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Original Research Article

# Assessment of relationship between craniocervical morphology, posture and sagittal skeletal discrepancies among Indian population – A cephalometric study

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ABSTRACT

**Objective**: The objective of this study was to investigate the relationship between sagittal skeletal discrepancies and craniocervical posture in Indian population.

**Background:** The anthropological literature has shown a great deal of interest in the issue of whether head morphology and posture are related. Given the correlation between the morphology and dimensions of the upper cervical spine and the variations in craniofacial morphology observed among individuals of diverse ethnic backgrounds, it is plausible that there exist variations in upper spine morphology among different ethnic groups. This study aimed to investigate the relationship between sagittal skeletal discrepancies and craniocervical posture in Indian population.

**Materials and Methods**: Lateral cephalograms of 98 subjects of Indian origin were taken in Natural Head Position(NHP). Cephalometric analysis was performed to determine the growth pattern, sagittal position of maxilla and mandible with respect to cranial base, maxillomandibular relationship and craniocervical angles. The craniocervical angles used in this study were NSL/OPT, NSL/CVT, NL/OPT NL/CVT. These variables were then correlated.

**Results**: A positive association was observed between the NSL/OPT- Y-Axis, NSL/OPT-FMPA. However, this relationship was not statistically significant($p>0.05$). A positive association was observed between NSL/CVT- Y-Axis, NSL/CVT-FMPA which was statistically significant ($p>0.05$).

**Conclusions:** The postural variables were slightly higher than those previously reported in European population. More upright craniocervical posture was associated with Class II maxillomandibular relation. As the craniocervical angles reduced, the maxillary and mandibular prognathism increased. Cervical spine flexion was seen to be associated with horizontal growers and more erect spine was seen in vertical growers.



## 1. Introduction

For diagnosing and treating morphological and functional abnormalities in the masticatory system and surrounding regions, a better knowledge of the coordinating processes that support normal craniofacial development is crucial. The association between head posture and craniofacial morphology is one element that might be relevant in this context. The anthropological literature has shown a great deal of interest in the issue of whether head morphology and posture are related. The evolutionary implications of the simultaneous development of the human brain, cranial base flexion, and erect posture have received special attention. The evidence of altered craniofacial morphology in animals after intentionally induced changes in body position has provided experimental support for the

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existence of a link between morphology and posture.[1,2] As early as 1926, a connection was made between neck position and malocclusion. In a study on the impact of upper airway obstruction in children, Schwartz concluded that malocclusion develops when a youngster is unable to breathe normally. This theory was supported by the observation that individuals with airway blockage exhibited a forward head posture, or a forward cervical inclination along with an extended head position(extended cranio-cervical angle). Not only has the association between head position and malocclusion been shown in patients with airway blockage, but also in those with regular breathing patterns.[3–6] A pattern of correlation between head and neck posture and malocclusion was shown in research by Solow and Sonnesen[7], which involved individuals with severe malocclusions and no airway issues. They concluded that a more extended cervical inclination or forward-postured neck was seen in those with severe malocclusion. Researchers examining the relationships between NHP, cranio-cervical posture, and craniofacial morphology in various populations have discovered that ethnic origin may have an impact on head and neck position. Given the correlation between the morphology and dimensions of the upper cervical spine and the variations in craniofacial morphology observed among individuals of diverse ethnic backgrounds, it is plausible that there exist variations in upper spine morphology among different ethnic groups. According to a study by Banerjee et al.[8], people of Indian descent differed from people of Asian and European/American descent in a few morphological parameters in the cervical spine area. Furthermore, because earlier research[9–14] has demonstrated a correlation between the morphology and dimensions of the upper spine and the morphology of the mandible and craniofacial morphology, the purpose of this study was to evaluate this relationship in the Indian population and ascertain how it differs between various growth patterns and classes of skeletal malocclusion.

## 2. Materials and Methods

### *2.1. Study design*

This is an in-vitro cephalometric study which aimed to examine the relationship between sagittal skeletal discrepancy, growth pattern and craniocervical posture among Indian population.

### *2.2. Sample size*

Lateral cephalograms of 98 subjects of Indian origin that were taken in Natural Head Position(NHP) were obtained from the records of Orthodontics department of Government Dental College, Mumbai, India.

### *2.3. Inclusion criteria*

1. Subjects with Class I, Class II, or Class III skeletal pattern.
2. Subjects exhibiting horizontal, vertical or average growth pattern.
3. Subjects who have completed skeletal growth(CVMI Stage 6 according to Hassel and Farman Index).
4. Subjects of Indian origin.

## 3. Method of Investigation

With the patient in the natural head position, all radiographs were acquired using a standard focus-film distance and a distance from the film to the medial plane. To reduce inter-examiner variability, the lead investigator manually traced the individuals' lateral cephalograms on acetate paper. The reference points used are described in Table 1. Reference variables used for cephalometric analysis are described in Table 2. Sagittal skeletal discrepancy was assessed with the help of 3 angular and 3 linear measurements.(Table 2 and Figure 1). Growth pattern was evaluated by assessing 3 angular measurements and 1 ratio(Table 2 and Figure 2). 4 angular measurements were used to determine relationship between head and cervical posture.(Table 3 and Figure 3). These variables were then correlated.

### *3.1. Reliability*

The same researcher retraced 20 cephalometric radiographs(20% of the entire sample) at random to assess intraexaminer error in measuring and tracing. These duplicates were carried out at least one month following the initial trace. Paired sample correlations and tests were used to calculate the method error. The procedure error was deemed insignificant.

### *3.2. Statistical Analysis*

Version 17 of the SPSS(Statistical Package for Social Sciences) was used for all statistical analyses(SPSS Inc., Chicago, IL, USA). Every measurement was given a mean value, a standard deviation(SD), and descriptive statistics. NSL/OPT and NSL/CVT, two cranio-cervical measures, were correlated with sagittal discrepancies using Pearson's correlation coefficient. The cutoff point for statistical significance was $P < 0.05$.

## 4. Results

Cephalometric analysis was done on 98 patients of Indian ethnicity. The mean SNA of the study population was 81.7 ± 3.10 and the mean SNB 77.04±4.53. The mean ANB angle was 5.04±2.10 and WITS analysis was 2.45±2.06. The mean NA linear was -8.63±4.03 and NB linear was -11.02±6.83. The mean Y axis was 62±4.27 and Gonial angle was 124.5±6.7. The mean FMPA of study population

was 25.23±5.99 and Jarabak's ratio was 60.86±80.70.

The mean NSL/OPT of the study population was 100.72±8.09 and the main NSL/CVT was 107.22±6.80. The relationship between Cranio-cervical Parameters and Sagittal Discrepancies exhibited that there was a Negative association between NSL/OPT and SNA, SNB, NA Linear and NB Linear values whereas there was a positive association between NSL/OPT and ANB, Wits. It was observed that this relationship was statistically significant between NSL/OPT and ANB.

When NSL/CVT were tried to be associated with sagittal discrepancies it exhibited that there was a positive association between NSL/CVT-SNA, NSL/CVT-ANB, NSL/CVT-Wits, NSL/CVT- NA Linear and this relationship was statistically significant between NSL/CVT and ANB. But there was no statistically significant link($p>0.05$) between these two variables. Y-Axis, FMPA, and NSL/CVT-Gonial angle showed a positive correlation, but NSL/CVT-Jarabak's Ratio and Gonial angle showed a negative correlation. Nevertheless, the statistical significance of this relationship was maintained at $p>0.05$.

**Table 1:** