Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies ***NLM ID:*** *101716117*

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Index Copernicus value = 85.10

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Original Research

A Cephalometric evaluation of dentoskeletal variables and ratios in three different facial types

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ABSTRACT:

Objective: To study the variation of dental and skeletal cephalometric variables found in horizontal, average and vertical growth patterns and compute the ratio of maxillary 1st molar dentoalveolar height to ramal height. **Methods**: Pretreatment lateral cephalograms were drawn from the Department of Oral Medicine and Radiology of patients who have reported for orthodontic treatment. Cephalograms showing cervical vertebral maturation stage 5 without facial asymmetry, without canting of the occlusal plane were chosen. Analysis was done using Nemostudio Software 2019 from Nemotec Madrid, Spain. A total of 33 parameters were evaluated. **Results**: Horizontal growth patterns showed longer and wider rami and symphysis, greater posterior facial height, but decreased total anterior facial height, in particular, decreased lower anterior facial height when compared with average and vertical growers. Upper molar height/ ramal height, (UMH/RH) and total molar height/ramal height (TMH/RH) new ratios evaluated for this study, were significantly different in the three growth patterns. **Conclusion**: The new ratio UMH/RH and TMH/RH were found to be higher in the vertical growth pattern at 0.56 and 1.35 respectively and decreased to 0.46 and 1.12 respectively towards the horizontal growth pattern.

Keywords: Facial types, Dentoskeletal variables, Cephalometric evaluation.

Received: November 24, 2020 Accepted: December 27, 2020

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This article may be cited as: UU Hakeem, Sidhu MS, Prabhakar M. A Cephalometric evaluation of dentoskeletal variables and ratios in three different facial types. J Adv Med Dent Scie Res 2021;9(1):51-63.

INTRODUCTION:

Growth and development of the facial structures is studied using cephalograms. Growth of facial structures relative to cranial base has variable vectors along horizontal forward and vertical downward growth. Growth proportions in horizontal and vertical directions are relatively constant for each individual. Increments of growth in the anterior facial skeleton should equalize the increments of growth in the posterior facial skeleton in amount and timing otherwise disproportions will result in rotation of the mandible and maxilla resulting in imbalanced facial types (1).

Disproportionate vertical development of posterior dentoalveolar region is a major factor leading to extreme facial types namely long face and short face subjects. Posterior molar excess heights are seen in long face syndrome. The classification of vertical facial heights has been done based on percentage and extent of dental overbite, ratio of the upper and lower anterior facial heights, the angle between the mandibular plane and frankfort horizontal plane and visual perception of the change in the lower anterior facial height. These however are an arbitrary selection criteria (2).

Prediction of facial growth has been done in young patients considering the inclination of the mandibular plane with respect to the frankfort horizontal plane and the sella-nasion plane. Schudy et al (3,4) reported the relation between the changes of the mandibular rotation during growth and the inclination of the mandibular plane with respect to the cranial base plane (SN). In vertical growers there is a large mandibular plane angle (MP-SN) angle with the chin moving backwards. In horizontal growers the MP – SN angle is smaller with the tendency of the chin to move forwards and mandible becoming flat. This has been demonstrated by Bjork and Skeiller (5,6) in their implant studies. They demonstrated the forward and backward rotations of the mandible and the remodeling of the mandibular plane which masks this rotation. In their study majority of the subjects (19 out of 21) showed forward rotation where as only 2 out of 21 subjects showed backward mandibular rotation.

Bishara and Jakobsen (7) examined longitudinal growth according to 3 facial types: relative long, average, and relative short faces. The subjects were divided into different groups using the ratio of posterior to anterior face heights (S-Go/N-Me) and the Frankfort Horizontal-MP angle (FH-MP) of the adult cephalograms. Most subjects (77%) had the same facial type at 5 years and 25.5 years of age; there was a strong tendency to maintain the original facial type with age. Also, the subjects in each facial type had relatively large variations in the size and relationships of the various dentofacial structures.

To evaluate the skeletal effects of age, sex and physical frame it is always useful to study ratios rather than absolute values, as linear and angular variables show variations within the same facial type. Ratios can be generalized for the same facial type and are a better prism into the understanding of the facial types. So the aim of the study was to study the dentoskeletal variables in different facial types and the relation of the molar height to ramal height ratio.

MATERIAL AND METHODS:

Lateral Cephalograms were drawn from the data bank of Department of OMR comprising cephalograms of patients who have reported to the OPD for orthodontic treatment.

Inclusion criteria: Pre treatment cephalograms of CVMI Stage 5 and above.

Exclusion Criteria: Patients with facial asymmetry or craniofacial anomalies syndrome.

Methodology:

The Lateral Cephalograms were taken from the Department of OMR using Planmeca Promax (Finland) Lateral Ceph System.

The cephalograms obtained from the data bank were segregated such that they could be included in one of the following groups based on the angulation of the Frankfort Horizontal Plane with the Mandibular Plane with 20 patients in each group.

Group 1: Horizontal growth pattern (HG): FH-MP angle of 12-20º. (n=20)

Group 2: Average growth pattern (AG) : FH- MP angle of 20-28º. (n=20)

Group 3: Vertical growth pattern (VG): FH-MP angle of 28-38º. (n=20)

The images of Lateral Cephalogram were taken as JPEG (Joint Photographics Experts Group) Image and using Nemostudio Software 2019 from Nemotec Madrid, Spain analysis carried out.

Following steps were done

1. Patients Name, Sex and Date of Birth entered. Thus a file of Patient made.(Figure 6)
2. The JPEG image of the patient was acquired and captured on the software. (Figure 7)
3. Image was calibrated to a 10 mm reading using the scale present on the headpiece of the lateral cephalogram.(Figure 8)
4. Tracing performed, first the master points were marked colored red , then structures and soft tissue adjustment were made and these control points were marked blue by the software (Figure 9). The master points marked were based on the parameters defined and given in Tables 1-5.
5. The cephalograms were the oriented along the FH plane to standardize all images and readings.(Figure 10)
6. The software gave the reading of various parameters through analysis already incorporated in it.(Figure 11)
7. Remaining parameters condylar height, condylar width, ramus width, condylar axis, depth of antegonial notch, upper molar angle and lower molar angle were manually calculated with the help of a measuring scale and angle option provided by the software.(Figures 2-5)

RESULTS:

A total of 33 parameters including 14 linear skeletal parameters, 5 linear dental parameters, 4 ratios, 6 angular skeletal and 4 angular dental parameters were evaluated. The results were obtained using Statistical Package for Social Science (SPSS) from IBM Corp version 25 and analyzed.

