

**EVALUATION AND COMPARISON OF
ANTERIOR AND POSTERIOR OCCLUSAL
PLANES IN ANGLES CLASS I, CLASS II
DIVISION 1 AND CLASS II DIVISION 2
MALOCCLUSIONS
- A CEPHALOMETRIC STUDY.**

Dissertation submitted to

Maharashtra University of Health Sciences, Nashik

in the Partial Fulfillment of Regulations

for the award of the Degree of

MDS

IN

ORTHODONTICS AND DENTOFACIAL ORTHOPEDICS

BRANCH V

2017-2020

CONTENTS

| Sr. No. | Title | Page No. |
|-----------------|---|-----------------|
| 1. | Introduction | 1 |
| 2. | Aim and Objectives | 5 |
| 3. | Review of Literature | 7 |
| 4. | Materials and Method | 27 |
| 5. | Statistical Analysis and Results | 40 |
| 6. | Discussion | 52 |
| 7. | Limitations | 66 |
| 8. | Summary and Conclusion | 67 |
| 9. | Bibliography | 70 |
| 10. | Tables and Graphs | 90 |
| ANNEXURE | | |
| | <ul style="list-style-type: none">• Case History Proforma | i |
| | <ul style="list-style-type: none">• Informed Consent Form | iii |
| | <ul style="list-style-type: none">• Master chart | |

LIST OF TABLES

| Table no. | Title | Page no. |
|-----------|--|----------|
| 1 | Comparison of skeletal patterns amongst the three groups | 90 |
| 2 | Comparison of dental patterns amongst the three groups | 91 |
| 3 | Multiple comparisons of skeletal patterns amongst three group | 92 |
| 4 | Multiple comparisons of dental patterns amongst three group | 93 |
| 5 | Correlation between skeletal and dental patterns in Class I group | 94 |
| 6 | Correlation between skeletal and dental patterns in Class II division 1 group | 95 |
| 7 | Correlation between skeletal and dental patterns in Class II division 2 group | 96 |
| 8 | Correlation between occlusal planes and dental patterns in Class I group | 97 |
| 9 | Correlation between occlusal planes and dental patterns in Class II division 1 group | 97 |
| 10 | Correlation between occlusal planes and dental patterns in Class II division 2 group | 97 |

LIST OF GRAPHS

| Graph no. | Title | Page no. |
|------------------|---|-----------------|
| 1 | Comparison of MPA amongst the three groups | 98 |
| 2 | Comparison of Facial axis amongst the three groups | 98 |
| 3 | Comparison of Gonial angle amongst the three groups | 99 |
| 4 | Comparison of PPA amongst the three groups | 99 |
| 5 | Comparison of Ramal inclination amongst the three groups | 100 |
| 6 | Comparison of Na-A amongst the three groups | 100 |
| 7 | Comparison of Na-Pog amongst the three groups | 101 |
| 8 | Comparison of Ramal height amongst the three groups | 101 |
| 9 | Comparison of Mandibular length amongst the three groups | 102 |
| 10 | Comparison of Maxillary length amongst the three groups | 102 |
| 11 | Comparison of Anterior occlusal plane amongst the three groups | 103 |
| 12 | Comparison of Posterior occlusal plane amongst the three groups | 103 |
| 13 | Comparison of U1-FH amongst the three groups | 104 |

| Graph no. | Title | Page no. |
|------------------|---|-----------------|
| 14 | Comparison of L1-MP amongst the three groups | 104 |
| 15 | Comparison of FMIA amongst the three groups | 105 |
| 16 | Comparison of U6-FH amongst the three groups | 105 |
| 17 | Comparison of U7-FH amongst the three groups | 106 |
| 18 | Comparison of U1-PP amongst the three groups | 106 |
| 19 | Comparison of U5-PP amongst the three groups | 107 |
| 20 | Comparison of U7-PP amongst the three groups | 107 |
| 21 | Comparison of U1-MP amongst the three groups | 108 |
| 22 | Comparison of L5-MP amongst the three groups | 108 |
| 23 | Comparison of L7-MP amongst the three groups | 109 |
| 24 | Comparison of U6-PTV amongst the three groups | 109 |

LIST OF COLOUR PLATES

| Plate no. | Title | Page no |
|------------------|---|---------|
| Plate I | A. Digital Lateral Cephaogram Machine | 34 |
| | B. Digital Printer (Fujifilm Dry Pix Smart | 34 |
| Plate II | C. Matte acetate tracing paper, Geometric box | 35 |
| | D. Lateral cephalogram | 35 |
| Plate III | E. Study model | 36 |
| | F. Tracing | 36 |
| Plate IV | G. Anterior and posterior occlusal planes | 37 |
| | H. Skeletal Pattern: Angular measurements | 37 |
| Plate V | I. Skeletal Pattern: Linear measurements | 38 |
| | J. Dental Pattern: Angular measurements | 38 |
| Plate VI | K. Dental Pattern: Linear measurements | 39 |

LIST OF ABBREVIATIONS

| Sr. No. | Abbreviations | Full form |
|---------|---------------|------------------------------------|
| 1 | OP | Occlusal plane |
| 2 | FOP | Functional Occlusal plane |
| 3 | MP | Mandibular plane |
| 4 | AOP | Anterior Occlusal plane |
| 5 | POP | Posterior Occlusal plane |
| 6 | IOP | Inclination of Occlusal plane |
| 7 | BOP | Bisecting Occlusal plane |
| 8 | MMC | Maxillomandibular complex |
| 9 | DFO | Dentofacial deformity |
| 10 | SAP | Smile arc protection |
| 11 | NHP | Natural head position |
| 12 | FH (plane) | Frankfort horizontal plane |
| 13 | FX | Facial axis |
| 14 | TMD | Temporomandibular disorders |
| 15 | Go-A | Gonial angle |
| 16 | PP | Palatal plane |
| 17 | RAM-I | Ramus inclination |
| 18 | POG | Pogonion |
| 19 | Na | Nasion |
| 20 | RAM-H | Ramus height |
| 21 | MAND-L | Mandibular length |
| 22 | MAX-L | Maxillary length |
| 23 | U1 | Upper central incisor |
| 24 | L1 | Lower central incisor |
| 25 | FMIA | Frankfort mandibular incisor angle |
| 26 | U6 | Upper first molar |

| Sr. No. | Abbreviations | Full form |
|----------------|----------------------|------------------------------------|
| 27 | U7 | Upper second molar |
| 28 | U5 | Upper second premolar |
| 29 | U7 | Upper second molar |
| 30 | L1 | Lower central incisor |
| 31 | L5 | Lower second premolar |
| 32 | L7 | Lower second molar |
| 33 | S | Sella |
| 34 | N | Nasion |
| 35 | ANOVA | Analysis of variance |
| 36 | P - value | Probability value |
| 37 | AP | Antero-posterior |
| 38 | EMG | Electromyography |
| 39 | 2D/3D | Two dimensional/ Three dimensional |
| 40 | TMJ | Temporomandibular joint |
| 41 | OSAS | Obstructive sleep apnoea syndrome |
| 42 | PSG | Polysomnography |
| 43 | LO | LeFort I osteotomy |
| 44 | SO | Step osteotomy |
| 45 | MPA | Mandibular plane angle |
| 46 | PTV | Pterygoid vertical |
| 47 | i.e. | That is |

Introduction

Early in the history of Orthodontics, both clinicians and researchers were aware of the relevance of the occlusal plane in the diagnosis and treatment of malocclusions. References to the occlusal plane can be found throughout the orthodontic literature. In 1947, Bjork¹ mentioned in his textbook that the steepness of the occlusal plane diminishes with prognathism. Bushra² stated that “the flatter the occlusal plane, the more forward the face.” Downs³ in 1948, noted that Class II malocclusions tends to have steeper occlusal planes, and Class III malocclusions have flatter occlusal planes. Riedel⁴ observed an apparent perpendicular relationship between the occlusal plane and the A-B plane in normal occlusions. Schudy⁵ in 1963, mentioned the relationship of the occlusal plane to function and its significance in

treatment. Several authors stated that Tweed obtained more favourable profiles because of his control of the occlusal plane by minimizing the untoward effects of Class II mechanics with his anchorage preparation.⁶⁻⁸ The relationship of the occlusal plane to mandibular position continued to be observed as numerous studies, starting in 1970s, began to show that during normal dentofacial development, both the occlusal plane and the mandibular plane flattened as the mandible rotated forward with growth.⁹⁻¹¹ Sato et al¹² demonstrated that the occlusal plane flattened excessively in growing patients with skeletal Class III malocclusions.

Traditionally, the occlusal plane was defined as a line from the incisors to the first molars. In a 1996 study, the authors proposed an alternative way to describe the curvature of the occlusal plane.¹³ They divided it into anterior and posterior components, where the anterior occlusal plane is a line drawn from the incisal edge of the maxillary central incisor to the cusp tip of the maxillary second premolar, and the posterior occlusal plane (POP) is a line from the cusp tip of the maxillary second premolar to the midpoint of the maxillary second molar at the occlusal surface. In orthodontic diagnosis, occlusal plane is represented by a line drawn from the midpoint of the upper and lower central incisor edges to the occlusal surface of the upper and lower first molars on the lateral cephalogram should be carefully evaluated. The cant of the occlusal plane must relate to the sagittal inclination of the condylar path and the guidance of lingual concavity of the upper incisor (Dawson, 1989)¹⁴. In a strict sense, however, the occlusal plane is not a line.

In a case with a severe curve of Spee, the occlusal plane drawn in a conventional manner is erroneously represented. Several studies have stated that an

excessive curve of Spee is characterized in Class II division 1 malocclusions (Jarabak and Fizzel, 1972; Nanda, 1983)^{15,16}. This characteristic occlusion might affect its own skeletal growth pattern. The masticatory function is characterized as a three-dimensional mandibular movement to the occlusal surface of the upper dentition. More attention should thus be focused on the occlusal curvature in the upper dentition. Langlade (1978)¹⁷ emphasized the importance of upper anterior occlusal plane control and stated that the goal of intervention must be the optimum function and not just the straight teeth.

To fit this characteristic feature of the occlusal plane of the posterior dentition, a functional occlusal plane has been used so far. In this study, the occlusal plane will be considered as two planes divided into the anterior and posterior segments. In this sense, it seems clear that the relationship between the occlusal deviation and the skeletal pattern is closely related.

In dento-alveolar bimaxillary malocclusion cases, the four first-premolar extraction is performed and followed by retraction of six maxillary and mandibular anterior teeth. It is preferred that in bimaxillary protrusion case treatment, fixed orthodontic appliance is used^{18,19}. In dento-alveolar bimaxillary protrusion, the most general treatment is premolar extraction, because the position of premolar is very advantageous, i.e. between anterior and posterior segments²⁰. Occlusal plane inclination changes also can occur due to the mesial molar movement (anchorage loss). Kocadereli²¹ stated that it is necessary to give attention to the posterior anchorage, so the position is not changed during anterior retraction in bimaxillary protrusion treatment. In addition, the occlusal plane inclination changes can also be

caused by (changes in molar and incisors) extrusion and intrusion. The occlusal plane inclination change should not happen during the dento-alveolar bimaxillary protrusion treatment by four first premolar extraction because it can result in temporomandibular joint disorder (TMD)^{21,2,23}. The occlusal plane inclination changes can affect dental occlusion. Each occlusal rotation of 1° can result in 0.5 mm change of dental occlusion relationship²⁴. In addition, the change can result in treatment result instability²⁵. The plane of occlusion is particularly difficult to delineate precisely when the occlusion follows a curve (the Curve of Spee) rather than a plane in the lateral view, and when the dentition is completely intact. The functional relevance of the occlusal plane should be recognized, however, the occlusion as a particular site or boundary pertinent to the study of craniofacial growth and development, represents the composite effects of both alveolar bone and dental growth. The occlusal junction of the teeth has been regarded as a "specialized kind of movable articulation essentially comparable to other bone to bone junctions" (Enlow et. al. 1971)²⁶. It seems however, that despite its conceivable functional relevance to the masticatory system the occlusal plane has not been a very popular plane of reference because it does not fulfil the standard criteria of accurate identification, or stability over time.

Aim and Objectives

AIM

The present study aimed to evaluate and compare anterior and posterior occlusal planes in Angles Class I, Class II division 1 and Class II division 2 malocclusions in Central India Population - A Cephalometric study.

OBJECTIVES

- Evaluation of anterior occlusal plane in Angles
Class I malocclusion
Class II division 1 malocclusion
Class II division 2 malocclusion

- Evaluation of posterior occlusal plane in Angles
 - Class I malocclusion
 - Class II division 1 malocclusion
 - Class II division 2 malocclusion

- Comparison of anterior occlusal plane in Angles
 - Class I malocclusion
 - Class II division 1 malocclusion
 - Class II division 2 malocclusion

- Comparison of posterior occlusal plane in Angles
 - Class I malocclusion
 - Class II division 1 malocclusion
 - Class II division 2 malocclusion

Review of Literature

Review of literature will be under following heads:

1. Influence of inclination of occlusal plane on jaw growth.
2. Relationship of occlusal plane with condylar path.
3. Sagittal relationship between maxilla and mandible.

Downs (1948)³ - The OP (occlusal plane) is a two-dimensional segmentation of a three dimensional phenomenon; on cephalometric radiograph, a straight line is used to represent an imaginary plane at the level of occlusion. There are various ways for determining the occlusal plane, in which the bisected occlusal plane (BOP) is most commonly used.

Tovstein BC (1955)⁵⁹ - The FOP (functional occlusal plane) represents a structural limitation of mandibular motion, and all masticatory forces are focused on this plane and intimately related to it. The change of muscular environment is cited as a cause for relapse; if the inclination of functional OP changed remarkably, the OP might revert to its original position after treatment.

Schwartz (1960)²⁷ - Concluded from his cephalometric and gnathometric analysis that “there is no essential causal connection between malocclusions and skull architecture.” Every malocclusion can be combined with the most different natural variations of skull architecture.

Bjork (1963)^{32, 33} - During normal growth, the mandible moves along a forward and downward vector. This vector can be divided into two components: a forward component, which can be called mandibular response, and a vertical component.

Schudy (1964 and 1965)²⁸ - Found no correlation between the morphologic pattern and specific types of occlusion in 270 subjects. In 400 malocclusions the only notable finding was that, the occlusal/mandibular plane angle and the S-N/mandibular plane angle were excellent indicators of facial type.

Harvold (1968)²⁹ - Evaluated sagittal changes with activator treatment by measuring projections on the functional occlusal plane from points A and B. He stated that during growth it might not provide an accurate appraisal due mainly to the changes in the cant of the functional occlusal plane; this has been confirmed by Sherman et al.

Andrews (1972)⁶¹ - Noted that the occlusal planes in 120 non-orthodontically treated and ostensibly normal occlusions varied from being generally flat to having a slight curve of Spee. This finding led him to believe that the presence of a curve of Spee could be associated with post-orthodontic treatment relapse. Andrews concluded, “even though not all of the orthodontic normals had flat planes of occlusion, a flat plane should be a treatment goal as a form of overtreatment.” A deep curve of Spee may make it almost impossible to achieve a Class I canine relationship, though it may also result in occlusal interferences that will manifest during mandibular function.

Simons and Joondeph (1973)⁶² - In a 10-year post-retention study, reported that proclination of lower incisors and a clockwise rotation of the occlusal plane during treatment were significant relapse factors. The stability of posterior extrusion is controversial. Variables such as the amount of growth and the patient's age during treatment, muscle strength, adaptation, and the original malocclusion have all been postulated as factors contributing to the long-term stability of correction of curve of Spee.

L’Estrange and Vig (1975)⁶⁶ - Found a marked parallelism between the maxillary plane (a line joining the anterior and posterior nasal spines) and the occlusal plane in edentulous subjects. In a dentate group, significant differences in the angles of the occlusal maxillary planes were associated with the combined effects of the height and length of the maxillomandibular space.

Thurrow RC. (1977)⁴⁸ - Posterior discrepancy, in addition to the eruption force of the third molars (from 17-21 years) at the end of the growing period, should

be considered a probable causative factor for the abrupt flattening of the OP in Class III development.

Wolford et al. (1978)³⁵ - Orientation of the cranial base is significantly different in patients with low mandibular plane angle skeletal morphology as compared with those with high mandibular plane angle skeletal morphology. Thus, the sella nasion plane and/or Frankfort horizontal (FH) plane may have very different orientations in each facial type and to each other within the same facial type, thus making it difficult to obtain an accurate diagnosis based on these cephalometric cranial-base references.

McNamara³⁹ (1979) and Harvold (1968) - Preliminary studies with nonhuman primates demonstrated the relationship between mandibular deviation induced by occlusal alteration and jaw growth, attributing to the temporomandibular joint in the condylar region a functional capacity to adapt to changes in mandibular position.

Proffit (1980)³⁶ - Traditional management with double-jaw surgery has relied either on autorotation of the mandible to determine an acceptable angle for the occlusal plane, or the angle of the occlusal plane is increased relative to the FH to improve stability.

Proffit (1980)³⁶ - The occlusal plane undergoes constant change during growth, so what would be considered normal in childhood, would not be considered normal for an adolescent or adult. The occlusal plane adapts to the variations of vertebral, dental and chronological age, in accordance with biological rhythms.

Monteith B. D (1985)⁵⁰ and Foley F. P (1986)⁵¹ - Dynamic changes in the craniofacial growth and development affect many changes in occlusal relationships. Therefore, understanding the static and dynamic details of occlusion is crucial for achieving a harmonic function of the masticatory system. The shape and inclination of the occlusal plane is an individual characteristic and is connected with the function of the stomatognathic system.

Johnston (1986)⁶³ - Has evaluated the treatment effects of younger versus older adolescent patients in the correction of Class II malocclusions. In the younger patient, tooth movement accounted for about 40% of the molar correction, whereas apical base change represented the remaining 60%. Older adolescents exhibited very little apical base change. Adult teeth tend to tip more easily than teeth in adolescents, but the density of bone in adults makes it difficult to achieve the amount of dental bodily movement often seen in adolescents.

Sherman et al. (1988)³⁰ - Analysed that the value of Wits appraisal does not remain stable throughout the growth period. The readings are not entirely dependent upon the relative sagittal movements of points A and B. They also showed that any change in the angulation of the functional occlusal plane may profoundly influence the positions of points A and B relative to that plane, and therefore to the value of the Wits appraisal. The direction and magnitude of any change in the Wits appraisal depends upon the direction of facial growth and treatment mechanics.

Braun S (2000)⁵⁶ and Thayer TA. (1990)⁵⁷ - The functional occlusal plane (FOP) is a plane formed by bisecting the intercuspation of the first premolars and the intercuspation of the first molars.

Kuboki et al. (1991)⁸² - Reported that the masticatory muscles act as both a positioner that functionally maintains the optimal mandibular position and a power producer that produces an actual function. The role as a power producer may be mainly determined by the masseter and medial pterygoid muscles and that as a positioner mainly by the temporal muscle. Those authors also defined the position of the total force of the masticatory muscles and found a marked shift in the total force from the median line to the masticatory side during unilateral chewing.

Richardson ER (1991)⁴⁵ and Bathia SN (1993)⁴⁶ - On average, the MP and the OP tend to rotate forward with age, denoting a relationship between OP alteration and mandibular adaptation during growth and development.

Larry M. Wolford (1993)³⁷ - When increasing the occlusal plane angle it is usually easier to reposition the maxilla first, creating a posterior open bite, but maintaining a predetermined incisor relationship, be it class I, II, or III.

Larry M. Wolford (1993)³⁷ - When the occlusal plane angulation is decreased, it is usually easier to set the mandible into its new position first with rigid fixation, using an intermediate splint to create a posterior open bite. The maxillary surgery then becomes much simpler, requiring completion of the osteotomies and mobilization and placement of the segment(s) into occlusion with the mandible, with or without a final splint.

Larry M. Wolford (1993)³⁷ - When decreasing the occlusal plane angle and advancing the mandible, the A-P dimension of the oropharyngeal airway will increase approximately 40% of the mandibular advancement measured at the genial tubercles.

Wolford LM (1994)³⁸ - In conventional treatment plans, usually the change in the OP was an inevitable consequence when conducting any maxillary vertical modification allowing for mandibular autorotation.

Nanda and Merrill (1994)³¹ - Attempts were further made to identify an appropriate reference line by using palatal plane. The projections from points A and B on the palatal plane (App-Bpp) was found the best indicator of sagittal jaw relationships.

Sato S (1994)⁴⁰ - The spatial position and inclination of the occlusal plane in the lower face influences the functional position of the mandible.

Fushima (1989)⁴¹ and Sato S (1994)⁴⁰ - Specifically, the vertical height of the occlusion can affect the cant of the posterior occlusal plane and, subsequently, mandibular position and function in different skeletal malocclusion types. This agrees with Dawson⁴³, who stated that mandibular position is influenced by the vertical relationship of the dentition in the buccal segments, and the relationship between the cant of the occlusal plane of the maxillary dentition related to the sagittal inclination of the condylar path and the guidance of lingual concavity of the maxillary incisor, is another aspect to consider in terms of functionality.

Sylvie Lamarque (1995)³⁴ - For all other patients with Class II malocclusions, mildly hypodivergent, normodivergent, and hyperdivergent, the diagnostic choices and the treatment must attempt to enhance the mandibular response because mandibular response facilitates improvement in facial balance and harmony. To

enhance the response of the mandible to treatment, the horizontal planes, especially the occlusal plane, must be controlled.

Protacio C (1995)⁴⁷ - It was postulated that the position of the OP (occlusal plane) in the denture frame can be greatly influenced by a tooth-to denture base discrepancy posterior to the first molar (posterior discrepancy) due to the “squeezing out” effect that causes overeruption of the maxillary and mandibular posterior teeth. Consequently, a less steep OP develops and adversely affects the vertical dimension (elongation) of the dentition; this interferes with the functional occlusion and induces malpositioning of the mandible followed by abnormal mandibular condylar growth in the developing skeletal Class III malocclusion.

Hidaka et. al. (1996)⁷⁷ - Evaluated electromyographically the lateral inclination of the occlusal plane and right–left differences in the masticatory muscles in patients with mandibular lateral displacement and observed high muscle activity in the temporal and masseter muscles on the non-displaced side.

Holan (1998)⁸⁴ - The treatment modalities for temporomandibular joint condylar fracture vary from open reduction to physiotherapy only and depend on the type and severity of the fracture, timing of diagnosis and treatment, and the surgeon’s experience. However, little is known about the occlusal manifestations following early diagnosed and treated jaw fractures.

Charles J. Burstone (1998)⁸⁶ - An occlusal plane should be established that is the treatment plane of occlusion. The emphasis is on the word "plane," which is three-dimensional in nature so an occlusal line can be evaluated either as a lateral or a

frontal line. The occlusal plane and dental axial inclinations measured to this plane can then be used to establish the presence of either a dental or skeletal asymmetry. This supplements the previous database of the facial bones that was established from the clinical examination, photographs, and radiographs.

Charles J. Burstone (1998)⁸⁶ - The patient who is treated surgically should have the occlusal plane, as evaluated from the frontal view, parallel to facial structures, such as the eyes. In the nonsurgical patient with a skeletal asymmetry, there may be a cant to the plane of occlusion relative to the face. This cant is not easily altered from a line connecting posterior teeth because of mechanical difficulties in intruding entire posterior segments. Furthermore, the lips may also be angled so that a more aesthetic relationship of the canted occlusion and the lips is observed.

Umemori M. et al. (1999)⁷⁴ and Kravitz ND. et al. (2007)⁷⁵ - Skeletal anchorage appeared a few years ago as an excellent alternative for the treatment of asymmetries. It has no adverse effects on mechanics and does not rely on patient's compliance, meaning that treatment is more predictable and reliable. Specifically for occlusal plane inclination, mini-implants may be the favoured option for cases of minor discrepancies and two mini-implants should be preferably used in order to increase retention. Other problems related to mini-implants is the risk of root contact during treatment, as the intrusion movement is performed towards the mini-implant.

Burstone C. J. (2000)⁶⁵ - Suggested an occlusal aesthetic plane that took into account the position of molars, maxillary incisors and upper lip. The authors stated that maxillary incisors should be 3 mm below the upper lip. Although similar to the plane proposed in the present study, the occlusal plane presented by those authors did

not take into account the position of mandibular incisors nor their relationship with the face.

Motoyoshi et al. (2000, 2002, 2003)⁷⁹⁻⁸¹ - A lateral inclination of the occlusal plane induced cervical spine displacement and caused the stress distribution in this area to be asymmetrical, thus affecting posture evaluated electromyographically.

Le Bell et al. (2002)⁶⁴ - Indicate that subjects with no TMD history may respond differently to experimental interferences than individuals with a former TMD history: in a randomized double-blind clinical investigation, these clinicians found that subjects without a TMD history showed fairly good adaptation to artificial occlusal interferences, while individuals with a TMD history were characterized by a significant increase in clinical signs compared with the other groups. It should be noted that the increase related only to clinical signs of TMDs but not to symptoms. Based on these findings, it appears feasible that individuals with a history of TMDs may indeed have a greater risk of developing TMD signs in response to occlusal changes from dental work, so their dentists should be aware of that possibility.

Sarver (2003)⁶⁷ - Conversely, the results also suggest that there are limitations with preadjusted edgewise appliance therapy in modifying the curvature of the smiling line of malocclusions with the following presentations: 1. congruency between the pre-treatment AOP (anterior occlusal plane) and FOP (functional occlusal plane), and 2. normal inclination of the incisors. Therefore, increasing the curvature of the smiling line is one of the treatment objectives in these malocclusions, treatment options. In the literature, depending on the complexity of the malocclusion, other investigators have recommended other options to increase the curvature of the smiling

line. One of the options includes individualized vertical repositioning of the brackets. By repositioning the brackets of the maxillary anterior teeth more cervically, the teeth will be repositioned more inferiorly with respect to the posterior teeth. This will orthodontically increase the inclination of the occlusal plane; whereas in more complex malocclusions, orthognathic maxillofacial surgery or posterior intrusion with vertical skeletal anchorage have been reported to increase the inclination of the occlusal plane more significantly.

