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Validity and Variability of Soft Tissue Landmarks to Cook's Plane to Occlusal Plane(An In-Vivo Cephalometric Study

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I. Introduction

Occlusal plane is defined as the average plane established by the incisal and occlusal surfaces of the teeth (GPT)[1]. Although the orientation of occlusal plane is under the control of the clinician, it should be established taking onto considerations the esthetics, phonetics and biomechanical factors. It is generally recognized that vertical height of occlusal plane in anterior region is governed by aesthetic and phonetic requirements, there are contrasting views on the orientation of artificial occlusal plane in posterior region[2]. Many biometric landmarks and methods have been used over the years for the determination of occlusal plane in posterior region which include: establishing the occlusal plane according to aesthetic requirements anteriorly and parallel to the ala-tragus line posteriorly, positioning the occlusal plane to and midway between the residual ridges, orienting the occlusal plane with the buccinator grooves and the commissure of lips, terminating the occlusal plane posteriorly at the middle or upper third of the retromolar pad, and positioning the occlusal plane on the same level as the lateral border of the tongue.[3] Several guidelines have been given for determining the occlusal plane both clinically and using cephalometric radiographs

According to previous surveys conducted it was found that the ala-tragus line, height of retromolar pad and parallelism of ridges are commonly used methods by the practitioners for orienting the plane of occlusion in edentulous patients. Among these ala-tragus line with various anterior and posterior reference points is the most widely used method and is also the most commonly taught method in dental institutions. Every suggested guidelines have got their own variability and validity as reported by previous studies.

However certain intraoral anatomic landmarks like buccinators groove and Hamular notch – Incisive papilla (HIP)plane were reported to be less variable. Since a few reports are available in this regard, the present study was done in an attempt to establish their validity and variability related to occlusal plane. This study will be undertaken to determine whether or not there was any correlation between fixed cranial landmarks and the plane of occlusion. It was necessary to select points of reference that would not be affected either by degenerative processes or surgical interference, and that could readily be identified on an edentulous maxillary cast. The hamular notches and the anterior nasal spine were chosen since they are constant to both the maxillary cast and the skull. A line is drawn connecting the anterior nasal spine (ANS) and the hamular notch on cephalogram. This line, called Cook's plane, forms an angle with the occlusal plane that varies inversely with the distance separating the two reference points. Thus the greater the distance between ANS and the hamular notch, the more acute the angulation of the occlusal plane, and, conversely, the smaller the distance, the more obtuse the angle will be. This tendency has been confirmed by the cephalometric analysis.[4] Therefore a cephalometric analysis was used in an effort to determine the predictable relationship of the occlusal plane with cook's plane, HIP plane and buccinator groove.

II. Aim& Objectives

AIM: To determine the relation of Buccinator groove and Cook's plane as a guide for the orientation of occlusal plane in dentulous patients.

OBJECTIVES:

1. To determine the relation between buccinator groove and occlusal plane in dentulous patients.
2. To determine the relation between Cook's plane and occlusal plane in dentulous patients.
3. To compare and evaluate the accuracy of Cook's plane and buccinators groove with occlusal plane in dentulous group. To suggest the best suitable intraoral soft tissue landmarks in determination of occlusal plane

III. Materials And Method

I. Study design

A total of 30 volunteers (15 male and 15 female) aged between 19 to 29 years with normal occlusion were selected after screening undergraduate and postgraduate dental students from Buddha Institute of Dental Sciences &Hospital. The subjects selected were based on the following criteria.

Inclusion Criteria:i) He/she was having fully erupted permanent dentition teeth (at least 28 teeth) in normal occlusion.ii) Subjects in the age group between 19-29 years.iii) Bilateral Angle's class I molar relationship and anterior teeth with normal overjet and overbite

Exclusion criteria Subjects with the following conditions were excluded from the study:i) Attritionii) Temporomandibular joint pathologiesiii) Extensive restorations which includes long span bridges (>4 units) in the posteriorsegment of the maxillary or mandibular arch.iv) History of Orthodontic treatmentv) Periodontal disease which includes, periodontal pockets, trauma from occlusion,pathological drifting of teeth.

Armamentarium required :1. Lateral cephalograms X-ray unit 2. Lateral cephalograms X-ray film 3. Automatic X-ray film processor4.19 and 22 Gauage orthodontic wire.5. Single sided adhesive tape.6. Tracing sheet 7.pencil.8.Paper clips.9. X-ray viewer.10. Indelible pencil and protracter.