Table 6: Shows the comparison between linear skeletal parameters of 3 groups of growth patterns (ANOVA).

The mean ramal height was highest (45.76 ± 4.56 mm) in the horizontal growth pattern, and showed a decreasing trend towards the average growth pattern (43.75 ± 4.30 mm) and vertical growth pattern (40.28 ± 3.83 mm) and this was highly significant.

Lower anterior facial height (LAFH) and total posterior facial (TPFH) ($p=0$), ramal height (RH) ($p \leq .001$) and symphyseal width (SW) ($p \leq .001$), were found to be highly significant with respect to the growth pattern. The condylar height (CH) ($p \leq .039$), condylar width (CW) ($p \leq .039$), condylar axis (CdA) ($p \leq .032$), corpus axis (CrA) ($p \leq .007$), corpus width (CrW) ($p \leq .002$), total anterior facial height (TAFH) ($p \leq .007$), symphyseal height (SH) ($p \leq .017$) were found to be statistically significant in relation to the growth pattern. Remaining variables were not significantly related with the growth pattern.

The ramal height was less in the vertical growers as compared to the horizontal growers, the condylar height was more in the vertical growers and similar in the average and horizontal growers, the condylar width was more in the horizontal growers and similar in the average and vertical growers, the condylar axis was more in the horizontal growers and average growers as compared to the vertical growers, the corpus axis and corpus width were more in the horizontal growers as compared to the average and vertical growers, the total anterior and lower anterior facial height were more in the vertical grower as compared to the average growers followed by the horizontal growers, the symphyseal height was more in the vertical growers followed by the average and vertical growers, the symphyseal width was more in the horizontal and average growers as compared to the vertical growers.

Table 7: Shows the comparison between linear dental parameters of 3 groups of growth patterns (ANOVA).

The mean of the upper molar height ranged from 21.20 ± 2.14 mm in the horizontal growth pattern to 21.59 ± 2.93 mm in the average growth pattern to 22.73 ± 2.39 mm in the vertical growth pattern but this wasn't of any significance. The mean of the lower molar height ranged from 30.13 ± 3.55 mm in the horizontal growth pattern to 30.67 ± 2.99 mm in the average growth pattern to 31.67 ± 2.82 mm in the vertical growth pattern but the differences were not significant.

The upper incisor height UIH (p=0) was highly significant and lower incisor height LIH ($p \leq .002$) was statistically significant in relation to the growth pattern. The extent of overbite was more in the horizontal growers going to an increased bite in the horizontal growers as compared to the average and normal growers. The upper incisor height and lower incisor height were more in the vertical growers followed by the average growers and vertical growers.

Table 8 : Shows the comparison between ratios of 3 groups of growth patterns (ANOVA).

All the ratios (p=000) were highly significant in relation to the growth pattern.

Both the upper molar height/ ramal height and total molar height/ramal height were more in the vertical growers as compared to the average and vertical growers. The facial height index and Jarabak's ratio were more in the horizontal growers followed by the average and vertical growers.

Table 9: Shows the comparison between angular skeletal parameters of 3 groups of growth patterns (ANOVA).

All the parameters (p=0) were highly significant in relation to the growth pattern.

Table 10: Shows the comparison between angular dental parameters of 3 groups of growth patterns (ANOVA).

The lower molar angulation (LMA) (P = 000) and lower incisor angulation (LIA) ($p \leq .001$) were highly significant and upper incisor angulation (UIA) ($p \leq .011$), upper molar angulation (UMA) ($p \leq .006$) were significant in relation to the growth pattern.

Table 1: List of defined landmarks used for the study

S.No.	Landmark	Definition
1	Sella (S)	Midpoint of Sella Turcica.
2	Nasion (N)	Most anterior point of the Fronto Nasal Suture in the mid sagittal plane.
3	Orbitale (Or)	The inferior most point on the infra orbital rim.
4	A-Point Hard (A)	Deepest point on the curve of the maxilla between the anterior nasal spine and the dental alveolus.
5	B-Point Hard (B)	Most posterior point in the concavity along the anterior body of the mandibular symphysis.
6	Pogonion Hard (Pog)	Most anterior point on the mandibular symphysis.
7	Gnathion Hard (Gn)	Most anterior and inferior point on the mandibular symphysis.
8	Menton Hard(Me)	Most inferior point on the mandibular symphysis.
9	Gonion (Go) Anatomic(GoA) Constructed(GoC)	The point of on intersection of the tangents to the posterior border of the ramus and the mandibular plane. Anatomic is on the mandible and constructed is on the intersection of the two planes.
10	Porion(Po)	The superior most point on the external acoustic meatus.
11	Apex of Upper Incisor(AUI)	Root apex of the most prominent permanent maxillary central incisor.
12	Tip of Upper Incisor(TUI)	Incisal tip of the most prominent permanent maxillary central incisor.
13	Apex of Lower Incisor(ALI)	Incisal tip of most prominent permanent mandibular central incisor
14	Tip of Lower Incisor(TLI)	Incisal tip of most prominent permanent mandibular central incisor.
15	Cusp Tip of Upper Molar (U6)	The mesiobuccal cusp tip of the permanent maxillary first molar.
16	Cusp Tip of Lower Molar (L6)	The mesiobuccal cusp tip of the permanent mandibular first molar.

