, incisal guidance angle, and tooth form have been devised and advocated.

Occlusal plane position is the foundation of clinical treatment and one of the most important criteria used to judge the degree of treatment success. Much research

is being done in this area; unfortunately little clinical application has filtered into treatment procedures.

In complete denture construction, the prosthodontist is responsible for restoring the natural esthetics of the patient and for developing an occlusion that is compatible with the functional movements of the mandible. From the functional viewpoint, the occlusal table is a milling surface, strategically placed so that the tongue on the lingual side and the buccinator muscle on the buccal side are able to position the food bolus onto it and hold it there while mastication takes place.

According to the **Glossary of Prosthodontic terms,** the occlusal plane is defined as "***the average plane established by the incisal and occlusal surfaces of the teeth. Generally, it is not a plane but represents the planar mean of the curvature of these surfaces."***

The orientation of occlusal plane is lost in patients rendered edentulous and should be relocated if complete dentures are to be aesthetic and to function satisfactorily. Where the occlusal plane is too high, the tongue cannot rest on the lingual cusps of the lower denture and prevent its displacement. There is also a tendency for accumulation of food in the buccal and lingual sulci. An occlusal plane that is too low, could lead to tongue and cheek biting.

The correct orientation of the occlusal plane plays a vital role in optimal esthetic achievement. In the natural smile, the incisal tips follow the curve of the

lower lip. If the plane hangs posteriorly, the lip line viewed from the front will appear straight and contribute more than any other factor to the so called **"Denture look"**. With the occlusal plane correctly oriented, however the natural anterior curve will be achieved almost automatically and contribute a proper sense of perspective to the dental composition.

The function and esthetics of removable prostheses are dependent on the correct orientation of the occlusal plane. Many theories and methods have been proposed over the years to facilitate correlation of the artificial occlusal plane to the natural one. The precise location of the occlusal plane for edentulous patients is a controversial matter. There appears to be a lack of agreement on how it should be orientated for individual patients.

Camper's line, postulated in 1780 by the Dutch anatomist **Peter Camper**, extends from the alae of the nose to the center of the external auditory meatus and is widely used as a guide in the orientation of the occlusal plane. There are intraoral landmark which are used by the authors to determine the occlusal plane, these include height of retromolar pad, the buccinators grooves, commisures of lips, and lateral border of the tongue.

However, in the edentulous patient, locating the occlusal plane in the same position as it was when natural teeth were present is ideal. The occlusal plane should be established as nearly as possible to the position of occlusal plane of the natural dentition.

Anthropologists have long studied the ethnographic determination of facial form and pattern. By studying different ethnic, age, and sex groups and by measuring the size of the various parts and recording variations in position of cranial and facial structures , broad standards were devised that describe the human head . As a specialised part of anthropometry, "the measurement of man", study of the head became known as **"craniometry"** or **"cephalometry".**

Cephalometric analysis has served for many years as a valuable adjunct to dental research and diagnosis. Although its clinical application has been directed largely toward orthodontics, yet cephalometrics is valuable tool in Prosthodontics to re-establish the spatial position of lost structures such as the teeth. This is achieved by identifying predictable relationships between the teeth and other cranial landmarks that are not subject to post extraction changes.

Frankfort Horizontal plane has long been considered as a reliable reference plane used for cephalometric analysis in Orthodontics. Its use in Prosthodontics is documented with equal success and it can serve as a useful reference plane in performing cephalometric studies in edentulous patients.

The search for a method that establishes an occlusal plane that is in complete harmony with the enviorenment of an edentulous situation is yet not accomplished. The present study was undertaken to evaluate and establish an occlusal plane in edentulous patients that more closely resembles the one occurring naturally. Three methods were tried for occlusal plane determination Viz. parallel to Camper's plane,

parallel to the plane between the corner of the mouth and the junction of middle and upper third of the retromolar pad, and parallel to Hamular notch-Incisive Papilla plane to evaluate the most physiologic position of occlusal plane in Complete Denture wearers.

The Null hypothesis was presumed as, all the three methods used to establish the occlusal plane in edentulous patients tend to position it close to the one that occurs naturally.

Aim:

To evaluate and establish a reliable method of occlusal plane determination in edentulous individuals

Objectives:

1. To evaluate the close relationship of the occlusal plane established in edentulous group with that of dentate individuals.

2. To determine the reliability of Camper's plane, junction of middle and upper third of the retromolar pad, and Hamular notch-Incisive Papilla plane to establish the occlusal plane in edentulous individuals.

3. Cross verifying the results obtained from the dentulous group to the edentulous subjects.

The occlusal plane position is the foundation of clinical treatment and one of the most important criteria used to judge the degree of treatment success. It is an important factor which harmonizes morphology and function of stomatognathic system.

Various authors have defined the occlusal plane in many different ways. The various definitions of the occlusal plane in the literature are as follows:-

1. "An imaginary surface that touches the incisal edges of incisors and tips of the occluding surface of the posterior teeth".[1]
2. "A line bisecting the molar and incisor overbite".[2]
3. "A line extending from mesio incisal angle of upper central incisor to the mesiopalatal cusp of first maxillary molars".[3]
4. It represents the functional table of occlusion in the first permanent molar, second premolar and the first premolar area.
5. **a.**The average plane established by the incisal and occlusal surfaces of the teeth. Generally, it is not a plane but represents the planar mean of the curvature of these surfaces.

b.The surface of wax occlusion rims contoured to guide in the arrangement of denture teeth.

c. A flat metallic plate used in arranging denture teeth - comp to curve of occlusion.[5]

This review of literature aims to clarify the various concepts concerning the occlusal plane orientation and the different techniques followed by various authors in their attempts to correctly orient the occlusal plane. It was also necessary to stress the importance of finding sound principles for proper orientation of the occlusal plane in Complete Denture Prosthodontics. The following are the reviews given by various authors for the orientation and establishment of the occlusal plane.

Robert B. Sloane and Jack Cook, 1953[6] performed a study to determine whether or not there was any correlation between fixed cranial landmarks and the plane of occlusion. It was concluded that;

1. Cook's plane forms an angle with the plane of occlusion which falls within predictable limits.
2. The angle formed by Cook's plane and the plane of occlusion is related to the distance from the anterior nasal spine to the hamular notch. The greater the distance, the more acute the angle; the shorter the distance, the more obtuse the angle.
3. Though there is a certain bilateral asymmetry in the skulls and casts measured. It is negligible in its effect on the basic correlations.
4. Though the distances from the anterior nasal spine and the hamular notches to the plane of occlusion varied, the difference between the two measurements approached a constant, enough to permit the practical use of the average value.

5. Within esthetic considerations, the anterior aspect of the plane of occlusion should be kept parallel to the pupils of the eyes.

Also from the study it was concluded that, it is important to select points of references that would not be affected by the degenerative process and that could readily be identified on the edentulous maxillary casts. Since the ANS is difficult to locate on the edentulous maxillary cast, incisive papilla seems to be a viable option.

Howard J. Merkeley, 1954[7] advocated the use of vestibular impressions for the location of occlusal plane. A series of four vestibular impressions were made in an effort to analyze the exact location, effect, and various and changing applied action of the accessory masticatory muscles, during the masticatory cycle. The subject had natural dentition and the teeth were barely occluded and the impression material was plastic. The first impression was made with the lips protruded, and so maintained until the impression had set. The impression showed 1) A deep horizontal groove that had been made by the horizontal fibres of the buccinators muscles when they were stretched during lip protrusion.

2) A triangular depression where the stretched fibres of the triangularis muscle impinged on the impression material. The bottom of the groove cut by the buccinators muscle proved to correspond with the occlusal plane. This suggested a simple method of locating the correct position for the occlusal plane for complete dentures. The technique is to make bilateral vestibule impression with the trial bases in place and very lightly occluded, and with lips well protruded. The bottom of the groove cut by

the buccinators muscle is perforated by a line of holes reaching into the wax base, and the occlusal plane is adjusted to this line of holes.

Hall WA, 1958,[8] proposed that each patient's occlusal plane is consistent with his oral physiology and esthetic requirement. To orient any plane in space, 3 points must be located. In the denture space, one is located in the anterior region, and one is in each of the posterior segments. The anterior height of the occlusal plane is determined by the length of the incisal edge of the upper occlusion rim above or below the upper lip while it is in repose and when the lip is properly supported. The two posterior points of orientation of the occlusal plane fall within the height of the distal half of the retromolar pad. The entire plane is parallel to the ridge planes.

Smith ES, 1958[9] stated that the height of the occlusal plane anteriorly should be in harmony with the type of lip. Rather than to follow a set rule for establishing the anterior segment of this plane slightly below the border of the relaxed upper lip, as is so often recommended, the plane of orientation should be above and hidden if the lip is long and flexible, or it should be below and plainly in view if the lip is short, tight, and tense. It is only for those patients who have lips of average length that the plane of orientation should be slightly below the relaxed upper lip. From the frontal aspect, the plane of orientation should be horizontal. It may not be parallel with a line through the pupils of the eyes, as this line is not always horizontal. The plane of orientation should be parallel with the floor as the patient stands erect. An estimation of this parallelism can be made easily by observation while the dentist stands at arms' length in front of the patient and stretches the corners of the patient's mouth. The

approximate height of the plane posteriorly can be estimated by placing the tip of one's index finger over the mandibular ridge. Then while the mandible is thus held in a position of approximate centric relation, the imaginary plane can be projected posteriorly. If the plane is properly located, it will intersect the retromolar pad at or near its base.

McGee GF, 1960[10] proposed that the triangular retromolar pads are outlined in pencil on the lower edentulous cast, and marks are made on the cast opposite the apex of the triangle. The pads are bisected in an anteroposterior direction, and marks are also made on the cast opposite these points. The first mark indicates the position of the distal surface of the second molar, and the second mark indicates the height of the occlusal plane. The occlusal plane to retromolar pad relationship may be observed on any lower cast of natural teeth where the third molars are missing. The older method of placing the occlusal plane at a point midway between the upper and lower edentulous ridges often places it too high in relation to the lower ridge. The additional leverage thus created usually causes discomfort to the denture patient and instability of the denture. It was also confirmed that the incisive papilla remains in a constant position. Even after the removal of teeth the papilla remains in its original position. However, because of progressive bone loss, especially that of the labial plate, an illusion is produced and the papilla seems to move forward.

Boucher CO, 1963[11]**,** was of the opinion that the occlusal plane should be oriented exactly as it was when the natural teeth were present. Thus, with the anterior teeth positioned correctly for esthetic appearance and with the posterior end of the

occlusal plane located approximately level with the top of the retromolar pad, the factor of orientation of the occlusal plane is fixed. If the relation of the soft tissues to the occlusal plane is important, the orientation of the occlusal plane becomes the third factor of occlusion.

Malson TS, 1964[12], proposed that Anatomic landmarks in the mouths of edentulous people can be used to locate accurately the height of the distal end of the occlusal plane. A straight edge placed on top of the lower cuspid and in contact with the crest of the highest cusp of the most posterior tooth in the mouth of a dentulous person will contact the retromolar pad about one quarter of the distance from its top. This phenomenon occurs even though some of the posterior teeth may have been lost and regardless of the age of the patient. Therefore, one quarter of the distance from the top of the retromolar pad is a reliable anatomic landmark for the height of the distal end of the occlusal plane.

Ismail YH and Bowman JF., 1968[13] conducted a roentgenographic cephalometric investigation to compare the position of the occlusal plane of the artificial teeth with that of the natural teeth which existed before the remaining teeth extracted. Occlusal plane of the trial dentures was first oriented to parallel the ala-tragus line and then modified so that the occlusal surfaces of the second molars were placed at the level of the middle third of the retromolar pad. This location of the artificial occlusal plane was found to be at a lower level than the natural one in the posterior region. Hence, the findings indicate that the occlusal plane should be

positioned so that the second molars are placed at the level of the upper third of the retromolar pad.