IV. Methodology

Preparation of oral screen for vestibular impression.

Diagnostic impressions of the maxillary and mandibular arches were made using hydrocolloid impression material (Align,DPI) , casts were poured with dental stone (Pyrex) and mounted on mean value articulator.An oral screen of auto polymerising resin(DPI;Dentalproducts of India Ltd) was fabricated for each subject which extended from the distal aspect of both maxillary and mandibular 2nd molar on one side to that of the other side . A single sheet of relief wax was placed as a spacer on the medial surface of the screen to prevent impingment of soft tissues A loop of 19 gauge stainless steel wire which would serve as a handle was made and placed at the level of maxillary central incisors. The perforations were made at the periphery on each side of the oral screen with a round bur to facilitate mechanical interlocking of the zinc oxide eugenol impression paste(DPI Impression Paste) The oral screen was used to support zinc oxide eugenol impression paste for the vestibular impression.

The oral screen was then reinserted into the subject's oral cavity. A thin mix of zinc oxide eugenol impression paste was filled completely around the vestibular side of oral screen . It was made certain that the distal aspects of the buccal vestibules on both sides were filled. The subject was then asked to pucker his/her lips as in sucking and to make `ooo` sounds without the loss of occlusal contact of teeth. It was seen that the position of the buccinator groove on either side were recorded on the vestibular impression. If not, the procedure was repeated to record it. Later the position of the groove is checked and marked with an indelible pencil. Then 22 gauge wire was adapted on the marking using sticky wax.

Preparation of palatal plate for recording HIP plane

A retentive palatal plate holding a metal ball(radiopaque) on incisive papilla(IP) of 4mm diameter using clear autopolymerising resin(DPI;Dental products of India Ltd) was fabricated in each subject . The subject was seated in an upright position on the dental chair and was instructed to occlude the teeth in centric occlusion. The position of oral screen and retention plate was checked in the subject's oral cavity and care was taken to avoid soft tissue impingement. The patient was positioned in the cephalostat and lateral cephalogram was taken and were developed using Automatic processor .

Cephalometrictracing: Cephalometric X-rays were traced on acetate tracing paper using pencil. The following cephalometric planes and angles were drawn for the purpose of the study.

A. Cephalometric Planes: i) Occlusal plane: The average plane established by the Incisal and occlusal surfaces ofthe teeth. (OP)ii)Cook`s plane: A line from the superior aspect of the hamular notch to the anterior nasal spine.iii) HIP plane: A line from superior aspect of hamular notch to incisive papilla.

B. Cephalometric Angles: The angles formed were.i) Occlusal plane To HIP planeii) Occlusal plane to cook's plane

C.TheStudy: The data from the thirty cephalometric radiographs was collected and subjected to statistical analysis to predict the relationship of these three landmarks to occlusal plane

V. Results

The purpose of this clinical study was to evaluate the relationship between Cook's plane, HIP plane and natural occlusal plane in normal dentulous male and female subjects.Statistical Analysis: The recorded value were represented as mean ± standard deviation and statistically analyzed using student 't' test using statistical software Graph Pad (Version 5).**Table 1** represents master chart of the data obtained from15 male and 15 female subjects respectively.The master chart includes subject No, Age, Sex and one measurement of cooks –occlusal plane angle & hip-occlusal plane angle. All the measurements of the planes (Cook's and HIP) have given positive values with the occlusalplane.**Table 2 and Graph 1** depict the no of subjects under each particular age group.**Table 3andGraph 2** shows then sex distribution among the no of subjects.

Table 4 and Graph 3 represents comparison of mean and standard deviation values of Group A (HIP) and Group B (Cooks plane) from the base (Occlusal plane).

