ASSESSMENT OF TRANSVERSE DIMENSIONS IN DIFFERENT FACIAL GROWTH PATTERNS - A POSTERO - ANTERIOR CEPHALOMETRIC STUDY

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By

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I hereby declare that this dissertation entitled **"ASSESSMENT OF TRANSVERSE DIMENSIONS IN DIFFERENT FACIAL GROWTH PATTERNS: A POSTERO-ANTERIOR CEPHALOMETRIC STUDY"** is a bonafide and genuine research work carried out by me under the guidance of ***Dr. Sneh Lata Verma***, Reader, and ***Dr. Kamna Srivastava***, Reader, Department of Orthodontics and Dentofacial Orthopaedics, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

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-Dr. Sarbajit Saha

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S.NO.	ABBREVIATED FORM	FULL FORM
1.	PA	Postero-anterior cephalogram
2.	FMA	Frankfort's Mandibular plane angle
3.	S	Sella
4.	Or	Orbitale
5.	N	Nasion
6.	Po	Porion
7.	Go	Gonion
8.	Me	Menton
9.	FHP	Frankfort Horizontal plane
10.	PFH	Posterior Facial Height
11.	AFH	Anterior Facial Height
12.	Zf	Fronto-zygomatic suture
13.	ZA/AZ	Zygomatic arch
14.	Or,me	Outer medial bony orbital boundary
15.	ANS	Anterior nasal spine
16.	J	Jugale point

17.	AG/GA	Antegoneal notch
18.	A6/6A	Right maxillary molar/Left maxillary molar
19.	B6/6B	Right mandibular molar/Left mandibular molar
20.	A3/3A	Right maxillary canine/Left maxillary canine
21.	B3/3B	Right mandibular canine/Left mandibualr canine
22.	Co	Mandibular condyle
23.	Cg	Crista galli
24.	A1	Maxillary central incisor
25.	B1	Mandibular central incisor
26.	OP	Occlusal point
27.	MSR	Mid-sagittal reference plane

Aim: To evaluate and compare transverse dimensions in subjects with variable facial growth patterns using postero-anterior (PA) cephalogram.

Material and method: Lateral cephalogram of 70 subjects who fulfilled the inclusion criteria were selected from records of subjects who came to Department of Orthodontics, B.B.D.CODS, Lucknow for Fixed orthodontic treatment, for sample distribution based on facial divergence using Jarabak ratio and Frankfort's mandibular plane angle.

Postero-anterior (PA) cephalogram was taken for selected subjects and divided into three groups: Group I (normodivergent subjects, n=20); Group II (hypodivergent subjects, n=20) and Group III (hyperdivergent subjects, n=20). PA cephalogram was traced using Nemotec software and nine skeletal and four dental parameters were measured and tabulated for all groups and appropriate statistical tests (ANOVA, Tukey's HSD test) were used for appropriate comparison of transverse dimensions.

Result: The skeletal transverse dimensions – inter-canthal width, facial width, maxillary width and mandibular width and dental parameters - inter-molar distance showed statistically significant difference between groups. On inter-group comparison, Group II differed significantly with Group I as well as Group III. However, Group I vs Group III did not show any statistically significant difference.

Conclusion: Transverse skeletal dimensions increased with decrease in mandibular plane angle. Hence, growth pattern must be considered when planning correction of discrepancies in transverse plane.

Keywords: Transverse discrepancy, Facial divergence, Normo-divergent, Hypodivergent,

Hyperdivergent.

Orthodontic diagnosis involves collection of relevant data in a systematic manner to help in identifying the nature and cause of the malocclusion in all three planes of space i.e. antero-posterior, vertical and transverse planes.[1]

Management of orthodontic discrepancies involves correction of malocclusion in each plane, as discrepancy in one plane is influenced by discrepancies in other planes as well. This is the reason for adding maxillary expansion in myofunctional appliances in growing subjects, so as to correct transverse discrepancy for smooth functional positioning of mandible in sagittal plane.

Radiographic investigation[2] is an essential part of orthodontic diagnosis; however, most of the emphasis has been given to the lateral cephalometric evaluation which provides the information about dentoalveolar and soft tissue disarrangements in sagittal and vertical plane.

Growth completes in transverse plane firstly, followed by antero-posterior dimension and vertical dimension attain growth completion lastly. Hence, early assessment of transverse discrepancy is of paramount importance in making proper diagnosis in frontal plane[3]. Also, it is important to differentiate between skeletal and dental inputs for transverse discrepancy.

Transverse maxillary dimension is one of the critical aspects of a functional and stable occlusion. Foster and Hamilton[4] in 1969, conducted an assessment of occlusion of children under 3 years old. They deduced that malocclusion in the transverse plane had a prevalence of 8-16% in primary dentition as opposed to 9-24% in adults. Bjork[3] stated that growth of the facial structures in all planes is normally completed by the age of 17 years and the mean transverse growth between the ages of four years to adulthood is about 6.9 mm only. Another longitudinal growth study by McNamara and Brudon[5] found that the transpalatal width increased by just 2.6 mm between the ages of 7 and 15 for both the genders. As growth in transverse plane completes at younger age group, hence early identification is important to avoid its unfavorable sequelae.

When left undiagnosed, a transverse discrepancy can lead to adverse periodontal response, unstable dental camouflage, and less than optimal dentofacial esthetics. Discrepancy in Transverse plane can result in posterior crossbite,[6] that could be bilateral or unilateral, if there is convenient swing of mandible to one of the sides to achieve occlusion with maxillary arch.

The assessment of discrepancies in transverse plane can be done by assessment of arches on study models or using two-dimensional or three-dimensional radiographs.

Many studies have tried to establish relationship between arch width and arch form and vertical facial morphology with different malocclusion types. They found that subjects with dolichofacial types had leptoprosopic facial form with dental crowding exhibited in the dental arches, while brachyfacial types had euryprosopic faces with broad dental arches. Forster[7] found decreased width of dental arch with increasing mandibular plane angle for Class I subjects. Similar findings, were seen by Giuntini et al[8] for maxillary arch form in Class II subjects both in inter-molar and inter-canine regions. Most of these studies stressed on respecting individual arch form of subjects as per growth pattern. Dental discrepancy as seen on study model should be correlated with skeletal discrepancy of underlying jaw bases.

For evaluating the structure of the craniofacial skeleton in transverse and vertical plane, the postero-anterior cephalogram is an effective tool which allows to look at the facial skeleton from frontal view. This helps in evaluation of facial asymmetries or other craniofacial anomalies and helps in differentiating between discrepancies of right and left side in transverse plane. Also, three-dimensional imaging techniques like computed tomography or Cone Beam Computed Tomography (CBCT)[9] helps in assessment of discrepancy in the transverse plane. However, CBCT had certain disadvantages like limited contrast resolution, requirement of extensive armamentarium and additional radiographic exposure. Therefore, postero-anterior Cephalogram was taken to assess discrepancies in transverse plane in present study

Various analyses had been developed to assess discrepancies in transverse plane using postero-anterior cephalograms. Betts et al.[10] developed a cephalometric analysis for postero-anterior cephalograms, which calculates the transverse maxillomandibular width differential. Grummons[11] and Ricketts'[12] frontal analysis are used commonly to assess variable parameters in transverse plane. Amongst these, it was decided to assess the transverse plane discrepancy using selected parameters for Ricketts' analysis.

Grayson et al[13] stressed on the importance of postero-anterior (PA) cephalometric radiograph to assess the severity of the facial asymmetry. Liu et al[14] in his in-vivo study described dental arch dimensions, and for determining the occlusal plane tilt in subjects with transversal malocclusion with crossbite on the right side. This study highlighted the fact that patients with transversal disharmony had constriction on the corpus maxillae and higher angular values were reported in subjects presenting with a unilateral cross-bite.

Transverse plane had been assessed in study models for subjects with variable facial growth pattern. However, none of the studies had evaluated dental and skeletal characteristics in transverse plane in subjects with different facial growth patterns.

Considering this, the aim of the present study was to evaluate and assess transverse dimensions in subjects with variable facial growth patterns, using postero–anterior cephalograms.

AIM:

The aim of this study was to evaluate and compare transverse dimensions in subjects with variable facial growth patterns, using postero-anterior cephalograms.

OBJECTIVES:

1. To access the facial transverse dimension in subjects with average growth patterns.
2. To access the facial transverse dimension in subjects with horizontal growth patterns.
3. To access the facial transverse dimension in subjects with vertical growth patterns.
4. To compare transverse dimensions in subjects with different growth patterns.

Foster D T and Hamilton C M (1969)[4] conducted a study on the dentition and dental arch dimensions in British children at the age of 2 and a half to 3 years. It was found from the study that Malocclusion in the transverse plane has a prevalence of 8-16% in primary dentition as opposed to 9-24% in adults.

Bjork A and Skieller V (1977)[3] studied the transverse growth of the maxilla by means of the metallic implant method. The sample consisted of 9 boys without malocclusion of the teeth who had never received orthodontic treatment. Follow up was done annually from 4 years of age. From frontal radiographs, sutural growth in the width of the maxilla was determined as the increase in the distance between metallic implants inserted at the lower aspect of the maxillary zygomatic process on each side of the maxilla in this area. To assess whether growth in the median suture was of the same amount throughout its length, metallic implants were also inserted anteriorly into the maxilla on each side of the median suture, on a level with the apices of the central incisors. It was seen that the increase in distance between the laterally placed implants were three times greater than between the anterior implants for a corresponding period of time. Thus, it was concluded that the sutural separation of the two maxillae was greater posteriorly than anteriorly, and consequently they rotate in the transvers plane in relation to each other.

Staley N. Robert, Stuntz R. Wendell, Peterson C. Lawrence (1985)[15] conducted a study to compare arch widths and other cast and cephalometric measurements of 36 subjects with normal occlusion (19 males, 17 females) and 39 subjects with Class II Div I malocclusion (20 males, 19 females). The subjects with normal occlusion had larger maxillary molar widths, maxillary canine widths, and maxillary alveolar height widths than the maxillary occlusion subjects. Further, the normal occlusion and malocclusion groups had similar mandibular canine widths and when the lower molar and alveolar widths were subtracted from corresponding upper widths, the remainders of the Class II group were negative instead of positive, contrary to the normal group. This revealed a posterior crossbite tendency in the Class II group.

Grummons D C, Coppello Kappeyne A M (1987)[11] introduced a method of analysis of the face, that offered an assessment of quantitative and comparative symmetry. He said that this information can be correlated with lateral cephalometric data to complete a three-dimensional facial assessment. Several standard points and planes from the PA radiograph were chosen and additional points were selected on the basis of their reliability in determining asymmetry. Four planes were drawn to show the degree of parallelism and symmetry of the facial structures. The MSR was selected as a key reference line as it closely follows the visual plane formed by subnasale and the midpoints between the eyes and the eyebrows. It was concluded that this analysis provided a practical functional method of determining the locations and amounts of facial asymmetry, and when integrated with data from lateral and submentovertex radiographs, it had much more clinical importance.

Grayson H B, McCarthy G J , Booksteinn F (1988)[13] presented a multi-plane three-dimensional cephalometric analysis on a subject with Hemifacial Microsomia, that permitted visualization of skeletal midlines at selected depths of the craniofacial complex. Thus, the study of structures in various coronal and transverse planes made it possible to measure and record the three-dimensional relationships of anatomic structures to one another. When the midlines and associated anatomic structures are studied sequentially, the individual midlines may be combined conceptually into a warped midsagittal "plane."

Snodell F Stephen, Nanda S. Ram, Currier Frans G (1993)[16] conducted a cephalometric study to investigate longitudinal growth changes using radiographs of 25 male subjects from 4 to 25 years of age and 25 female subjects from 4 to 20 years of age who had Class I skeletal and dental patterns. Each cephalometric radiograph was traced, and the landmarks were computer digitized. Nine transverse measurements namely, the Cranial width, facial width, nasal width, maxillary width, mandibular width, intermolar widths of the maxillary and mandibular first and second molars were taken. Also, five linear vertical measurements were taken i.e. Total facial height, upper facial height, lower facial height, right and left ramus height. The data were analyzed for growth changes in group means and growth changes at the individual level. The study's results supported earlier reports that found there was significantly more vertical growth than transverse growth between the ages of 6 and 18. In this study, the largest dimension of the face was its facial width. Also, large increase in percentages was seen in all vertical dimensions within the range of 32% to 40% in males aged 6 to 18 years. Vertical measurements rose by roughly 19% to 26% for females. Excluding cranial width, skeletal transverse measurements rose by 18% to 27% in men and 13% to 25% in women. The increase in cranial width was much smaller, ranging from 4% to 6%. The percentage change between 6 and 12 years showed that there was not much of a difference between the transverse and vertical skeletal measurements (10% to 20%).

Betts J N, Vanarsdall L R, Barber D H, Barber Higgins K (1995)[10] stated that the kind and severity of the transverse deficiency, the patient's growth status, stability considerations, dentofacial esthetics, and the condition of the periodontal tissues must all be taken into account while formulating an appropriate treatment plan. Their report recommended surgical procedures that were to be undertaken, in order to improve frontal dentofacial esthetics, and for improved stability, and promoting long-term periodontal health. Also, included were particular adjustments to surgical technique related to the timing, sequencing, and repair of transverse deficit.

Vanarsdall L. Robert, Jr (1999)[17] discussed the importance of the skeletal differential between the width of the maxilla and the width of the mandible. The undiagnosed transverse discrepancy leads to adverse periodontal response, unstable dental camouflage, and less than optimal dentofacial aesthetics. Eliciting tooth movement for children (orthopedics, lip bumper, Cetlin plate) in all three planes of space by muscles, eruption and growth, develops the broader arch form (without the mechanical forces of fixed or removable appliances) and has also demonstrated impressive long-term stability.

Lee T. Robert (1999)[18] presented a number of clinical cases to illustrate the potential for change in arch dimension. According to them, limited degrees of arch expansion can be produced regularly, but careful case selection is necessary and it is most likely to be achieved in the growing patient with correction of crossbites., correction of a Class II malocclusion, and achievement of a good intercuspation without extractions.

Huertas D, Ghafari J (2001)[19] evaluated posteroanterior (PA) cephalometric characteristics in a normal longitudinal database and compared these measurements with corresponding measures in a group of patients treated with rapid maxillary expansion. The treatment group included the pre-treatment postero-anterior (PA) cephalographs of 24 patients (16 girls and 8 boys) treated with rapid maxillary expansion in the orthodontic graduate clinic of the University of Pennsylvania School of Dental Medicine. The results support previous conclusions that different normative data should be used for males and females when linear measurements are considered. Interestingly, using the linear difference ([AG}AG]-[J-J]) between the jaws, the angles J-CO-AG showed greater correlations than J-Cr-AG. This helped to identify which of the jaws deviates from the norm in addition to identifying any disagreement between the jaws and the angles J-Cr-midline and AG-Cr-midline, or the related measures linking J and AG to the vertical through CO parallel to the midline. These angles also help to determine asymmetry of jaw position between right and left sides.

Trpkova B, Prasad G. Narasimha, Lam NW Ernest, Raboud Donald, Glover E. Kenneth, Major W Paul (2003)[20] tested ten horizontal and 15 vertical reference lines, including best-fit lines and lines most commonly used in postero-anterior (PA) analysis. A model of a dry skull was devised to create 30 asymmetric positions of the maxillomandibular complex. The true transverse and vertical asymmetries were calculated based on measurement of changes in the position of 24 skeletal and dental landmarks. Linear regressions analyses were used to compare the actual asymmteries with those measured cephalometrically indicated excellent agreement between the true asymmetries and the measured vertical asymmetries. It was further deduced that Crista-galli-anterior nasal spine and nasion-anterior nasal spine had the lowest validity and should not be used in cephalometric analysis of asymmetries. The position of anterior nasal spine will be altered in facial asymmetry involving the maxilla.

Kusayama Masaomi, Motohashi Nobuyoshi, Kuroda Takayoki (2003)[21] evaluated the relationship between transverse dental anomaly and skeletal asymmetry, using frontal cephalometric and 3-dimensional dental model analyses of 44 adult Japanese Class III patients (mean age 21 years 11 months) who required orthognathic surgery because of severe skeletal deformities. The transverse asymmetry was assessed using the following metrics: Lo/Lo} (ratio) for the upper face; Mx/Mx (ratio), Mo/Mo (ratio), Zyg/Zyg (ratio), U1 (mm) for the middle face; Go/Go (ratio), Me (mm), and L1 (mm) for the mandible. The vertical imbalance was assessed using the following metrics: Mandible: Cd-Cd (°), Go-Go} (°); middle face: Zyg-Zyg (°), Mx~Mx (°), Mo-Mo (°). After the patients were split into two groups based on the degree of facial asymmetry, notable morphological variations were identified in the frontal cephalometric study but absent from the lateral analysis. Statistical comparison disclosed more detailed transverse anomalies like upward slanting of the occlusal planes, significant differences in the Curve of Spee, lateral overjet, labial tipping of the maxillary molar inclination and lingual tipping of the mandibular molar inclination of the mandibular shifted side.

Alarashi M, Franchi L, Marinelli A, Defraia E (2003)[22] compared the dentoskeletal features of Class II malocclusion with Class I malocclusion in the transverse plane by means of a morphometric analysis applied to postero-anterior cephalograms. When a thin-plate spline (TPS) analysis was used on PA cephalograms, it was possible to see significant shape variations between patients with Class II malocclusion and those with normal occlusion in the mixed dentition.

Franchi L, Baccetti T. (2004)[23] conducted a study to evaluate the dentoskeletal features of subjects with either Class II or Class III malocclusions in the mixed dentition using both conventional cephalometric analysis and TPS morphometric analysis applied to postero-anterior (PA) cephalograms. TPS analysis of postero-anterior (PA) cephalograms on 49 Class II and 20 Class III subjects. Maxillary width was smaller in both Class II and Class III subjects compared with normal as measured conventionally. The TPS analysis revealed transverse plane compression and extension in the vertical plane. It was concluded that in Class II and Class III subjects, the maxillary width was smaller 2.5 mm and 4 mm respectively than subjects with normal width.

Janson G, Bombonatti R, Cruz S. Karina, Hassunuma Y. Cristina, Santo D. Marinho (2004)[24] in their study compared the buccolingual inclination of the posterior teeth in subjects with a horizontal growth pattern with that of subjects with a vertical growth pattern. The final sample consisted of 70 subjects' pretreatment dental study models, split into two groups based on their horizontal and vertical facial growth patterns. Two groups of seventy subjects with permanent dentition were formed. Thirteen male and twenty female subjects with Class II Division 2 malocclusion made up Group I, while fifteen male and twenty female subjects with a vertical growth pattern made up Group II. By measuring the occlusal surface inclination of the first molar and second premolar (represented by an imaginary line connecting the lingual and buccal cusps), the buccolingual inclinations of these teeth were indirectly evaluated on photos of the buccolingual sections of these teeth. T tests were used to compare the groups ($P < 0.05$). When compared to subjects with a horizontal growth pattern (group I), the maxillary posterior teeth of subjects with a vertical growth pattern (group II) had a significantly greater buccal inclination. The maxillary palatal cusp height of group I was statistically greater than that of group II; no other significant difference was observed regarding intergroup cusp heights.

Tancan U, Zafer S (2005)[25] conducted a study to establish cephalometric norms from posteroanterior cephalograms for untreated Turkish adults with ideal occlusion and well-balanced faces. They wanted to identify possible gender differences in these norms, and also compare Turkish norms with the norms of other groups, in order to identify possible correlations between all investigated transverse linear measurements. It was found that for Turkish adults, posterior-anterior transverse linear norms were largely comparable to Ricketts' clinical norms. Fifteen out of the nineteen craniofacial transverse measurements demonstrated a notable sexual dimorphism. All investigated measures were higher in Turkish men than in women. In the majority of the measurements, statistically significant correlations were found.