Lundquist DO and Luther WW, 1970[14], undertook an investigation to determine whether certain intraoral landmarks could accurately predict the location of occlusal plane. The relationship between the plane of occlusion and the retromolar pad, the parotid papilla, the buccinator grooves, and the commissure of the lips was evaluated in subjects with ideal occlusions of natural teeth. Because of the close correlation found among the occlusal plane, the buccinators grooves, and the commissures of the lips, a vestibular impression technique is suggested for determining the location of the occlusal plane in completely edentulous individuals.

Javid NS, 1974[15] stated that it is difficult to establish a correct occlusal plane without using an extra device (tongue blade, ruler, or the like). A J-shaped aluminum device, called a "J plane" for use with a Fox planet to establish the occlusal plane was suggested. Place the narrow side of the J plane against the nasion with its long axis passing through the interpupillary line. The position of the anterior border of the Fox plane should be parallel with the border of the J plane.

L'Estrange PR. and Vig PS., 1975[16], conducted a study in dentulous and edentulous subjects to determine the location of occlusal plane as related to the maxillomandibular space. The results from both the dentulous and edentulous groups indicate a close angular affinity between the occlusal and maxillary planes. In the dentulous group, significant associations were found between the angulations of the

occlusal plane to the maxillary plane and the height and length of the maxillomandibular space. The occlusal plane in the long-and-low type of maxillomandibular space tends to be more parallel to the maxillary plane, while the occlusal plane in the short-and-high types of maxillomandibular space tends to be more steeply angulated to the maxillary plane. The occlusal plane deviates away from a mean angulation to the maxillary plane when the height and length of the maxillomandibular space tend to be toward the opposite extremes of the normal range.

Carey PD, 1978[17], conducted a study to test masticatory efficiency when tile orientation of the occlusal plane was varied. Complete dentures were constructed for subjects. Following three types of occlusal plane were constructed;

- *Occlusal plane A* -correspond with the lower border of the retromolar pad.
- *Occlusal plane B* - correspond with the junction of the lower and middle third of the retromolar pad.
- *Occlusal plane C* - correspond with the junction of the upper and middle thirds of the retromolar pad.

From the results obtained in this study it would appear that within certain limits function was not appreciably affected and that a certain amount of leeway is permissible when orienting the occlusal plane.

Okane *et al,* 1979[18], conducted a study to investigate the effect of anteroposterior inclination of the occlusal plane on muscle activity during clenching and biting force and to estimate physiologically the applicability of the ala-tragus line. The integrated electromyographic activity and biting forces of patients were examined at three different anteroposterior inclinations of the occlusal plane at a constant vertical dimension of occlusion. The following **conclusions** were reached;

1. Biting force during maximum clenching was the greatest when the occlusal plane was made parallel to the ala-tragus line. It decreased when the occlusal plane was inclined about 5 degrees anteriorly or about 5 degrees posteriorly.

2. The efficiency of biting force exertion during maximum clenching showed the best value when the occlusal plane was made parallel to the ala-tragus line.

3. Muscle activity during clenching at various given forces was least when the occlusal plane was made parallel to the ala-tragus line.

Douglas JB *et al*, 1983[19] A cephalometric continuing longitudinal investigation was to study the changes on the craniofacial complex in complete denture wearers; herein are reported the 20-year findings.

1. The mandible auto rotated in a counterclockwise direction resulting in the loss of vertical dimension of occlusion (decrease on lower face height) and an increase in relative prognathism (class III appearance).

2. The mandibular bony edentulous ridge height was significantly reduced; the maxillary was not.

3. The dentures exhibited a slight counterclockwise rotation and a slight anterior shift.

4. Statistically there were no significant differences between men and women and no significant differences between the groups wearing the standard dentures compared with the group wearing the complex dentures.

Tuncay OC. *Et al*, 1984[20], analyzed the longitudinal cephalometric head films of edentulous patients over a 10 year period. The purpose of the investigation was to document changes within the craniofacial complex, residual ridge resorption, and position of the dentures. The changes were correlated with the following variables: age, sex, skeletal pattern, number of years edentulous, technique of denture fabrication, and night time wear of the dentures.

Findings in this study suggest the following;

1. The maxillae and the mandible showed sagittal spatial counterclockwise displacement.
2. Complete dentures exhibit a counterclockwise rotation and forward movement.
3. Soft tissue seating is more important than alveolar ridge resorption in the positional changes of complete dentures.
4. Variation in denture techniques had no influence on the observed changes.
5. Artificial porcelain teeth did not show a measurable amount of attrition during the l0-year observation period.

6. Observed changes were not significantly affected by variables such as sex, year's edentulous, night time wear, or skeletal pattern. Two exceptions were that the skeletal pattern affects prognathism and number of years edentulous affects mandibular ridge resorption.

Van Niekerk FW., 1985[21], conducted a cephalometric study where complete dentures were fabricated with criteria other than the ala-tragus line used to establish the occlusal plane. Patients were completely satisfied with esthetics, function, and comfort. Lead foil adapted to the right mandibular posterior teeth indicated the occlusal plane. A strip of foil taped to the face pointed at the inferior borders of the ala and tragus. The study concluded that ala-tragus line has a close relationship with the occlusal plane and could be used as a landmark when the maxillary occlusion rim is trimmed to the occlusal plane. Positioning of the occlusal plane depends on mature clinical judgment and must ultimately satisfy esthetics, function, and denture stability.

Monteith BD., 1985[22], conducted a study to investigate the possibility of a correlation between the PoNANS (Porion-Nasion to Anterior nasal spine) angle and the occlusal angle formed by the intersection of the occlusal and Frankfort planes. The results obtained appear to uphold the hypothesis: an increase in the PoNANS angle has a flattening effect on the orientation of the occlusal plane, while a narrowing of the angle appears to force the occlusal plane into assuming a steeper attitude. Arising out of the close interrelationship of these two variables is the

important benefit that if one of them is absent, its best value can be predicted from the measured value of the other.

Monteith BD., 1986[23], continued the study the accuracy with which an earpiece face bow can transfer the Frankfort horizontal and the reliability with which a PoNANS angle produced occlusal plane orientation is consistent with a natural looking dental composition. The difference between the radiographic and predicted occlusal plane angles was such that the final angle obtained was in no case greater than that originally intended. The flattening effect observed could be ascribed to an idiosyncracy manifesting as a tendency to locate the orbitale reference on the patient's face at a point slightly higher than its corresponding bony level. Alternatively, the weight of the face-bow might have been sufficient to cause the ear-rods to sag slightly, thus lowering the posterior reference point.

Chaconas SJ., 1986[24], proposed that there is a strong clinical indication that TMJ problems can occur when the posterior position of the occlusal plane is the furthest from the center of the ramus (X_i point). Therefore the occlusal plane should pass through the center of the ramus to ensure proper occlusal function. This plane usually passes through the superior half of the retromolar pad clinically.

Karkazis HC and Polyzois GL, 1987[25], conducted a Cephalometric study on eighteen dentulous subjects and fifty-six complete denture wearers to determine the location of the natural and artificial occlusal planes as related to Camper's plane.

The conclusions of this study can be summarized as follows;

1. The natural occlusal plane was not parallel to Camper's plane. The deviation between the two planes varied from -5° to +9° with an average of 2.88°.
2. The artificial occlusal plane determined at the delivery appointment on processed complete dentures was not parallel to Camper's plane. The deviation between the two planes varied from - 7 to +13° with an average of 3.25°.
3. The final anteroposterior inclination of the artificial occlusal plane on processed complete dentures was almost the same as the inclination of the natural occlusal plane.

Di Paolo RJ, 1987[26], presented a method that uses cephalometric lateral films to determine the occlusal plane position for the individual patient.

1. A relationship exists between the occlusal plane position and the lower-face skeletal pattern of the patient.

2. The occlusal plane position can be determined after identifying the individual skeletal pattern present.

3. Identifying the occlusal plane position becomes an important factor in dentistry, especially in procedures in which changes occur in the occlusal relation, such as in maxillofacial surgery, prosthetics, and orthodontics.

Sinobad D, 1988[27], conducted a cephalometric investigation to evaluate the spatial position of the occlusal plane to certain cranial landmarks in dentulous subjects with various skeletal jaw-relationships. The aim of the investigation was to establish the differences in its position in various natural occlusions which can be used as predictable guides in prosthetic treatment of edentulous patients. According to the results obtained no significant associations were observed between the position of the occlusal plane to the maxillary plane and skeletal relation of the jaws. However, concerning its relation to the mandibular plane, significant differences were found between the groups with various skeletal classes. This can be connected with the various positions of the mandible relative to the maxilla in various types of natural occlusions.

Richard KK, and Djeng SK, 1989[28], Craniofacial reference lines representing anatomic planes with prosthodontic importance were studied together with the angles reflecting maxillary dimensions for dentulous Chinese (Singaporean) adults by the use of lateral skull radiographs. The ala-tragus line showed high variability when oriented to the maxillary occlusal line and could limit its use as an index for the occlusal plane. A vertically high and horizontally receded upper face was found in Chinese subjects, which contrasted significantly with the norms reflected in a white (North American) population. These significant differences in skeletal pattern of the maxillary region could account for an increase in inclination of the Frankfort Horizontal plane for the Chinese subjects compared with the white subjects.

Richard KK and Djeng SK, 1990[29], conducted a study on dentulous Chinese adult men with lateral skull radiographs. The orientation of the plane of occlusion was analyzed in relation to traditional Prosthodontics planes. The use of the Frankfort Horizontal line in the assessment of occlusal line orientation was limited, attributing to the acknowledged variation of the Frankfort Horizontal line inclination between Chinese and Swedish (white) patients. The inclination of the maxillary occlusal line to Camper's line was significantly shallower by 1.6 degrees for Chinese Singaporean men compared with Swedish men. This difference was an indication that the anatomic cant of the occlusal line was shallower for the Chinese patients. The procumbent position of incisors characterized by Chinese patients is a major ethnic factor that accounts for the diminished inclination of the occlusal plane.

Karkazis HC, Polyzois GL., 1991[30], conducted a cephalometric study to check the hypothesis that the angulation of the occlusal plane is generally related to the skeletal base of the maxillae.

The following conclusions were made;

1. No evidence was found that any of the three studied parameters (Cook's plane, ANS-PNS, and PO Na ANS) could be used as a reliable guideline for determination of the occlusal plane through a regression formula.

2. The HIP plane tends to parallel the occlusal plane, giving one more guideline for its determination, although further clinical application is necessary.

3. Monteith's formula cannot determine the occlusal plane in edentulous subjects, although it provides occlusal planes closely oriented to the clinically determined ones.

Kazanoglu A. and Unger JW, 1992[31], presented a device called Camper's plane indicator to be used for establishing the plane of occlusion in complete dentures. This device is simple, practical, and accurate with all the necessary parts assembeled in one instrument and, in addition, the procedure can be performed by only one person. It is easy to use when the plane of occlusion of edentulous patients is to be made parallel with Camper's plane.

Celebiec, 1995[32], conducted a study to check the reliability of the intraoral method which orients the occlusal plane to terminate at the upper level of the retromolar pad. Thirty individuals all with natural teeth and 34 complete denture wearers participated in the study. Stone casts were mounted in the S.A.M. 2 articulator by a quick mount face bow transfer. The angle between the occlusal plane and the articulator horizontal plane was measured in both groups. The angle was 9.42 degrees +/- 4.1 degrees in dentate individuals and 8.53 degrees +/- 2.8 degrees in complete denture wearers. No statistically significant difference was found between the groups ($t = 0.72$, $P > 0.05$). Therefore, the method can be advocated for a wide clinical use, as it is a simple method and places the artificial occlusal plane very close to the position of the natural plane of occlusion.

D'Souza NL, 1996[33], performed a study to examine the validity of Camper's plane as a guide to determine the occlusal plane in edentulous subjects. Based on the data collected from the cephalometric tracing of the edentulous and dentulous subjects and with the use of the significant correlation of the variables of the maxillomandibular space established from the dentulous group, the dentulous and edentulous group were classified into four subdivision based on the length and maxillomandibular angle.

