Research Article

An evaluation of inter-relationship between cervical posture and skeletal malocclusions

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ABSTRACT

Introduction: The growth pattern of the cervical spine and the craniocervical structure are interconnected, influencing one another both morphologically and functionally. As a result, stretching the head in relation to the cervical spine leads to notable changes, including greater anterior facial height, a shorter sagittal dimension, and a posterior rotation of the jaw. This study was conducted to determine the correlation between cervical curvature in different sagittal skeletal malocclusions and association between cervical lordosis and maxillary and mandibular base.

Materials and Method: One hundred fifty adults presenting with skeletal Class I, II, and III malocclusion were investigated, irrespective of growth pattern. Three groups were delineated based on the lateral cephalograms of the selected participants: Group 1 (50 skeletal Class I), Group 2 (50 skeletal Class II), and Group 3 (50 skeletal Class III). A comprehensive assessment of cervical posture was conducted through the measurement of manually traced 15 specific angles, which were carefully chosen to provide a detailed characterization of cervical variations across all three groups. Validity was assessed using Wilk and Kolmogorov-Smirnov tests, and analysis was done using One way Analysis of variance and Post hoc Turkey's test.

Result: Statistically significant correlations (P<.05) were found between angles OPT/HOR and CVT/HOR(representing cervical inclination with reference to the true horizontal plane),NSL/CVT, and FH/CVT (indicating middle craniocervical posture), NSL/RL, FH/RL, and NL/RL(reflecting rotation of mandibular ramus)

Conclusion: It was proven that changes in head posture and craniofacial development are strongly correlated. The rotation of the mandibular ramus in relation to the cranium was compared between groups, and was found that skeletal Class II malocclusion subjects had more posterior rotation of the ramus in relation to the cranium and extended head compared to those with skeletal Class III and skeletal Class I malocclusion subjects.

KEYWORDS: Cranio-cervical posture, Head posture, Rotation of mandibular ramus

INTRODUCTION

With the convexity of the curve facing anteriorly, the cervical vertebral column has been seen to exhibit an inward curvature known as lordosis.[1]

The growth pattern of the cervical spine and the craniocervical structure, which are nearby structures that are morphologically and functionally connected, influence one another. Hence, a greater anterior facial height, a shorter sagittal dimension, and a posterior rotation of the jaw occur when the head is stretched in reference to the cervical spine.[2,3]

Intracranial reference planes, such as the Sella-Nasion (SN) and Frankfort (FH) horizontal planes, are widely used in combination with other planes in contemporary cephalometric analysis to assess vertical or sagittal skeletal relationship. Natural head position as a reference system has been advocated mainly due to its good intra-individual reproducibility to a true vertical line in both short and long periods of time.[4]

During the last two decades, considerable attention has been given to the position of the hyoid bone in relation to the facial skeleton. Studies on various population samples have shown that changes in hyoid bone position seem to be related to changes in mandibular position.

Therefore, this study was undertaken with the objective of establishing the correlation between cervical curvature in various sagittal skeletal malocclusions and elucidating potential associations between cervical lordosis and the maxillary and mandibular base. Through a comprehensive analysis of these factors, the research aims to enhance our understanding of the intricate relationship between cervical spine alignment and craniofacial morphology.

MATERIALS AND METHOD

The patients visiting the Out Patient Department(OPD) of the department of orthodontics and dentofacial orthopaedics at Seema Dental College and Hospital, Rishikesh, were screened and cephalograms were collected for skeletal sagittal malocclusion identification. Subsequently, the selected participants were categorized into three groups: Group 1 (comprising 50 skeletal Class I malocclusion), Group 2 (consisting 50 skeletal Class II malocclusion), and Group 3 (containing 50 skeletal Class III malocclusion) regardless of growth pattern.

Patient's lateral cephalograms were captured with them standing in orthoposition, ensuring consistent positioning of the cervical column and head. The radiographs were manually traced by the principal investigator to assess maxilla-mandibular relationship using the ANB angle, with a normal value of 2 ± 2° (Class I)

A) Inclusion criteria for a patient in Class I skeletal pattern:

1) ANB angle of 2±2°
2) Witts's appraisal of 0-1mm
3) Beta angle within a range of 27-35°

B) Inclusion criteria for a patient in Class II skeletal pattern:

1) ANB angle of >4°
2) Witts's appraisal above 0-1mm (more positive value)
3) Beta angle less than of 27°

C) Inclusion criteria for a patient in Class III skeletal pattern:

1) ANB angle of <0°
2) Witts's appraisal above 0-1mm (negative value)
3) Beta angle more than of 35°

Inclusion criteria of the study:

1. Skeletal Class I, II and Class III.
2. Patients at the end of growth.
3. Skeletal malocclusion regardless of growth pattern.
4. The 18 to 35-year-old age range
5. No previous experience of surgical, orthodontic or physical therapy treatments
6. The fourth cervical vertebrae had to be seen on the lateral cephalogram.