Takahisa Shimazaki (2003)⁸³ - In this model, the right–left differences in masticatory muscle activity may have acted in a direction that cancelled the influence of the inclined occlusal surface, minimizing the influence on the cervical spine. Thus, activation of the masticatory muscles on the nondisplaced side in patients with mandibular lateral displacement may play a role in postural control.

Reyes et. al. (2006)⁶⁰ - Compared normal occlusion in 5- to 16-year-old caucasians with untreated class III Caucasians of the same age. The dentoalveolar differences between class I and class III subjects were sporadic and the main dentoalveolar finding was a larger extrusion of class III maxillary molars at ages 11–15 years. More maxillary molar eruption fits the flat POPs (posterior occlusal plane) of skeletal class III group but not the steep POPs of Angle class III group. Different outcomes between Angles classification and skeletal pattern indicate a certain independence of the molar relationship from the facial skeleton.

Posnick et al. (2006)⁷⁰ - Facial esthetics can be achieved by changes in OP (Occlusal plane) by counter clockwise or clockwise rotation of the MMC but emphasized that it is not a central point to quantify angular measurements of OP in

the pre or post operatives, being more valid esthetic optimization by simply obtaining the most harmonic relations between skeletal structures and disposition of soft facial tissues.

Ben-Bassat et al. (2006)⁸⁵ - It was expected that the asymmetric morphologic occlusal features such as Class II subdivision, crossbites, and midline deviation would be more prevalent in the study group. These features have been observed, for example, in patients developing dental asymmetries due to idiopathic scoliosis.

Fushima (1989)⁴¹ and **Akimoto S. (2007)**⁴² - Occlusal deviations are related to facial growth in patients with mandibular asymmetry with transverse inclination of the occlusal plane and different muscle activity on both sides because of disparities between the left and right occlusal vertical dimensions.

Tanaka and Sato (2008)⁴⁹ - It is likely that the inclination of the maxillary posterior occlusal plane (OP) during growth and development is a factor corroborating with the continuous adaptive capacity of the mandible.

Hashimoto T, Fukunaga T. et. al. (2009)⁷³ - Occlusal plane inclination has always represented a challenge for orthodontists. The common options for treatment included asymmetric mechanics with high pull headgears, asymmetric bite blocks or even orthognathic surgery in some cases. In such cases, conventional mechanics require a long time to be performed, and adverse effects are often present, thus compromising and limiting treatment results. Furthermore, patients frequently refuse orthognathic surgery and, as such, all treatment options for a canted occlusal plane have limitations. The introduction of skeletal anchorage has increased the number of

treatment options for these cases. Mini-implants or miniplates may aid intrusion of a group of teeth, either in the maxillary or mandibular arches, without adverse effects while greatly reducing total treatment time. For large asymmetries, it is preferable to use miniplates, owing to the greater stability and success rate obtained with this device in comparison with mini-implants.

Ishizaki K, (2010)⁵⁵ - During dentoskeletal growth, reduced vertical height of dentition unilaterally affects the mandibular position, subsequently leading to a lateral condylar shift during functional movement, such as opening and closing. Occlusal deviations are related to transverse inclination of the OP, and contralateral differences in occlusal vertical dimension can reduce muscular balance eventually, resulting in a mandibular asymmetry.

Batwa et al. (2011)⁵³ - The upper smile arc is the relationship of the curvature of the maxillary incisal and canine edges to the curvature of the lower lip during the social smile, which is influenced by the OP angle. By producing a computerized prediction of the appearance of the smile at differing OP angles, concluded that changing the OP angle does affect relative smile attractiveness.

Zimmer et al. (2012)⁵⁸ - Observed several significant changes in the occlusal plane inclination due to oppositely guided intermaxillary elastics, the induced shift with class II elastics was clockwise, while class III elastics was counterclockwise.

Waeil Batwa (2012)⁶⁸ - According to dentists and patients, changing the occlusal plane angle does affect smile attractiveness. Patients tended to rate the 10 degree smile better than 0 and 20 degree smiles, and dentists tended to rate the

15 degree smile better than 0 and 20 degree smiles. This suggests that patients and dentists did not tolerate extreme deviations in the occlusal plane angle. Patients showed higher tolerance to occlusal plane changes (accepting 5, 10, and 15 degree smiles) than did dentists (accepting 10 and 15 degree smiles). Study suggested that large changes in the occlusal plane angle would affect relative smile.

Jin-le Li. (2014)⁵⁴ - It was found that the BOP (bisected occlusal plane) was a more reproducible reference plane compared with FOP (functional occlusal plane) during cephalometric tracing process, while FOP showed stability in orthodontically treated patients with all three skeletal patterns.

Kim J. Y. et al. (2014)⁶⁹ - Used to assess facial asymmetry in diagnosis for orthognathic surgeries, and suggested that mandibular and occlusal plane deviations greater than 2 mm were considered as asymmetries.

E. A. Al-Moraissi (2016)⁷¹ - A systematic review and meta-analysis of postsurgical skeletal stability between counter clockwise and clockwise rotation of the MMC for correction of DFD (Dentofacial deformities) concluded that from screening and eligibility, three available studies were reviewed and showed that counter clockwise and clockwise rotations of the MMC (maxillomandibular complex) were stable outcomes immediately after surgery and at longest follow-up, with no statistically significant difference between treatment planning, mainly, when there is no pre-existing temporomandibular joint pathology. Both Class III patients had similar skeletal stability because the postoperative outcomes have remained stable regarding facial esthetic and occlusal functionality in a follow-up over 2 years.

Perhaps, they had treated by different planning based on alteration of OP (occlusal plane) from bimaxillary orthognathic surgery.

Marcel Marchiori Farret et. al. (2016)⁷⁶ - Traditionally, the treatment options for asymmetries in the occlusal plane have been considered to be major challenges for orthodontists. Despite the complexity of procedures, surgical approaches have always been considered to be a good option, as they have a reduced treatment time and avoid some adverse effects of conventional orthodontic mechanics. However, the majority of patients refuse orthognathic surgery and treatment must therefore focus on orthodontic camouflage. One option is to use a unilateral bite block, which is another alternative for treatment and may provoke a minor intrusion on the side where it is located and a more significant extrusion on the other side. The limitation of this treatment modality is that it is not possible to attain moderate to high intrusion movements with these devices, in addition to the possibility of developing temporomandibular disorders after long periods of use. So the literature herein demonstrated that miniplates are a reliable device for the correction of occlusal plane inclination, eliminating the need for orthognathic surgery in some cases and reducing the complexity of orthodontic mechanics.

Thomas R. Pitts (2017)⁹² - Research has shown that actual clinical torsional play in self-ligating brackets can be as much as two and a half times more than predicted by mathematical models⁹³, making reliable expression of 3rd-order movements problematic. With SAP (Positioning the upper brackets to protect or enhance the smile arc has come to be called SAP bracket positioning) bracket positioning, the effective prescription of the bracket is reduced relative to the occlusal

plane, so that torsional moments for uprighting proclined teeth are engaged early in wire progressions. It is important to recognize that the maxillary occlusal plane, as viewed in NHP, is a significant contributor to the esthetics of the smile. Obviously, the flatter the plane, the more difficult it is to manage the case esthetically. Rotating the maxillary occlusal plane clockwise will produce more incisor display and a more convex smile arc. Counterclockwise rotation, which can occur when the upper anterior brackets are placed incisally to the recommended SAP positions, can result in esthetic decline.

In combination with the appropriate use of bite turbos and immediate light, short elastics, SAP bracket positioning helps control the cant of the maxillary occlusal plane from the outset of treatment, offering a wider range of treatment options. Individual bracket positions should be based mainly on the length of the canines and incisors, as well as the patient's esthetic needs. If the occlusal plane is flat, the gingival bracket divergence should be increased even farther from traditional positioning to enhance enamel and gingival incisor display. In a deep-bite case, the SAP bracket divergence in the upper arch is counteracted by increased overleveling of the lower arch to achieve an optimal overbite. Because it is crucial not to deepen the bite while enhancing the smile arc with individual bracket positioning,⁹⁴ anterior bite turbos should be used to allow eruption of the lower molars.

Daniel Amaral Alves Marlière (2018)⁷² - Finally, Class III patients had undergone same surgical treatment for correction of DFD (Dentofacial deformities), but different clinical features and inclination of OP (occlusal plane) helped to define treatment planning by clockwise rotation or counterclockwise rotation of the MMC.

The clockwise and counter clockwise rotations of the MMC (maxillomandibular complex), also known as alteration of OP, should be considered to achieve soft tissue harmony among the subnasal, upper lip and lower lip support, and chin, because it influenced underlying facial skeleton integrated with the dental structures. Harmonic outcomes between facial esthetics and occlusion are possible to achieve combining surgeon's clinical perception and qualitative evaluation of OP inclination, mainly, patients without facial asymmetry, because bidimensional images can represent the inclination bilaterally.

Pio Modi (2018)⁸⁷ - When evaluating a canted smile, a key point is to determine the level of cant and whether that cant is aesthetically acceptable. Kokich et. al.⁸⁸ found that laypersons were not able to detect an asymmetric cant until it reached a 4-degree inclination. In a study focusing exclusively on the perceptions of canting of the occlusal plane, a similar finding occurred where orthodontists, general dentists and laypersons were sensitive to a 4-degree occlusal canting. Once an occlusal cant has been identified as an aesthetic concern for both the patient and clinician, a choice must then be made for the primary treatment modality used to correct it. The treatment modality chosen will be based on the cause of the etiology of the cant, including tooth wear, alterations to tooth eruption and skeletal developmental problems. Treatment options to correct the cant include orthodontics with or without orthognathic surgery, restorative dentistry and periodontal crown lengthening surgery. Often a combination will be needed based on what the other aesthetic, functional and dental goals are for the patient. Choosing which treatment options to correct a cant is/are predicated on a systematic breakdown and evaluation

of the four main areas of examination (Aesthetic, Functional, Structure and Biologic Health).

Pio Modi (2018)⁸⁷ - As much as we may want to go straight to the veneer preps and insertions for our cosmetic cases, by not doing a thorough treatment plan to address both the aesthetic demands and also what is needed to achieve long-term stability, imminent failure may occur. As Dr. Peter Dawson⁸⁹ has stated in his lectures and textbooks: “90% of cases that fail, fail not during the restorative phase but in the treatment planning phase. Failing to plan is planning to fail.” Working with an exceptional lab technician and group who understand the aesthetic and functional goals of the case while also being able to manage and deliver the micro-aesthetic demands of the patient is crucial to delivering a favourable cosmetic result. And by going through a systematic 4-stage evaluation for finishing a case including a) Functional-Esthetic Evaluation using 2-D and 3-D workups b) Diagnostic Wax-up c) Provisional Prototype Restorations to work out the functional matrix and overall occlusion and then finally d) Definitive Restorations, this will ensure both long term predictability and an overall esthetic success for both the patient and practitioner.⁹⁰

Eric Jein-Wein Liou (2019)⁹¹ - The left side up anterior occlusal cant improved 7.0° in this report. This was due to both the auxiliary intrusive arms and Yin-Yang archwire. The auxiliary intrusive lever arms firstly contributed for 40% (2.8/7.0) of the improvement in 6.5 months of enmasse anterior retraction, and the Yin-Yang archwire secondarily contributed for 60% (4.2/7.0) of the improvement in 6 months. In comparison to the auxiliary intrusive lever arms, the Yin-Yang archwire was more effective for the improvement of anterior occlusal cant. The most

controversial point of this report is the lip cant which was improved both after the improvement of the bimaxillary dentoalveolar protrusion and occlusal cant, and furthermore the soft tissue chin deviation improved after the improvement of occlusal cant by the Yin-Yang archwire, although the skeletal mandibular asymmetry remained the same after treatment. This is contradicted to the conventional orthodontic concept that the soft tissue asymmetry could not be improved without correction of the underlying skeletal asymmetry through orthognathic surgery. The improvement of soft tissue chin deviation without surgical improvement of the underlining mandibular asymmetry has never been reported before, and it is not possible to answer the reasons merely from this report. Although the improvement of soft tissue chin deviation of this report was after the application of Yin-Yang archwire, the role of improvement of bimaxillary dentoalveolar protrusion and changes of circumoral musculature on the improvement of soft tissue chin deviation could not be ignored. The improvement of soft tissue chin deviation through orthodontic management without surgical intervention in this report might have opened a completely new window toward a different side in orthodontics that has not been explored before.

Markkanen et al. (2019)⁹⁵ - When the occlusal characteristics, upper dental arch dimensions, and soft tissue profile measurements were tested separately between palatine tonsil size, adenoid size, and breathing habit, the only statistically significant finding ($P = 0.047$) was that inter canine width was slightly narrower among mouth breathing children than nose breathing children, 27.0 (25.5–27.2) and 27.7 (27.1-29.5), median and interquartile range 0.25–0.75, respectively. Pacifier usage did not differ significantly between the groups. 55.6% ($n = 5$) of children with OSAS

(obstructive sleep apnoea syndrome) and 72.2% (n = 13) of nonsnoring children used or had used pacifier. It was detected that minor changes in dental arch morphology can already be found in 2.5-year-old children with OSAS. Larger adenoid size and mouth breathing tendency were also more common among children with OSAS than PSG (polysomnography)-verified non-snoring children. The most interesting finding in our material was the narrower upper inter canine width among children with OSAS.

Kazuto Kurohara et al. (2019)⁹⁶ - The current study also examined the probable influence of occlusal cant correction on the stability in both groups. Statistically significant difference between LO (original Le Fort I osteotomy) and SO (step osteotomy) was observed only in the group without occlusal cant correction (Group AC and Group BC). In the group without occlusal cant correction, the difference (1.01 mm) in vB was statistically significant during the entire duration of follow-up. Without occlusal cant correction, the variation in the measurement of vB is small because the direction of the relapse is simple, and the difference between LO and SO may be reflected to cause a significant difference in the amount of post-operative change in vB.

Materials and Method

Lateral cephalogram and study models of Class I, Class II division 1 and Class II division 2 untreated samples were utilized for the study.

| | CLASS I | CLASS II DIVISION 1 | CLASS II DIVISION 2 |
|---------------|--------------------|--------------------------------|--------------------------------|
| SAMPLE | 30 | 30 | 30 |
| AGE | 18-30 years of age | 18-30 years of age | 18-30 years of age |
| SEX | Male/Female | Male/Female | Male/Female |

INCLUSION CRITERIA:

- Patients aged 18-30 years.
- Skeletal and Angles class I, class II division 1 and class II division 2 malocclusion.
- Full complement of teeth with no history of extraction.
- Well aligned arches with mild to moderate crowding.
- No craniofacial anomalies, systemic, neuromuscular and TMJ disorders.

EXCLUSION CRITERIA:

- History of previous orthodontic treatment, orthognathic and maxillofacial surgeries.
- History of trauma.
- History of endodontic restorations with high points.
- History of severe attrition.
- Patients with facial asymmetry.

MATERIALS OR ARMAMENTARIUM

1. Digital panoramic and cephalometric system(KODAK 8000 C)
2. Digital printer (FUJI FILM DRY PIX SMART)
3. Radiograph – lateral cephaogram
4. Dental casts of 90 subjects
5. Matte acetate tracing paper
6. Radiograph viewer
7. Lead pencil
8. Geometric box

METHOD

Radiographs

For the craniofacial dimensions, the profile radiographs were taken with the teeth in occlusion and in the standardized natural head posture, the mirror position, as described by Siersbaek-Nielsen and Solow. To obtain a standardized orientation of the head, referred to as the natural head position is possible by focusing at a distant point.

The concept of natural head position was originally defined by Broca as being the position of the head when an individual stands with the visual axis in the horizontal plane and was introduced in orthodontics in the 1950's. The visual axis can be aligned with the horizontal plane by asking a relaxed subject to look at a distant reference point or by asking an individual to take a step forward. While taking a step forward an individual usually will attain a natural head position also known as orthoposition.

In the present study all the lateral cephalogram were taken in natural head position using the mirror position in which a long mirror was used to accommodate the different inclinations of the head in individuals while taking the radiographs. The radiographs were taken in a cephalostat with a film-to-focus distance of 180 cm and a film to- median plane distance of 10 cm. No correction was made for the constant linear enlargement of 5.6%. All the cephalometric reference points and measurements were done manually and double checked by another observer.

Cephalometric measurements

Cephalometric measurements on the occlusal planes, as well as the skeletal and dental patterns were obtained using the following criteria:

Occlusal planes

1. Anterior occlusal plane

A line drawn from the incisal edge of the upper central incisor to the cusp tip of the upper second premolar.

2. Posterior occlusal plane

A line drawn from the cusp tip of the upper second premolar to the midpoint of the upper second molar at the occlusal surface.

The Frankfort horizontal (FH) plane was determined utilizing anatomical porion and orbitale as reference points (Ricketts, 1960).

A-OP - The anterior angle between the anterior occlusal plane and the FH plane. When the A-OP anterior occlusal plane slopes upward and forward in relation to the FH plane, the angle is read as minus. (Fig. G)

P-OP - The anterior angle between the posterior occlusal plane and the FH plane.

(Fig. G)

OP-diff. - The angular difference between A-OP and P-OP.

MEASUREMENTS

Skeletal Pattern: Angular measurements (Fig. H)

1. Mandibular plane angle (MP) - The angle between the mandibular plane and the FH plane (Downs, 1948).
2. Facial axis (FX) - The angle between the facial axis and the basion-nasion line (Ricketts, 1960).
3. Gonial angle (GO-A) - The angle between the posterior border line of the ramus and the mandibular plane.
4. Palatal plane angle (PP) - The angle between the palatal plane and the FH plane. A positive value is given when the plane inclines downward and forward in relation to the FH plane (Kim, 1974).
5. Ramus inclination (RAM-I) - The angle between the posterior border line of the ramus and the FH plane.

Skeletal Pattern: Linear Measurements (Fig. I)

1. Na perpendicular to A (A) - The distance from point A to the line drawn from nasion perpendicular to the FH plane (McNamara, 1983).
2. Na vertical to Pog (POG) - The distance from pogonion to the line drawn from nasion perpendicular to the FH plane (McNamara, 1983). AP difference (AP-diff.): the distance of item 1 subtracted from the distance of item 2.
3. Ramus height (RAM-H) - The distance from the cross-point of the FH plane and the posterior border line of the ramus to the cross-point of the posterior border line of the ramus and the mandibular plane.

4. Mandibular length (MAND-L) - The distance from the cross point of the FH plane and the posterior border line of the ramus to gnathion.
5. Maxillary length (MAX-L) - The distance from the posterior nasal spine to a point which is drawn perpendicularly up from point A to the palatal plane.

Dental Pattern: Angular measurements (Fig. J)

1. U1 to FH - The posterior-inferior angle formed by the long axis of the upper central incisor and the FH plane.
2. LI to MP - The angle formed by the long axis of the lower central incisor and the mandibular plane (Downs, 1948).
3. FMIA - The angle formed by the long axis of the lower central incisor and the FH plane (Tweed, 1966).
4. U6 to FH - The anterior-inferior angle formed by the long axis of the upper first molar and the FH plane.
5. U7 to FH - The anterior-inferior angle formed by the long axis of the upper second molar and the FH plane.

Dental Pattern: Linear measurements (Fig. K)

1. U1-PP - The perpendicular distance from the upper central incisal edge to the palatal plane.
2. U5-PP - The perpendicular distance from the cusp of the upper second premolar to the palatal plane.
3. U7-PP - The perpendicular distance from the midpoint between the mesial and distal buccal cusps of the upper second molar to the palatal plane.

4. L1-MP - The perpendicular distance from the lower central incisal edge to the mandibular plane.
5. L5-MP - The perpendicular distance from the cusp of the lower second premolar to the mandibular plane.
6. L7-MP - The perpendicular distance from the midpoint between the mesial and distal buccal cusps of the lower second molar to the mandibular plane.
7. U6-PTV - The distance from the distal crown surface of the upper first molar to the PT vertical line (Ricketts, 1960).

COLOUR PLATE I



Fig. A : Digital Lateral Cephaogram Machine



Fig. B: Digital Printer (Fujifilm Dry Pix Smart)

COLOUR PLATE II



Fig. C: Matte acetate tracing paper, Geometric box



Fig. D: Lateral cephalogram

COLOUR PLATE III



Fig. E: Study model

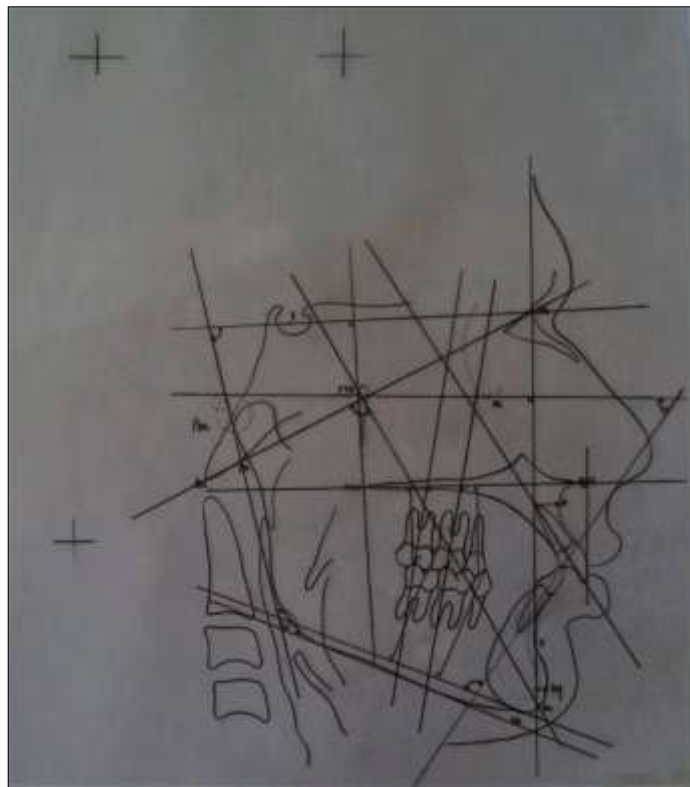


Fig. F : Tracing

COLOUR PLATE IV

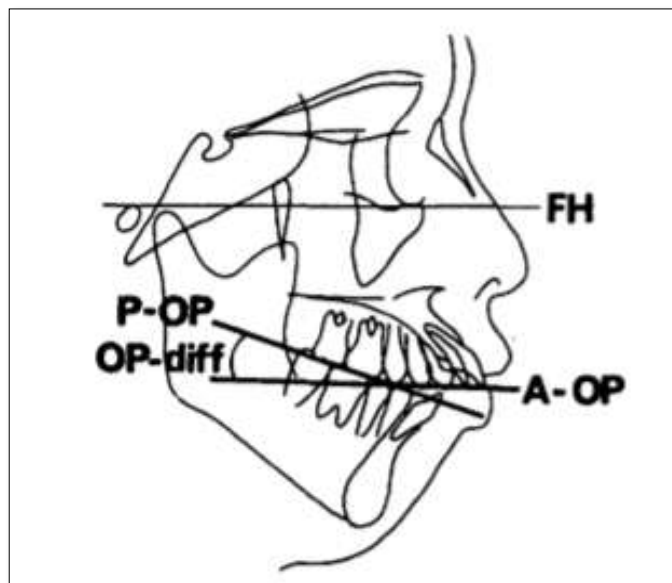


Fig. G : Anterior and posterior occlusal planes

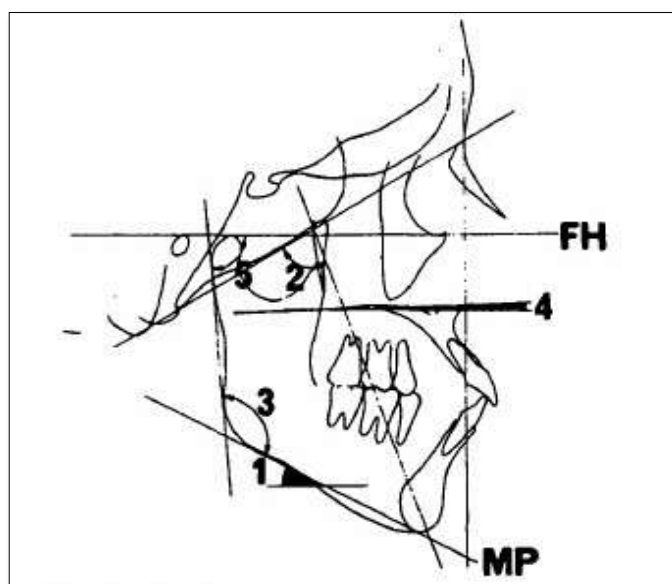


Fig. H : Skeletal Pattern: Angular measurements

COLOUR PLATE V

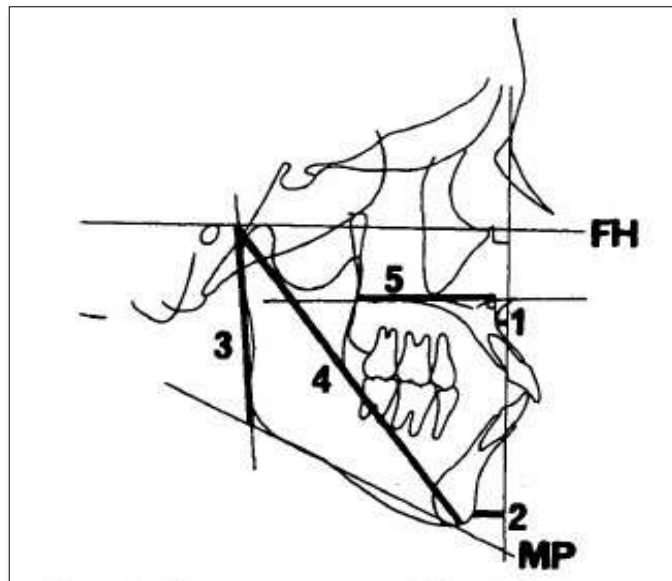


Fig. I : Skeletal Pattern: Linear measurements

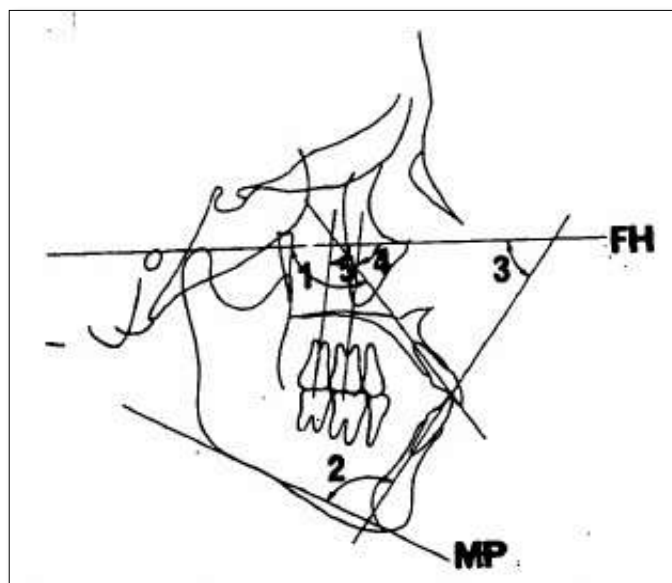


Fig. J : Dental Pattern: Angular measurements

COLOUR PLATE VI

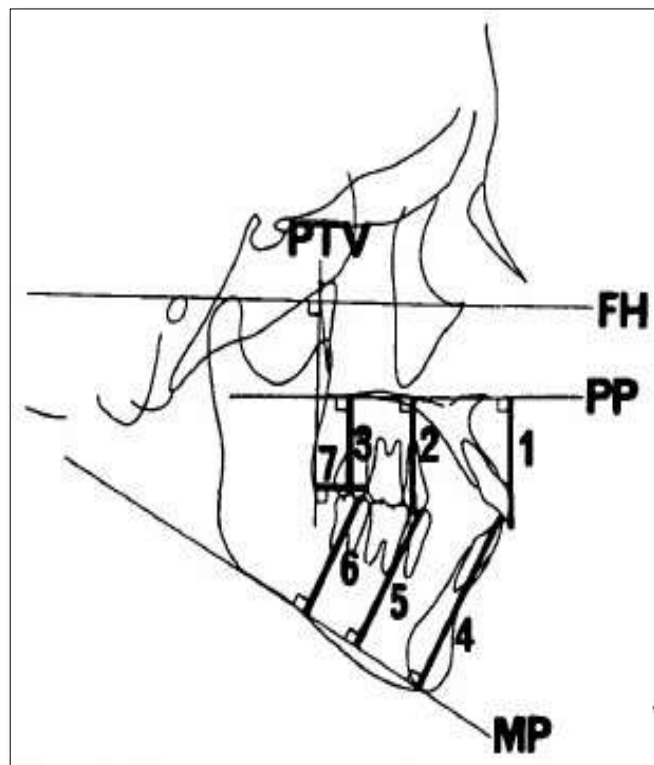


Fig. K: Dental Pattern: Linear measurements

Results

The mean values of skeletal and dental patterns were calculated along with their standard deviations using descriptive statistics amongst the following three malocclusion groups. (tab 1 & tab 2)