The following conclusions were made in this study;

1. A significant difference exists in the mean values of the occlusal maxillary plane angles between the dentulous and edentulous groups.

2. No significant difference existed in the mean values of the occlusal mandibular plane angles between the dentulous and edentulous groups in subdivision long and large and short an large

3. The reliability of camper's plane as a guideline to simulate the natural plane is questionable.

Nissan J. *et al*, 2003[34], conducted a study to investigate the relationship between the anatomical structures commonly used to determine the occlusal plane and the facial skeletal shape of complete dentures using cephalometric analysis. No correlation was found between the anatomical structures that could be used

productively to establish the occlusal plane in edentulous patients. At present, cephalometric analysis can only be used as a rough guide to occlusal plane location because of the wide variation in anatomical structures between subjects. Intra-oral structures must be considered.

Ciancaglini R. *et al,* 2003[35], conducted a study to assess the existence of any association between orientation of craniofacial planes with signs and symptoms of TMD in non-patient young adults having full natural dentition and normal occlusion. It was concluded that a weak association exists between signs and symptoms of TMD and orientation of craniofacial planes in young adults with normal occlusion, and that this relationship might be primarily expressed in head posture rather than in craniofacial morphology.

Shigli K.*et al,* 2005[36] performed a study to determine whether certain intraoral landmarks could accurately predict the location of occlusal plane and the relationship between the planes of occlusal, retromolar pad, parotid papilla, buccinators grooves was evaluated. By utilizing a vestibular impression technique it was possible to correlate the occlusal plane with the intraoral landmarks. The study concluded a close correlation among occlusal plane, buccinator groove and parotid papilla.

Jayachandran S, Ramachandran CR, Varghese R, 2008[37], carried out a study to assess the reliability of hamular notch/incisive papilla plane (HIP) in establishing the occlusal plane, by identifying the relationship between the two planes. Within the studied population, the HIP tends to parallel the occlusal plane.

Due to this observation, this plane may be used in the determination of inclination of occlusal plane during complete denture construction.

Shetty NL., 2009[38], conducted a study with the following aims and objectives:-

4. To identify intraoral landmarks such as parotid papilla, retromolar pad, buccinator groove and corner of the mouth and correlate them to occlusal plane.

5. To determine the degree of deviation if any, of each of these references to the established ala-tragus plane and determine the feasibility of these landmarks to obtain accurate occlusal plane.

The following conclusions were drawn from the study:-

1. A plane starting from the corner of the mouth through the buccinators groove is a reliable guide for accurate location of occlusal plane; the vestibular impression method is recommended as a routine clinical procedure for occlusal plane determination.

2. The mean vertical distance between the parotid papilla and occlusal plane is 3.94mm on the left side and 3.52 on the right side. Because of its variation and difficulty in accurately measuring the soft tissue landmark, the parotid papilla can only be used as an adjunctive aid in the determination of the occlusal plane.

3. The occlusal plane terminated in the upper half of the retromolar pad in 89% of the subjects, implying that the orientation of the occlusal plane to the upper half of the retromolar pad can also be used as a reliable landmark in the determination of the occlusal plane.

STUDY DESIGN:

This in-vivo comparative study was undertaken to compare the natural occlusal plane in dentulous subjects and established occlusal plane in edentulous patients cephalometrically based on angulations between inclinations of the occlusal plane in dentulous subjects with anatomical Frankfort horizontal plane. This study was performed from May 2009 to July 2010 in the department of prosthodontics , Tamilnadu 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.

ARMAMENTARIUM FOR CLINICAL EXAMINATION:

1. Kidney Tray
2. Mouth mirror
3. Cheek retractor
4. Disposable gloves
5. Mask
6. Torch

ARMAMENTARIUM FOR PRIMARY AND SECONDARY IMPRESSIONS AND CASTS:

1. Impression compound – Aslate (Punjab)
2. Hot water bath
3. Maxillary and Mandibular stock trays
4. Bard Parker blade no.15 and handle
5. Chip blower
6. Type II Dental plaster
7. Rubber bowl and spatula
8. Green stick compound(DPI)
9. Custom made self cure acrylic tray
10. Light body addition silicone impression material(virtual, Ivoclar)
11. Tray adhesive(Caulk, Dentsply)
12. Type III dental stone (Kalabhai)
13. Model trimmer

ARMAMENTARIUM FOR MAKING RECORD BASES AND OCCLUSAL RIMS:-

1. Autopolymerizing acrylic resin.(DPI)
2. Cold mold seal (DPI)
3. Wax sheet (Rolex)
4. Hot plate
5. Wax knife and spatula

ARMAMENTARIUM FOR ESTABLISHING OCCLUSAL PLANE BY METHOD I, II AND III

1. Thread
2. Plaster
3. Fox plane
4. Scale
5. Mandibular cast
6. Indelible marker
7. Dental Surveyor

ARMAMENTARIUM FOR OCCLUSAL PLANE EVALUATION

1. Cephalostat
2. X-ray film
3. X-ray film processing unit
4. Lead foils

ARMAMENTARIUM FOR CEPHALOMETRIC TRACING:

1. Lead acetate tracing paper
2. Mathematical instrument box (Faber castell)
3. X-ray view box
4. Lead pencil
5. Stapler

S.NO	NAME (COMMERCIAL NAME)	FORM OF THE MATERIAL	MANUFACTURER DETAILS
1.	Aslate impression compound	Impression compound	Aslate , India
2.	Jabbar trays	Stock tray	Jabbar & co. India
3.	White gold	Type II Dental plaster	Asian chemicals, India
4.	DPI Pinnacle tracing sticks	Green stick compound	DPI, The Bombay Burmah Trading Corporation, Mumbai
5.	Caulk Tray Adhesive	Tray adhesive	Caulk, Dentsply, U.S.A
6.	Virtual Light body	Light body addition silicone impression material	Ivoclar , Vivadent,U.S.A
7.	Kalstone	Type IIIdental stone	Kalabhai , India
8.	Model trimmer	Metal equipment	Confident dental equipments , India
9.	Rolex modelling wax	Wax sheets	Ashoosons, Delhi
10.	Dental Surveyor	Metal equipment	
11.	Cephalostate	X-ray machine	Panmeca , 2002 CC,Proline,
12.	X –ray film	Film	Indu , India

METHODOLOGY:

1. SOURCE OF DATA
2. SUBJECT SELECTION (DENTULOUS AND EDENTULOUS)
3. METHOD OF COLLECTION OF DATA FOR DENTULOUS SUBJECTS
4. MAKING PRIMARY AMD SECONDARY IMPRESSIONS AND CASTS
5. MAKING RECORD BASES AND WAX OCCLUSAL RIMS
6. ESTABLISHING OCCLUSAL PLANE BY THREE METHODS
7. ADAPTATION OF LEAD FOIL ON THE OCCLUSAL RIMS
8. TAKING LATERAL CEPHALOGRAM (ONE FOR EACH METHOD)
9. TRACING THE LATERAL CEPHALGRAM
10. METHOD OF STATISTICAL ANALYSIS

1. SOURCE OF DATA:

Patients reporting to the Department of Prosthodontics , Tamilnadu Government Dental College and Hospital.

2. SUBJECT SELECTION:

This study was done between two groups viz**. Group I** - consisting of 30 dentulous subjects and

Group II - Consisting of 30 edentulous subjects.

Each selected subject in group II was further included into three subgroups depending upon the method of establishment of the occlusal plane as:-

1. Group II A: all subjects in which the occlusal plane posteriorly was established using ala-tragus line as the reference.
2. Group II B: all subjects in which the occlusal plane posteriorly was established using anterior two third (junction of middle and upper third) of the retromolar pad and corner of the mouth anteriorly as the reference.
3. Group III C: all subjects in which the oclusal plane posteriorly was established using incisive papilla – hamular notch plane as the reference.

Selection criteria for Group I (Dentulous groups):

1. Subjects between age group of 35-45 years who were willing to participate in the study after being explained the purpose of the study.
2. Subjects having 28 to 32 natural teeth in acceptable arch alignment with angle's class I molar relationship.
3. Subjects with no history of orthodontic treatment.
4. Subjects with absence of any removable or fixed partial denture in the oral cavity

Selection criteria for Group II (Edentulous group)

1. Patient between age group of 50-60 years who were willing to participate in the study after being explained the purpose of the study.

2. Edentulous patients with normal (class I) ridge relationship.
3. Patient with no flabby ridges.
4. Patient with no physical disability which would interfere with the study.

3. METHOD OF COLLECTION OF DATA FOR DENTULOUS GROUP (GROUP I)

A right lateral cephalogram of each of the selected dentulous subjects was taken after keeping their jaw approximated in centric occlusion.

The cephalogram were taken from a cephalometric machine standardized by the following parameters:

1. Head position – the head was stabilized using a cephalostat in a natural head position (that is standing erect with Frankfort horizontal plane parallel to the floor and eyes looking straight ahead at a fixed point at the level.
2. Distance between head and cassette - 5 inches
3. Voltage – 75 KVP
4. Current -12 MA
5. Exposure time – 20 millisecond
6. Storage phosphor plate (SPP) - (8” X 10”)

To ensure utmost accuracy of the study, the cephalostat with its long target to the subject distance minimized the distortion of the radiographic image.

4. MAKING PRIMARY AND SECONDARY IMPRESSIONS AND CASTS

Primary impressions were made using impression compound and primary casts were made with Type II dental plaster and custom trays are fabricated using autopolymerizing acrylic resin by dough method.

Using green stick compound and light body impression material, secondary impressions were made using selective pressure impression technique and master casts are made by Type III dental stone.

5. MAKING RECORD BASES AND WAX OCCLUSAL RIMS

Record bases were made on the master casts using autopolymerizing acrylic resin. After checking the stability of the record bases intraorally , occlusal rims were made with modelling wax. Three sets of record bases and bite blocks were made ,one for each of the three methods for establishing the occlusal plane employed in the study.

6. ESTABLISHING OCCLUSAL PLANE BY THREE METHODS

METHOD I:

The occlusal plane was established in the maxillary occlusal rim . Anteriorly, the plane is established by shaping the occlusal rim so that the incisal plane is parallel to the interpupillary line.[39] The upper lip is used as guide to determine the height of

the occlusal rim anteriorly by keeping the incisal edge of the rim 2mm below the resting upper lip.[16]

Posteriorly, the occlusal plane is established by making it parallel to the ala-tragus line. Ala-tragus line is marked on the patient's face with a thread coated with plaster. The inferior most point on the ala and the middle of the tragus was taken as the anterior and posterior reference points respectively.[40] The parallelism of the plane of the rim to the ala-tragus line is checked with a Fox plane-guide. The patient's head is kept erect during this procedure so that the Frankfort horizontal plane is parallel to the floor. Once the occlusal plane is established, the lower occlusal rim is adjusted to meet evenly with the upper rim and reduced until sufficient interocclusal distance has been obtained.[39]

METHOD II:

The occlusal plane was established in the mandibular occlusal rim. Anteriorly, the plane is established by shaping the occlusal rim so that the incisal plane is in level with the lower lip and the corners of the mouth in a relaxed state. As it goes posteriorly, the occlusal rim is kept at the level of the lateral border of the tongue.

Posteriorly, the plane of the occlusal rim is shaped to the level of the anterior two thirds (junction of middle and upper third) of the retromolar pad. On the mandibular master cast, the retromolar pad areas are marked with an indelible marker on both right and left side. The marked areas are then divided into three equal thirds and the corresponding points are marked on the land areas of the cast. Keeping these

markings in consideration, the posterior plane of occlusion is established at the level of two thirds of the height of the retromolar pad. The plane is then confirmed intraorally. Once the plane of occlusion has been established, the maxillary occlusal rim is adjusted to meet evenly with the mandibular rim and reduced until sufficient interocclusal distance has been obtained.