Exclusion criteria:

1. Patients with craniofacial defects.
2. Patients in active growth.
3. Patients with systemic disorders.
4. Patients with temporomandibular joint disturbances.
5. Patients with scoliosis.

Table 1: Cephalometric landmarks used in study (Figure 1)

S.NO.	LANDMARK	DESCRIPTION
1.	Sella (S)	The midpoint of the Hyophyseal fossa
2.	Nasion (N)	The Nasofrontal Suture's most anterior point in the median plane
3.	Point A	Deepest midline point along the Maxilla's curved bony contour from the base to the Alveolar process
4.	Point B	Most posterior point in the outer contours of the mandibular alveolar process, in the median plane.
5.	Point H	The most superior, anterior point on the body of the hyoid bone
6.	CV2SP	Most posterior- superior point on the body of the second cervical vertebra.
7.	CV2IP	Most posterior-inferior point on the body of the second cervical vertebra
8.	CV41P	Most posterior-inferior point on the body of the fourth cervical vertebra

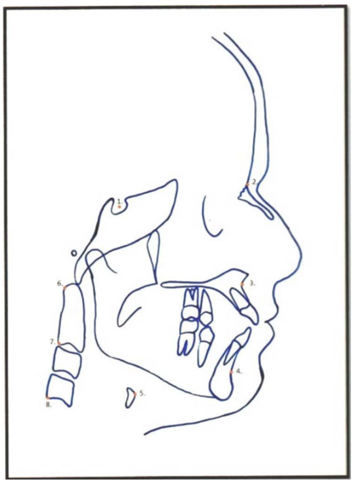


Figure 1

Table 2: Planes used in study (Figure 2)

S.NO.	PLANE	DESCRIPTION
1.	S-N Plane	Line joining Sella to Nasion
2.	NL line	Nasal line. Line through anterior and posterior nasal spines.
3.	ML	Mandibular line. Tangent to the lower border of mandible.
4.	RL	Ramus line. Tangent to the posterior border of mandibular ramus.
5.	FH	Frankfort horizontal line. Line through orbitale and porion points.
6.	HRL	Horizontal reference line passing S point 7° to SN plane.
7.	VRL	Vertical reference line passing through S point perpendicular to HRL
8.	Odointoid process Tangent	A posterior tangent line to the odontoid process was constructed that passed both the most posterior-superior point (CV2SP) and posterior-inferior point (CV2IP) on the body of the second cervical vertebra.
9.	Cervical Vertebral Tangent	A posterior tangent line to the odontoid process that passed the most posterior superior point on the body of the second vertebra(CV2SP) and most posterior-inferior point on the body of the forth cervical vertebra.
10.	HOR	True Horizontal plane.

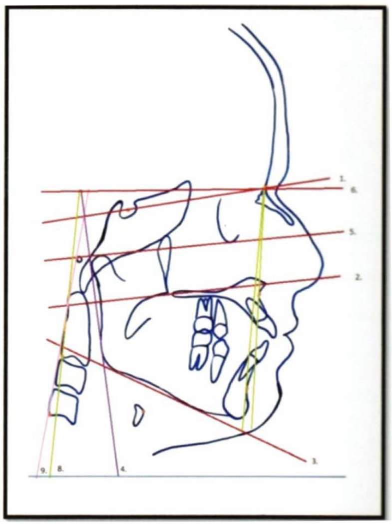


Figure 2

Table 3: Parameters used for selection of sample (Figure 3)

S.NO.	PARAMETERS	DESCRIPTION
1.	ANB	Difference of SNA and SNB
2.	WITTS	Distance in linear degrees between the perpendiculars from points A and B, onto the occlusal plane, which is drawn through the area of maximum cuspal interdigitation. Labelled AO and BO are the points of contact between points A and B on the occlusal plane.
3.	BETA ANGLE	Angle created by a line connecting the condyle's centre to point B and a line connecting points A and B, both drawn perpendicularly from point A.

