EVALUATION OF OCCLUSAL AND CRANIOFACIAL PLANES IN TEMPOROMANDIBULAR DISORDER PATIENTS USING BROADRICK'S OCCLUSAL PLANE ANALYZER AND CEPHALOMETRIC METHODS

A Dissertation submitted to the

THE TAMILNADU DR. MGR MEDICAL UNIVERSITY

In partial fulfillment of the requirements for the degree of

MASTER OF DENTAL SURGERY

(BRANCH – I)

(PROSTHODONTICS AND CROWN & BRIDGE)

2015 – 2018

EVALUATION OF OCCLUSAL AND CRANIOFACIAL PLANES IN TEMPOROMANDIBULAR DISORDER PATIENTS USING BROADRICK'S OCCLUSAL PLANE ANALYZER AND CEPHALOMETRIC METHODS

A Dissertation submitted to the

THE TAMILNADU DR. MGR MEDICAL UNIVERSITY

In partial fulfillment of the requirements for the degree of

MASTER OF DENTAL SURGERY

(BRANCH – I)

(PROSTHODONTICS AND CROWN & BRIDGE)

2015 – 2018

CERTIFICATE

This is to certify that **DR.SUGANTHAPRIYA S,** Post Graduate student (2015 - 2018) in the Department of Prosthodontics and Crown and Bridge, has done this dissertation titled "**EVALUATION OF OCCLUSAL AND CRANIOFACIAL PLANES IN TEMPOROMANDIBULAR DISORDER PATIENTS USING BROADRICK'S OCCLUSAL PLANE ANALYZER AND CEPHALOMETRIC METHODS**" under my direct guidance and supervision in partial fulfillment of the regulations laid down by **The Tamil Nadu Dr. M.G.R. Medical University, Guindy, Chennai – 32** for **M.D.S.** in **Prosthodontics and Crown & Bridge (Branch I)** Degree Examination.

Guided by

Dr.A.MEENAKSHI,M.D.S.,

Professor, Department Of Prosthodontics,
Tamil Nadu Govt. Dental College
&Hospital,
Chennai-600 003.

Head of the department

DR.C.SABARIGIRINATHAN.M.D.S.,

Professor and Head Of The Department
Department of Prosthodontics
TamilNadu Govt.Dental College
And Hospital, Chennai – 600 003

Head of the institution

Dr.SARAVANAN,M.D.S.,
PRINCIPAL
Tamil Nadu Govt. Dental College & Hospital,
Chennai-600 003.

DECLARATION

I Dr.S.SUGANTHAPRIYA do hereby declare that the dissertation titled **"EVALUATION OF OCCLUSAL AND CRANIOFACIAL PLANES IN TEMPOROMANDIBULAR DISORDER PATIENTS USING BROADRICK'S OCCLUSAL PLANE ANALYZER AND CEPHALOMETRIC METHODS"** was done in the Department of Prosthodontics, Tamil Nadu Government Dental College and Hospital,Chennai-600 003. I have utilized the facilities provided in the Government Dental College and Hospital for the 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 2015-2018 under the conceptualization and guidance of my dissertation guide **Professor Dr.A.MEENAKSHI.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 and 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 and Hospital, Chennai- 600 003, but with the vested right that I shall be cited as author(s).

Signature of Student **Signature of HOD**

Signature of Head of the Institution

TRIPARTITE AGREEMENT

This agreement herein after the “Agreement” is entered into on this day, **____________,2018** between the **Tamil Nadu Government Dental College and Hospital** represented by its Principal having address at Tamil Nadu Government Dental College and Hospital, Chennai-3, (hereafter referred to as, ‘the College’)

And

Dr.A.MEENAKSHI,M.D.S., aged 51 years working as Professor, Department of Prosthodontics and crown and bridge at Tamil Nadu Government Dental College and Hospital, Chennai-3 having residence address at No. 137, fifth street, secretariat colony, Kelleys,Chennai-10 (herein after referred to as the ‘Researcher and Principal investigator’)

And

Dr.S.SUGANTHAPRIYA aged 33 years currently studying as Post Graduate student in the Department of Prosthodontics and Crown & Bridge, Tamil Nadu Government Dental College and Hospital, Chennai-3 having residence address at B/F, RCN Apartments, Renga Nagar, Mutharasanallur, Sri Rangam (T.k),Trichy-620101 (herein after referred to as the ‘PG/Research student and Co- investigator’).

Whereas the ‘PG/Research student as part of his curriculum undertakes to research on the study titled **“EVALUATION OF OCCLUSAL AND CRANIOFACIAL PLANES IN TEMPOROMANDIBULAR DISORDER PATIENTS USING BROADRICK’S OCCLUSAL PLANE ANALYZER AND CEPHALOMETRIC METHODS”** for which purpose the Researcher and Principal investigator shall act as Principal investigator and the College shall provide the requisite infrastructure based on availability and also provide facility to the PG/Research student as to the extent possible as a Co-investigator

Whereas the parties, by this agreement have mutually agreed to the various issues including in particular the copyright and confidentiality issues that arise in this regard

Now this agreement witness as follows ;

1. The parties agree that all the research material and ownership therein shall become the vested right of the college, including in particular all the copyright in the literature including the study, research and all other related papers.
2. To the extent that the College has legal right to do go, shall grant to licence or assign the copyright do vested with it for medical and/or commercial usage of interested persons/entities subject to a reasonable terms/conditions including royalty as deemed by the college.
3. The royalty so received by the college shall be equally by all the parties.
4. The PG/Research student and PG/Principal Investigator shall under no circumstances deal with the copyright, confidential information and know how generated during the course of research/study in any manner whatsoever, while shall sole vest with the manner whatsoever and for any purpose without the express written consent of the college.
5. All expenses pertaining to the research shall be decided upon by the Principal investigator/Co-investigator or borne sole by the PG/Research student (Co-investigator).
6. The College shall provide all infrastructure and access facilities within and in other institutes to the extent possible. This includes patient interactions, introductory letters, recommendation letters and such other acts required in this regard.
7. The principal investigator shall suitably guide the student research right from selection of the research topic and area till its completion. However the selection and conduct of research, topic and area research by the student researcher under guidance from the principal investigator shall be subject to the prior approval, recommendations and comments of the Ethical Committee of the college constituted for this purpose.

8. It is agreed that as regards other aspects not covered under this agreement, but which pertain to the research undertaken by the Student Researcher, under guidance from the Principal Investigator, the decision of the college shall be binding and final.
9. If any dispute arises as to the matters related or connected to this agreement herein, it shall be referred to arbitration in accordance with the provisions of the Arbitration and Conciliation Act, 1996.

In witness whereof the parties herein above mentioned have on this the day month and year herein above mentioned set their hands to this agreement in the presence of the following two witnesses.

College represented by its Principal   Student Guide

Witnesses   PG Student

1.

2.

MY ACKNOWLEDGEMENT AND SINCERE THANKS TO MY GUIDE

With immense pleasure and honor I take this opportunity to express my humble and heartfelt gratitude to my mentor, a relentless source of inspiration and dissertation guide **Dr.A.MEENAKSHI, M.D.S**., Professor, Department of Prosthodontics, Tamil Nadu Government Dental College and Hospital, for her able guidance and support. I am grateful for her help at various stages of the dissertation. Without her help this dissertation would not have come out in a befitting manner. Each word said to describe the experience as her student, which was a boon in disguise, would be an understatement. Her esteemed and able guidance made this dissertation a possibility. Her dedication to work which made us realizes the worth of discovering our own capabilities. Her unprecedented calm and patient personality, an unfailing, caring and understanding demeanor made each endeavor easier.

ACKNOWLEDGEMENT

I am extremely thankful to **DR.C.SABARIGIRINATHAN.M.D.S.,** Professor and Head of the Department, Department of prosthodontics, Tamil Nadu Government Dental College and Hospital, Chennai, for his wholehearted support, constant guidance, help, encouragement, valuable suggestions and support he has rendered at various stages of the dissertation. I also thank him for the valuable guidance; he has given throughout my post graduation. Without him immense help this dissertation would not have come out in a befitting manner.

My sincere thanks to **Prof.Dr.B.Saravanan M.D.S.,** Principal, Tamil Nadu Government Dental College and Hospital for his kind help, valuable suggestions in this study and permitting to use all the facilities in the institution. I also thank him for the valuable guidance; he has given throughout the period of my post graduate course.

With immense pleasure I take this opportunity to express my humble and heartfelt gratitude to my dissertation guide **DR.A.MEENAKSHI.M.D.S.,** Professor, Department of Prosthodontics, Tamilnadu Government Dental College and Hospital for her valuable guidance and support throughout this dissertation work.

My sincere thanks to **DR.K.VINAYAGAVEL.M.D.S.,** Professor, Department of Prosthodontics, Tamilnadu Government Dental College and Hospital for his valuable guidance throughout my study.

I am thankful to my Associate Professors,**Dr.R.Rupkumar.M.D.S., Dr.G.Sriramprabu.M.D.S., Dr.M.Rajakumar.M.D.S.,** for guiding and helping me at different stages of this study.

I am thankful to my Assistant Professors,**Dr.T.Jeyanthikumari.M.D.S., Dr.M.Kanmani.M.D.S., Dr.S.Vinayagam.M.D.S., Dr.J.Gandhimathi.M.D.S., Dr.V.Harishnath.M.D.S., Dr.V.Parimala,M.D.S., Dr.PreethiChandranM.D.S., Dr.S.SivaSakthiKumar.M.D.S.,** for helping me at different stages of this study.

I am thankful to all the students of Tamil Nadu Government Dental College and Hospital, Chennai – 03, who have participated in my study & help me carrying out the study.

I thank **Dr.Mohammed Junaid MDS (Community Dentistry)**, Chennai for helping me, to carryout statistical analysis of the various test results.

My special thanks to **my family and friends** for their constant support and motivation. I owe my sincere thanks to all my senior postgraduates and junior postgraduate students in the department for their constant encouragement and timely help.

Above all I thank the **ALMIGHTY** for giving me the strength and courage to complete this monumental task.

TAMIL NADU GOVERNMENT DENTAL COLLEGE & HOSPITAL, CHENNAI – 3.

TELEPHONE : 044-253403343

FAX: 044- 25300681

Ref No: R. C. NO: 0420/DE/2016

date : 30-11-2016

Sub: IEC review of the research proposals,

Title of the work:	EVALUATION OF OCCLUSAL AND CRANIOFACIAL PLANES IN TEMPOROMANDIBULAR DISORDER PATIENTS USING BROADRICK'S OCCLUSAL PLANE ANALYZER AND CEPHALOMETRIC METHODS
Investigator:	Dr.Suganthapriya S, II year , MDS
Department :	Department of Prosthodontics and Crown & Bridge, Tamil Nadu Govt. Dental College & Hospital , Chennai-3

Thank you for submitting your research proposal , which was considered at the Institutional Ethics Committee meeting held on 30-09-2016, at TN Govt. Dental College. The documents related to the study referred above were discussed and the modifications done as suggested and reported to us through your letter On 28-11-2016 have been reviewed. The decision of the members of the committee , the secretary and the Chairperson IEC of TN Govt. Dental College is here under:

Approved	Approved and advised to proceed with the study
Approved with suggestions	---------------------------------
Revision	-------------------------------------- -
Rejected	------------------------------------

The principal investigators and their team are advised to adhere to the guide lines given below:

1. You should get detailed informed consent from the patients / participants and maintain confidentiality.
2. You should carry out the work without affecting regular work and without extra expenditure to the Institution or the Government.
3. You should inform the IEC, in case of any change of study procedure, site, and investigating guide.
4. You should not deviate from the area of work for which you have applied for ethical clearance.
5. You should inform the IEC immediately in case of any adverse events or serious adverse reactions. You should abide to the rules and regulations of the institution(s) .
6. You should complete the work within specific period and if any extension of time is required, you should apply for permission again to do the work.
7. You should submit the summary of the work to the ethical committee every 3 months and on completion of the work.
8. You should not claim any kind of funds from the institution for doing the work or on completion/ or for any kind of compensations.
9. The members of the IEC have the right to monitor the work without prior intimation.
10. Your work should be carried out under the direct supervision of the guide/ Professor.
11. The investigator and Guide should each declare that no plagiarism is involved, in this whole study and enclose the undertaking in dissertation/ thesis.

MEMBER SECRETARY,
INSTITUTIONAL ETHICS COMMITTEE
Tamil Nadu Govt. Dental College & Hospital
Chennai

CHAIRPERSON
INSTITUTIONAL ETHICS COMMITTEE
Tamil Nadu Govt. Dental College & Hospital
Chennai

URKUND

Urkund Analysis Result

Analysed Document: PLAGIARISM DOC.docx (D34332891)
Submitted: 1/4/2018 6:25:00 AM
Submitted By: dr.sakthi.sairam@gmail.com
Significance: 3 %

Sources included in the report:

plagiarism test.docx (D34317938)
10 Jill- THESIS.docx (D34321644)
Tez - İng.pdf (D14880187)
Stability after Mandibular Advancement using Bilateral Sagittal Split Osteotomy. Erica Larsson, Ellinore Jacobsson.docx (D28709892)
final thesis.docx (D34243454)
https://www.slideshare.net/indiandentalacademy/occlusal-plane
https://www.sciencedirect.com/science/article/pii/0022391379902415

Instances where selected sources appear:

18

<u>CERTIFICATE – II</u>

This is to certify that this dissertation work titled "**EVALUATION OF OCCLUSAL AND CRANIOFACIAL PLANES IN TEMPOROMANDIBULAR DISORDER PATIENTS USING BROADRICK'S OCCLUSAL PLANE ANALYZER AND CEPHALOMETRIC METHODS** "of the candidate **DR. SUGANTHA PRIYA S** with registration number **241511005** for the award of **MASTER OF DENTAL SURGERY** in the branch of **PROSTHODONTICS AND CROWN & BRIDGE**. I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows **3%** percentage of plagiarism in the dissertation.

Guide & Supervisor sign with Seal.

CONTENTS

LIST OF ABBREVIATIONS

Sl.No	ABBREVIATION	EXPANSION
1	TMJ	Temporomandibular joint
2	TMD	Temporomandibular disorder
3	BOPA	Broadrick's occlusal plane analyzer
4	GPT	Glossary of Prosthodontic terms
5	MIO	Maximal interincisal opening
6	PMS	Pankey Mann Schuyler
7	S.D	Standard deviation
8	SPSS	Statistical Package for Social Services
9	mm	Millimeter
10	cm	Centimeter

LIST OF PHOTOGRAPHS

LIST OF TABLES

LIST OF BAR DIAGRAMS

INTRODUCTION:

The Temporomandibular joint (TMJ) is a synovial joint consisting of the movable condyloid process and its articulating counterpart, the articular eminence, which forms the anterior aspect of the glenoid fossa.The articular disk is interposed between the condyle and the articular eminence, which allows for rotational and translatory movements. This complex combination of movements allows for painless and efficient chewing, swallowing, and speaking. The articulating surfaces are lined with fibrous connective tissue; this avascular and noninnervated structure has a greater capacity to resist degenerative change and regenerate itself than the hyaline cartilage of other synovial joints.

The difference between the TMJ and other joints in the body is the influence of the teeth on the relationship of the articulating components. When the teeth are not in occlusion, this relationship is determined by the morphology of the bones, and by the muscles and ligaments that cross the joint. However, when the teeth do come into contact, they determine the final position of the condyle.

Temporomandibular disorders (TMD) are, according to the Guidelines of the American Academy of Orofacial Pain,

‘a collective term embracing a number of clinical problems that involve the masticatory musculature, the temporomandibular joints and associated structures, or both’ (Okeson)

There exists a functional homeostatic balance between the various components of the masticatory system including the teeth, periodontium (hard and soft tissue supporting structures), masticatory and cervical musculature, temporomandibular joint structures, and the psyche of each individual. This balance may be disrupted by a number of factors acting either alone or in combination resulting in the expression of signs and symptoms associated with TMD[1].

The most frequent complaint is pain and a decrease in the maximal interincisal opening (MIO).The following symptoms as pain at rest, during maximum mouth opening and chewing,tenderness to palpation of the joint, clicking,crepitation, difficulty in opening the mouth, intermittent lock, closed lock, the stiffness of joint in the early morning might be present. TMD is seen most commonly in people between the ages of 20 and 40 years and occurs more often in women.

The occlusion is treated not only as the ratio of contact between teeth, but as a dynamic, morphological and functional relation between all components of the stomatognathic system, presenting a great influence on chewing, swallowing and speech. There is a huge controversy in literature regarding the association between occlusion and TMD. Some authors have reported high turnout of occlusal factors in signs and symptoms of TMD. Others are skeptical about it and others believe that occlusion plays a limited role, but it cannot be underestimated[2].

Proper orientation of the occlusal plane plays an important role in achieving optimum functional and aesthetic demands. According to Dr.Peter Dawson,

"The plane of occlusion refers to an imaginary surface that theoretically touches the incisal edges of the incisors and the tips of the occluding surfaces of the posterior teeth[3]".

As is apparent from the definition, that the occlusal plane is not flat but represents the planar mean of the curvature of these surfaces[4]. These are as follows

1. Curve of Spee + Curve of Wilson + Curve of Incisal Edges = Curve of Occlusion
2. Curve of Occlusion + Its relationship to the Cranium = Plane of Occlusion

The curve of Spee may be pathologically altered in situations resulting from rotation, tipping, and extrusion of teeth. Restoration of the dentition to such an altered occlusal plane can introduce posterior protrusive interferences . Such interferences have been shown to cause abnormal activity in mandibular elevator muscles, especially the masseter and temporalis muscle ,thereby leading to dysfunction of temporomandibular joint[5].

The methods that have been most commonly used for establishing an acceptable plane of occlusion are direct analysis on natural teeth through selective grinding on natural teeth by directly analyzing it, indirectly analyzing mounted facebow transfer casts with properly set condylar paths, and using the Broadrick occlusal plane analyzer (BOPA) by Pankey-Mann-Schuyler (PMS) method indirect analysis[6].