Here the mean value of Group A (HIP plane) is **9.83** with S.D of ± 2.21 and mean value of Group B (Cooks plane) is 14.70 with standard deviation of ±4.09. The **t-value** of both the groups A & B is **5.726. p-Value** is less than 0.0001 hence is extremely statistically significant.**Table 5 and Graph 4** represents comparison of mean and standard deviation values of Group A (HIP) and Group B (Cooks plane) the base (Occlusal plane) within male subjects. Here the mean value of Group A (HIP plane) is **9.67** with S.D of ± 1.50 and mean value of Group B (Cooks plane) is 14.80 with standard deviation of ±2.98. The **t-value** of both the groups A & B is **5.961. p- Value** is less than 0.0001 hence is extremely statistically significant.**Table 6 and Graph 5** represents comparison of mean and standard deviation values of Group A (HIP) and Group B (Cooks plane) the base (Occlusal plane) within female subjects. Here the mean value of Group A (HIP plane) is **10.0** with S.D of ± 2.80 and mean value of Group B (Cooks plane) is 14.60 with standard deviation of ±5.08. The **t-value** of both the groups A & B is **3.070. p- Value =** 0.0047, statistically significant.**Table 7 and Graph 6** represents comparison of mean and standard deviation values of Group A (HIP) and Group B (Cooks plane) the base (Occlusal plane) within male and female subjects. The mean value of Group A (HIP plane) of age 19-23, male **10.0** with S.D of ± 1.41 and mean value of Group B (Cooks plane) is 13.44 with standard deviation of ±2.92. The **t-value** of both the groups A & B is **3.185. p- Value** = 0.0058, statistically significant.The mean value of Group A (HIP plane) of age 19-23, Female **8.80** with S.D of ± 2.49 and mean value of Group B (Cooks plane) is 16.04 with standard deviation of ±4.722. The **t-value** of both the groups A & B is **3.183. p- Value** = 0.0129, statistically significant.The mean value of Group A (HIP plane) of age 24-29, male **9.16** with S.D of ± 1.60 and mean value of Group B (Cooks plane) is 16.83 with standard deviation of ±1.72. The **t-value** of both the groups A & B is **7.983. p- Value** = 0.0001, statistically significantThe mean value of Group A (HIP plane) of age 24-29, Female **10.60** with S.D of ± 2.87 and mean 0fvalueGroup B (Cooks plane) is 13.70 with standard deviation of ±5.25. The **t-value** of both the groups A & B is **1.638. p- Value** = 0.1189, statistically not significant

VI. Discussion

The study of occlusion and its relationship to the function of masticatory system has been a topic of interest in dentistry since many years. One of the chief aim of preventive and restorative dentistry is to maintain an occlusion that will function in harmony with the other components of the masticatory mechanism, by preserving their health and at the same time providing the optimum masticatory function. Several researchers of science have given their attention to achieve this objective.

Due to differences in growth pattern of cranium and face, the maxillary occlusal plane equally descends the same at its posterior as well as anterior end till the physiologic growth end . In true sense the maxillary and mandibular occlusal plane develops individually to meet at a plane where they interdigitate to perform the function of mastication. This interdigital functional plane is guided by the neuro muscular coordination.Hence the occlusal plane established for an individual should be placed in the same position as it was before the loss of teeth as stated by Lammie[5].

In literature, the occlusal plane has been described as 'merely a convenient term for the purpose of discussion' which says that 'like the equator, it occupies an imaginary position of reference'. However, it is unfortunate for dentists that there is little agreement as to where this 'imaginary position of reference' is located. This lack of agreement exists between and within the different dental specialties.[6]

According to GPT-8, occlusal plane is 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.When all natural teeth are lost, the prosthodontist concerned with the provision of the complete denture has less reliable indicators. The guides in use are often remote from the position of the occlusal plane, diffuse, poorly defined and inconsistent.The orientation of the occlusal plane is lost in patients rendered edentulous and should be relocated if complete dentures are to be aesthetic and functional A high occlusal plane may not allow the tongue to rest over the lingual cusps of the lower denture to provide stability, at the same time there may be accumulation of food in the buccal and lingual sulci. A low occlusal plane would lead to tongue and cheek biting and also reduces masticatory efficiency.A range of alternative guides have been proposed by several authors to orient the occlusal plane in complete dentures like Ala-tragus line/ Camper's plane, residual alveolar ridges, lateral border of tongue, retromolar pad, buccinators groove, corner of mouth , parotid papilla and Hamular notch and Incisive papilla (HIP) plane.

Among the above mentioned landmarks campers plane is the most commonly used clinical guide, however it has been reported to be variable. Parotid papilla doesn't give the exact plane but suggests the probable location of occlusal plane. Lateral border of tongue also showed a lot of variability as the tongue is highly muscular and mobile. Retromolarpad, commissure of lip also have been reported to be variable.