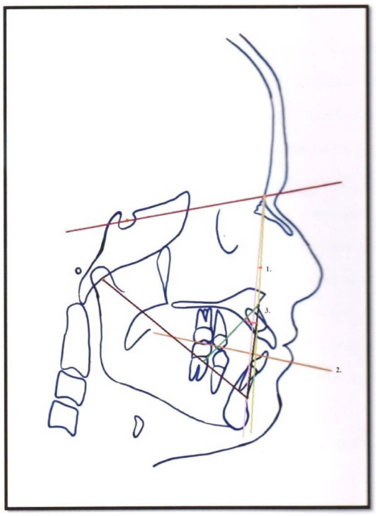


Figure 3

Cephalometric measurements:

For assessing the cervical curvature, reference lines and points were constructed. The second cervical vertebra's body's most posterior-superior point (CV2SP) and posterior-inferior point (CV2IP) were both crossed by a posterior tangent to the odontoid process. This was the Odontoid Process Tangent (OPT). The fourth cervical vertebra's most inferior-posterior point (CV4IP) and the second vertebra's most posterior superior point (CV2SP) both lie along the Cervical Vertebra Tangent (CVT), a posterior tangent line to the odontoid process.

The cervicohorizontal angles are created by the intersection of the OPT (Odontoid Process Tangent) and CVT (Cervical Vertebral Tangent) planes with the true horizontal plane (HOR).

1) OPT/HOR and CVT/HOR angles illustrate the cervical inclinationrelative to the true horizontal plane.
2) OPT/CVT angle created between the two tangents determines the degree of curvature of the cervical column.
3) Angles that describe the upper craniocervical posture included:
   - NSL/OPT
   - FH/OPT
   - NL/OPT
   - ML/OPT
4) Angles that describe the middle craniocervical posture included:
   - NSL/CVT
   - FH/CVT
   - NL/CVT
   - ML/CVT
5) Angles that describe rotation of mandibular ramus in relation to cranium:
   - NSL/RL
   - FH/RL
   - NL/RL
6) Angles that describe the relation of hyoid bone in relation to mandible:
   - H/ML

Firty lateral cephalograms were randomly selected and retraced by the same observer to remove technique error in order to evaluate intra-observer error. Similarly, 50 lateral cephalogram were randomly selected and retraced by different observer to assess inter-observer error and eliminate method error. The calculated intraobserver and interobserver correlation coefficients exceeded 0.8, indicating highly reproducible values.

The cephalometric measurements and resulting data were statistically analysed using Statistical Package for Social Sciences programme (SPSS version 22.0). Shapiro-Wilk and Kolmogorov-Smirnov tests were performed to validate the data for statistical significance, with a significance level set at $p < 0.05$. Since the data demonstrated normal distribution, parametric tests of significance were utilized. Specifically, one way Analysis of variance (ANOVA) was applied for multiple group comparison, followed by post hoc Tukey's test due to presence of significant difference between the groups.

RESULT

The results of the study revealed significant differences in varios cephalometric angles among individuals with different skeletal sagittal malocclusions.

Anova analysis showed statistically significant differences ($p<0.05$) in parameters between the three groups indicating distinct craniofacial morphologies associated with each malocclusion class (Table 4).

There is Class-specific angular patterns. While some angles showed similarities between certain classes, others exhibit distinct differences, further emphasizing the heterogeneity of craniofacial features among malocclusion groups (Table 5).

The observed cephalometric variations between malocclusion classes are not influenced by gender (Table 6).

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
ANB	.097	150	.002	.984	150	.079
SNA	.063	150	.200*	.989	150	.278
SNB	.079	150	.022	.985	150	.110
WITTS (mm)	.112	150	.000	.974	150	.007
BETA ANGLES	.062	150	.200*	.988	150	.246
NSL/OPT	.047	150	.200*	.986	150	.118
FH/OPT	.047	150	.200*	.983	150	.063
NL/OPT	.054	150	.200*	.986	150	.145
ML/OPT	.065	150	.200*	.989	150	.317

NSL/CVT	.045	150	.200*	.987	150	.185
FH/CVT	.051	150	.200*	.986	150	.124
NL/CVT	.152	150	.000	.682	150	.000
ML/CVT	.076	150	.033	.987	150	.184
NSL/RL	.077	150	.031	.975	150	.008
FH/RL	.065	150	.200*	.985	150	.101
NL/RL	.057	150	.200*	.976	150	.010
OPT/CVT	.149	150	.000	.934	150	.000
OPT/HOR	.046	150	.200*	.985	150	.114
CVT/HOR	.067	150	.098	.986	150	.122
H/ML	.057	150	.200*	.991	150	.463

*. This is a lower bound of the true significance.

Table 4 Presents a one-way ANOVA-based mean comparison of groups across all parameters.

Angles	Grp	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min.	Max.	F	p value
					Lower Bound	Upper Bound				
ANB	1	2.91	1.40	0.20	2.51	3.31	0	7	153.62	0.001**
	2	6.22	1.92	0.27	5.67	6.77	2.5	11		
	3	-1.37	2.91	0.41	-2.20	-0.54	-9	8		
SNA	1	81.90	3.57	0.51	80.88	82.92	75	90	4.60	0.012*
	2	83.49	3.70	0.52	82.44	84.54	76.5	91		
	3	81.11	4.63	0.65	79.79	82.43	73.5	94.5		
SNB	1	79.19	3.43	0.48	78.22	80.16	72.5	86.5	25.11	0.001**
	2	77.26	3.28	0.46	76.33	78.19	68	84.5		
	3	82.40	4.21	0.60	81.20	83.60	74.5	92		
WITTS (mm)	1	0.65	2.14	0.30	0.04	1.26	-4.5	6	135.18	0.001**
	2	3.66	2.20	0.31	3.03	4.29	-0.5	11		
	3	-4.70	3.23	0.46	-5.62	-3.78	-14	2		
BETA ANGLES	1	31.68	2.73	0.39	30.90	32.46	25	37	151.64	0.001**
	2	24.65	4.84	0.68	23.28	26.03	15.5	33		
	3	39.03	4.50	0.64	37.75	40.31	30	50		
NSL/OPT	1	100.29	8.50	1.20	97.87	102.71	81	129	2.61	0.077
	2	101.19	7.54	1.07	99.05	103.33	88	121		
	3	97.86	6.42	0.91	96.03	99.69	87	111		
FH/OPT	1	93.97	7.65	1.08	91.80	96.15	75	123	3.01	0.053
	2	94.94	7.31	1.03	92.86	97.02	80.5	110		
	3	91.54	6.41	0.91	89.72	93.36	81.5	105		

NL/OPT	1	93.60	7.85	1.11	91.37	95.83	75	120	2.67	0.073
	2	93.63	7.48	1.06	91.50	95.76	78.5	113.5		
	3	90.75	6.02	0.85	89.04	92.46	79	106		
ML/OPT	1	67.82	8.79	1.24	65.32	70.32	51.5	90.5	1.08	0.343
	2	68.60	9.65	1.37	65.86	71.34	44	87		
	3	66.05	8.19	1.16	63.72	68.38	48	88		
NSL/CVT	1	103.70	7.71	1.09	101.51	105.89	82	130	4.52	0.012
	2	104.40	7.47	1.06	102.28	106.52	89	123		
	3	100.25	6.97	0.99	98.27	102.23	81.5	114		
FH/CVT	1	96.72	7.46	1.06	94.60	98.84	75.5	124	3.50	0.033
	2	98.07	7.22	1.02	96.02	100.12	84	113		
	3	94.39	6.39	0.90	92.58	96.21	84	108		
NL/CVT	1	98.17	15.51	2.19	93.76	102.58	76	191	2.35	0.099
	2	96.20	7.61	1.08	94.04	98.36	79.5	116		
	3	93.61	5.91	0.84	91.93	95.29	82.5	110		
ML/CVT	1	70.67	8.59	1.21	68.23	73.11	53	92	1.39	0.253
	2	71.87	9.63	1.36	69.13	74.61	52	92		
	3	68.97	7.95	1.12	66.71	71.23	51	90		
NSL/RL	1	88.6	4.67	0.66	87.28	89.94	80	104	8.78	0.001**
	2	89.4	4.86	0.69	88.03	90.79	79.5	99.5		
	3	85.4	5.80	0.82	83.70	87.00	65	96		
FH/RL	1	81.72	5.29	0.75	80.22	83.22	69	98.5	8.62	0.001**
	2	83.25	4.88	0.69	81.86	84.64	72	92		
	3	78.93	5.63	0.80	77.33	80.53	60	90		
NL/RL	1	81.21	5.59	0.79	79.62	82.80	66	96.5	7.14	0.001**
	2	81.92	4.95	0.70	80.51	83.33	71.5	92		
	3	78.11	5.53	0.78	76.54	79.68	57	90		
OPT/CVT	1	3.10	1.98	0.28	2.54	3.66	0.5	8	0.23	0.799
	2	3.37	2.09	0.30	2.78	3.96	0	8.5		
	3	3.28	2.08	0.29	2.69	3.87	0	10		
OPT/HOR	1	86.40	8.22	1.16	84.07	88.74	57	106	4.30	0.015*
	2	85.95	7.54	1.07	83.81	88.09	67	100		
	3	89.93	6.44	0.91	88.10	91.76	77	104		
CVT/HOR	1	83.73	8.18	1.16	81.41	86.06	55	105	4.64	0.011*
	2	82.53	7.19	1.02	80.49	84.57	65	98.5		
	3	86.85	6.48	0.92	85.01	88.69	73	102.5		
H/ML	1	8.18	5.31	0.75	6.67	9.69	-4	21.5	0.54	0.583
	2	9.16	5.85	0.83	7.50	10.82	-1	22		
	3	9.24	5.85	0.83	7.58	10.90	-5	17.5		

*Values showed statistically significant difference between groups using ANOVA ($p<0.05$)

** values showed statistically high significant difference between groups using ANOVA

Table 01- Shows intergroup comparison between groups using one way ANOVA across all parameters.

The angles such as ANB, SNA, SNB, WITTS (mm), BETA ANGLES, NSL/CVT, FH/CVT, NSL/RL, FH/RL, NL/RL, OPT/HOR and CVT/HOR shows statistically significant difference with p value <0.05.

The angle such as NSL/OPT, FH/OPT, NL/OPT, ML/OPT, NL/CVT, ML/CVT, OPT/CVT and H/ML doesn't show statistically significant difference between groups.

Table 5: Post Hoc comparison between groups based on all parameters Bonferroni correction.

S. No	Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	p value
1.	ANB	1	2	-3.31	0.001**
		1	3	4.28	0.001**
		2	3	7.59	0.001**
2.	SNA	1	2	-1.59	0.118
		1	3	0.79	0.585
		2	3	2.38	0.009*
3.	SNB	1	2	1.93	0.025
		1	3	-3.21	0.001**
		2	3	-5.14	0.001**
4.	WITTS (mm)	1	2	-3.01	0.001**
		1	3	5.35	0.001**
		2	3	8.36	0.001**
5.	BETA ANGLES	1	2	7.03	0.001**
		1	3	-7.35	0.001**
		2	3	-14.38	0.001**
6.	NSL/OPT	1	2	-0.90	0.822
		1	3	2.43	0.244
		2	3	3.33	0.073
7.	FH/OPT	1	2	-0.97	0.776
		1	3	2.43	0.208
		2	3	3.40	0.049*
8.	NL/OPT	1	2	-0.03	1
		1	3	2.85	0.118
		2	3	2.88	0.113
9.	ML/OPT	1	2	-0.78	0.9
		1	3	1.77	0.582
		2	3	2.55	0.327

10.	NSL/CVT	1	2	-0.70	0.884
		1	3	3.45	0.054
		2	3	4.15	0.016*
11.	FH/CVT	1	2	-1.35	0.604
		1	3	2.33	0.226
		2	3	3.68	0.027*
12.	NL/CVT	1	2	1.97	0.619
		1	3	4.56	0.081
		2	3	2.59	0.438
13.	ML/CVT	1	2	-1.20	0.772
		1	3	1.70	0.596
		2	3	2.90	0.225
14.	FH/RL	1	2	-1.53	0.318
		1	3	2.79	0.025*
		2	3	4.32	0.001**
15.	OPT/CVT	1	2	-0.27	0.788
		1	3	-0.18	0.899
		2	3	0.09	0.974
16.	OPT/HOR	1	2	0.45	0.951
		1	3	-3.53	0.049*
		2	3	-0.04	0.022
17.	CVT/HOR	1	2	1.20	0.691
		1	3	-3.12	0.087
		2	3	-4.32	0.01*
18.	H/ML	1	2	-0.98	0.664
		1	3	-1.06	0.62
		2	3	-0.08	0.997

*Values showed statistically significant difference between groups using POST HOC with Bonferroni correction. ($p<0.05$)

Table 02- Shows post hoc comparison between individual groups with Bonferroni correction.