Group 1: Class I

Group 2: Class II division 1

Group 3: Class II division 2

The statistical analysis was done using the Statistical Package for the Social Science (SPSS version 22, Armonk, NY: IBM Corp). The recorded values were statistically evaluated using the one-way analysis of variance test (ANOVA),

followed by Tukey post hoc test for multiple comparisons (tab 3 & tab 4). The one-way analysis of variance (ANOVA) was used to determine whether there are any significant differences between the means of two or more independent (unrelated) groups. The relationship between the occlusal planes, skeletal and dental patterns was determined using Pearson's correlation (tab 5-10). The "p" values were considered significant at or below 0.05.

Skeletal patterns

Angular measurements:

- **Mandibular plane angle (MPA):** The mean MPA was almost equivalent in Class I, 26.4 ± 5.5 and Class II division 1 group, 26.3 ± 5.8 . It was slightly less for Class II division 2, 25.2 ± 5.0 and this difference was not statistically significant ($p=0.65$).
- **Facial axis:** The mean values for facial axis were greater in Class I group, 90.3 ± 1.2 , followed by Class II division 1, 88.8 ± 3.2 and were least for Class II division 2, 87.7 ± 6.2 . This difference was statistically ($p = 0.05$) significant amongst all the three groups as shown by ANOVA. Upon subject to multiple comparisons by post hoc analysis, it was observed that a statistically significant difference existed only between Class I and Class II division 2 ($p = 0.04$), whereas no significant difference existed between class I and Class II division 1 ($p = 0.32$) and between Class II division 1 and division 2 ($p = 0.57$).
- **Gonial angle:** The mean Gonial angle was almost equivalent in Class I and Class II division 1, i.e. 124.0 ± 6.5 and 124.2 ± 6.1 respectively. It was less in

Class II division 2, 120.7 ± 7.6 . This difference was not statistically significant ($p = 0.08$)

- **Palatal plane angle (PPA):** The PPA values were not statistically significant ($p = 0.82$) amongst the three groups. It was almost equivalent in all the three groups, 2.2 ± 3.8 for Class I, 2.7 ± 3.0 for Class II division 1 and 2.4 ± 3.1 for Class II division 2.
- **Ramal inclination:** The ramal inclination was significantly ($p=0.001$) larger in Class II division 2, 87.6 ± 1.4 , followed by Class II division 1, 82.8 ± 2.8 . It was less in Class I, 79.2 ± 1.5 . Upon subject to multiple comparisons by Post hoc analysis, it was revealed that statistically significant difference ($p = 0.001$) existed between all the three groups.

Linear measurements:

- **Na perpendicular to A (Na-A):** The mean values of Na-A were not significant ($p = 0.11$) amongst the three groups. The mean values were nearly equivalent in Class I, -2.1 ± 3.0 , and Class II division 1, -2.3 ± 3.6 . The values were relatively less for Class II division 2 group, -3.8 ± 3.4 .
- **Na vertical to Pog (Na-Pog):** The mean values for nasion perpendicular to pogonion were significantly ($p = 0.001$) smaller in Class II division 2, -13.8 ± 6.7 followed by Class II division 1, -10.0 ± 1.0 . This value was larger in Class I group, -6.7 ± 6.0 .
- **Ramus height:** For the size of mandible, ramal height was greater in Class I group, 57.3 ± 0.9 , followed by Class II division 1, 52.1 ± 1.1 . It was smaller for Class II division 2, 50.5 ± 1.0 and this difference was statistically

significant ($p = 0.001$) as shown by ANOVA. Upon subject to multiple comparisons by Post hoc analysis, it was revealed that statistically significant difference ($p = 0.001$) existed between all the three groups.

- **Mandibular length:** The mandibular length was significantly ($p = 0.001$) larger in Class I group, 107.4 ± 6.7 , followed by Class II division 1, 82.2 ± 18.7 . The values were smaller in Class II division 2 group, 76.3 ± 14.1 . The difference amongst the three groups was statistically significant ($p = 0.001$) as shown by ANOVA. Upon subject to multiple comparisons by post hoc analysis, it was observed that statistically significant ($p = 0.001$) difference existed only between Class I and Class II division 1 and between Class I and Class II division 2, whereas no significant difference existed between Class II division 1 and division 2 ($p = 0.23$).
- **Maxillary length:** There was no statistically significant ($p = 0.38$) difference for maxillary length amongst all the three groups. The values were greater in Class II division 2 group, 46.0 ± 4.9 , followed by Class II division 1 group, 45.6 ± 2.7 and smaller in Class I group, 44.9 ± 3.6 .

Dental patterns

Angular measurements:

- **Anterior occlusal plane (A-OP):** There was a statistically significant ($p = 0.001$) difference amongst all the three groups with respect to anterior occlusal plane as shown by ANOVA. The mean values of anterior occlusal plane were greater for Class I group, 12.1 ± 0.8 , followed by Class II division 1, 9.5 ± 0.8 and less for Class II division 2, 7.1 ± 0.8 . Upon subject to multiple

comparisons by Post hoc analysis, it was revealed that statistically significant difference ($p = 0.001$) existed between all the three groups.

- **Posterior occlusal plane (P-OP):** The posterior occlusal plane value was significantly ($p = 0.001$) larger for Class II division 2, 20.5 ± 4.3 followed by Class II division 1, 16.5 ± 1.6 . It was less steep for Class I group, 14.1 ± 5.0 . Post hoc analysis revealed statistically significant difference ($p = 0.001$) between all the three groups (multiple comparisons).
- **U1-FH:** The U1-FH angle was significantly ($p = 0.001$) greater in Class II division 1, 120.6 ± 1.3 followed by Class I occlusion, 116.1 ± 1.4 whereas it was smaller in Class II division 2 group, 89.4 ± 9.5 . Post hoc analysis revealed statistically significant difference ($p = 0.001$) between Class I and Class II division 2 and Class II division 1 and Class II division 2. The significant difference between Class I and Class II division 1 was $p = 0.04$.
- **L1-MP:** The labial inclination of lower central incisor measured by L1-MP was significantly ($p = 0.001$) greater in Class II division 1, 102.1 ± 8.4 followed by Class II division 2 occlusion, 96.1 ± 4.6 . This angle was less in Class I occlusion, 93.8 ± 1.6 . Upon subject to post-hoc analysis, it was seen that a statistically significant difference existed between Class I and Class II division 1 ($p = 0.001$) and Class II division 1 and Class II division 2 ($p = 0.001$) whereas no significant difference was observed between Class I and Class II division 2 ($p = 0.27$).
- **FMIA:** The labial inclination of lower central incisors measured by FMIA was significantly ($p = 0.001$) greater in Class II division 1, 63.4 ± 1.3 followed

by Class II division 2, 56.1 ± 0.8 , whereas it was less in Class I occlusion, 53.9 ± 7.1 . The post hoc analysis revealed that there was no statistically significant difference ($p=0.13$) between Class I and Class II division 1, whereas statistically significant difference ($p = 0.001$) existed between Class I and Class II division 2; and Class II division 1 and Class II division 2.

- **U6-FH:** The anterior-inferior angle formed by the long axis of upper first molar and FH plane was significantly ($p = 0.001$) greater in Class II division 2 group, 90.5 ± 12.1 followed by Class II division 1 group, 88.1 ± 5.1 , while it was less in Class I group, 80.5 ± 2.1 . The post hoc analysis revealed that statistically significant difference ($p = 0.001$) existed between Class I and Class II division 1; and Class I and Class II division 2, whereas the significant difference observed between Class II division 1 and Class II division 2 was $p = 0.05$.
- **U7-FH:** The U7-FH angle was significantly ($p=0.001$) larger in Class II division 2 group, 87.9 ± 14.5 , followed by Class II division 1, 72.0 ± 5.6 , while it was least in Class I, 68.7 ± 0.9 . Upon subject to multiple comparisons by post hoc analysis, it was observed that a statistically significant difference ($p = 0.001$) existed between Class I and Class II division 1; and Class I and Class II division 2, whereas no significant difference ($p = 0.33$) was observed between Class II division 1 and Class II division 2.

Linear measurements:

- **U1-PP:** The U1-PP values were nearly equivalent in all the three groups. The mean values in Class I were 28.4 ± 10.1 , followed by Class II division 2,

27.1 \pm 2.1 and 25.2 \pm 2.4 in Class II division 1 group. These differences were not statistically significant ($p = 0.14$).

- **U5-PP:** The U5-PP values were nearly equivalent in all the three groups. The mean values in Class I were 23.8 \pm 2.2, followed by Class II division 1, 22.8 \pm 3.4 and Class II division 2, 22.3 \pm 2.3. These differences were not statistically significant ($p = 0.12$)
- **U7-PP:** There was a statistically significant ($p = 0.001$) difference amongst the three groups with respect to U7-PP. The mean values of U7-PP were greater in Class I group, 22.1 \pm 1.2 followed by Class II division 1, 18.9 \pm 2.4 and Class II division 2, 14.1 \pm 1.3. Upon subject to multiple comparisons by Post hoc analysis, it was revealed that statistically significant difference ($p = 0.001$) existed between all the three groups.
- **L1-MP:** There was a statistically significant ($p = 0.02$) difference amongst all the three occlusion groups with respect to L1-MP. The mean values of L1-PP were larger in Class I group, 40.0 \pm 3.3 followed by Class II division 1, 38.5 \pm 2.4 and Class II division 2, 37.6 \pm 4.3. The post hoc analysis revealed that there was statistically significant ($p = 0.02$) difference only between Class I and Class II division 2. There was no significant difference observed between Class I and Class II division 1 ($p = 0.19$) and between Class II division 1 and division 2 ($p = 0.62$).
- **L5-MP:** The mean values of L5-MP were significantly ($p = 0.001$) greater in Class I occlusion group, 31.5 \pm 2.5 followed by Class II division 2, 29.6 \pm 3.6 while it was less in Class II division 2 group, 28.1 \pm 2.1. The post hoc analysis

revealed that a statistically significant difference existed between Class I and Class II division 1 ($p = 0.001$) and between Class I and Class II division 2 ($p = 0.03$), whereas no significant difference was noted between Class II division 1 and division 2 ($p = 0.09$).

- **L7-MP:** There was a statistically significant ($p = 0.02$) difference amongst the three occlusion groups with respect to L7-MP. The mean values of L7-MP were relatively greater in Class I group, 26.3 ± 2.7 as compared to Class II division 2, 25.5 ± 3.4 and were least in Class II division 1 group, 24.3 ± 1.9 . Upon subject to multiple comparisons by post hoc analysis, it was observed that statistically significant difference existed only between Class I and Class II division 1 ($p = 0.01$), whereas no significant difference was observed between Class I and Class II division 2 ($p = 0.47$) and between Class II division 1 and division 2 ($p = 0.22$).
- **U6-PTV:** There was a statistically significant ($p = 0.001$) difference amongst all the three occlusion groups with respect to U6-PTV. The mean values were greater in Class II division 2 group, 13.5 ± 5.7 followed by Class II division 1, 12.8 ± 6.4 while they were least in Class I occlusion group, 7.7 ± 3.8 . The post hoc analysis revealed a statistically significant ($p = 0.001$) difference between Class I and Class II division 1 and between Class I and Class II division 2, whereas no significant difference was observed between Class II division 1 and division 2 ($p = 0.87$).

Relationship between Dental and skeletal patterns in Class I, Class II division 1 and Class II division 2 malocclusion groups:**Class I group:**

On evaluating the relationship between skeletal and dental patterns in class I occlusion group, it was observed that L1-MP was significantly related to ramal height (0.43), U5-PP was significantly related to mandibular plane angle (0.42). There was a significant correlation between U7-PP and facial axis (0.41). There was a moderate correlation between L1-MP (linear) and Mandibular length (0.52) whereas the correlation between L1-MP (linear) and Maxillary length was weak (0.38) although significant. L5-MP showed weak although significant correlation with Mandibular length (0.42) and Maxillary length (0.36). U6-PTV showed moderate correlation with Na-Pog (0.52) and weak correlation with mandibular plane angle (0.38) although both were significant.

Class II division 1 group:

On evaluating the relationship between skeletal and dental patterns in class II division 1 group, it was observed that the anterior occlusal plane was significantly correlated to mandibular plane angle (0.39), palatal plane angle (0.38), Na-Pog (0.38), facial axis (0.41) and mandibular length (0.39). The posterior occlusal plane had a significant although weak correlation with mandibular plane angle (-0.38), facial axis (0.39), gonial angle (-0.37), ramal inclination (-0.36), Na-Pog (-0.37), mandibular length (0.46) and maxillary length (-0.42). The U1-FH values had significant weak correlation with mandibular plane angle (-0.39) and facial axis (-0.40), and significant moderate correlation with Na-Pog (0.54). The L1-MP values had significant although weak correlation with mandibular plane angle (-0.37), gonial angle (-0.42) and

maxillary length (0.43), and moderate correlation with Na-A (0.51). FMIA had significant moderate correlation with Na-Pog (0.57). U6-FH had significant weak correlation with mandibular plane angle (-0.45), Na-Pog (-0.44) and mandibular length (-0.38). U7-FH had significant weak correlation with mandibular plane angle (-0.38), Na-Pog (-0.39) and mandibular length (0.38).

The U1-PP values had significant weak correlation with mandibular plane angle (0.37) and Na-A (-0.39) and moderate correlation with facial axis (0.64). the U7-PP values had weak significant correlation with maxillary length (0.37). L1-MP had significant weak correlation with mandibular plane angle (0.45), facial axis (0.49), gonial angle (0.40) and Na-Pog (-0.44). L5-MP had moderate correlation with mandibular plane angle (0.51) and Na-Pog (-0.55) whereas it had weak correlation with facial axis (0.47) and gonial angle (0.48). U6-PTV had significant moderate correlation with Na-Pog (0.50) and mandibular length (-0.50) whereas it had weak correlation with palatal plane angle (0.39) and maxillary length (0.47).

Class II division 2 group:

The correlation between dental and skeletal patterns in Class II division 2 group revealed that a significant moderate correlation existed between the anterior occlusal plane and Na-Pog (0.56), mandibular length (0.50) whereas a significant weak correlation was observed between anterior occlusal plane and mandibular plane angle (-0.41), facial axis (-0.45), palatal plane angle (0.41) and ramal inclination (0.46). The posterior occlusal plane had significant moderate correlation with ramal height (-0.63) and Na-Pog (-0.55) followed by significant weak correlation with mandibular plane angle (0.39), facial axis (0.39), ramal inclination (-0.38),

mandibular length (-0.45) and maxillary length (-0.42). The U1-FH values had a significant moderate correlation with Na-Pog (-0.65) and significant weak correlation with mandibular plane angle (0.40), facial axis (0.42) and ramal height (-0.46). L1-MP had significant strong correlation with gonial angle (-0.72) followed by moderate correlation with mandibular plane angle (-0.60), mandibular length (0.60) whereas it had weak correlation with Na-A (0.43), Na-Pog (0.43). FMIA was shown to have significant although weak correlation with mandibular plane angle (-0.37), facial axis (-0.40), gonial angle (-0.40), ramal inclination (0.47) and ramal height (0.45). U6-FH had significant weak correlation with mandibular plane angle (0.45), facial axis (-0.38), ramal height (0.39) and mandibular length (-0.38). U1-PP had significant weak correlation with mandibular plane angle (0.41), facial axis (0.46), ramal inclination (0.37) and Na-A (-0.37). U5-PP was shown to have significant weak correlation with facial axis (0.41) and maxillary length (0.46). L1-MP (linear) had significant weak correlation with facial axis (0.46), Na-Pog (-0.46) and maxillary length (0.37). Likewise, L5-MP bore significant weak correlation with facial axis (0.38) and Na-Pog (0.40). L7-MP had significant weak correlation with facial axis (0.40) and maxillary length (0.48). U6-PTV had significant weak correlation with mandibular length (-0.37) and maxillary length (0.39).

Relationship between occlusal planes and dental patterns in Class I, Class II division 1 and Class II division 2 malocclusion groups:**Class I group:**

In evaluating correlation between occlusal planes and dental patterns in Class I occlusion group, the anterior occlusal plane (A-OP) showed significant weak correlation with U5-PP (-0.38).

Class II division 1 group:

In evaluating correlation between occlusal planes and dental patterns in Class II division 1 occlusion group, A-OP showed significant weak correlation with U1-FH (-0.41), FMIA (-0.39), U6-FH (0.40), U1-PP (0.38) and U6-PTV (0.39). The posterior occlusal plane (P-OP) showed significant moderate correlation with U6-PTV (-0.50) and weak correlation with FMIA (-0.38), U6-FH (-0.41), U7-FH (0.46) and U7-PP (-0.43). The OP-difference had significant weak correlation with L1-MP (0.38), U7-FH (0.39) and U7-PP (0.39).

Class II division 2 group:

In evaluating correlation between occlusal planes and dental patterns, it was observed that A-OP had significant moderate correlation with U6-FH (0.51) and weak correlation with U1-FH (-0.44), FMIA (0.43), U1-PP (-0.47) and U6-PTV (0.44). The posterior occlusal plane (P-OP) showed significant moderate correlation with U6-FH (-0.58), U7-FH (0.52), U7-PP (0.51), U6-PTV (0.52) and weak correlation with FMIA (-0.41). The OP-difference showed to have significant moderate correlation with U7-FH (0.53) and weak correlation with L1-MP (-0.41), U7-PP (-0.45).

Discussion

The orthodontic literature contains numerous studies that attempt to evaluate the skeletal and dental effects of various treatment modalities, especially those concerned with Class II correction. In such studies, the primary aim is to assess the contribution of the mandibular and maxillary skeletal and dental changes (growth or treatment induced) on the overall change of anteroposterior occlusal relationship. Unfortunately, the cephalometric analysis that are commonly used are those that have been developed for diagnosis and treatment planning. In this study a cephalometric measurement system is proposed, in order to gain a better understanding of relationship of anterior and posterior occlusal planes in class I, class II division 1 and class II division 2 malocclusions.

Dynamic changes in the craniofacial growth and development affect many changes in occlusal relationships. Therefore, understanding the static and dynamic details of occlusion is crucial for achieving a harmonic function of the masticatory system⁹⁷. The shape and inclination of the occlusal plane is an individual characteristic and is connected with the function of the stomatognathic system.^{98,99}. Occlusal plane characteristics have been changing during phylogenetic evolution. 150 million years ago, in the late Jurassic period, the temporomandibular joint was located at a lower level relative to the occlusal plane¹⁰⁰. Subsequently, with the uprighting of the head, the occlusal plane assumed an inferior position relative to the joint¹⁰¹. The occlusal plane adapts to the variations of vertebral, dental and chronological age, in accordance with biological rhythms^{102,103}. It is not possible to predict correctly the direction and intensity of growth of the relevant craniofacial structures, even when evident signs of the specific growth type are present, because they are not sufficient for a definite prediction of the occlusal relationships to be made¹⁰⁴.

Many experiments and theories have addressed craniofacial growth-related dentoskeletal problems. It has been stated many times in the literature that the mandible moves forward the exact amount of the posterior horizontal condylar growth, if no autorotation occurs¹⁰⁴⁻¹⁰⁷. In addition, Schudy¹⁰⁷ pointed out that the relationship between effective vertical condylar growth (horizontal growth) and vertical growth of the molars, determines whether the mandible rotates backward or forward, or whether it does not rotate. The occlusal plane is the effect, not the cause, of anatomic relationships attributing condylar growth (related to vertical growth) as the key to the changes of the occlusal plane. Nevertheless, some authors have proposed that the vertical dimension of the posterior part of the dentition might affect

the cant of the maxillary posterior occlusal plane and the functional positioning of the mandible, and, consequently, the condyle adapts (secondarily) to the new adopted position of the mandible during growth¹⁰⁹.

Preliminary studies with nonhuman primates demonstrated the relationship between mandibular deviation induced by occlusal alteration and jaw growth, attributing to the temporomandibular joint in the condylar region a functional capacity to adapt to changes in mandibular position¹¹⁰⁻¹¹². Therefore, the Dentofacial complex is obviously adaptable to the functional demands in the occlusal configuration^{113,114}. The spatial position and inclination of the occlusal plane in the lower face influences the functional position of the mandible¹¹⁴. Dawson¹¹⁵, stated that mandibular position is influenced by the vertical relationship of the dentition in the buccal segments, and the relationship between the cant of the occlusal plane of the maxillary dentition related to the sagittal inclination of the condylar path and the guidance of lingual concavity of the maxillary incisor, is another aspect to consider in terms of functionality.

So in order to gain a better understanding of morphological features of class II malocclusion; 30 adults with class II division 1 and 30 adults with class II division 2 were examined and compared with class I malocclusion. It was demonstrated that the skeletal problems of Class II malocclusion included a retruded mandible (Na vertical-POG), rotation of the mandible in a backward direction (FX, RAM-I) and small mandible (RAM-H, MAND-L) (Fig. 1-24). The skeletal features of Class II malocclusion were not characterized by overgrowth of the maxilla, but a restrained growth of the mandible with a backward rotation. McNamara (1981)¹⁵⁰ studied 277

children with Class II malocclusion, and concluded that class II malocclusion is not a single clinical entity, rather it can result from numerous combinations of components and the results indicate the retrusion of mandible (pogonion to nasion perpendicular) is the most commonly occurring factor contributing to class II malocclusion and the maxilla was in a neutral position on average (point A to nasion perpendicular) and excessive anterior vertical development (lower face height) were the most common components of Class II malocclusion. The results of the present study appear to agree with that finding.

Based on the dental patterns in the present study Class II malocclusion showed steep posterior occlusal plane and severe occlusal curvature in the upper dentition (table 8, 9, 10). First or second molar supraeruption may be due to lack of space in the dental arch for the erupting third molar. This eruption could produce an anterior pressure on the second molars leading to potential second molar crowding and/or supraeruption¹¹⁶. An occlusal interference can be produced simultaneously that could lead to a functional alteration of the occlusal plane and, may be, to abnormal growth. In clockwise growing individuals the mandibular plane is usually hyperdivergent. In response to this, the occlusal plane would likely be steeper to be able to establish a functional occlusion. In cases where the occlusal plane is not steep enough, posterior occlusal interferences are likely to occur that could further affect the vertical relationship of the dentition.

Solow¹¹⁷ examined the association between skeletal and occlusal measures using linear correlation and factor analysis procedures. This latter multivariate technique identified several orthogonally derived factors composed of both occlusal and skeletal measures but did not directly examine the relationship between multiple

occlusal variables and multiple skeletal morphologic measures. Keeling et. al.¹¹⁸ matched the features of occlusion and craniofacial morphology and found a poor association in 9 to 16 year olds, i.e. specific skeletal types did not show typical occlusal categories or combinations. Furthermore, occlusion did not reflect the sagittal position of either the maxilla or mandible, and the highest correlations between molar relation and skeletal measurements explained 31% of the variance. Regarding the extent of the curve of Spee, cephalometric measurements explained 34% of its total variance¹²⁰. Consequently, other factors than craniofacial shape might influence the cant of the occlusal plane, for example myofunction, jaw function, extent of tooth eruption, and anterior or posterior dental crowding. Based upon geometric morphometrics of lateral cephalometric tracings, the cranial shapes of individuals with normal occlusion and malocclusion overlapped without formation of distinct clusters¹²¹. In other words, extensive variation of cranial shape did not substantiate a tight relation between craniofacial morphology and occlusal pattern.

An accurate AP measurement of jaw relationships is critically important in orthodontic treatment planning. The most popular parameter for assessing the sagittal jaw relationship remains the ANB angle, but it can be affected by various factors and can be misleading. A popular alternative that the Wits appraisal does not depend on cranial landmarks or rotation of the jaws but still has problem of correctly identifying the functional occlusal plane, which can sometime be impossible. Furthermore, changes of Wits measurement throughout orthodontic treatment might also reflect change in FOP (functional occlusal plane), rather than pure sagittal changes of the relationship of the jaw^{122,123}.

Literature both in the orthodontic as well as the restorative and prosthodontic arena constitutes that maxillary to cranial base orientation is related to earth's horizontal level. The orthodontic and orthopedic literature acknowledges a need to properly align the head position and cranial base for cephalometric evaluation and diagnosis. The orthodontic and prosthetic literature have also consistently confirmed through scientific studies and techniques that the maxillary occlusal plane does produce a downward angulating average slant of 6-10 degrees as referenced from a level head position^{124,125}. (Figure 25) Although very little has been written to discuss the correlation of the neuromuscular myo-trajectory in the antero-posterior and frontal domain and its impact on head position and the cervical neck relationship, it must be recognized that form follows function.

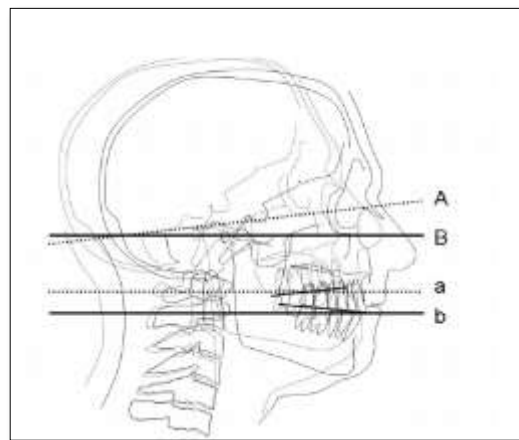


Figure 25: Head posture is a resultant response of environmental influences on the growth and development of the cranio-mandibular complex. The occlusal plane plays a major role in postural stability. Upward head posture with an accompanying upward sloping occlusal plane (A and a). Physiologic head position with a 6-10 degree anterior sloping occlusal plane (B and b).

During growth and development there is a natural tendency toward downward and forward growth of the face relative to the cranial base¹²⁶. The mandible remodels in a predominately posterior superior manner as it simultaneously becomes developed

in an anterior inferior direction. It is sufficient to realize that as the mandible develops in a down and forward fashion over time that, if harnessed or entrapped during orthodontic therapy or comprehensive restorative treatment, the mandibulo-occlusal entrapment will have significant bearing on the stability and long term prognosis of the patient's health.

Ferrario, Sforza, Serrao, and Ciusa (2000)¹²⁶ in their classic occlusal plane studies have confirmed through in vivo measurements that the occlusal plane deviates from the true horizontal by about 14 degrees. Camper's plane (acanthion-external auditory meatus plane) deviated at a steeper angle by 18 degrees from true horizontal. A three-dimensional orientation of the occlusal plane both sagittally and frontally using: 1) natural head positioning relative to the ground, 2) orientation of the occlusal plane relative to the subjects intrinsic facial planes and 3) antero-posterior discrepancies of the dental bases were studied using several dental and soft tissue landmarks using 24 healthy subjects with 24 Angle Class I occlusion. Their measurements were found to be repeatable and easily determined.

Rotational effects of the jaw relative to the cranial reference planes (S-N) can effect the maxillary and mandibular base as well as the occlusal plane angulation relative to horizontal level. (Figure 26 and 27) Orthodontic literature confirms clockwise or counterclockwise rotations relative to the cranial base (S-N) reference plane produces the effect of Class II type jaw relationships (clockwise rotation) and Class III type jaw relationship (counterclockwise rotation). The rotational effect of the S-N line virtually had no effect on the antero-posterior position of nasion point. It was known that dental occlusion is influenced by changes in the cant of the occlusal plane.

Braun studied and defined the geometric and mathematical relationships between dental occlusion and rotations of the occlusal plane in the sagittal view. As a general clinical guide, he reported that each degree of rotation of the occlusal plane will result in a half millimetre change in the dental occlusal relationship. This is of importance, because changes in the cant of the occlusal plane are sometimes unintentional, as well as intentional during orthodontic or restorative therapy. An earlier study has documented that the occlusal plane rotates naturally upward and forward approximately 6 degrees during growth and development. This phenomenon tends to develop a Class II dental relation and therefore has important implications for the developing dentition¹²⁸.

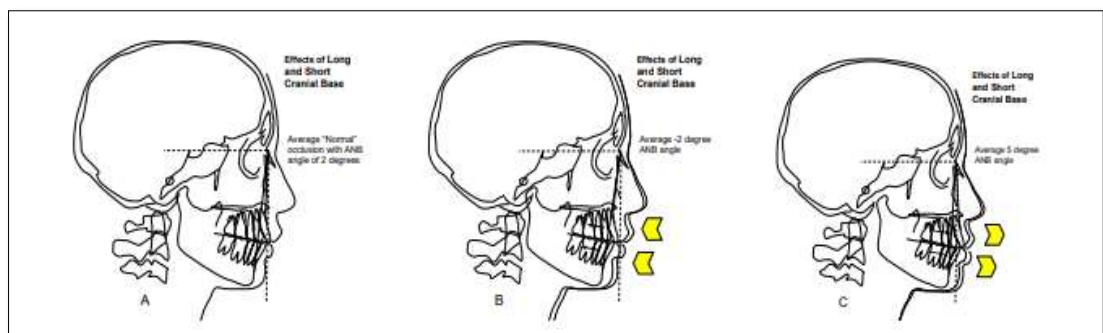


Figure 26: The effect of short and long cranial bases on the ANB angle relative to S-N plane. As the maxillary to mandibular jaw relationship is maintain, both jaws can be positioned either forward or backward relative to nasion in the cranio-facial complex. (A) Normal facial profile, (B) Retrognathic profile, (C) Prognathic profile.

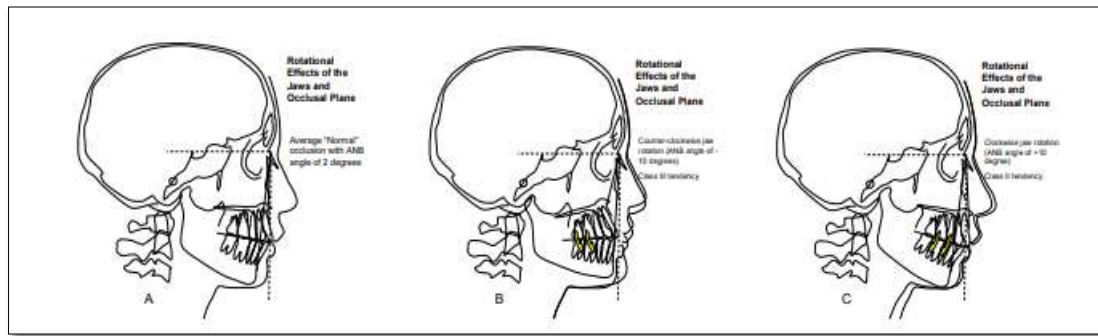


Figure 27: The rotational effects of the maxillary and mandibular occlusal plane relative to the anterior cranial base on the ANB angle. (A) Normal Class I dental and skeletal profile (occlusal plane slopes downward) with even distribution of lip posture. (B) Counter-clockwise rotational direction of the jaws relative to the S-N plane produces a Class III type jaw relationship, upward sloping occlusal plane, short upper lip and prognathic lower jaw tendency. (C) Clockwise rotation of the jaws relative to the cranium produces a Class II type jaw relationship, steep downward sloping occlusal plane, longer upper lip and retrognathic lower jaw tendency.

The inclination of the occlusal plane (IOP) is one of the key factors governing occlusal balance¹²⁸. Studies using cephalometrics have shown that the occlusal plane inclination during craniofacial growth relative to various facio-cranial reference lines varied in anterior rotation during growth. The most significant changes of the occlusal plane inclination were from maxillary base, Frankfort horizontal and cranial base reference lines. Small but significant correlating changes have been reported with these reference lines. It has also been reported that no significant differences according to sexes have been observed¹²⁹.

Okuda (1990)¹³⁰, in his investigative study, reported the importance of a correct occlusal plane and fundamental factors in establishing a correct occlusal plane was based on correct mandibular positioning and dental arch form. Using cephalograms and functional EMG studies of masseter, anterior and posterior temporalis activity, results of the occlusal plane angle showed; 1) close correlations

with the mandibular plane angle, Camper's plane angle and palatal plane angle, 2) correlations with the duration of activity of anterior temporal muscles and the sagittal angle of chewing pathway. These results also conclude that the occlusal plane inclination and angle is an important factor which harmonizes morphology and function of the stomatognathic system.

Ogawa (1997)¹³¹, showed how the inclination of the occlusal plane also influenced the masticatory closing pattern in the sagittal plane. (Figure 28 and 29) Anterior convex closure patterns dominated when the occlusal plane inclined in the anterior direction. In contrast, the majority of posterior convex closure patterns were induced by the posteriorly inclined occlusal plane. The appearance of these types seemed to reflect a harmonious relationship between the inclination of the occlusal plane, tooth guidance, and other central and peripheral control. The correlation between the inclination of the occlusal plane and masticatory closing movement serve as a functional background to the significance of the occlusal plane inclination.

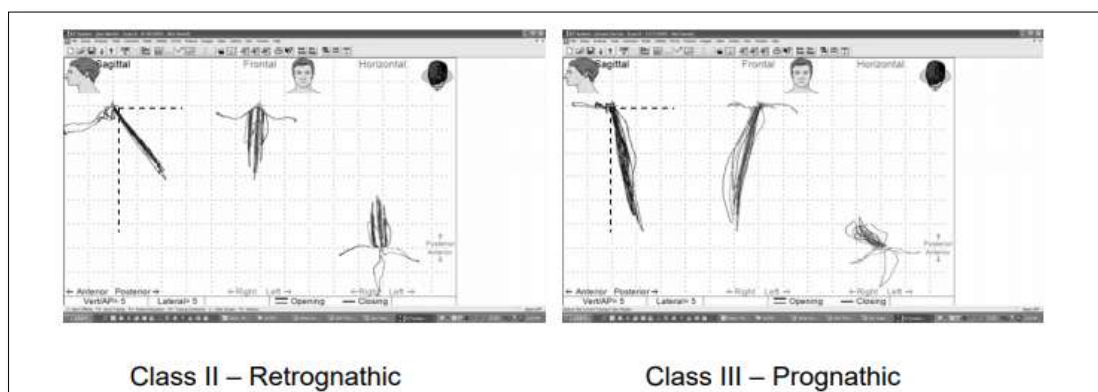


Figure 28: Chewing patterns of Class II and Class III type occlusal plane inclinations. (A) in the retrognathic (skeletal class II) shows a dominating anterior angled chew pattern (Scan 8 chew cycle - Myotronics K7 Kineseograph*). (B) Prognathic (skeletal class III) chewing patterns shows a more vertical closure pattern.

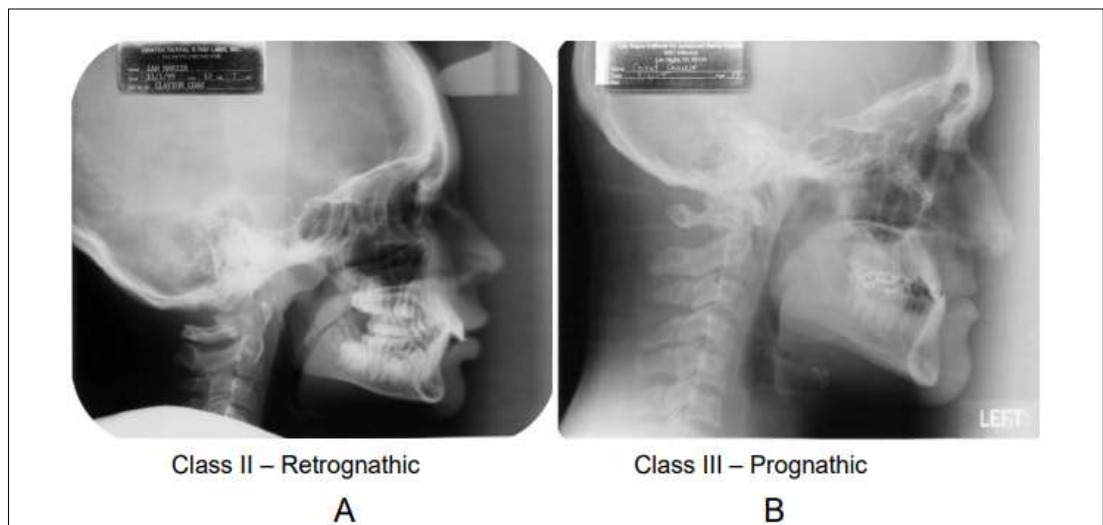


Figure 29: Supportive lateral cephalograms of Figure 28: (A) Class II retrognathic (clockwise rotation) male age 10.5 years old. (B) Class III prognathic (counterclockwise rotation) male 17 years old.

Effect of Class II elastics on occlusal plane:

In 1845, Stephen Perry patented the rubber band and by the early 1900's Baker was using interarch rubber bands to treat class II malocclusions. In 1907, Angle¹³⁷ popularized interarch elastics in his book *Treatment of Malocclusion of the Teeth* where he endorsed the use of interarch elastics to replace headgear in the treatment of maxillary dental protrusion. In 1938, Brodie¹³⁸ published a series of class II patients treated with class II elastics. He reported that pre and post treatment cephalograms showed that the majority of the class II correction was achieved by mesialization of the lower dentition with little stimulation of mandibular growth or distalization of the upper dentition. As a result, various treatment protocols and schools of thought were developed to account for the excess anchorage loss in the mandibular dentition. Tweed developed a “dynamic anchorage” technique that involved tipping back the lower molars in an effort to decrease their mesial migration^{139,140}. Fisher¹⁴¹ advocated for the use of headgear only, without the use of

elastics for the correction of class II malocclusion. However, in the first half of the 20th century, the majority of orthodontists were using a combination of headgear, class II elastics and either lingual holding arches or molar tip backs for lower molar anchorage¹⁴⁰. Today, interarch elastics remain an important tool in the correction of class II malocclusions. However, Proffit¹⁴² encourages the orthodontist to exercise caution in selecting cases for the use of class II elastics to minimize the potentially negative side effects. These negative effects referred to the tendency for class II elastics to produce proclination of the lower incisors, extrusion of the maxillary incisors, extrusion of the lower first molars and a clockwise rotation of the occlusal and mandibular plane. In 2013, Jansen et. al.¹⁴³ published a systematic review that investigated the correction of class II malocclusion with class II elastics. The review included 11 studies which lead the authors to the following conclusions: 1) class II elastics are effective in correcting class II malocclusions up to an Angle ½ cusp class II; 2) the main effects of class II elastics are dentoalveolar, including lingual tipping, retrusion and extrusion of the maxillary incisors, labial tipping and intrusion of the mandibular incisors, and mesialization and extrusion of the mandibular molars; 3) in the long-term, the effects of class II elastics are similar to those produced by functional appliances from a skeletal and dentoalveolar perspective.

Clinical Significance of the Occlusal Plane:

Determination of IOP (Inclination of the Occlusal Plane) is an important step before construction of full arch restorative, orthodontic and full denture type cases. Evaluating and assessing the bilateral occlusal plane of the maxillary arch for symmetry, balance and form is desirable to meet the demands of function and

appearance. Anteroposterior IOP is typically determined with a device called the Fox occlusal plane¹²⁹, which is commonly positioned parallel to Camper's plane or can be used to capture the occlusal plane slope by orienting the Fox plane (modified) parallel to the horizontal level (the floor) and patient's head positioned at level using bite recording material¹³⁴. Ear bows or face bows have been traditionally been used in the gnathologic arena to register the steepness and tilt of the occlusal plane using the auditory meatus, nasion and orbitale as reference points. The IOP often reflects occlusal dysfunction along with often associated periodontal problems as well as temporomandibular disorders. Determination of IOP has been found to be of value during the diagnostic and rehabilitation treatment phases. It is the opinion of many that right- and left-side antero-posterior IOP should be evaluated before any major treatment/rehabilitation program, whether prosthetic or orthodontic, is undertaken. Tooth intrusion or extrusion should aim not only to align occlusal surfaces, but also to correct for alterations in IOP, and thus improve aesthetics. Similarly, taking a correct IOP into account during the planning of a prosthetic or orthodontic program may reduce the risk of unnecessary tooth removal, intrusion or extrusion, especially in the posterior regions.

Shimazaki, et al. (2003)¹³⁴ reported on the effect occlusal alteration and masticatory imbalance has on the cervical spine. Results from a 3D comparative model study indicated strong implications that lateral inclination of the occlusal plane and imbalance between the right and left masticatory muscles antagonistically act on displacement of the cervical spine, i.e. the morphological and functional Class II – Retrognathic Class III – Prognathic A B 31 characteristics in patients with mandibular lateral displacement may play a compensatory role in postural control.

The occlusal plane inclination or slope is an important and critical aspect during functional movements of mastication, especially in the posterior region during excursive non centric positioning and when the chewing functioning path is outside the intercuspal range. The masticatory path of closure near the intercuspal range has shown to be only influenced by occlusal guidance. Ogawa (1998) reported the gliding or grinding type masticatory pattern was observed predominately in cases with flat or posteriorly inclined occlusal planes. In contrast, a chopping or more vertical type closure pattern was observed predominately in cases with an anterior inclining occlusal plane¹³⁶.

The importance of the inclination of the occlusal plane during masticatory movement in the excursive functional movement is much greater and of significance through the closing phase, except near the terminal intercuspal position. These observations once again confirm that an anterior occlusal plane inclination or slope is important and significant in order to optimize the masticatory and cervical system toward homeostasis. Ignoring the functional excursive closing movements, including those masticatory movements that occur beyond cuspid rise, will lead to continued pathologic grinding and further unresolved hyperactivity of muscle. It is these finer nuances of neuromuscular occlusion that are often overlooked and often ignored during clinical occlusal management of the TMD and the restorative/prosthetic case.

Limitations

1. The evident limitation of the present study is a small sample size.
2. Comparative evaluation groups of the present study should have included class III group.
3. For actual detailing of the parameters advanced radiographic tool i.e. 3D imaging (CBCT) should have been used.
4. TMJ evaluation with reference to occlusal alteration can be carried out to observe the morphological evaluation of TMJ in relation to occlusal plane.

Summary and Conclusion

The purpose of this cross-sectional study was to evaluate and compare anterior and posterior occlusal planes in Angles Class I, class II division 1 and class II division 2 malocclusions subjects. The study was carried out in a sample of 90 subjects (aged 18– 30 years) which were divided into three groups (30 subjects each) according to Angles and skeletal malocclusion.

It is concluded that change in occlusal plane inclination during growth and development is towards an anterior sloping inclined relative to horizontal. The orthodontic, restorative and prosthetic literature substantially confirms time and time again that the human occlusal plane slopes anteriorly in physiologic normal states and has been confirmed beyond reasonable doubt with lateral radiographic imagery (Sato

(2006), Vukusic, (2000), Ogawa (1998), Xie (1993), Kazanoglu, (1992), Koller (1992)^{124,128,129,145}.

Graber et. al.¹⁴⁷ stated that the occlusal plane angle should be maintained. Occlusal plane increase will affect masticatory muscle balance. According to Burstone et. al.¹⁴⁸ occlusal plane in patients with fine posterior occlusion should be maintained during orthodontic treatment. The occlusal plane change in the posterior that causes posterior axial inclination will change and lead to treatment result instability. The result was different with the Braun et al.¹⁵¹ result. In his study, there was occlusal plane inclination change using class II and class III elastics, because of the posterior dental extrusion. The differences were on the selection and sample size, treatment technique and cases used in the study and different race of the sample.

From the present study following conclusions were made:

1. Results of the study has revealed that the skeletal problems in Class II malocclusions were affected by the fact that the mandible is retruded, small, and rotated in a backward orientation. The maxilla was found to be average in size anterior-posteriorly.
2. The anterior and the posterior occlusal planes were established for this investigation. It was found that a large number of Class II malocclusions had a steep posterior occlusal plane.
3. The steep cant of the posterior occlusal plane showed a strong correlation with a small, retruded mandible with a backward rotation as skeletal problems in Class II malocclusion.
4. A steep posterior occlusal plane was found to be correlated strongly with a short vertical height of the upper second molars.

5. The increased vertical height of the lower second premolars was found to be related to the backward rotation of the mandible.

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Table 1: Comparison of skeletal patterns amongst the three groups

| | Class I (n=30) | Class II division 1 (n=30) | Class II division 2 (n=30) | p-value |
|-------------------|---------------------------|---|---|----------------|
| Skeletal Patterns | Mean ± SD | Mean ± SD | Mean ± SD | |
| Angular | | | | |
| MPA | 26.4 ± 5.5 | 26.3 ± 5.8 | 25.2 ± 5.0 | 0.65 |
| Facial axis | 90.3 ± 1.2 | 88.8 ± 3.2 | 87.7 ± 6.2 | 0.05* |
| Gonial angle | 124.0 ± 6.5 | 124.2 ± 6.1 | 120.7 ± 7.6 | 0.08 |
| PPA | 2.2 ± 3.8 | 2.7 ± 3.0 | 2.4 ± 3.1 | 0.82 |
| Ramal inclination | 79.2 ± 1.5 | 82.8 ± 2.8 | 87.6 ± 1.4 | 0.001** |
| Linear | | | | |
| Na-A | -2.1 ± 3.0 | -2.3 ± 3.6 | -3.8 ± 3.4 | 0.11 |
| Na-Pog | -6.7 ± 6.0 | -10.0 ± 1.0 | -13.8 ± 6.7 | 0.001** |
| RH | 57.3 ± 0.9 | 52.1 ± 1.1 | 50.5 ± 1.0 | 0.001** |
| Mandibular Length | 107.4 ± 6.7 | 82.2 ± 18.7 | 76.3 ± 14.1 | 0.001** |
| Maxillary Length | 44.9 ± 3.6 | 45.6 ± 2.7 | 46.0 ± 4.9 | 0.38 |

*p≤0.05 statistically significant, **p≤0.001 highly significant using one way ANOVA

Table 2: Comparison of dental patterns amongst the three groups

| | Class I (n=30) | Class II division 1 (n=30) | Class II division 2 (n=30) | p-value |
|----------------------|---------------------------|---|---|----------------|
| Dental Parameters | Mean ± SD | Mean ± SD | Mean ± SD | |
| Angular | | | | |
| A-OP | 12.1 ± 0.8 | 9.5 ± 0.8 | 7.1 ± 0.8 | 0.001** |
| P-OP | 14.1 ± 5.0 | 16.5 ± 1.6 | 20.5 ± 4.3 | 0.001** |
| U1-FH | 116.1± 1.4 | 120.6 ± 1.3 | 89.4 ± 9.5 | 0.001** |
| L1-MP | 93.8 ± 1.6 | 102.1 ± 8.4 | 96.1 ± 4.6 | 0.001** |
| FMIA | 53.9 ± 7.1 | 63.4 ± 1.3 | 56.1 ±0.8 | 0.001** |
| U6-FH | 80.5±2.1 | 88.1±5.1 | 90.5±12.1 | 0.001** |
| U7-FH | 68.7 ± 0.9 | 72.0 ± 5.6 | 87.9 ± 14.5 | 0.001** |
| Linear | | | | |
| U1-PP | 28.4 ±10.1 | 25.2 ± 2.4 | 27.1 ± 2.1 | 0.14 |
| U5-PP | 23.8 ± 2.2 | 22.8 ± 3.4 | 22.3 ± 2.3 | 0.12 |
| U7-PP | 22.1 ± 1.2 | 18.9 ± 2.4 | 14.1 ± 1.3 | 0.001** |
| L1-MP | 40.0 ± 3.3 | 38.5 ± 2.4 | 37.6 ± 4.3 | 0.02* |
| L5-MP | 31.5 ± 2.5 | 28.1 ± 2.1 | 29.6 ± 3.6 | 0.001** |
| L7-MP | 26.3 ± 2.7 | 24.3 ± 1.9 | 25.5 ±3.4 | 0.02* |
| U6-PTV | 7.7 ± 3.8 | 12.8 ± 6.4 | 13.5 ± 5.7 | 0.001** |

*p≤0.05 statistically significant, **p≤0.001 highly significant using one way ANOVA