Cephalometric analysis has been used in dental research especially in orthodontic and prosthodontics as it can be used to re-establish spatial position of lost structures such as teeth. There is a predictable relationship between teeth and other cranial landmarks that are not subjected to post extraction changes. The suggested planes are FH Plane and Cook's Plane. It has been established by the prosthodontist and anatomist that FH Plane and Occlusal Plane form an angulation of 30º. Cook's Plane is defined as the plane from superior aspect of Hamular notch to Anterior Nasal Spine. This Plane has been accepted as stable cephalometric landmark which is almost parallel to occlusal plane forming a minimal angle of 4 degree.[7]

Cooperman and Rich observed that in their study the occlusal plane showed a close relationship to Hamular notch –Incisive papilla plane. Fu et al in their study used 3D surveying software and stated that HIP plane is parallel to natural occlusal plane.

A few more studies[8,9,10] have stated that buccinators groove is most reliable landmark for the location of occlusal plane while others have said that the buccinators could be a reliable landmark only in patients with good muscle tone as ageing causes decreased muscle tone and the groove may not be recorded that efficiently. Therefore the present study was done to interrelate these three landmarks to occlusal plane.

Methodology followed recording the buccinator groove using vestibular impression technique as suggested by Luther and Lundquist. And lateral cephalometry was used as it is a standard technique for comparing the cranial landmarks with the occlusalplane.For the study, age group of 19-29 years was preferred because by 19 years 1st and 2nd permanent molars are fully erupted and come in proper occlusion with antagonist maxillary arch teeth and after 29 year of age, the chances of loss of teeth due to decay, periodontal disease or trauma and alteration of tooth structure due to attrition, abrasion and erosion are increased. The 3rd molars were excluded from the study because in majority of population they are not fully erupted and if still they erupt either they will be partially impacted or will be angulated.Subjects who had undergone previous orthodontic treatment, craniofacial surgeries like orthognathic surgery or trauma were not included in the present study because they may furnish false or distorted relationship of altered occlusion plane to Cook's plane.Based on results obtained from present study the mean angle formed by HIP plane with the occlusal plane was 9.83 which was extremely statistically significant with a p value of <0.0001 indicating that HIP plane is closely parallel to the occlusalplane.This result is in agreement with the statement given by Rich H that HIP plane tends to parallel to occlusal plane and he suggested further studies with clinical implications in this regard.Augsburger indicated that a strong correlation is present in the location of occlusal plane in individual with different facial types. He also said the distance between the Hamular Notch and Incisive Papilla also effect the cant of occlusalplane.BrianD.Monteith based on his cephalometric studies stated that the HIP plane tends parallel the occlusal plane giving another useful Intra oral landmark for clinical application.Incisive Papilla is a soft tissue anatomical landmark located anteriorly behind the maxillary central incisors. Its position is stable and does not change either with the age of the patient or loss of teeth. Hamular Notch located posteriorly is a cephalometrically stable landmark on the maxilla forms a mean angle (9.84) as reported from present study with the occlusal plane. Therefore it can be suggested that HIP plane is an useful guidline for eastablishing the occlusal plane and its angulation. However this plane may not be helpful for the superior-inferior positioning of occlusal plane.

It has been postulated for almost a century that the occlusal plane is curved because of sagittal inclination of teeth which is dictated by the growth patterns and the musculature. It has also been stated and agreed that the cephalometric landmarks do not change with age or loss of structures like teeth therefore the role of cephalometric landmarks in locating occlusal plane in edentulous patient is of clinical importance.From standpoint of pure mechanics the occlusal plane to be located at right angles to the lines of force. Therefore initially it was stated by many prosthodontists to place the occlusal plane close to the crest of ridge for lever

balance. But from biomechanical standpoint, these lines of force are understandably different as dictated by the neuromuscular forces.

Lammie gave a bold statement that the occlusal plane should be placed in the same position as it has been there before the loss of teeth. This statement is logical since the musculature of tongue and cheeks were trained to function normally when they are called upon to stabilize the bolus at this level when natural teeth were present. This is an important requirement in complete denture wearers to stabilize the denture base on the slippery mucosa.The results from the present study indicate the cant of occlusal plane to be parallel with the cooks plane and HIP plane thus indicating that the cant of occlusal plane can be established with the help of HIP plane in an edentulous patient.