The angles such as ANB, WITTS (mm) and BETA ANGLES shows significance between all groups, where as there is no difference between Class 1 vs Class 2 and 3 whereas class 2 and 3 shows significance in SNA and FH/RL.

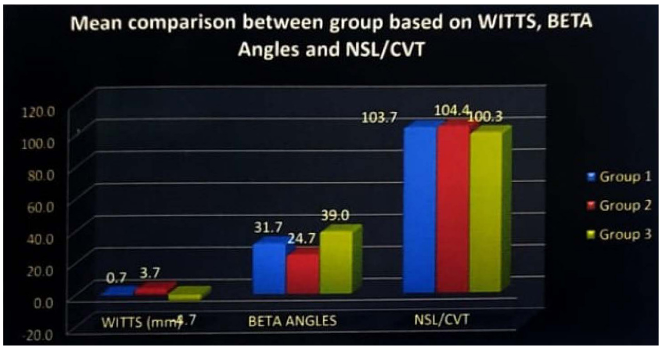
SNB, FH/OPT, NSL/CVT, FH/CVT angle shows a similar feature in class 1 and 2 whereas class 3 is different from the other. OPT/HOR is the only angle which significant difference in class 1 and class 3 whereas no difference in class 1 versus 2.

Table 6: Sub group analysis between groups-based gender with h/ml using one way ANOVA.

h/ml	Group	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.	F value	p value
						Lower Bound	Upper Bound				
Male	1	13	10.92	5.31	1.47	7.71	14.14	0.50	18.00	1.06	0.353
	2	21	12.91	5.20	1.14	10.54	15.27	4.00	22.00		
	3	23	11.07	3.87	0.81	9.39	12.74	3.00	16.00		
Female	1	37	7.22	5.02	0.83	5.54	8.89	-4.00	21.50	0.326	0.697
	2	29	6.45	4.73	0.88	4.65	8.25	-1.00	16.00		
	3	27	7.69	6.82	1.31	4.99	10.38	-5.00	17.50		

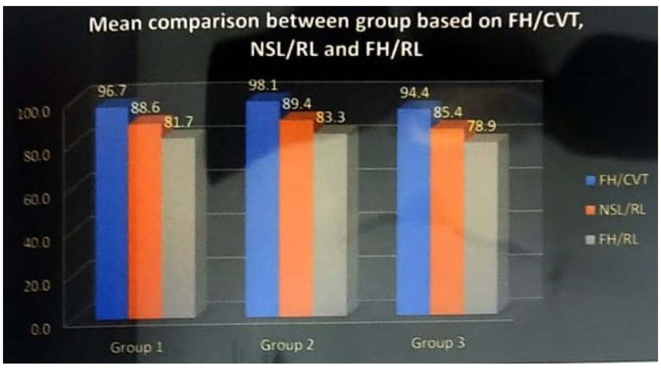
Table 03- Shows subgroup analysis based on gender and it indicates there no any significant difference based on groups among male and female.

Graph 1: Mean comparison between group based on WITTS, BETA Angles and NSL/CVT



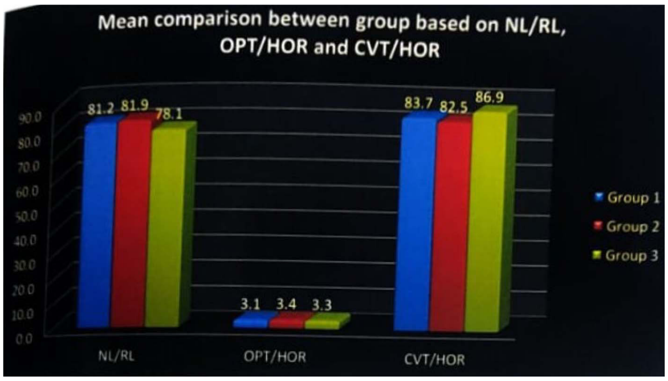
Graph 1.The mean comparison between group 1, group 2 and 3 for angles WITTS (mm), are 0.7, 3.7 and -4.7indicates class 2 have increased angle. BETA ANGLES shows 31.7, 24.7 and 39.0, which is also similar. NSL/CVT angle 103.7, 104.4 and 100.3 indicating the same as class 2 with a higher value respectively.