Wagner M. Dawn, Chung HC (2005)[26] in their cephalometric study investigated the maxillary and mandibular transverse growth in untreated female subjects with low, average, and high mandibular plane angles longitudinally from ages 6 to 18. 31 of the 81 white girls in the sample were drawn from the Bolton-Brush Growth Study at 50 miles from the Burlington Growth

Centre at the University of Toronto in Canada and Western Reserve University in Cleveland, Ohio. The definitions of the landmarks of the PA and lateral cephalograms corresponded to those given by Ricketts et al and Riolo et al. The sample was divided into 3 groups according to the MP-SN angles as high, average and low angle. In this study, it was found that, compared to the low-angle group, the high-angle group's maxillary (J-J) and mandibular (Ag-Ag) widths were smaller at age 6. Up until the age of eighteen, this pattern persisted. From ages 6 to 14, all three groups experienced a similar increase in maxillary transverse growth (J-J) of 0.90 to 0.95 mm annually. After the age of 14, there was little to no more maxillary transverse growth. Up until the age of 14, the mandibular transverse growth (Ag-Ag) of the low-, average-, and high-angle girls increased at a constant rate (1.6 mm/year). The high-angle group showed a plateau at age 14, while the low- and average-angle groups continued to grow until age 18 (0.85 mm and 0.39 mm per year, respectively). Also, it was deduced that vertical facial patterns (with low or high MP-SN angles) may be strongly related to the mandible's and maxilla's transverse growth.

Behbehani F, Artun J, AJ Badreia, Kerosuo H (2006)[27] conducted a cephalometric study to ascertain whether cephalometric values differed in Kuwaiti adolescents' from those of Caucasian adolescents and if there was any disparity between males and females in both the groups. Between the ages of 11 and 14, standardized cephalometric films were taken from 36 Kuwaiti females and 32 Kuwaiti boys. By deducting the White cephalometric value from the Kuwaiti cephalometric value (Kuwaiti 2 White) for each variable in each paired film, the differences between the Kuwaiti and White cephalometric values were computed. The significant differences between Kuwaitis and Whites were found using paired t-tests. According to the findings, the Kuwaiti population and the White population differ significantly from one another for the majority of the variables examined ($P < 0.01$).

Hesby M. Richard, Marshall S (2006)[28] conducted a postero-anterior cephalometric study to determine the transverse skeletal changes that accompany molar movements during growth. The sample consisted of 89 boys and 86 girls of primarily northern European descent and above-average socioeconomic status. Orthodontic records were taken semi-annually from ages 3 to 12 years, annually during adolescence, and once during early adulthood. All subjects were free of facial or skeletal disharmony and had normal (Angle Class I) molar and canine occlusions.

Transverse maxillary and mandibular dentoalveolar and skeletal widths were measured for each subject by using posteroanterior radiographs and dental casts. It was found that transverse maxillary basal bone width, maxillary alveolar process width, and mandibular alveolar process bone width increase are consistent with transverse maxillary molar movements during growth. On the other hand, transverse mandibular molar movement do not account for this magnitude of basilar mandibular change during growth.

Azevedo PR Angela, Janson G, Fernando J, Henriques C, Freitas R. Marcos (2006)[29] conducted a study in which the radiographic asymmetry of subjects of Class II Div I malocclusion was assessed by measuring the relative difference in spatial position of dental and skeletal landmarks between right and left sides in both anteroposterior and transverse dimensions in the submentovertex and in the transverse and vertical dimensions in the posteroanterior radiographs with subjects with normal occlusion. It was found that the distal location of the mandibular first molars on the Class II side was the main factor contributing to the disparities between the two groups. The mandibular dental midline and the antegonial angle were distorted on the Class II side, as assessed by the posteroanterior radiograph, as a result of the more common asymmetry in the lower part of the face.

Forster MC, Sunga E, Chung HC (2008)[7] conducted a study using cephalometric radiographs and study models to compare the dental arch widths of untreated male and female adults and determine whether there is a correlation between dental arch width and the vertical facial pattern based on the mandibular plane's steepness. Initial orthodontic records of one hundred and eighty-five untreated Caucasian adults (92 males, 93 females) aged from 18 to 68 years were taken from the University of Pennsylvania and six other local private practice offices. The sample was randomly selected, and then, for descriptive purposes, the subjects were classified into three different groups according MP – SN angle: low <27 degrees, average 27 – 37 degrees, and high >37 degrees. For each subject, MP – SN angle was measured. The mandibular plane was drawn from menton (Me) to the inferior border of the angular area of the mandible. Intra-examiner measurement error showed a high correlation with Pearson’s correlation coefficient values (r) of 0.90 – 0.99 for all angular and linear measurements.

Perez E. Ivan, Chavez Allison, Ponce Dario (2011)[30] conducted a study to characterize the posteroanterior cephalometric norm values from Peruvian non-adult Hispanic patients between 2009 and 2010. The objective was to pinpoint any potential gender differences, and compare their findings with comparable research in the literature using Ricketts' analysis. Transverse significant differences in the following parameters were seen between males and females: maxillary width, mandibular width, nasal width, nasal height, right molar to maxillae distance, and inter-molar width. Therefore, it was advisable to use the Rickett´s PA cephalometric norm values.

Bajaj Kamal, Rathee Pooja, Jain Pradeep Panwar R. Vasim (2011)[31] compared the reliability of anatomic cephalometric points obtained from two modalities: Conventional posteroanterior cephalograms and 3D CT of patients with facial asymmetry. Nine patients (5 males and 4 females) with a mean age of 17.11 years and a range of 14 to 21 years were included in the sample. Their treatment plan included correction of the asymmetry. all measurement points on the frontal cephalograms were traced twice with 2 weeks separation. The tracings were superimposed and the average distance between replicate points readings were used as a measure of intra- and interobserver reliability. According to the study, 3D CT regularly outperforms traditional frontal cephalometry in terms of accuracy and dependability. However, a computerized tomography examination is expensive, and is therefore used only as a last resort by surgeons and orthodontists.

Belluzzo LH regina, Faltin K, Ortolani C, Chelotti A (2013)[32] conducted a cephalometric study to assess samples in the transverse dimension from frontal radiographs. The study was designed to correlate the transversal and vertical measures by Ricketts-Faltin frontal analysis. The sample consisted of 45 Brazilian children (25 girls and 20 boys); all presenting mixed dentition, with balanced facial aesthetics and no previous orthodontic/orthopedic treatment. The analyzed transverse Ricketts measurements were: FTD (Facial Transverse Dimension), NTD (Nasal Transverse Dimension), MxTD (Maxillary Transverse Dimension), MdTD (Mandibular Transverse Dimension) and LITD (Lower Intermolar Transverse Dimension). The Faltin vertical measures were: OVD (Occlusal Vertical Dimension) and TVD (Total Vertical Dimension). The objective of this study was to determine the correlations of these seven orthodontic measurements carried out in two different times (T1 and T2) and also to consider whether or not they were maintained with growth (T1 x T2); T1 being 7 years, 7 months and T2 being 13 years, 3 months. It was concluded that the face retains interdependent regions that correlate positively with each other, both transversely and vertically, and these relationships are maintained or strengthened with growth.

Lee Km, Hwang HS, Cho JH (2014)[33] obtained CBCT scans and PA cephalograms from 20 men aged between 24-49 years and 20 women aged between 20-28 years, with normal occlusion. On CBCT images, maxillary and mandibular bone widths were measured at three posterior sites and five bone levels. The differences between maxillary and mandibular bone widths were calculated and compared with conventional transverse width of PA cephalograms. It was seen that statistically significant differences in maxillary and mandibular bone widths were detected at different levels and sites. Also, there was significant increase in bone widths from the alveolar crest towards the basal bone in the maxillary molar and mandibular second premolar and molar areas. The results of this study suggested that three-dimensional assessment of maxillomandibular width is mandatory for the transverse analysis.

Hirpara N, Jain H. Sandhya, Hirpara SV, and Punyani R. Prateek Punyani (2016)[34] evaluated 1080 patients, and out of that 31 subjects with gross facial symmetry were selected who required a routine OPG and PA cephalogram for diagnosis of facial asymmetry. Asymmetry indices were calculated from bilateral linear measurements and Distortion factor was calculated in horizontal and vertical directions for both radiographs. From the evaluated parameters, results showed that Condyle had the highest asymmetry index while maxilla had the lowest asymmetry index. The asymmetry indices between the two radiographs did not show any statistically significant differences except the corpus index which was highly significantly positively correlated between standardized digital OPG and PA cephalogram.

Friedrich E. Reinhard , Christ George, Scheuer T. Hannah, Scheuer A. Hannah (2021)[35] analyzed PA radiographs of 23 healthy young adults. Distances from reference measuring points to the median sagittal plane and the orbital horizontal plane were taken and all individuals showed ideal occlusion. The measurements results showed a high degree of lateral symmetry of the skeletal reference points and planes. Also, comparison of the vertical reference lines confirmed the symmetrical constitution of the facial skeleton.

This study was conducted in Department of Orthodontics, BBDCODS, with an aim to assess transverse dimensions in subjects with variable facial growth patterns, using postero-anterior (PA) cephalogram collected from the patients reporting to the Department of Orthodontics for fixed orthodontic treatment. Lateral cephalogram of subjects were taken for sample distribution into groups according to their growth pattern (Group I - Normodivergent, Group II - Hypodivergent and Group III - Hyperdivergent), using two cephalometric parameters i.e. Frankfort Mandibular Plane angle (FMA) and Jarabak Ratio. Final sample included twenty subjects in each group. Postero-anterior cephalogram of 60 subjects were taken to evaluate and compare the transverse dimensions (9 skeletal and 4 dental parameters) among three groups – Group I (n=20), Group II (n=20) and Group III (n=20).

The approval was taken from Ethical Committee of Babu Banarasi Das College of Dental Science, BBDU, Lucknow before conducting the study. An informed consent was taken from all the participants of the study.

Eligibility criteria

Inclusion criteria:

1. Patients more than 18 years of age, so as to ensure completion of growth.
2. Patients who had not undergone previous orthodontic treatment or any type of orthognathic surgery.
3. Patients having full complement of teeth except third molar.
4. Patients who were willing to participate in the study.

Exclusion criteria:

1. Subjects with history of trauma of craniofacial region.
2. Subjects having chin deviation with functional shift of the mandible.
3. Subjects having asymmetry due to Cyst, tumor, abscess, etc. of hard and soft tissues of the face and jaws.
4. Subjects with cleft lip and palate.
5. Subjects with history of any systemic illness.

Sample:

Lateral cephalogram of subjects who fulfilled the inclusion criteria were selected from patients who came to Department of Orthodontics, B.B.D.CODS, Lucknow for fixed orthodontic treatment. All lateral cephalogram were traced and Jarabak ratio and Mandibular plane angle (FMA) was measured for all the subjects to distribute them according to growth pattern using Nemotec software. **Table 1 and Table 2** shows mean values as obtained in present study for sample distribution using two parameters for assessment of growth pattern - Frankfort's Mandibular plane angle and Jarabak Ratio.

Table 1: Normal values of Frankfort's Mandibular plane angle and Jarabak, considered to divide the sampleaccording to growth pattern.

	Group I (Normodivergent)	**Group II (Hypodivergent)**	**Group III (Hyperdivergent)**
Frankfort's Mandibular Angle (in degrees**)**	23^0-27^0	< 23^0	> 27^0
Jarabak Ratio (%)	62-65%	> 65%	< 62%

Table 2: Mean values of Frankfort's Mandibular plane angle and Jarabak Ratio as obtained for the subjects in the present study.

	Group I (Normodivergent)	**Group II (Hypodivergent)**	**Group III (Hyperdivergent)**
Frankfort's Mandibular Angle (in degrees**)**	$25.2^0 \pm 1.2603^0$	$20.675^0 \pm 3.1079^0$	$30.835^0 \pm 3.3334^0$
Jarabak Ratio (%)	65.67 ± 2.4794	70.080 ± 4.3315	61.165 ± 3.0521

Final sample included 60 subjects divided into three groups (Table 3) :-

- Group I included 20 subjects with Normodivergent growth pattern.
- Group II included 20 subjects with Hypodivergent growth pattern.
- Group III included 20 subjects with Hyperdivergent growth pattern.

Table 3: Distribution of Final sample.

Group	N	Mean age (years)
Group 1 (Normodivergent)	20	20.80 ± 2.949
Group II (Hypodivergent)	20	21.00 ± 1.806
Group III (Hyperdivergent)	20	22.1 ± 3.059

Postero-anterior Cephalogram (PA) Cephalogram of all the subjects were then taken for assessment of transverse dimensions (9 skeletal and 4 dental parameters).

Materials

A. Material used for taking lateral cephalogram and P.A Cephalogram

1. Cephalostat machine (Planmeca proline XC) in Department of Oral Medicine and Radiology **(Fig. 1)**
2. Radiograph sheet (AGFA Drystar 2B) Film 11 x 14 inch **(Fig. 2)**
3. Thermal printer (AGFA Drystar 2B) **(Fig. 3)**

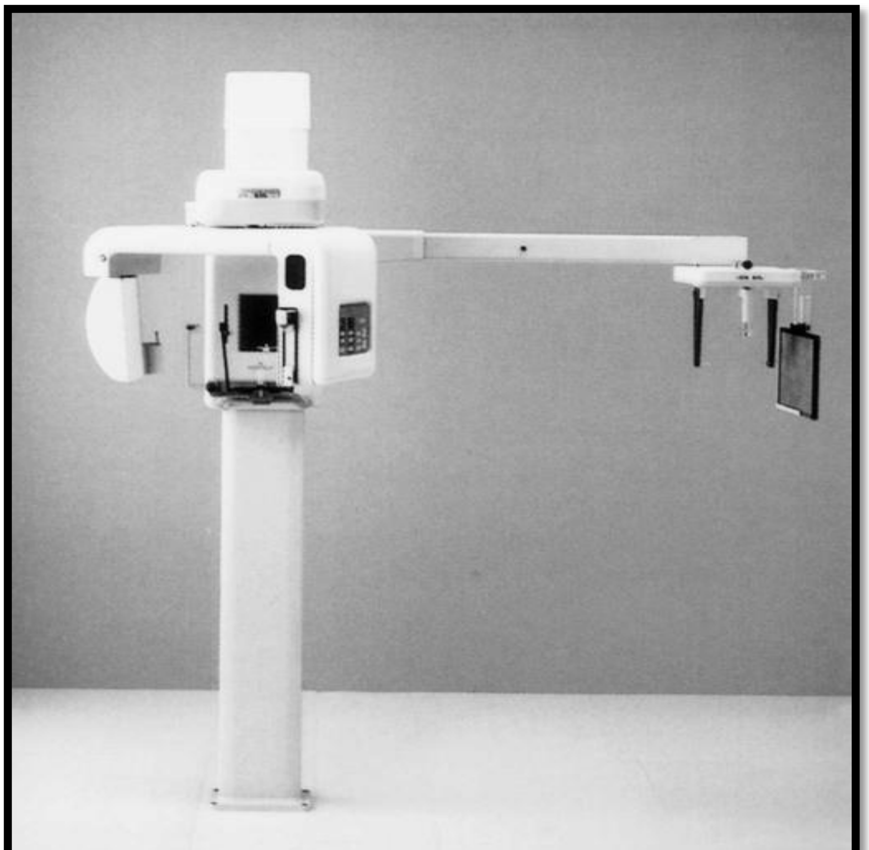


Figure 1. Cephalostat machine for taking Lateral cephalogram and PA Cephalogram

Fig. 2: Radiograph sheet (AGFA Drystar 2B) Film 11 x 14 inch.

Fig. 3: Thermal printer (AGFA Drystar 2B)

B. Material used for tracing and assessment of Lateral cephalogram and P.A Cephalogram

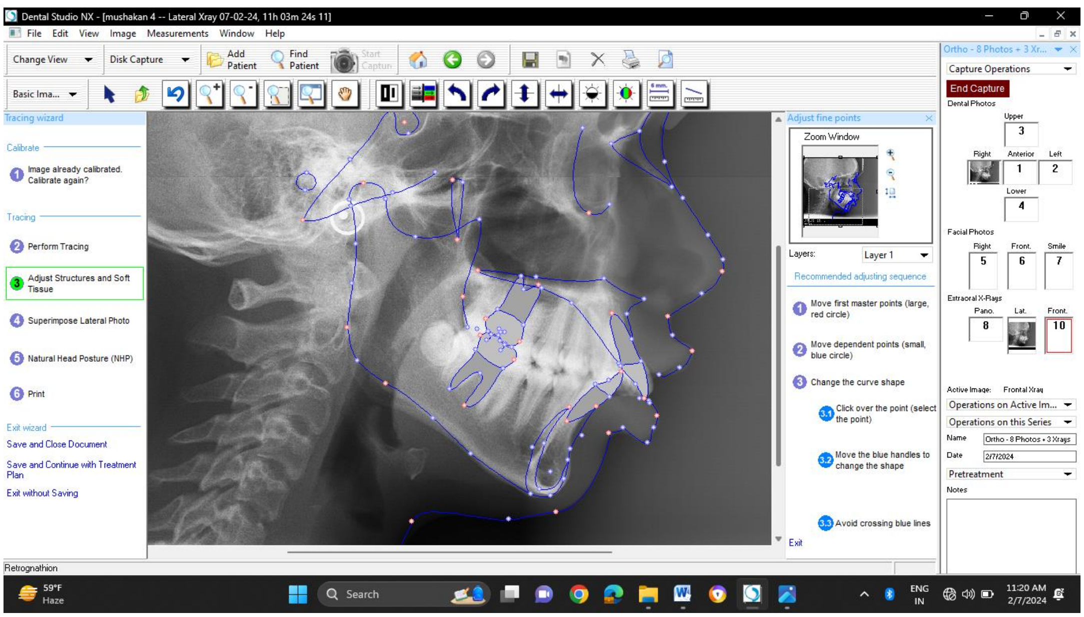


Fig. 4: Nemotec software for analysis.

METHOD:

A) For Taking Lateral cephalogram

1. Planmeca proline XC was used to take the digital lateral cephalogram of selected subjects. The lateral cephalograms were taken in natural head position with lips relaxed and teeth in centric occlusion **(Fig. 5).** Natural head position is a standardized and reproducible orientation of head that was attained by asking patients to look into mirror placed in front of them. The ear posts were used for correct alignment of the patients head for undistorted symmetrical image of the patient. Relaxed lip was achieved by giving direct instructions to the patient. The receptor- source distance was fixed at 60 inch. The exposure values were set at 68kV, 5mA at 23 second exposure time.

2. All the Lateral cephalograms were transferred to a computer loaded with Planmeca software from where they were saved in bitmap files and taken in a CD ROM. The soft copies of all the lateral cephalograms were transferred to Nemotec software program (Dental studio – NX, version 6.0).

3. The images were calibrated by identifying two crosshairs 10 mm apart on lateral cephalogram. The image enhancement feature of the software (basic and advanced cephalometric tools), like brightness, contrast adjustment and magnification were used to identify individual cephalometric landmarks as precisely as possible. The landmarks were marked with the help of cursor.

4. After identification of landmarks and Reference planes used in the study, digital tracing was done. Two parameters were assessed on the lateral cephalogram for assessment of growth pattern.

Fig. 5: Patient position on cephalostat machine to take lateral cephalogram.

<u>Landmarks and Reference Planes used in the study to assess growth pattern</u>

A. <u>Landmarks used in the present study to assess growth pattern (Fig. 6)</u>

Following landmarks[36] were identified on Lateral Cephalogram (**Fig. 6**) for measuring parameters to assess growth pattern:

1. **Sella (S):** The geometric center of the pituitary fossa.
2. **Orbitale (Or):** The lowest point on the inferior rim of the orbit.
3. **Nasion (N):** The most anterior point in the frontonasal suture in the midsagittal plane.
4. **Porion (Po):** the most superiorly positioned point on the external auditory meatus located by using the ear roads of the cephalostat (mechanical porion).
5. **Gonion (Go):** A point on the curvature of the angle of the mandible located by bisecting the angle formed by lines tangent to the posterior ramus and the inferior border of the mandible.
6. **Menton (Me):** The lowest point on the symphyseal shadow of the mandible seen on a lateral cephalogram.