In the present study cephalometric tracing of buccinators followed the curved plane of occlusion showing that there is a strong correlation between buccinator groove and occlusal plane. The results are in agreement with Lundquist and Luther, Shigli et al and Gupta etal.Dr.Shigli et al did not use the cephalometric method to locate the position of buccinators groove. They used an index and related that index on to the occlusal surface of the cast buccally and reported that the buccinators groove was located 0.94mm below occlusal plane. Rubinagupta et al used a level analyser and stated that buccinators groove was the reliable method. In the present study cephalometic method was used to relate the buccinators groove to occlusal plane. A 22gauge soft wire was adapted over the groove and cephalogram was taken. This enabled, to read the curvature of buccinator groove along the occlusal plane which was strongly coinciding. It was also noticed that the buccinator groove recorded was extending from the region of 2^{nd} molar uptopremolars.Buccinator is a broad band of muscle forms the entire cheek from corner of the mouth anteriorly and along the outer surface of maxilla and mandible until it reaches the ramus. The fibres run parallel to the occlusal plane. The muscle has upper fibres running horizontally towards the corner of mouth and lower fibres running horizontally towards the corner where they cross each other i.e the upper fibres run into the lower lip and the lower fibres merge with the upper. This forms a hub of wheel at the corner of mouth. The middle fibres pass horizontally across the commissures of lip. This is known as modiolus into which many other muscles get mingled. Its action and function is to place the bolus onto the occlusal table. Therefore during the contraction the muscle makes an impression along the line of contraction which is very close to the occlusaltable.Therefore it is suggested to record the functional impression to relate the buccinator groove for the superior-inferior location of the occlusal plane in edentulous patients.

Within the limitations of the present study it can be conducted; based on the results obtained, it can be concluded that HIP plane can be used to relate the cant of the occlusal plane as it is almost parallel to the cooks plane in edentulous patients. The superior-inferior position of occlusal plane can be determined by using functional recording of the buccinators groove. Further studies are suggested to establish the validity of the Resultsstated.

VII. Conclusion

From the present study it was observed that, of the three anatomic landmarks [i.e. Buccinators groove, HIP plane and cook's plane] were amost parallel to the occlusal plane and they can be considered as a valid landmarks for deciding occlusal plane.

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Tables

TABLE 1:-MASTER CHART OF DATA OBTAINED FROM 30 SUBJECTS

S.NO	AGE	SEX	GROUP A	GROUP B
			HIP Plane (angle in degree)	Cook's Plane (angle in degree)
1	23	M	10°	9°
2	28	F	8°	10°
3	22	M	10°	13°
4	23	F	7°	23°
5	25	M	9°	17°
6	25	F	12°	15°
7	27	F	14°	10°
8	28	M	8°	16°
9	24	F	10°	13°
10	25	M	11°	14°
11	26	F	7°	22°
12	25	M	9°	17°
13	27	F	6°	23°
14	23	M	13°	10°
15	22	F	7°	19°
16	19	M	8°	13°
17	29	F	10°	16°
18	27	M	11°	18°
19	26	F	14°	9°
20	20	F	9°	12°
21	24	F	13°	10°
22	22	M	9°	16°
23	23	M	10°	14°
24	21	F	8°	16°
25	20	M	11°	12°
26	28	F	12°	9°
27	29	M	7°	19°
28	21	M	9°	18°
29	20	M	10°	16°
30	22	F	13°	12°

TABLE -2: AGE DISTRIBUTION IN PATIENTS

AGE GROUP	NO. OF SUBJECTS
19-23	14 (46.67%)
24-29	16 (53.33%)
TOTAL	30 (100%)