An occlusal plane analyzer has long been used in the development of an initial mandibular occlusal plane in diagnostic casts and later as an integral part of both the contours of the definitive restorations and the guidelines for the actual tooth preparations. Broadrick's occlusal plane analyzer (BOPA) by PMS method is the simplest and practical method which helps in establishing primary occlusal plane on facebow transferred mounted diagnostic cast. This analyzer has been adapted only to few articulator systems, like Denar Anamark Fossae (Teledyne Waterpik, Ft Collins, Colo) and all models of Hanau articulators (Teledyne Waterpik)[7,8]. A custom made clear acrylic resin BOPA can be fabricated for those semi adjustable articulators which does not provide such occlusal plane analyzer[9].

The Broadrick flag permits construction of the curve of Spee in harmony with anterior condylar guidance allowing total posterior tooth disclusion on mandibular protrusion.

Various theories have been proposed about the orientation of occlusal plane in dentulous subjects and accordingly different methods for locating the occlusal plane have been advocated using number of intra-oral as well as extra-oral landmarks.

The commonly used method is based on anatomical landmarks which advises the positioning of occlusal plane between the corner of the mouth anteriorly and posteriorly at the level of the junction of middle and upper third of the retro-molar pad and parallel to the ala-tragus plane (Camper's line) upper border of tragus in the posterior region and to the inter-pupillary line in the anterior region[10]. Even though the above method is commonly used, orienting occlusal plane still remains controversial.

The purpose of analyzing the occlusal plane cephalometrically is to determine its correct vertical position in both the anterior and posterior segments. An esthetically pleasing occlusal plane is close to the centre of the ramus (Xi point) at the posterior and slightly below the lip embrasure at the anterior. The posterior level of the occlusal plane should approach the level of Xi point[11,12,13]. A cephalometric study conducted to compare the plane of occlusion in edentulous and dentulous subjects showed that the reliability of camper's plane as a reference to orient occlusal plane is questionable[7].

Contemporary concepts advocate establishing the plane of occlusion as close as possible to the position, which was previously occupied by the occlusal plane of the natural teeth to ensure normal function of the cheek, tongue and masticatory muscles[14]. Broadrick's concept appears to be the most in line with the above objective.

In case of dentulous individual, the disto incisal edge of mandibular canine is taken as the the anterior reference point and disto buccal cusp of the last erupted molar is taken as the posterior reference point for Broadrick occlusal plane analyzer method[6].

Many studies have found relationship between TMD and various occlusal changes such as rotation, tipping, supraeruption which in turn leads to disturbed occlusal plane. The present study helps to determine the relationship that exists between occlusal plane and craniofacial planes namely Campers plane, maxillary plane in Temporomandibular disorder patients.

AIM OF THE STUDY:

The aim of this study is to assess the existence of correlation between the orientation of occlusal plane obtained by custom made Broadrick's occlusal plane analyzer and the craniofacial planes by cephalometric imaging modality in Temporomandibular disorder patients.

OBJECTIVES OF THE STUDY:

1. To evaluate the position of occlusal plane by custom made Broadrick's occlusal plane analyzer in normal subjects and Temporomandibular disorder patients.
2. To evaluate the position of craniofacial planes (Camper's plane and Maxillary plane) using cephalometric radiograph in normal subjects and Temporomandibular disorder patients.
3. To assess the existence of correlation between occlusal plane and craniofacial planes in the two groups.

REVIEW OF LITERATURE

Occlusal plane concepts in dentulous individuals:

Ferdinand Graf Spee[15], described an antero posterior curve referred to as the curve of Spee, which passes connecting the cusp tip of the mandibular canine and the buccal cusp tips of the mandibular premolars and molars, and extends in the posterior direction to pass through the most anterior point of the mandibular condyle in the sagittal plane. The center of the curve lies along "a horizontal line which passes through the middle of the orbits behind the crista lachrymal posterior," as per the explanation of Spee, the radius of the curve was estimated to be 2.5 inches.

George Monson[16](1920), by combining the concepts of Bonwill's 4-inch triangle and bilateral balanced occlusion, Von Spee's compensating curve (anterior-posterior and buccal- lingual curvature), and the observances of Blackwill and Christensen on condylar movement, suggested a 3-dimensional configuration of the occlusal curve in the shape of a sphere. Monson combined antero-posterior and medio-lateral curves and proposed a sphere passed through the incisal edges and occlusal surfaces of the mandibular teeth. The surface of the sphere is convex for maxillary teeth and concave for mandibular teeth. Instead of the 2.5 inches radius proposed by Spee, a sphere of 4-inches was advocated by him.

Foley[17] in 1985, conducted a study investigating the anatomic relationship of the parotid papilla to the occlusal plane in dentulous patients. A total of 407 adults (293-men, 114-women) from the dental patient population at Ft. Gordon, Georgia were examined to determine the distance from the inferior border of the right and left parotid papillae to the position of the corresponding mandibular buccal cusp tips. The mean distance of all parotid papillae above the plane of occlusion was 3.3 mm, while for the right papilla it was 3 mm, and for the left papilla it was 3.5 mm. They found out that a distance of 3.3 mm can be used as a guideline to establish the occlusal plane in complete dentures. This study determined that a constant relationship exists between the parotid papilla and the occlusal plane. At the same time, this relationship may not be the same on each side of the mouth.

Orthlieb[18], in 1997, conducted study on cephalometric images to establish the fundamentals of geometry of plane of occlusion. They conducted the study in 470 subjects.The results indicated that the mandibular incisors followed the law of tangent. The posterior mandibular teeth followed a progressive differential angle with the direction of the tangent. Also, there was significant variations in the curve depending upon the degree of overbite and skeletal relation.

Several hypotheses have been suggested to explain the functional significance of this arrangement:

1. Due to incorporation of monson's curve in dentition, the dentition will have better resistance against occlusal forces and chewing and there will be increased stability of the dental arches.

2. The functional consideration has control over the teeth arrangement based on increase in chewing efficiency in molar region.

3. Dynamic considerations are determined by protrusive movements in relationship to the curve of Spee, the angle of eminentia, height of the molar cusp, incisor overbite and the posterior contacts.

In 1997, **Ferrario and coworkers[19]**, studied the three dimensional curvature of the mandibular arch using a three dimensional digitizer. Three dimensional positions of the cusp tips of all the teeth except third molars was obtained. A spherical model of the occlusal plane was obtained using the same, the results were calculated from the best interpolating sphere and they came to a conclusion that:

1. Despite all the computer variables were larger in men than women, gender did not influence the occlusal curvature of mandibular arch.

2. The overall sphere, right and left curves of Spee, and curve of Wilson in the molar region measured a radius of about 105 mm in men and about 100 mm in women.

3. The mean radius of the sphere was very close to the classical value of 4 inch in men confirming Monson’s observation. Due to large intra sample variability, the gender influence on the three dimensional characteristics of occlusal curvature could not be determined.

In 2002, **Mauro Farella et al**[20], using cephalometry,studied the relationship between the sagittal, vertical craniofacial dimensions and the position of the mandibular condyle with respect to occlusal plane. Dental casts and lateral cephalograms were acquired from 59 orthodontic patients. Lateral digital photographs showed the amount of concavity of the curve of Spee. The variables revealed 34% of the total variance of the curve of Spee.

The amount of curvature for curve of Spee was significantly related to

1. The horizontal position of the condyle with regard to the dentition,

2. The position of the mandible in relation to the anterior cranial base in sagittal plane,

3. The posterior and anterior facial height ratio.

The study further concluded that

1. The other cephalometric variables were not significantly related to the curve of Spee.

2. The age and gender of the individuals does not have any influence on the curve of Spee.

Hui Xu et al[21], (2004), investigated the curve of Spee in the maxilla and mandible of human permanent dentition. With a sample of 50 Japanese adults, he investigated the differences in the curve of Spee between the maxillary and mandibular arches and the effects of gender on the curve of Spee. The standardized digital pictures of the right side of maxillary and mandibular dental casts were taken with predetermined settings. On the digitalized images the cusp tips of the molars, premolars and canines of the maxilla and mandible were located. Using computer software, the radius and depth of curve of Spee were measured on dental cast.

The results pointed out that

1. The radii of curves of Spee in the maxillary arch were significantly greater than those in mandibular arch.

2. In the maxillary arch the depth of the curve was 1.6mm approximately and it was 1.9mm in the mandibular arch.

3. The mandibular arch showed a significantly deeper curve of Spee than the maxillary arch.

The study concluded that

1. In the investigated population, no gender influence was found in relation to the curve of spee.

2. The curve of Spee in the maxillary arch was found to be significantly flatter than that in the mandibular arch.

Fu and coworkers[22],(2007), analysed geometry of occlusal plane in 100 Taiwanese young adults in relation to Hamular notch – Incisive papilla plane. All predetermined points were marked precisely, three dimensional measurements were made and depending on these points, four geometrically different occlusal planes were defined. The angular relationship between the four occlusal planes and the

Hamular notch – incisive papilla plane were studied. Vertical distance was measured between the cusp tips and the incisal edges of maxillary teeth to the Hamular notch – incisive papilla plane. The study concluded that the Hamular notch –Incisive papilla plane was found to be parallel to the occlusal plane.

Jayachandran et al[23], 2008, studied the orientation of occlusal plane in relation to Hamular notch – Incisive papilla plane for 30 edentulous and 60 dentulous Indian individuals. The mean differences from the right canine were: 0.055 cm at the left canine, 0.05 cm at the right molar, and 0.065 cm at the left molar in dentulous subjects and 0.001 cm between the incisive papilla and hamular notch in edentulous subjects. The paired t- test did not show any statistically significant difference. Therefore they concluded that Hamular notch – Incisive papilla plane was parallel to the occlusal plane in the subjects evaluated.

Occlusal plane configuration in edentulous patients

In 1953, **Sloane and Cook[24]** investigated the relation between fixed cranial landmarks and plane of occlusion. The relation between the occlusal plane and the Cook's plane, which passes through anterior nasal spine and hamular notches were studied.

The results indicated that:

1. The angle between the Cook's plane and the plane of occlusion falls within expected limits.

2. The angle formed by Cook's plane and plane of occlusion, and distance between anterior nasal spine and hamular notch were found to be in relation to each other.

3. The bilateral asymmetry in skulls and casts studied did not have significant effect on basic relation.

4. Though there was variability in the distances from the anterior nasal spine and the hamular notches to the occlusal plane, the difference between them was constant enough to permit the use of the mean value practically.

5. For preserving the aesthetics, the anterior part of the occlusal plane must be parallel to the pupils of the eyes.

The study also pointed out that , the selection of the reference points should be such that they would not be affected by the degenerative process and readily be located on the edentulous maxillary cast. As ANS is relatively difficult to identify on the cast, incisive papilla can be used.

In 1958, **Hall**[25], stated that the position of the occlusal plane depends upon each patient's oral physiology and aesthetic need. In order to establish any plane, three points must be present. One is located in the anterior region and one in each posterior segment for the establishment of occlusal plane of a denture. the anterior point is determined by the length of the incisal edge of the upper occlusion rim above or below the upper lip when the lip is properly supported. The two posterior points are determined by the height of distal half of the retro-molar pad on each side. The occlusal plane is parallel to the plane of the residual ridges.

Boucher[26] (1963) opined that the artificial occlusal plane should be constructed in such a way that it must resemble the natural occlusal plane. According to him, the position of the anterior teeth is determined by aesthetics and posterior end of occlusal plane should be established in such a way that it is approximately at the level of distal part of the retro-molar pad.

Ismail and Bowman[27], in 1968, compared the plane of occlusion of the artificial teeth with that of the natural teeth which were present, before planning to be extracted. The ala-tragus line was used as a guide for the plane of occlusion which was then altered to coincide occlusal surface of the second molar with the middle third of retro-molar pad. In the posterior region, the plane of natural teeth was observed to be above this position. The study revealed that the occlusal plane should be established so that the second molars should be located at the level of upper third of the retro-molar pad.

Lundquist D. O[28]**.** in 1970,conducted a study on 20 Caucasian subjects with ideal occlusion to determine whether certain intra-oral landmarks could estimate the location of the occlusal plane. The retro-molar pad, parotid papilla, commissure of lips and buccinators groove were analyzed for their relationship with natural plane of occlusion. They analyzed that in 75% of subjects, the occlusal plane terminated in the area of lower half of retro-molar pad and in remaining 25% subjects occlusal plane terminated in upper half of retro-molar pad. The vertical location of parotid papilla varied from a point in level with the mesio-buccal cusp tip of maxillary second molar or disto-buccal cusp tip of maxillary first molar to 10 mm above these cusp tips. The plane of occlusion had shown only vertical correlation with the commissures of lip. It was concluded that the soft tissue landmarks remained difficult to be accurately measured but the occlusal plane , buccinators grooves and commissure of lips were closely related.

L'Estrange and Vig[29], in 1975, investigated the relation between location of plane of occlusion and maxillomandibular space in dentate and edentate individuals. In both the groups,the angles between occlusal and maxillary planes were closely related. A significant relation was observed between angulation of the occlusal plane to the maxillary plane and maxillomandibular space. When the maxillomandibular space was long-and-low type, then the occlusal plane was parallel to the maxillary plane. The occlusal plane was steeply angulated to the maxillary plane when the maxillomandibular was short-and-high type. It was concluded that the extremes of maxillomandibular space will cause deviation of occlusal plane away from a mean angulation of maxillary plane.

Okane H[30]. in 1979, conducted a study on 4 patients (3 men and 1 woman) wearing complete dentures of age between 61-79 years to study the effect of anteroposterior inclination of the occlusal plane on muscle activity during clenching, on biting force and to estimate physiologically the applicability of ala-tragus line. At three different antero-posterior inclinations of the occlusal plane, at a constant vertical dimension of occlusion, the integrated electromyographic activity and biting forces of the patients were studied. Three orientations were used- first plane parallel to ala-tragus line extending from inferior point of ala of nose to lower border of tragus and other two planes were 5 degrees anteriorly and 5 degrees posteriorly inclined to the first plane. It was observed that biting force and clenching was greatest when the occlusal plane was parallel to ala-tragus line and it decreased when the plane was inclined about 5 degrees anteriorly or 5 degrees posteriorly. The antero-posterior inclination of the plane of occlusion affects the biting force and the ala-tragus line seems to be the most reasonable for orientation of occlusal plane.

Douglas and coworkers[31] , in 1983, conferred the results of their cephalometric study done on edentulous complete denture wearers over a period of 20 years. They examined the changes in the craniofacial complex of the subjects in the study.

The observations made in the study were:

1. As time progressed, there was counterclockwise rotation of the mandible , resulting in loss of vertical dimension and an increase in relative prognathism of the mandible.

2. The mandibular bony edentulous ridge was significantly reduced during the duration of the study when compared to maxillary edentulous ridge.

3. Due to changes in craniofacial complex, the dentures showed counterclockwise rotation and a mild amount of anterior shift.

4. There were no significant differences with regard to gender. Moreover there were no significant changes between patients using standard and complex dentures.

Another cephalometric study was conducted by **Tuncay and coworkers**[32] in 1984, over a period of 10 years to investigate the changes in craniofacial complex, residual ridge resorption and position of the dentures in relation to cephalometric landmarks. The study was conducted to determine the relation between changes in craniofacial complex and factors such as age, sex, skeletal pattern, duration of edentulousness, technique for denture fabrication and wearing of denture during night time.

The observations of the study were:

1. There was counterclockwise rotation of both maxillae and mandible in sagittal plane.

2. Along with associated forward movement, the complete dentures seems to undergo counterclockwise rotation.

3. The positional changes in the complete dentures were caused by soft tissue component changes as compared to residual ridge resorption.

4. The denture technique used was not responsible for such changes.

5. Over the study period of 10 years, the porcelain teeth of the dentures did not undergo significant attrition.

6. Age, sex and wearing of dentures during night time did not found to have influence on the changes observed.

7. The skeletal pattern influenced the degree of prognathism over a period of time.

8. The duration of edentulism was found to be associated with the amount of mandibular ridge resorption.

Van Niekerk[33] , in 1985, conducted a cephalometric study where complete dentures were fabricated with criteria other than the ala-tragus line to establish the occlusal plane. The patients included in the study were satisfied with esthetic, function and comfort of the prosthesis. The occlusal plane on the denture was indicated by a lead foil adapted in the right mandibular posterior region. Another lead foil was positioned over the face from lower border of ala to the tragus. The relation between two markers was studied with the help of a cephalogram. A significant parallelism between the two markers was seen. They concluded ala-tragus line is closely associated to the occlusal plane and it can be used as landmark to establish the occlusal plane for complete dentures.

A correlation between the PoNANS (Porion-Nasion-Anterior Nasal Spine) angle and the angle formed by intersection of the occlusal and Frankfort planes was studied by **Montieth**[10] in 1985. He found significant correlation between the angles studied. The orientation of the occlusal plane tends to be flattened by an increase in the Porion-Nasion-Anterior Nasal Spine angle; while an acute Porion-Nasion-Anterior Nasal Spine angle results in steeper occlusal plane. It was also concluded that based upon the known value of either angle, the unknown value of the remaining angle can be established with high predictability.

In a continued investigation, **Montieth**[34] in 1986 studied the accuracy of the earpiece facebow in transferring the Frankfort horizontal plane to the articulator and the reliability of the orientation of the occlusal plane by the Porion-Nasion-Anterior Nasal Spine angle in establishing the natural looking dentition. 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 can be attributed to idiosyncrasy 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.

With the help of cephalometry, **Karkazis and Polyzois**[35]**,** in 1987, studied the relation of artificially established and natural occlusal plane to the Camper's plane. He studied cephalometric images of 18 dentulous and 56 complete denture wearers. The results of the study can be summarized as follows:

1. The natural dentition occlusal plane was not parallel to the Camper's plane. The deviation ranged from -5° to $+9^{\circ}$. The average deviation was noticed as 2.88° .

2. The artificial occlusal plane was not parallel to the Camper's plane, as noted at the prosthesis insertion appointment. The deviation varied from -7° to $+13^{\circ}$ with an average of 3.25° .

3. The anteroposterior inclination of the artificial dentition occlusal plane was almost similar to that of the natural dentition.

Karkazis and Pylozois[36] , in 1991, conducted a cephalometric study in a continued research on geometry of occlusal plane. The aim was to check the hypothesis that the angulation of the occlusal plane is generally related to the skeletal base of the maxillae.