Table 3: Multiple comparisons of skeletal patterns amongst three groups

| Skeletal patterns | Groups | p-value |
|--------------------------|--------------------------------|----------------|
| MPA | Class I- Class II div 1 | 0.99 |
| | Class I-Class II div 2 | 0.14 |
| | Class II div 1- Class II div 2 | 0.12 |
| Facial axis | Class I- Class II div 1 | 0.32 |
| | Class I-Class II div 2 | 0.04* |
| | Class II div 1- Class II div 2 | 0.57 |
| Gonial angle | Class I- Class II div 1 | 0.99 |
| | Class I-Class II div 2 | 0.14 |
| | Class II div 1- Class II div 2 | 0.12 |
| PPA | Class I- Class II div 1 | 0.81 |
| | Class I-Class II div 2 | 0.97 |
| | Class II div 1- Class II div 2 | 0.92 |
| RI | Class I- Class II div 1 | 0.001** |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.001** |
| Na-A | Class I- Class II div 1 | 0.97 |
| | Class I-Class II div 2 | 0.13 |
| | Class II div 1- Class II div 2 | 0.20 |
| Na-Pog | Class I- Class II div 1 | 0.04* |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.01* |
| R-H | Class I- Class II div 1 | 0.001** |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.001** |
| Mand L | Class I- Class II div 1 | 0.001** |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.23 |
| Max L | Class I- Class II div 1 | 0.95 |
| | Class I-Class II div 2 | 0.56 |
| | Class II div 1- Class II div 2 | 0.38 |

* $p \leq 0.05$ statistically significant, ** $p \leq 0.001$ highly significant using one way ANOVA

Table 4: Multiple comparisons of dental patterns amongst three groups

| Dental patterns | Groups | p-value |
|-----------------|--------------------------------|---------|
| A-OP | Class I- Class II div 1 | 0.001** |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.001** |
| P-OP | Class I- Class II div 1 | 0.01* |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.001** |
| U1-FH | Class I- Class II div 1 | 0.04* |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.001** |
| L1-MP | Class I- Class II div 1 | 0.001** |
| | Class I-Class II div 2 | 0.27 |
| | Class II div 1- Class II div 2 | 0.001** |
| FMIA | Class I- Class II div 1 | 0.13 |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.001** |
| U6-FH | Class I- Class II div 1 | 0.001** |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.05* |
| U7-FH | Class I- Class II div 1 | 0.001** |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.33 |
| U1-PP | Class I- Class II div 1 | 0.12 |
| | Class I-Class II div 2 | 0.72 |
| | Class II div 1- Class II div 2 | 0.44 |
| U5-PP | Class I- Class II div 1 | 0.33 |
| | Class I-Class II div 2 | 0.11 |
| | Class II div 1- Class II div 2 | 0.81 |
| U7-PP | Class I- Class II div 1 | 0.001** |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.001** |
| L1-MP | Class I- Class II div 1 | 0.19 |
| | Class I-Class II div 2 | 0.02* |
| | Class II div 1- Class II div 2 | 0.62 |
| L5-MP | Class I- Class II div 1 | 0.001** |
| | Class I-Class II div 2 | 0.03* |
| | Class II div 1- Class II div 2 | 0.09 |
| L7-MP | Class I- Class II div 1 | 0.01* |
| | Class I-Class II div 2 | 0.47 |
| | Class II div 1- Class II div 2 | 0.22 |
| U6-PTV | Class I- Class II div 1 | 0.001** |
| | Class I-Class II div 2 | 0.001** |
| | Class II div 1- Class II div 2 | 0.87 |

*p≤0.05 statistically significant, **p≤0.001 highly significant using one way ANOV

Table 5: Correlation between skeletal and dental patterns in Class I group

| | Skeletal patterns | | | | | | | | | |
|-----------------|-------------------|-------------|--------------|-------|-------|-------|--------|-------|--------|-------|
| Dental patterns | MPA | Facial axis | Gonial angle | PPA | RI | Na-A | Na-Pog | RH | Mand-L | Max-L |
| A-OP | -0.17 | 0.13 | 0.03 | -0.02 | 0.24 | -0.00 | 0.03 | 0.24 | -0.21 | -0.16 |
| P-OP | -0.06 | 0.20 | -0.06 | 0.19 | 0.02 | 0.12 | -0.05 | -0.21 | -0.09 | -0.13 |
| U1-FH | -0.01 | 0.00 | 0.13 | 0.07 | 0.23 | 0.08 | -0.02 | -0.17 | -0.17 | -0.23 |
| L1-MP | 0.03 | -0.24 | 0.04 | -0.21 | -0.13 | -0.10 | 0.11 | 0.43* | 0.03 | 0.01 |
| FMIA | 0.30 | -0.05 | 0.12 | 0.14 | -0.24 | -0.34 | -0.32 | -0.18 | 0.14 | 0.31 |
| U6-FH | -0.18 | 0.04 | -0.27 | -0.21 | 0.00 | -0.28 | -0.03 | 0.28 | 0.06 | 0.17 |
| U7-FH | -0.13 | 0.03 | -0.21 | -0.02 | -0.02 | -0.25 | -0.05 | 0.10 | 0.07 | 0.27 |
| U1-PP | -0.02 | -0.08 | -0.21 | -0.34 | 0.06 | -0.14 | 0.02 | 0.26 | 0.11 | 0.03 |
| U5-PP | 0.42* | -0.01 | 0.26 | -0.1 | -0.29 | -0.29 | -0.31 | 0.12 | 0.14 | -0.03 |
| U7-PP | 0.14 | 0.41* | 0.07 | -0.00 | -0.04 | 0.04 | -0.1 | -0.3 | 0.06 | -0.08 |
| L1-MP | 0.3 | -0.18 | 0.11 | -0.23 | -0.26 | -0.26 | -0.17 | 0.00 | 0.52** | 0.38* |
| L5-MP | 0.22 | -0.19 | -0.17 | -0.17 | 0.01 | 0.02 | -0.18 | 0.01 | 0.42** | 0.36* |
| L7-MP | -0.06 | -0.09 | -0.07 | -0.01 | 0.04 | -0.21 | -0.04 | 0.15 | 0.31 | 0.22 |
| U6-PTV | -0.38* | -0.31 | -0.15 | -0.09 | 0.28 | 0.33 | 0.52** | 0.11 | 0.35 | 0.22 |

**Correlation is significant at 0.01 level; *Correlation is significant at 0.05 level

Table 6: Correlation between skeletal and dental patterns in Class II division 1 group

| | Skeletal patterns | | | | | | | | | |
|-----------------|-------------------|-------------|--------------|-------|--------|--------|---------|-------|--------|---------|
| Dental patterns | MPA | Facial axis | Gonial angle | PPA | RI | Na-A | Na-Pog | RH | Mand-L | Max-L |
| A-OP | 0.39* | 0.41** | 0.26 | 0.38* | -0.02 | -0.16 | -0.38* | -0.00 | -0.39* | 0.16 |
| P-OP | -0.38* | 0.39* | -0.37* | -0.14 | -0.36* | -0.05 | -0.37* | 0.01 | 0.46** | -0.42** |
| U1-FH | -0.39* | -0.40* | -0.23 | -0.28 | -0.05 | 0.19 | 0.54** | 0.11 | -0.05 | -0.09 |
| L1-MP | -0.37* | -0.36 | -0.42* | -0.05 | 0.13 | 0.51** | -0.02 | -0.19 | 0.08 | 0.43* |
| FMIA | -0.24 | -0.10 | -0.04 | -0.18 | -0.09 | -0.12 | 0.57** | 0.11 | -0.10 | -0.19 |
| U6-FH | -0.45* | -0.17 | -0.00 | 0.08 | -0.16 | 0.14 | -0.44** | 0.22 | 0.38* | 0.06 |
| U7-FH | -0.38* | -0.34 | -0.11 | -0.00 | -0.25 | 0.30 | -0.39** | -0.08 | 0.38* | 0.20 |
| U1-PP | 0.37* | 0.64** | 0.26 | -0.08 | -0.12 | -0.39* | 0.05 | 0.16 | 0.10 | -0.33 |
| U5-PP | 0.25 | 0.15 | 0.26 | 0.11 | 0.18 | -0.15 | 0.23 | 0.23 | -0.08 | -0.23 |
| U7-PP | 0.30 | 0.28 | 0.20 | 0.23 | 0.23 | -0.07 | -0.02 | 0.20 | -0.27 | 0.37* |
| L1-MP | 0.45* | 0.49** | 0.40* | 0.05 | -0.05 | -0.20 | -0.44** | 0.26 | -0.12 | 0.08 |
| L5-MP | 0.51** | 0.47** | 0.48** | 0.22 | 0.11 | -0.30 | -0.55** | 0.05 | 0.03 | 0.00 |
| L7-MP | 0.09 | 0.31 | -0.03 | 0.03 | 0.10 | -0.09 | 0.03 | -0.14 | -0.22 | 0.05 |
| U6-PTV | -0.00 | -0.33 | -0.05 | 0.39* | 0.29 | 0.29 | 0.50** | 0.05 | -0.5** | 0.47** |

**Correlation is significant at 0.01 level; *Correlation is significant at 0.05 level

Table 7: Correlation between skeletal and dental patterns in Class II division 2 group

| | Skeletal patterns | | | | | | | | | |
|-----------------|-------------------|-------------|--------------|-------|--------|--------|---------|---------|---------|--------|
| Dental patterns | MPA | Facial axis | Gonial angle | PPA | RI | Na-A | Na-Pog | RH | Mand-L | Max-L |
| A-OP | -0.41** | -0.45** | -0.23 | 0.41* | 0.46** | 0.19 | 0.56** | -0.19 | 0.50** | 0.18 |
| P-OP | 0.39* | 0.39* | 0.22 | -0.17 | -0.38* | -0.13 | -0.55** | -0.63** | -0.45** | -0.42* |
| U1-FH | 0.40* | 0.42** | 0.27 | -0.06 | 0.13 | -0.25 | -0.65** | -0.46** | 0.15 | 0.00 |
| L1-MP | -0.60** | 0.19 | -0.72** | -0.04 | 0.13 | 0.43* | 0.43* | -0.03 | 0.60** | 0.34 |
| FMIA | -0.37* | -0.40** | -0.40* | 0.25 | 0.47** | 0.10 | 0.20 | 0.45** | 0.26 | 0.30 |
| U6-FH | 0.41** | -0.44** | 0.12 | 0.06 | -0.18 | 0.11 | 0.16 | -0.39* | 0.47** | -0.18 |
| U7-FH | 0.45** | -0.38* | 0.15 | 0.29 | 0.06 | 0.01 | 0.06 | 0.39* | -0.38* | -0.02 |
| U1-PP | 0.41** | 0.46* | 0.05 | -0.07 | 0.37* | -0.37* | -0.13 | 0.08 | -0.02 | 0.32 |
| U5-PP | -0.17 | 0.41* | -0.36 | 0.01 | 0.32 | -0.13 | 0.00 | 0.05 | 0.12 | 0.46** |
| U7-PP | 0.03 | -0.00 | 0.07 | 0.20 | -0.06 | -0.05 | 0.00 | -0.03 | -0.16 | 0.02 |
| L1-MP | 0.08 | 0.46* | 0.05 | -0.23 | 0.14 | -0.22 | -0.46** | 0.06 | -0.06 | 0.37* |
| L5-MP | 0.03 | 0.38* | -0.01 | -0.19 | 0.30 | -0.17 | 0.40** | -0.01 | -0.32 | -0.12 |
| L7-MP | -0.18 | 0.40* | -0.31 | 0.04 | 0.24 | 0.05 | 0.28 | 0.02 | 0.26 | 0.48** |
| U6-PTV | -0.05 | 0.09 | 0.01 | 0.08 | -0.04 | 0.11 | 0.00 | -0.06 | -0.37* | 0.39* |

**Correlation is significant at 0.01 level; *Correlation is significant at 0.05 level

Table 8: Correlation between occlusal planes and dental patterns in Class I group

| | Dental patterns | | | | | | | | | | | |
|---------|-----------------|-------|-------|-------|-------|-------|--------|-------|-------|-------|-------|--------|
| | U1-FH | L1-MP | FMIA | U6-FH | U7-FH | U1-PP | U5-PP | U7-PP | L1-MP | L5-MP | L7-MP | U6-PTV |
| A-OP | 0.29 | 0.16 | -0.15 | 0.13 | -0.01 | 0.08 | -0.38* | 0.13 | -0.30 | -0.24 | -0.20 | 0.25 |
| P-OP | -0.17 | -0.08 | -0.25 | 0.04 | 0.17 | -0.20 | 0.18 | 0.11 | 0.04 | -0.11 | 0.06 | 0.06 |
| OP-diff | 0.21 | 0.18 | 0.22 | 0.13 | 0.14 | 0.05 | 0.25 | 0.03 | 0.11 | 0.20 | 0.17 | 0.10 |

**Correlation is significant at 0.01 level; *Correlation is significant at 0.05 level

Table 9: Correlation between occlusal planes and dental patterns in Class II division 1 group

| | Dental patterns | | | | | | | | | | | |
|---------|-----------------|-------|--------|---------|-------|-------|-------|---------|-------|-------|-------|---------|
| | U1-FH | L1-MP | FMIA | U6-FH | U7-FH | U1-PP | U5-PP | U7-PP | L1-MP | L5-MP | L7-MP | U6-PTV |
| A-OP | -0.41** | -0.01 | -0.39* | 0.40** | -0.00 | 0.38* | 0.04 | 0.16 | 0.34 | 0.33 | 0.24 | 0.39* |
| P-OP | -0.17 | 0.14 | -0.38* | -0.41** | 0.46* | 0.10 | -0.11 | -0.43** | -0.30 | 0.31 | -0.26 | -0.50** |
| OP-diff | 0.30 | 0.38* | 0.25 | 0.35 | 0.39* | 0.21 | 0.15 | 0.39* | 0.22 | -0.14 | 0.04 | -0.32 |

**Correlation is significant at 0.01 level; *Correlation is significant at 0.05 level

Table 10: Correlation between occlusal planes and dental patterns in Class II division 2 group

| | Dental patterns | | | | | | | | | | | |
|---------|-----------------|--------|---------|---------|--------|---------|-------|---------|-------|-------|-------|--------|
| | U1-FH | L1-MP | FMIA | U6-FH | U7-FH | U1-PP | U5-PP | U7-PP | L1-MP | L5-MP | L7-MP | U6-PTV |
| A-OP | -0.44** | 0.14 | 0.43** | 0.51** | 0.24 | -0.47** | 0.03 | 0.13 | -0.15 | -0.23 | 0.00 | 0.44** |
| P-OP | 0.16 | -0.10 | -0.41** | -0.58** | 0.52** | -0.18 | -0.17 | 0.51** | -0.10 | 0.13 | -0.21 | 0.52** |
| OP-diff | 0.28 | -0.41* | 0.31 | 0.26 | 0.53** | 0.29 | 0.14 | -0.45** | 0.03 | 0.19 | 0.24 | 0.32 |