GRAPH-1.AGE DISTRIBUTION IN PATIENTS

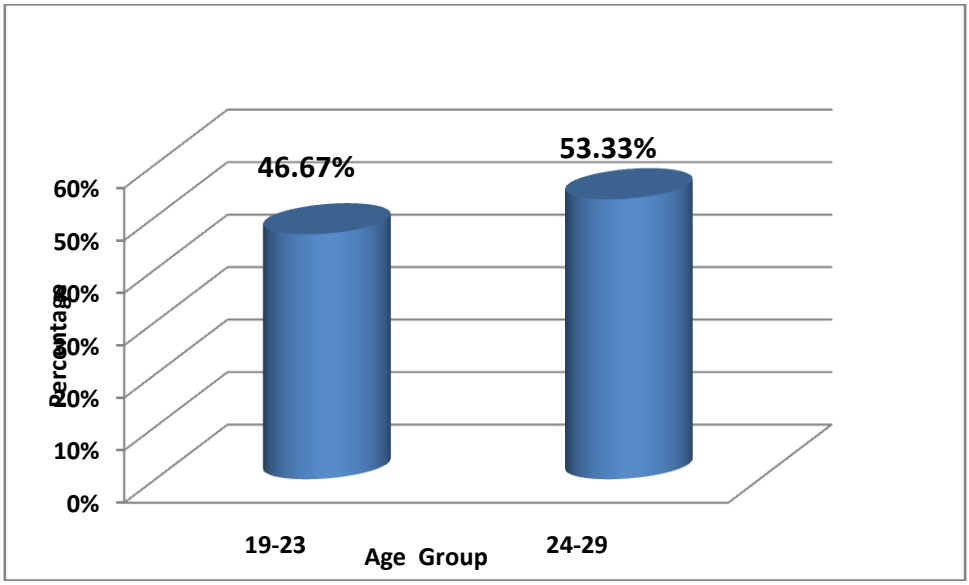


TABLE-3: SEX DISTRIBUTION

SEX	NO. OF SUBJECTS
MALE	15 (50%)
FEMALE	15 (50%)
TOTAL	30 (100%)

GRAPH.2:SEX DISTRIBUTION

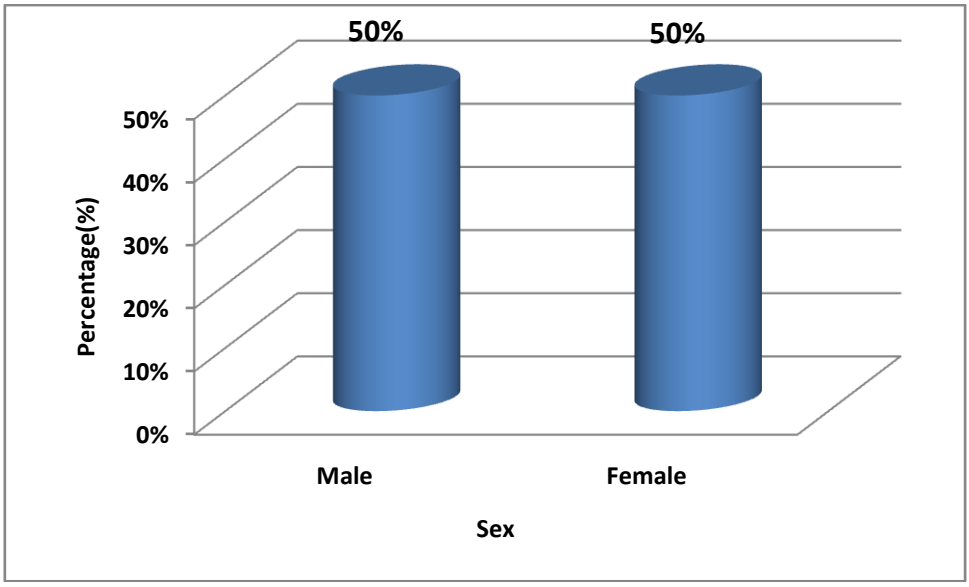


TABLE-4: COMPARISON OF GROUP A & GROUP B FROM BASE

GROUP	MEAN±SD	T-VALUE, DF	P VALUE
GROUP A (HIP PLANE)	9.83±2.21	5.726, 58	<0.0001
GROUP B (COOK'S PLANE)	14.70±4.09		

Student's t test is used for the analysis the result p <0.05 consider statistically significant