17	Anterior Point on Occlusal Plane (OpA)	The point bisecting the vertical overlap of the maxillary and mandibular permanent central incisors in case of a deep bite.The point midway between the incisal edges of the maxillary and mandibular permanent central incisor
18	Posterior Point on Occlusal Plane (OpP)	The point where the mesio buccal cusp of the permanent maxillary first molar meets with the permanent mandibular first molar.
19	Anterior Nasal Spine (ANS)	Most anterior midpoint of the anterior nasal spine of the maxilla.
20	Posterior Nasal Spine (PNS)	The sharp and well defined posterior extremity of the nasal crest of hard palate.
21	Articulare (Ar)	The point of intersection of the images of the posterior border of the ramal process of the mandible and the inferior border of the basilar part of occipital bone.
22	Basion (Ba)	The most anterior point on the anterior margin of the foramen magnum where the mid sagittal plane of the skull intersects the plane of the foramen magnum.
23	Condylion (Co)	A point on the postero superior head of the condyle.
24	Pterygomaxillary Point (Pt)	Most superior and posterior point on the ptergomaxillary fissure. Can be approximated at the 10:30 (face of a clock) position on the circular outline of the superior border of the pterygomaxillary fissure.
25	Pterygoid Vertical (PTV)	A line drawn throgh the distal most point of the pterygomaxillary fissure perpendicular to the FH plane.
26	Protuberance Menti (PM)	Point on the mandibular symphysis where the outline changes from concave to convex.
27	Center of Condyle (DC)	The point in the center of condylar neck along the basion nasion plane.
28	R1	Deepest point on the curve of the anterior border of the ramus, located half way between the superior and inferior curves.
29	R2	Located opposite to R1 on the posterior border of the ramus.
30	R3	Deepest point on the sigmoid notch, half way between the anterior and posterior curves.
31	R4	Located opposite R3 on the inferior border of the ramus.
32	Xi Point(Xi)	Center of the intersection of the diagonals of rectangle formed by drawing lines tangent to four points R1, R2, R3 and R4.

Table 2 Planes used in the study

S. No.	Plane	Definition
1	Frankfort Horizontal Plane	Plane formed by joining points Po and Or.
2	Mandibular Plane	Plane formed by joining points GoC and Me.
3	Occlusal Plane	Plane formed by joining points OcP and OcA in case of a deepbite. Plane formed by joining points OcP and OcA taken midway between the incisal edge of the permanent maxillary and mandibular incisors in case of an open bite.
4	Palatal Plane	Plane formed by joining point ANS and PNS.

Table 3 Linear Skeletal Parameters used in the study

S.No.	Parameter	Definition
1	Ramal Height(RH)	Articulare(Ar) to Anatomic Gonion(GoA).
2	Ramal Width(RW)	R1 To R2.
3	Condylar Height(CH)	Po to DC.
4	Condylar Width(CW)	Greatest diameter of the condyle along Basion Nasion plane.
5	Condylar Axis(CdA)	Extends from Center of Condyle(DC) to Xi point. Describes the morphological features of the Mandible (Rickets).
6	Corpus Width(CrW)	Extends from Anatomic Gonion(GoA) to Menton(Me).
7	Corpus Axis(CrA)	Extends from Xi point to Protuberance Menti(Pm). (Rickets)
8	Symphyseal Height(SH)	Extends apex tip of mandibular permanent incisor to Gnathion.
9	Symphyseal Width(SW)	Greatest Diameter of the Symphysis.
10	Depth Of Antegonial Notch (AN)	Taken Perpendicular to tanget to the lower border of the Mandible to the incurvation present on the lower border of the mandible.
11	Total Anterior Facial Height (TAFH)	Extends from Nasion(N) to Menton(Me).
12	Upper Anterior Facial Height (UAFH)	Extends from Nasion(N) to Anterior Nasal Spine(ANS).
13	Lower Anterior Facial Height (LAFH)	Extends from Anterior Nasal Spine(ANS) to Menton(Me).
14	Total Posterior Facial Height (TPFH)	Extends from Sella to Constructed Gonion(GoC).
15	Facial Height Index(FHI)	(UAFH/LAFH) X 100.
16	Jarabak's Ratio	(Total Posterior Facial Height/Total Anterior Facial Height) x 100

Table 4 Linear Dental Parameters used in the study

S.No.	Parameter	Definition
1	Upper Incisor Height(UIH)	The Perpendicular distance taken from the tip of most prominent permanent maxillary incisor to the palatal plane(ANS-PNS).
2	Lower Incisor Height(LIH)	The Perpendicular distance taken from the tip of the most prominent permanent mandibular central incisor to the mandibular plane(GoC-Me).
3	Upper Molar Height(UMH)	The Perpendicular distance taken from the mesio buccal cusp tip of the permanent maxillary 1st molar to the palatal plane(ANS-PNS).
4	Lower Molar Height(LMH)	The Perpendicular distance taken from the mesio buccal cusp tip of the permanent mandibular 1st molar to the mandibular plane(GoC-Me).
5	Over Bite(B)	Taken from Upper Incisor Tip to Lower Incisor Tip perpendicular to the Occlusal Plane. No overlap taken as negative, overlap taken as positive.

Table 5 Angular Parameters used in the study

S.No.	Parameter	Definition
1	Mandibular Plane Angle(MP: Po-Or x GoC-Me)	The Angle formed between the Frankfort Horizontal Plane (FH) and the Mandibular Plane.
2	Facial Axis Angle (FA: Ba- Na x Pt-Gn)	The Angle formed between the Basion Nasion Plane and the plane from foramen rotendum(PT point) to gnathion(Gn).
3	Gonial Angle (Go: Ar-GoC-Me)	The Angle formed by the Ramal Plane with the Mandibular Plane.
4	Lower Facial Height Angle(LFHA: ANS-Xi-Pm)	The Inner Angle formed by the lines drawn from ANS and Pm to Xi point.
5	Mandibular Arc Angle (MA: DC-Xi-Pm)	Angle formed by the intersection of Condylar Axis and Corpus Axis.
6	Basal Plane Angle (BA:ANS-PNS X Tangent Lower Border through Me)	The Angle formed by the Palatal Plane (ANS –PNS) and Tangent to the lower border of mandible passing through menton.
7	Upper Incisor Inclination (UIA: Long axis wrt ANS-PNS)	The angle formed by the long axis of the most prominent permanent maxillary incisor with the palatal plane.
8	Lower Incisor Inclination (LIA:Long axis wrt GoC-Me)	The angle formed by the long axis of the most prominent permanent mandibular incisor with the mandibular plane.
9	Upper Molar Inclination (UMA: Long axis MB wrt ANS-PNS)	The angle formed by the line passing through the mesiobuccal cusp tip of the permanent maxillary 1st molar and the mesiobuccal root tip with the palatal plane.
10	Lower Molar Inclination (LMA: Long axis MB wrt GoC – Me)	The angle formed by the line passing through mesiobuccal cusp tip of the permanent mandibular 1st molar and the mesiobuccal root tip with the mandibular plane.