**Correlation is significant at 0.01 level; *Correlation is significant at 0.05 level

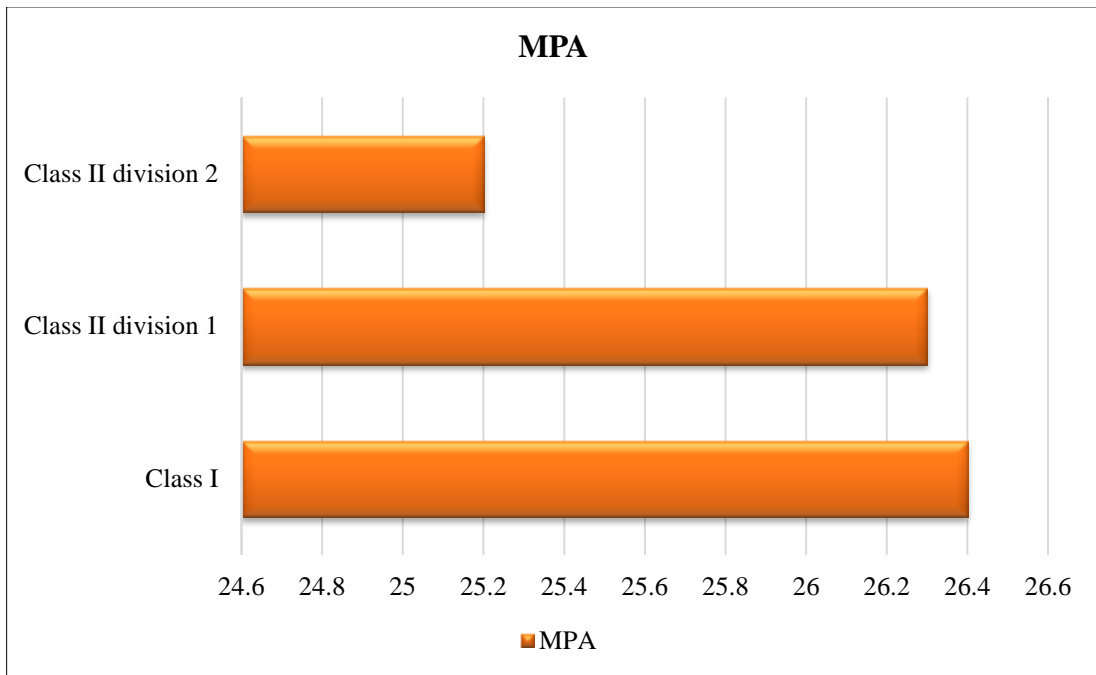


Fig. 1: Comparison of MPA amongst the three groups

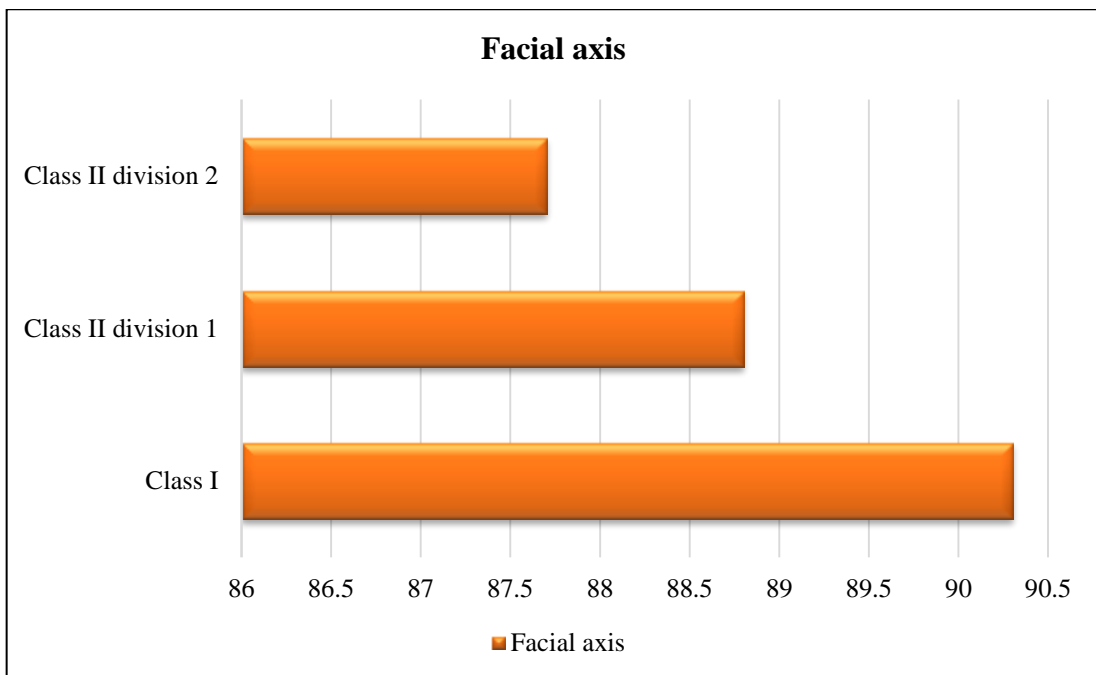


Fig. 2: Comparison of Facial axis amongst the three groups

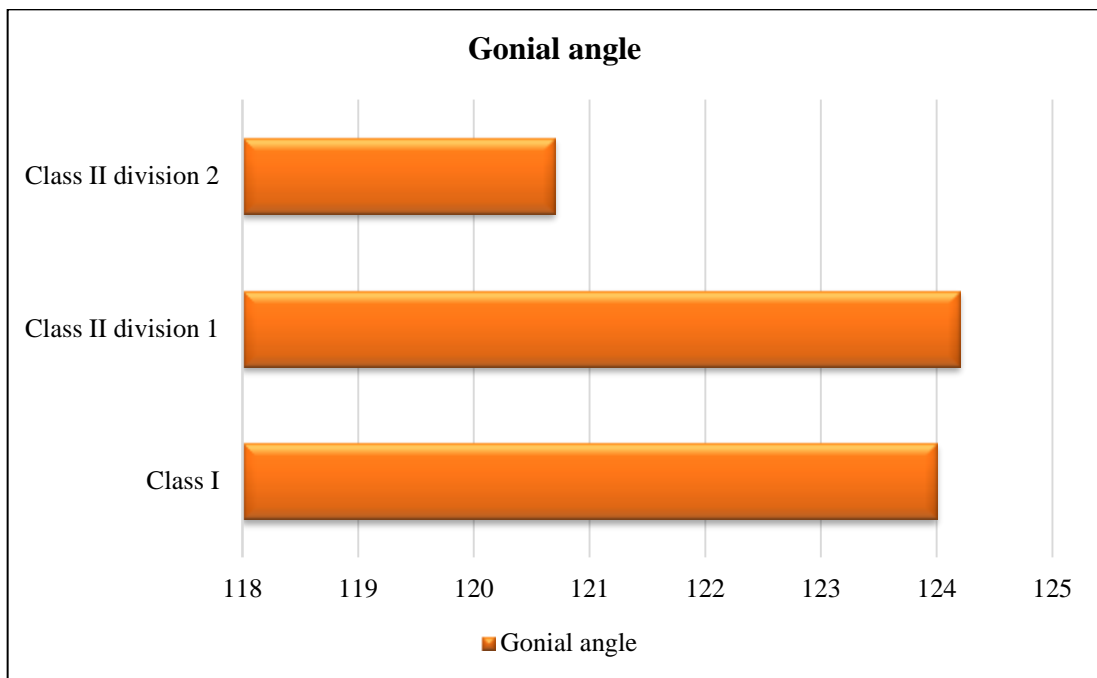


Fig. 3: Comparison of Gonial angle amongst the three groups

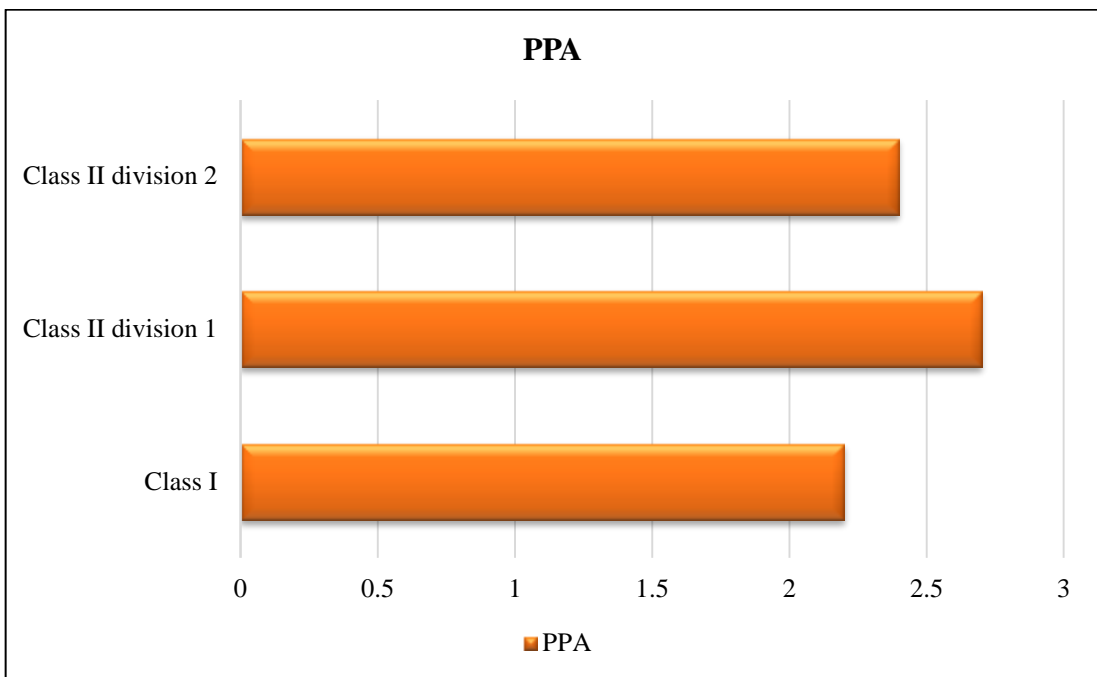


Fig. 4: Comparison of PPA amongst the three groups

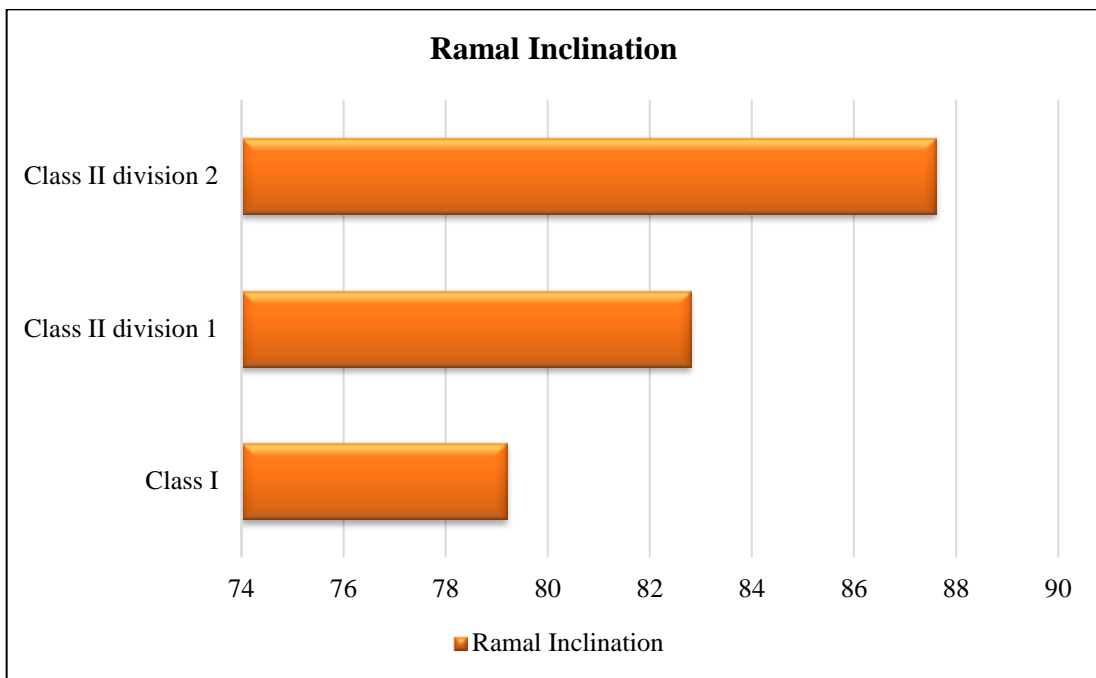


Fig. 5: Comparison of Ramal inclination amongst the three groups

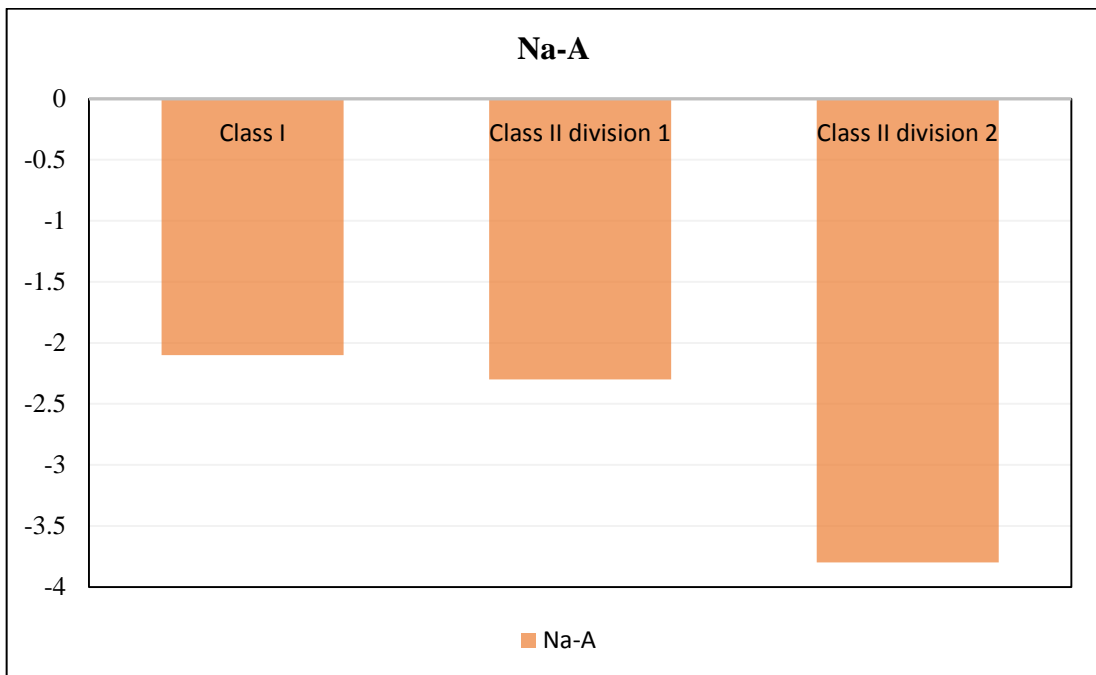


Fig. 6: Comparison of Na-A amongst the three groups

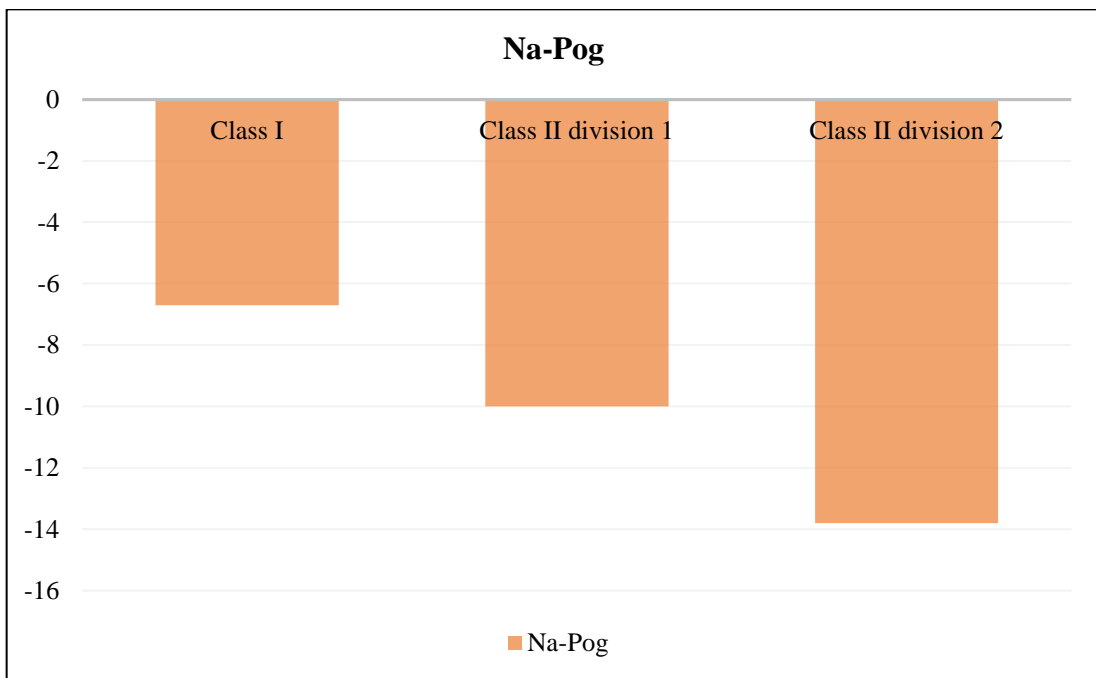


Fig. 7: Comparison of Na-Pog amongst the three groups

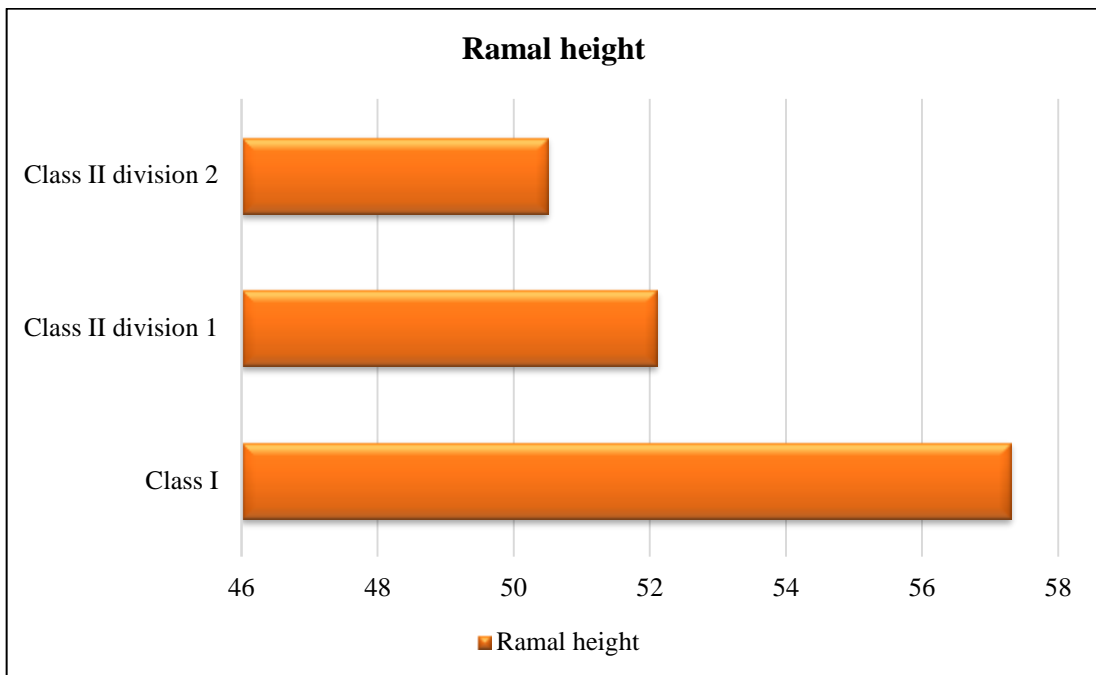


Fig. 8: Comparison of Ramal height amongst the three groups

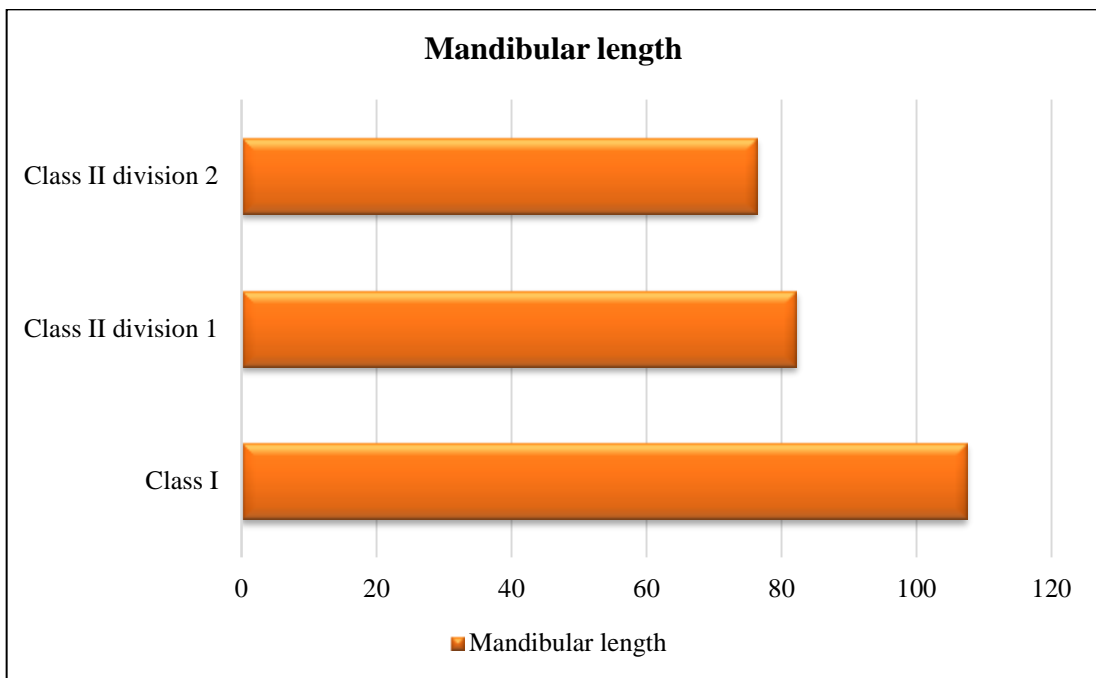


Fig. 9: Comparison of Mandibular length amongst the three groups

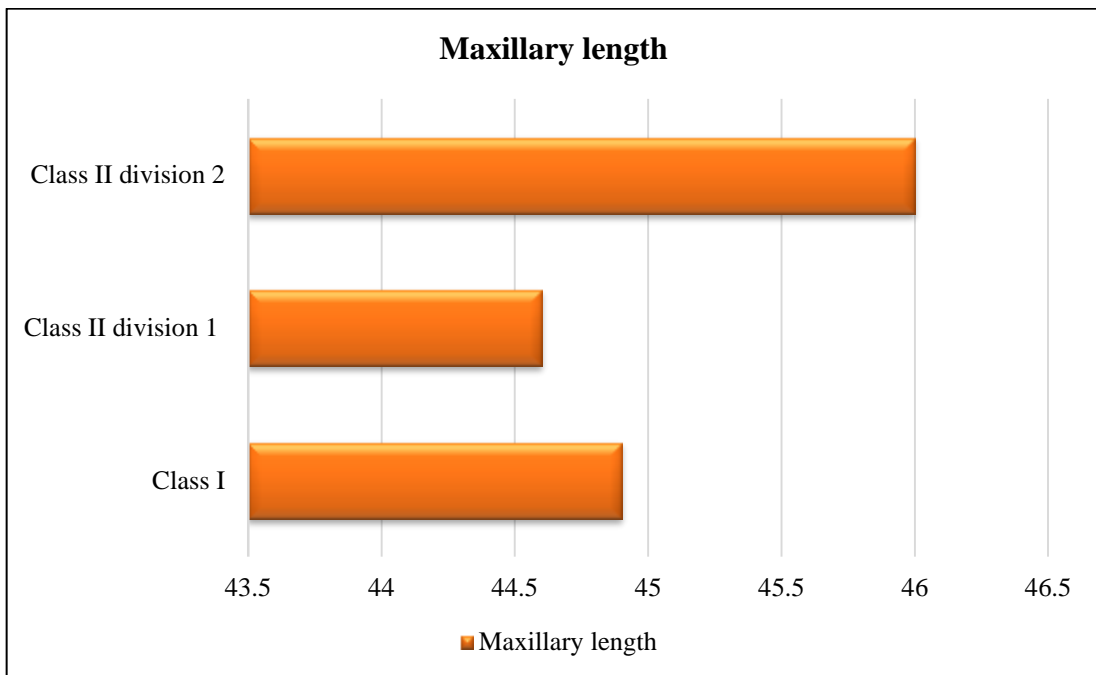


Fig. 10: Comparison of Maxillary length amongst the three groups

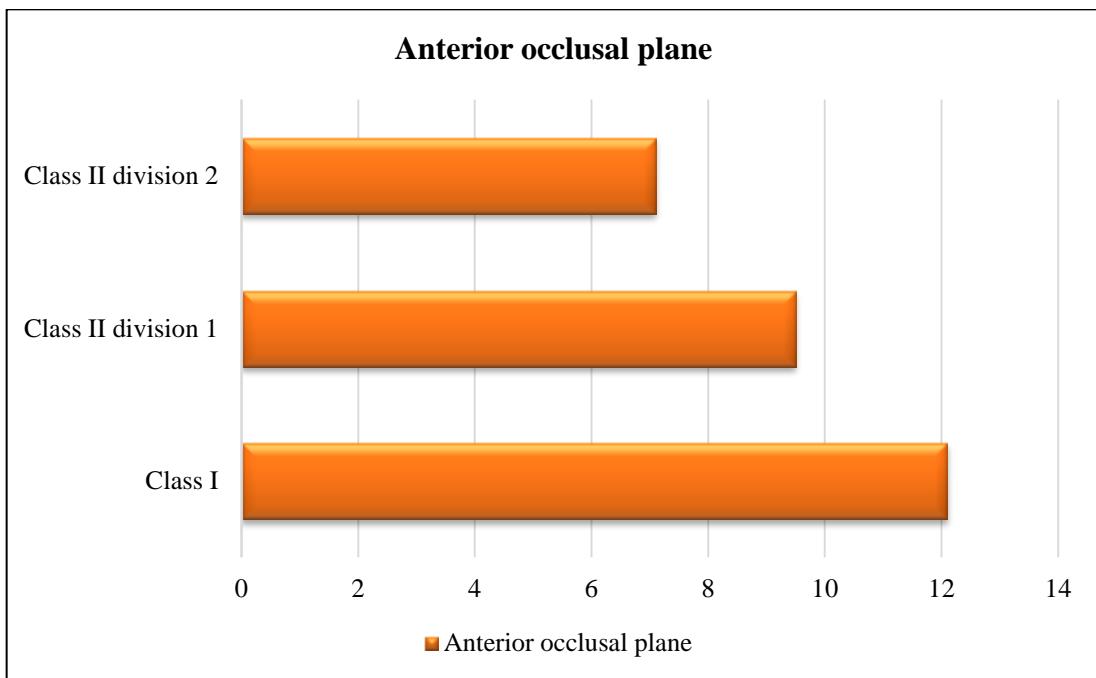


Fig. 11: Comparison of Anterior occlusal plane amongst the three groups

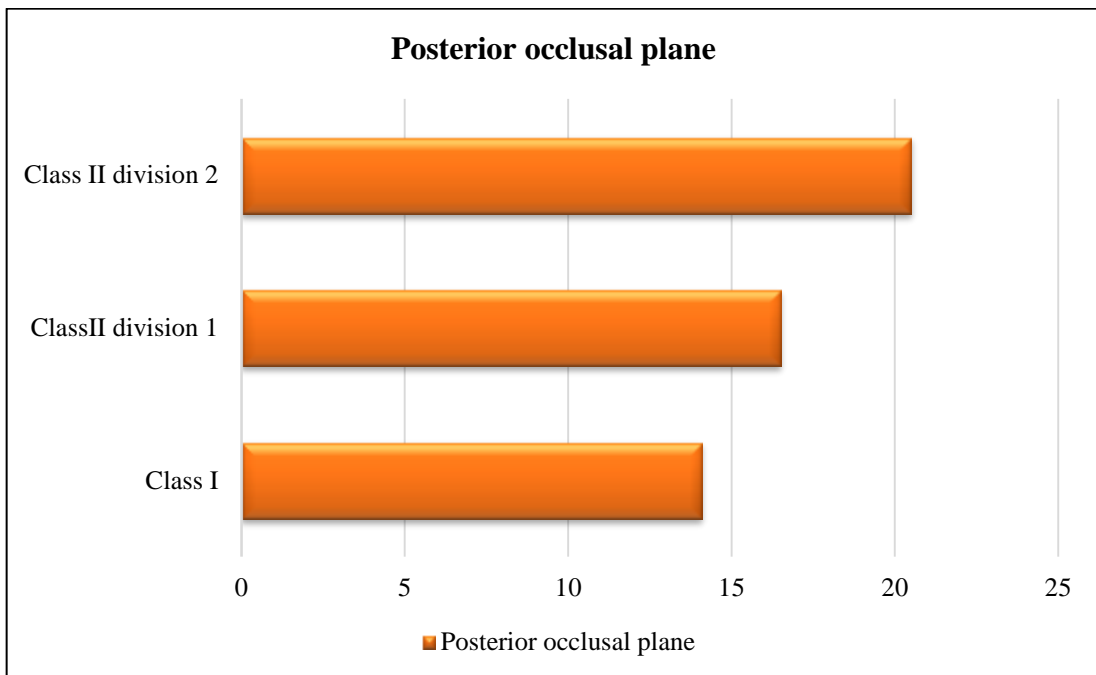


Fig. 12: Comparison of Posterior occlusal plane amongst the three groups

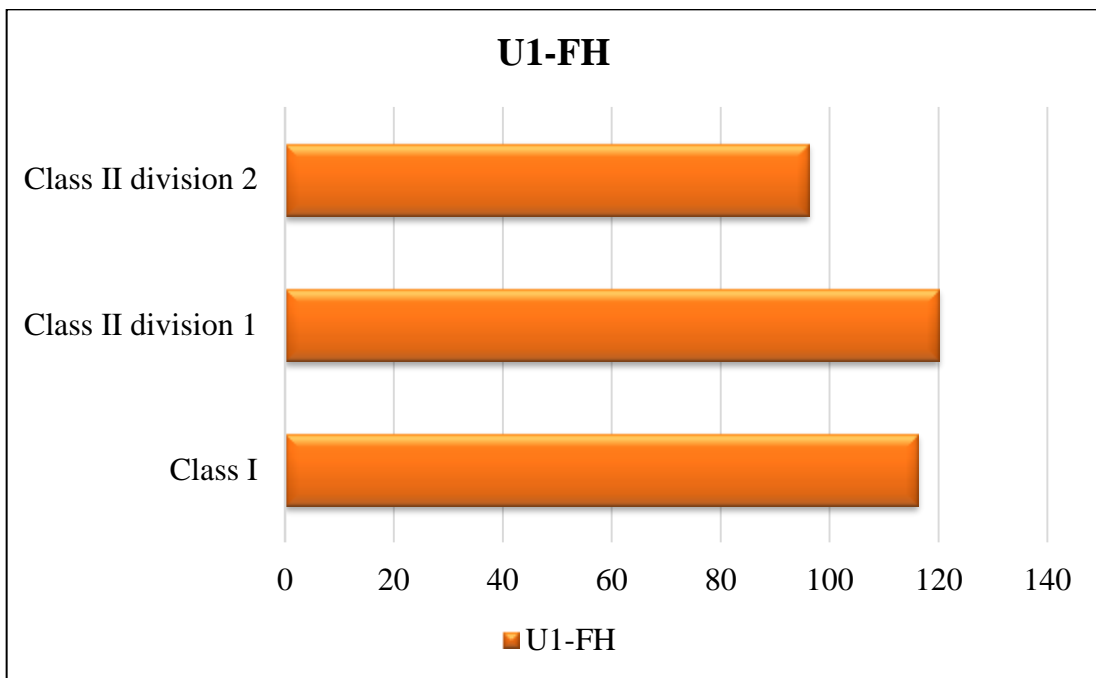


Fig. 13: Comparison of U1-FH amongst the three groups

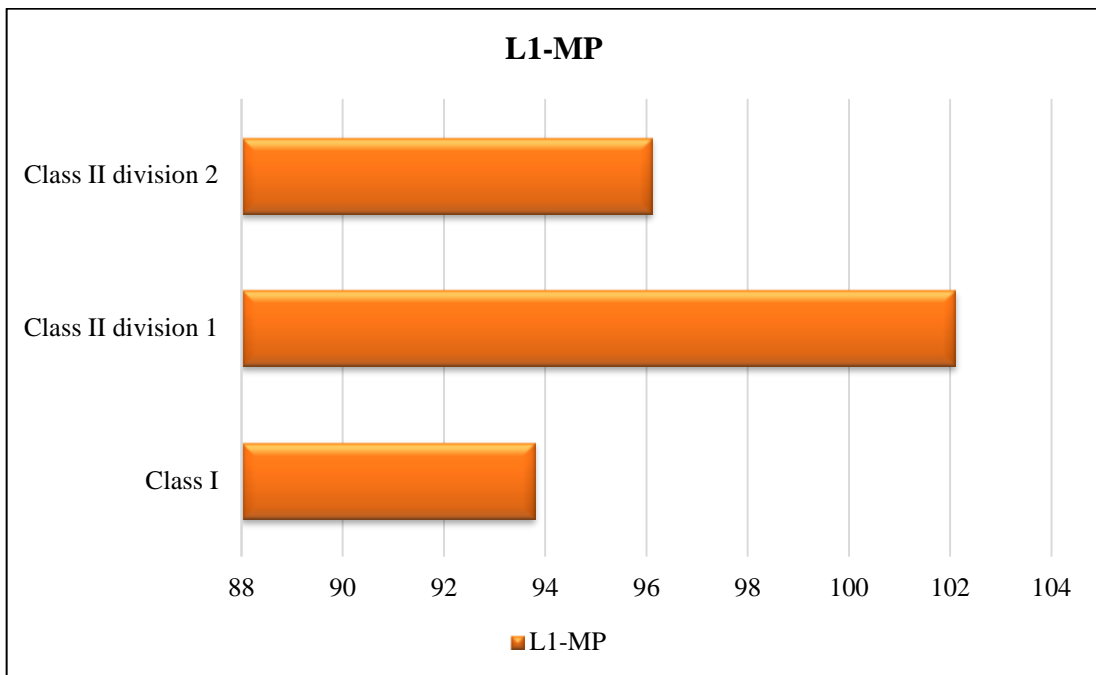


Fig. 14. Comparison of L1-MP amongst the three groups

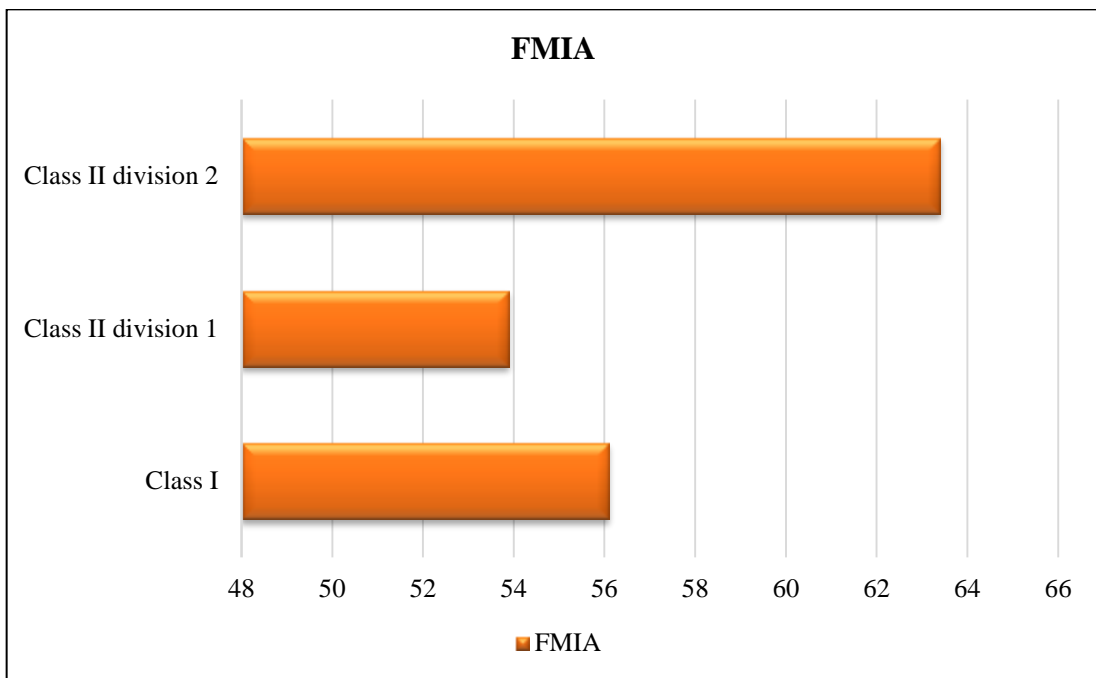


Fig. 15: Comparison of FMIA amongst the three groups

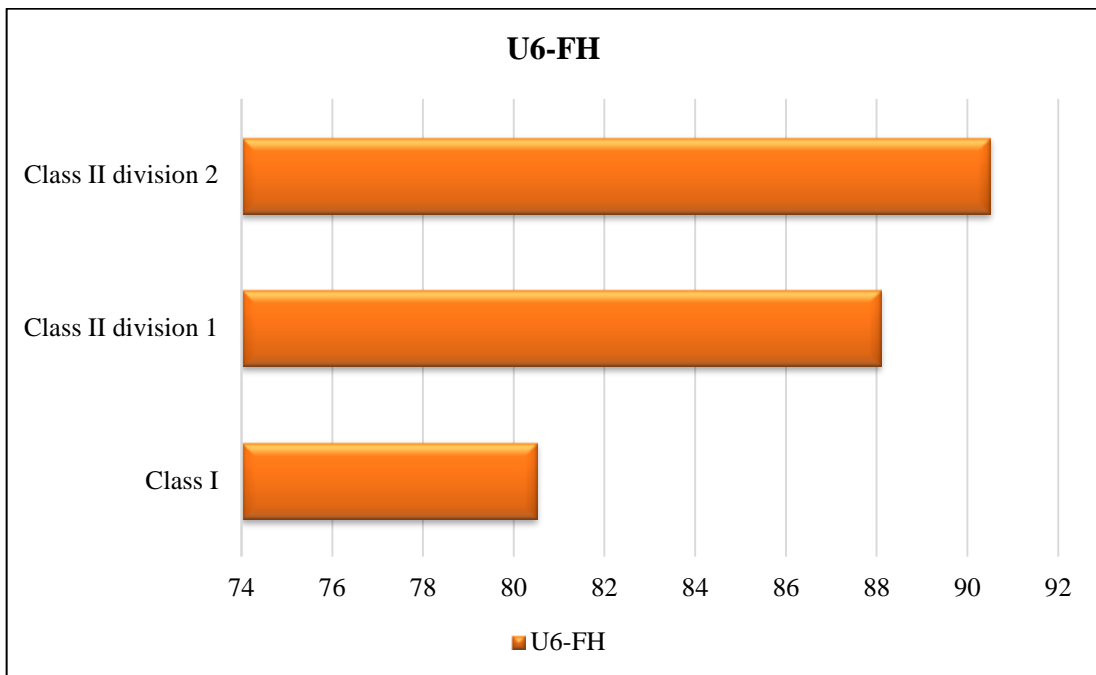


Fig. 16: Comparison of U6-FH amongst the three groups

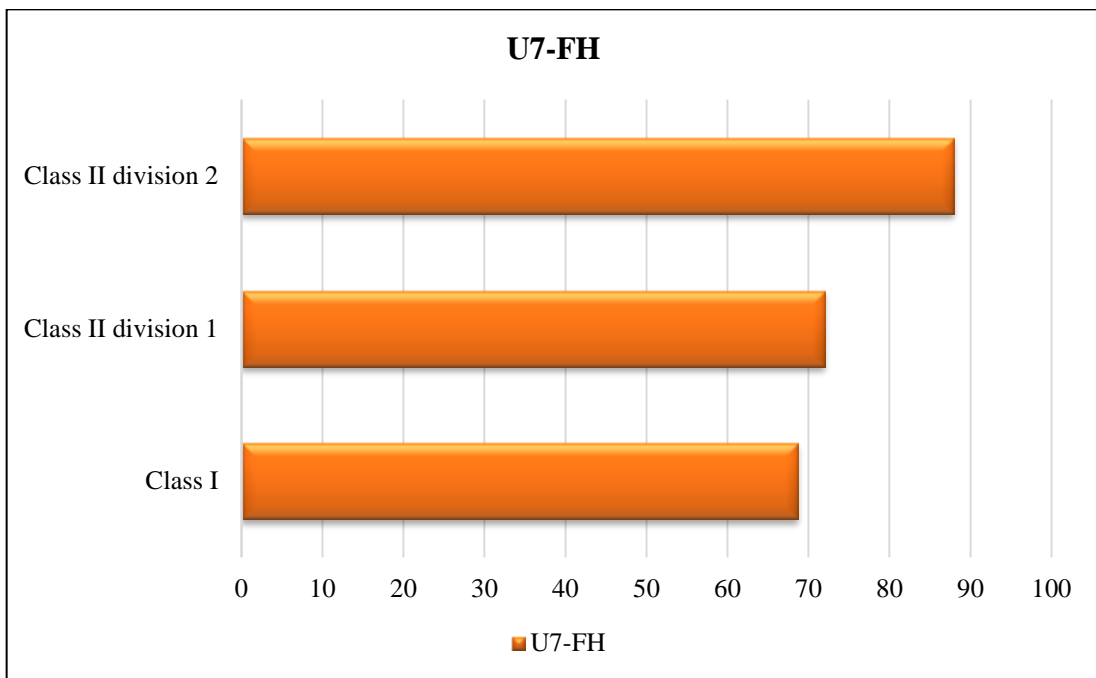


Fig. 17: Comparison of U7-FH amongst the three groups

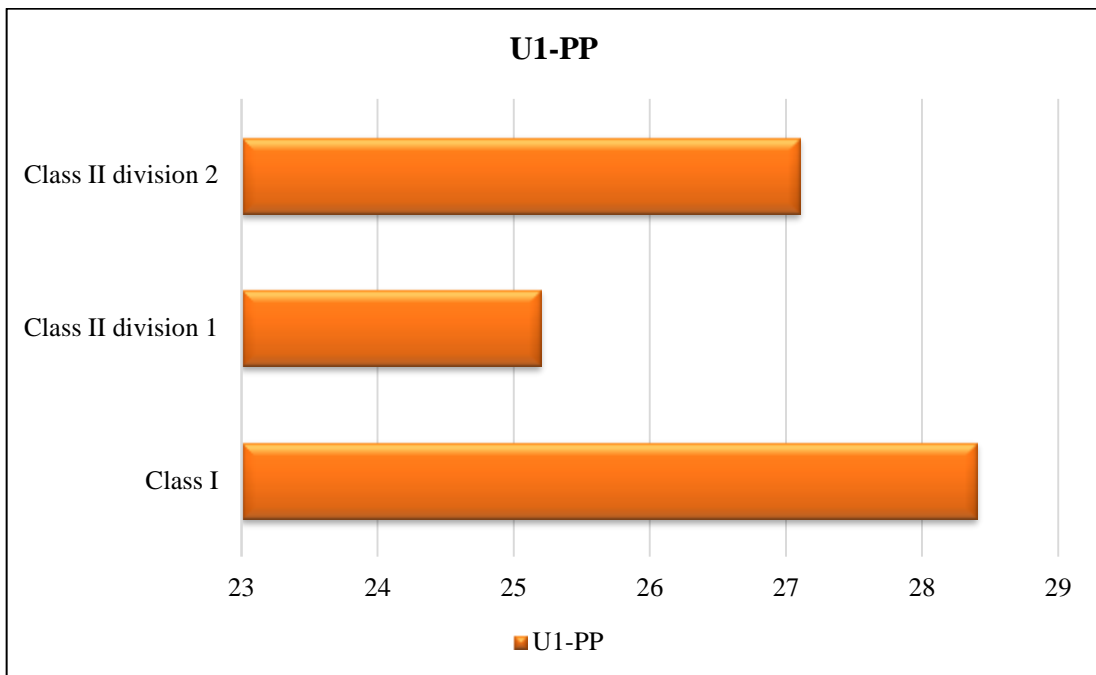


Fig. 18: Comparison of U1-PP amongst the three groups

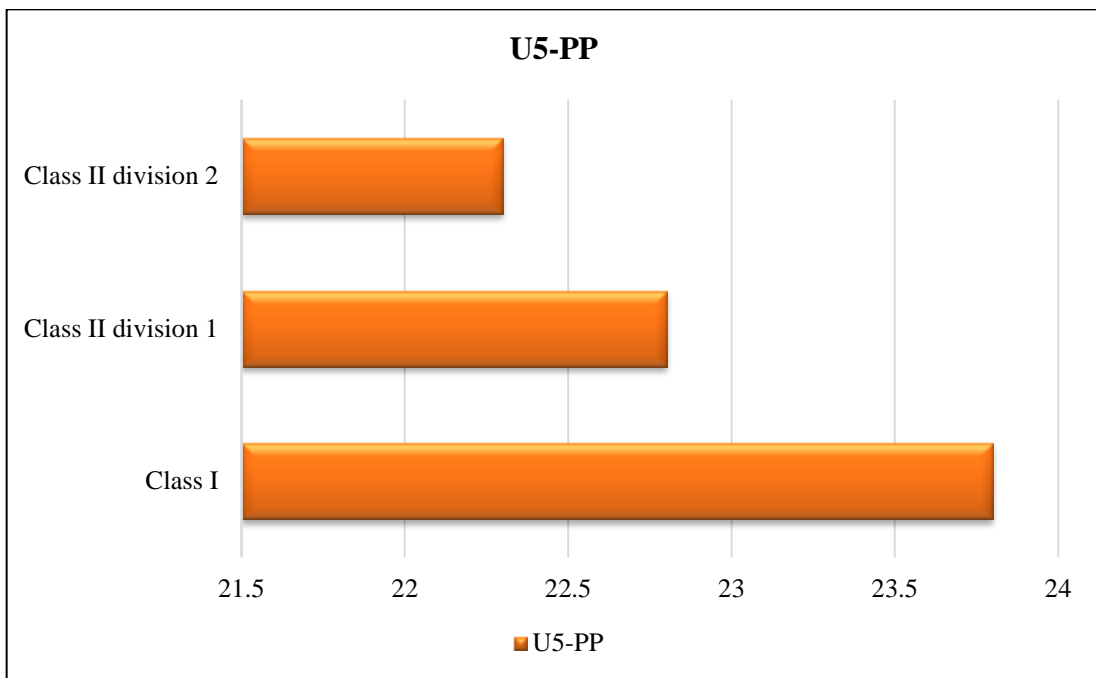


Fig. 19: Comparison of U5-PP amongst the three groups

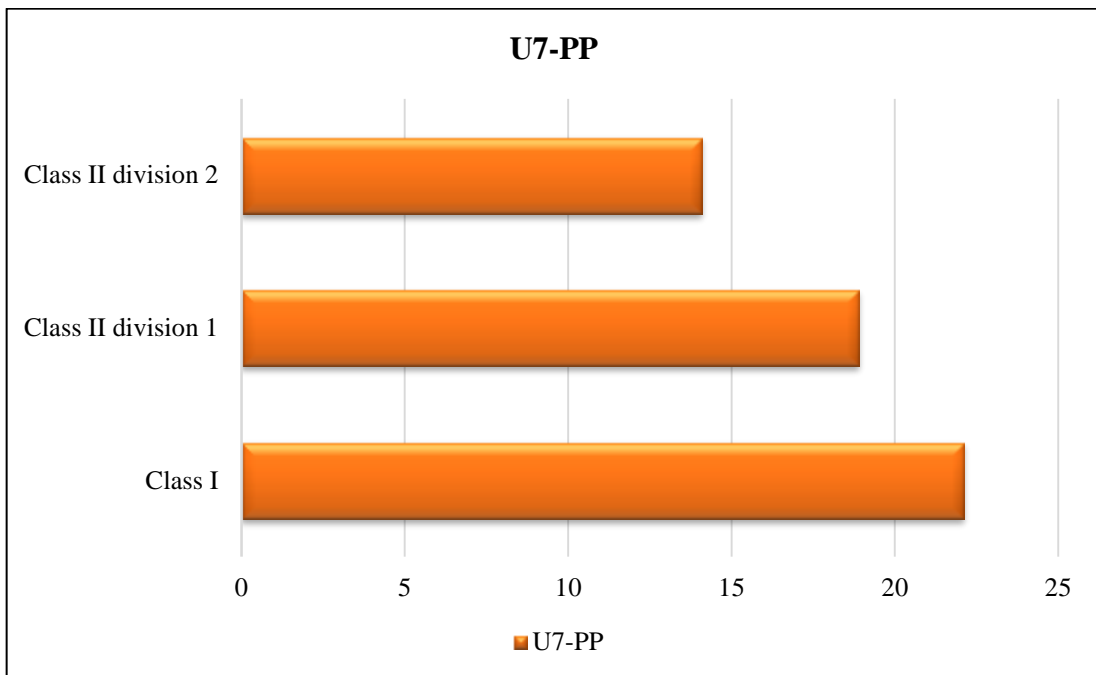


Fig. 20: Comparison of U7-PP amongst the three groups

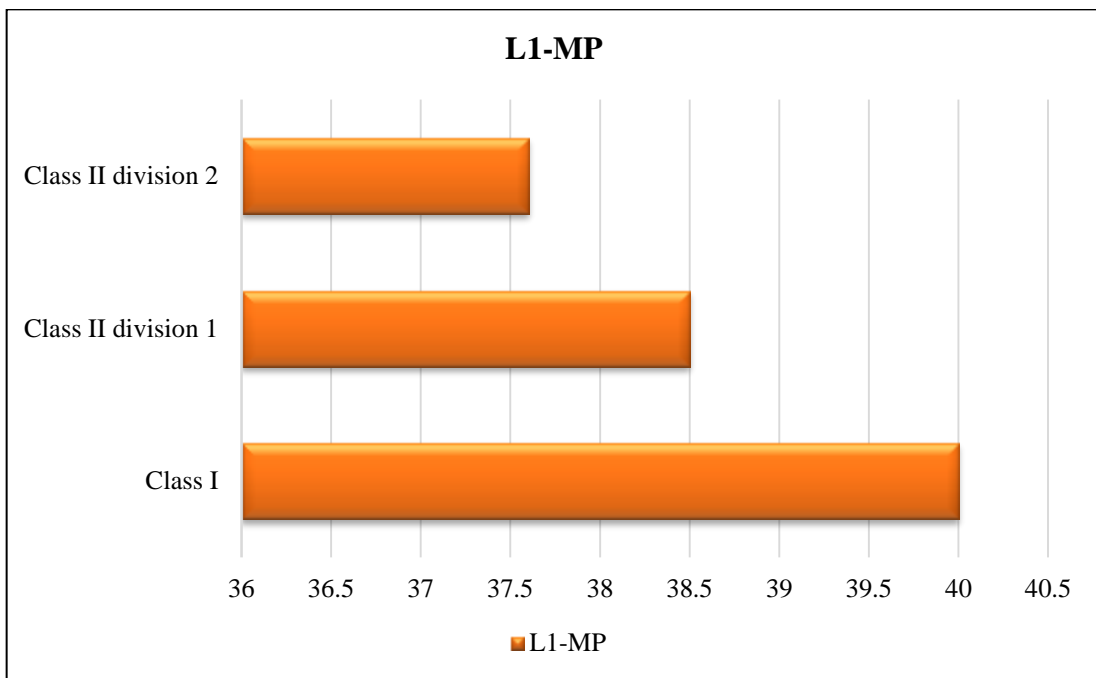