METHOD III:

The occlusal plane was established in the maxillary occlusal rim. Anteriorly, the plane is established by shaping the occlusal rim so that the incisal plane is parallel to the interpupillary line. The upper lip is used as guide to determine the height of the occlusal rim anteriorly by keeping the incisal edge of the rim 3mm below the resting upper lip.

Posteriorly, the occlusal plane is made parallel to the hamular notch-incisive papilla (HIP) plane. The deepest point on the hamular notches and the center of the incisive papilla were marked with an indelible marker on the maxillary master cast. Cast is placed on the dental surveyor and the vertical arm of the surveyor is held at a fixed position. The cast is tilted so that all the three marked points are in contact with the analysing rod of the fixed vertical arm. This tripoding method establishes the HIP plane on the same horizontal position on which the vertical arm is fixed. In addition this makes the HIP plane parallel to the surveying platform of the surveyor.[37] Once this tilt of the cast is established, the maxillary occlusal rim, with anterior height already established in the patient's mouth is placed on the master cast. The posterior

plane of the occlusal rim is then adjusted so that it is parallel to the floor of the surveyor. The plane thus established is also parallel to the HIP plane.

Once the occlusal plane is established, the mandibular rim is adjusted to meet evenly to meet the maxillary rim and reduced until sufficient interocclusal distance has been obtained.

7. ADAPTATION OF THE LEAD FOIL ON THE OCCLUSAL RIMS:

Lead foils measuring 10mm X 4mm wide and 0.002 inch thick was placed on the maxillary occlusal rims when the occlusal plane was established by method I and II. When method III was used to establish the occlusal plane, lead foil was placed on the mandibular occlusal rim. Since right cephalograms were taken for all the subjects, the lead foil was kept on the right side of the occlusal rims. The lead foil was secured with an adhesive .

8. TAKING THE LATERAL CEPHALOGRAM:

Three lateral cephalograms were taken for each subject of the Group II corresponding to the three methods by which the occlusal plane was established. The occlusal rim with the established plane (bearing the lead foil) was seated in the mouth and the corresponding opposing occlusal rim was inserted for stabilization. This was done for all the three planes employed. The patient was asked to close the jaws in centric relation. Right lateral cephalograms were then taken with all the standardization maintained as in the Group I (dentulous group).

This was done for all the three subgroups of Group II.

All radiographs were processed manually in the same time using the visual method in a well equipped light proof dark room as described by **Goaz P. W., White S.C(1994)**[41]

9. TRACING THE LATERAL CAEPHALOGRAM:

All the lateral cephalograms were hand traced. A lead acetate tracing paper was stapled to one side of the cephalogram and it was viewed over the X-ray viewer. Following points and planes were marked with a 0.3mm lead pencil:-

1. **Nasion :** the most anterior point of the suture at the junction of the frontal and nasal bones.
2. **Machined Porion:** plotted to coincide with the center of the ear rod shadow of the cephalostat.
3. **Orbitale :** inferior most point on the bony orbit.
4. **Frankfort horizontal plane:** joining porion and orbitale.
5. **Occlusal plane**

The occlusal plane in group I was located from the point midway between the incisal tips of the maxillary and mandibular incisors to the point midway between the mesiobuccal cusps of the maxillary and mandibular first permanent molar.[16]

The occlusal plane in group II was indicated by the radiopaque lead foil and was located by drawing a line over it.

A line parallel to the occlusal plane was drawn close to FH plane in such a way that the parallel line intersects the FH plane . The angle between the FH plane and this parallel line was measured with a protractor. The value obtained will indicate the angle between FH plane and the occlusal plane. This was done for all the cephalograms.

10. Method of statistical analysis:

1. ANOVA One way variance test and

2. Tukey HSD test for multiple comparisons

Photograph 1a: Armamentarium for clinical examination

Photograph 1b: Armamentarium for impression procedures

Photograph 1c: Armamentarium for record base and occlusal rim fabrication

Photograph 1d: Armamentarium for cephalometric tracing

Photograph 1e: Cephalostat

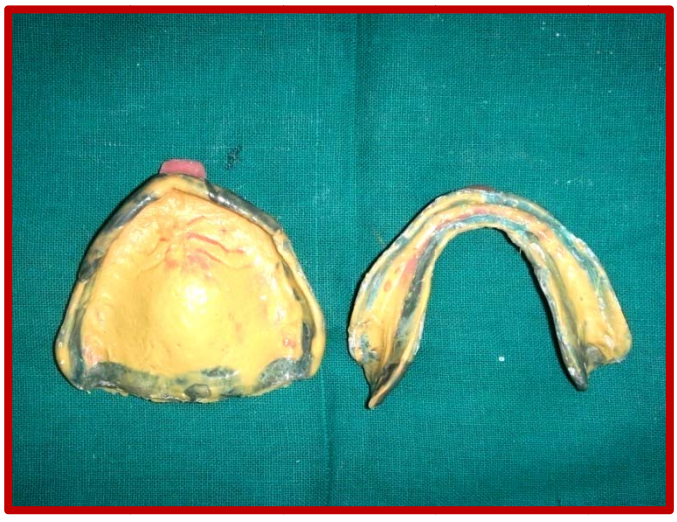
Photograph 1f: Dental Surveyor

Photograph 2: Cephalogram taken for the dentulous patient

Photograph 3a Primary Impressions and 3b Primary cast

(3a) (3b)

Photograph 4a Secondary Impressions and 4b Secondary cast



(4a) (4b)

Photograph 5: Record bases and occlusal rims

Photograph 6a: Representative of Group II-A height of the occlusal rim adjusted anteriorly 2mm below the resting upper lip line

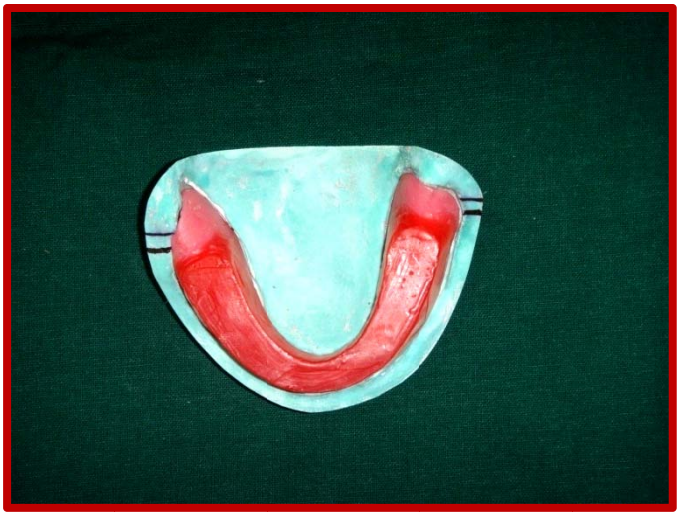
Photograph 6b: Anterior plane established parallel to the inter papillary line

(6a) **(6b)**

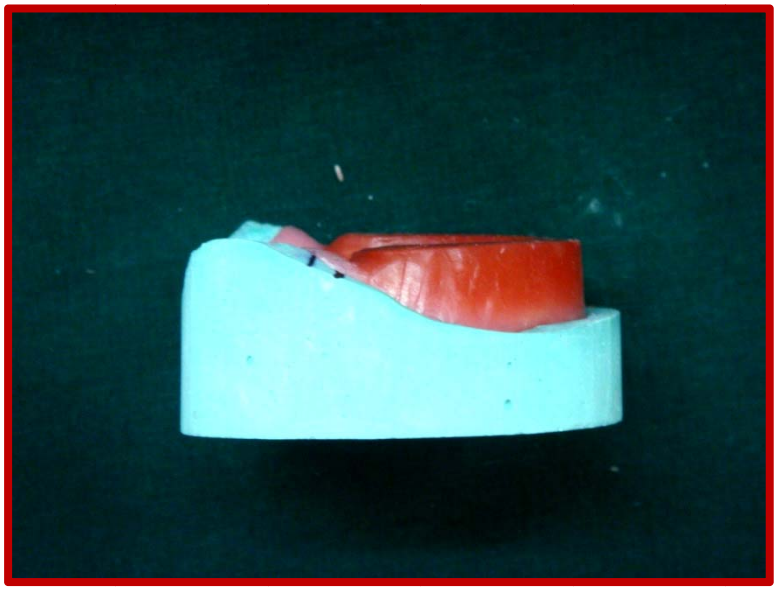
Photograph 6c: Posterior plane established parallel to the Ala-tragus line

Photograph 7a: Representative of Group II-B Anterior plane established in level with lower lip

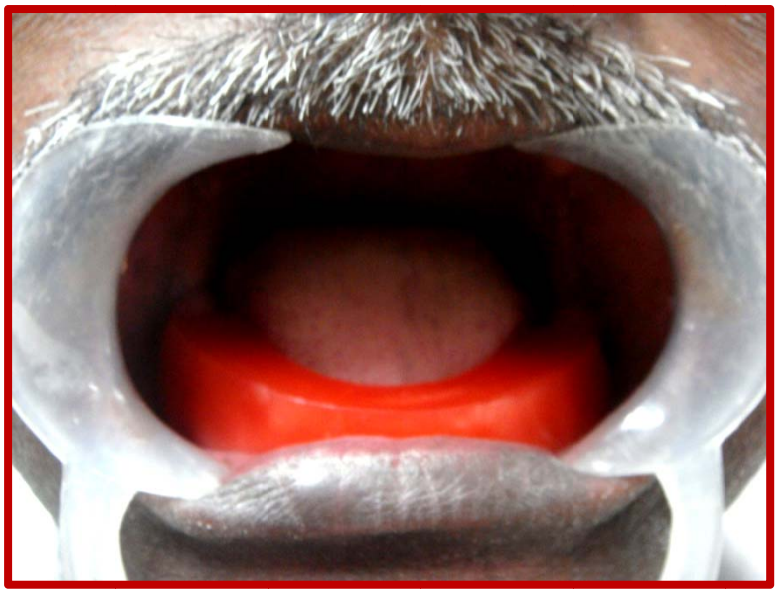
Photograph 7b: Retromolar pad areas marked on the cast.



Photograph 7c: Posterior plane established in level with the junction of middle and upper third-occlusal view.



7d: Lateral view

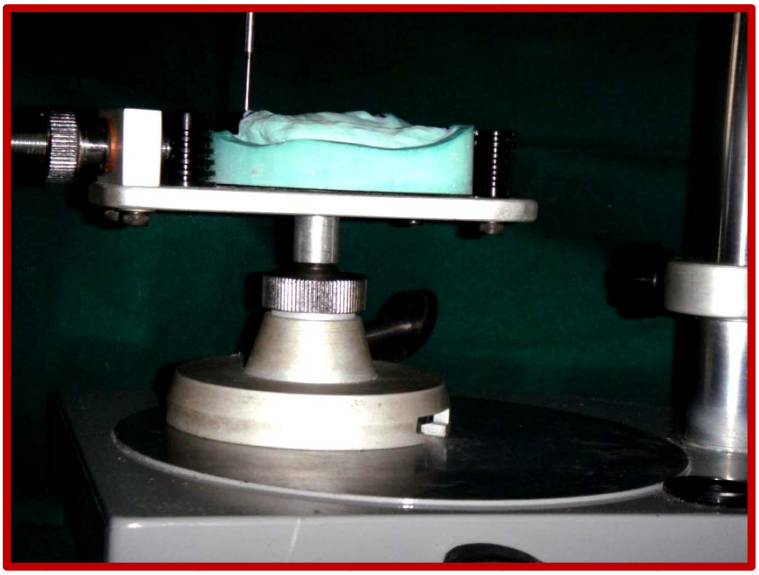


7e : Intraoral view

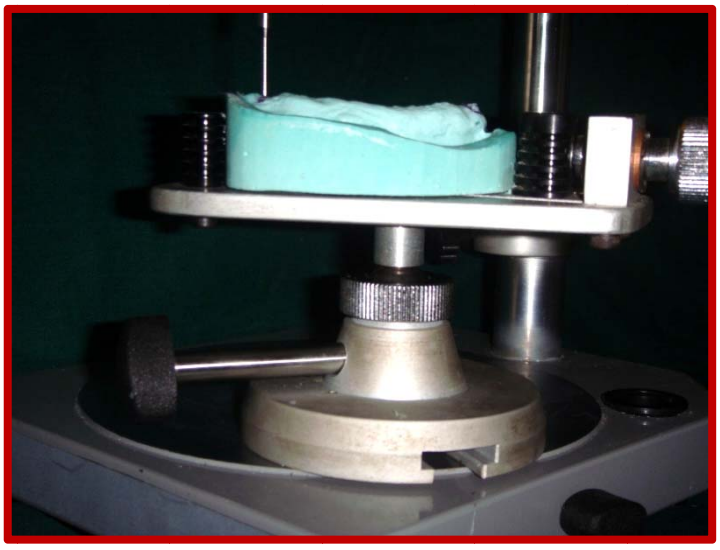
Photograph 8a : Representative of Group II-C height of the occlusal rim adjusted anteriorly 2mm below the resting upper lip.