Table 6 Shows the comparison between linear skeletal parameters of 3 groups of growth patterns (ANOVA)

Parameters	Group 1(Horizontal) (n=20)	Group 2(Average) (n=20)	Group 3(Vertical) (n=20)			
Linear Skeletal	Mean ± SD(mm)	Mean ± SD(mm)	Mean ± SD(mm)	F-value	p-value	Sig.
RH	45.76 ± 4.56	43.75 ± 4.30	40.285 ± 3.83	8.55	0.001	**HS****
RW	26.945 ± 3.24	26.69 ± 2.64	25.5 ± 2.26	1.58	0.214	NS
CH	10.13 ± 1.91	10.07 ± 2.84	11.835 ± 2.42	3.44	0.039	**S***
CW	10.06 ± .99	9.88 ± 1.08	9.23 ± 1.04	3.45	0.039	**S***
CDA	31.09 ± 3.70	30.41 ± 2.87	28.58 ± 2.37	3.66	0.032	**S***
CRA	66.4 ± 4.05	62.87 ± 3.58	62.61 ± 4.58	5.36	0.007	**S***
CRW	71.55 ± 4.90	67.47 ± 4.04	66.41 ± 4.69	7.07	0.002	**S***
TAFH	106.35 ± 8.10	108.89 ± 7.87	113.795 ± 5.57	5.42	0.007	**S***
UAFH	49.21 ± 3.80	49.04 ± 3.53	48.93 ± 2.90	0.033	0.968	NS
LAFH	58.71 ± 6.53	62.31 ± 5.97	68.165 ± 4.66	13.67	0.000	**HS****
TPFH	78.23 ± 6.60	73.54 ± 5.92	69.935 ± 4.29	10.71	0.000	**HS****
SH	16.48± 3.30	17.51 ± 2.25	19.22 ± 3.20	4.38	0.017	**S***
SW	14.58 ± 1.93	14.12 ± 2.02	12.32 ± 1.51	8.42	0.001	**HS****
AN	1.55 ± .85	1.56 ± .92	1.85 ± 1.06	0.649	0.526	NS

*p<0.05- significant, **p<0.001-highly significant

Table 7 Shows the comparison between linear dental parameters of 3 groups of growth patterns (ANOVA)

Parameters	Group 1(Horizontal) (n=20)	Group 2(Average) (n=20)	Group 3(Vertical) (n=20)			
Linear Dental	Mean ± SD(mm)	Mean ± SD(mm)	Mean ± SD(mm)	F-value	p-value	Sig.
UIH	24.14 ± 3.87	26.55 ± 2.77	29.04 ± 2.18	13.16	0.000	**HS****
LIH	38.13 ± 3.77	39.3 ± 3.37	42.08 ± 3.18	6.933	0.002	**S***
UMH	21.20 ± 2.14	21.59 ± 2.93	22.735 ± 2.39	2.035	0.140	NS
LMH	30.13 ± 3.55	30.67 ± 2.99	31.67 ± 2.82	1.251	0.294	NS

*p<0.05- statistically significant, **p<0.001- highly significant

Table 8 Shows the comparison between ratios of 3 groups of growth patterns (ANOVA)

Parameters	Group 1(Horizontal)	Group 2(Average)	Group 3(Vertical)			
Ratio	Mean ± SD	Mean ± SD	Mean ± SD	F-value	p-value	Sig.
UMH/RH	0.46 ± 0.05	0.49 ± 0.04	0.562 ± 0.06	18.457	0.000	**HS****
TMH/RH	1.12± 0.08	1.19 ± 0.08	1.35 ± 0.09	38.18	0.000	**HS****
UAFH/LAFH	84.42 ± 10.20	79.18 ± 7.55	72.045 ± 5.74	11.92	0.000	**HS****
JAR RATIO	73.59 ± 3.55	67.58 ± 3.35	61.81 ± 2.68	66.98	0.000	**HS****

*p<0.05- statistically significant, **p<0.001- highly significant

Table 9 Shows the comparison between angular skeletal parameters of 3 groups of growth patterns (ANOVA)

Parameters	Group 1(Horizontal)	Group 2(Average)	Group 3(Vertical)			
Angular Skeletal	Mean ± SD(degrees)	Mean ± SD(degrees)	Mean ± SD(degrees)	F-value	p-value	Sig.
MP	16.9 ± 2.49	24.65± 2.68	33.35 ± 3.87	144.94	0.000	**HS****
FA	92±3.30	87.85± 3.45	83.55 ± 4.61	24.24	0.000	**HS****
MA	44.4±5.19	37.4± 3.77	31.35 ± 4.09	44.20	0.000	**HS****
GO	112.45±7.64	120.55±5.34	130.15 ± 4.97	42.17	0.000	**HS****
LFHA	38.95±3.20	43.7± 3.60	49.5±3.75	44.94	0.000	**HS****
BA	15.8±4.24	23.4± 3.35	32.2±3.50	97.55	0.000	**HS****

*p<0.05- statistically significant, **p<0.001- highly significant

Table 10 Shows the comparison between angular dental parameters of 3 groups of growth patterns (ANOVA)

Parameters	Group- 1(Horizontal) (n=20)	Group 2(Average) (n=20)	Group 3(Vertical) (n=20)			
Angular Dental	Mean ± SD(degrees)	Mean ± SD(degrees)	Mean ± SD(degrees)	F-value	p-value	Sig.
UIA	120.25 ± 6.86	116.9 ± 7.68	111.9 ± 10.50	4.90	0.011	**S***
LIA	102.9 ± 8.88	105.3 ± 8.92	95.4 ± 6.14	8.16	0.001	**HS****
UMA	87.57 ± 7.24	83.75 ± 4.05	82.035 ± 4.30	5.51	0.006	**S***
LMA	83.885 ± 6.30	81.79 ± 4.45	74.30 ± 9.09	10.74	0.000	**HS****