The study concluded that

1. As per regression formula used in investigation, there was no evidence to accept the reliability of any of the three studied parameters (Cook’s plane, ANS-PNS and PoNANS) to establish the occlusal plane with high accuracy.

2. The Hamular notch-Incisive papilla plane tends to parallel the occlusal plane which can provide guideline for occlusal plane determination. But the reliability of the method should be verified by further clinical application.

3. The formula given by Montieth can provide the occlusal plane which is closely related to the clinically determined one.

Celebice[37] , in 1995 investigated the reliability of the intraoral method of occlusal plane determination which orients the occlusal plane to terminate at the upper level of the retro-molar pad. Total 64 individuals (30 completely dentate controls and 34 complete denture wearer subjects) were included in the study. The stone casts from each patient were mounted in SAM 2 articulator with the help of quick mount face-bow transfer. The angle between the occlusal plane and the articulator horizontal plane was measured for both the groups. For dentate group of individuals the angle was 9.42° +/- 4.1° while the angle of 8.53° +/- 2.80° was noted for edentate group. Statistically there was no significant difference between the values obtained for both the groups. The results indicated intraoral method for occlusal plane determination for edentate patient can be used with high predictability which is similar to the occlusal plane of natural dentition.

Nissan[38] in 2003 investigated the relationship between commonly used anatomical structures to determine the occlusal plane and the facial skeletal shape of complete denture wearers using cephalometric analysis. During investigation no correlation was found between the anatomical structures that could be used to establish the occlusal plane in edentate patients with high predictability. The current status of the cephalometric analysis can only be limited as a rough guide to occlusal plane location. The wide variation in anatomical structures between individuals can be attributed for limited applicability of the cephalometric analysis. For occusal plane determination, intra-oral structures must be considered.

Shigli[39] , in 2005, evaluated applicability of certain intraoral landmarks to determine the plane of occlusion. The retro-molar pad , parotid papilla and buccinators grooves were used to determine the location of occlusal plane . The occlusal plane was established with respect to intraoral anatomical landmarks using the vestibular impression technique. The study supported a close correlation among occlusal plane, buccinators groove and parotid papilla.

Veena H[40]**,** in 2006 conducted a study on 30 Indian subjects to ascertain the role of intraoral and extraoral soft tissue landmarks in determining the occlusal plane. The soft tissue landmarks considered in the study were retro-molar pad, parotid papilla, commissure of lips, buccinators groove and ala-tragus line. It was observed that lower 1/3 of retro-molar pad was consistent with the mandibular occlusal plane. The mean distance of parotid papilla was 2.56 mm above the maxillary occlusal plane. The mean values of all readings of buccinators groove were 0.94mm below the mandibular occlusal plane. The line drawn from the ala of nose to the middle of the tragus was found to be parallel to maxillary occlusal plane.

Petricevic N & his co- workers[41] in 2006 did a study on 56 dental students with complete natural dentition and Angle's class I occlusion to assess the angles between craniofacial planes and gravity horizontal plane. An ISSA computer program (Visual analysis and measurement systems) was used for direct angular measurements of digital images. In frontal view, orientation of bipupilar line and Fox plane was roughly horizontal in natural head position. In lateral view, parallelism with Camper's plane was not found and was concluded that Camper's plane is not a reliable landmark for establishing occlusal plane.

Amit D. Hindocha et al[42] in 2010, performed a cephalometric study to determine the plane of occlusion in completely edentulous patients, by determining the relationship between the plane of occlusion and the Camper's line (ala-tragus line). After outlining the tragus and the base of ala of nose with radiopaque markers, lateral cephalograms of 105 dentulous subjects were obtained. Tracings of the cephalograms were done and the relationship between the plane of occlusion and the Camper's line (ala-tragus line) was noted. The most common tragal reference as a posterior landmark for determination of plane of occlusion was found to be below inferior (in 30.48% of subjects), and inferior (in 24.76% of subjects). The least common tragal reference was found to be above superior (in 3.82% of subjects) followed by superior of tragus and the point between superior and middle of the tragus (in 6.66% of subjects). In this study population, the tragal reference was more towards the inferior of the tragus, with most of the times being below the inferior border. Hence, the orientation of the plane of occlusion using the superior of tragus as a posterior landmark (according to the widely accepted definition of Camper's line) may be considered to be questionable. Further, the use of the tragus as a posterior landmark for the orientation of the plane of occlusion may be questioned on the basis of the findings of this study.

S C Deogade et al[43], in 2011 conducted a study using lateral cephalograms and emphasized on its importance in positioning the occlusal plane in natural and artificial dentitions as related to other craniofacial planes. The analysis included 47 fully dentate subjects (21-34 years) with Angle's class I molar relationship and no history of orthodontic treatment. Left lateral cephalograms were taken with mandible closed in maximum intercuspation. Barium sulphate creamy mix was applied incisal edge of the left maxillary central incisor, mesio-palatal cusp of left maxillary first molar. It was also painted on left side of the patient's face, as triangular mark on required landmarks to be shown in the final radiographs.

The angles studied were:

i) *Camp I-OP*: Angle between Camper's I (superior border of tragus) and occlusal plane

ii) *Camp II-OP*: Angle between Camper's II (middle border of tragus) and occlusal plane

iii) *Camp III-OP*:Angle between Camper'sIII(inferior border of tragus) and occlusalplane.

Angular measurements were recorded to the nearest degree. Results showed Camper's plane had lowest mean value in angle formed with camper's I with score of 2.1° , highest with camper's III with score of 6.1° , mean angle formed with camper's II score 3.2° . The difference between three planes was found to be significant. So, it was concluded using cephalometric analysis that the superior border of the tragus with the inferior border of the ala of the nose was most accurate in orienting the occlusal plane.

Carole Abi- Gosn et al[44] in 2012, conducted a study to determine the relationship between the occlusal plane corresponding to the lateral borders of the tongue and ala-tragus line in edentulous patients. After completion of neutral zone dentures, 20 edentulous subjects were selected. Duplicate wax rims were inserted in subject's mouth and standard lateral cephalograms were taken , two months after denture insertion.

The landmarks used in the study were as follows:

1) *ATL I*: The line extending from the inferior border of the ala of the nose to the superior border of the tragus of the ear.

2) *ATL II*: The line extending from the inferior border of the ala of the nose to the tip of the tragus of the ear.

3) *ATL III*: The line extending from the inferior border of the ala of the nose to the inferior border of the tragus of the ear.

4)*Prosthetic occlusal plane*: The line extending from the mesioincisal angle of the maxillary central incisor to the mesio- palatal cusp of the maxillary first molar.

Small radio-opaque ball shaped pellets of 1mm in diameter were used for radiographic reference. Tracings were done and no parallelism was found between the prosthetic OP and ATL 1 or ATL 2 or ATL 3.

The findings of the study indicated that ATLs, extending from inferior border of the ala of the nose to

1) the tip of the tragus of the ear and

2) the inferior border of the tragus presented the closest relationship to the prosthetic occlusal plane corresponding to the lateral border of the tongue.

Ciancaglini[45] , in 2003, conducted a study to investigate the relationship between the orientation of craniofacial planes relative to the true horizontal and temporomandibular disorder (TMD), in normal occlusion. Fourteen university dental students, with full natural dentition and bilateral Angle Class I occlusion, who exhibited signs and symptoms of TMD, were compared with 14 age- and sex-matched healthy controls. Frontal and lateral photographs were taken in natural head position with the subject standing up, clenching a Fox plane and having a facial arch positioned. Photographs were examined by a standardized image analysis. Inter-pupillary axis, Frankfurt, occlusal and Camper planes were evaluated.

The results obtained were

1) In frontal view, the Frankfurt plane was right rotated relative to the true horizontal both in TMD subjects and controls , but rotation was larger in TMD subjects. No significant deviation from the horizontal or difference between groups was observed for the interpupillary axis and occlusal plane.

2) In lateral view, the Frankfurt plane was upward-orientated relative to the true horizontal in TMD group. The occlusal and Camper planes were downward-orientated in both groups, but inclination of occlusal plane tended to be smaller in TMD subjects. Angles between any craniofacial planes did not significantly differ between groups.

The findings showed that in young adults with normal occlusion, a weak association exists between the orientation of craniofacial planes in natural head position and signs and symptoms of TMD. Furthermore, they suggested that, within this population, TMD might be mainly associated with head posture rather than with craniofacial morphology.

OCCLUSAL PLANE ANALYZER

The 3 most commonly used methods for establishing an acceptable plane of occlusion are

1. Direct analysis on natural teeth through selective grinding.
2. Indirect analysis of facebow mounted casts with properly set condylar paths.
3. Indirect analysis using the Pankey-Mann-Schuyler (PMS) method with the Broadrick occlusal plane analyzer (BOPA).

Pankey and Mann[46] described a method for establishing the occlusal plane by using an instrument in concept for full mouth rehabilitation . The device followed the 4-inch radius for establishing the mandibular posterior occlusal plane. It established successful rehabilitation for the patient. However, the design and application of the instrument was quite complex.

In 1963**, Dr Lawson Broadrick**[47] developed an instrument to serve as a guide to the most suitable position and orientation of the posterior occlusal scheme where the natural Curve of Spee has been deranged. Dr Broadrick worked on Spee's comment: "The center of the curvature of curve of Spee can be located by reconstruction and measurement with the compass." This instrument is known as Broadrick occlusal plane analyzer, more commonly as Broadrick's flag. A laminated piece of cardboard is attached to the superior aspect of the upper member of a semi-adjustable articulator. It functions to permit reconstruction of the Curve of Spee in harmony with anterior and condylar guidance.

In 1972, **McLaughlin**[48]**,** described the procedure to adapt, Broadrick occlusal plane analyzer, model 142-1,Hanau engineering Co, to the Whipmix articulator systems.

The Denar articulator systems have adopted simplified occlusal plane analyzer which is known as Simplified occlusal plane analyser has been adapted by. The position of the center of curve in correct relation to condyle is automatically established by the system. Hence a single survey point is required by this sytem whereas the Broadrick occlusal plane analyzer needs two points.

Wynne[49], in 2005, developed occlusal plane analyzer system for Sam 3 articulator system. The system was similar to broadrick occlusal plane analyzer for other articular systems. The advantages of Sam series of articulators were enhanced by the Wynne occlusal plane analyzer.

Lynch and McConnel[50] described the use of teeth for both the anterior and posterior survey points for determination of the occlusal curve.In their study, the mandibular canine was selected as 'Anterior Survey Point' from which an arc of 4 inches was drawn using the compass on the Broadrick flag.The 'Posterior Survey Point' (PSP) was distal incline of the disto-buccal cusp of the most distal molar.The intersecting point of the two was used as center of the circle which forms the occlusal part.The article described the importance of curve of Spee in prosthodontic dentistry and successful prosthodontic management of the patient.

Toothaker and Angela[51] described a simple modification for adaptation of an occlusal plane analyzer to semi-adjustable articulator. A model 2240, Whipmix Corp. articulator was selected. The occlusal plane analyzer (No.D122, Teledyne Waterpik, Fort Collins, Colo) was adapted on the upper member of the articulator by using commonly available laboratory tools. Earlier, there were limited options like the Hanau semi-adjustable or Teledyne Waterpik semi-adjustable or fully adjustable instrumentation for such occlusal plane analysis. This modification enabled the practitioner to easily use semi-adjustable articulator with Teledyne Waterpik occlusal plane analyzer as an accessory for prosthodontics rehabilitation.

Bedia and coworkers[6], described method for determination of occlusal plane by using custom-made occlusal plane analyzer. Model 8800 Whipmix Corporation articulator was used. A 2mm-thick clear acrylic resin sheet was fitted into the slot of the same dimensions in clear acrylic resin base, which served as the flag part of the occlusal plane analyzer. The whole assembly was attached to the upper member of the articulator. Markings were written on a sheet of blank paper attached to both sides of the flag. Surveying could be done and the required correction in the occlusal plane done to rehabilitate the patient with fixed restorations.

Craddock et al[52] evaluated the reliability of broadrick ideal occlusal plane to the existing occlusal plane in dentate patients.100 subjects with full complement of teeth were studied.55 individuals out of 100 had a plane of occlusion that coincided with the plane established by broadrick occlusal plane analyzer. Little deviation from broadrick ideal occlusal plane was noted for the subjects studied along with good intra-examiner reliability.

Craddock and coworkers[53] (2006) studied deviation of occlusal plane from broadrick occlusal curve following posterior teeth loss.180 individuals were studied in which posterior teeth were missing for 5 years or more. It was concluded that the positional changes in the teeth caused deviation from the Broadrick curve when posterior teeth have remained unopposed for long duration. Broadrick occlusal plane analyzer provides an accurate reproduction of the occlusal curve for such cases.

Supriya Manvi et al[54] investigated the applicability of a custom made occlusal plane analyzer for determination of occlusal plane.The study compared the deviation of the clinical occlusal curve with the ideal ones after determining the appropriate occlusal curve for individual patients. A total of 20 patients (10 completely dentate patients as control group and 10 partially edentate patients).The data was collected on original object itself after recording the deviation of the occlusal plane on the articulated cast.There was a marked deviation from ideal occlusal plane for partially edentulous as compared to completely dentate controls.It was found that the existing occlusal plane of dentate patients has a close relation to the Broadrick occlusal plane.They concluded that a correct determination of occlusal plane can be made with proper utilization of the broadrick flag on a semi-adjustable articulator.

Jagadeesh KN et al[55] in 2012, verified reliability of Broadrick flag in Indian population. Patients with skeletal class I,II and III jaw relations were included in the study.They concluded that the broadrick flag method was a reliable method for Indian population and advocated use of 4-inch radii for Class I, 3.75 inch radii for Class II and 5-inch radii for Class III.

C.Radha et al[56] conducted occlusal plane rehabilitation using Broadrick's Flag.The importance of the curve of Spee in prosthodontics and restorative dentistry were discussed and case reports were presented demonstrating the use of the Broadrick flag in occlusal plane correction.

Misch[57] advocated the use of occlusal plane analyzer for diagnosis and correction of the occlusal plane of remaining natural teeth in dental implant treatment.

MATERIALS AND METHODS:

The present in-vivo study was intended to evaluate the correlation between the occlusal plane and craniofacial planes in Temporomandibular disorder subjects. Dentulous temporomandibular disorder patients were selected from the Department of Prosthodontics, Crown and Bridge, Tamilnadu Government Dental College, Chennai. The sample consisted of completely dentulous subjects irrespective of sex, satisfying the laid down inclusion and exclusion criteria, divided into two groups. In both the groups, occlusal plane was evaluated using custom made Broadrick's occlusal plane analyzer, Camper's plane and maxillary plane were evaluated cephalometrically. The correlation between the three planes were assessed using cephalometric analysis.

ETHICAL COMMITTEE APPROVAL

The ethical clearance was obtained from institutional ethical committee before starting the study. All ethical aspects were considered and respected.

MATERIALS AND EQUIPMENTS USED FOR THE STUDY ARE AS FOLLOWS

ARMAMENTARIUM FOR CLINICAL EXAMINATION: (Fig.1)

1. Kidney tray
2. Mouth mirror
3. Williams Periodontal probe
4. Cheek retractor
5. Disposable glove and mask

ARMAMENTARIUM FOR STUDY MODELS PREPARATION

1. Maxillary and mandibular stock trays- dentulous
2. Irreversible hydrocolloid impression material,Alginate (Algitex,DPI,The Bombay Burmah Trading Co., India)
3. Type II Dental Plaster (White gold – Asian chemicals, India)
4. Type III Dental stone (Kalabhai & Co., India)
5. Rubber bowl and spatula

ARMAMENTARIUM FOR FACEBOW TRANSFER

1. Earpiece type springbow (Hanau professional facebow, whipmix Co.,)
2. Semi adjustable,Arcon articulator (Hanau wide vue II articulator, Whipmix Co.,)
3. Bite registration paste, medium viscosity vinyl polysiloxane (Bonabite, DMP Ltd.,)
4. Automixing gun and mixing tip
5. Low fusing modelling compound (DPI, The Bombay Burmah Trading Co., India)
6. Type II Dental plaster (White gold-Asian chemicals, India)

ARMAMENTARIUM FOR BROADRICK'S OCCLUSAL PLANE ANALYZER CUSTOMIZATION:

1. Semi adjustable,Arcon articulator (Hanau wide vue II articulator, Whipmix Co.,)
2. Rectangular stainless steel plate (height-10 cm, width- 11 cm)
3. Duplicated Aluminium rod
4. Graph paper

5. Scissors
6. Glue
7. Paper cutter

ARMAMENTARIUM FOR OCCLUSAL PLANE ANALYSIS:

1. Custom made Broadrick's occlusal plane analyzer
2. 4HB pencil
3. Compass
4. Measuring scale

ARMAMENTARIUM REQUIRED FOR CEPHALOMETRIC ANALYSIS

1. Lateral cephalogram unit (ORTHOPHOS XG MACHINE, 64 KV, 8 mA,14.1 sec)
2. Lead foil
3. Scissors
4. Paper cutter
5. Glue

METHODOLOGY:

STUDY POPULATION:

Dentulous patients (of age 20-45 years) having full complement of natural teeth with Class I skeletal relationship were randomly selected from the patients reporting to the outpatient section of Department of Prosthodontics, Tamilnadu Government Dental College & Hospital, Chennai, Tamilnadu, India.

SAMPLE SIZE AND DESIGN:

A total of 60 samples were included in the study. The samples were divided into two groups- Completely dentulous normal subjects (Group A- 30) and completely dentulous Temporomandibular disorder patients (Group B- 30). The study population was selected irrespective of gender.

EXAMINATION:

All participants were examined clinically and radiographically to ensure absence of pathology of alveolar ridge, mucosa or bone.

CRITERIA FOR SELECTION

INCLUSION CRITERIA

1. Both males and females of age 20 - 45 years
2. Full complement of natural teeth
3. Normal physiological occlusion and bilateral Angle Class I molar and canine relation
4. No history of systemic illness
5. No history of orthodontic treatment or maxillofacial surgery
6. No missing teeth or any kind of restoration
7. Presence of at least two of the following signs or symptoms of Temporomandibular disorder:

   temporomandibular joint (TMJ) sounds,

   tenderness or painful to palpation of the TMJ or of the masticatory muscles,

   painful limitations of mandibular movements (Wallace & Klineberg, 1994).