Fig. 21: Comparison of U1-MP amongst the three groups

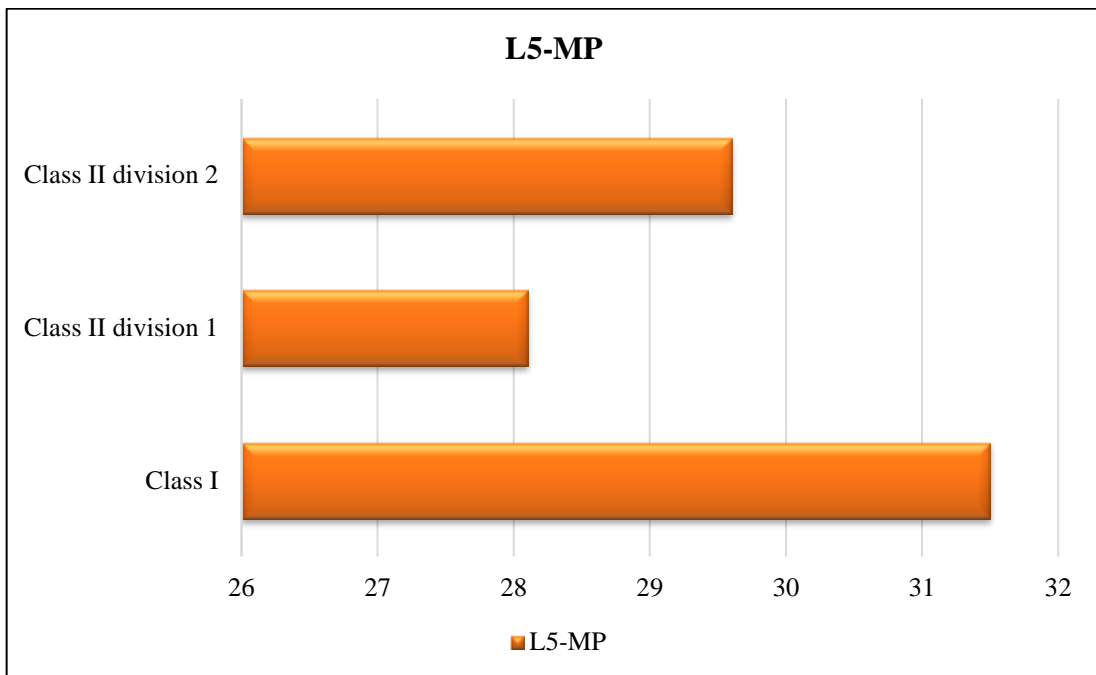


Fig. 22: Comparison of L5-MP amongst the three groups

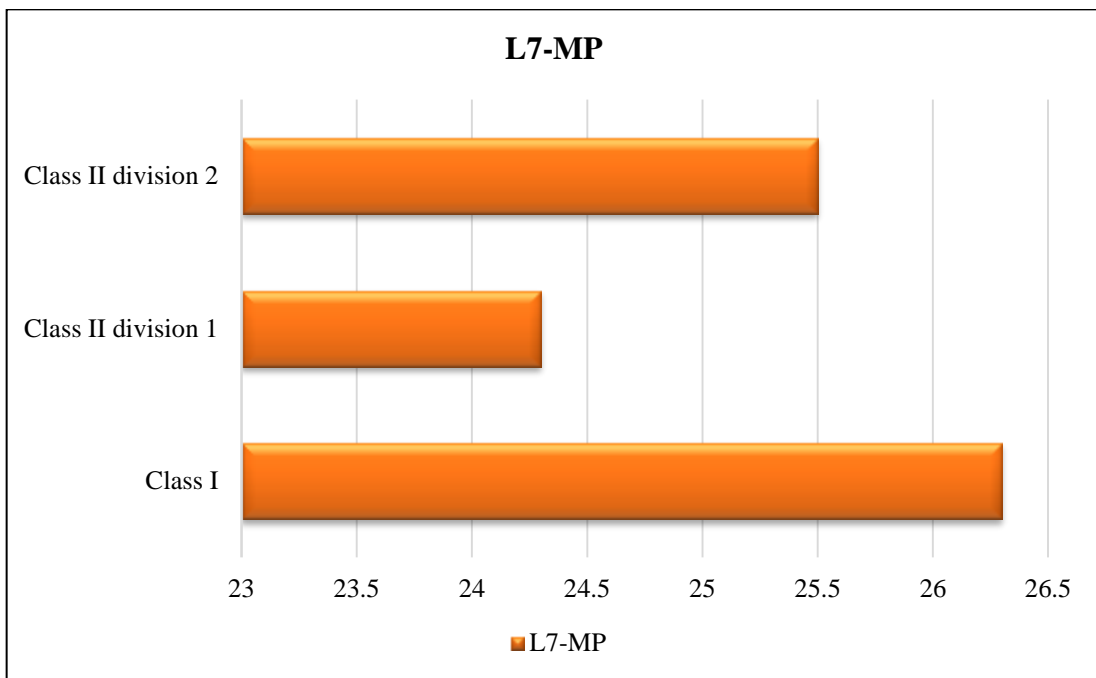


Fig. 23: Comparison of L7-MP amongst the three groups

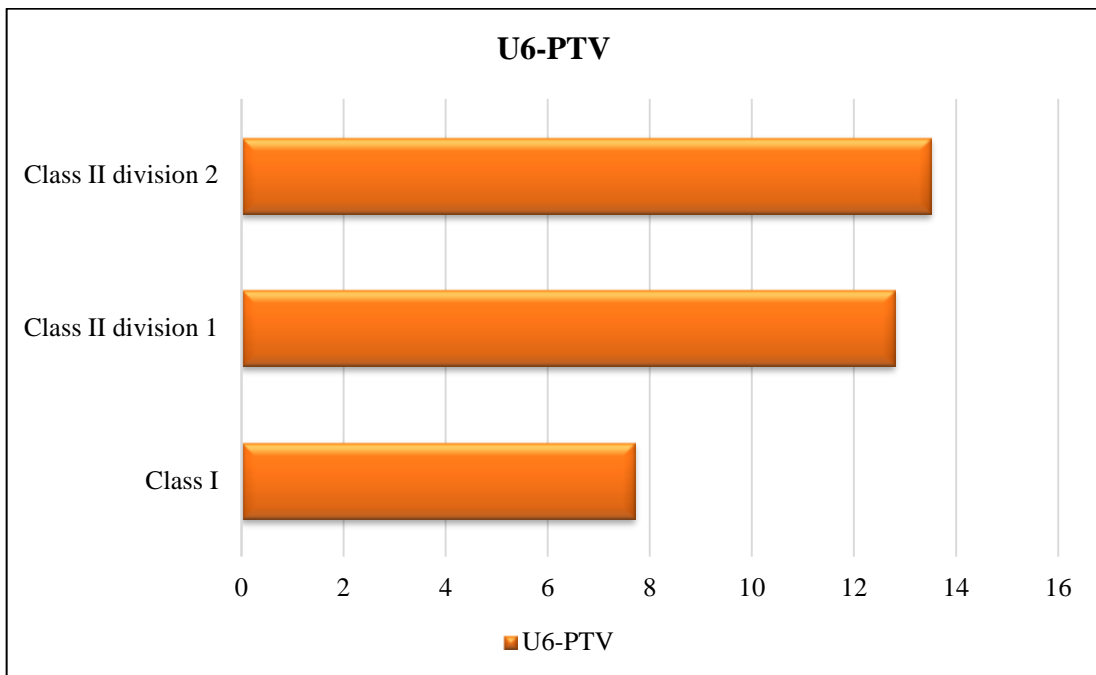


Fig. 24: Comparison of U6-PTV amongst the three groups

"Evaluation and comparison of anterior and posterior occlusal planes in Angles class I, class II division 1 and class II division 2 malocclusions - A cephalometric study."

CASE HISTORY PROFORMA

Name: _____ Age/ Sex: _____
Address: _____
Contact number: _____ OPD number: _____
Chief Complaint: _____
Past medical history: _____
Past dental history: _____
History of abnormal habit: _____

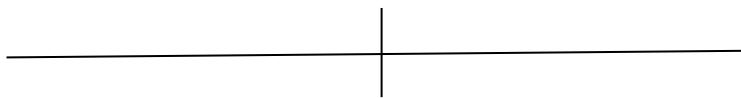
CLINICAL EXAMINATION:

• **EXTRAORAL EXAMINATION:**

Facial profile:
Facial symmetry:
Lip competency:
Nasolabial angle:
Mentolabial sulcus:
TMJ examination:

- **INTRAORAL EXAMINATION:**

Teeth present:



Teeth in occlusion:

Molar relation:

Canine relation:

Overjet:

Overbite:

Other findings:

- **PROBABLE DIAGNOSIS:**

Investigations:

Date

Staff signature

(Confidential)
Informed Consent Form

**"Evaluation and comparison of anterior and posterior occlusal planes in Angles
class I, class II division 1 and class II division 2 malocclusions
- A cephalometric study."**

NAME: Mr./Master/Mrs./Miss. _____

Resident of: _____

_____ aged _____ years, exercising my free will/choice, without any pressure/lure of incentive in any form, hereby give my consent for the project to be conducted by **Dr.** _____.

I acknowledge the receipt of "patient's information sheet", and also the doctor has informed me about this research project suitably and sufficiently to my satisfaction.

I agree to let my X-rays, photographs, other investigations to be taken as required.

I agree to take part in this project and will not mix any other projects during the period of this trial. I shall report to the dental hospital or other place where called on given appointment dates and time.

I certify that I have read or had read to me the contents of this form.