Graph 2: Mean comparison between group based on FH/CVT, NSL/RL and FH/RL



Graph 2.The mean comparison between group 1, group 2 and 3 for angles FH/CVT are 96.7, 98.1 and 94.4 indicates class 2 have increased angle. Similarly, NSL/SNB and angle FH/RL 88.6, 89.4, 85.4 ,81.7, 83.3 and 78.9 respectively.

Graph 3: Mean comparison between group based on NL/RL, OPT/HOR and CVT/HO



Graph 3.The mean comparison between group 1, group 2 and 3 for angles NL/RL are 81.2, 81.9 and 78.1 indicates class 1 and 2 have increased angle than class 3. OPT/HOR shows 3.1, 3.4 and 3.3. CVT/HOR angle 83.7, 82.5 and 86.94 respectively.

DISCUSSION

The study examined cervical curvature in different sagittal skeletal malocclusions and its association with maxillary and mandibular base. It included 150 adults with Class I, II, and III malocclusion, regardless of growth pattern, divided into three groups. Cervical posture was assessed using 15 specific angles traced from lateral cephalograms.

According to research by Oktay and Ishikawa et al.[6,7] ANB is the measurement that is the most frequently used, most accurate, and most dependable for evaluating anteroposterior disharmony of the jaws. With a cephalogram, the reference points are clearly visible and repeatedly reproducible.

According to studies by Jacobson, Hussel, and Nanda[8,9] beta angle and Wit's assessment were utilised as a further measurement of anteroposterior jaw relations to overcome the limitations of ANB, such as the unstable anteroposterior position of the nasion and rotational growth of the jaws. The procedure involves drawing perpendicular lines from points A and B on the maxilla and mandible, respectively, onto the occlusal plane because Witts's assessment does not depend on cranial landmarks. the perpendiculars' point of contact with the occlusal plane are called AO and BO, respectively, that determines the degree of anteroposterior jaw dysplasia, in contrast to Beta angle, which uses three locations on the jaws:

- Point A
- Point B and
- Condyle's apparent axis (Point C)

Hence, variations in this angle only reflect variations in the jaws. In contrast to ANB angle, Beta angle has the advantage of maintaining a fair amount of stability even when the jaws are rotated. For instance, if the C-B line is rotated in the same direction as the B point, the perpendicular from point A is carried along with it. The Beta angle is largely consistent because the A-B line is likewise rotating in the same direction. Hence, whereas clockwise and anticlockwise rotation of the jaws would generally tend to conceal it, the Beta angle can assess the sagittal jaw relationship in skeletal patterns.

According to Hassel and Farman10 CVMI with C2, C3, and C4 as guides was utilised to overcome the limitations of unreliable chronological age as an indicator of skeletal maturity, and patients with CVMI stage 5 and higher were taken for the study. For the purpose of evaluating the relationship between skeletal malocclusions and craniocervical position, a total of 15 angles were taken.

The study's findings showed that, on average, the OPT/HOR and CVT/HOR craniohorizontal angles in Group 2 were lower than those in Group 1 and Group 3 malocclusion, suggesting that the cervical spine is inclined forward.

Group 3 nevertheless displayed greater craniohorizontal angles. In a study to determine cervical posture in various skeletal sagittal malocclusions and to determine whether there was a correlation between cervical posture and skeletal relationships, Sanam Tauheed et al.[1] found that skeletal Class II, on average, had smaller cervicohorizontal angles than skeletal Class I and Class III, which indicated a backwardly inclined cervical spine. These findings are consistent with those of that study.

Angles used to describe the middle craniocervical posture included NSL/CVT, which shows statistically significant difference in Group 3 showing decreased angle with a mean value of 100.25°±6.27° as compared to Group 2 with a mean of 104.40°±7.47°and Group 1 with a mean value of 103.70°±7.71°; and FH/CVT, which also showed significant difference in Group 3 with decreased angle with a mean of 94±6.39° in comparison with group 2 with a mean value of 98.07°±7.22° and Group 1 with a mean value of 96.72°±7.46°. These results support the findings of Beni Solow et al.[11] and C Sandovel et al[12], who discovered a link between Class II malocclusion and craniocervical extensions.

Rocabado et al similarly noted the substantial relationship between the cranial-cervical position and the rotation of the mandibular ramus in regard to the cranium that was seen in our investigation in Class II participants. These authors claim that a forward cervical inclination along with an expanded craniocervical angle are associated with Class II malocclusion.