EXCLUSION CRITERIA

1. Patients with marked facial asymmetry
2. Presence of neurological,cervical,visual and/or vestibular disturbances
3. Presence of any disabling complaint
4. Patients with psychological disorders
5. History of severe systemic illness
6. History of maxillofacial trauma or surgery
7. Acute infection
8. Medically compromised individual
9. Debilitated individuals
10. Mentally challenged persons

PROCEDURE FOR PREPARATION OF STUDY MODELS:

For each individual, both the maxillary and mandibular preliminary impressions were made using irreversible hydrocolloid impression material (Alginate) in stock trays. The study models were poured in Type III dental stone, trimmed and polished.

PROCEDURE FOR FACEBOW TRANSFER AND MOUNTING OF MAXILLARY CAST ON ARTICULATOR:

The softened low fusing impression compound on the biteplane of the bitefork is seated against the maxillary occlusal surface to create a distinct imprint without metal contact.Then the facebow frame was slid into the stem of the bitefork. By adjusting the intercondylar distance of the face-bow frame, orbitale pointer and stem of the bite fork, orientation jaw relation was obtained. The relation was transferred to the articulator using transfer jig assembly and mounting of the maxillary cast was done on the articulator.

PROCEDURE FOR MAKING OF INTER-OCCLUSAL RECORD AND MOUNTING OF MANDIBULAR CAST ON THE ARTICULATOR:

To register the positional relationship of the mandibular teeth to the maxillary teeth an interocclusal record at centric occlusion was made using medium bodied vinylpolysiloxane impression material (bite registration paste) in the patient’s mouth. The mandibular cast was mounted on the articulator according to the interocclusal record obtained.

PREPARATION OF CUSTOMIZED OCCLUSAL PLANE ANALYZER:

For the present study, customized occlusal plane analyzer was made for Hanau wide vue II articulator.For preparation of customized occlusal plane analyzer, the method advocated by Sumit Bedia et al was followed with some modification.

The supporting rod of the articulator was duplicated in aluminium. A rectangular stainless steel plate of dimension 10 cm height and 11 cm width was prepared. One end of the stainless steel plate was encircled around the duplicated rod and was fixed to the rod with screws. Rigidity of the joint was assessed. The original supporting rod was removed and the duplicated rod along with plate of metal was placed in that position. The junction of the rod and plate of metal was adjusted so that the plate falls exactly in the middle of the upper member. The graph paper was pasted on the metal plate on both the sides. This custom made occlusal plane analyzer was used for the study purpose.

EVALUATION OF OCCLUSAL PLANE USING CUSTOM MADE OCCLUSAL PLANE ANALYZER:

The maxillary cast was removed from the upper member of the articulator. Supporting rod of the articulator was removed and the customized occlusal plane analyzer was attached to the upper member of the articulator. Center position of the analyzer was verified in relation to the upper member.

The anterior survey point was the disto-incisal edge of the mandibular canine from which a long arc with a 4-inch radius was drawn on the analyzer using a compass and the posterior survey point was the distobuccal cusp of the mandibular second molar. From the posterior survey point, a short arc was drawn to intersect the long arc. The point of intersection is called as occlusal plane survey center. One end of the compass was placed at occlusal plane survey center and other end with the 4HB pencil, was swept over the occlusal surfaces of the posterior teeth and an arc was obtained, which conformed to the occlusal plane.

METHOD FOR CEPHALOMETRIC EXAMINATION:

After completion of occlusal plane analysis, conventional lateral cephalogram of the patient was taken. For every individual, two lateral cephalograms were taken for each side, to assess the occlusal plane, campers plane and maxillary plane.

PREPARATION FOR LATERAL CEPHALOGRAMS:

Two triangular shaped pieces of lead foil were cut, one piece was pasted on the inferior border of the ala of nose and the other one was pasted on the superior margin of the tragus of the ears of both the sides of the face of the patient, to obtain the orientation of the Camper's plane in the lateral cephalogram. A lead foil sheet was adapted on the occlusal surfaces of the mandibular teeth of every subject so that it covers the occlusal surface only till the Broadrick's occlusal plane extends. The lead foil is adapted starting from the tip of mandibular canine till the distobuccal cusp of the mandibular second molar so as to obtain the orientation of occlusal plane in lateral cephalogram.

LATERAL CEPHALOGRAMS:

All the conventional lateral cephalometric radiographs were taken on a Orthophos XG digital panoramic and cephalometric system with a 3D volume of 8×8 cm. The subjects were positioned in the cephalostat with the median sagittal plane perpendicular to the path of X-ray, and the Frankfurt plane parallel to the floor, 5 feet away from the X ray source. They were instructed to wear a lead apron, to keep their teeth in the maximum intercuspal position, and their lips slightly pressed. The exposure parameters were 64 kvp, 8 Ma, for 14.1 sec.

CEPHALOMETRIC ANALYSIS:

Lateral cephalograms were traced digitally using SIDEXIS software.

Cephalometric landmarks used in the study:

Po- Porion

Orbitale- O

ANS- Anterior nasal spine

PNS- Posterior nasal spine

P_B- Clinically established occlusal plane by Broadrick's method/ Broadrick plane [Red colour]

P_C- Camper's plane [Blue colour]

P_O- Existing occlusal plane[Yellow colour]

P_M- Maxillary plane [Green colour]

P_{FH}- Frankfurt Horizontal plane [Black colour]

The Frankfurt Horizontal plane (connecting porion and orbitale) was used as the reference plane. P_B was marked digitally by tracing the radio opaque line evident in the radiograph. P_C was traced by joining the radio opaque triangular shaped images created in the radiograph. P_M was traced by joining ANS and PNS digitally. The inclination of all the planes from the Broadrick occlusal plane were found. The deviation of the occlusal plane was evaluated and the results were tabulated.

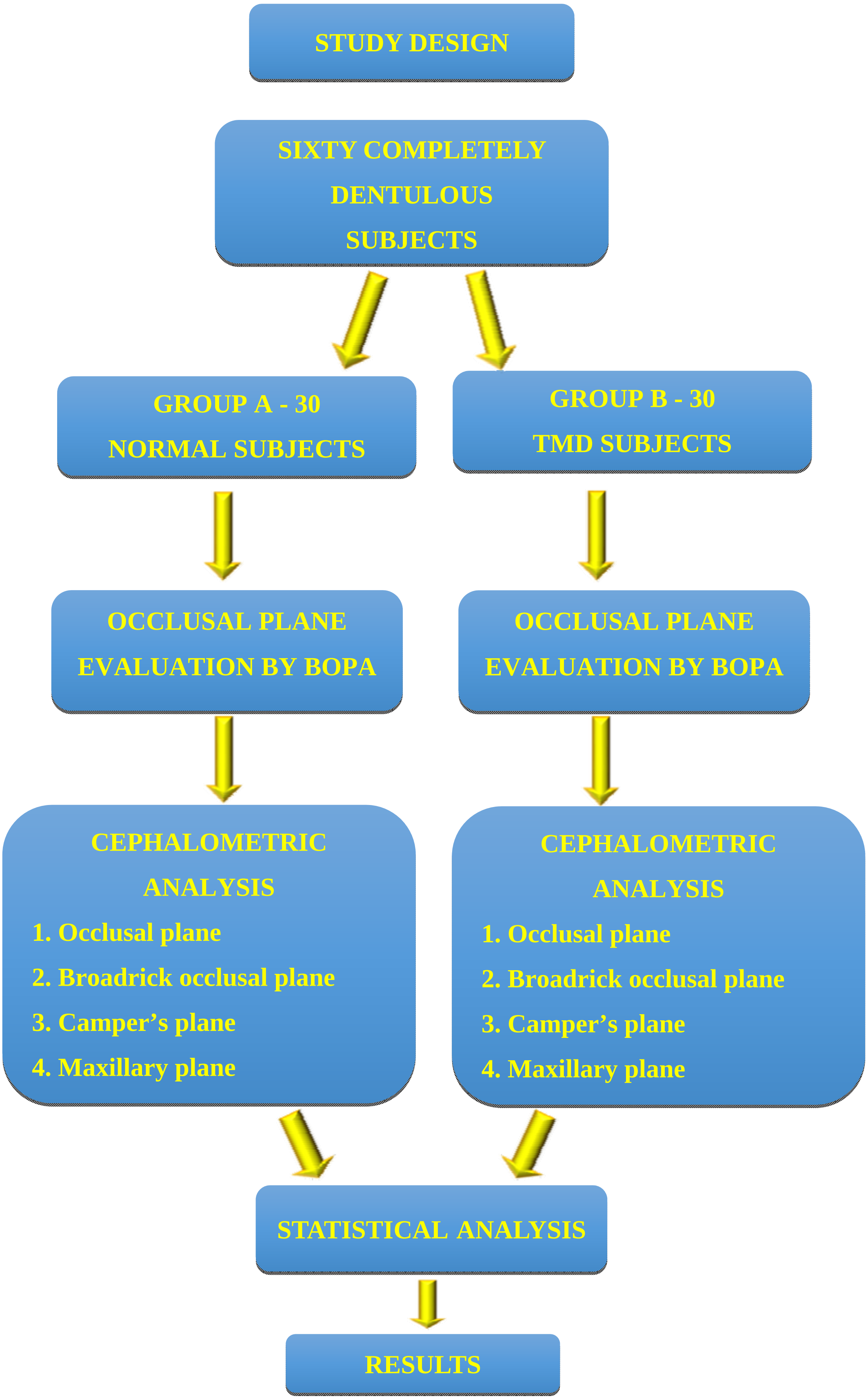

STUDY DESIGN
SIXTY COMPLETELY DENTULOUS SUBJECTS
GROUP A - 30 NORMAL SUBJECTS
GROUP B - 30 TMD SUBJECTS
OCCLUSAL PLANE EVALUATION BY BOPA
OCCLUSAL PLANE EVALUATION BY BOPA
CEPHALOMETRIC ANALYSIS
1. Occlusal plane
2. Broadrick occlusal plane
3. Camper's plane
4. Maxillary plane
CEPHALOMETRIC ANALYSIS
1. Occlusal plane
2. Broadrick occlusal plane
3. Camper's plane
4. Maxillary plane
STATISTICAL ANALYSIS
RESULTS