Photograph 8b : Anterior plane established parallel to the interpupillary line.

Photograph 8c: Establishing HIP parallel to the floor of the surveyor –Fixed vertical arm in contact with the incisive papilla on the cast.



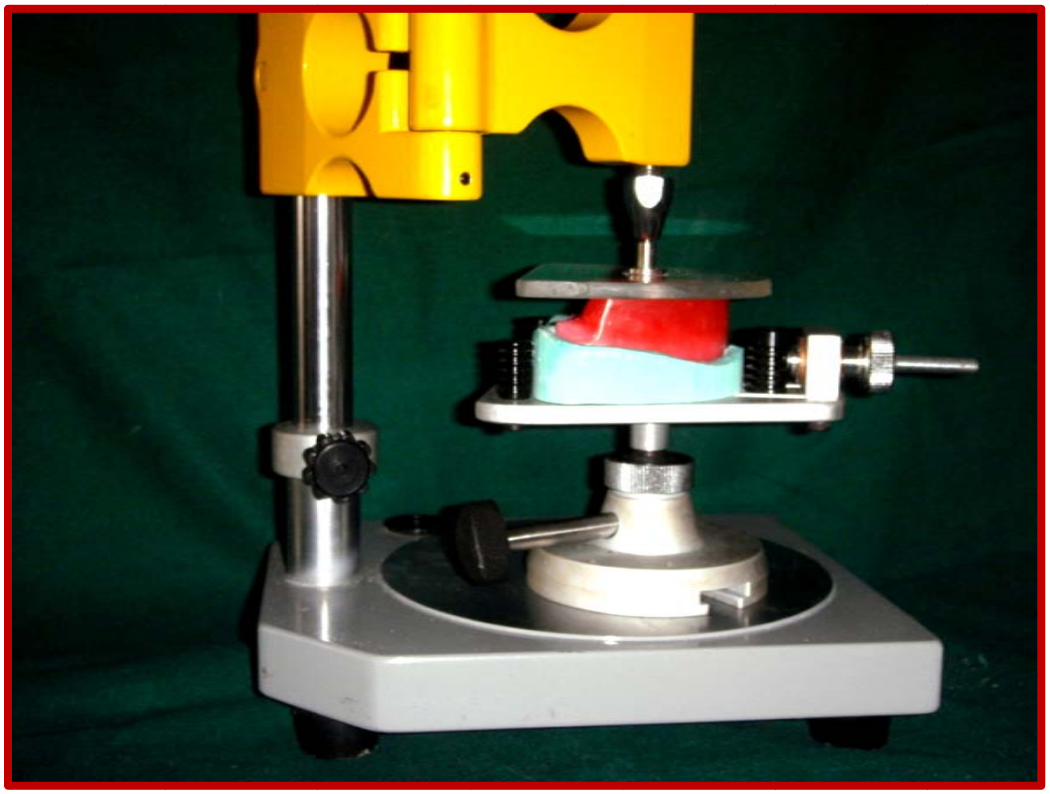
Photograph 8d fixed vertical arm in contact with the hamular notch on the cast –right side and Photograph 8e on the left side.



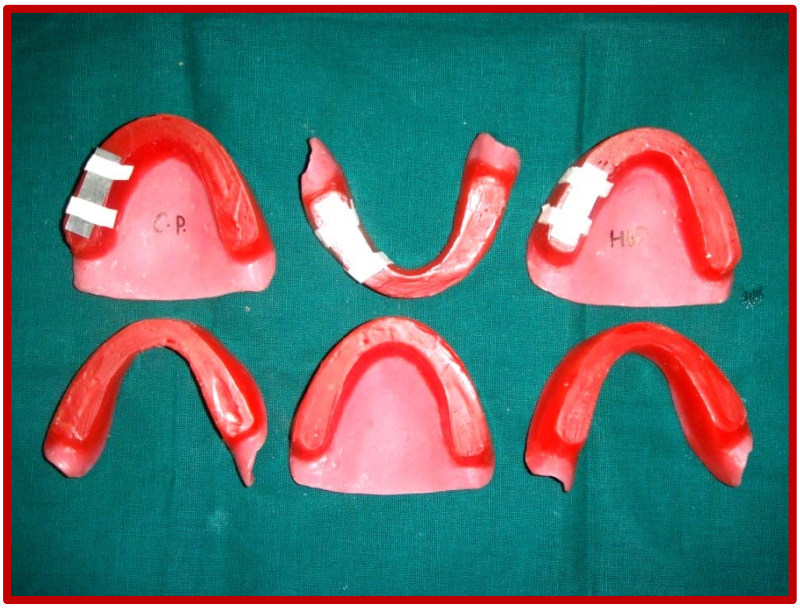
(8d)

(8e)

Photograph 8f Posterior plane of the occlusal rim established parallel to the HIP and floor of the surveyor.



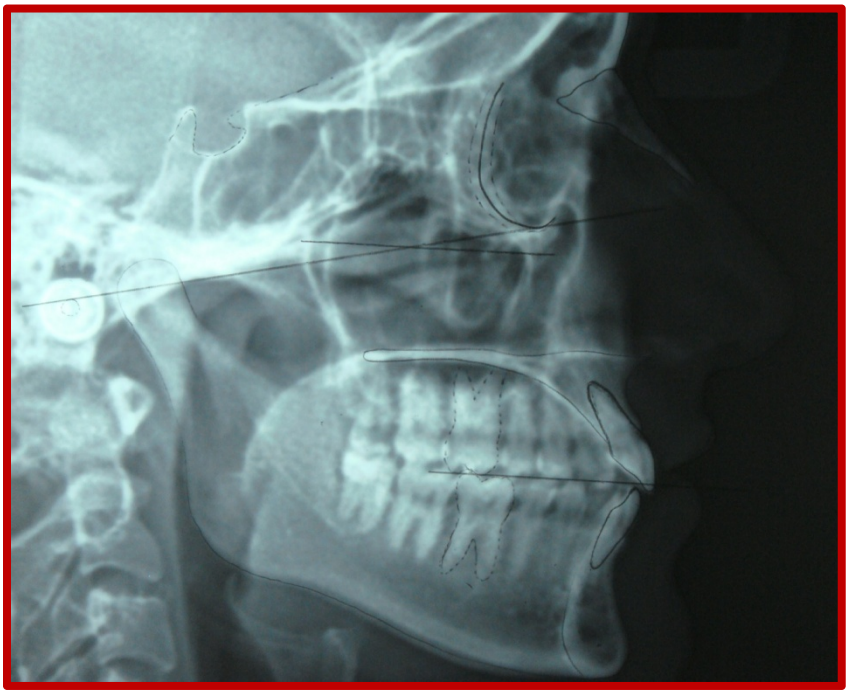
Photograph 9: Occlusal rims with representative of Group –II A, B & C, lead foil adapted and secured with adhesive tape.



Photograph 10: Lateral cephalogram taken for the patient.

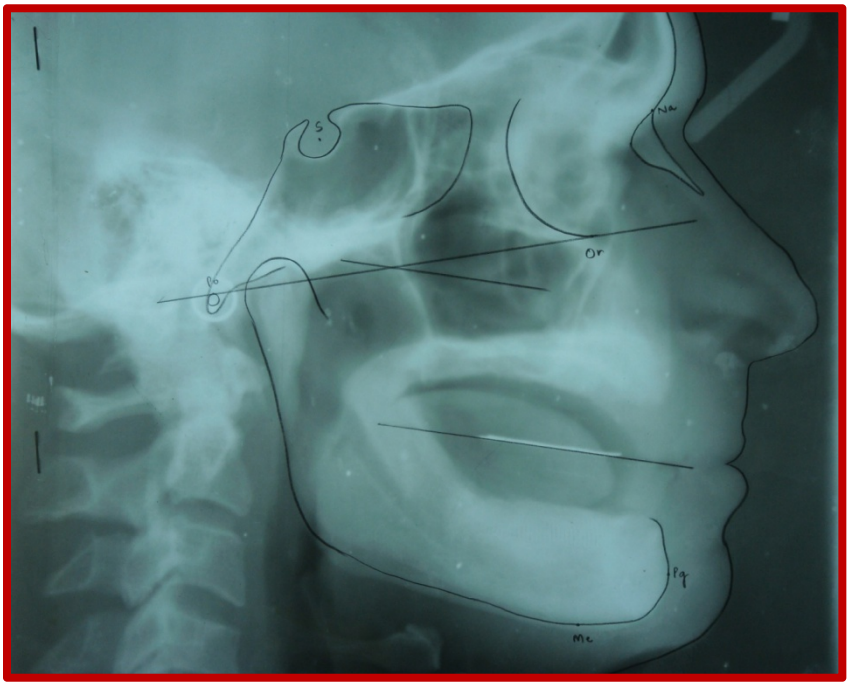
Photograph 11a : Cephalogram representative of Group I

Photograph 11b : Cephalometric tracing done



Photograph 12a : Cephalogram representative of Group II A

Photograph 12b : Cephalometric tracing done



Photograph 13a : Cephalogram representative of Group IIB

Photograph 13b : Cephalometric tracing done

Photograph 14a : Cephalogram representative of Group IIC

Photograph 14b : Cephalometric tracing done

In the present study, subjects were divided into two groups as:

1. Group I : 30 Dentulous subjects.
2. Group II: 30 Edentulous subjects. Group II was further divided into three subgroups depending upon the method of establishing the occlusal plane:
    - Group II A: All the 30 edentulous subjects in whom Occlusal plane was established by making it parallel to the Camper's line.
    - Group II B: All the 30 edentulous subjects in whom Occlusal plane was established by terminating it at the level of the junction of the middle and upper third of the retromolar pad.
    - Group II C: All the 30 edentulous subjects in whom Occlusal plane established by making it parallel to the HIP.

Right lateral cephalograms were taken for both the groups and cephalometric tracings were done.

Variations in the occlusal plane was evaluated by measuring the angle between the occlusal plane established by each method in edentulous group with the Frankfort horizontal plane and comparing it with the angle found in the dentate individuals between the respective planes.

Table I and Table II shows the basic values obtained for the angle between the natural occlusal plane and Frankfort Horizontal plane for Group I.

Table III shows the basic values for the angle between the established occlusal plane and Frankfort Horizontal plane for Group IIA , II B, and II C

Table IV and Figure 1 describes the mean value of the angle between the natural occlusal plane and Frankfort horizontal plane in Group I and the mean values of the angle between the established occlusal plane and Frankfort horizontal plane in Group II A , II B and II C as calculated by ANOVA One way variance test.

The mean value of angle between OP and FH in group I is 9.367 with a standard deviation of 1.047. The mean value of the OP and FH in group II A is 11.333 with a standard deviation of 2.2869. The mean value of angle between OP and FH in Group II B is 10.050 and the standard deviation is 1.7437. The mean value of the angle between OP and FH in Group II C is 9.733 with a standard deviation of 1.4065. the p value for Group II A is less than 0.001 which is statistically significant at 1% level.