After a comparison was conducted using a one-way ANOVA with a p value of 0.05, and the results showed that Highly significant statistical differences were observed with respect to the angles describing the rotation of the mandibular ramus, including NSL/RL in Group 1 with a mean of 88.6°±4.67°, Group 2 with a mean value of 89.4°±4.86°, Group 3 with a mean value of 85.4°±5.80°, FH/RL in Group 1 with a mean value of 81.72°±5.29°, NL/RL in Group 1 had a mean value of 81.21°±5.59°, Group 2 had a mean value of 81.92°±4.95°, and Group 3 had a mean value of 78.11°±5.53°.

Skeletal Class II (Group 2) demonstrated greater angles when compared to Skeletal Class I (Group 1) and Class III (Group 3), which is consistent with research conducted by Ying Liu et al[14] who assessed the relationship between sagittal skeletal discrepancy, natural head position, and craniocervical posture in young Chinese children and came to the conclusion that the rotation of the ramus in relation to the cranium was greatest in Group 2 (skeletal Class II) and smallest in Group 3 (skeletal Class III). It had been established that variations in head position were associated to mandibular rotational growth patterns and craniofacial development. Lowering the value of the angles between the horizontal reference lines and the ramus indicated that the ramus was rotating with respect to the cranium. NSL/OPT, FH/OPT, NL/OPT, ML/OPT, NL/OPT (angles determining the upper craniocervical posture), NL/CVT, ML/CVT (angles determining the middle craniocervical posture), OPT/CVT (angle determining the cervical curvature), and H/ML were the angles that did not exhibit any statistically significant differences (angle used to evaluate the relation of hyoid bone in relation to mandible).

FH/OPT between Class II and Class III with a significant p value of 0.049, NSL/CVT between Class II and Class III with a significant value of 0.016, FH/CVT between Class II and Class III with a p value of 0.027, and FH/RL showing correlation in between Class I and Class III with a p value of 0.025 and highly significant p value of 0.001 in the Post-Hoc comparison between groups based on Bonferroni correction, angles with statistically significant value are OPT/HOR between Class I and Class III with a p value of 0.049 and CVT/HOR between Class II and Class III with a p value of 0.01.

The horseshoe-shaped lingual bone, also known as the hyoid bone, is located between the thyroid cartilage and the chin in the anterior midline of the neck. At rests it lies between the third cervical vertebra and the base of the mandible. The hyoid bone is composed of unstable hard tissues that are entirely supported by soft tissues that connect it to the base of the skull, the jaw, the throat, and the tongue. It is also greatly influenced by the tissues around it. The suprahyoid muscles, infrahyoid muscles, and surrounding tissues of the hyoid bone are evaluated for their physiological equilibrium state using a positional examination of the hyoid bone. Numerous researchers have studied the hyoid bone, highlighting its functional anatomy, the relationship between the hyoid bone's anatomic position and cervicofacial morphologic traits, the various factors influencing the hyoid bone's position, and the diagnostic value of hyoid bone position in clinical orthodontics.[13]

With a mean value of 8.18 mm in Group I, 9.1 mm in Group II, and 9.24 mm in Group III, which included skeletal Class III, the present study's linear measurements describing the vertical position of the hyoid bone with respect to the mandibular plane show diagnostic significance in between groups. These values suggest that the hyoid bone is positioned upward in skeletal Class II and downward in skeletal Class III, with the which was consistent with research by Kocakara G et al[15]; nevertheless, no statistically significant change was seen.

This study's inadequacies stemmed from the fact that it was a two-dimensional analysis of a three-dimensional face. Future research can therefore attempt to use three-dimensional approach and use a considerably larger sample size. The cephalometric tracings and measurements were performed manually predisposing to chances of error and inaccuracy. The inadvertent movement of head while taking lateral cephalogram can also contribute to inaccurate interpretation

CONCLUSION

1. It was established that there is a strong correlation between changes in head posture with craniofacial development.
2. The rotation of the mandibular ramus in relation to the cranium was compared between the groups, and it was found that skeletal Class II malocclusion subjects had a more posterior rotation of the ramus in relation to the cranium and an extended head than skeletal Class III and skeletal Class I malocclusion subjects.
3. Linear measurements describing the vertical position of hyoid bone with respect to mandibular plane shows diagnostic significance in between groups, suggestive of upward positioning of hyoid bone in skeletal Class II and downward in skeletal Class III malocclusion, however no statistical difference was seen.

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