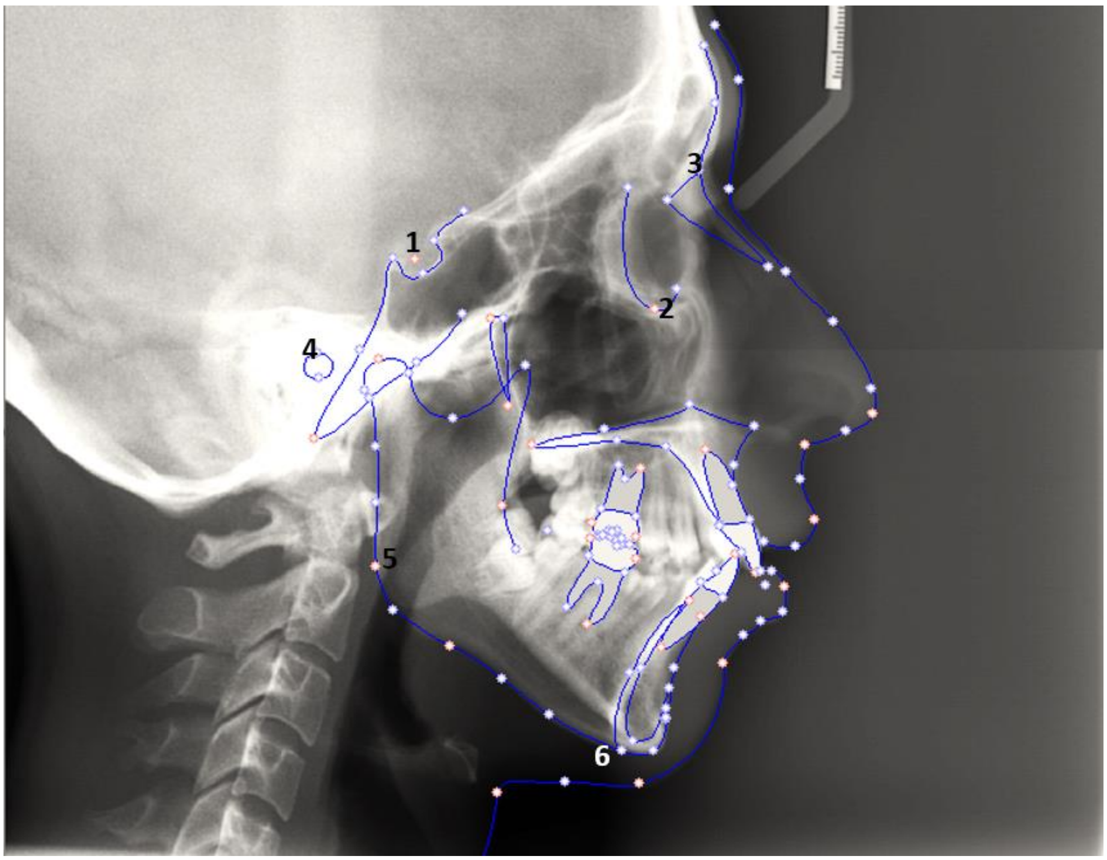


Fig.6: Landmarks identified on Lateral Cephalogram to measure Frankfort's Mandibular Plane angle and Jarabak Ratio.

1- Sella	**4 - Porion**
2- Orbitale	**5 - Gonion**
3- Nasion	**6 - Menton**

B. Reference Planes (Fig. 7)[36]

1. **Frankfort Horizontal plane:** A line joining Orbitale (Or) and Porion (Po).
2. **Mandibular Plane (Tweed's):** A line joining Gonion (Go) and Menton (Me).
3. **Posterior Facial Height:** Measured from Sella (S) to Gonion (Go).
4. **Anterior Facial Height:** Measured from Nasion (N) to Menton (Me).

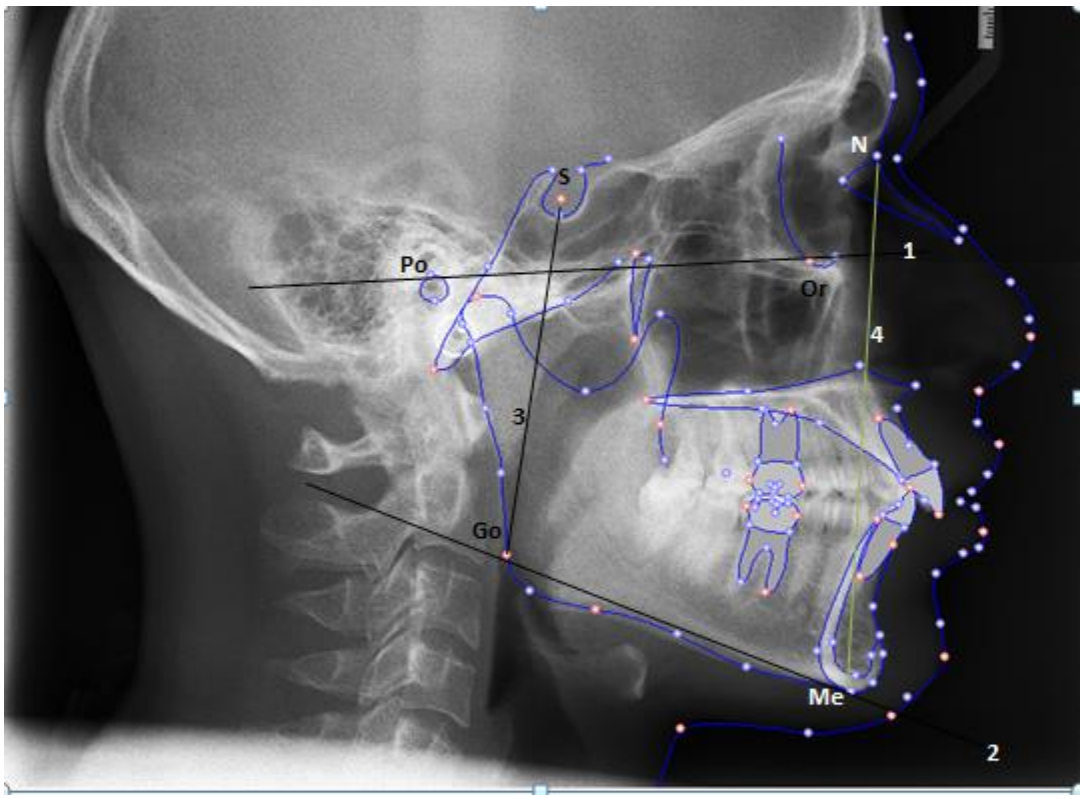


Fig. 7: Reference Planes identified on Lateral Cephalogram Cephalogram to assess Frankfort's Mandibular Plane angle and Jarabak Ratio.

1 - Frankfort Horizontal Plane

2 – Mandibular Plane (Tweed's)

3 – Posterior Facial Height (S-Go).

4 – Anterior Facial Height (N-Me).

Parameters used in present study to assess growth pattern[36] (**Fig. 8)**:

1. **Jarabak Ratio:** The ratio of the posterior facial height (sella-gonion) and anterior facial height (nasion-menton). It is expressed as a percentage. Jarabak Ratio (%) = (S-Go)/(N-Me) × 100.

2. **Frankfort Mandibular Angle (FMA):** It is the angle formed by the intersection of the Frankfort horizontal plane (FHP) and the Tweed's mandibular plane.

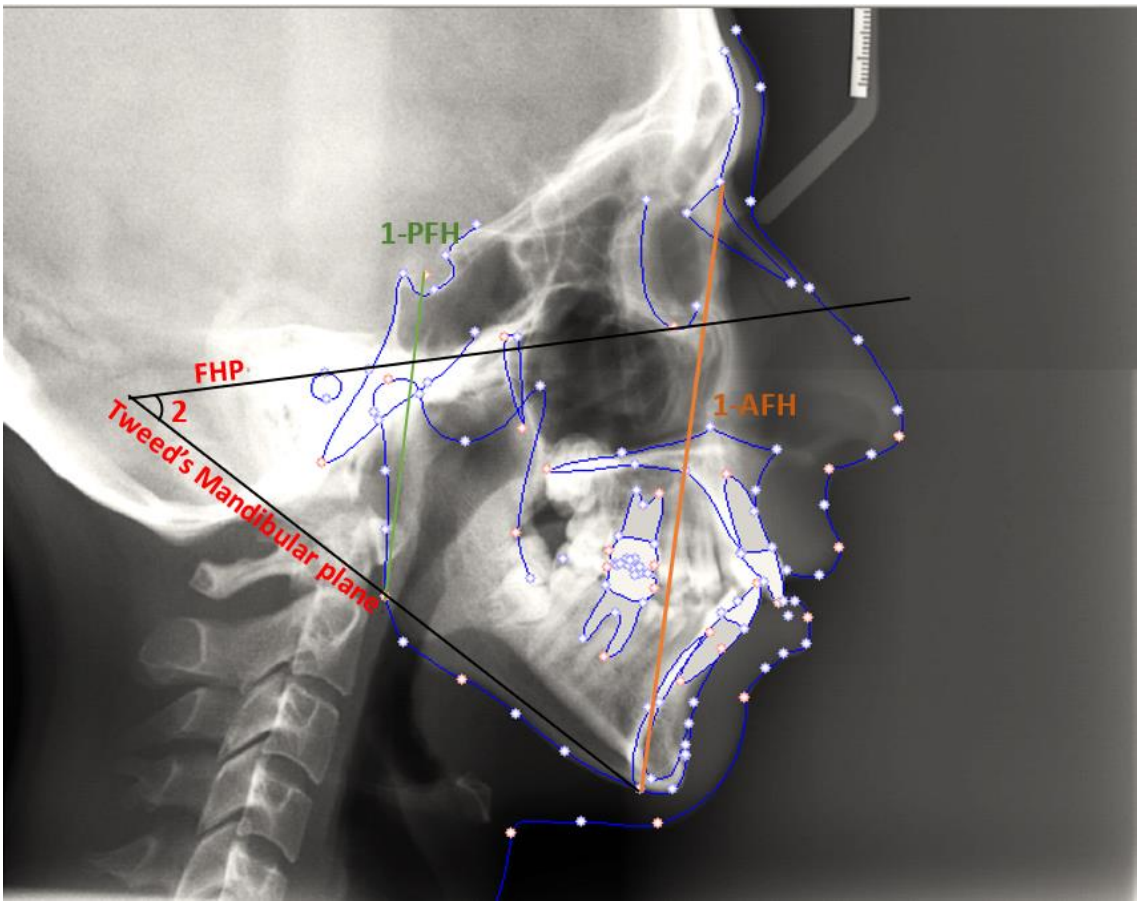


Fig. 8: Parameters assessed on Lateral Cephalogram.

1- **Jarabak Ratio = (PFH/AFH) x 100**
2- **Tweed's Frankfort Mandibular Plane Angle (FMA)**

For Taking Postero-anterior (PA) Cephalogram.

- Planmeca proline XC was used to take the PA of selected patients. The postero-anterior (PA) ceph was taken in natural head position with lips relaxed and teeth in centric occlusion **(Fig. 9)**. Natural head position is a standardized and reproducible orientation of head. The ear posts were used for correct alignment of the patients' head for undistorted symmetrical image of the patient. The exposure values were set at 68 Kv, 5mA at 23 seconds exposure time.

Fig. 9: Position of patient for taking Postero-anterior (PA) Cephalogram.

- All the PA cephalograms were transferred to a computer loaded with Planmeca software from where the PA cephalogram were saved in bitmap files and taken in a CD ROM. The soft copies of all the P.A cephalograms were transferred to Nemotec software program (Dental studio – NX, version 6.0).

- As done for lateral cephalogram, the images were caliberated by identifying two crosshairs 10 mm apart on postero-anterior (PA) cephalogram. The image enhancement feature of the software (basic and advanced cephalometric tools), like brightness, contrast adjustment and magnification were used to identify individual cephalometric landmarks as precisely as possible. The landmarks were marked with the help of cursor.

- After identification of landmarks and Reference planes used in the study, digital tracing was done. Nine skeletal parameters and four dental parameters were assessed on the postero-anterior (PA) cephalogram for assessment of transverse discrepancy.

Landmarks and Reference Planes used on Postero-anterior (PA) Cephalogram to assess Transverse parameters[12,36]

A. The following cephalometric landmarks[12,36] were identified on P.A Cephalogram (Fig. 10):

1. **ZfR/ZfL**: The innermost point on the medial margin of the fronto-zygomatic suture. It is marked as ZfR for right side and ZFL for left side.
2. **ZA/AZ** : The outermost (lateral) point of the zygomatic arch. It is marked as ZA for right side and AZ for left side.
3. **Orbit, medial (Or,me):** Point on the outer medial bony orbital boundary. It is marked as Or,meR for right side and Or,meL for left side.
4. **ANS**: Anterior tip of the nasal spine.
5. **CN/NC** : The outermost point of the nasal cavity. It is marked as CN for right side and NC for left side.
6. **Jugale point (JR/JL)** : The highest point on the maxillary alveolar process. It is marked as JR for right side and JL for left side.
7. **Antegonial notch (AG/GA)** : Point located at the greatest concavity of the antegonial notch of the mandible. It is marked as AG for right side and GA for left side.
8. **Me**: The lowest point of the mandibular symphysis.
9. **A6/6A**: The outermost point on the vestibular face of the upper molar. (Right & left). It is marked as A6 for right side and 6A for left side.
10. **B6/6B** : The outermost point on the vestibular face of the lower molar (Right & left). It is marked as B6 for right side and 6B for left side.
11. **A3/3A**: Tip of the Maxillary canine's cusp. It is marked as A3 for right side and 3A for left side.
12. **B3/3B**: Tip of the Mandibular canine's cusp. It is marked as B3 for right side and 3B for left side.
13. **Co** : The highest point on the mandibular condyle.
14. **Crista Galli (Cg)**: A cockscomb-like protrusion of the upper edge of the perpendicular plate of the ethmoid bone. The most posterior and inferior point of the perpendicular plate of the ethmoid bone where it joins the cribriform plate from a sagittal view and centered mediolaterally on the
15. **A1**: The most marginal point at the incisal level of the upper central.
16. **B1**: The most marginal point at the incisal level of the lower central.

17. **Occlusal Point – Right (OPR) –** Drawn on the outer boundary of Ramus at the level of B6..

18. **Occlusal Point – Left (OPL) -** Drawn on the outer boundary of Ramus at the level of 6B.

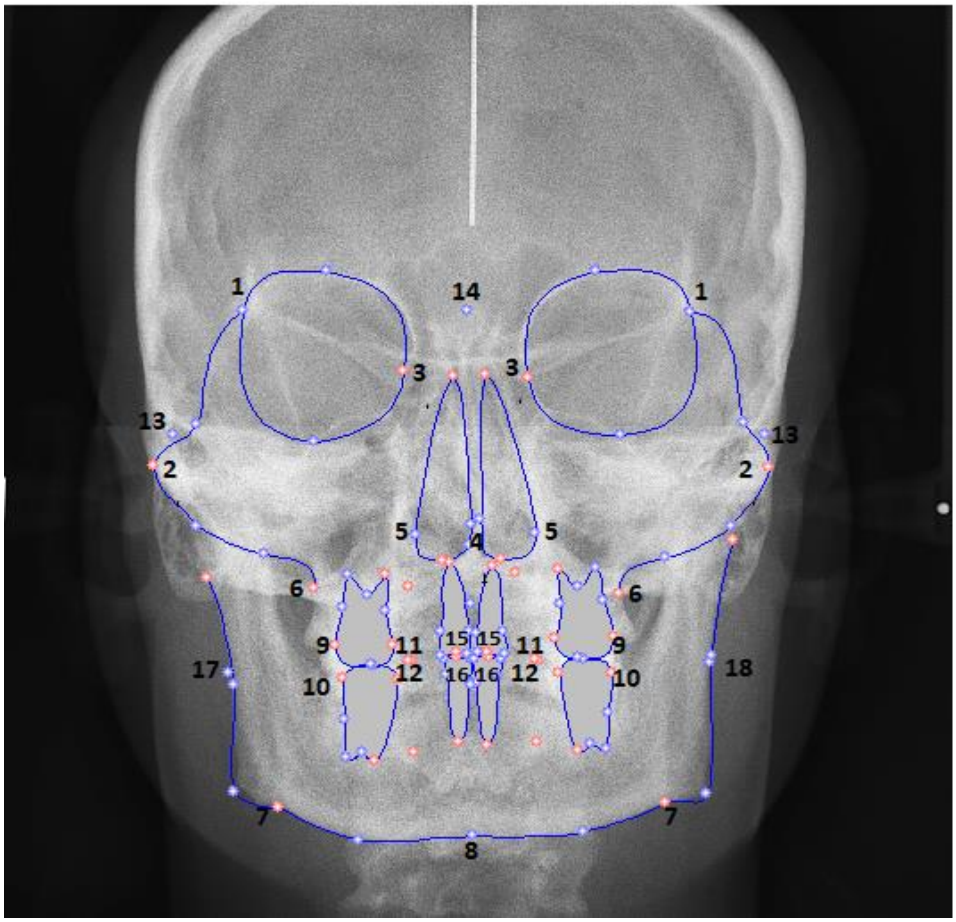


Fig. 10: Landmarks identified on Postero-anterior (PA) Cephalogram

1 -Frontozygomatic suture	**10- B6/6B**
2- Zygomatic arch	**11- A3/3A**
3- Outer medial bony orbital boundary	**12- B3/3B**
4- ANS	**13- Co**
5- Outermost point of nasal cavity	**14- Crista galli**
6- Jugale point (JL/JR)	**15- A 1**
7- Antegonial notch	**16- B 1**
8- Menton	**17- Occlusal Point (Right)**
9- A6/6A	**18- Occlusal point (Left)**

B. Following Reference Planes[12,36] were marked on Postero-anterior (PA) Cephalogram (Fig. 11):

Vertical Plane

1. **MSR plane:** It is constructed by joining the Crista galli (Cg), through Anterior nasal spine (ANS) to the chin area. It is typically perpendicular to the Z-plane.

Horizontal Planes

2. **Z-plane:** It is constructed by joining the inner margin of right and left frontozygomatic suture (ZfR - ZfL).
3. **Inter-orbital Reference plane:** It is constructed by joining points (Or,meR - Or,meL)

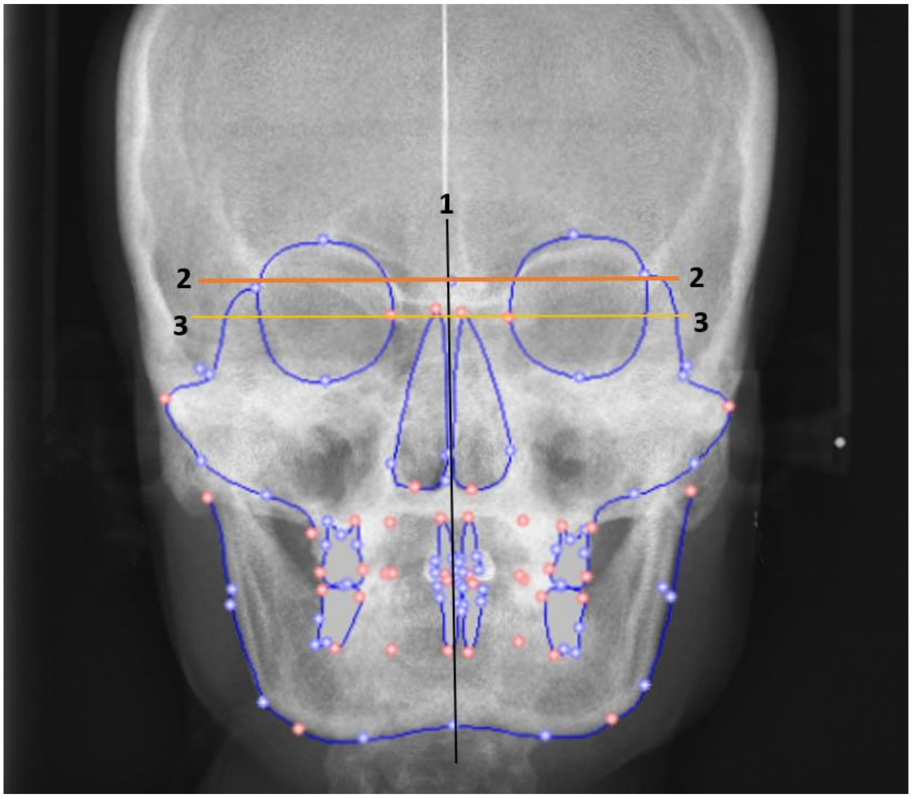


Fig. 11: Vertical and Horizontal Reference planes marked on Postero-anterior (PA) Cephalogram.

1- Midsagittal Reference Plane (MSR Plane)
2- Z Plane
3- Interorbital Reference Plane

Skeletal and Dental parameters measured on PA Cephalogram[12,36]

Following Skeletal parameters were measured on the P.A Cephalogram **(Fig. 12 & 13)**:

1. ***Intercanthal width* (ZL/ZR):** Medial margin of the Right fronto-zygomatic suture to Midsagittal reference line/medial margin of the Left fronto-zygomatic suture to the Midsagittal reference line.
2. ***Facial width* (ZA/AZ):** Outermost (lateral) point on Right zygomatic arch to Midsagittal reference line/ outermost (lateral) point on Left zygomatic arch to Midsagittal reference line.
3. ***Nasal width* (CN/NC):** Outermost point on nasal cavity (Right) to Midsagittal reference line/ outermost point on nasal cavity (Left) to Midsagittal reference line.
4. ***Maxillary Width* (JL/JR)**: Jugal point right to Midsagittal reference line/ Jugal point left to Midsagittal reference line.
5. ***Mandibular Width* (AG/GA)**: Antegonial notch right to midsagittal reference line/ Antegonial notch left to midsagittal reference line.
6. ***Maxillomanibular Width (Right):*** It is measured as perpendicular from point J to plane drawn from Frontozygomatic suture (ZR) to Antegonioal Notch (AG).
7. ***Maxillomanibular Width (Left):*** It is measured as perpendicular from point J to plane drawn from Frontozygomatic suture (ZL) to Antegonioal Notch (GA).
8. ***Denture midline*:** Used to describe a skeletal midline discrepancy. It is measured as difference between OPR to A1 and A1 to OPL.
9. ***Postural symmetry (Right & Left*):** It is measured as a difference in the angles between zygomatic frontal suture to Antegonial point for right (ZfR – AG) and left (ZfL – GA) respectively.

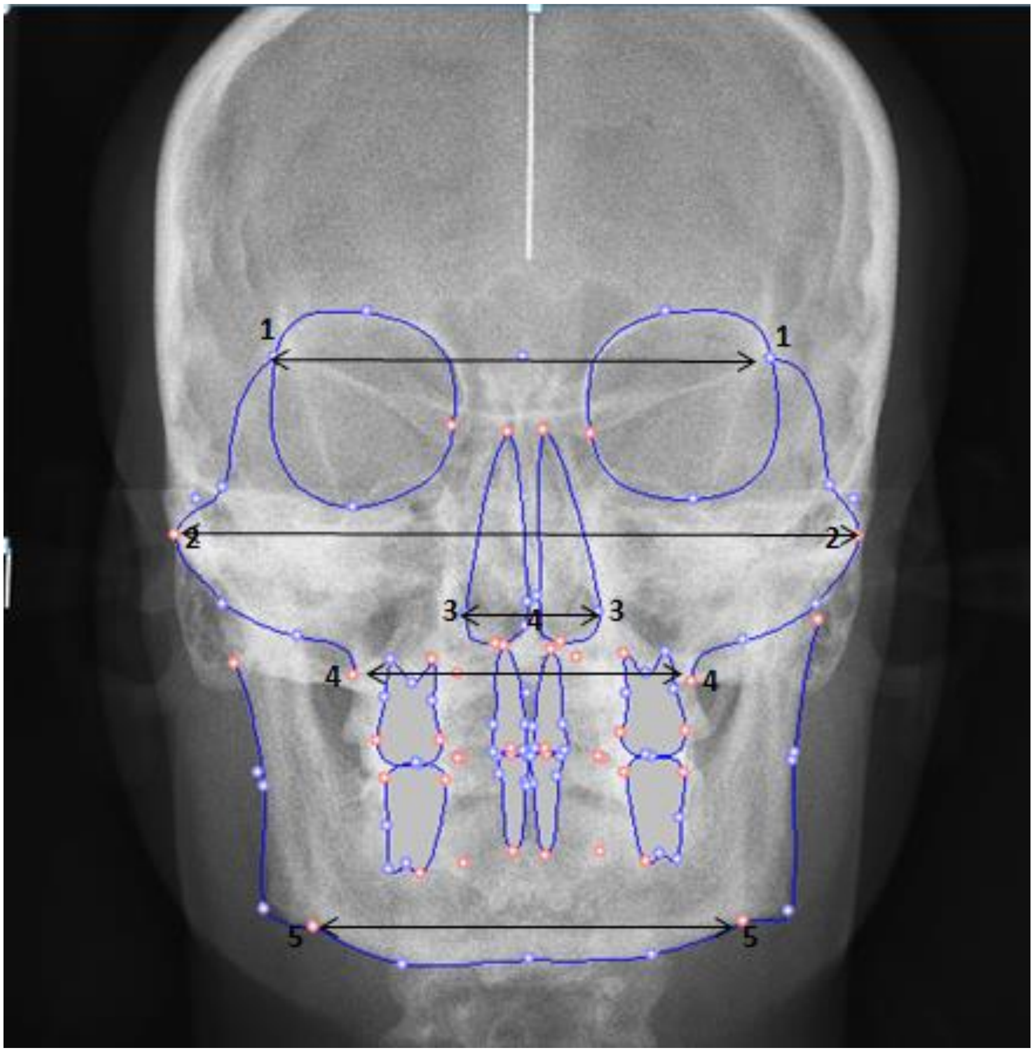


Fig. 12: Skeletal parameters measured on the Postero-anterior (PA) Cephalogram.

1-Intercanthal width

2- Facial width

3- Nasal width

4- Maxillary width

5- Mandibular Width

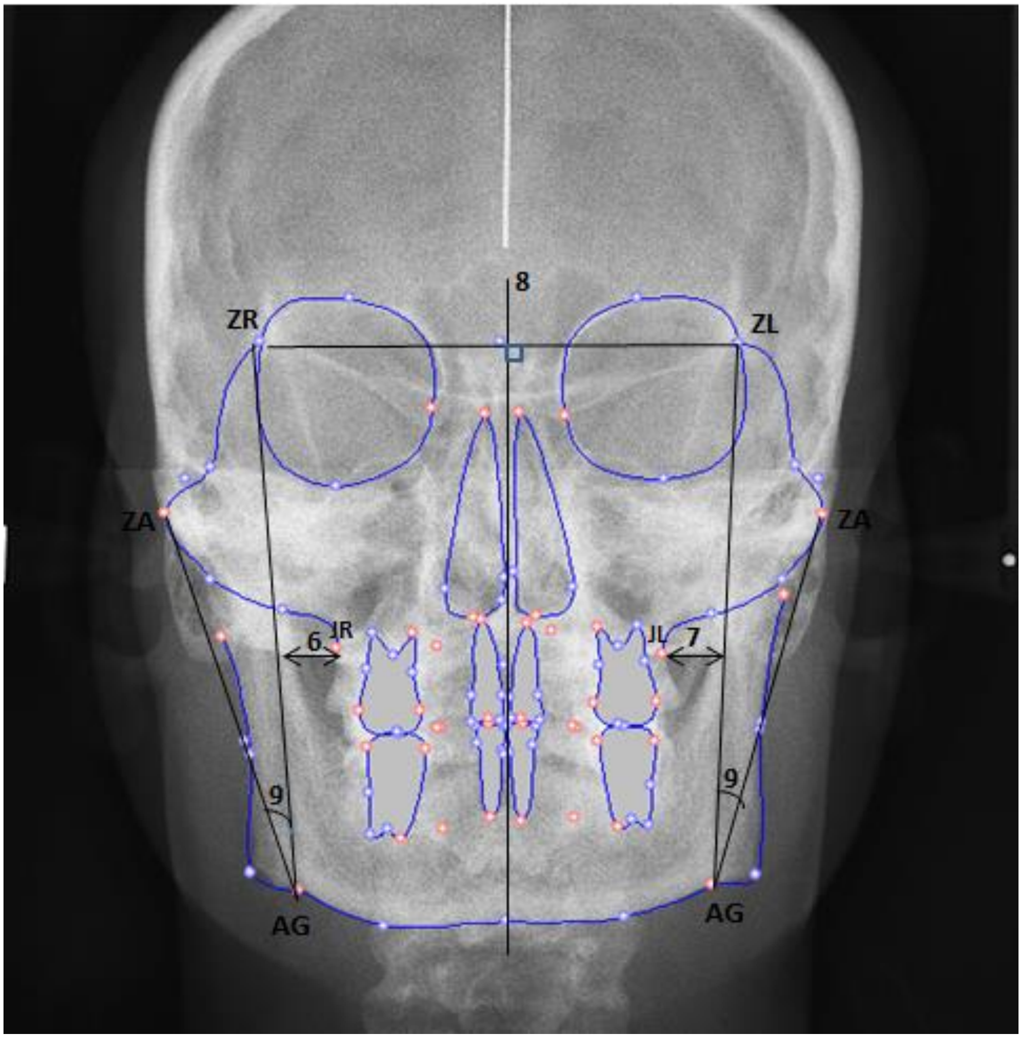


Fig. 13: Skeletal parameters measured on the Postero-anterior (PA) Cephalogram.

6-Maxillo-mandibular Width (Right)
7- Maxillo-mandibular Width (Left)
8- Denture Midline
9- Postural Symmetry (Right &Left)

Following Dental parameters[12,36] were measured on the PA Cephalogram (**Fig. 14**):

1. ***Inter-molar width: Mandible* (B6/6B):** It is measured as a distance from B6 (right) to 6B (left).
2. ***Inter-canine width: Mandible* (B3/3B):** It is measured as a distance from B3 (right) to 3B (left).
3. ***Lower Molar to Jaw (Left):*** Perpendicular distance from B6 to line drawn from JL – GA.
4. ***Lower Molar to Jaw (Right):*** Perpendicular distance from 6B to line drawn from JR – AG.

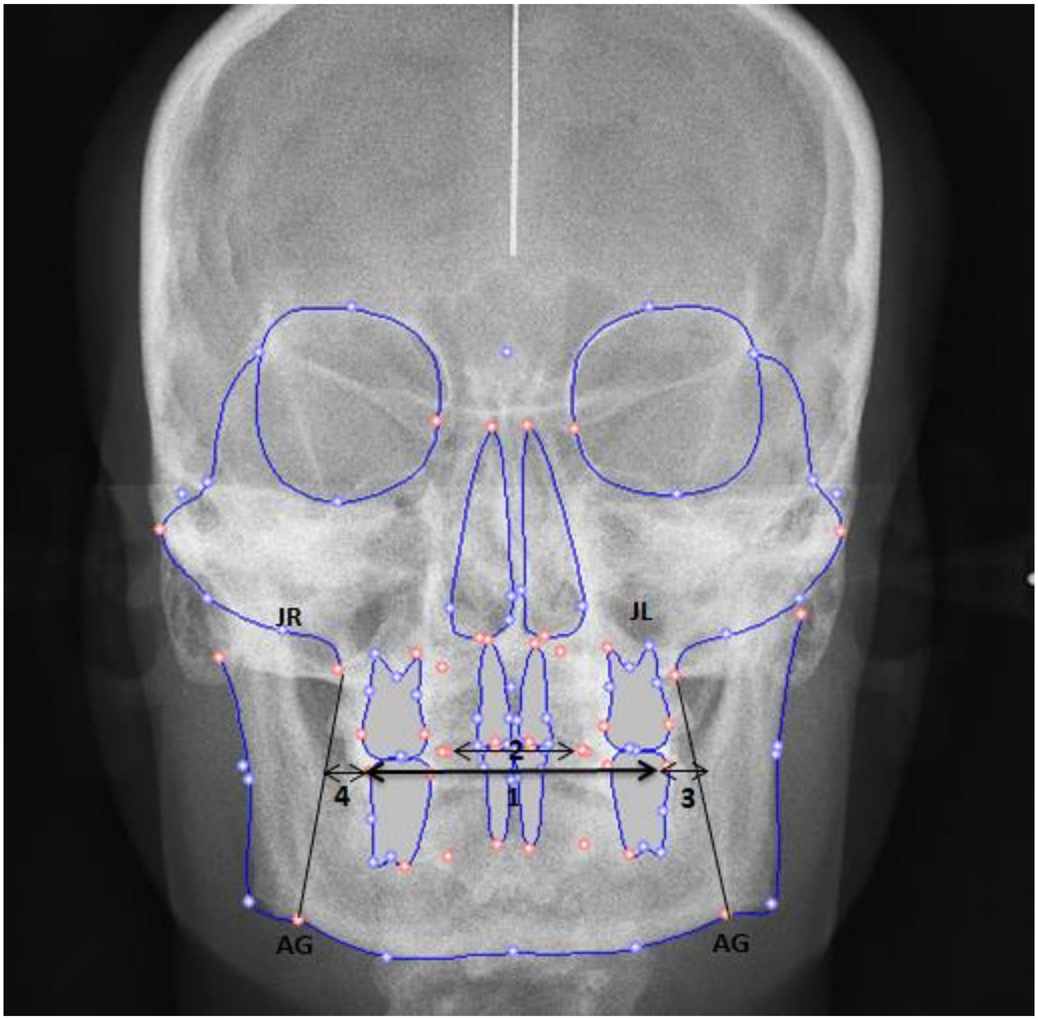


Fig. 14: Skeletal parameters measured on the Postero-anterior (PA) Cephalogram.

1- Inter-Molar width **3- Lower Molar to Jaw (Left)**

2- Inter-canine width **4- lower Molar to Jaw (Right)**

Following this, data was tabulated and adequate comparison made between the three groups.

Measurement of Reliability

Reliability of measurements was done by repeating the measurements of 6 subjects selected from the sample at 1 week interval from the first set of evaluation to the second set of evaluation by the same observer.

The comparison was done between the first and second set of measurements by student t test. Statistically no significant difference was noted between them. (Table 4).

Table 4: Reliability Analysis

		Mean	N	Std. Deviation	Std. Error Mean	P VALUE
INTERCANTHAL WIDTH	OBSERVATION 1	89.100	6	4.6282	1.8894	0.321
	OBSERVATION 2	88.93	6	4.819	1.968	
FACIAL WIDTH	OBSERVATION 1	130.900	6	9.5026	3.8794	0.354
	OBSERVATION 2	130.733	6	9.7379	3.9755	
NASAL WIDTH	OBSERVATION 1	29.183	6	2.6080	1.0647	0.345
	OBSERVATION 2	29.150	6	2.5782	1.0525	
MAXILLARY WIDTH	OBSERVATION 1	65.483	6	4.4278	1.8077	0.365
	OBSERVATION 2	65.450	6	4.4939	1.8346	
MANDIBULAR WIDTH	OBSERVATION 1	83.667	6	4.1341	1.6877	0.362
	OBSERVATION 2	83.650	6	4.1467	1.6929	
MAXILLOMANDIBULAR WIDTH RIGHT	OBSERVATION 1	22.683	6	31.0491	12.6757	0.341
	OBSERVATION 2	22.517	6	31.1269	12.7075	

MAXILLOMANDIBULAR WIDTH LEFT	OBSERVATION 1	11.200	6	1.7527	0.7155	0.309
	OBSERVATION 2	11.150	6	1.6837	0.6874	
DENTURE MIDLINE	OBSERVATION 1	2.083	6	1.0068	0.4110	0.311
	OBSERVATION 2	2.000	6	1.0826	0.4420	
POSTURAL SYMMETRY	OBSERVATION 1	1.917	6	1.2073	0.4929	0.360
	OBSERVATION 2	1.900	6	1.1916	0.4865	
INTERMOLAR WIDTH	OBSERVATION 1	62.933	6	5.7169	2.3339	0.702
	OBSERVATION 2	62.917	6	5.7451	2.3454	
INTERCANINE WIDTH	OBSERVATION 1	30.800	6	5.1734	2.1120	0.367
	OBSERVATION 2	30.767	6	5.2102	2.1271	
LOWER MOLAR TO JAW LEFT	OBSERVATION 1	4.900	6	1.0881	0.4442	0.345
	OBSERVATION 2	4.883	6	1.0610	0.4331	
LOWER MOLAR TO JAW RIGHT	OBSERVATION 1	3.983	6	1.3834	0.5648	0.344
	OBSERVATION 2	3.950	6	1.3620	0.5560	

P > 0.05 NS; P < 0.05 just significant*; P < 0.01 significant**; P < 0.001 highly significant***.

Statistical Tools used in the study

Data was entered into Microsoft Excel spreadsheet and was checked for any discrepancies. Summarized data was presented using Tables and Graphs. The data was analysed by SPSS (21.0 version). Shapiro Wilk test was used to check which all variables were following normal distribution. Data was normally distributed therefore, inferential statistics were performed using parametric test i,e one way Anova followed by Tukeys test for post hoc pairwise comparison. Level of statistical significance was set at p-value less than 0.05

TOOLS FOR STATISTICAL ANALYSIS

Formula used for the analysis

A. The Arithmetic Mean

The most widely used measure of central tendency is arithmetic mean, usually referred to simply as the mean, calculated as

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

B. The Standard Deviation

The standard deviation (SD) is the positive square root of the variance, and calculated as

$$SD = \sqrt{\frac{\sum X_i^2 - \frac{(\sum X_i)^2}{n}}{n-1}}$$

where, n= no. of observations and also denoted by subtracting minimum value from maximum value as below.

C. Tests of significance

Test of significance are used to estimate the probability that the relationship observed in the data occurred purely by chance was there a relationship between the variables. They are used to test the hypothesis proposed at the start of the study.

<u>In this study Parametric tests were used</u>

a) **<u>The data was normally distributed</u>**
b) **<u>The data was obtained from the sample which is randomly selected</u>**
c) **<u>The data was quantitative data</u>**

I. ANALYSIS OF VARIANCE

Analysis of variance (ANOVA) is used when we compare more than two groups simultaneously. The purpose of one-way ANOVA is to find out whether data from several groups have a common mean. That is, to determine whether the groups are actually different in the measured characteristic. One way ANOVA is a simple special case of the linear model. For more than two independent groups, simple parametric ANOVA is used when variables under consideration follows Continuous exercise group distribution and groups variances are homogeneous otherwise non parametric alternative Kruskal-Wallis (H) ANOVA by ranks is used. The one way ANOVA form of the model is

$$Y_{ij} = \alpha_{.j} + \varepsilon_{ij}$$

where:

- Y_{ij} is a matrix of observations in which each column represents a different group.
- $\alpha_{.j}$ is a matrix whose columns are the group means (the –dot j‖ notation means that α applies to all rows of the j^{th} column i.e. the value α_{ij} is the same for all i).
- ε_{ij} is a matrix of random disturbances.

The model posits that the columns of Y are a constant plus a random disturbance. We want to know if the constants are all the same.

Assumptions are:

a) Response variable must be normally distributed (or approximately normally distributed).
b) Samples are independent.
c) •Variances of populations are equal.
d) The sample is a simple random sample (SRS).

Two-way ANOVA is used when we have one measurement variable and two nominal variables, and each value of one nominal variable is found in combination with each value of the other nominal variable. It tests three null hypotheses: that the means of the measurement variable are equal for different values of the first nominal variable; that the means are equal for different values of the second nominal variable; and that there is no interaction (the effects of one nominal variable don't depend on the value of the other nominal variable). When we have a quantitative continuous outcome and two categorical explanatory variables, we may consider two kinds of relationship between two categorical variables, In this relationship we can distinguish effect of one factor from that of the other factor. This type of model is called a **main effect model** or **no interaction** model.

Tukey Multiple Comparison Test

After performing ANOVA, **Tukey's HSD (honestly significant difference) post hoc test** is generally used to calculate differences between group means as

where,

$$q = \frac{\bar{X}_1 - \bar{X}_2}{SE}$$

$$SE = \sqrt{\frac{S^2}{2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

S^2 is the error mean square from the analysis of variance and n_1 and n_2 are number of data in group 1 and 2 respectively.

Statistical significance

Level of significance "p" is level of significance signifies as below:

$p > 0.05$ Not significant (ns)

$p < 0.05$ significant (*)

The present study was conducted in the Department of Orthodontics & Dentofacial Orthopaedics, Babu Banarsi Das College of Dental Sciences, Lucknow to assess transverse dimensions in subjects with variable facial growth patterns, using postero-anterior (PA) cephalogram collected from 70 subjects visiting the department of Orthodontics for fixed orthodontic treatment. The subjects were divided into three groups – (Group I – Normodivergent, Group II – Hypodivergent, Group III – Hyperdivergent), after assessment of two cephalometric parameters i.e. Frankfort Mandibular plane angle (FMA) and Jarabak Ratio. Group I had 20 subjects with mean age of 20.8 years, group II had 20 subjects with mean age of 21 years, and Group III had 20 subjects with mean age of 22.1 years. The data obtained were recorded on Microsoft Excel sheet and subjected to statistical analysis. The result of the study is tabulated as follows:

Table 5A: Descriptive statistics of Skeletal and Dental parameters of Group I,

Table 5B: Descriptive statistics of Skeletal and Dental parameters of Group II,

Table 5C: Descriptive statistics of Skeletal and Dental parameters of Group III,

Table 6: Inter-Group comparison of Skeletal and Dental parameters using one way ANOVA (Group I vs Group II vs Group III).

Table 7: Inter-Group comparison of Skeletal and Dental parameters using Tukey's HSD test (Group I vs Group II).

Table 8: Inter-Group comparison of Skeletal and Dental parameters using Tukey's HSD test (Group I vs Group III).

Table 9: Inter-Group comparison of Skeletal and Dental parameters using Tukey's HSD test (Group II vs Group III).

Table 5A: Descriptive statistics of Skeletal and Dental parameters of Group I (Normodivergent subjects)

Skeletal Parameters	Mean ± Standard Deviation(in mm)	Standard Error	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Intercanthal Width	84.050 ± 2.2821	0.6812	82.982	85.118
Facial Width	123.055 ± 7.5814	1.5035	119.507	126.603
Nasal Width	28.330 ±3.8511	0.8004	26.528	30.132
Maxillary Width	61.545 ±4.2334	0.7627	59.564	63.526
Mandibular Width	78.8 ±5.1602	0.9737	76.385	81.215
Maxillomandibular Width - RIght	9.56 ±1.9808	0.4174	8.633	10.487
Maxillomandibular Width – Left	10.475 ±2.1178	0.2715	9.484	11.466
Denture Midline	0.125 ±1.543	0.43	-0.597	0.847
Postural Symmetry	1.8 ±1.6367	0.2902	1.034	2.566
Dental Parameters				
Inter-molar Width	57 ±3.9782	1.1058	55.138	58.862
Inter-canine Width	30.375 ±3.3941	0.7725	28.787	31.963
Lower molar to Jaw - Left	6.145 ±1.3648	0.4286	5.506	6.784
Lower molar to Jaw - Right	5.230 ±1.8874	0.4788	4.347	6.113

Table 5B: Descriptive statistics of Skeletal and Dental parameters of Group II (Hypodivergent subjects)

Skeletal Parameters	Mean ± Standard Deviation (in mm)	Standard Error	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Intercanthal Width	90.530 ± 3.0465	0.5103	89.104	91.956
Facial Width	133.9 ± 6.7237	1.6952	130.753	137.047
Nasal Width	29.390 ±3.5796	0.8611	27.715	31.065
Maxillary Width	66.5 ±3.411	0.9466	64.904	68.096
Mandibular Width	83.945 ±4.3544	1.1538	81.907	85.983
Maxillomandibular Width - RIght	9.905 ±1.8667	0.4429	9.031	10.779
Maxillomandibular Width – Left	10.83 ±1.214	0.4736	10.262	11.398
Denture Midline	-1.050 ±1.9229	0.345	-1.95	-0.15
Postural Symmetry	1.640 ±1.2979	0.3660	1.033	2.247
Dental Parameters				
Inter-molar Width	62.745 ±4.9454	0.8896	60.43	65.05
Inter-canine Width	31.235 ±3.4549	0.7589	29.618	32.852
Lower molar to Jaw - Left	5.515 ±1.9168	0.3052	4.618	6.412
Lower molar to Jaw - Right	4.375 ±2.1411	0.4220	3.733	5.737

Table 5C: Descriptive statistics of Skeletal and Dental parameters of Group III (Hyperdivergent subjects)

Skeletal Parameters	Mean ± Standard Deviation(in mm)	Standard Error	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Intercanthal Width	84.620±5.2719	1.1788	82.153	87.087
Facial Width	121.2±10.9062	2.4387	116.096	126.304
Nasal Width	27.870±4.0454	0.9046	25.977	29.763
Maxillary Width	61.18 ±5.7981	1.2965	58.466	63.894
Mandibular Width	78.295 ±6.7251	1.5038	75.148	81.442
Maxillomandibular Width - RIght	9.625 ±1.915	0.4282	8.729	10.521
Maxillomandibular Width – Left	9.895 ±2.2549	0.5042	8.84	10.95
Denture Midline	-0.225 ±1.5005	0.3355	-0.927	0.477
Postural Symmetry	1.87 ±1.6784	0.3753	1.084	2.656
Dental Parameters				
Inter-molar Width	57.205 ±4.7034	1.0517	55.004	59.406
Inter-canine Width	30.135 ±3.1164	0.6968	28.676	31.594
Lower molar to Jaw - Left	6.175 ±1.2515	0.2798	5.589	6.761
Lower molar to Jaw - Right	4.69 ±1.5808	0.3535	3.95	5.43

Table 6: Inter-Group comparison of Skeletal and Dental parameters using one way ANOVA (Group I vs Group II vs Group III).

Skeletal Parameters	**Mean ± Standard Deviation (in mm)**	**Mean ± Standard Deviation (in mm)**	**Mean ± Standard Deviation (in mm)**	**P Value**
Intercanthal Width	84.050 ± 2.2821	90.530 ± 3.0465	84.620±5.2719	0.001***
Facial Width	123.055 ± 7.5814	133.9 ± 6.7237	121.2±10.9062	0.001***
Nasal Width	28.330 ±3.8511	29.390 ±3.5796	27.870±4.0454	0.442
Maxillary Width	61.545 ±4.2334	66.5 ±3.411	61.18 ±5.7981	0.001***
Mandibular Width	78.8 ±5.1602	83.945 ±4.3544	78.295 ±6.7251	0.003**
Maxillomandibular Width - Right	9.56 ±1.9808	9.905 ±1.8667	9.625 ±1.915	0.834
Maxillomandibular Width – Left	10.475 ±2.1178	10.83 ±1.214	9.895 ±2.2549	0.306
Denture Midline	0.125 ±1.543	-1.050 ±1.9229	-0.225 ±1.5005	0.081
Postural Symmetry	1.8 ±1.6367	1.640 ±1.2979	1.87 ±1.6784	0.891
Dental Parameters				
Inter-molar Width	57 ±3.9782	62.745 ±4.9454	57.205 ±4.7034	0.001***
Inter-canine Width	30.375 ±3.3941	31.235 ±3.4549	30.135 ±3.1164	0.549
Lower molar to Jaw - Left	6.145 ±1.3648	5.515 ±1.9168	6.175 ±1.2515	0.317
Lower molar to Jaw - Right	5.230 ±1.8874	4.375 ±2.1411	4.69 ±1.5808	0.606

P > 0.05 NS; P < 0.05 just significant*; P < 0.01 significant**; P < 0.001 highly significant***.

Table 5 (A-C) and Table 6 shows the descriptive and comparative statistics of skeletal and dental parameters to assess transverse facial dimensions in different growth patterns (Group I, II, III).

<u>Skeletal Parameters</u>

The mean value for ***intercanthal width*** was highest for Group II (90.530 ± 3.0465 mm), followed by Group III (84.62 ±5.2719 mm), and then Group I (84.050 ±2.2821 mm), and the differential mean was statistically significant (p = 0.001) **Group II > Group III > Group I**. The mean value for ***facial width*** was highest for Group II (133.9 ± 6.7237 mm), followed by Group I (123.055 ±7.5814 mm), and then Group III (121.2 ± 10.9062 mm). The differential mean was statistically significant (p = 0.001) **Group II > Group I > Group III**. The ***nasal width*** was highest in Group II with a mean value of (29.390 ± 3.5796 mm), followed by Group I (28.330 ± 3.8511 mm), and then Group III (27.870 ± 4.0454 mm). The differential mean was not statistically significant (p = 0.442), in these parameters **Group II> Group I > Group III.**

The ***maxillary width*** was highest for Group II with a mean value of (66.5 ± 3.411 mm), followed by Group I (61.545 ± 4.2334 mm), and then Group III (61.18 ± 5.7981 mm), and differential mean was statistically significant (p = 0.001) **Group II > Group I > Group III.** The highest ***mandibular width*** was indicated for Group II (83.945 ± 4.3544 mm), followed by Group III (78.295 ±6.7251 mm), and then Group I (78.8 ± 5.1602 mm), and the differential mean was statistically significant (p = 0.003) **Group II > Group III > Group I.**

The ***maxillomandibular width on the right side*** was highest for Group II with mean value of (9.905 ± 1.8667 mm), followed by Group III (9.625 ± 1.9150 mm), and then Group I (9.56 ± 1.9808 mm) and differential mean was not statistically significant (p = 0.834) **Group II > Group III > Group I.** On the ***left side,*** the mean value of maxillomandibular width value was highest for Group II (10.830 ± 1.214 mm), followed by Group I (10.475 ±
2.1178 mm), and then Group III (9.895 ± 2.2549 mm), and the differential mean was not statistically significant (p = 0.306) **Group II > Group I > Group III.**

For ***denture midline***, mean value was highest for Group I (0.125 ± 1.5430 mm), followed by Group III (-0.225 ± 1.5005 mm), and then Group II (-1.050 ± 1.9229 mm). However, the differential mean was not statistically significant (p = 0.081) **Group I > Group III > Group II**. The highest mean value for ***postural symmetry*** was for Group III (1.870 ± 1.6784 mm), followed by Group I (1.8 ± 1.6367 mm), and then Group II (1.640 ± 1.2979 mm). The differential mean was not statistically significant (p value= 0.891) **Group III > Group I > Group II.**

Dental Parameters

The mean ***inter-molar width*** was highest for Group II (62.745 ± 4.9454 mm), followed by Group III (57.205 ± 4.7034 mm), and then Group I (57 ± 3.97782 mm). The differential mean was statistically significant (p = 0.001**) Group II > Group III > Group I.** For ***inter-canine wid****th*, the mean value was highest for Group II (31.235 ± 3.4549 mm), followed by Group I (31.375 ± 3.3941 mm), and then Group III (30.135 ± 3.1164 mm). However, the differential mean was not statistically significant (p = 0.549) **Group II > Group I > Group III.**

The ***lower molar to jaw distance on the right side*** was highest for Group III (6.175 ± 1.2515 mm), followed by Group I (6.145 ± 1.3648 mm), and then Group II (5.515 ± 1.9168 mm). The differential mean was not statistically significant (p = 0.317) **Group III > Group I > Group II.** Contrary to this, the ***lower molar to jaw distance on the left side*** was highest for Group I (5.230 ± 1.8874 mm), followed by Group II (4.735 ± 2.1411 mm), and then Group III (4.690 ± 1.5808 mm). However, the differential mean was not statistically significant (p = 0.606) **Group I > Group II > Group III.**

Table 7: Inter-Group comparison of Skeletal and Dental parameters using Tukey's HSD test (Group I vs Group II).

Parameters	Group I vs Group II				
		Group I Mean ± Standard Deviation(in mm)	**Group II Mean ± Standard Deviation(in mm)**	**Mean Difference (in mm)**	**P Value**
Skeletal	**Intercanthal Width**	84.050 ± 2.2821	90.530 ± 3.0465	**6.48**	**0.000*** **
	Facial Width	123.055 ± 7.5814	133.9 ± 6.7237	**10.845**	**0.001*** **
	Nasal Width	28.330 ±3.8511	29.390 ±3.5796	**1.06**	**0.658**
	Maxillary Width	61.545 ±4.2334	66.5 ±3.411	**4.955**	**0.003** **
	Mandibular width	78.8 ±5.1602	83.945 ±4.3544	**5.145**	**0.012**
	Maxillomandibular Width - Right	9.56 ±1.9808	9.905 ±1.8667	**0.345**	**0.838**
	Maxillomandibular Width – Left	10.475 ±2.1178	10.83 ±1.214	**0.355**	**0.829**
	Denture Midline	0.125 ±1.543	-1.050 ±1.9229	**1.175**	**0.075**
	Postural Symmetry	1.8 ±1.6367	1.640 ±1.2979	**0.16**	**0.943**
Dental	**Inter-molar Width**	57 ±3.9782	62.745 ±4.9454	**5.745**	**0.001*** **
	Inter-canine Width	30.375 ±3.3941	31.235 ±3.4549	**0.86**	**0.694**
	Lower molar to jaw - Left	6.145 ±1.3648	5.515 ±1.9168	**0.63**	**0.404**
	Lower molar to jaw - Right	5.230 ±1.8874	4.375 ±2.1411	**0.495**	**0.685**

P > 0.05 NS; P < 0.05 just significant*; P < 0.01 significant**; P < 0.001 highly significant***.

Table 7 depicts the Inter-Group comparison of Skeletal and Dental parameters between **Group I vs Group II**, using Tukey's HSD test.

Skeletal parameters

For ***Inter-canthal width,*** on inter-group comparison between Group I vs Group II, the mean difference was 6.48 mm (Group II > Group I), and differential mean was statistically significant with (p = 0.000). For ***facial width***, the mean difference was 10.845 mm on inter-group comparison (Group II > Group I) and differential mean was statistically significant with (p = 0.001). The mean difference for ***nasal width*** between Group I vs Group II was 1.06 mm. (Group II > Group I). However, no statistically significant difference was seen. (p = 0.658). On inter-group comparisons of ***maxillary width*** between Group I vs Group II, the mean difference was 4.955 mm **(Group II > Group I**). The differential mean was statistically significant (p = 0.003). On inter-group comparisons of ***mandibular width*** between Group I vs Group II, the mean difference was 4.955 mm **(Group II > Group I).** The differential mean was statistically significant (p = 0.012).

On inter-group comparison of ***maxillomandibular width on the right side***, the mean difference was 0.345 mm **(Group II > Group I**). The differential mean was not statistically significant (p = 0.838). For **maxillomandibular width on the left side,** the mean difference was 0.355 mm **(Group II > Group I**). The differential mean was not statistically significant (p = 0.829). Similarly, for ***denture Midline,*** on inter-group comparison between Group I vs Group II the, mean difference was 1.175 mm **(Group I > Group II**). The differential mean was not statistically significant (p = 0.075). For ***postural symmetry,*** on inter-group comparison between Group I vs Group II the, mean difference was 0.16 mm **(Group I > Group II**). The differential mean was not statistically significant (p = 0.943).

Dental Parameters

Among the dental parameters, on inter-group comparison of ***inter-molar width***, the mean difference was 5.745 mm **(Group II > Group I).** A statistically significant difference was seen (p = 0.001). However, for *inter-canine width*, the mean difference was 0.86 mm **(Group II > Group I)** and not statistically significant (p = 0.694). On inter-group comparison of ***left and right lower molar to jaw distances,*** the mean differences were 0.63 mm and 0.495 mm, respectively **(Group I > Group II).** However, the values were not statistically significant. (p = 0.404 and 0.685 respectively).

Table 8: Inter-Group comparison of Skeletal and Dental parameters using Tukey's HSD test (Group I vs Group III).

Parameters	Group I vs Group III				
		Group I Mean ± Standard Deviation (in mm)	**Group III Mean ± Standard Deviation (in mm)**	**Mean Difference (in mm)**	**P Value**
Skeletal	**Intercanthal Width**	84.050 ± 2.2821	84.620±5.2719	0.57	0.0881
	Facial Width	123.055±7.5814	121.2±10.9062	1.855	0.775
	Nasal Width	28.330 ±3.8511	27.870±4.0454	0.46	0.924
	Maxillary Width	61.545 ±4.2334	61.18 ±5.7981	0.365	0.966
	Mandibular width	78.8 ±5.1602	78.295 ±6.7251	0.505	0.955
	Maxillomandibular Width - Right	9.56 ±1.9808	9.625 ±1.915	0.065	0.994
	Maxillomandibular Width – Left	10.475 ±2.1178	9.895 ±2.2549	0.58	0.607
	Denture Midline	0.125 ±1.543	-0.225 ±1.5005	0.35	0.785
	Postural Symmetry	1.8 ±1.6367	1.87 ±1.6784	0.07	0.989
Dental	**Inter-molar Width**	57 ±3.9782	57.205 ±4.7034	0.205	0.989
	Inter-canine Width	30.375 ±3.3941	30.135 ±3.1164	0.24	0.972
	Lower molar to jaw - Left	6.145 ±1.3648	6.175 ±1.2515	0.03	0.998
	Lower molar to jaw - Right	5.230 ±1.8874	4.69 ±1.5808	0.54	0.638

P > 0.05 NS; P < 0.05 just significant*; P < 0.01 significant**; P < 0.001 highly significant***.

Table 8 depicts the Inter-Group comparison of Skeletal and Dental parameters between **Group I vs Group III**, using Tukey's HSD test.

Skeletal parameters

For ***Inter-canthal width,*** on inter-group comparison between Group I vs Group III, the mean difference was 0.57 mm **Group III > Group I.** However, the mean difference was not statistically significant with (p = 0.881). For ***facial width,*** the mean difference was 1.885 mm on inter-group comparison between Group I vs Group III (**Group III > Group I).** However, the mean difference was not statistically significant with (p = 0.775). The mean difference for ***nasal width*** between Group I vs Group III was 0.46 mm **(Group III > Group I)**. However, no statistically significant difference was seen. (p = 0.924). On inter-group comparisons of ***maxillary widths*** between Group I vs Group III, the mean difference was 0.365 mm **Group III > Group I)**. However, no statistically significant difference was seen. (p = 0.966). On inter-group comparisons of ***mandibular widths*** between Group I vs Group III, the mean difference was 0.505 mm **Group III > Group I)**. However, no statistically significant difference was seen. (p = 0.955).

On inter-group comparison of ***maxillomandibular width on the right side***, the mean difference was 0.065 mm **(Group I > Group III)**. However, no statistically significant difference was seen. (p = 0.994). On the left side, the mean difference was 0.58 mm (**Group III > Group I)**. However, no statistically significant difference was seen. (p = 0.607). Similarly, for ***denture Midline***, on inter-group comparison between Group I vs Group III the, mean difference was 0.35 mm **(Group I > Group III)**. However, no statistically significant difference was seen. (p = 0.785). For ***postural symmetry***, on inter-group comparison between Group I vs Group III the, mean difference was 0.07 mm **(Group III > Group I)**. However, no statistically significant difference was seen (p = 0.989).