*p<0.05- statistically significant, **p<0.001- highly significant

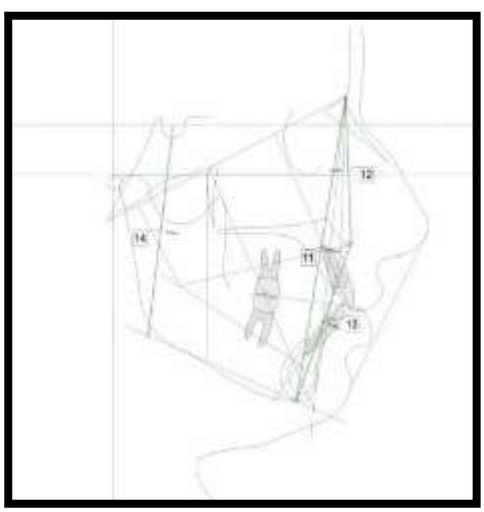

Figure 1: List of landmarks used in the study

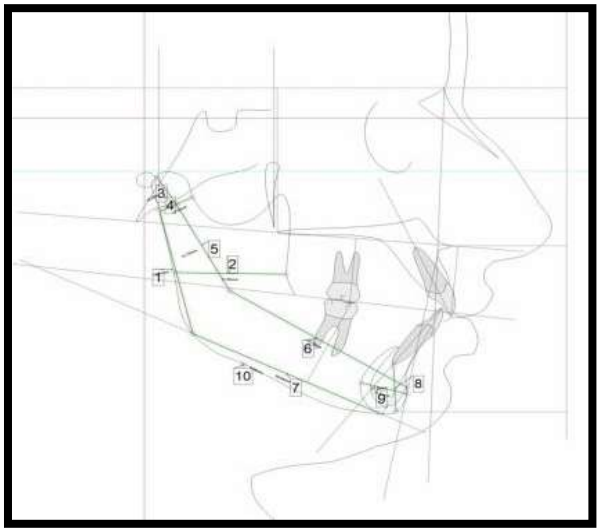

Figure 2: Linear Skeletal Parameters used in the study

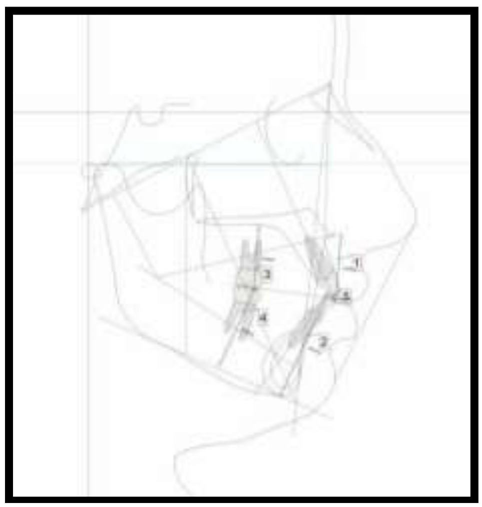

Fig 3: Linear Dental Parameters Used in the Study

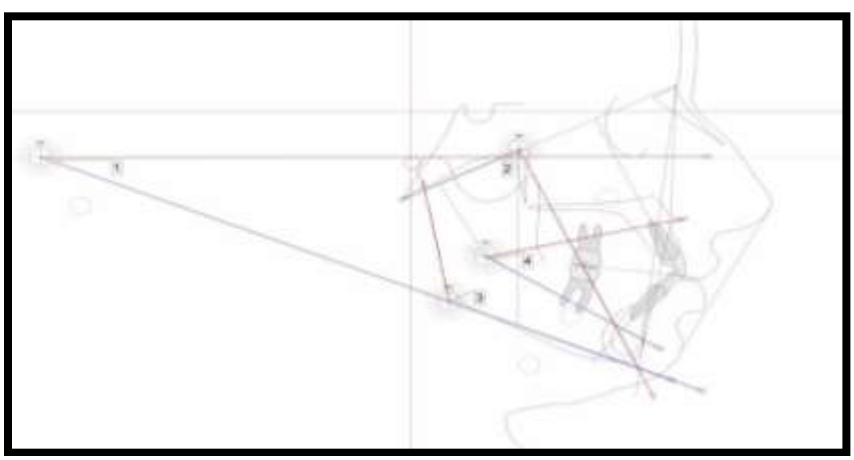

Figure 4: Angular Parameters used in the study

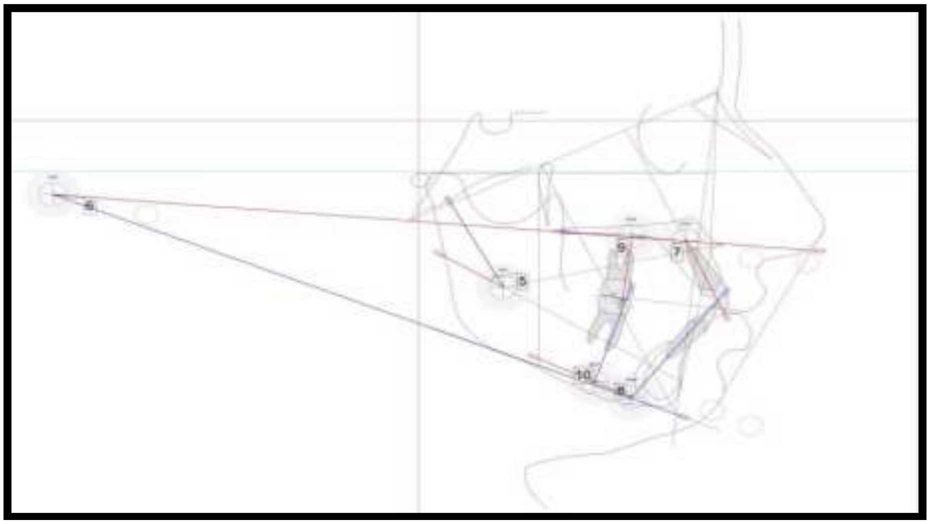

Fig 5: Angular Parameters continued

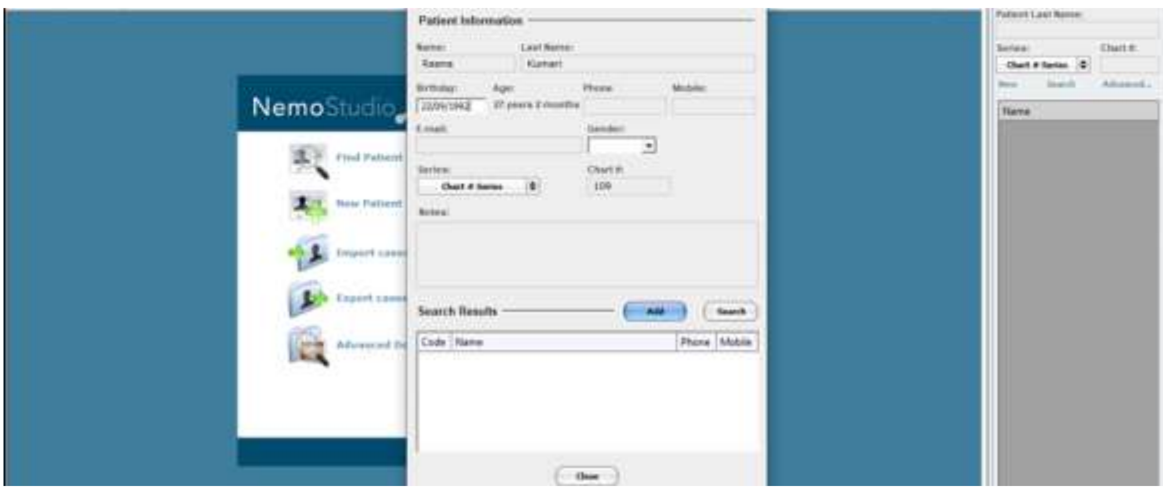