Date

Patient /legally authorized representative signature

MASTER CHART

| Sr. No. | Type of malocclusion | Skeletal Measurements | | | | | | | | | | | | | | Dental Measurements | | | | | | | | | |
|---------|----------------------|-----------------------|-------------|--------------|-----|-------------------|---------------------|----------|--------------|-------------------|------------------|----------------------|---------|------|---------|---------------------|---------|---------|---------|---------|---------|---------|----------|------|------|
| | | Angular Measurements | | | | | Linear Measurements | | | | | Angular Measurements | | | | Linear Measurements | | | | | | | | | |
| | | MPA | Facial Axis | Gonial Angle | PPA | Ramus Inclination | Na - A | Na - pog | Ramus Height | Mandibular Length | Maxillary Length | U1 - FH | L1 - MP | FMIA | U6 - FH | U7 - FH | U1 - PP | U5 - PP | U7 - PP | L1 - MP | L5 - MP | L7 - MP | U6 - PTV | A-OP | P-OP |
| 1 | CLASS I | 25 | 90 | 119 | -3 | 78 | -2 | -7 | 57 | 107 | 44 | 115 | 90 | 53 | 98 | 102 | 33 | 27 | 22 | 56 | 33 | 30 | 7 | 10 | 12 |
| 2 | CLASS I | 30 | 91 | 123 | -8 | 78 | -5 | -10 | 58 | 99 | 44 | 114 | 95 | 45 | 109 | 110 | 28 | 23 | 22 | 56 | 28 | 25 | 0 | 12 | 12 |
| 3 | CLASS I | 27 | 89 | 126 | 4 | 80 | -2 | -9 | 56 | 112 | 50 | 115 | 93 | 53 | 100 | 107 | 26 | 23 | 23 | 56 | 32 | 26 | 11 | 12 | 13 |
| 4 | CLASS I | 21 | 90 | 113 | 6 | 81 | -4 | -5 | 56 | 106 | 42 | 118 | 95 | 68 | 92 | 103 | 22 | 20 | 21 | 57 | 30 | 26 | 6 | 12 | 14 |
| 5 | CLASS I | 31 | 90 | 127 | 1 | 78 | -5 | -15 | 58 | 113 | 47 | 118 | 95 | 51 | 111 | 109 | 32 | 26 | 21 | 56 | 31 | 28 | 2 | 12 | 14 |
| 6 | CLASS I | 30 | 91 | 128 | 8 | 78 | -1 | -11 | 58 | 102 | 45 | 115 | 93 | 58 | 100 | 105 | 24 | 22 | 23 | 57 | 31 | 23 | 10 | 13 | 12 |
| 7 | CLASS I | 17 | 90 | 120 | 0 | 80 | 5 | 6 | 57 | 107 | 45 | 118 | 94 | 47 | 94 | 98 | 20 | 18 | 21 | 55 | 26 | 23 | 10 | 13 | 10 |
| 8 | CLASS I | 23 | 90 | 125 | 4 | 80 | 2 | 5 | 58 | 116 | 44 | 114 | 93 | 63 | 61 | 62 | 22 | 22 | 22 | 57 | 30 | 29 | 9 | 11 | 10 |
| 9 | CLASS I | 22 | 89 | 128 | -3 | 81 | 7 | -3 | 57 | 105 | 47 | 116 | 95 | 63 | 83 | 77 | 25 | 21 | 22 | 56 | 37 | 23 | 12 | 12 | 12 |
| 10 | CLASS I | 24 | 92 | 120 | 5 | 79 | -3 | -2 | 57 | 107 | 44 | 115 | 95 | 58 | 98 | 105 | 24 | 23 | 23 | 55 | 28 | 24 | 9 | 12 | 11 |
| 11 | CLASS I | 30 | 90 | 123 | 6 | 78 | -6 | -13 | 57 | 121 | 55 | 115 | 94 | 50 | 101 | 106 | 29 | 26 | 21 | 58 | 37 | 30 | 6 | 10 | 10 |
| 12 | CLASS I | 21 | 91 | 125 | 2 | 78 | -2 | -3 | 58 | 102 | 41 | 116 | 95 | 61 | 104 | 106 | 23 | 21 | 22 | 55 | 28 | 26 | 7 | 13 | 11 |
| 13 | CLASS I | 30 | 92 | 132 | 6 | 81 | -4 | -13 | 60 | 112 | 52 | 115 | 95 | 43 | 93 | 96 | 22 | 22 | 23 | 56 | 32 | 27 | 8 | 13 | 12 |
| 14 | CLASS I | 27 | 89 | 123 | 3 | 82 | -2 | -6 | 58 | 104 | 46 | 118 | 94 | 50 | 99 | 102 | 27 | 26 | 21 | 55 | 29 | 24 | 10 | 12 | 12 |
| 15 | CLASS I | 25 | 90 | 129 | 3 | 81 | -3 | -10 | 58 | 100 | 43 | 117 | 95 | 43 | 88 | 79 | 28 | 25 | 20 | 57 | 33 | 36 | 8 | 13 | 12 |
| 16 | CLASS I | 28 | 91 | 116 | 3 | 80 | -3 | -12 | 55 | 103 | 45 | 115 | 93 | 52 | 78 | 76 | 31 | 22 | 25 | 56 | 33 | 28 | 5 | 12 | 10 |
| 17 | CLASS I | 27 | 91 | 124 | 4 | 80 | -2 | -11 | 57 | 100 | 44 | 118 | 90 | 47 | 78 | 72 | 27 | 27 | 22 | 57 | 30 | 24 | 6 | 13 | 10 |
| 18 | CLASS I | 38 | 90 | 137 | 2 | 78 | 0 | -10 | 57 | 100 | 40 | 117 | 95 | 97 | 80 | 74 | 27 | 25 | 21 | 56 | 31 | 24 | 8 | 11 | 14 |
| 19 | CLASS I | 25 | 89 | 128 | 1 | 75 | -6 | 2 | 57 | 120 | 50 | 116 | 95 | 54 | 85 | 83 | 27 | 25 | 21 | 57 | 32 | 27 | 11 | 12 | 15 |
| 20 | CLASS I | 18 | 95 | 118 | 6 | 79 | -4 | -13 | 56 | 97 | 40 | 117 | 92 | 46 | 84 | 75 | 27 | 25 | 23 | 56 | 31 | 25 | 5 | 12 | 14 |
| 21 | CLASS I | 31 | 89 | 129 | 1 | 77 | 0 | -10 | 58 | 102 | 43 | 115 | 95 | 51 | 79 | 71 | 30 | 25 | 22 | 55 | 32 | 26 | 7 | 12 | 14 |
| 22 | CLASS I | 31 | 90 | 125 | 3 | 80 | -4 | -14 | 57 | 113 | 50 | 115 | 93 | 46 | 79 | 75 | 27 | 23 | 23 | 57 | 34 | 28 | 11 | 13 | 12 |
| 23 | CLASS I | 17 | 90 | 115 | -2 | 80 | -2 | 4 | 58 | 118 | 40 | 115 | 95 | 48 | 93 | 86 | 27 | 25 | 23 | 55 | 33 | 28 | 14 | 13 | 14 |
| 24 | CLASS I | 20 | 90 | 113 | -2 | 81 | -3 | -1 | 59 | 111 | 46 | 117 | 95 | 53 | 118 | 89 | 27 | 23 | 20 | 55 | 34 | 27 | 18 | 13 | 12 |
| 25 | CLASS I | 33 | 91 | 134 | -3 | 78 | -3 | -6 | 57 | 111 | 41 | 118 | 92 | 91 | 93 | 83 | 30 | 24 | 25 | 57 | 33 | 23 | 4 | 13 | 11 |
| 26 | CLASS I | 27 | 89 | 120 | -1 | 78 | -4 | -5 | 57 | 105 | 46 | 115 | 95 | 41 | 82 | 74 | 28 | 24 | 22 | 57 | 32 | 27 | 11 | 12 | 11 |
| 27 | CLASS I | 25 | 90 | 115 | 8 | 79 | -7 | -13 | 58 | 97 | 42 | 115 | 95 | 58 | 89 | 83 | 23 | 23 | 21 | 56 | 29 | 23 | 0 | 12 | 10 |
| 28 | CLASS I | 26 | 90 | 126 | 9 | 81 | -1 | -7 | 56 | 108 | 46 | 118 | 90 | 54 | 84 | 81 | 22 | 23 | 22 | 55 | 29 | 24 | 7 | 12 | 13 |
| 29 | CLASS I | 24 | 91 | 122 | 3 | 80 | 2 | 1 | 58 | 117 | 45 | 115 | 93 | 58 | 90 | 80 | 27 | 27 | 23 | 55 | 34 | 29 | 6 | 11 | 12 |
| 30 | CLASS I | 40 | 90 | 138 | 0 | 78 | -2 | -12 | 58 | 108 | 42 | 117 | 95 | 49 | 74 | 69 | 35 | 28 | 22 | 56 | 34 | 25 | 4 | 12 | 11 |

| Sr. No. | Type of malocclusion | Skeletal Measurements | | | | | | | | | | | | Dental Measurements | | | | | | | | | | | |
|---------|----------------------|-----------------------|-------------|--------------|-----|-------------------|--------|---------------------|--------------|-------------------|------------------|---------|---------|----------------------|---------|---------|---------|---------|---------|---------------------|---------|---------|----------|------|------|
| | | Angular Measurements | | | | | | Linear Measurements | | | | | | Angular Measurements | | | | | | Linear Measurements | | | | | |
| | | MPA | Facial Axis | Gonial Angle | PPA | Ramus Inclination | Na - A | Na - pog | Ramus Height | Mandibular Length | Maxillary Length | U1 - FH | L1 - MP | FMIA | U6 - FH | U7 - FH | U1 - PP | U5 - PP | U7 - PP | L1 - MP | L5 - MP | L7 - MP | U6 - PTV | A-OP | P-OP |
| 31 | CLASS II DIV 1 | 27 | 89 | 129 | 1 | 80 | -6 | -10 | 50 | 99 | 41 | 114 | 106 | 48 | 70 | 75 | 28 | 22 | 15 | 36 | 27 | 24 | 2 | 9 | 18 |
| 32 | CLASS II DIV 1 | 33 | 95 | 125 | 0 | 80 | -7 | -9 | 52 | 99 | 40 | 119 | 97 | 51 | 72 | 67 | 28 | 24 | 18 | 37 | 25 | 21 | 3 | 9 | 18 |
| 33 | CLASS II DIV 1 | 31 | 92 | 132 | 2 | 80 | -3 | -10 | 52 | 106 | 41 | 122 | 91 | 58 | 81 | 78 | 26 | 21 | 18 | 38 | 29 | 23 | 5 | 9 | 17 |
| 34 | CLASS II DIV 1 | 27 | 94 | 126 | 2 | 80 | -7 | -8 | 53 | 106 | 42 | 127 | 93 | 61 | 82 | 72 | 26 | 24 | 20 | 40 | 28 | 24 | 4 | 9 | 18 |
| 35 | CLASS II DIV 1 | 27 | 94 | 124 | 5 | 87 | -2 | -10 | 51 | 110 | 46 | 117 | 115 | 38 | 65 | 63 | 31 | 27 | 21 | 37 | 30 | 27 | 8 | 10 | 18 |
| 36 | CLASS II DIV 1 | 23 | 87 | 128 | 2 | 80 | -4 | -11 | 53 | 106 | 45 | 111 | 96 | 60 | 75 | 71 | 21 | 19 | 14 | 37 | 25 | 20 | 2 | 10 | 16 |
| 37 | CLASS II DIV 1 | 27 | 87 | 129 | 4 | 85 | 2 | -10 | 53 | 107 | 51 | 117 | 118 | 48 | 81 | 78 | 25 | 22 | 21 | 41 | 30 | 24 | 20 | 9 | 17 |
| 38 | CLASS II DIV 1 | 25 | 94 | 122 | 1 | 80 | -1 | -12 | 52 | 63 | 43 | 113 | 88 | 67 | 81 | 70 | 25 | 22 | 18 | 40 | 29 | 26 | 14 | 10 | 18 |
| 39 | CLASS II DIV 1 | 25 | 83 | 125 | 3 | 85 | 0 | -8 | 53 | 73 | 43 | 133 | 99 | 59 | 73 | 68 | 23 | 36 | 18 | 36 | 25 | 22 | 21 | 9 | 16 |
| 40 | CLASS II DIV 1 | 18 | 87 | 118 | -1 | 85 | 0 | -9 | 52 | 71 | 45 | 127 | 109 | 53 | 75 | 69 | 25 | 19 | 15 | 36 | 26 | 25 | 13 | 9 | 16 |
| 41 | CLASS II DIV 1 | 38 | 93 | 138 | 6 | 86 | -8 | -9 | 53 | 69 | 45 | 127 | 90 | 57 | 77 | 68 | 28 | 29 | 26 | 45 | 34 | 29 | 26 | 11 | 10 |
| 42 | CLASS II DIV 1 | 32 | 93 | 130 | 3 | 87 | -7 | -10 | 55 | 69 | 43 | 119 | 91 | 58 | 78 | 63 | 26 | 24 | 21 | 41 | 30 | 25 | 13 | 9 | 16 |
| 43 | CLASS II DIV 1 | 23 | 87 | 125 | 3 | 85 | -3 | -10 | 52 | 67 | 46 | 117 | 103 | 59 | 74 | 68 | 24 | 22 | 19 | 39 | 27 | 25 | 16 | 12 | 16 |
| 44 | CLASS II DIV 1 | 28 | 90 | 124 | 3 | 83 | -5 | -12 | 52 | 69 | 44 | 117 | 99 | 54 | 75 | 69 | 25 | 24 | 20 | 39 | 29 | 25 | 13 | 9 | 17 |
| 45 | CLASS II DIV 1 | 30 | 91 | 121 | 4 | 80 | -7 | -11 | 53 | 71 | 41 | 117 | 104 | 46 | 82 | 75 | 26 | 24 | 21 | 41 | 31 | 25 | 14 | 10 | 19 |
| 46 | CLASS II DIV 1 | 24 | 86 | 119 | 6 | 80 | -4 | -11 | 53 | 66 | 45 | 118 | 115 | 51 | 87 | 87 | 25 | 23 | 21 | 37 | 28 | 24 | 16 | 10 | 16 |
| 47 | CLASS II DIV 1 | 35 | 87 | 136 | 9 | 86 | -3 | -10 | 51 | 69 | 51 | 100 | 100 | 45 | 79 | 76 | 23 | 21 | 19 | 39 | 29 | 22 | 18 | 10 | 15 |
| 48 | CLASS II DIV 1 | 15 | 87 | 115 | -4 | 85 | 2 | -9 | 49 | 74 | 46 | 124 | 103 | 63 | 80 | 76 | 23 | 20 | 18 | 38 | 29 | 26 | 19 | 10 | 15 |
| 49 | CLASS II DIV 1 | 28 | 88 | 119 | 3 | 80 | 0 | -10 | 51 | 47 | 45 | 116 | 102 | 51 | 70 | 63 | 27 | 20 | 18 | 38 | 26 | 24 | 5 | 9 | 16 |
| 50 | CLASS II DIV 1 | 27 | 90 | 122 | 2 | 82 | -6 | -9 | 51 | 73 | 43 | 120 | 108 | 46 | 73 | 64 | 30 | 23 | 19 | 43 | 30 | 27 | 16 | 10 | 16 |
| 51 | CLASS II DIV 1 | 19 | 86 | 114 | 6 | 87 | 5 | -11 | 52 | 72 | 45 | 120 | 113 | 49 | 81 | 75 | 22 | 22 | 21 | 36 | 25 | 24 | 19 | 9 | 17 |
| 52 | CLASS II DIV 1 | 22 | 87 | 126 | -4 | 80 | 2 | -10 | 50 | 74 | 44 | 130 | 102 | 57 | 86 | 78 | 27 | 25 | 23 | 38 | 29 | 25 | 19 | 9 | 16 |
| 53 | CLASS II DIV 1 | 17 | 87 | 113 | 0 | 80 | 4 | -10 | 53 | 72 | 49 | 125 | 111 | 54 | 79 | 78 | 23 | 23 | 20 | 40 | 27 | 25 | 18 | 9 | 18 |
| 54 | CLASS II DIV 1 | 28 | 88 | 124 | 3 | 80 | -1 | -12 | 53 | 72 | 48 | 130 | 97 | 56 | 80 | 68 | 27 | 23 | 19 | 38 | 26 | 24 | 14 | 10 | 18 |
| 55 | CLASS II DIV 1 | 37 | 87 | 122 | 6 | 80 | -2 | -9 | 52 | 70 | 46 | 120 | 106 | 47 | 81 | 80 | 24 | 21 | 18 | 39 | 30 | 26 | 17 | 11 | 16 |
| 56 | CLASS II DIV 1 | 22 | 83 | 117 | 4 | 86 | -3 | -9 | 52 | 67 | 45 | 136 | 95 | 65 | 78 | 70 | 21 | 19 | 18 | 33 | 25 | 21 | 15 | 8 | 16 |
| 57 | CLASS II DIV 1 | 22 | 87 | 123 | 5 | 86 | -6 | -10 | 52 | 106 | 43 | 108 | 93 | 65 | 84 | 73 | 26 | 24 | 19 | 35 | 28 | 25 | 4 | 9 | 18 |
| 58 | CLASS II DIV 1 | 18 | 86 | 119 | -2 | 85 | 2 | -10 | 52 | 105 | 47 | 121 | 118 | 43 | 77 | 75 | 24 | 19 | 16 | 39 | 27 | 23 | 7 | 9 | 16 |
| 59 | CLASS II DIV 1 | 33 | 92 | 134 | 3 | 86 | 2 | -12 | 53 | 101 | 41 | 122 | 102 | 49 | 83 | 73 | 25 | 23 | 19 | 40 | 30 | 23 | 9 | 10 | 16 |
| 60 | CLASS II DIV 1 | 27 | 87 | 126 | 7 | 80 | -4 | -10 | 52 | 115 | 46 | 131 | 100 | 60 | 84 | 70 | 23 | 19 | 16 | 38 | 29 | 25 | 16 | 10 | 16 |

| Sr. No. | Type of malocclusion | Skeletal Measurements | | | | | | | | | | Dental Measurements | | | | | | | | | | | | | |
|---------|----------------------|-----------------------|-------------|--------------|-----|-------------------|---------------------|----------|--------------|-------------------|------------------|----------------------|---------|------|---------|---------|---------------------|---------|---------|---------|---------|---------|----------|------|------|
| | | Angular Measurements | | | | | Linear Measurements | | | | | Angular Measurements | | | | | Linear Measurements | | | | | | | | |
| | | MPA | Facial Axis | Gonial Angle | PPA | Ramus Inclination | Na - A | Na - pog | Ramus Height | Mandibular Length | Maxillary Length | U1 - FH | L1 - MP | FMIA | U6 - FH | U7 - FH | U1 - PP | U5 - PP | U7 - PP | L1 - MP | L5 - MP | L7 - MP | U6 - PTV | A-OP | P-OP |
| 61 | CLASS II DIV 2 | 20 | 83 | 115 | 2 | 89 | -1 | -9 | 51 | 100 | 47 | 78 | 95 | 65 | 68 | 69 | 26 | 20 | 9 | 64 | 24 | 22 | 0 | 8 | 19 |
| 62 | CLASS II DIV 2 | 22 | 89 | 115 | 4 | 89 | 0 | -8 | 49 | 113 | 48 | 112 | 108 | 50 | 68 | 75 | 27 | 24 | 15 | 63 | 31 | 30 | 17 | 8 | 21 |
| 63 | CLASS II DIV 2 | 14 | 87 | 111 | 1 | 87 | 2 | -6 | 51 | 73 | 43 | 73 | 99 | 68 | 70 | 83 | 27 | 25 | 15 | 64 | 32 | 28 | 25 | 8 | 21 |
| 64 | CLASS II DIV 2 | 25 | 89 | 122 | -3 | 89 | -8 | -33 | 51 | 70 | 49 | 90 | 97 | 58 | 68 | 80 | 28 | 24 | 12 | 64 | 31 | 24 | 16 | 6 | 20 |
| 65 | CLASS II DIV 2 | 21 | 85 | 110 | 3 | 87 | -6 | -8 | 49 | 77 | 56 | 97 | 100 | 63 | 69 | 78 | 29 | 24 | 14 | 64 | 36 | 31 | 16 | 7 | 18 |
| 66 | CLASS II DIV 2 | 20 | 84 | 112 | 4 | 85 | 0 | -14 | 51 | 74 | 48 | 76 | 99 | 77 | 69 | 73 | 24 | 21 | 15 | 63 | 26 | 23 | 13 | 8 | 20 |
| 67 | CLASS II DIV 2 | 28 | 81 | 127 | 3 | 84 | -4 | -14 | 50 | 72 | 46 | 89 | 95 | 58 | 68 | 68 | 23 | 19 | 14 | 63 | 23 | 24 | 15 | 7 | 21 |
| 68 | CLASS II DIV 2 | 33 | 73 | 136 | 7 | 87 | -7 | -22 | 50 | 63 | 42 | 90 | 87 | 61 | 69 | 66 | 26 | 19 | 14 | 63 | 31 | 20 | 16 | 7 | 21 |
| 69 | CLASS II DIV 2 | 28 | 97 | 131 | -2 | 85 | 0 | -11 | 51 | 63 | 41 | 98 | 93 | 58 | 69 | 72 | 27 | 20 | 13 | 60 | 32 | 23 | 16 | 7 | 22 |
| 70 | CLASS II DIV 2 | 30 | 88 | 119 | 10 | 89 | -6 | -11 | 51 | 78 | 56 | 86 | 96 | 54 | 71 | 63 | 30 | 26 | 15 | 64 | 27 | 28 | 16 | 8 | 21 |
| 71 | CLASS II DIV 2 | 27 | 90 | 118 | 1 | 87 | -9 | -14 | 49 | 67 | 40 | 93 | 95 | 58 | 68 | 78 | 27 | 22 | 15 | 63 | 31 | 23 | 11 | 6 | 21 |
| 72 | CLASS II DIV 2 | 29 | 96 | 124 | 3 | 89 | -3 | -12 | 52 | 67 | 41 | 91 | 97 | 55 | 70 | 67 | 27 | 22 | 14 | 62 | 33 | 26 | 14 | 6 | 20 |
| 73 | CLASS II DIV 2 | 29 | 93 | 128 | 0 | 87 | -6 | -19 | 51 | 74 | 46 | 92 | 91 | 60 | 67 | 65 | 31 | 25 | 12 | 61 | 29 | 30 | 10 | 6 | 20 |
| 74 | CLASS II DIV 2 | 20 | 83 | 115 | 2 | 88 | -1 | -9 | 53 | 100 | 47 | 78 | 95 | 65 | 68 | 69 | 26 | 20 | 14 | 65 | 24 | 22 | 0 | 6 | 18 |
| 75 | CLASS II DIV 2 | 22 | 89 | 115 | 4 | 88 | 0 | -8 | 51 | 113 | 48 | 112 | 108 | 50 | 69 | 75 | 27 | 24 | 14 | 66 | 31 | 30 | 17 | 7 | 20 |
| 76 | CLASS II DIV 2 | 14 | 87 | 111 | 1 | 88 | 2 | -6 | 51 | 73 | 43 | 73 | 99 | 68 | 69 | 83 | 27 | 25 | 14 | 64 | 32 | 28 | 25 | 8 | 20 |
| 77 | CLASS II DIV 2 | 25 | 89 | 122 | -3 | 87 | -8 | -33 | 52 | 70 | 49 | 90 | 97 | 58 | 68 | 80 | 28 | 24 | 16 | 63 | 31 | 24 | 16 | 7 | 21 |
| 78 | CLASS II DIV 2 | 21 | 85 | 110 | 3 | 89 | -6 | -8 | 52 | 77 | 56 | 97 | 100 | 63 | 68 | 78 | 29 | 24 | 15 | 65 | 36 | 31 | 16 | 7 | 21 |
| 79 | CLASS II DIV 2 | 20 | 84 | 112 | 4 | 87 | 0 | -14 | 50 | 74 | 48 | 76 | 99 | 77 | 68 | 73 | 24 | 21 | 15 | 64 | 26 | 23 | 13 | 7 | 22 |
| 80 | CLASS II DIV 2 | 28 | 81 | 127 | 3 | 87 | -4 | -14 | 50 | 72 | 46 | 89 | 95 | 58 | 69 | 68 | 23 | 19 | 14 | 63 | 23 | 24 | 15 | 8 | 21 |
| 81 | CLASS II DIV 2 | 33 | 73 | 136 | 7 | 89 | -7 | -22 | 51 | 63 | 42 | 90 | 87 | 61 | 70 | 66 | 26 | 19 | 15 | 63 | 31 | 20 | 16 | 8 | 21 |
| 82 | CLASS II DIV 2 | 28 | 97 | 131 | -2 | 87 | 0 | -11 | 50 | 63 | 41 | 98 | 93 | 58 | 68 | 72 | 27 | 20 | 14 | 64 | 32 | 23 | 16 | 6 | 21 |
| 83 | CLASS II DIV 2 | 30 | 88 | 119 | 10 | 88 | -6 | -11 | 50 | 78 | 56 | 86 | 96 | 54 | 68 | 63 | 30 | 26 | 14 | 64 | 27 | 28 | 16 | 8 | 18 |
| 84 | CLASS II DIV 2 | 27 | 90 | 118 | 1 | 88 | -9 | -14 | 50 | 67 | 40 | 93 | 95 | 58 | 69 | 78 | 27 | 22 | 14 | 63 | 31 | 23 | 11 | 8 | 25 |
| 85 | CLASS II DIV 2 | 29 | 96 | 124 | 3 | 90 | -3 | -12 | 51 | 67 | 41 | 91 | 97 | 55 | 69 | 67 | 27 | 22 | 16 | 64 | 33 | 26 | 14 | 8 | 20 |
| 86 | CLASS II DIV 2 | 29 | 93 | 128 | 0 | 86 | -6 | -19 | 51 | 74 | 46 | 92 | 91 | 60 | 71 | 65 | 31 | 25 | 15 | 62 | 29 | 30 | 10 | 6 | 20 |
| 87 | CLASS II DIV 2 | 27 | 90 | 118 | 1 | 87 | -9 | -14 | 48 | 67 | 40 | 93 | 95 | 58 | 68 | 78 | 27 | 22 | 14 | 63 | 31 | 23 | 11 | 7 | 20 |
| 88 | CLASS II DIV 2 | 29 | 96 | 124 | 3 | 89 | -3 | -12 | 51 | 67 | 41 | 91 | 97 | 55 | 68 | 67 | 27 | 22 | 14 | 65 | 33 | 26 | 14 | 6 | 21 |
| 89 | CLASS II DIV 2 | 29 | 93 | 128 | 0 | 90 | -6 | -19 | 50 | 74 | 46 | 92 | 91 | 60 | 69 | 65 | 31 | 25 | 14 | 64 | 29 | 30 | 10 | 8 | 21 |
| 90 | CLASS II DIV 2 | 20 | 83 | 115 | 2 | 87 | -1 | -9 | 50 | 100 | 47 | 78 | 95 | 65 | 68 | 69 | 26 | 20 | 15 | 61 | 24 | 22 | 0 | 8 | 20 |