Dental Parameters

Among the dental parameters, on inter-group comparison of ***inter-molar width***, the mean difference was 0.205 mm for Group I vs Group III **(Group III > Group I)**. However, no statistically significant difference was seen. (p = 0.989). For ***inter-canine width***, the mean difference was 0.24 mm **(Group III > Group I)**. However, no statistically significant difference was seen. (p = 0.972). On inter-group comparison *of left and right lower molar to jaw distances*, the mean differences were 0.03 mm and 0.54 mm, respectively **(Group I > Group III).** However, these values were also not statistically significant (p = 0.998 and 0.638 respectively).

Table 9: Inter-Group comparison of Skeletal and Dental parameters using Tukey's HSD test (Group II vs Group III).

Parameters	Group II vs Group III				
		Group II Mean ± Standard Deviation (in mm)	**Group III Mean ± Standard Deviation (in mm)**	**Mean Difference (in mm)**	**P Value**
Skeletal	**Intercanthal Width**	90.530 ± 3.0465	84.620±5.2719	5.91	0.000***
	Facial Width	133.9 ± 6.7237	121.2±10.9062	12.7	0.000***
	Nasal Width	29.390 ±3.5796	27.870±4.0454	1.52	0.426
	Maxillary Width	66.5 ±3.411	61.18 ±5.7981	5.32	0.002**
	Mandibular width	83.945 ±4.3544	78.295 ±6.7251	5.65	0.005**
	Maxillomandibular Width - Right	9.905 ±1.8667	9.625 ±1.915	0.28	0.890
	Maxillomandibular Width – Left	10.83 ±1.214	9.895 ±2.2549	0.935	0.28
	Denture Midline	-1.050 ±1.9229	-0.225 ±1.5005	0.825	0.269
	Postural Symmetry	1.640 ±1.2979	1.87 ±1.6784	0.23	0.886
Dental	**Inter-molar Width**	62.745 ±4.9454	57.205 ±4.7034	5.54	0.001***
	Inter-canine Width	31.235 ±3.4549	30.135 ±3.1164	1.1	0.551
	Lower molar to jaw - Left	5.515 ±1.9168	6.175 ±1.2515	0.66	0.37
	Lower molar to jaw - Right	4.375 ±2.1411	4.69 ±1.5808	0.045	0.997

P > 0.05 NS; P < 0.05 just significant*; P < 0.01 significant**; P < 0.001 highly significant***.

Table 9 depicts the Inter-Group comparison of Skeletal and Dental parameters between **Group II vs Group III**, using Tukey's HSD test.

Skeletal parameters

For ***Inter-canthal width***, on inter-group comparison between Group II vs Group III, the mean difference was 5.91 mm **(Group II > Group III).** The mean difference was statistically significant (p = 0.000). For ***facial width***, the mean difference was 12.7 mm on inter-group comparison **(Group II > Group III).** The mean difference was statistically significant (p = 0.000). The mean difference for **nasal width** between Group II vs Group III was 1.52 mm **(Group II > Group III).** However, no statistically significant difference was seen. (p = 0.426). On inter-group comparisons of ***maxillary width*** between Group II vs Group II, the mean difference was 5.32 mm **(Group II > Group III).** The mean difference was statistically significant (p = 0.002). On inter-group comparison of ***mandibular width*** between Group II vs Group III, the mean difference was 5.65 mm **(Group II > Group III).** The mean difference was statistically significant (p = 0.005).

On inter-group comparison of ***maxillomandibular width on the right side***, the mean difference was 0.28 mm **(Group II > Group III).** However, no statistically significant difference was seen (p = 0.890). On the ***left side***, the mean difference was 0.935 mm **(Group II > Group III).** The mean difference was not statistically significant (p = 0.28). Similarly, for ***denture Midline***, on inter-group comparison between Group II vs Group III the, mean difference was 0.825 mm **(Group II > Group III).** However, no statistically significant difference was seen (p = 0.269). For ***postural symmetry***, on inter-group comparison between Group II vs Group III the, mean difference was 0.23 mm **(Group III > Group II).** However, no statistically significant difference was seen (p = 0.886).

Dental Parameters

Among the dental parameters, on inter-group comparison of ***inter-molar width***, the mean difference was 5.54 mm **(Group II > Group III).** The mean difference was statistically significant (p = 0.001). For ***inter-canine width,*** the mean difference was 1.1 mm **(Group II > Group III).** However, no statistically significant difference was seen (p = 0.551). On inter-group comparison *of* ***left and right lower molar to jaw distances,*** the mean differences were 0.66 mm and 0.045 mm, respectively **(Group III > Group II).** However, no statistically significant difference was seen on both left and right side (p = 0.837 and 0.997 respectively).

Orthodontic diagnosis involves collection of relevant data in a systematic manner to help in identifying the nature and cause of the malocclusion in all three planes of space i.e. antero-posterior, vertical and transverse planes.

Management of orthodontic discrepancies involves correction of malocclusion in each plane, as discrepancy in one plane is influenced by discrepancies in other planes as well. This is the reason for adding maxillary expansion in myofunctional appliances in growing subjects, so as to correct transverse discrepancy for smooth functional positioning of mandible in sagittal plane.
The majority of attention has been focused on the lateral cephalometric evaluation, which provides information on dentoalveolar and soft tissue changes in the sagittal and vertical plane, despite the fact that radiographic evaluation is an essential component of orthodontic diagnosis.

Growth completes in transverse plane firstly, followed by antero-posterior dimension and vertical dimension attain growth completion lastly. Hence, early assessment of transverse discrepancy is of paramount importance in making proper diagnosis in frontal plane. Also, it is important to differentiate between skeletal and dental inputs for transverse discrepancy.

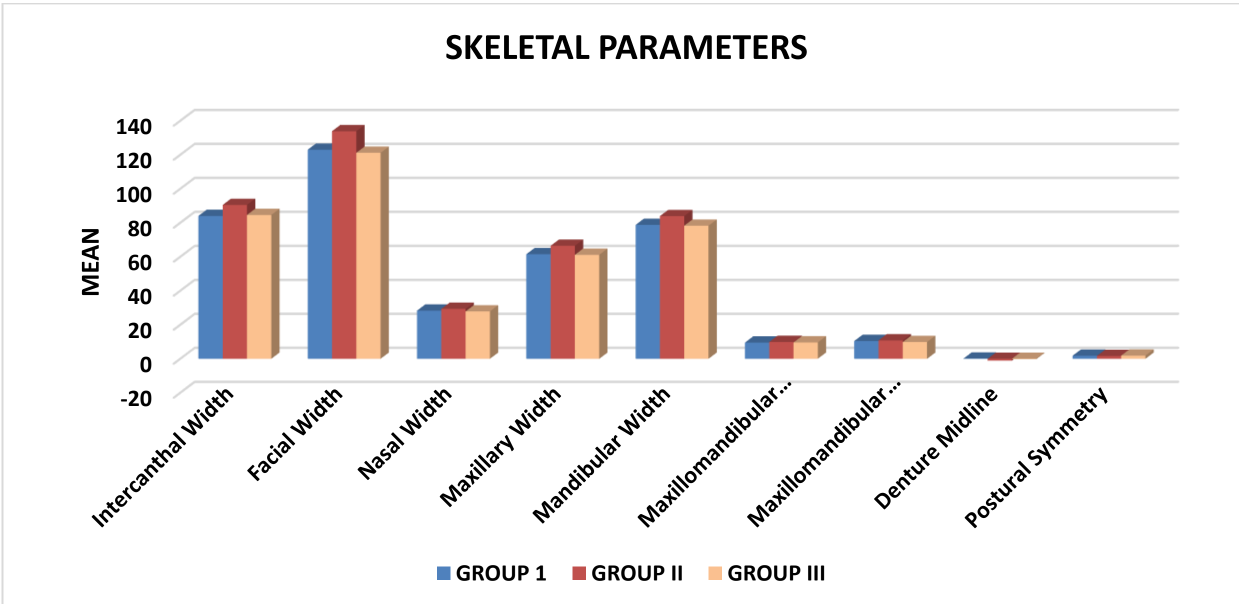
Numerous research studies[15,16,25] have attempted to determine the correlation between arch form, width, and vertical facial morphology in connection to various types of malocclusion. According to Ricketts et al[12], a person with a long face typically has narrower transverse dimensions (dolichofacial), whereas a person with a short face typically has larger transverse dimensions (brachyfacial). Forster's research[7] revealed that male dental arch widths were much wider than female dental arch widths. Also, the arch width tended to decrease in both males and females with increase in mandibular plane angles. Similar findings, were seen by Giuntini et al[8] for maxillary arch form in Class II subjects both in inter-molar and inter-canthal regions. Most of these studies stressed on respecting individual arch form of subjects as per growth pattern.

Transverse dental dimensions had been assessed in study models for subjects with variable facial growth pattern. However, none of the studies had compared dental and skeletal characteristics in transverse plane in subjects with different facial growth patterns, using postero-anterior cephalogram. The postero-anterior cephalogram is a useful technique for examining the structure of the craniofacial skeleton in both the transverse and vertical planes while providing a frontal view of the face skeleton. This also help in the assessment of various craniofacial deformities, such as face asymmetries, and aids in distinguishing between differences between the right and left sides in the transverse plane.

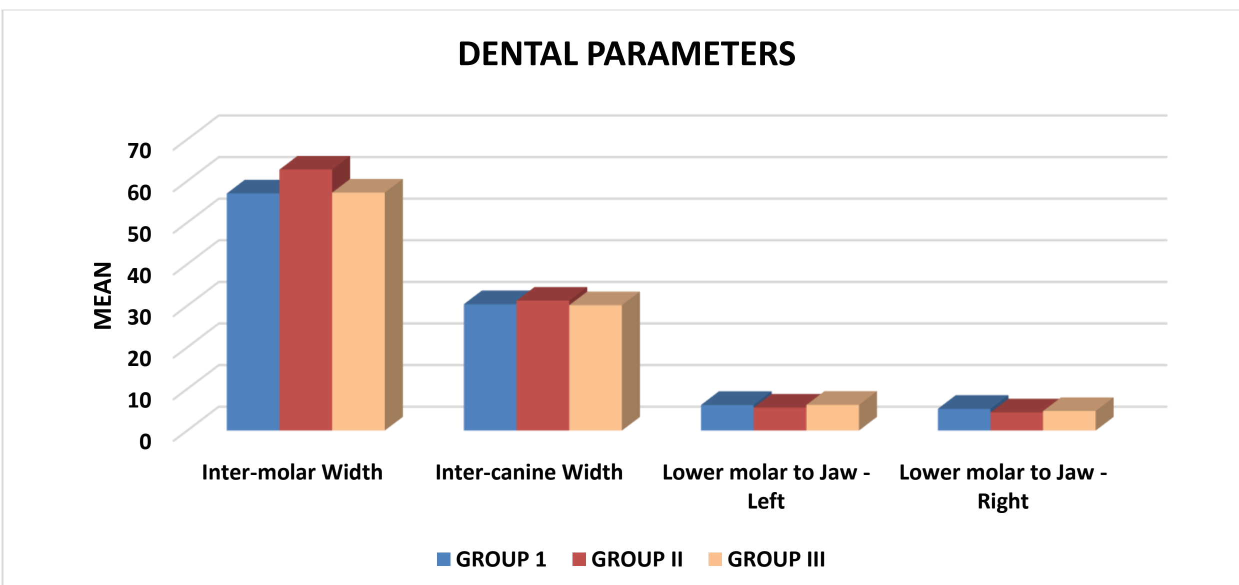
The present study was conducted in Department of Orthodontics, BBDCODS, with an aim to assess and compare the transverse dimensions in subjects with variable facial growth patterns, using postero-anterior (PA) Cephalogram collected from the patients visiting the department of Orthodontics for fixed orthodontic treatment. Frankfort's mandibular plane angle (FMA) and Jarabak ratio were measured on lateral cephalogram of all the patients to distribute the patients into groups according to their growth pattern. Final sample for the study included 20 Normo-divergent subject (Group I), 20 Hypodivergent subjects (Group II) and 20 Hyperdivergent subjects (Group III).

Postero-anterior cephalogram of selected subjects was taken and nine skeletal and four dental parameters were measured to assess the transverse dimensions among subjects with different growth patterns using Ricketts' frontal facial analysis. The data obtained was tabulated on Microsoft Excel sheet and subjected to statistical analysis using ANOVA and Tukey's HSD test.

The results of the present study suggested that statistically significant inverse relation existed between facial divergence and transverse facial width. All skeletal transverse parameters had highest mean values in Group II (Hypodivergent growth pattern), followed by Group I (Normodivergent growth pattern) and then Group III (Hyperdivergent growth pattern) **(Table 5 A-C, Graph 1).** Similar trend was seen for transverse dental parameters in different facial divergence groups. **(Table 5 A-C, Graph 2)**



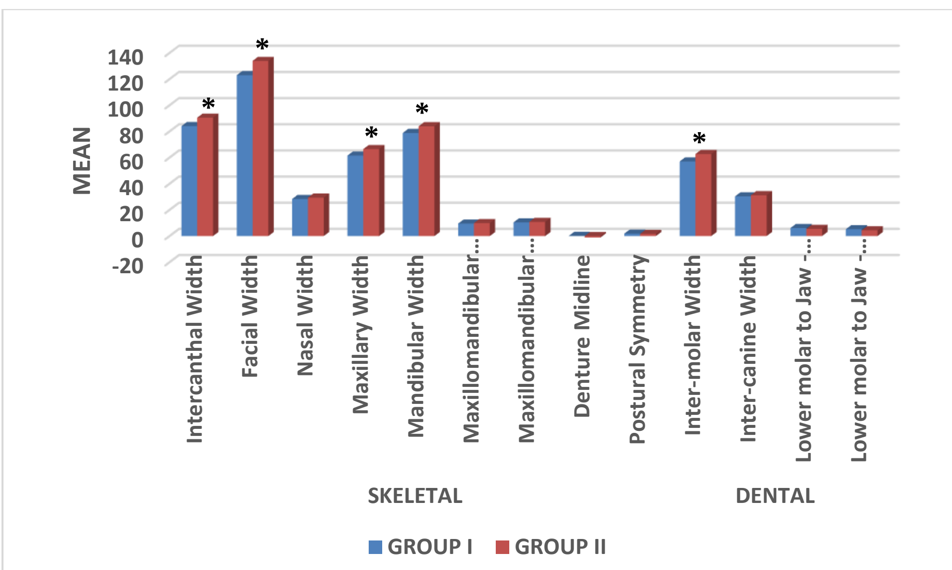
Graph 1: Descriptive statistics of Skeletal parameters to assess Transverse dimensions



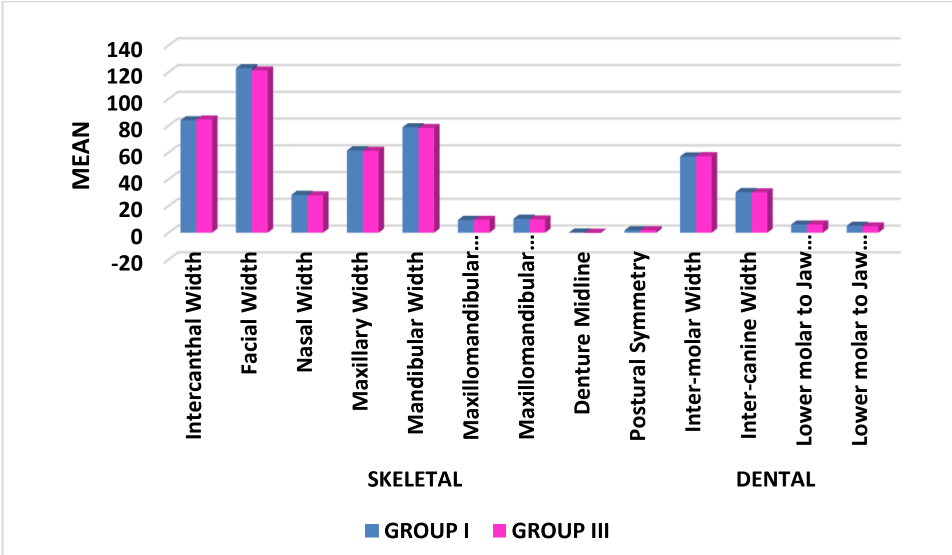
Graph 2: Descriptive statistics of Dental parameters to assess Transverse dimensions

The skeletal parameters - ***inter-canthal width (ZL-ZR), facial width (ZA-AZ), maxillary width (JL_JR) and mandibular width (AG-GA)*** showed statistically significant difference between different facial divergence groups whereas other parameters – ***nasal width (CN-NC)*, denture midline, postural symmetry on right and left side**, did not differ significantly with facial divergence. For dental parameters, only ***inter-molar width (B6-6B)*** showed statistically significant difference between different divergence groups. Other dental parameters like the ***inter-canine width (B3-3B), lower molar to jaw distance on left and right side***, did not show statistically significant difference between divergence groups.

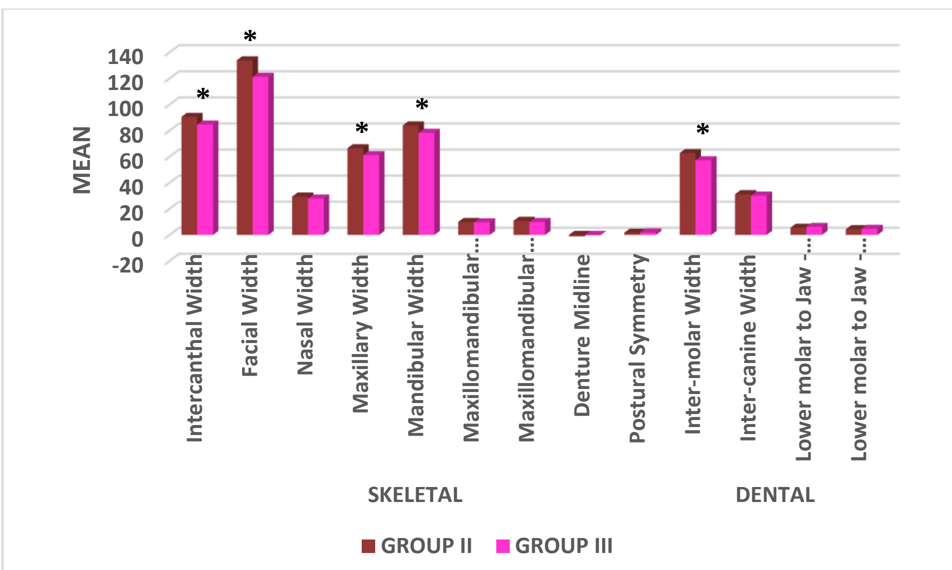
Intergroup comparison showed statistically significant difference for skeletal parameters - **inter-canthal width (ZL-ZR), facial width (ZA-AZ), maxillary width (JL-JR) and mandibular width (AG-GA), and single dental parameter - inter-molar width showed statistically significant difference between Group I vs Group II (Graph 3) and also for Group II vs Group III (Graph 5). This is suggestive of the fact that transverse dimensions were significantly different between hypodivergent groups and other groups.** However, no statistically significant difference was seen for above mentioned skeletal and dental parameters between **Group I and Group III (Graph 4)**.



Graph 3: Inter-Group comparison of Skeletal and Dental parameters using Tukey's HSD test (Group I vs Group II).



Graph 4: Inter-Group comparison of Skeletal and Dental parameters using Tukey's HSD test (Group I vs Group III).



Graph 5: Inter-Group comparison of Skeletal and Dental parameters using Tukey's HSD test (Group II vs Group III).

As transverse dimension had not been evaluated using postero-anterior (PA) cephalogram in subjects with different facial divergence, hence direct comparison was not possible. The results would be compared to photographic studies that evaluated facial width or other studies that correlated dental width on study models to facial divergence.

<u>Skeletal Parameters</u>

Inter-canthal width

In the present study, the inter-canthal distance (ZL-ZR) was highest for Group II subjects with Hypodivergent growth pattern (90.530 ±3.0465 mm) and least for Group I subjects with Normodivergent growth pattern (84.050 ± 2.2821 mm). A photographic study undertaken by Raval et al[37] (2020) reported that the inter-canthal distance had the highest mean of 95.05 ± 2.38175 mm and 96.52±1.50560 mm in males and females respectively, amongst hyperdivergent subjects, whereas hypodivergent subjects showed the least mean of 92.51±2.40887 mm and 93.44 ±2.67032 mm in males and females respectively. These results are contrary to other findings as they measure inter-canthal width from outer canthus to outer canthus whereas inter-canthal width was measured from ZfL-ZfR in present study. Also, soft tissue thickness variation in photographic study could be responsible for contrary findings.