Fig 1. ARMAMENTARIUM FOR CLINICAL EXAMINATION

Fig 2. ARMAMENTARIUM FOR CLINICAL PROCEDURE

Fig 3.INTRAORAL PHOTOGRAPHS

Fig 4. PRELIMINARY IMPRESSIONS OF MAXILLARY & MANDIBULAR ARCH

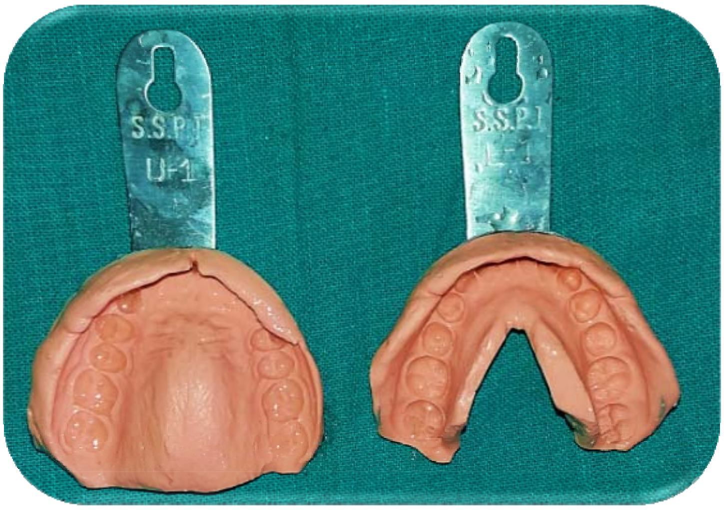


Fig 5. STUDY MODELS OF MAXILLARY & MANDIBULAR ARCH

Fig 6.CLINICAL PROCEDURE-FACEBOW RECORD

Fig 7.CLINICAL PROCEDURE-FACEBOW TRANSFER

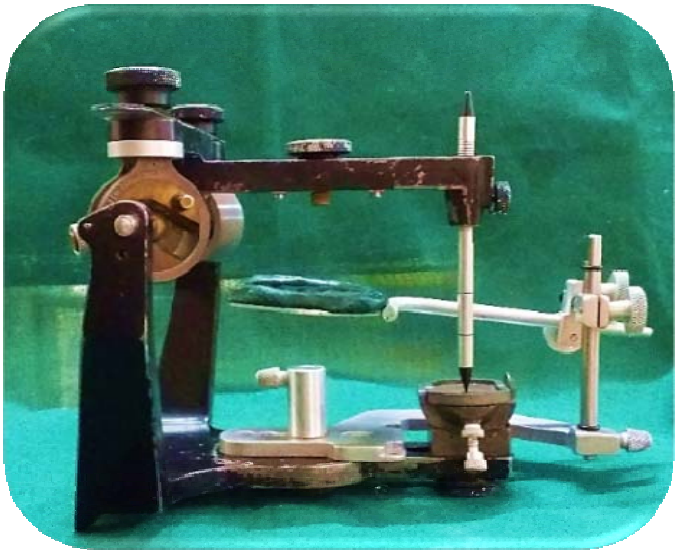


Fig 8.CLINICAL PROCEDURE - ARTICULATION

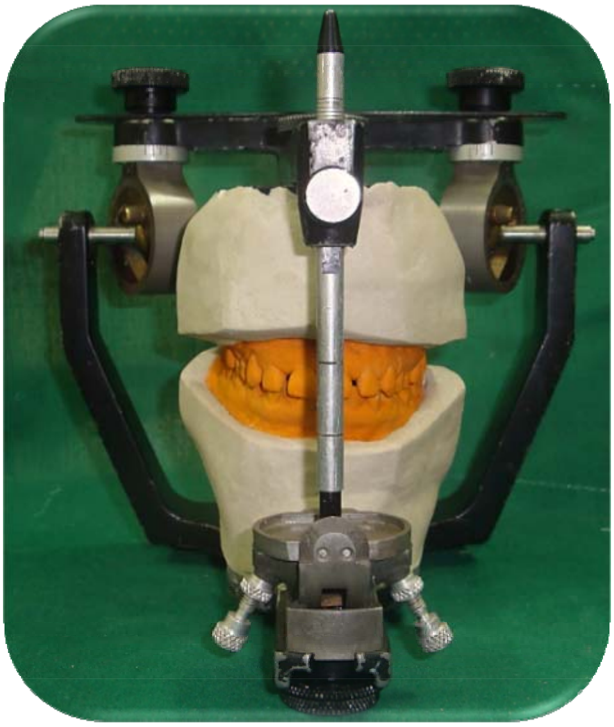


Fig 9.BROADRICK'S OCCLUSAL PLANE ANALYZER

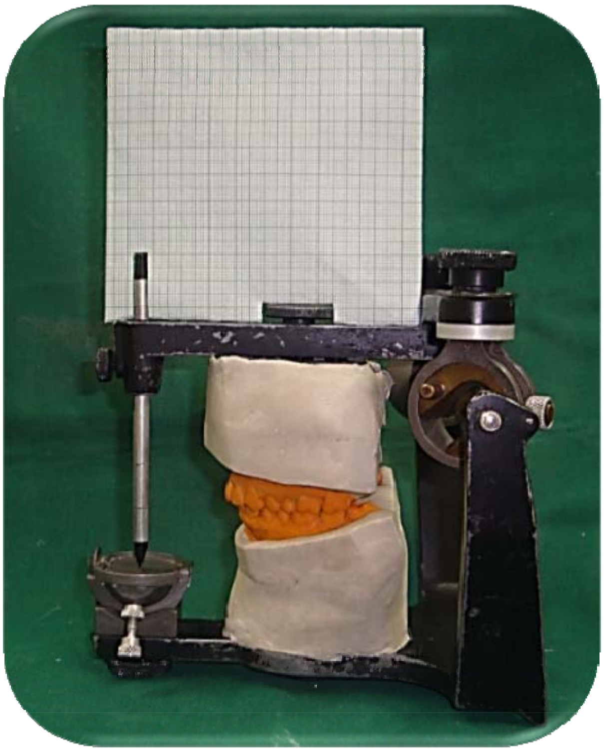


Fig 10.ANTERIOR SURVEY POINT

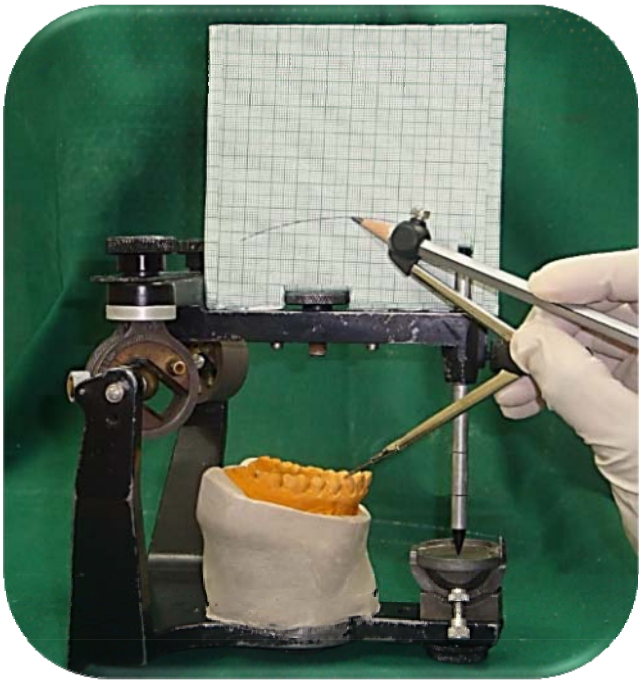


Fig 11.POSTERIOR SURVEY POINT

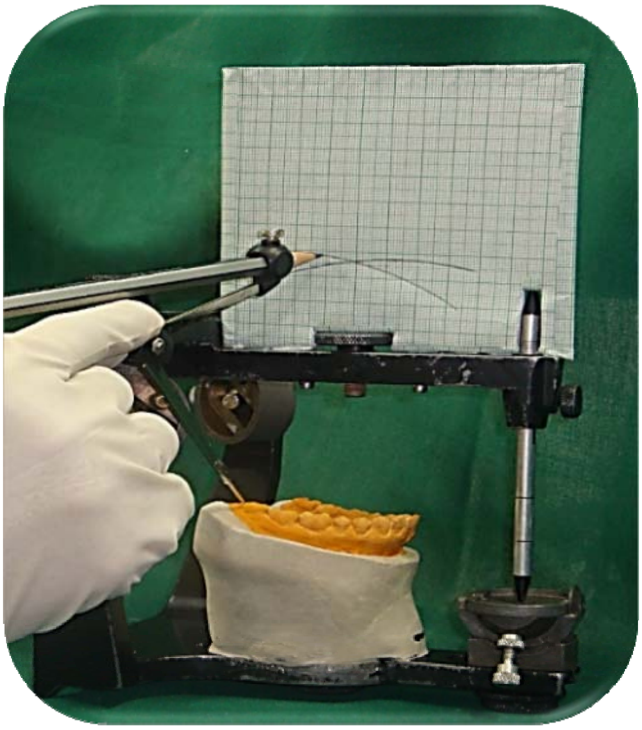


Fig 12.TRACING OF OCCLUSAL PLANE

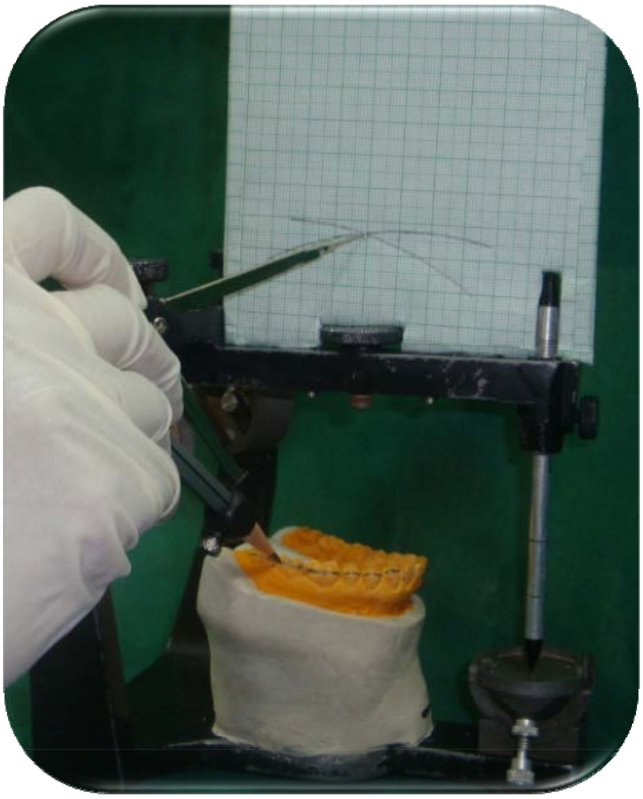


Fig 13.BROADRICK'S IDEAL OCCLUSAL PLANE

Fig 13A. IDEAL OCCLUSAL PLANE- RIGHT SIDE

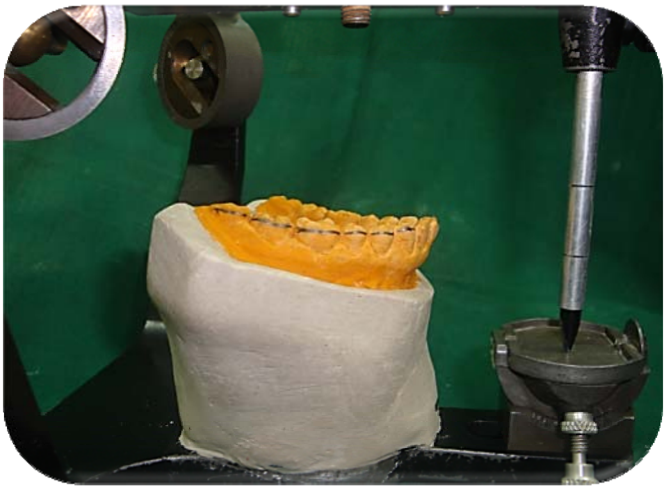
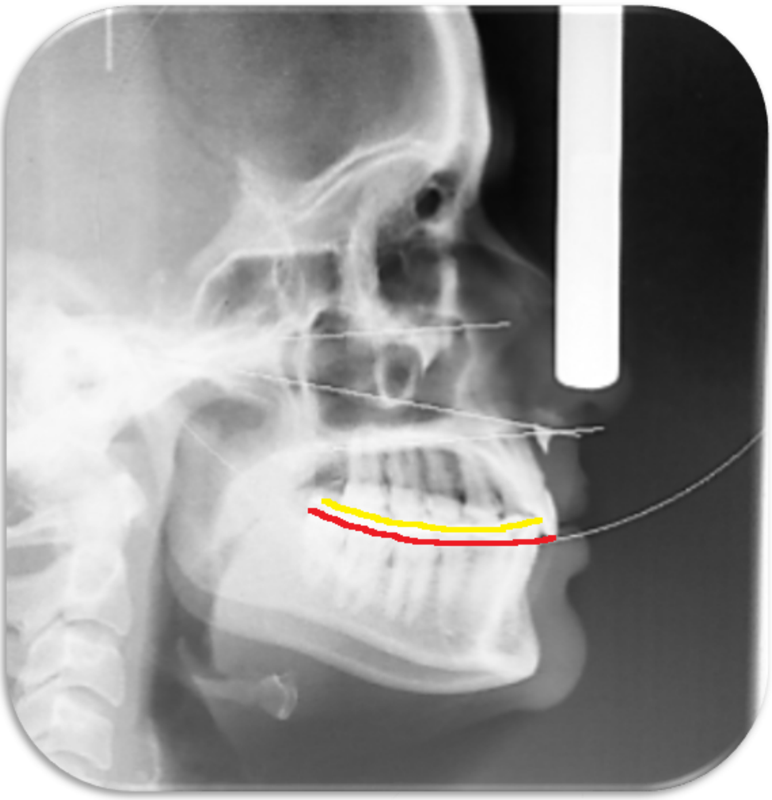


Fig 13B. IDEAL OCCLUSAL PLANE- LEFT SIDE

Fig 14.LEAD FOIL ADAPTATION

Fig 15.RADIOGRAPHIC IMAGING

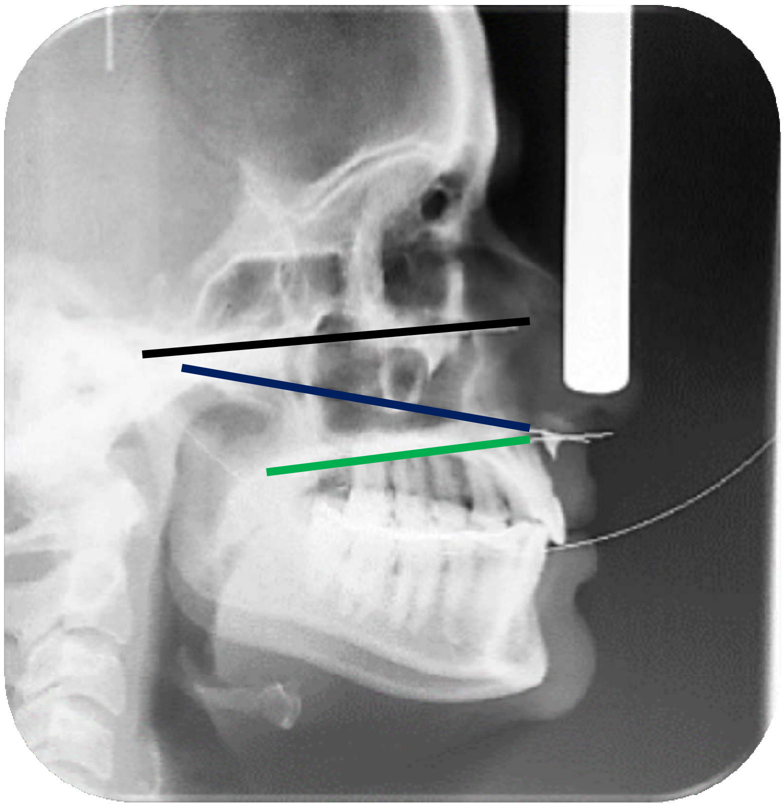
Fig 16. CEPHALOMETRIC ANALYSIS- OCCLUSAL PLANE



P_O- Existing occlusal plane [Yellow colour]

P_B- Broadrick plane [Red colour]

Fig 17. CEPHALOMETRIC ANALYSIS- CRANIOFACIAL PLANES



P_{FH}- Frankfurt's horizontal plane [Black colour]

P_C- Camper's plane [Blue colour]

P_M- Maxillary plane [Green colour]

TABLE 1:

COMPARISON OF OCCLUSAL PLANE AND CRANIOFACIAL PLANES IN GROUP A (NORMAL SUBJECTS) AND GROUP B (TMD PATIENTS) BY DESCRIPTIVE STATISTICS:

GROUPS		CEPHALOMETRIC PLANES	Mean	Std. Deviation
GROUP A NORMAL N=30	DENTULOUS RIGHT	Campers plane	16.556	1.778
		Maxillary plane	15.850	2.148
		Occlusal plane	29.793	2.139
		Occlusal plane - Broadrick	30.253	1.970
	DENTULOUS LEFT	Campers plane	16.610	1.670
		Maxillary plane	15.156	1.719
		Occlusal plane	27.693	3.553
		Occlusal plane - Broadrick	28.890	2.944
GROUP B TMD N=30	DENTULOUS RIGHT	Campers plane	18.730	1.132
		Maxillary plane	14.940	1.660
		Occlusal plane	30.173	2.964
		Occlusal plane - Broadrick	33.693	1.642
	DENTULOUS LEFT	Campers plane	16.650	.906
		Maxillary plane	14.586	1.560
		Occlusal plane	31.140	2.340
		Occlusal plane - Broadrick	33.100	2.289

TABLE 2

COMPARISON OF MEANS USING INDEPENDENT SAMPLES TEST:

	PLANES EVALUATED	MEAN DIFF	STD. ERROR DIFF	95% Confidence Interval of Diff		p-VALUE
				lower	upper	
RIGHT	Campers plane	-2.173	.384	-2.943	-1.402	**.000**
		-2.173	.384	-2.946	-1.399	
	Maxillary plane	.910	.495	-.082	1.902	.072
		.910	.495	-.083	1.903	
	Occlusal plane	-.380	.667	-1.715	.955	.571
		-.380	.667	-1.718	.958	
	Occlusal plane - Broadrick	-3.440	.468	-4.377	-2.502	**.000**
		-3.440	.468	-4.378	-2.501	
LEFT	Campers plane	-.040	.347	-.734	.654	.909
		-.040	.347	-.739	.659	
	Maxillary plane	.570	.423	-.278	1.418	.184
		.570	.423	-.278	1.418	
	Occlusal plane	-3.446	.776	-5.001	-1.891	**.000**
		-3.446	.776	-5.006	-1.886	
	Occlusal plane - Broadrick	-4.210	.680	-5.572	-2.847	**.000**
		-4.210	.680	-5.574	-2.845	

TABLE 3A:
PERCENTAGE AND FREQUENCY ANALYSIS OF GROUP A AND GROUP B FOR OCCLUSAL PLANE DEVIATION –RIGHT SIDE

			Right		Total
			C	D	
Groups	**Normal subjects**	Count	26	4	30
		% within Groups	86.7%	13.3%	100.0%
		% within Right	76.5%	15.4%	50.0%
	TMD patients	Count	8	22	30
		% within Groups	26.7%	73.3%	100.0%
		% within Right	23.5%	84.6%	50.0%
Total		Count	34	26	60
		% within Groups	56.7%	43.3%	100.0%
		% within Right	100.0%	100.0%	100.0%

TABLE 3B:
INTER- GROUP COMPARISON OF ASSOCIATION USING FISHER'S EXACT TEST FOR OCCLUSAL PLANE DEVIATION-RIGHT SIDE

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	21.991[a]	1	.000		
Continuity Correction[b]	19.615	1	.000		
Likelihood Ratio	23.752	1	.000		
Fisher's Exact Test				**.000**	.000
Linear-by-Linear Association	21.624	1	.000		
N of Valid Cases[b]	60				

TABLE 4A:
PERCENTAGE AND FREQUENCY ANALYSIS OF GROUP A AND GROUP B FOR OCCLUSAL PLANE DEVIATION- LEFT SIDE

			Left		Total
			C	D	
Groups	**Normal Patients**	Count	20	10	30
		% within Groups	66.7%	33.3%	100.0%
		% within Left	64.5%	34.5%	50.0%
	TMD patients	Count	11	19	30
		% within Groups	36.7%	63.3%	100.0%
		% within Left	35.5%	65.5%	50.0%
Total		Count	31	29	60
		% within Groups	51.7%	48.3%	100.0%
		% within Left	100.0%	100.0%	100.0%

TABLE 4B:
INTER- GROUP COMPARISON OF ASSOCIATION USING FISHER'S EXACT TEST FOR OCCLUSAL PLANE DEVIATION- LEFT SIDE

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.406[a]	1	.020		
Continuity Correction[b]	4.271	1	.039		
Likelihood Ratio	5.491	1	.019		
Fisher's Exact Test				**.038**	.019
Linear-by-Linear Association	5.316	1	.021		
N of Valid Cases[b]	60				

TABLE 5A:

FREQUENCY ANALYSIS FOR TYPE OF DEVIATION OF THE OCCLUSAL PLANE ON THE RIGHT SIDE OF GROUP B

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	ANT	13	21.7	**59.1**	59.1
	POS	9	15.0	**40.9**	100.0
	Total	22	36.7	**100.0**	
Missing	System	38	63.3		
Total		60	100.0		

TABLE 5B:

FREQUENCY ANALYSIS FOR TYPE OF DEVIATION OF THE OCCLUSAL PLANE ON THE LEFT SIDE OF GROUP B

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	ANT	11	18.3	**57.9**	57.9
	POS	8	13.3	**42.1**	100.0
	Total	19	31.7	**100.0**	
Missing	System	41	68.3		
Total		60	100.0		

INTERPRETATION OF RESULTS:

The present study was carried out to determine the correlation between occlusal plane and craniofacial planes. The occlusal plane evaluated using the Broadrick's occlusal plane analyser was transferred to the lateral cephalogram and was compared with the craniofacial planes on both the sides.

60 patients (GROUP A- 30, GROUP B -30) were randomly selected for the study satisfying the inclusion and exclusion criteria set forth in the beginning of the study. The occlusal plane, craniofacial planes namely Camper's plane and maxillary plane were traced on the lateral cephalogram digitally and they were analysed. Then the coincidence with and the deviation of the occlusal plane from the occlusal plane evaluated using Broadrick's occlusal plane analyzer was analysed for both the groups. Later on the analysis for the type of deviation for the study group (GROUP B) was done.

Both the groups were compared on all paramaters and the results were tabulated. Data thus collected was statistically analysed using MS EXCEL 2010 (Microsoft Corp.,Redmond, WA, USA) and Statistical Procedures for Social Services SPSS (16.0) software package (SPSS Inc., Chicago, IL, USA).

To describe about the data, mean, S.D, frequency analysis and percentage analysis were used. To find the significance in the samples, INDEPENDENT SAMPLES TEST was used. To compare the association between the groups for occlusal deviation, FISHERS EXACT TEST was used. Frequency and percentage analysis was done for the type of occlusal plane deviation.

Table 1 shows the mean and S.D of the data for the cephalometric analysis of all the parameters with respect to both groups A and B for both the sides. On the right side, Broadrick's occlusal plane had the greatest mean value for both Group A

(30.253) and the Group B (33.693), Maxillary plane had the least mean value for both Group A (15.8500) and the Group B (14.940). On the left side, Broadrick's occlusal plane had the greatest mean value for both Group A (28.890) and the Group B (33.100).

Table 2 shows the comparison of means using Independent samples test. On the right side , the mean difference was found to be statistically significant for Camper's plane (p = 0.000) and for Occlusal plane – Broadrick (p = 0.000). On the left side, the mean difference was found to be statistically significant for Occlusal plane (p = 0.000) and for Occlusal plane – Broadrick (p = 0.000). No significant mean difference was found for Maxillary plane on both the sides.

Table 3A shows the percentage and frequency analysis of both the groups A and B for deviation of occlusal plane of right side.

In group A, among 30 subjects, 26 coincided and 4 deviated from the broadrick occlusal plane. So the percentage of coincidence within the groups was 86.7 and the percentage within right side was 76.5.The percentage of deviation was 13.3 within the groups and 15.4 within the right side.

In group B, 8 coincided and 22 deviated from the broadrick occlusal plane out of 30 patients. The percentage of coincidence within the groups was 26.7 and the percentage within right side was 23.5.The percentage of deviation was 73.3 within the groups and 84.6 within the right side.

Table 3B shows the comparison of association between the two groups A and B for occlusal plane deviation using the non parametric Fishers Exact test. The association between group A and group B was found to be statistically significant with the p – value of 0.000. ($p < 0.05$).

Table 4A shows the percentage and frequency analysis of both the groups A and B for deviation of occlusal plane of left side.

In group A, out of 30, 20 coincided and 10 deviated from the broadrick occlusal plane. On percentage analysis, coincidence percentage was 66.7 within the groups and within left side it was 64.5 .The percentage of deviation was 33.3 within the groups and 34.5 within the left side.

In group B, 11 patients coincided and 19 deviated from the broadrick occlusal plane out of 30 patients. The percentage of coincidence within the groups was 36.7 and the percentage within left side was 35.5.The percentage of deviation within the groups was 63.3 and 65.5 within the left side.

Table 4B shows the inter group comparison of association for occlusal plane deviation using the non parametric Fishers Exact test on the left side. The association between group A and group B was found to be statistically significant with the p – value of 0.038. ($p < 0.05$).

Table 5A shows the analysis for the type of deviation of occlusal plane on the right side for the study group B (TMD patients). Among the 22 patients whose occlusal plane deviated from the Broadrick occlusal plane, 13 deviated anteriorly and 9 deviated posteriorly. The valid percentage was found to be 59.1 and 40.9 respectively .