Table V and Figure 2 describes the sum of the squares of the mean values between the groups and within the groups.

Table VI and Figure 3 describes the difference between the means of the values obtained from the different groups as calculated by Tukey HSD Test and compares Group I with Group II A, B, and C. The mean difference between the Group I and Group II A is 1.967 with a standard error of 0.4346 and a p value less than 0.05 which is statistically highly significant. The lower and upper bounds for this mean difference is 3.100 and 0.834 respectively. The mean difference between the Group I and Group II B is 0.683 with a standard error of 0.4346 and a p value of 0.398 which is more than 0.05 and statistically not significant. The lower and upper bounds for this mean difference is 1.816 and 0.450 respectively. The mean difference between the

means of Group I and Group II C is 0.367 with a standard error of 0.4346 and a p value of 0.833 which is more than .05 and statistically not significant. The lower and upper bounds for this mean difference is 1.500 and 0.766 respectively.

Table VII and Figure 4 describes the difference between the means of the values obtained from the different groups as calculated by Tukey HSD Test and compares Group II A with Group I, Group II B and C. The difference of means between Group II A and Group I is 1.967 with a standard error of 0.4346 and a p value less than 0.05 which is statistically highly significant. The lower and upper bounds for this mean difference is 0.834 and 3.100 respectively. The difference of means between Group II A and Group II B is 1.283 with a standard error of 0.4346. The p value for this is 0.020 which is less than 0.05 and is statistically highly significant. The lower and upper bounds for this mean difference is 0.150 and 2.416 respectively. The difference of means between Group II A and Group II C is 1.600 with a standard error of 0.4346. The p value for this is 0.002 which is less than 0.05 and is statistically highly significant. The lower and upper bound for this mean difference is 0.467 and 2.733 respectively.

Table VIII and Figure 5 describes the difference between the means of the values obtained from the different groups as calculated by Tukey HSD Test and compares Group II B with Group I, Group II A and Group II C. The mean difference between the Group II B and Group I is 0.683 with a standard error of 0.4346 and a p value of 0.398 which is more than 0.05 and statistically not significant. The lower and upper bounds for this mean difference are 0.450 and 1.816 respectively. The

difference of means between Group II A and Group II B is 1.283 with a standard error of 0.4346. The p value for this is 0.020 which is less than 0.05 and is statistically highly significant. The lower and upper bounds for this mean difference are 2.416 and 0.150 respectively. The mean difference the Group II B and Group II C is 0.317 with a standard error of 0.4346 and a p value of 0.885 which is more than 0.05 which is statistically highly significant. The lower and upper bounds for this mean difference are 0.816 and 1.450 respectively.

Table IX and Figure 6 describes the difference between the means of the values obtained from the different groups as calculated by Tukey HSD Test and compares Group II C with Group I , Group II A and Group II B. The mean difference between Group II C and Group I is 0.367 with a standard error of 0.4346 and a p value of 0.833 which is more than .05 and statistically not significant. The lower and upper bounds for this mean difference is 0.766 and 1.500 respectively. The difference of means between Group II C and Group II A is 1.600 with a standard error of 0.4346. The p value for this is 0.002 which is less than 0.05 and is statistically highly significant. The lower and upper bound for this mean difference is 2.733 and 0.467 respectively. The mean difference the Group II C and Group II B is 0.317 with a standard error of 0.4346 and a p value of 0.885 which is more than 0.05 which is statistically highly significant. The lower and upper bounds for this mean difference are 1.450 and 0.816 respectively

Table X and Figure 7 describes the means for groups in homogenous subsets where each group has a harmonic sample size of 30. It shows that Group II A is not homogenous with Group I, Group II B and Group II C.

Table I and II: basic values obtained for the angle between occlusal plane and Frankfort Horizontal plane for Group I

Table I

SlNo.	Value
1.	8
2.	8.5
3.	9
4.	8
5.	10.5
6.	11.5
7.	8.5
8.	9.5
9.	10
10.	8.5
11.	8
12.	9.5
13.	8.5
14.	9.5
15.	10.5

Table II

SlNo	Value
16.	10
17.	9
18.	11
19.	10.5
20.	8.5
21.	10.5
22.	9.5
23.	9
24.	10
25.	10.5
26.	9.5
27.	10.5
28.	8
29.	7.5
3o.	9

Table III: basic values obtained for the angle between Occlusal plane and Frankfort Horizontal for Group II A, Group II B, and Group IIC.

Sl. No.	II A	II B	II C
1.	11	13	9.5
2.	9.5	10.5	10.5
3.	8	12	11
4.	7	9.5	9
5.	7.5	7	12
6.	9	10	11.5
7.	14.5	9.5	8
8.	14	12	9.5
9.	11.5	11.5	8
10.	13	10.5	10.5
11.	12	12.5	11.5
12.	13	8	10.5
13.	13.5	9	8.5
14.	9.5	9.5	9.5

15.	14	8	8
16.	13	10	11
17.	12	8	8
18.	10.5	8.5	8.5
19.	14.5	8.5	11
20.	11	9	9
21.	12.5	10.5	10.5
22.	13.5	9	7
23.	12	11	12
24.	9	11	10.5
25.	11	12	9
26.	8	7.5	9.5
27.	13	13	9
28.	13.5	9.5	12
29.	7.5	13	9.5
30.	12	8.5	8

Table IV: Mean values of the angle between OP and FH in Group I, Group II A, Group II B, and Group IIC and their standard deviation.

Values				
Group	N	Mean	SD	P value
Group I	30	9.367	1.0417	<0.001**
Group II A	30	11.333	2.2869	
Group II B	30	10.050	1.7437	
Group II C	30	9.733	1.4065	
Total	120	10.121	1.8207	

Note: ** Denotes significance at 1% level

Table V: sum of squares of the mean values between the groups and within the groups.

Values					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	65.823	3	21.941	7.744	.000
Within Groups	328.675	116	2.833		
Total	394.498	119			

Table VI: Mean difference between Group I and Group II A, Group II B, Group II C.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Group I	Group II A	-1.967(*)	.4346	.000	-3.100	-.834
	Group II B	-.683	.4346	.398	-1.816	.450
	Group II C	-.367	.4346	.833	-1.500	.766

* The mean difference is significant at the .05 level.

Table VII: Mean difference between Group II A and Group I, Group II B and Group II C.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Group II A	Group I	1.967(*)	.4346	.000	.834	3.100
	Group II B	1.283(*)	.4346	.020	.150	2.416
	Group II C	1.600(*)	.4346	.002	.467	2.733

* The mean difference is significant at the .05 level.

Table VIII: Mean difference between Group II B and Group I, Group II A and Group II C.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Group II B	Group I	.683	.4346	.398	-.450	1.816
	Group II A	-1.283(*)	.4346	.020	-2.416	-.150
	Group II C	.317	.4346	.885	-.816	1.450

* The mean difference is significant at the .05 level.

Table IX: Mean difference between Group II C and Group I, Group II A and Group II B.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Group II C	Group I	.367	.4346	.833	-.766	1.500
	Group II A	-1.600(*)	.4346	.002	-2.733	-.467
	Group II B	-.317	.4346	.885	-1.450	.816

* The mean difference is significant at the .05 level.

Table X: means for groups in homogenous subsets.

Group	N	Subset for alpha = .05	
		1	2
Group I	30	9.367	
Group II C	30	9.733	
Group II B	30	10.050	
Group II A	30		11.333
Sig.		.398	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 30.000.

Fig 1: mean values for the angle between Occlusal plane and Frankfort Horizontal for Group I, Group II A, Group II B, and Group II C and their standard deviation.

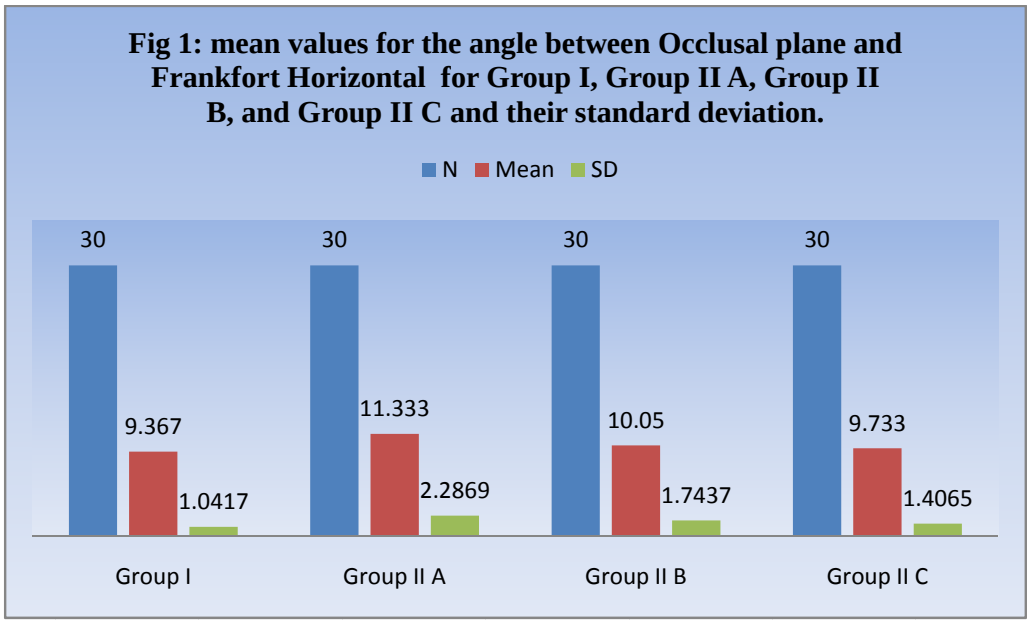


Fig 2: sum of the squares of the mean values between the groups and within the groups