Facial Width

The facial width was highest in Group II subjects (Hypodivergent growth pattern) with a mean value of 133.9 ± 6.7237 mm, followed by Group I subjects (Normodivergent growth pattern) with a mean value of 123.055 ± 7.5814 mm, and then Group III subjects (Hyperdivergent growth pattern) with a mean value of 121.2 ± 10.9062 mm. Facial width (ZA-AZ) was measured by Ricketts et al[12] (1982) and showed a mean value of 115.7 mm at the age of 9 years, with 2.4 mm increases per year; their prediction for an adult was 137.3 mm, at an age of 18 years.

Snodell et al[16] (1993) found a mean facial width of 114.7 mm for females at age of 9 years with an increment of 1.4 – 2.0 mm per year and 117.1 mm in males at age 9 years, with increment of 1.2 to 3.1 mm per year. Facial divergence of all the three groups of present study were closer to values as per above mentioned studies.

Nasal Width

In present study, Hypodivergent subjects (Group II) had the highest mean nasal width of 29.390 ± 3.5796 mm, following by Normodivergent subjects (Group I) with a mean nasal width of 28.330 ± 3.8511 mm, and then Hyperdivergent subjects (Group III) with mean value of 27.870 ± 4.0454 mm.

Ricketts' et al[12] found nasal width (NC-CN) to have a mean of 25 mm for 9 year old subjects, increasing 0.7 mm per year. The CN - NC measurement was approximately 31.3 for an adult at an age of 18 years. A postero-anterior cephalometric study done by Uysal et al[25] (2003) on Turkish adults reported mean nasal width to be of 32.4mm. The difference in nasal width in present study with above mentioned studies could be due to racial variation or sample was not segregated on basis of facial divergence in these studies.

Maxillary and Mandibular Width

In the present study, the mean maxillary width (JL-JR) was highest in Group II subjects (Hypodivergent growth pattern) with a mean value of (66.5 ± 3.411 mm), and least in Group III subjects (hyperdivergent growth pattern) with a mean value of 61.18 ± 5.7981 mm. Normodivergent subjects had a mean maxillary width of 61.545 ± 4.2334 mm.

In the present study, the mean mandibular width (AG - GA) was highest in Group II subjects (Hypodivergent growth pattern) with a mean value of (83.945 ± 4.3544 mm), followed by Group III subjects (Hyperdivergent growth pattern) with a mean value of 78.8 ± 5.1602 mm. Normodivergent subjects showed the least mandibular width of 78.295 ± 6.7251 mm.

The results from this study were consistent with most of the previous studies in the literature. Christie[38] (1977) found that adult brachyfacial males had greater maxillary and mandibular widths than 'standard' males, based on postero-anterior (PA) cephalograms. However, the arch widths of 'standard' females and brachyfacial females did not differ. Ricketts' et al[12] (1982) found that the width of the maxilla (JL-JR) was 61.9 mm for a 9-year-old subject and increased 0.6 mm per year. According to them, at age 18, the JL-JR distance is approximately 67.3 mm, which is in accordance to the maxillary width (JL-JR) of hypodivergent group (66.5 ± 3.411 mm) of the present study.

Wagner et al[26] in his postero-anterior (PA) cephalometric study concluded that vertical facial patterns (with low and high SN-MP angle) may be strongly related to mandibular and maxillary transverse growth. They found smaller maxillary (JL-JR) and mandibular (AG-GA) width in high angle groups as compared to low angle group at age 6, and until age 18 this pattern persisted.

Snodell et al's[16] (1993) postero-anterior (PA) cephalometric study revealed a mean maxillary width of 58.1 mm for females that increased from 0.5 to 1.5 mm per year and 60.0 mm for males that increased from 0.5 to 1.7 mm per year. Another postero-anterior (PA) cephalometric study undertaken by Uysal et al[25] (2005) reported a mean JL – JR distance of 63.81 ± 3.33 mm for women and 69.86 ± 4.30 mm for men.

The mandibular width, measured from the antegonial notch points (AG - GA) by Ricketts' et al[12] (1982) was reported to be approximately 88.7 mm for a young adult. Similar to this, Cortella et al[38] (2022) established postero-anterior (PA) cephalometric norms for AG-GA in a young adult population based on data from the Bolton Study Group. They recorded a AG-GA distance of 86.4 ± 4.5 mm. Snodell et al's[16] (1993) postero-anterior (PA) cephalometric study found mandibular width of 82.7 mm for females and 85.2 for males at age 9 years, increasing from 0.5 to 2.0 mm for females and 1.5 to 3.0 mm for males. Wagner and Chung[26] (2005) and Ricketts at al[12] (1982) found that while the growth of the maxilla plateaus at about 14 years of age, the skeletal width of the mandible continues to grow, at least in hypodivergent and normodivergent groups.

According to Cortella et al[39], J-J and Ag-Ag showed comparable initial rates of increase, on contrary to result of studies by Wagner and Chung[26] and Ricketts et al[12]. They discovered that the rate varies depending on gender and is not maintained during growth. They further suggested that J-J and Ag-Ag growths stop in females at the age of sixteen. In males, Ag-Ag keeps up its growth rate until at least the age of 18, whereas J-J only slightly slows it down. Snoddel et al[16] reported that the mandibular growth continued until the age of 18, whereas Krogman[40] proposed that growth in both jaw widths typically finishes before the adolescent growth spurt. This could be possible explanation of higher maxillary and mandibular width in hypodivergent subjects in present study.

Maxillo – mandibular width

In the present study, the maxillo-mandibular width on both the right and left sides were highest for Group II subjects (Hypodivergent growth pattern) than other groups but mean difference was not statistically significant.

Maxillo-mandibular width on the right side was highest for hypodivergent subjects (Group II) with mean value of 9.905 ± 1.8667 mm, followed by hyperdivergent subjects (Group III) with mean value of 9.625 ± 1.915 mm and then normodivergent subjects (Group I) with mean value of 9.56 ± 1.9808 mm. On the left side, the maxilla-mandibular width was highest for hypodivergent subjects (Group II) with mean value of 10.83 ± 1.214 mm, followed by normodivergent subjects (Group I) with mean value of 10.475 ± 2.1178 mm and then hyperdivergent subjects (Group III) with mean value of 9.895 ± 2.2549 mm.

Denture Midline

In the present study, for denture midline, mean value was highest (0.125 ± 1.543 mm) for normodivergent subjects (Group I), followed by hypodivergent subjects (Group II) with a mean value of (– 1.050 ± 1.9229 mm) and least for hyperdivergent subjects (Group III) with mean value of (– 0.225 ± 1.5005 mm). However, the mean difference was not statistically significant ($p = 0.081$).

Most of the normative date in literature have focused on assessment and comparison of transversal dimensions rather than asymmetry in subjects with variable facial growth patterns. Therefore, it was not possible to correlate the findings of this study with other studies. Huang et al[41] (2013) proposed that a perfect bilateral symmetry almost never exists in the human body. This could be the reason for existence of minor midline asymmetry of less than 1 mm in all the groups, that is considered as clinically non-obvious facial asymmetry.

Postural Symmetry

In the present study, for postural symmetry, mean value was highest (1.87 ± 1.6784 mm) for hyperdivergent subjects (group III), followed by normodivergent subjects (Group I) with a mean value of (1.8 ± 1.6367 mm) and least (1.640 ± 1.2979 mm) for hypodivergent subjects (Group II). However, the difference between groups was not statistically significant ($p = 0.891$).

<u>Dental Parameters</u>

Inter-molar width

In the present study, subjects with Hypodivergent growth pattern (Group II) showed highest mean value for mandibular inter-molar width (62.745 ± 4.9454 mm). They were followed by subjects with Hyperdivergent growth pattern (Group III) who presented a mean value of (57.205 ± 4.7034 mm). Subjects with a Normodivergent growth pattern in Group I depicted the least inter-molar width with mean value of 57 ± 3.997782 mm. The results would be compared to studies that evaluated inter-molar width on study models. (Snoddel et al[16], Uysal et al[25], Goyal et al[44], Khera et al[45], Prasad et al[46])

Khera's study[45] (2012) showed that the mean of mandibular first inter-molar width as well as the arch perimeter were decreased from hypodivergent to hyperdivergent subjects. The mean mandibular inter-molar width was 43.81±2.36 mm, 45.60±1.58 mm, 42.54±2.69 mm in males and 42.97±1.88 mm, 43.77±2.14 mm, 41.75±1.34 mm in females, for normodivergent, hypodivergent and hyperdivergent subjects respectively. In Nasby et al's[43] study (1972), it was noted that the mean mandibular inter-molar width were greater in adolescent subjects with low MP-SN angle (35.9±3.16 mm) as compared to subjects with high MP-SN angle (33.6±2.57 mm); Forster's study[7] reported the mean mandibular inter-molar width was 53.03±2.68 mm, 54.39±3.21 mm, 53.46±4.18 mm in males and 52.24±2.99 mm, 51.82±2.65 mm, 52.36±2.51 mm in females, for average, low and high MP-SN angle subjects respectively.

Goyal et al's cephalometric and model study (2023)[44] reported the mandibular inter-molar width was 50.30±2.87 mm, 50.63±2.43 mm and 49.09±2.68 mm for normodivergent, hypodivergent and hyperdivergent subjects respectively. Similar findings were seen by Prasad et al[46] in his model and cephalometric study, where the inter-molar width was 42.75±1.2 mm, 44.02±0.9 mm, 42.31±1.8 mm in males and 42.07±1.2 mm, 42.48±1 mm, 40.71±1.2 mm in females, for subjects with average, low and high MP-Sn angles respectively. Isaacson et al[42] (1971) reported that subjects with longer faces presented with a decrease in maxillary intermolar width.

Snodell et al's[16] study (1993) on Class I skeletal and dental subjects indicated that the mean mandibular inter-molar width (B6-6B) was 56.00±2.96 mm in males and 54.10±2.17 mm in females. Uysal et al's[25] cephalometric study reported intermolar distance norm value to be 61.47 ± 3.43 mm among Turkish males and 57.86±3.04 mm in Turkish females. Inter-molar width of present study, though evaluated in different divergence groups were similar to these studies.

Correct identification of a patients' arch form is an important aspect of achieving a stable, functional and aesthetic orthodontic treatment result; failure to preserve the arch form might increase the probability of relapse. The patient's ethnic background is one genetic factor influencing the dental arch form along with facial divergence and could be the reason of mild variations with above mentioned studies.

Inter-canine width

In the present study, for inter-canine width, mean value was highest (31.235±3.4549 mm) for hypodivergent subjects (Group II), followed by normodivergent subjects (Group I) with a mean value of (30.375±3.3941 mm) and then in hyperdivergent subjects (Group III), where mean value was 30.135±3.1164 mm. However, the differential mean was not statistically significant ($p = 0.549$).

A recent study by Goyal et al[44] (2023) concluded that maxillary and mandibular inter-canine width were maximum (27.39 ± 2.52 mm) in hypodivergent subjects, followed by normodivergent subjects (26.52 ± 2.16 mm) and minimum (25.78 ± 2.13 mm) in subjects with hyperdivergent growth pattern. Thus, an inverse relationship between vertical facial morphology and dental arch width at canine. Similar findings were supported by Nasby et al[43] (1972), Khera et al[45] (2012), Prasad et al[46] (2013), Grippaudo et al[47] (2013), etc. These results are contrary to findings of present study where inter-canine width did not differ significantly with facial divergence. The reason could be variation in method used to measure inter-canine width as canines are measured on curved arch on study models whereas a postero-anterior (PA) cephalogram is a planar representation of curved mandibular arch.

Lower molar to Jaw distance

In the present study, on the left side, Hyperdivergent subjects (Group III) had the highest mean distance (6.175 ± 1.2515 mm) from lower molar to the jaw, followed by Normodivergent subjects (Group I) with mean distance of 6.145 ± 1.3648 mm and least for Hypodivergent subjects (group II) with mean distance of 5.515 ± 1.9168 mm. On the right side, the highest mean distance (5.230 ± 1.8874 mm) was reported for Normodivergent subjects (Group I), followed by Hyperdivergent subjects (Group III) with mean distance of 4.69 ± 1.5808 mm and least for Hypodivergent subjects (group II) with mean distance of 4.375 ± 2.1411 mm. The increased value in hyperdivergent group could be attributed to forward tongue posture resulting in mesial thrust on dentition or increased downward and backward rotation of the mandible.

This could be explained by role of musculature activity as a potential link between the transverse dimension and vertical facial morphology, musculature has been proposed as a potential link. Hypodivergents may have wider alveolar and dental arches due to strong or thick mandibular elevator muscles in short face individuals. Increased mechanical loading of the jaws due to this muscular hyperfunction may induce sutural growth and bone apposition, which in turn may lead to increased transverse growth of the jaws and the bases of the dental arches. A study[55] (1999) showed a correlation between brachycephaly and large masticatory muscles. Long-faced subjects have significantly smaller masseter and medial pterygoid muscles than normal subjects, according to Van Spronsen et al[50] (1992). According to ultrasonographic measurements of masseter muscle thickness by Satiroglu, Arun, and Isik's[56] (2005), people with thicker masseters had vertically shorter facial patterns, while people with thinner masseters had longer faces.

Studies on the thickness of the masseter have also shown that this muscle has an impact on the inclination of the posterior teeth. Specifically, subjects with shorter faces tend to have larger masseters, which may lead to more lingually inclined posterior teeth.[48,49,50,51,52]

The major limitations of the present study were small sample size and the sample was not distributed with gender. Also, other possible shortcomings may include errors in landmark identification, digitizing and faulty head positioning with variations in X-ray projection. Within limitations of the present study, it was seen that transverse dimensions increased with decrease in mandibular plane angle.

The main clinical implication of present study is that while planning for expansion in subjects, growth pattern must be considered. Dental expansion if not corroborated with skeletal expansion might relapse. Hence, caution must be taken during expansion in subjects with hyperdivergent growth pattern. Also, arch form must be maintained as per patient's pre-treatment arch form, after due consideration of transverse width and growth pattern. This is in accordance to Little's[57] study, where he suggested to refrain from expanding the lower arch unless it was necessary due to concerns about the facial profile or in order to harmonize the occlusion with maxillary palatal expansion accomplished for cross-bite correction or unusual narrowness. He also stated that decrease in mandibular dental arch dimensions gradually appear to be a normal physiological phenomenon in both treated and untreated malocclusions.

Further studies on larger sample size divided on basis of gender can validate the result of the present study. So, different norms for various transversal dimensions in different divergence group could be established our population. Also, transverse dimensions could be assessed using CBCT and facial divergence groups could be further segregated on the basis of sagittal malocclusion for better understanding of relations between transverse dimension and vertical facial divergence.

Conclusion

Following conclusions may be drawn from the present study conducted with an aim to assess transverse dimensions in subjects with variable growth patterns using poster-anterior cephalogram:

1. Transverse facial dimensions (skeletal and dental) differed with facial divergence, and showed inverse relationship between them.
2. Hypodivergent subjects had significantly higher transverse dimensions than normodivergent and hyperdivergent subjects.
3. Normodivergent and hypodivergent subjects did not differ significantly for various transverse dimensions.
4. Hypodivergent subjects have increased inter-canthal width, facial width, maxillary width and mandibular width.
5. Dental transverse dimensions followed similar trend as skeletal transverse dimensions.
6. The inter-molar distance was significantly higher in hypodivergent subjects, followed by normodivergent subjects and then hyperdivergent subjects.

It could be suggested that variation in transverse dimension due to facial divergence must be considered while planning transverse expansion by orthodontic or ortho-surgical means.

Orthodontic diagnosis involves collection of relevant data in a systematic manner to help in identifying the nature and cause of the malocclusion in all three planes of space i.e. antero-posterior, vertical and transverse planes.

Management of orthodontic discrepancies involves correction of malocclusion in each plane, as discrepancy in one plane is influenced by discrepancies in other planes as well. This is the reason for adding maxillary expansion in myofunctional appliances in growing subjects, so as to correct transverse discrepancy for smooth functional positioning of mandible in sagittal plane.

The majority of attention has been focused on the lateral cephalometric evaluation, which provides information on dentoalveolar and soft tissue changes in the sagittal and vertical plane, despite the fact that radiographic evaluation is an essential component of orthodontic diagnosis.

Growth completes in transverse plane firstly, followed by antero-posterior dimension and vertical dimension attain growth completion lastly. Hence, early assessment of transverse discrepancy is of paramount importance in making proper diagnosis in frontal plane. Also, it is important to differentiate between skeletal and dental inputs for transverse discrepancy.

Numerous research studies have attempted to determine the correlation between arch form, width, and vertical facial morphology in connection to various types of malocclusion.

Transverse dental dimensions had been assessed in study models for subjects with variable facial growth pattern. However, none of the studies had compared dental and skeletal characteristics in transverse plane in subjects with different facial growth patterns, using postero-anterior cephalogram.

The purpose of this study was to evaluate and compare transverse dimensions in subjects with variable facial growth patterns, using postero-anterior cephalograms.

This study was conducted in department of Orthodontics, BBDCODS, with an aim to assess transverse dimensions in subjects with variable facial growth patterns, using postero-anterior (PA) cephalogram collected from the patients reporting to the Department of Orthodontics for fixed orthodontic treatment. Lateral cephalogram of subjects were taken for sample distribution into groups according to their growth pattern (Group I - Normodivergent, Group II - Hypodivergent and Group III - Hyperdivergent), using two cephalometric parameters i.e. Frankfort mandibular plane angle (FMA) and Jarabak Ratio. Sample included thirty subjects in each group. Postero-anterior cephalogram of 60 subjects were taken to evaluate and compare the transverse dimensions (9 skeletal and 4 dental parameters) among three groups – Group I (n=20), Group II (n=20) and Group III (n=20).

The approval was taken from Ethical Committee of Babu Banarasi Das College of Dental Science, BBDU, Lucknow before conducting the study. An informed consent was taken from all the participants of the study. The data obtained was tabulated and adequate comparison made between the three groups.

The following conclusions may be drawn from the present study conducted to assess transverse dimensions amongst subjects with variable facial divergence taken into account.

1. Transverse facial dimensions (skeletal and dental) differed with facial divergence, and showed inverse relationship between them.
2. Hypodivergent subjects had significantly higher transverse dimensions than normodivergent and hyperdivergent subjects.
3. Normodivergent and hypodivergent subjects did not differ significantly for various transverse dimensions.
4. Hypodivergent subjects have increased inter-canthal width, facial width, maxillary width and mandibular width.
5. Dental transverse dimensions followed similar trend as skeletal transverse dimensions.
6. The inter-molar distance was significantly higher in hypodivergent subjects, followed by normodivergent subjects and then hyperdivergent subjects.

The major limitations of the present study were small sample size and the sample was not distributed with gender. Also, other possible shortcomings may include errors in landmark identification, digitizing and faulty head positioning with variations in X-ray projection. Within limitations of the present study, it was seen that transverse dimensions increased with decrease in mandibular plane angle.

The main clinical implication of present study is that while planning for expansion in subjects, growth pattern must be considered. Dental expansion if not corroborated with skeletal expansion might relapse. Hence, caution must be taken during expansion in subjects with hyperdivergent growth pattern. Also, arch form must be maintained as per patient's pre-treatment arch form, after due consideration of transverse width and growth pattern. This is in accordance to a previous study, where it was suggested to refrain from expanding the lower arch unless it was necessary due to concerns about the facial profile or in order to harmonize the occlusion with maxillary palatal expansion accomplished for cross-bite correction or unusual narrowness. He also stated that decrease in mandibular dental arch dimensions gradually appear to be a normal physiological phenomenon in both treated and untreated malocclusions.