Table 5B shows the analysis for the type of deviation of occlusal plane on the left side for the study group B (TMD patients). 11 deviated anteriorly and 8 deviated posteriorly, out of 19 patients whose occlusal plane was found to be deviating from Broadrick occlusal plane. The percentage was found to be 57.9 and 42.1 with respect to anterior and posterior deviation of occlusal plane on the left side.

Fig 1. MEAN AND SD OF GROUP A- NORMAL SUBJECTS

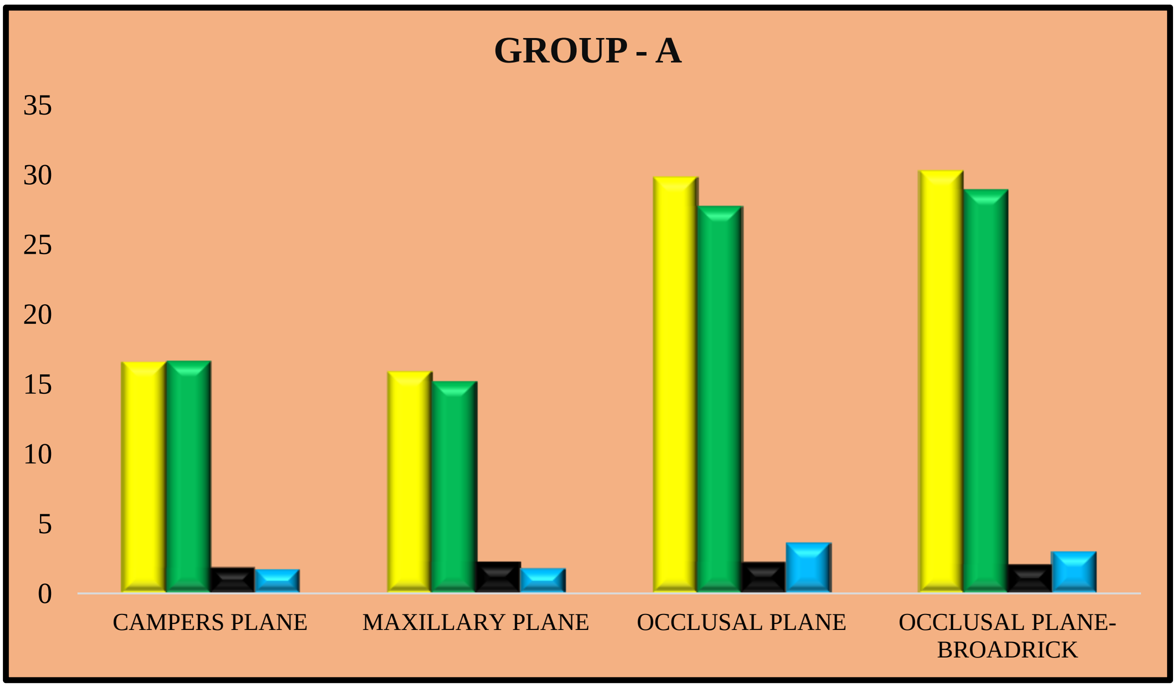


Fig 2. MEAN AND SD OF GROUP B- TMD PATIENTS

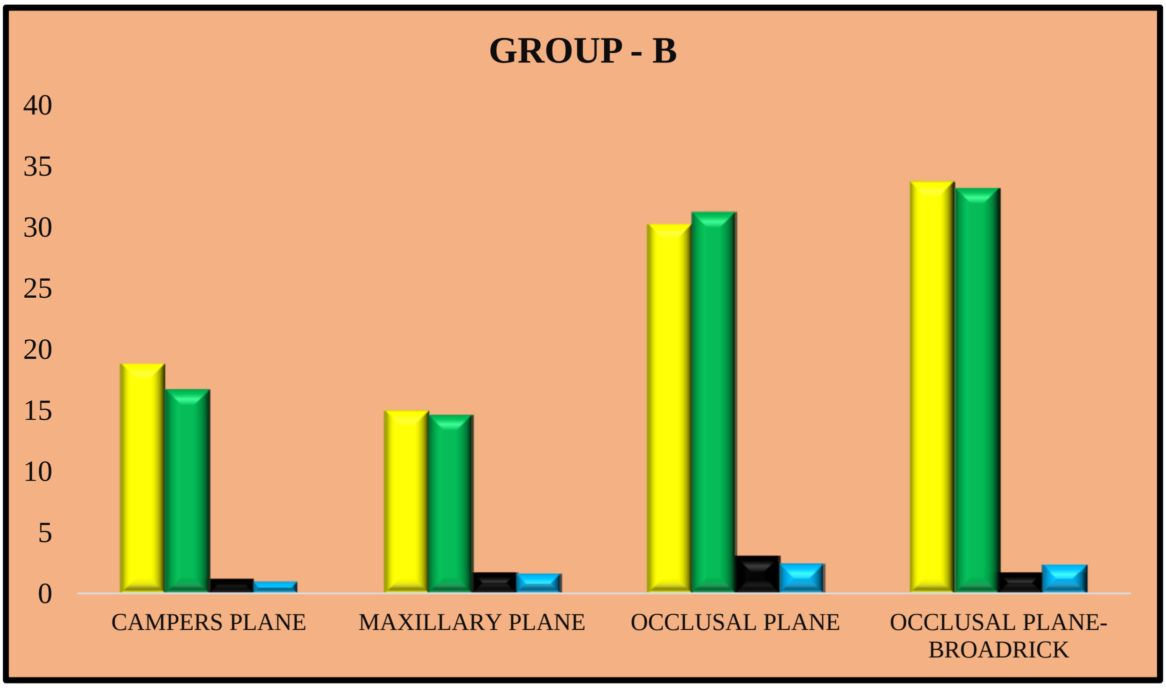


Fig 3. FREQUENCY ANALYSIS OF GROUP A AND GROUP B FOR OCCLUSAL PLANE DEVIATION- RIGHT SIDE

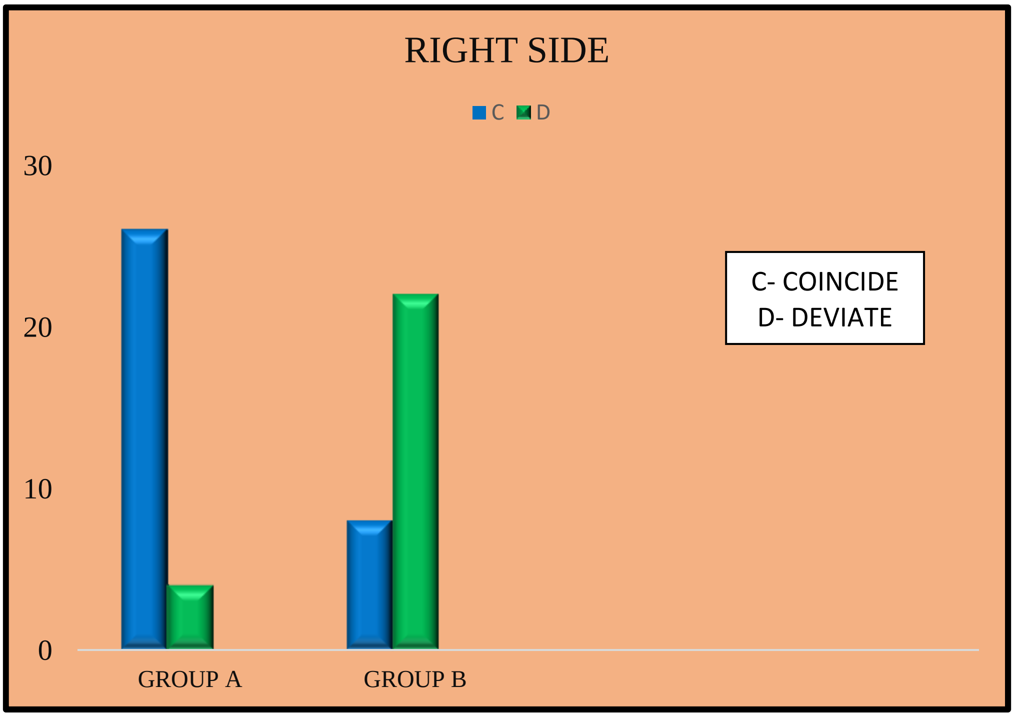


Fig 4. FREQUENCY ANALYSIS OF GROUP A AND GROUP B FOR OCCLUSAL PLANE DEVIATION- LEFT SIDE

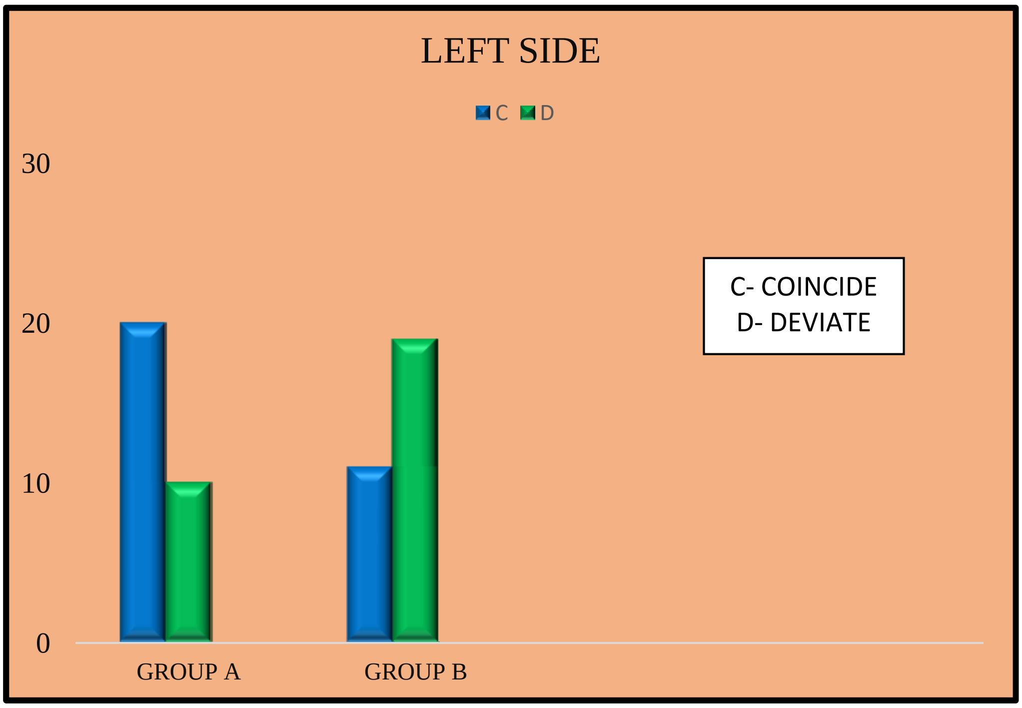


Fig 5. PERCENTAGE ANALYSIS OF GROUP A AND GROUP B FOR OCCLUSAL PLANE DEVIATION- RIGHT SIDE

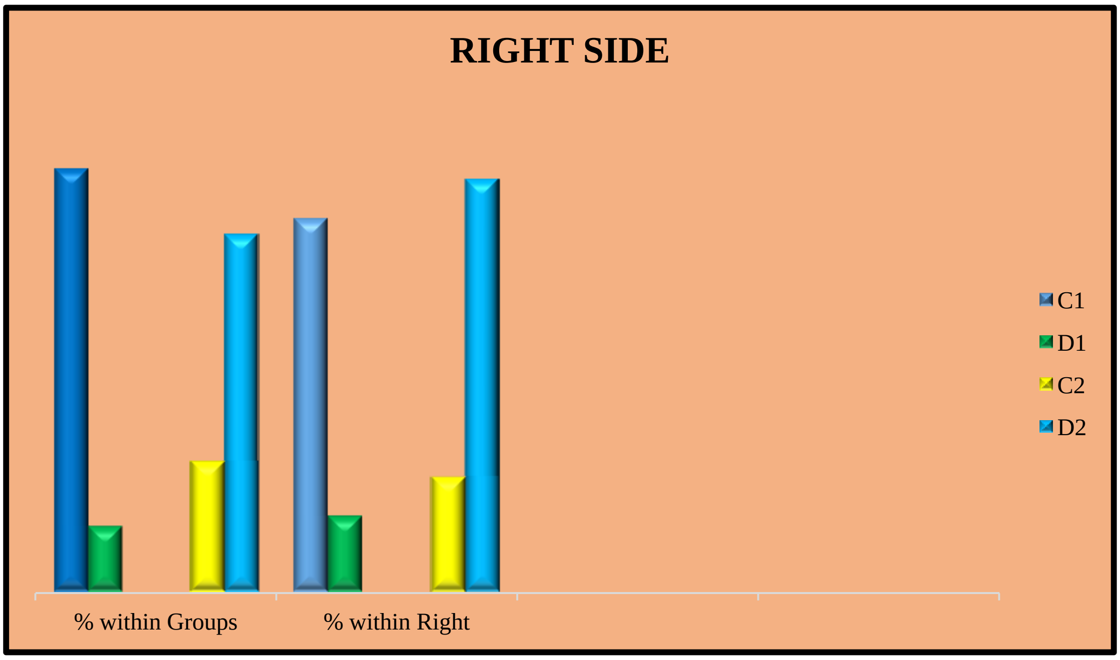
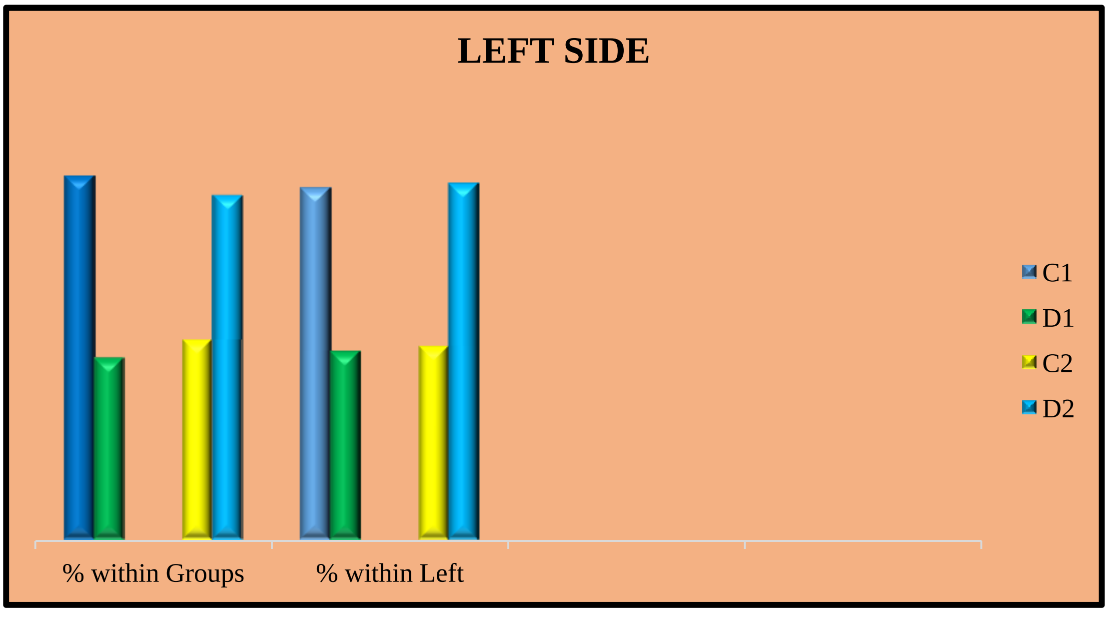


Fig 6. PERCENTAGE ANALYSIS OF GROUP A AND GROUP B FOR OCCLUSAL PLANE DEVIATION- LEFT SIDE



C1-COINCIDENCE-GROUP A, D1- DEVIATION- GROUP A, C2- COINCIDENCE-GROUP B, D2-DEVIATION- GROUPB

Fig 7. PERCENTAGE ANALYSIS FOR DEVIATION TYPE-RIGHT SIDE

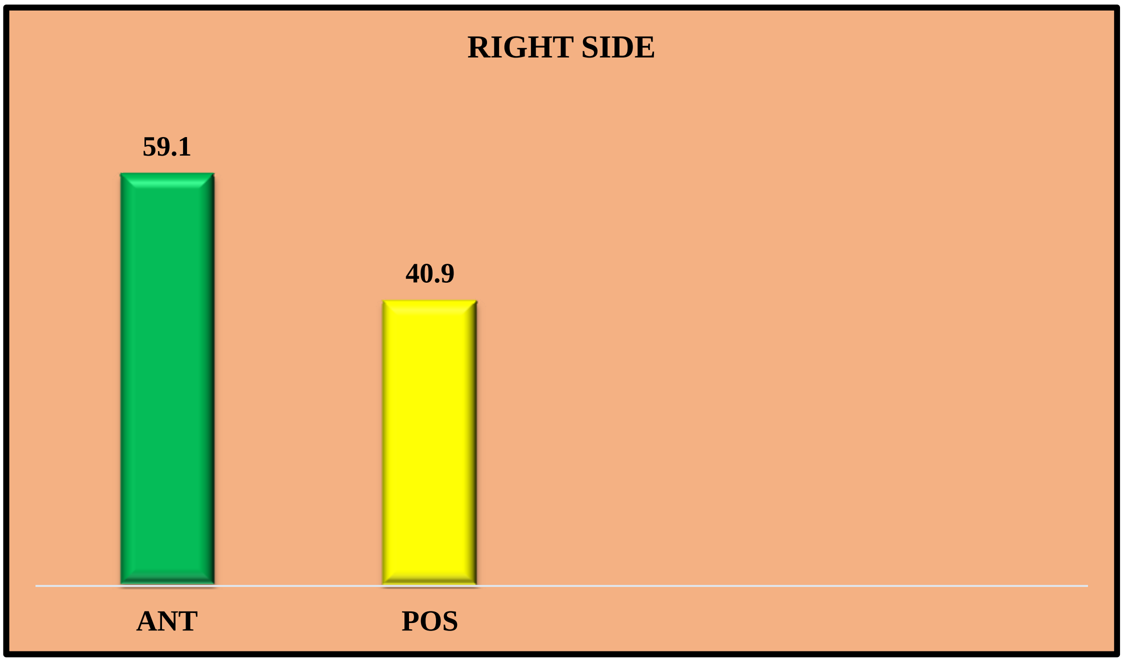
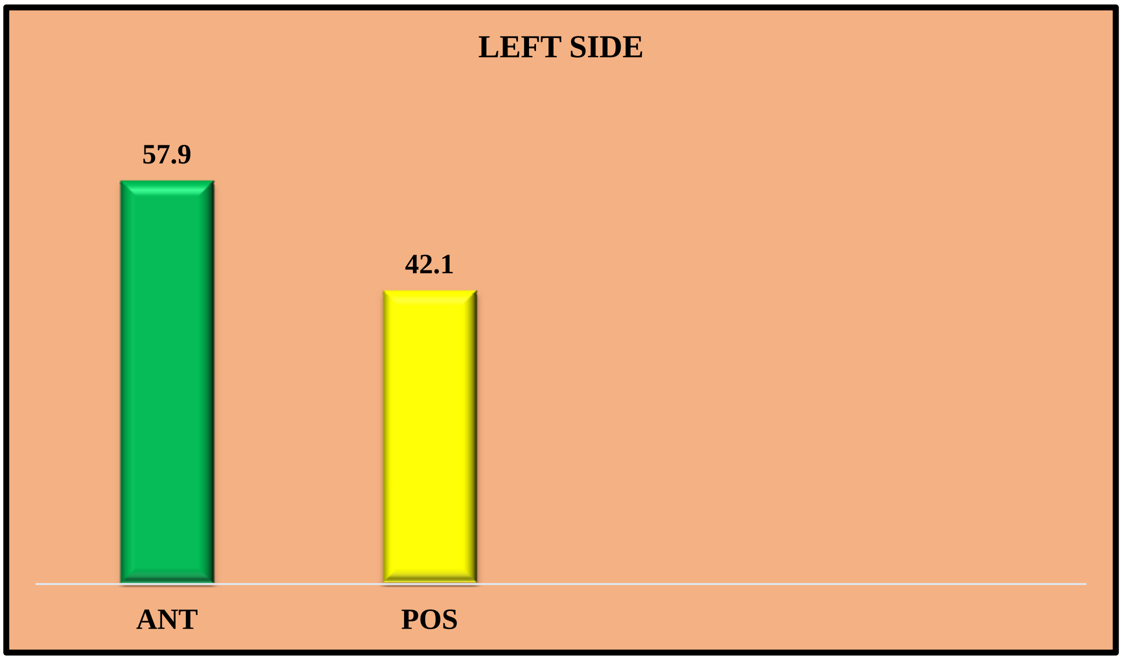