Fig 6: Creating patient ID, Name and Date of Birth

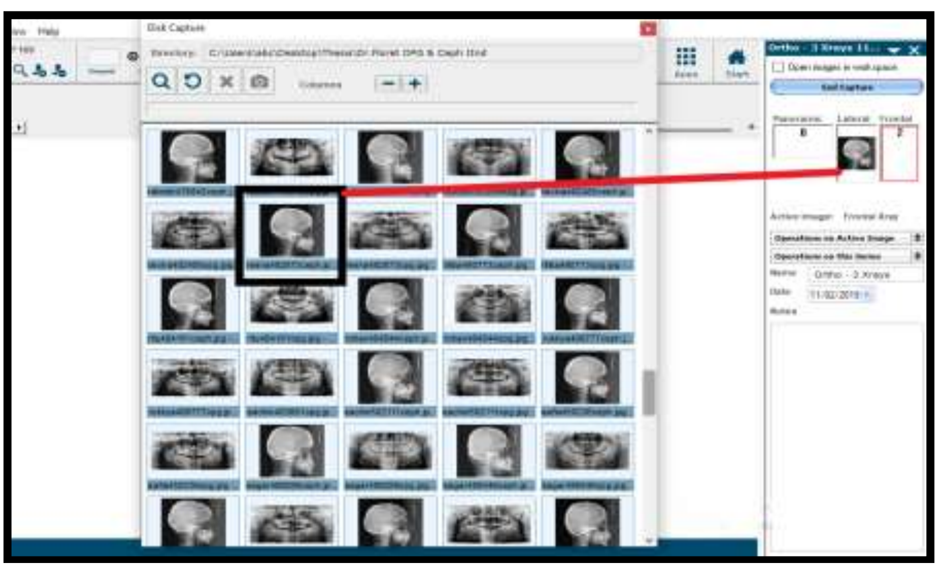

Fig 7: Selecting Image and placing it in the type of Image that is panoramic, lateral or frontal

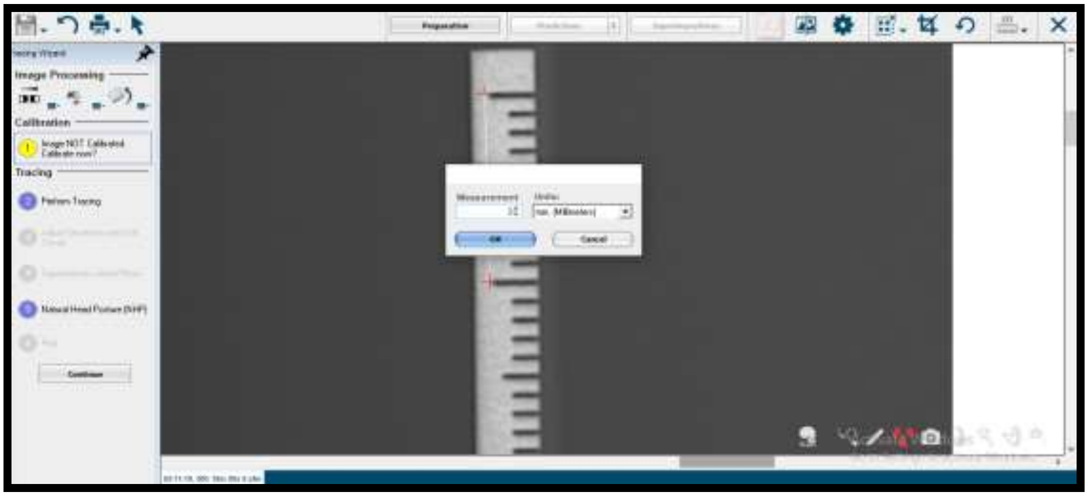

Fig 8: Calibration of Image to a 10 mm reading with the help of guide on the cephalogram.

Fig 9: Digitization of Landmarks as per the software. Outlines and soft tissues contoured by both master points in red and control points in blue.

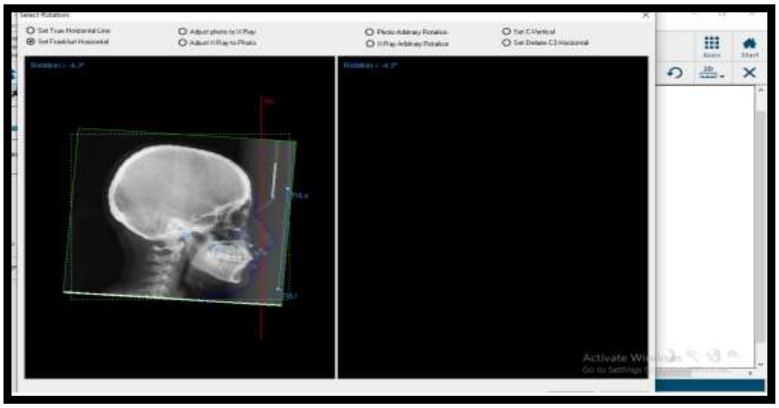

Fig 10: Orientation of the Image along FH plane for standardization.