Further studies on larger sample size divided on basis of gender can validate the result of the present study. So, different norms for various transversal dimensions in different divergence group could be established our population. Also, transverse dimensions could be assessed using CBCT and facial divergence groups could be further segregated on the basis of sagittal malocclusion for better understanding of relations between transverse dimension and vertical facial divergence.

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ANNEXURE-I

BABU BANARASI DAS UNIVERSITY

BBD COLLEGE OF DENTAL SCIENCES, LUCKNOW

BBD UNIVERSITY

INSTITUTIONAL RESEARCH COMMITTEE APPROVAL

The project titled **"Assessment Of Transverse Dimension In Subjects With Variable Facial Growth Patterns – A P.A. Cephalometric Study"** submitted by **Dr Sarbajit Saha** Postgraduate student in the **Department of Orthodontics & Dentofacial Orthopaedics** for the Thesis Dissertation as part of MDS Curriculum for the academic year 2021-2024 with the accompanying proforma was reviewed by the Institutional Research Committee in its meeting held on **14th September, 2022** at BBDCODS.

The Committee has granted approval on the scientific content of the project. The proposal may now be reviewed by the Institutional Ethics Committee for granting ethical approval.

Prof. Dr. Puneet Ahuja
Chairperson

Dr. Mona Sharma
Co-Chairperson

ANNEXURE-II

BABU BANARASI DAS UNIVERSITY
BBD COLLEGE OF DENTAL SCIENCES, LUCKNOW

BBD UNIVERSITY

BBDCODS/IEC/09/2022 **Dated: 16th September, 2022**

Communication of the Decision of the Xth Institutional Ethics Sub-Committee Meeting

IEC Code: 14

Title of the Project: Assessment Of Transverse Dimension In Subjects With Variable Facial Growth Patterns – A P.A. Cephalometric Study.

Principal Investigator: Dr Sarbajit Saha **Department:** Orthodontics & Dentofacial Orthopaedics

Name and Address of the Institution: BBD College of Dental Sciences Lucknow.

Type of Submission: New, MDS Project Protocol

Dear Dr Sarbajit Saha,

The Institutional Ethics Sub-Committee meeting comprising following members was held on 15th September, 2022.

1.	Dr. Lakshmi Bala Member Secretary	Prof. and Head, Department of Biochemistry
2.	Dr. Praveen Singh Samant Member	Prof. & Head, Department of Conservative Dentistry & Endodontics
3.	Dr. Jiji George Member	Prof. & Head, Department of Oral Pathology & Microbilogy
4.	Dr. Amrit Tandan Member	Professor, Department of Prosthodontics and Crown & Bridge
5.	Dr. Rana Pratap Maurya Member	Reader, Department of Orthodontics & Dentofacial Orthopaedics

The committee reviewed and discussed your submitted documents of the current MDS Project Protocol in the meeting.
The comments were communicated to PI, thereafter it was revised.

Decisions: The committee approved the above protocol from ethics point of view.

Forwarded by:

Lakshmi Bala
16/09/22

Prof. Dr. Puneet Ahuja
Principal 16/9
BBD College of Dental Sciences
BBD University, Lucknow

PRINCIPAL
Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow-226028

Dr. Lakshmi Bala
Member-Secretary
Institutional Ethics Sub-Committee (IEC)
BBD College of Dental Sciences
BBD University, Lucknow

Member-Secretary
Institutional Ethic Committee
BBD College of Dental Sciences
BBD University
Faizabad Road, Lucknow-226028

ANNEXURE -III

Babu Banarasi Das College of Dental Sciences

(Babu Banarasi Das University)

BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

Guidelines for Devising a Participant / Legally Acceptable RepresentativeInformation Document (PID) in English

1. **Study Title**

   Assessment of Transverse Dimensions in subjects with variable Facial Growth Patterns – Postero-anterior cephalometric study

2. **Invitation Paragraph**

   You are being invited to take part in a research study. Before you decide it is important for you to understand why the research/study is being done and what it will involve. Please take time to read the following information carefully and discuss it with friends, relatives and your treating physician/family doctor if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

3. **What is the purpose of the study?**

   the purpose of the study is to assess and compare transverse dimensions in subjects with variable facial growth pattern.

4. **Why have I been chosen?**

   No patient is required as it is an in vitro study

5. **Do I have to take part?**

   Not applicable.

6. **What will happen to me if I take part?**

Not applicable.

7. **What do I have to do?**

Not applicable

8. **What is the procedure that is being tested?**

The procedure will involve comparative evaluation of transverse dimensions invariable facial growth patterns: a comparative study

9. **What are the interventions for the study?**

- To evaluate the transverse dimensions in subjects with average growth pattern.
- To evaluate the transverse dimensions in subjects with horizontal growth pattern.
- To evaluate the transverse dimensions in subjects with vertical growth pattern.
- To compare the transverse dimensions in subjects with different growth pattern.

10. **What are the side effects of taking part?**

Not applicable

11. **What are the possible disadvantages and risks of taking part?**

Not applicable

12. **What are the possible benefits of taking part?**

Not applicable

13. **What if new information becomes available?**

Sometimes during the course of a research project, new information becomes available about the research being studied. If this happens, your researcher will tell you about it and discuss with you whether you want to continue in the study. If you decide to withdraw, your researcher/investigator will make arrangements for your withdrawal. If you decide to continue in the study, you may be asked to sign an updated consent form.

14. **What happens when the research study stops?**

If the study stops/finishes before the stipulated time, this will be explained to the patient/volunteer.

15. **What if something goes wrong?**

If any severe adverse event occurs, or something goes wrong during the study, the complaints will be handled by reporting to the institution (s), and Institutional ethical community.

16. **Will my taking part in this study be kept confidential?**Yes

17. **What will happen to the results of the research study?**

The results of the study will be used to be compare transverse dimensions among different growth patterns.

18. **Who is organizing the research?**

This research study is organized by the academic institution (B.B.D.CODS).

19. **Will the results of the study be made available after study is over?**

Yes

20. **Who has reviewed the study?**

The study has been reviewed and approved by the Head of the Dept, and the IEC/IRC of the institution.

21. Contact for further information

Dr. Sarbajit Saha

Department of Orthodontics and Dentofacial Orthopaedics

Babu Banarasi Das College of Dental Sciences.

Lucknow-227105

Mob- 9535332465

Dr. Rohit Khanna (HOD)

Department of Orthodontics and Dentofacial Orthopaedics

Babu Banarasi College of Dental Sciences.

Lucknow-227105

Mob-9415037011

Dr. Sneh Lata Verma (Reader)

Department of Orthodontics and Dentofacial Orthopaedics

Babu Banarasi College of Dental Sciences.

Lucknow-227105

Mob-8960943326

Signature of PI………………………………

Name……………………………………..

Date…………………………………………

ANNEXURE -IV

Babu Banarasi Das College of Dental Sciences

(Babu Banarasi Das University, Lucknow)

BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

प्रतिभागी के तिए सूचना पत्र

1.अध्ययन शीर्षक?

परिवर्तनशील चेहरे के विकास पैटर्न वाले विषयों में अनुप्रस्थ आयाम का आकलन –

पोस्टेरो-पूर्वकाल सेफलोमेट्रिक अध्ययन।

2. तनमंत्रण अनुच्छेद?

मवन्य हीं।

3. अध्ययन का उद्देश्य क्या है?

अध्ययन का उद्देश्य परिवर्तनशील चेहरे के विकास पैटर्न वाले विषयों में अनुप्रस्थ आयामों का आकलन और तुलना करना है।

4. मुझे इस अध्ययन के तिए क्ययं चुना गया है?

तकसी रोगी की आवश्यकिव हीं है।

5. क्या इसमें मुझे भाग िेना चातहए?

मवन्य रही।

6. मुझे क्या हयगा यतद मैं इस अध्ययन में भाग िेिा हं।

मवन्य रही।

7. मुझे क्या करना है?

मवन्य रही।

8. तकस प्रतिया का अध्ययन तकया जा रहा है?

इस प्रक्रिया में परिवर्तनशील चेहरे के विकास पैटर्न में अनुप्रस्थ आयामों का तुलनात्मक मूल्यांकन शामिल होगा: एक तुलनात्मक अध्ययन।

9. इस शयध में कौन से हस्तक्षेप तदए जाएं गे?

- औसत वृद्धि पैटर्न वाले विषयों में अनुप्रस्थ आयामों का मूल्यांकन करना।
- क्षैतिज विकास पैटर्न वाले विषयों में अनुप्रस्थ आयामों का मूल्यांकन करना।
- ऊर्ध्वाधर विकास पैटर्न वाले विषयों में अनुप्रस्थ आयामों का मूल्यांकन करना।
- परिवर्तनशील विकास पैटर्न वाले विषयों में अनुप्रस्थ आयामों की तुलना करना।

10. इस अध्ययन मेें भाग िेनेे केे क्या दुष्प्रभाव हैं?

मवन्य र्ही।

11. इस अध्ययन मेें भाग िेनेे केे संभातवि जयतिम और नुकसान क्या हैं?

मवन्य र्ही।

12. अध्ययन मेें भाग िेनेे केे संभातवि िाभ क्या है?

मवन्य र्ही।

13. क्या हयगा यतद कयई नई जानकारी उपिब्ध हय जािी है?

मवन्य र्ही।

14. क्या हयिा है जब अध्ययन / शयध परीक्षण बंद हय जािा है?

मवन्य र्ही।

15. क्या हयगा अगर कु छ गिि हय जािा है?

मवन्य र्ही।

16. क्या इस अध्ययन में मेरा तहस्सा गयपनीय रिा जाएगा?

मवन्य ।

17. अध्ययन / शयध परीक्षण के पररमाण का क्या हयगा?

अध्ययन के परिणामों का उपयोग विभिन्न विकास पैटर्न के बीच अनुप्रस्थ आयामों की तुलना करने के लिए किया जाएगा।

18. इस अध्ययन कय कौन आययतजि कर रहा है और इस परीक्षण के तिए धन कहां से आएगा?

यह शोध अध्ययर् शैक्षतणक संस्थवर् (बीबीडीसीओडीएस) द्ववरव आयोतजि तकयव जविव है।

19.क्या सेवाएं शयध ित्म हय जाने के बाद उपिब्ध रहेगी या नही?ं

हव।

20. अध्ययन की समीक्षा तकसने की है?

अध्ययन की समीक्षा और अनुमोदन विभाग के प्रमुख और संस्थान के आईईसी/आईआरसी द्वारा किया गया है।

21.अतधक जानकारी के तिए संपक करें ।

डॉ. सर्बजीत साहा
ऑर्थोडॉन्टिक्स और डेंटोफेशियल ऑर्थोपेडिक्स विभाग
बाबू बनारसी दास कॉलेज ऑफ डेंटल साइंसेज।
लखऊ-227105
मो.-
9535332465

डॉ. रोहित खन्ना (एचओडी)
ऑर्थोडॉन्टिक्स और डेंटोफेशियल ऑर्थोपेडिक्स विभाग
बाबू बनारसी दास कॉलेज ऑफ डेंटल साइंसेज।
लखऊ-227105
मो.-
9415037011

डॉ. स्नेह लता वर्मा
ऑर्थोडॉन्टिक्स और डेंटोफेशियल ऑर्थोपेडिक्स विभाग
बाबू बनारसी दास कॉलेज ऑफ डेंटल साइंसेज।
लखऊ-227105
मो.-
8960943326

bbdcods.iec@g
mail.com

पीआई के हस्ताक्षर………………………………

नाम…………………………………….. ..
तारीख…………………………………………

Annexures

DrillBit

The Report is Generated by DrillBit Plagiarism Detection Software

Submission Information

Author Name	Dr. Sarbajit Saha
Title	ASSESSMENT OF TRANSVERSE DIMENSIONS IN DIFFERENT FACIAL GROWTH PATTERNS - A POSTERO - ANTERIOR CEPHALOMETRIC STUDY
Paper/Submission ID	1561209
Submitted by	amarpal.singh056@bbdu.ac.in
Submission Date	2024-03-22 14:45:13
Total Pages	54
Document type	Dissertation

Result Information

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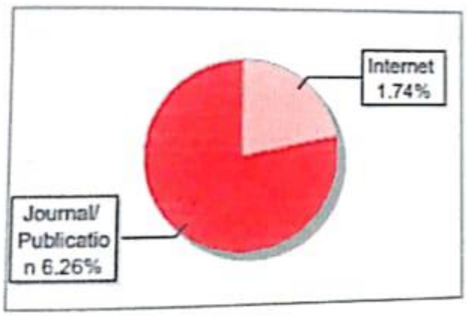

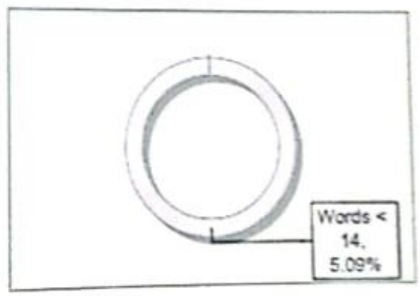

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Quotes	Excluded
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Database Selection

Language	English
Student Papers	Yes
Journals & publishers	Yes
Internet or Web	Yes
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Page 87

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8	11	A	A-Satisfactory (0-10%) B-Upgrade (11-40%) C-Poor (41-60%) D-Unacceptable (61-100%)
SIMILARITY %	MATCHED SOURCES	GRADE	

LOCATION	MATCHED DOMAIN	%	SOURCE TYPE
1	Thesis submitted to shodhganga - shodhganga.inflibnet.ac.in	2	Publication
2	Relationship between dental arch width and vertical facial morphology in untreat by Forster-2008	2	Publication
3	Thesis Submitted to Shodhganga, shodhganga.inflibnet.ac.in	1	Publication
4	Median mandibular flexure at different mouth opening and its relation to differe by Prasad-2013	1	Publication
5	www.ijdr.in	1	Internet Data
6	Thesis Submitted to Shodhganga Repository	<1	Publication
7	archive.jpda.com.pk	<1	Internet Data
8	archive.jpda.com.pk	<1	Internet Data
9	adoc.pub	<1	Internet Data
10	link.springer.com	<1	Publication
11	moam.info	<1	Internet Data

APPENDIX-III

Babu Banarasi Das College of Dental Sciences

(Babu Banarasi Das University)

BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

Consent Form (English)

Title of the Study: Assessment of transverse dimensions in different facial growth patterns: A postero-anterior cephalometric study

Study Number……..
Subject‘s Full Name……….
Date of Birth/Age ………
Address of the Subject…………………….
Phone no. and e-mail address………………
Qualification ………………………………
Occupation: Student / Self Employed / Service / Housewife/
Other (Please tick as appropriate)
Annual income of the Subject………………
Name and of the nominees(s) and his relation to the subject........................(For the purpose of compensation in case of trial related death).

1. I confirm that I have read and understood the Participant Information Document dated.......... for the above study and have had the opportunity to ask questions. **OR** I have been explained the nature of the study by the Investigator and had the opportunity to ask questions.

2. I understand that my participation in the study is voluntary and given with free will without any duress and that I am free to withdraw at any time, without giving any reason and without my medical care or legal rights being affected.
3. I understand that the sponsor of the project, others working on the Sponsor_s behalf, the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. However, I understand that my Identity will not be revealed in any information released to third parties or published.
4. I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s).

Yes [ ] No [ ] Not Applicable [ ]

6. I agree to participate in the above study. I have been explained about the complications and side effects, if any, and have fully understood them. I have also read and understood the participant/volunteer‘s Information document given to me.

Signature (or Thumb impression) of the Subject/Legally Acceptable Representative:……………..
Signatory_s Name……………. Date ……….
Signature of the Investigator………………… Date………..
Study Investigator_s Name.......................... Date………..
Signature of the witness…………………… Date………..

Name of the witness…………………………
Received a signed copy of the PID and duly filled consent form
Signature/thumb impression of the subject or legally Date……..

Acceptable representative

APPENDIX-IV

Babu Banarasi Das College of Dental Sciences

(Babu Banarasi Das University)

BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

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सहमति पत्र

अध्ययन का शीर्षक :- तितिध प्रकार के चेहरों में बहार तनकले दांतो को अंदर ले जाने की प्रक्रिया से सुंदरता में आये बदलाि का आकलन: ए सीफ्लोमेट्रिक अध्ययन I

अध्ययन सांख्या ....

तिर्य का पूरा नाम ....

जन्म की तारीख / आयु ....

तिर्य का पता ....

फोन नंबर। और ई-मेल पता ....

योग्यिा ....

व्यिसाय: छात्र / स्िियां कायषरत / सेिा / गृतहणी / अन्य (कृपया उतचि को रूप में तचतननत करें) तिर्य की िार्षिक आय ....

नाम और नामांकित व्यतत (नाम) और उनके तिर्य के संबंध में ....

(प्रयोजन के तलए मुकदमा सांबांतधि मौि के मामले में मुआिजे)

1. मैं पुति करता हूं कि मने प्रततभागी सचना दस्तािेज को पढ़ तलया है और समझ तलया है .... इसके बाद अध्ययन के तलए और सिाल पूछने का अिसर तमला ह।और सिाल पूछने का अिसर तमला ह।ै

या मुझे अन्िेर्क द्वारा अध्ययन की प्रकृति समझाई गई है

2. मैं समझिा हां क्रक अध्ययन में मेरी भागीदारी स्िैतछछक है और तबना क्रकसी दबाि के स्ितांत्र इछछा के साथ दी गई है और क्रकसी भी कारण के तबना क्रकसी भी समय तबना क्रकसी मेतडकल दखभाल या कानूनी अतधकारों को प्रभाितिि क्रकए तबना क्रकसी भी समय मैं िापस लेने के तलए स्ितांत्र ह।ां

3. मैं समझिा हां क्रक इस पट्ररयोजना के प्रायोजक, प्रायोजक की ओर से काम करने िाले अन्य लोग, एतथक्स कमेटी और तनयामक प्रातधकरणों को मरे मौजूदा अध्ययन के सांबांध में अपने स्िास्थ्य के ट्ररकाडष को दखने की मेरी अनुमति की आिश्यकिा नहीं है और आगे की शोध इसके सांबांध में आयोतजि क्रकया जा सकिा है, भले ही मैं परीक्षण से िापस ले जाऊं । हालांक्रक, मैं समझिा हां क्रक मेरी पहचान िीसरी पाटी के तलए जारी क्रकसी भी जानकारी या प्रकातशि में प्रकट नहीं होगी।

4. मैं इस अध्ययन से उत्पन्न क्रकसी भी डटा या पट्ररणामों के उपयोग को प्रतिबांतधि करने के तलए सहमि नहीं हां एक प्रयोग के िल िैज्ञातनक उद्‌दश्य
(प्रयोजनों) के तलए है
5. भतिष्य के अन्‍सांधान के तलए मैं सांग्रहीि नमूने (दाांि / ऊिक / रि) का उपयोग करने की अन्‍मति दिा हां
हाॅ ॅां नही [ ]

6. मैं उपरोि अध्ययन में भाग लेने के तलए सहमि ह। म्‍झे जट्रटलिाओं और साइड इफे क्‍स, यक्रद कोई हो, के बारे में समझाया गया है और उन्हें पूरी िरह से समझा ह।
/स्ियांसेिक के सूचना दस्िािेज को भी पढ़ा और समझ तलया है प्रतितनतध: ....
मैंने प्रतिभागी
स्िाक्षरकिाष का नाम ....िारीख ....।

अन्िेर्क के हस्िाक्षर .... क्रदनाांक ....
अध्ययन अन्िेर्क का नाम .... क्रदनाांक ....
गिाह के हस्िाक्षर .... क्रदनाांक ....
गिाह का नाम ....
पीआईडी की एक हस्िाक्षट्रि प्रति और तितधिि भरी सहमति फॉमष प्राप्त क्रकया तिर्य के हस्िाक्षर / अांगूठे का प्रभाि या कानूनी िौर पर क्रदनाांक ....

स्िीकायष प्रतितनतध