GRAPH.3: COMPARISON OF GROUP A & GROUP B FROM BASE

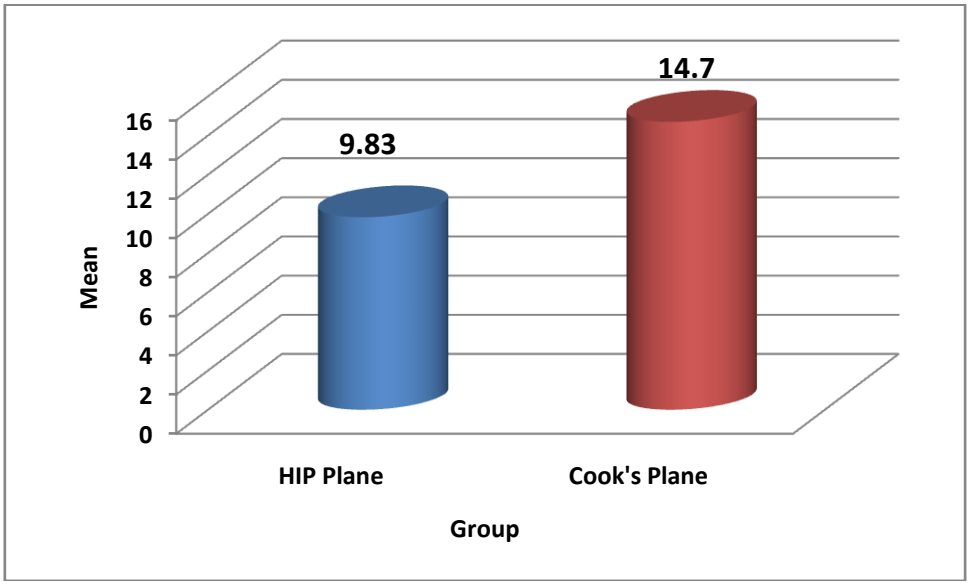


TABLE-5: COMPARISON OF GROUP A & GROUP B WITHIN MALE

MALE	MEAN±SD	T-VALUE, DF	P VALUE
GROUP A (HIP PLANE)	9.67±1.50	5.961, 28	<0.0001
GROUP B (COOK'S PLANE)	14.80±2.98		

Student's t test is used for the analysis the result p <0.05 consider statistically significant

GRAPH-4: COMPARISON OF GROUP A & GROUP B WITHIN MALE

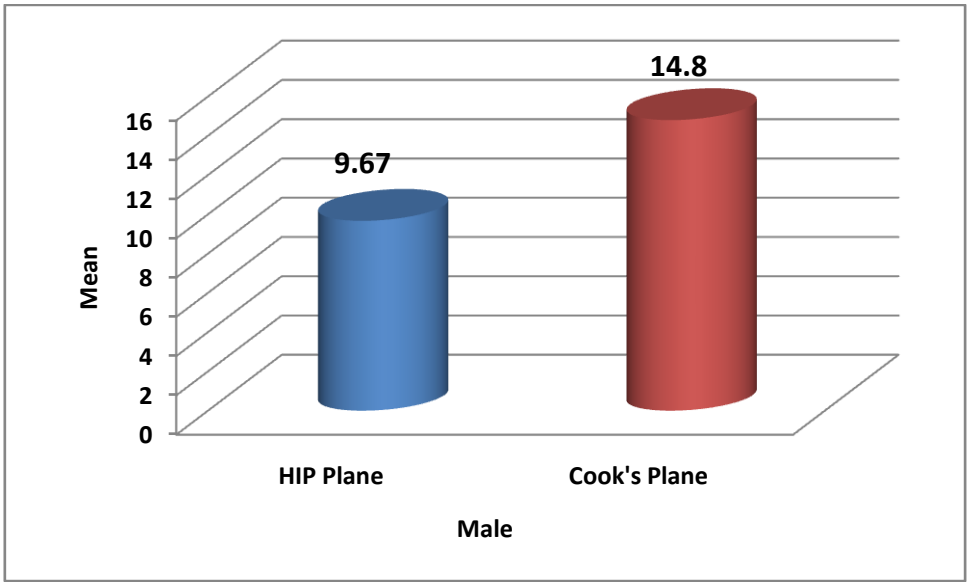


TABLE-6: COMPARISON OF GROUP A & GROUP B WITHIN FEMALE

FEMALE	MEAN±SD	T-VALUE, DF	P VALUE
GROUP A (HIP PLANE)	10.0±2.80	3.070, 28	0.0047
GROUP B (COOK'S PLANE)	14.60±5.08		

Student's t test is used for the analysis the result p <0.05 consider statistically significant