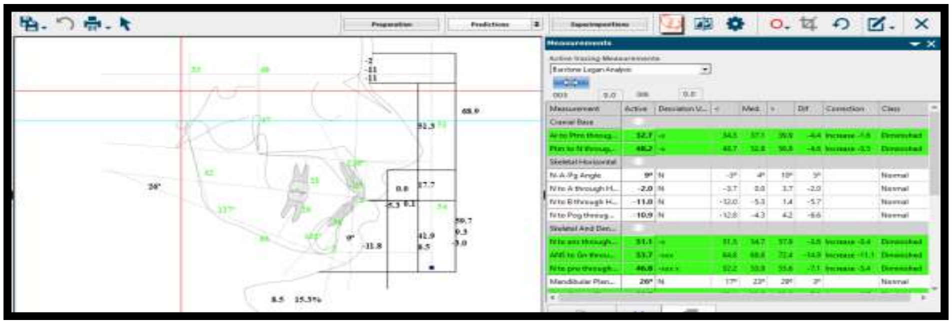

Fig 11: Representative Image of Patient RK. Burstone analysis along with readings.

S.No.	Description
Fig 1	1. Sella (S) 2. Nasion (N) 3. Orbitale (Or) 4. A-Point Hard (A) 5. B-Point Hard (B) 6. Pogonion Hard (Pog) 7. Gnathion Hard (Gn) 8. Menton Hard(Me) 9. Gonion (Go) Anatomic(GoA) 10. Porion(Po) 11. Apex of Upper Incisor(AUI) 12. Tip of Upper Incisor(TUI) 13. Apex of Lower Incisor(ALI) 14. Tip of Lower Incisor(TLI) 15. Cusp Tip of Upper Molar (U6) 16. Cusp Tip of Lower Molar (L6) 17. Anterior Point on Occlusal Plane(OpA) 18. Posterior Point on Occlusal Plane(OpP) 19. Anterior Nasal Spine(ANS) 20. Posterior Nasal Spine(PNS) 21. Articulare(Ar) 22. Basion(Ba) 23. Condylion(Co) 24. Pterygomaxillary Point (Pt) 25. Pterygoid Vertical (PTV) 26. Protuberance Menti (PM) 27. Center of Condyle (DC) 28. R1 29. R2 30. R3 31. R4 32. Xi Point(Xi)
Fig 2	1. Ramal Height(RH), 2. Ramal Width(RW), 3. Condylar Height(CH), 4.Condylar Width(CW) 5. Condylar Axis(CdA), 6.CorpusAxis(CrA), 7. Corpus Width(CrW), 8. Symphyseal Height(SH), 9. Symphyseal Width(SW), 10. Depth Of Antegonial Notch(AN), 11. Total Anterior Facial Height(TAFH), 12. Upper Anterior Facial Height(UAFH), 13. Lower Anterior Facial Height (LAFH), 14. Total Posterior Facial Height(TPFH)
Fig 3	1. Upper Incisor Height(UIH) , 2. Lower Incisor Height(LIH), 3. Upper Molar Height(UMH), 4. Lower Molar Height(LMH), 5. Over Bite(B)
Fig 4	1. Mandibular Plane Angle(MP), 2. Facial Axis Angle(FA), 3. Gonial Angle(Go), 4. Lower Facial Height Angle(LFHA)
Fig 5	5. Mandibular Arc Angle(MA) , 6. Basal Plane Angle (BA), 7. Upper Incisor Inclination (UIA), 8. Lower Incisor Inclination(LIA), 9. Upper Molar Inclination(UMA), 10. Lower Molar Inclination(LMA)

DISCUSSION

Orthodontic patients present as combination and permutations of dimensionally variable bony component comprising the dentofacial framework so no simple treatment applies to any 2 patients. Sexual dimorphism in facial patterns and varying facial types are seen, but the cause of these facial types is the key to treatment planning. Also trends in growth over decades of life starting from childhood to adolescence has been studied and the best time to start orthodontic treatment and growth modification have been noted. The interaction among dentoskeletal patterns to correct malocclusion can guide to an apt treatment plan.

Isaacson et al (1) showed variation in posterior dentoalveolar height exist in varying degrees of growth pattern groups based on the inclination of the Frankfort horizontal to the mandibular plane angle. Also studies like that Siriwat and Jarabak (9) , Bishara and Jakobsen (7), Nanda (10) analyzed the growth changes on subjects over the course of time and showed the growth trends in different growth stages. Genetics plays a strong role with the individuals maintaining the same malocclusion at the post pubertal stages of life.

Fields et al (8) found the gonial angle is steeper in vertical growth patterns but not all vertical growers will have a deep bite and the converse is also true not all deep bite cases are vertical growers. The depth of variations have to be critically analyzed and carefully treatment plans should be made. Their studies emphasized that the treatment should be centered on the cause of malocclusion and not effects. We need to know which parameter is the key to controlling disbalances in facial proportions and at what stage of growth to be able to reduce the variation in as many as parameters as possible and guide the orofacial apparatus to a stable equilibrium. If we can't achieve all treatment goals at a particular time, we are guided to a step wise treatment plan to arrive at a stable equilibrium sooner or later.

Linear Skeletal Parameters in the Growth Pattern Groups.

While comparing the linear parameters of the growth patterns the ramal height (RH) was significantly longer in the horizontal growth (HG) group and showed a decrease from the horizontal growth (HG) group to the average growth (AG) group to the vertical growth (VG) group. This is in accordance to the study of Isaacson et al (1) where the ramus was shortest in the high angle group and longest in the low angle group. This is also in accordance to the study of Fields et al (8) where the long faced adults had a shorter rami as compared to short face children. The ramal width (RW) was higher in the horizontal growth group (HG) and average growth (AG) group as compared to the vertical growth (VG) group but not of significance.