Fig 8. PERCENTAGE ANALYSIS FOR DEVIATION TYPE- LEFT SIDE



ANT - ANTERIOR

POS - POSTERIOR

DISCUSSION:

According to **Ramfjord and Ash**[58], TMD is due to any disharmony affecting the teeth and support structures, functional relations, the muscles of mastication, the maxilla and mandible, the TMJ, and the neurovascular supply of these structures. **Luther**[59] stated that the prevalence of TMD varies between 7% and 84% of the total world population, while according to **LeResche**[60], the 10% of the population affected will be above 18 years of age mostly.

As TMD is a cluster disorder, we cannot isolate a primary cause that predisposes the patients to suffer symptoms, this leads researchers to advocate that TMD is of multifactorial etiology. TMD is usually caused by an untoward interaction between neuromuscular, TMJ, occlusal and psychological factors. The factors which may cause TMD are parafunctional habits, activity of mandibular muscles, facial growth, and also other systemic, postural, metabolic, structural, traumatic, psychological, social and behavioral influences, which have been classified as predisposing, initiating, and maintaining factors for TMD[61,62,63].

The occlusion is observed to play an important role in TMD. Occlusal instability will produce abnormal loading of the masticatory system which then causes the temporomandibular damage. The knowledge of dynamic occlusion is very much important for the diagnosis and treatment of TMD patients. **Jarabak**[64] reports that occlusal instability with the absence of posterior support might cause some forms of TMD.

There are a lot of studies proving the association between occlusal factors to signs and symptoms of TMD. According to **Agne Dzingute**[65], the complaints of patients with TMD and static occlusion parameters are associated.

Kirveskari[66] assessed the association between occlusal interferences and signs of TMD over a period of 6 years in two cohorts of children, half of whom underwent yearly occlusal adjustment. They concluded that occlusal adjustment resulted in a decrease in the number of occlusal interferences, thereby revealing a significant association between the number of occlusal interferences and clinical sings of TMD in the two nonpatient child populations.

The occlusal plane posteriorly helps in the mastication and anteriorly in phonetics and aesthetics. Functionally, the inclination of the occlusal plane is one of the key factors governing the occlusal balance, so determination of occlusal plane inclination may be of value for diagnosis or rehabilitation planning .The inclination of the occlusal plane should harmonize with the muscle orientation, function and mandibular movement path. In cases such as extrusion of teeth, rotation and tipping the curve of Spee may be altered, the reconstruction of the dentition to such an altered occlusal plane can cause interference in the posterior region .Such protrusive interference in the posterior region could cause abnormal muscle activity, and in the temporomandibular joint. The abnormal muscle activity could be prevented by reconstructing the Curve of Spee to pass through the mandibular condyle, causing posterior disocclusion on mandibular protrusion.

Many authors have proposed various concepts and methods for occlusal plane establishment such as ; Camper's plane or ala-tragus line[35,36], residual alveolar ridges[67], lateral border of tongue[68], retro- molar pad[28], condylar path, buccinators groove[37], corner of mouth and parotid papilla[39], orienting plane by cephalometric method[29]. Some dentists even bisect the space present between the residual ridges[22].

The technique of using the ala- tragus line (Camper's line) to establish the occlusal plane is well documented. A debate always exists within the prosthodontic society over the exact definition of the ala- tragus or Camper's line. Most of the controversy is about which tragal reference is to be considered as a posterior landmark during orientation of the occlusal plane. The general consensus of opinion is set to the angulation of occlusal plane parallel to inter-pupillary line transversely and the ala-tragus line (Camper's plane) anteroposteriorly. For example, **Spratley[69] describes the ala-tragus line as running from the centre of the ala to the centre of the tragus whereas Ismail and Bowman[27] define it as a line that is passing from the ala of the nose to the centre of the external auditory meatus.**

Deogade et al[43] advocates that the superior border of the tragus is the most acceptable point for orienting the occlusal plane, which complies with Trapozzano and Boucher's findings. **Van Niekerk[33]** has reported the use of the inferior part of the tragus rather than middle or superior, while Ismail and Bowman suggested the use of the middle part of tragus.

Since the Camper's plane is parallel to the orientation of occlusal plane in most of the edentulous situations, it was chosen for the present study. And the superior border of the tragus was taken as the tragal reference point, as per the finding of the **Deogade et al[43].**

There are also a number of instruments which has been proposed over the time for occlusal plane orientation. **JE Scott[70]** described an instrument called , "the bite plane leveler" in 1952. The underside of this instrument only can be used to evaluate the parallelism of occlusal plane to the ala-tragus line. **Nikzad S Javid[71]** in 1974 recommended using J-plane with the fox plane for occlusal plane establishment. **Kazanoglu and John W Ugner[72]** in 1992 described about the "Camper's plane indicator" for the determination of the occlusal plane orientation. But it is time consuming as the orientation with the interpupillary line and the right and left Camper's plane has to be done separately. In 1998 **Urbano, Santana- Penin and Maria J Mora**[73] described another device for determining the inclination of the occlusal plane, which is made up of stainless steel, U shaped with one shorter inner arm which has to be positioned against the occlusal surface and another longer, outer arm which lies outside the mouth.

The biometric diagnostic tools such as T-scan, electromyography (EMG), joint vibratography (JVA) used in measuring the function of the masticatory system - dental occlusion, temporomandibular joints (TMJ) and muscles help in the practice and management of painful conditions related to temporomandibular disorders (TMD) (Jankelson et al., 1975)[74].Some studies have advocated that the precise location of occlusal contacts and repeatability is not possible with T-scan device.

Broadrick's occlusal plane analyzer is a widely accepted method for establishing the occlusal plane, as it is a practical and easy method for the initial occlusal plane determination on the casts. It can be used as a guide for the amount of tooth reduction that needs to be done or is needed for the establishment of the occlusal plane.

BROADRICK'S OCCLUSAL PLANE ANALYZER:

In 1963, **Dr. Lawson Broadrick** constructed an instrument which can act as a suitable guide for positioning and orientating the posterior occlusal scheme where there is derangement of natural curve of Spee. This device has been commercially marketed as the 'Broadrick Occlusal plane Analyzer', also referred to as the 'Broadrick flag'. It aids to permit reconstruction of the Curve of Spee of Monson's spherical theory, in harmony with anterior and condylar guidance[47]. Thus the

Broadrick flag can determine an acceptable occlusal curve for individual dentate patients where there is derangement of occlusal plane.

The use of the Broadrick flag method provides a good approximation of the natural occlusal curve for a wide range of patients. No correlation found between deviation for this curve and age or sex of the patients, or the incisal classification.

Curve of Spee:

In classical descriptions of an intact normal natural dentition, an antero-posterior curve exists, which passes through the cusp tip of the mandibular canine and the buccal cusp tips of the mandibular premolar and molar teeth and extends posteriorly to pass through the anterior point of the mandibular condyle. The radius of this curve is 4 inches, and is best viewed from the lateral aspect. The German anatomist **Ferdinand Graf Spee,** first described the curve in 1890, hence it is referred to as the ‘Curve of Spee’ after him[52].

There is a reason behind the design as well as the location of curve of Spee in relation to condyle.Variations in the axial alignment of lower teeth might result in changes in the location and design of the curve of Spee. The long axis of each lower tooth is aligned nearly parallel to its individual arc of closure around the condylar axis so that each tooth will have maximum resistance to functional loading. Such an alignment helps in dissipation of occlusal loads[56].

For the successful treatment, the curvature of the arch in three dimensions, including the curve of Spee and the curve of Wilson as well as the placement of the teeth, must be determined. The anatomical variations of the Spee curve influences the masticatory muscles contractions and joint clicks. On a sample of 100 individuals, **Kanavakis**[75] studied the association between the signs of TMD and the characteristics of Spee and Wilson curves. The results depicted that there was a highly significant association between the depth of the curves of Spee and Wilson and the presence of the joint clicks. An accentuated Spee curve results in the contraction of the masticatory muscles thereby leading to muscle dysfunction, without influence on the presence of joint sounds.

For partially edentulous patient when the occlusal scheme is disturbed posteriorly by rotation, tipping and over eruption, the Broadrick occlusal plane analyzer method for occlusal plane orientation is widely accepted for reconstruction of the Curve of Spee. It was based on an anthropological study in 1919, that Monson proposed the existence of an imaginary anteroposterior curve of the teeth forming a sphere, with the center of rotation located in the region of the glabella[16], and its radius was found to be 4 inches[6].

In his study, **Craddock et al[52]**, reported that 55 patients among 100 Caucasian patients did not have any deviation from the theoretically ideal occlusal plane obtained using the Broadrick occlusal plane analyzer.

Supriya Manvi and coworkers[54] reported that there was close correlation between the Broadrick occlusal plane and the existing occlusal plane of the Indian dentate individuals.

Jagadeesh KN et al[55] verified the reliability of the various radii for skeletal Class I, II and III jaw relations. They supported the findings proposed by Lynch and McConnell and advocated use of 4-inch for Class-I, 3.75-inch for Class-II and 5-inch radius for Class III. or Class I skeletal relation, 4-inch radius was used.

The articulator used in the study was Hanau wide vue II articulator, (Whipmix Co). The type of articulator is Arcon, semi-adjustable. The articulator has adjustable inter-condylar distance. The arbitrary earpiece type face-bow used in the study was actually spring bow, Hanau model professional facebow (whipmix Co.,). The main feature of this face-bow is that it is self-centering and the face- bow transfer is made easy and accurate as it has the transfer jig assembly.

For analyzing the occlusal plane, the method advocated by **Bedia et al**[6] was followed since it was practical, cost effective, easy to be adapted and did not involve any major changes to the articulator.

Pankey and Mann[46] were the first to advocate the use of occlusal plane analyzer and incorporation of the occlusal plane established in this way for full mouth rehabilitation. Moreover, occlusal plane analyzer is a documented method to establish occlusal plane for cases requiring single complete denture where the method is used to provide balanced occlusion in eccentric movements.

Cephalometric analysis has served as a valuable adjunct to diagnosis and dental research. Cephalometry is of special value to prosthodontics, in that it can be used to reestablish the correct position of lost structures, such as the teeth[43]. In present study, the cephalometric analyses were performed by a single investigator who was blinded to the selection criteria.

In our cephalometric study, we found that the there was correlation between the inclination of Camper's plane and Broadrick occlusal plane on the right side (p=0.000), and between the inclination of occlusal plane and Broadrick occlusal plane (p=0.000). The results were found to be statistically significant using Independent samples test. Many authors have done cephalometric studies to determine the plane of occlusion, mainly in relation to Camper's plane. But the perusal of the available literature failed to reveal any similar studies studying the location of the Broadrick's occlusal plane using cephalometrics in dentulous Temporomandibular dysfunction patients.

The deviation of the occlusal plane from Broadrick occlusal plane was evaluated for frequency on both the sides between Group A and Group B. The association was also evaluated statistically using the non- parametric Fisher's Exact test. The comparison for occlusal plane deviation between the groups was statistically significant on both right and left sides (p = 0.000, p = 0.038) respectively. This shows that there is a positive correlation between the patient's occlusal plane and the occlusal plane established by the Broadrick analyzer. This proves the reliability of using the Broadrick's occlusal plane analyzer in dentulous TMD patients for reestablishment of occlusal plane.

The type of occlusal plane deviation (anterior or posterior) was evaluated for frequency and percentage for Group B. On the right side, the occlusal plane deviated anteriorly for 59.1% and posteriorly for 40.9%.The occlusal plane deviated anteriorly for 57.9% and posteriorly for 42.1% on the left side. By knowing whether the deviation is in the anterior segment or posterior segment, correction could be done in that segment without disturbing the unaffected segment.

On the basis of the results obtained it can be said that the custom made Broadrick occlusal plane analyzer method can be used in establishing and analysing the occlusal plane in dentulous Temporomandibular patients.

The merits of the study were

1. In the present study, there is a positive correlation between the Camper's plane and the Broadrick occlusal plane on the right side. This confirms the reliability of the Camper's plane as a guide in locating the ideal occlusal plane.

2. By using the custom made Broadrick's occlusal plane analyzer for establishing the ideal occlusal plane, we were able to precisely locate the occlusal interferences

present which lead to the occlusal instability. This helps in correction of the interferences and therebyachieving occlusal balance and harmonybetween teeth, muscles and temporomandibular joint.

3. The method adopted is practical, simple, cost effective, less time taking and does not involve complex equipments.

.

SUMMARY:

This study was aimed at determining the correlation between the occlusal plane evaluated using the Broadrick's occlusal plane analyser and the craniofacial planes in completely dentulous normal subjects and completely dentulous Temporomandibular patients using cephalometry.

The 60 samples were divided into two groups of 30 completely dentulous normal subjects and 30 completely dentulous temporomandibular patients irrespective of gender. For both the groups, the ideal occlusal plane was evaluated using Broadrick's occlusal plane analyzer on both the right and left sides. Right and left lateral cephalograms were taken for each individual. The ideal occlusal plane was transferred to the lateral cephalogram and the inclination of the craniofacial planes (campers plane , maxillary plane) were digitally analysed. The values were recorded for statistical analysis. Descriptive statistics, frequency analysis, percentage analysis, Independent samples test and Fisher's Exact test were performed.

Results showed that the Broadrick occlusal plane had the greatest mean value with respect to both the right and left sides and were statistically significant. Maxillary plane had the least mean value on both the sides and the was not statistically significant.

The results of Fisher's Exact test revealed that there was statistically significant association between the groups for occlusal plane deviation with respect to both right and left sides.

CONCLUSION:

Within the limitations of the present study, it can be concluded that:

- The ideal occlusal plane reconstructed using the Broadrick occlusal plane analyzer has positive correlation with the orientation of the Camper's plane in dentulous TMD patients.
- Evaluating the occlusal plane and the craniofacial planes at the examination level of case history recording in a patient could help us in preventive education and early rehabilitation of temporomandibular dysfunction
- The knowledge of the orientation of the occlusal plane and craniofacial planes would be of much help in treatment planning and also for further studies on temporomandibular dysfunction .
- Small sample size and institutional population in this study restrict the field of this study. Studies with much larger sample size and population will provide more accurate and definitive results.

1. **Ramjford,** Role of occlusion in temporomandibular joint and associated muscle disorders,The Journal of Gnathology 1990;Vol 9,Num 1.2. Costa MD, Froes Junior GRT,

2. Santos CN. Evaluation of occlusal factors in patients with temporomandibular joint disorder. Dental Press J Orthod. 2012 Nov-Dec;17(6):61-8.

3. Dawson PE, Functional occlusion : From TMJ to Smile Design,Mosby;2007 pg.200

4. The glossary of prosthodontics terms, 8th ed. J Prosthet Dent 2005;94:10-92

5. Smriti, Arora A, Upadhyaya V , Sangwan R. Plane Analyzers – The Architectures. Indian Journal of Dental Sciences June 2016;Vol 8, Issue 2

6. Bedia SV, Dange SP, Khalikar AN. Determination of the occlusal plane using a custom-made occlusal plane analyzer: A clinical report .J Prosthet Dent 2007;98:348-352

7. Sehgal MM, Kapur S, Arora A. A custom made occlusal plane analyser for determining the occlusal plane- A clinical report.Journal of Orofacial and Health Sciences.2012 vol 3 iss 2

8. Small BW. Occlusal plane analysis using the Broadrick flag Gen Dent. 2005 Jul-Aug;53(4):250-2.

9. Chaturvedi S, Verma AK, Ali M, Shah M. Full mouth rehabilitation using a custom-made broadrick flag: A case report. International Journal of Case Reports and Images 2012;3(5):41–44.

10. Montieth BD.A Cephalometric method to determine the angulation of the occlusal plane in edentulous patients.J Prosthet Dent 1985;54 :81-7

11. Russell H. Augsburger: Occlusal plane relation to facial type : J Prosthet Dent 1953; 3, 755-770.

12. D'Souza & Bhargava: A cephalometric study comparing the occlusal plane in dentulous and edentulous subjects in relation to the maxillomandibular space: J Prosthet Dent 1996;75:177-82.