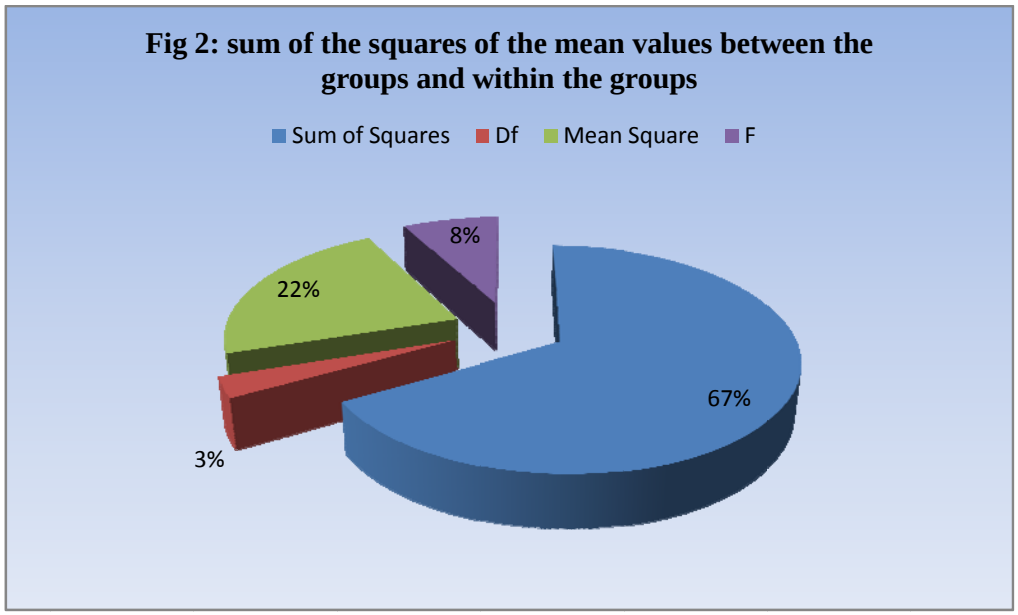


Fig 3: mean difference between Group I and Group II A, Group II B, Group II C

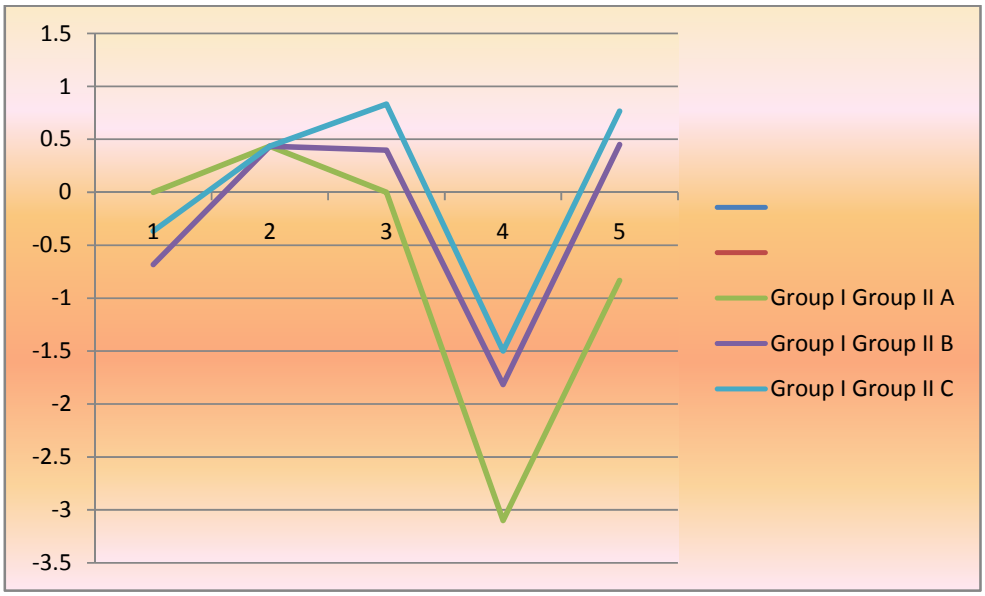


Fig 4: mean difference between Group II A and Group I, Group II B, Group II C

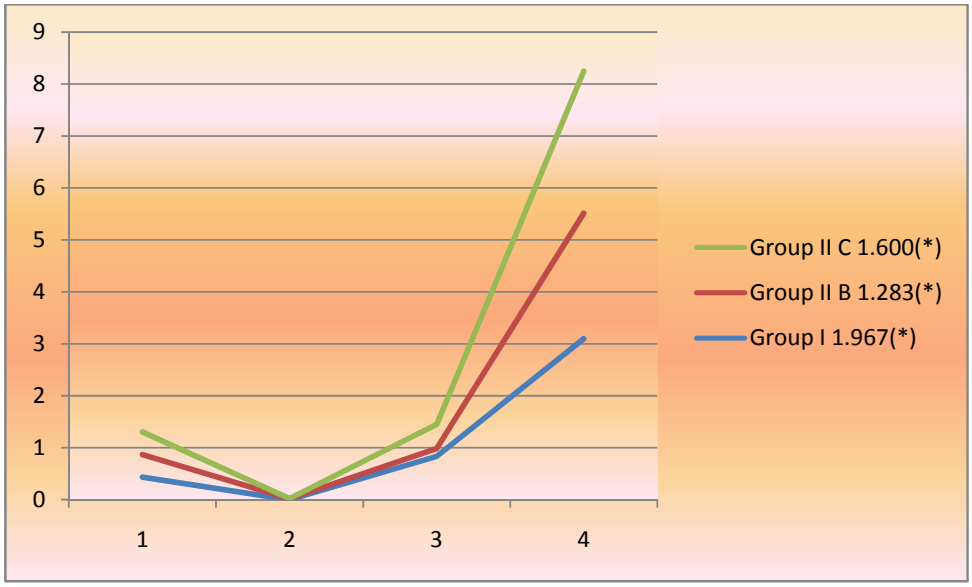


Fig 5: mean difference between Group II B and Group I, Group II A, Group II C.

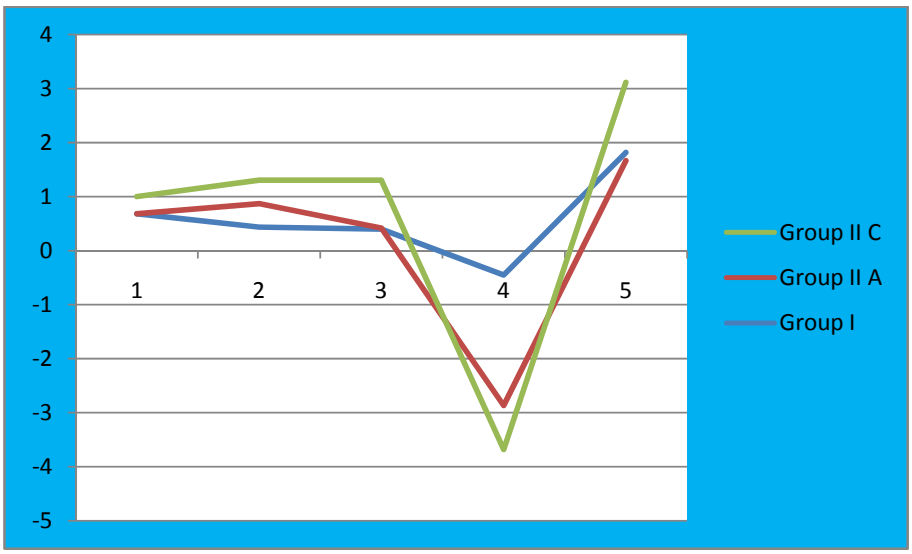


Fig 6: mean difference between Group II C and Group I, Group II A, Group II B.

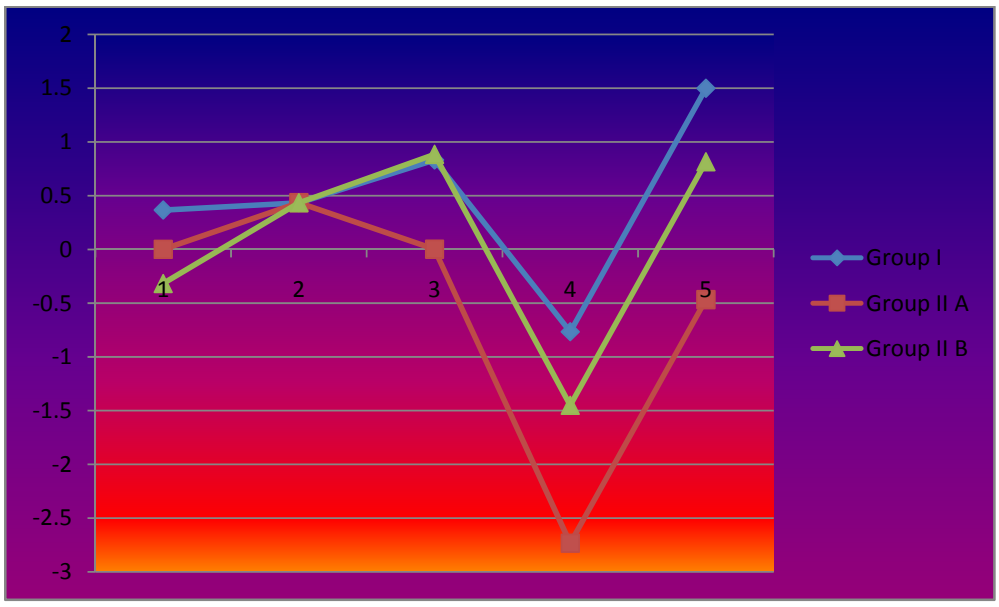
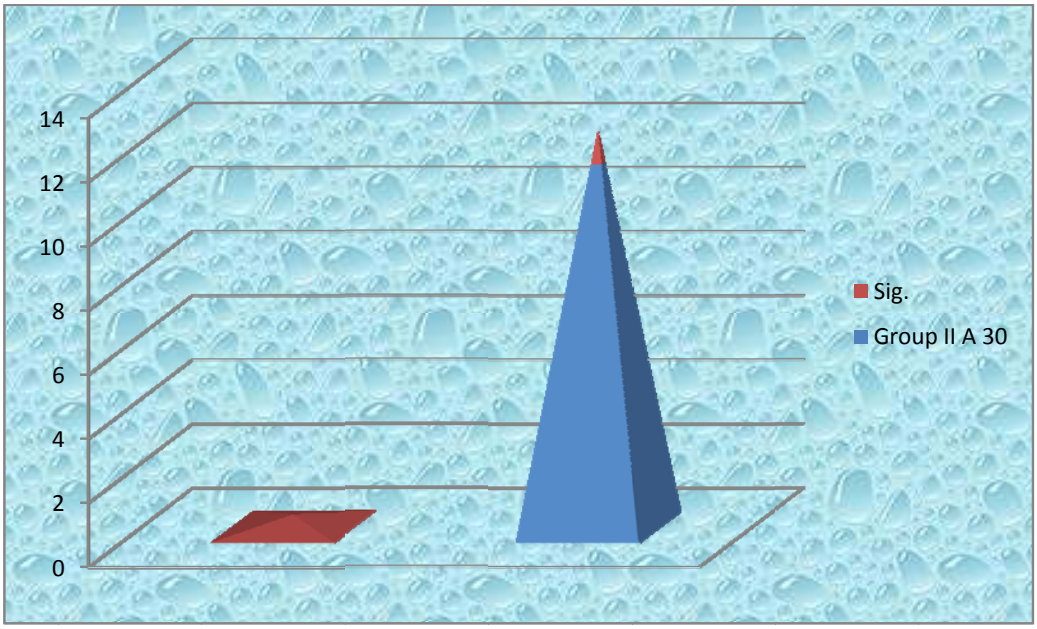


Fig 7: means for groups in homogenous subsets with a harmonic sample size of 30



The function and aesthetics of complete dentures are dependent on the correct orientation of the occlusal plane. Anteriorly, the occlusal plane mainly helps in achieving aesthetic and phonetics while posteriorly, it forms a milling surface where the tongue and the buccinator muscle are able to position the food bolus onto it and hold it there during mastication. Faulty orientation of occlusal plane will hamper this interaction between the tongue and buccinator muscle and result at one extreme in food collection in the sulcus and at other extreme in biting of the cheek or tongue. Thus, incorrect record of occlusal plane would hamper aesthetics, phonetics and mastication.[22]

During complete denture construction, the occlusal plane should be oriented as close to the natural as possible. This statement is logical since the musculature of the tongue and cheeks was trained to function normally at this level when the natural teeth were present and will again function correctly when they are called upon to stabilize the bolus at the same vertical position of the occlusal table as formerly existed.[13, 42]

It is generally agreed that in the anterior region the vertical height of the occlusal plane is governed by esthetic requirements and less frequently by functional requirements. However, there are contrasting views with regard to the orientation of the occlusal plane in the posterior region. The most common method of establishing occlusal plane is making it parallel with the ala-tragus line. There have been a few other guidelines for the precise location of posterior occlusal plane which include:[16]

- Positioning occlusal plane parallel to and midway between the residual ridges.
- Positioning occlusal plane on the same level as the lateral border of the tongue.
- Terminating occlusal plane posteriorly at the middle or upper third of the retromolar pad.[13,39,32]
- Orienting occlusal plane with the buccinator groove and commissures of the lips.[14]
- Maintaining a specific relation with parotid papilla.[43]
- Using certain cephalometric criteria.

The Camper's line or the ala-tragus line, postulated by the Dutch anatomist Peter Camper in 1780 extends from the ala of the nose to the center of the external auditory meatus and is widely used as a guide in the orientation of the occlusal plane.