GRAPH-5: COMPARISON OF GROUP A & GROUP B WITHIN FEMALE

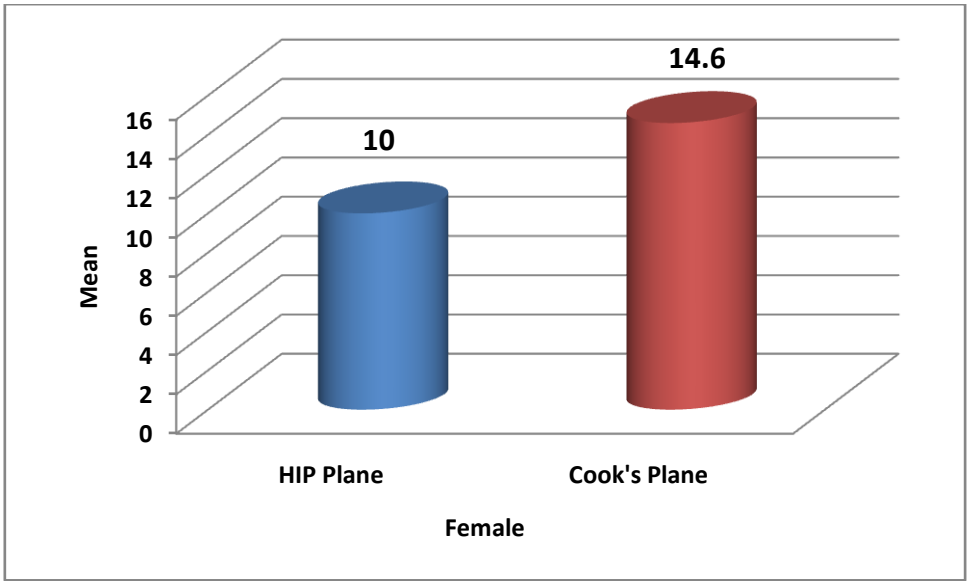
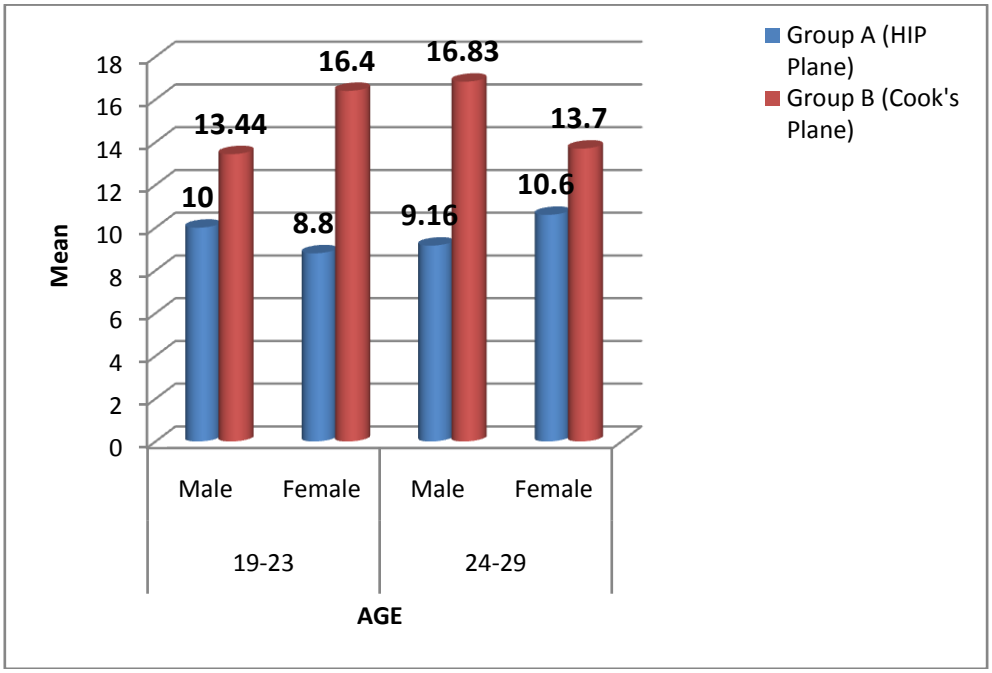


TABLE-7: COMPARISON OF GROUP A & GROUP B WITHIN MALE AND FEMALE OF AGE 19-23 AND AGE24-29

AGE	GENDER	GROUP A (HIP PLANE) MEAN±SD	GROUP B (COOK'S PLANE) MEAN±SD	T-VALUE, DF	P VALUE
19-23	MALE	10.00±1.41	13.44±2.92	3.185, 16	0.0058
	FEMALE	8.80±2.49	16.40±4.722	3.183,8	0.0129
24-29	MALE	9.16±1.60	16.83±1.72	7.983,10	0.0001
	FEMALE	10.60±2.87	13.70±5.25	1.638, 18	0.1189

Student's t test is used for the analysis the result p <0.05 consider statistically significant

GRAPH-6: COMPARISON OF GROUP A & GROUP B WITHIN MALE AND FEMALE OF AGE 19-23 AND AGE24-29



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