13. Ismail & Bowman: Position of the occlusal plane in natural and artificial teeth : J Prosthet Dent 1968;20:407-10

14. G.A.Zarb et al; Boucher's Prosthodontic Treatment for Edentulous Patients,10th edition 1990.C.V.Mosby Co.: St.Louis

15. Senthil Kumar KP, Tamizharasi S. Significance of curve of Spee: An orthodontic review. J Pharm Bioall Sci 2012;4:323-8.

16. Monson GS. Occlusion as applied to crown and bridgework. J Nat Dent Assoc 1920:7;399-413.
17. Foley PF, A study of the position of the parotid papilla relative to the occlusal plane: J Prosthet Dent 1985 ; 53: 1:124–126

18. Orthlieb JD,The curve of Spee: understanding the sagittal organization of mandibular teeth. J Cranio 1997 Oct;15(4):333-40.

19. Ferrario VF, Sforza C, Miani A Jr.Statistical evaluation of Monson's sphere in healthy permanent dentitions in man. Arch Oral Biol. 1997 May;42(5):365-9.

20. Farella M, Michelotti A, van Eijden TM, Martina R.The curve of Spee and craniofacial morphology: a multiple regression analysis. Eur J Oral Sci. 2002 Aug;110(4):277-81.
21. Xu H, Suzuki T, Muronoi M, Ooya K.An evaluation of the curve of Spee in the maxilla and mandible of human permanent healthy dentitions. J Prosthet Dent. 2004 Dec;92(6):536-9.

22. Fu PS, Hung CC, Hong JM, Wang JC.Three-dimensional analysis of the occlusal plane related to the hamular-incisive-papilla occlusal plane in young adults. J Oral Rehabil. 2007 Feb;34(2):136-40.
23. Jayachandran S, Ramachandran CR, Varghese. Occlusal plane orientation:A statistical and clinical analysis in different clinical situations. J Prosthodont. 2008 Oct;17(7):572-5.
24. Robert B. Sloane, Cook, A guide to the orientation of the plane of occlusion J Prosthet Dent 1953; 3:1,53–65

25. Hall WA. Important factors in adequate denture occlusion.J Prosthet Dent1958;5:764-775
26. Boucher CO, Discussion of “laws of articulation” J Prosthet Dent 1963; 13:1,45–48
27. Ismail YR, Bowman JF. Position of the occlusal plane in natural and artificial teeth.J Prosthet Dent 1968;5,407–411
28.Lundquist DO, Luther WW, Occlusal plane determination. J Prosthet Dent 1970; 23:5, 489–498
29. L'Estrange PR, Vig PS. A comparative study of the occlusal plane in dentulous and edentulous subjects. J Prosthet Dent. 1975 May;33(5):495-503.
30.Okane H, Yamashina T,Nagasawa T,Tsuru H, The effect of anteroposterior inclination of the occlusal plane on biting force.J Prosthet Dent 1979; 42(5):497–501
31. Douglass JB, Meader L, Kaplan A, Ellinger CW, Cephalometric evaluation of the changes in patients wearing complete dentures: A 20-year study. J Prosthet Dent.1993;69(3):270–275

32.Tuncay OC, Thomson S, Abadi B, Ellinger C. Cephalometric evaluation of the changes in patients wearing complete dentures. A ten-year longitudinal study. J Prosthet Dent. 1984 Feb;51(2):169-80.

33. Van Niekerk FW, Miller VJ, Bibby RE. The ala-tragus line in complete denture prosthodontics.J Prosthet Dent.1985; 53(1): 67–69

34. Monteith BD. Evaluation of a cephalometric method of occlusal plane orientation for complete dentures.J Prosthet Dent 1986;55(1):64–69

35. Karkazis HC, Polyzois GL.A study of the occlusal plane orientation in complete denture construction. J Oral Rehabil. 1987 Jul;14(4):399-404.

36. Karkazis HC, Polyzois GL. Cephalometrically predicted occlusal plane: Implications in removable prosthodontics. J Prosthet Dent 1991 Feb; 65(2):258–264

37. Celebice A. A study of the occlusal plane orientation by intra-oral method.(Retromolar pad). J Oral Rehab 1995;22:233-6

38. Nissan J, Barnea E, Zeltzer C, Cardash HS. Relationship between occlusal plane determinants and craniofacial structures. J Oral Rehabil. 2003 Jun;30(6):587-91.

39. Shigli K, Chetal BR, Jabade J. Validity of soft tissue landmarks in determining the occlusal plane.J Indian Prosthodont Soc 2005;5(3): 139-145

40. Veena H. Significance of the Frankfort mandibular plane angle in prosthetic management of partially or completely edentulous patients with Class II malocclusions.
J Indian Prosthodont Soc 2005;5(4): 175-179

41. Petricevic N, Celebic A, Celic R, Baucic-Bozic M. Natural head position and inclination of craniofacial planes. Int J Prosthodont. 2006 May-Jun;19(3):279-80.

42.Hindocha, Vikas N Vartak, Aruna J Bhandari, Mohit T Dudani.A cephalometric study to determine the plane of occlusion in completely edentulous patients.J Indian Prosthodont Soc 2010;10(4): 203-207

43. SC Deogade, PL Gupta, GN Shankaran, S Sharma, **A Mishra**. Lateral cephalometric radiographs: An adjunct in positioning the occlusal plane in natural and artificial dentitions as related to other craniofacial planes.J Indian Acad of Oral Med and Radiology.Oct-Dec 2011;23(4):620-623

44. Ghosn CA, Zogheib C, Makzoumé JE. Relationship between the occlusal plane corresponding to the lateral borders of the tongue and ala-tragus line in edentulous patients. J Contemp Dent Pract. 2012 Sep 1;13(5):590-4.

45. Ciancaglini, Colombo-bolla, Gherlone & Radaelli. Orientation of craniofacial planes and temporomandibular disorder in young adults with normal occlusion.Journal of oral rehabilitation 2003; 30; 878–886

46. Mann AW, Pankey LD, Oral rehabilitation: Part I. Use of the P-M instrument in treatment planning and in restoring the lower posterior teeth.J Prosthet Dent Jan-Feb 1960;10(1):135-150

47. Bowley JF, Stockstill JW, Attanasio R. A preliminary diagnostic and treatment protocol. Dent Clin North Am 1992;36:551-68

48. Mc Laughlin GJ. Adaptation of an occlusal plane analyzer to a semiadjustable articulator.J Prosthet Dent. Oct 1972;28(4):445–447

49. Wynne WP. Wynne 2000 Occlusal Plane Analyzer. The Art of Articulation. 2005; 3(1): 1-6.

50. Lynch CD, McConnell RJ. Prosthodontic management of the curve of Spee: Use of the Broadrick flag.J Prosthet Dent. June 2002; 87(6): 593–597

51. Toothtaker RW, Graves AR. Custom adaptation of an occlusal plane analyzer to a semiadjustable articulator.J Prosthet Dent. Feb 1999; 81(2): 240–242

52. Craddock HL, Lynch CD, Franklin P, Youngson CC, Manogue M. A study of the proximity of the Broadrick ideal occlusal curve to the existing occlusal curve in dentate patients. J Oral Rehab 2005;32:895-900

53. Craddock HL, Youngson CC, Manogue M. Deviation from the Broadrick occlusal curve following posterior tooth loss.j oral rehab 2006;33:423-429

54. Manvi S, Miglani S, Rajeswari CL,Srivatsa G,Arora S. Occlusal Plane Determination Using Custom Made Broadrick Occlusal Plane Analyser: A Case Control Study.ISRN Dent. 2012

55. Jagadeesh KN, Kashinatha HM, Bembalgi MS, Kumar PC, Yarlagadda KB, Ateeq PM. Reliability of Broadrick flag in determination of curve of Spee in Indian population. J Contemp Dent Pract. 2012 Sep 1;13(5):627-31.

56. Radha C, Chandrasekhar A, Praveen M, Aarti Saxena , Gautam kumar, Jothi rathinam. Occlusal plane rehabilitation using Broadrick flag technique: case reports. J Oral Research & Review.Aug 2012;4(2)

57. Misch CE. Dental Implant Prosthetics. 2005,Mosby Inc, Pages 162-163.

58. Ramfjord S, Ash MM. Occlusion. 3rd ed. Philadelphia: WB Saunders Co.; 1983.

59. Luther F.TMD and occlusion part II. Damned if we don't? Functional occlusal problems: TMD epidemiology in a wider context. Br Dent J. 2007 Jan 13;202(1):38-9.

60. LeResche, L. 1997. Epidemiology of Temporomandibular Disorders: implications for the investigation of etiologic factors. Crit Rev Oral Biol Med., 8:291–305

61. Greenberg, M.S., Glick, M., Ship, J.A. 2012. Burket's oral medicine. 11th ed. New Delhi: CBS Publishers and Distributers Pvt Ltd; p.223-56.

62. Baldini, A.,Beraldi, A.,Nota, A.,Danelon, F., Ballanti, F.,Longoni, S. 2012a. Gnathological postural treatment in a professional basketball player: case report and an overview of the role of dental occlusion on performance.Ann Stomatol (Roma),3(2): 51–8.

63. De Boever, J.A., Carlsson, G.E., Zarb, G.A., Sessle, B.E., Mohl, N.D. 1994. Etiology and differential diagnosis. In:. Temporomandibular joint and masticatory muscle disorders. 2nd ed. Copenaghen: Munksgaard – Mosby., p. 171–87.

64. Jarabak, J.R. (1956) An Electromyographic Analysis of Muscular and TM Joint Disturbances Due to Imbalances of Occlusion. Angle Orthodontist, 26, 170-190.

65. Agnė Dzingutė, Gaivilė Pileičikienė, Aušra Baltrušaitytė, Gediminas Skirbutis. Evaluation of the relationship between the occlusion parameters and symptoms of the temporomandibular joint disorder. Acta Medica Lituanica. 2017;24(3):167–175

66. Kirveskari P, Alanen P, Jämsä T. Association between craniomandibular disorders and occlusal interferences in children. J Prosthet Dent 1992; 67: 692-6.

67. D.Sinobad. The Position of the occlusal plane in dentulous subjects with various skeletal jaw relationships; J Oral Rehab 1988;15;489-98

68. Yasaki. The Height of the occlusal rim and the interocclusal distance. J Prosthet Dent.1961;11(1);26-31

69. Spratley MH. A simplified technique for determining the occlusal plane in full denture construction. J of Oral Rehab, 1980, Volume 7, pages 31-33

70. Scott JE. The Scott system of precision articulation in three-dimensional occlusion. J Prosthet Dent. May 1952;2(3): 362-380

71. Javid, N.S. (1974) A technique for determination of the occlusal plane. Journal of Prosthet Dent, 31; 270.

72. Kazanoglu, Unger JW. Determining the occlusal plane with the Camper's plane indicator. J Prosthet Dent 1992;67:499-501.

73. Santana-Penin, Maria J. Mora. The occlusal plane indicator: A new device for determining the inclination of the occlusal plane.J Prosthet Dent. Sep1998;80(3):374–375

74. Jankelson B, Swain CW, Crane PF, Radke JC (1975b). Kinesiometric instrumentation: a new technology. J Am Dent Assoc 90:834-840.

75. Kanavakis G, Mehta N. The role of occlusal curvatures and maxillary arch dimensions in patients with signs and symptoms of temporomandibular disorders. Angle Orthod 2014; 84(1):96-101.

INFORMED CONSENT FORM

STUDY TITLE:

EVALUATION OF OCCLUSAL AND CRANIOFACIAL PLANES IN TEMPOROMANDIBULAR DISORDER PATIENTS USING BROADRICK'S OCCLUSAL PLANE ANALYZER AND CEPHALOMETRIC METHODS

Name:

O.P.No:

Address: S. No:

Age / Sex:

Tel. no:

I, ____ age ________ years exercising my free power of choice, hereby give my consent to be included as a participant in the study"**EVALUATION OF OCCLUSAL AND CRANIOFACIAL PLANES IN TEMPOROMANDIBULAR DISORDER PATIENTS USING BROADRICK'S OCCLUSAL PLANE ANALYZER AND CEPHALOMETRIC METHODS**"

I agree to the following:

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

Name of the patient Signature / Thumb impression

PARTICIPANT INFORMATION SHEET

Investigator: Dr.Suganthapriya S Guide: Dr.A.MeenakshiMDS.,

Title:**"EVALUATION OF OCCLUSAL AND CRANIOFACIAL PLANES IN TEMPOROMANDIBULAR DISORDER PATIENTS USING BROADRICK'S OCCLUSAL PLANE ANALYZER AND CEPHALOMETRIC METHODS "**

Name of the research institution:Tamilnadu Government Dental College& Hospital, Chennai

Procedure: The following examinations and investigations will be done for the patient

- Complete medical history,oral cavity examination will be done.Lateralcephalometric radiographs will be taken for both right and left sides.
- Upper and lower alginate impressions will be taken. Facebow transfer will be done.

Risk of participation

Patients will be properly explained about the risks undergoing the procedure.

Human subject's protection

All the instruments used in the study will be sterilized properly. Patients will be properly protected by using lead aprons during radiographic exposure.

Participant's rights

Taking part in the study is voluntary. Patients are free to decide whether to participate in the study or to withdraw at any time; patient's decision will not result in any loss of benefits to which you are otherwise entitled. The results of this study will be intimated to the patient at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Benefits of participation and outcome of study

The results of this study will be of immense help in the field of Prosthodontics and for deliveringbetter treatment to the temporomandibular disorder patients.

Confidentiality

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

Funding

Self.

Compensation: Nil.

Contacts

For queries related to the study:	Contact details regarding rights of the participant:
Primary investigator: Dr.Suganthapriya S Contact details:II year PG student, Department of Prosthodontics, Tamilnadu Government Dental College &Hospital, Chennai-600 003. Phone no:9597222272	Dr.B.Saravanan, M.D.S,Ph.D., The Chairperson, Institutional Ethical Committee, Tamilnadu Government Dental College &Hospital, Chennai-600 003.

Name of the Patient Signature/thumb impression

Name of the investigatorSignature

ஆராய்ச்சி ஒப்புதல் படிவம்

டெம்பரோ மேண்டிபுலார் மூட்டு கோளாறு நோயாளிகளில் ப்ராட்ரிக் கடைவாய்ப்பல் அறவைப் பொருத்த தள பகுப்பாய்வி மற்றும் தலையளவியல் முறைகள் மூலம் கடைவாய்ப்பல் அறவைப் பொருத்த தளம் மற்றும் மண்டையோடு-முகத் தளங்களை மதிப்பீடு செய்தல்.

பெயர் : வயது/ பால்:

ஆராய்ச்சி சேர்க்கை எண்: புறநோயாளி எண்:

நான் என் சுய நினைவுடன் மற்றும் முழுசுதந்திரத்துடனும் இந்த மருத்துவ ஆராய்ச்சியில் சேர்ந்துகொள்ள ஒப்புதல் அளிக்கிறேன். கீழ் காணப்படும் நிபந்தனைகளுக்கு ஒப்புதல் அளிக்கிறேன். இந்த ஆராய்ச்சியின் நோக்கமும் அதன் சிகிச்சை முறைகளும் எனக்கு திருப்தி அளிக்கும் வகையில் அறிவுறுத்தப்பட்டது.

இந்த ஆராய்ச்சியின் போது நோயாளிக்கு பயன்படுத்தப்படும் ஊசி மருந்துகளையும், பல் குறைப்பதையும் 3 வெவ்வேறு பொருள்களை பயன்படுத்தும் முறைகளையும், தீங்கு தராமல் இருக்கும் அச்சீட்டு பொருட்களை உபயோகப்படுத்துவதையும் நன்கு அறிவேன் மற்றும் எனக்கு அனைத்து செயல்களையும் மருத்துவர் அவர்களால் விளக்கிக் கூறப்பட்டது.

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

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

நோயாளியின் பெயர்	கையொப்பம்	தேதி
ஆராய்ச்சியாளர் பெயர்	கையொப்பம்	தேதி

ஆராய்ச்சி பற்றிய தகவல் படிவம்

1) டெம்பரோ மேண்டிபுலார் மூட்டு கோளாறு நோயாளிகளில் ப்ராட்ரிக் கடைவாய்ப்பல் அறவைப் பொருத்த தள பகுப்பாய்வி மற்றும் தலையளவியல் முறைகள் மூலம் கடைவாய்ப்பல் அறவைப் பொருத்த தளம் மற்றும் மண்டையோடு- முகத் தளங்களை மதிப்பீடு செய்தல்.

2) நோயாளி பற்றிய குறிப்புகள் பிறர் அறியா வண்ணம் ஆராய்ச்சி முடியும் வரை இரகசியமாக பாதுகாக்கப்படும். அதை வெளியிடும் நேரத்தில் எந்த நோயாளியின் தனி அடையாளங்களும் வெளியிட வாய்ப்பு கிடையாது.

3) இந்த ஆராய்ச்சியில் பங்கு பெறுவது நோயாளியின் தனிப்பட்ட முடிவு மற்றும் நோயாளிகள் இந்த ஆராய்ச்சியில் இருந்து எப்பொழுது வேண்டுமானாலும் விலகிக்கொள்ளலாம். நோயாளியின் இந்த முடிவு அவருக்கோ அல்லது ஆராய்ச்சியாளருக்கோ எந்தவித பாதிப்பும் ஏற்படாது என்பதை தெரியப்படுத்துகிறோம்.

4) இந்த ஆராய்ச்சியின் முடிவுகள் நோயாளிகளுக்கு ஆராய்ச்சி முடியும் தறுவாயிலோ அல்லது இடையிலோ தெரிவிக்கப்படும். ஆராய்ச்சியின்பொழுது ஏதும் பின் விளைவுகள் ஏற்பட்டால் அதை சரி செய்ய தகுந்த உதவிகள் அல்லது தேவையான சிகிச்சைகள் உடனடியாக மேற்கொள்ளப்படும்.

நோயாளியின் பெயர் கையொப்பம்/கைரேகை

முதன்மை ஆய்வாளர்
தமிழ்நாடு அரசு பல் மருத்துவக்கல்லூரி,
சென்னை-600 003.