Another useful guide to orient the occlusal plane is to establish the occlusal plane in the mandibular complete denture at the level of the middle and upper third of the retromolar pad.[39] It has been established that the distolingual cusp of the natural mandibular second molar is at the level of the middle third of the retromolar pad. So using this landmark for complete denture construction can be considered to be reliable.[14]

A plane passing from the incisive papilla and the two hamular notches have been found to be parallel to the occlusal plane in the dentate individuals. The hamular notch is the palpable notch formed by the junction of the maxilla and the pterygoid

hamulus of the sphenoid bone.[5] The incisive papilla is the elevation of soft tissue that covers the foramen of the incisive or nasopalatine canal.[5] These are considered to be stable landmarks and a plane passing from the incisive papilla and the two hamular notches can be used to establish the artificial occlusal plane in complete dentures with reliability.[37]

With this background, a study was conducted to evaluate the most physiologic occlusal plane in the edentulous patients. The occlusal plane was established in the edentulous patients according to the three criterias mentioned above and compared with that of the dentate subjects to identify the plane closest to the one occurring in natural dentition.

Thirty dentulous and edentulous patients who came to the Department of Prosthodontics on an outpatient basis were selected for the study. They were categorized as follows:-

Group I – Thirty Dentulous subjects

Group II – Thirty edentulous subjects. These were further subgrouped depending upon the method of occlusal plane establishment:

- Group II A
- Group II B
- Group II C

Right lateral cephalogram of the 30 selected dentulous subjects were obtained after their jaws approximated together in centric relation. For all the 30 edentulous subjects, occlusal plane was established in the wax occlusal rims using the three

methods. A radiopaque material (lead foil strip) was kept between the occlusal rims and three right lateral cephalograms were taken for the three planes established. The cephalograms for the edentulous subjects were taken with their jaws approximated in centric relation. This was done in all the 30 subjects.

All the right lateral cephalograms obtained in this study were taken from a cephalostat standardized by certain parameter such as, head position of the subject ("Natural"), distance between the head and the cassette (5 inch), voltage (75 Kvp) current (10 mA) and exposure time(20millisecond).

All the lateral cephalograms were hand traced. The occlusal plane marked for dentulous subjects extended from a point midway between the incisal tips of the maxillary and mandibular incisors to the point midway between the mesiobuccal cusps of the maxillary and mandibular first permanent molar[16]. The angle between the occlusal plane and Frankfort Horizontal plane was measured. The Frankfort Horizontal plane was marked between orbitale (point on the inferior bony margin of the orbit) and machined porion (center of the ear rod shadow of the cephalostat).

In this study, SN (sella-nasion) plane was not used as a reference plane. According to **Hussels and Nanda (1984)[44],** after the growth ceases, the SN plane remains constant throughout life, but the variability in the position of point N is marked. The point Nasion shows variability in its position in both vertical and horizontal plane.

Maxillary plane was not used as the reference plane because according to **Tuncay (1984)[20],** the clockwise rotation of the palatal plane occurs and the relationship between the maxilla and the cranial base is not immutable in elderly

patients. Growth and development changes continue till the eighth decade of life. With this phenomenon, the behaviour of the dentures and the mandible are affected and the observed clockwise rotation of the palatal plane is accentuated by the presence of a new set of dentures.

Hence, in this study, the Frankfort Horizontal plane was selected as a reference plane. It was marked according to the cephalometric criteria with the exception of porion, which was plotted to coincide with the ear-rods of the cephalostate rather than its less frequently visible and more variable bony counterpart. Although contrary to **Ricketts[22],** this measure was adopted for prosthetic reasons.

The results obtained from the study showed that a significant difference was found when the occlusal plane was established using Ala-tragus line as reference compared to the other two methods. Hence the Null hypothesis was not found to hold true.

Variation of the occlusal plane in Edentulous subjects (Group II C) using HIP as the reference with the occlusal plane of the dentulous subjects (Group I)

In the present study, the mean value for the angle between the occlusal plane and the Frankfort Horizontal plane in Group I subjects was found to be **9.367** with a standard deviation of **1.0417**. The mean value for the angle between the occlusal plane established using HIP as the reference was **9.733** with a standard deviation of **1.4065**. The p value for this comparison was found to be **0.833** which is more than **.05**, which denotes that there is no significant difference between the occlusal plane in the dentulous subjects and the artificial occlusal plane established in the edentulous

subjects using HIP as the reference. This proves that HIP can be used as a reliable guideline to establish occlusal plane in complete denture wearers.

Rich (1982)[46] and Karkazis and Polyzois (1991)[30], have also confirmed that HIP is parallel to the occlusal plane found in the natural dentition.

Sloane and Cook (1953)[6], confirmed that it is necessary to select points of reference that would not be affected by degenerative process and that could be readily identified on an edentulous maxillary cast. The hamular notch and incisive papilla are found to be suitable landmarks in this respect. However, an exception occurs in the rare situation when excessive reduction or loss of alveolar bone is associated with the obliteration of the hamular notch.[36]

According to **McGee (1960)[10],** this plane remains unaltered with the loss of teeth, as the incisive papilla remains in a constant position.

Jayachandran S. (2009)[37], confirmed through a study that the HIP is parallal to the occlusal plane that exists in the dentate individuals and thus this plane can be reliably used in the determination of the occlusal plane during complete denture construction.

Variation of the occlusal plane in edentulous subjects(Group II B) established using the junction of middle third and upper third of the retromolar pad with that of the dentulous subjects(Group I):-

The mean value of the angle between the occlusal plane established using the junction of the middle third and upper third of the retromolar pad and the Frankfort Horizontal plane is found to be **10.050** with a standard deviation of **1.7437**. The p

value for this comparision is **0.398** which denotes that there is no significant difference between this plane and the natural occlusal plane. Thus, the junction of middle and upper third of the retromolar pad can be used as a reliable landmark for establishing the posterior occlusal plane during complete denture fabrication.

These results are in accordance with the study conducted by:

Hall (1958)[8], according to whom the two posterior points of orientation of the occlusal plane fall within the height of the distal half of the retromolar pad. The entire plane is parallel to the ridge planes.

Malson T.S. (1964)[12], who confirmed that a straight edge placed on top of the lower cuspid and in contact with the crest of the highest cusp of the most posterior tooth in the mouth of a dentulous person will contact the retromolar pad about one third the distance from the top. This phenomenon occurs even though some of the posterior teeth may have been lost and regardless of the age of the patient. Therefore, one third of the distance from the top of the retromolar pad is a reliable anatomic landmark for the height of the distal end of the occlusal plane.

Boucher (1970)[39] who maintains that the posterior end of the occlusal plane should be located so that if extended it would be level with the junction between the middle and distal third of the retromolar pad.

Celebiec (1995)[32], also confirmed that the occlusal plane in edentulous patients can be safely oriented at the level of the junction of the middle and upper third of the retromolar pad.

Shetty S.N. (2009)[38], concluded that the occlusal plane terminates in the upper half of the retromolar pad implying that the orientation of the occlusal plane to the

upper half of the retromolar pad can also be used as a reliable landmark in the determination of occlusal plane.

Variations of the occlusal plane in edentulous subjects (Group II A) using ala-tragus or camper's line as the reference with the occlusal plane in the dentulous subjects (Group I):

The mean value of the occlusal plane established in the edentulous subjects using ala-tragus or camper's line as the reference is found to be 11.333 with a standard deviation of 2.2869. The p value for this comparison is 0.001 which is less than 0.05. This means that there is a significant difference between the occlusal plane established in the edentulous subjects when ala-tragus line is used as the reference plane and the occlusal plane that exists in the natural dentition. This suggests that because of the variation seen in the ala-tragus line it is a less reliable reference plane to establish the occlusal plane during complete denture construction.

This is in accordance with the studies conducted by **Karkazis and Polyzois(1987)[25], Ow Richard K.K. (1989)[28], D'Souza (1996)[33].**

Karkazis and Polyzois(1987)[25], stated with conviction that both the natural and artificial occlusal planes were not parallel to Camper's plane. It was also concluded that the definition of ala-tragus line cause confusion because the exact point of posterior reference do not agree with some authors suggesting it to be the superior border of the tragus while others supporting the use of center of the tragus.

Ow Richard K.K. (1989)[28], concluded that the ala-tragus line showed a high degree of variability when oriented with the maxillary occlusal plane of the dentulous individuals and thus its use as an index for occlusal plane in edentulous subjects is limited.

D'Souza (1996)[33], also confirmed that the reliability of the Camper's plane as a guideline to simulate the natural occlusal plane is questionable.

But this is in **contradiction** to the study conducted by **Van Niekerk FW[21], and Okane et al, 1979[18]**.

Van Niekerk FW[21], concluded that the ala-tragus line has a close relationship with the occlusal plane and could be used as a landmark when the maxillary occlusal rim is trimmed to the occlusal plane.

Okane et al, 1979[18], concluded from his study that the masticatory efficiency of the complete dentures is greatest when the occlusal plane is made parallel to the ala-tragus line.

This contradiction might be due to the fact that in both the above studies the inferior border of the tragus was used as the posterior landmark to mark the ala-tragus line where as in the present study, the center of the tragus has been used.

According to **Dr. Solomon E.G.R. (2000)[46],** the variability in the ala-tragus line occurs because the tragal references recommended for the formation of the ala-tragus line is conflicting and controversial. Further, the ambiguity of the tragal nomenclature makes it difficult to select which part of the tragus should be considered to define this line. Three tragal references are recommended to obtain the ala-tragus line - the superior border, middle of the tragus and the inferior border. It is still not

clear as to which tragal reference should be used for more consistent results. The author confirms that the middle of the tragus can be located easily in the classical pointed tragus and to a certain extent in the round tragus. The middle position of the tragus is not easily definable in rudimentary and notched tragus forms, thus concluding that using the middle of tragus cannot be justified in all situations.

Further, the posterior landmark for ala-tragus line does not remain constant and cannot be easily identifiable, so it cannot be used as a consistent reference point for establishing the posterior occlusal plane during complete denture construction.

Further studies in geometrical analysis of establishing the occlusal plane may bring about the more reliable references. Also, different facial patterns can be taken into account.

For many years prosthodontists have been trying to find out the ideal location of Occlusal plane during complete denture fabrication. Though there is abundant literature which supports various methods to establish an artificial occlusal plane in edentulous patients, there is a lack of literature correlating which method establishes an occlusal plane that lies closest to the one occurring naturally.

Hence this study was done to evaluate and establish a reliable method of occlusal plane determination in edentulous individuals and was carried out in 30 dentulous and 30 edentulous patients using lateral cephalograms. This study was performed in the Department of Prosthodontics, Tamilnadu Government Dental College and Hospital, Chennai. In this study conducted,

1. The angulation between the occlusal plane established in the edentulous patients using Hamular notch - Incisive Papilla plane and Frankfort Horizontal plane had closely resembled the angulation between the natural occlusal plane and Frankfort Horizontal plane in dentulous subjects.
2. The angulation between the occlusal plane established in the edentulous patients using the junction of middle and upper third of the retromolar pad as the reference and Frankfort Horizontal plane had also closely resembled the angulation between the natural occlusal plane and Frankfort Horizontal plane of the dentulous subjects next to the similarity obtained from the HIP as reference.
3. The angulation between the occlusal plane established in the edentulous patients using the Camper's plane as the reference and Frankfort

Horizontal plane showed a marked degree of variation from the corresponding angulation seen in the dentulous subjects and the two previous groups.

4. The angulation of occlusal plane and Frankfort Horizontal plane showed the minimum variation in dentulous subjects.

Hence from the present study, it has been concluded that

- Among the three methods used to establish an artificial occlusal plane, HIP plane is found to be more reliable reference plane in complete denture construction.
- The occlusal plane established using the junction of the middle and upper third of the retromolar pad and the corner of the mouth as the reference can also be considered as a reliable guide to establish an artificial occlusal plane.
- Camper's plane shows a marked degree of variability as compared to the other two groups and it is not considered as a reliable reference plane to be used for establishing the occlusal plane during complete denture fabrication.
- 9.3 is the average value of the angle between the occlusal plane and Frankfort Horizontal plane in the Indian population.
- However, clinical judgement plays a major role in the assessment of occlusal plane in the edentulous patients. So this Geometrical analysis may be taken as a useful adjunct in establishing the occlusal plane.

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