The condylar height (CH) was significantly more in the vertical growth (VG) group as compared to the other two groups whereas the condylar width (CW) was significantly more in the horizontal growth (HG) group as compared to the other two groups. The condylar axis (CdA) followed the relation of the ramal height and was significantly longer in the horizontal growth (HG) group and showed a decrease from the horizontal growth (HG) group to the average growth (AG) group to the vertical growth (VG) group. The corpus axis (CrA) and corpus width (CrW) followed the same trend they were significantly more in the horizontal growth (HG) group as compared to the other two groups.

The total anterior facial height (TAFH) particularly the lower anterior facial height (LAFH) showed a significant increase from the horizontal growth (HG) group to the average growth (AG) group to the vertical growth (VG) group .This is in accordance with the study of Ha Y et al (12) where mean values of lower anterior facial height were greater in long faced subjects. The upper anterior facial height (UAFH) didn't show any significant change. This is in accordance with the study of Fields et al (8) where the upper anterior facial height wasn't significantly greater in long faced children. The total posterior facial height (TPFH) significantly showed a decrease from the horizontal growth (HG) group to the average growth (AG) group to the vertical growth group (VG) group.

The symphyseal height (SH) showed a significant increase from the horizontal growth (HG) group to the average growth (AG) group to the vertical growth (VG) group whereas symphyseal width (SW) was significantly higher in the horizontal growth (HG) group and the average growth (AG) group as compared to the vertical growth (VG) group. The antegonial notch (AN) didn't show any significant difference in its height.

Linear Dental parameters in the Growth Pattern Groups.

The upper incisor height (UIH) and lower incisor height (LIH) both were significantly elongated as transition was made from the horizontal growth (HG) group to the average growth (AG) group to the vertical growth (VG) group. The upper molar height (UMH) and lower molar height (LMH) were slightly elongated in the vertical growth (VG) group as compared to the horizontal growth (HG) and average growth (AG) groups but not of significance. This is similar to study of Isaacson et al (1) where the mandibular 1st molar height in the low and average group was essentially the same but in the high angle group it was increased by 3mm. Also in study of Fields et al (8) and Choi et al (14) where long faced children had significantly greater posterior upper and lower molar dental heights when compared to normal children. In growing patients with vertical growth pattern. Iscan et al (11) has reported that vertical pull head gears with force of 400 g/side worn 12 hours per day passing 3cm from the outer canthus of eyes can cause counter clockwise rotation of the mandible and reduce the lower anterior facial height also closing the amount of overbite. This exemplifies the beneficial effect of molar intrusion on anterior facial height using vertical pull head gear.

Ratios in the Growth Pattern Groups.

To evaluate the skeletal effects of age, sex and physical frame it is always useful to study ratios rather than absolute values. The ratios of molar heights (both upper molar height (UMH) and total molar height (TMH) to ramal height (RH) showed a significant increase from the horizontal growth (HG) group to the average growth (AG) group to the vertical growth (VG) group. The ratios both UMH/RH and TMH/RH indicated greater upper molar height (UMH) and total molar height (TMH) as compared to ramal height in vertical growth patterns, leading to greater ratios in in vertical growers. In other words when the ramal height isn't comensurate with the molar height or molar eruption it can cause clockwise rotation of the mandible as in vertical growers.

The upper anterior facial height/lower anterior facial height (UAFH/LAFH) ratio showed a significant decrease from the horizontal growth (HG) group to the vertical growth (VG) due to an increase in the lower anterior facial height. The Jarabak's ratio was significantly more in the horizontal growth (HG) group and showed a reduction from the horizontal growth (HG) group to the average growth (AG) group to the vertical growth (VG) group. This is in accordance with the study of Bjork (5,6) using implants and analyzing the growth patterns where the vertical growers had lower posterior facial heights and increased facial heights.

Although ramal height is genetically controlled, we as orthodontists can influence molar heights when the molar/ramal height ratio is of higher or lower than average value. This may influence the decision of molar intrusion and extrusion which helps divert extremes of growth patterns towards an average one.

Angular Skeletal Parameters in the Growth Pattern Groups.

While comparing the angular parameters in the growth groups the mandibular plane angle (MP), gonial angle (GO), lower facial height angle (LFHA) and basal plane angle (BA) all became significantly more steeper when there was shift from the horizontal growth (HG) group to the average growth (AG) group to the vertical growth (VG) group. The facial axis angle (FA) and the mandibular arc angle (MA) both showed a significant reduction as transition was made from the horizontal growth (HG) to the average growth (AG) group to the vertical growth (VG) group. This is in accordance to the study of Fields et al (8) where the gonial angle was significantly larger in the long faced subjects as compared to the short faced subjects.

Angular Dental Parameters in the Growth Pattern Groups.

The upper incisal angle (UIA) and lower incisal angle (LIA) both showed a significant decrease from the horizontal growth (HG) group to the average growth (AG) group to the vertical growth (VG) group. The upper molar angle (UMA) and lower molar angle (LMA) showed a significant decrease from the horizontal growth (HG) group to the average growth (AG) group to the vertical growth (VG) group. Indicating that the maxillary and mandibular molars tend to be distally tipped in vertical and upright in horizontal growers. This is in accordance with the study of Janson G et al (13). The distal inclination of the molars suggests that the basal plane angle is opened up in vertical growers.

CONCLUSION

1. Horizontal growth patterns showed characteristic skeletal differences like longer and wider rami, longer and wider symphysis, greater posterior facial height, but decreased total anterior facial height, in particular, lower anterior facial height when compared with average and vertical growers.
2. The mandibular plane, basal plane, gonial angle and lower facial height angles were found to be steeper in the vertical as compared to the horizontal group. The facial axis angle and the mandibular arc angle showed the opposite trend.
3. The dentoalveolar characteristics differentiating the growth patterns were seen as increased incisal heights in vertical growers and decreased incisor and molar angulations indicating a relatively mesially tipped dentition in horizontal growers.
4. Upper molar height/ ramal height and total molar height/ ramal height the new ratio evaluated for this study were significantly different in the three growth patterns along with upper anterior facial height/lower anterior facial height percentage and Jarabak's ratio The new ratio UMH/RH and TMH/RH were found to be higher in the vertical growth pattern at 0.56 and 1.35 respectively and decreased to 0.46 and 1.12 respectively towards the horizontal growth pattern.

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Conflicts of interest: No conflict of interest among the authors.

Funding: No funding was taken from any source.
Ethical Committee Reference Number :SGTU/Exam./SCY_17-18/10621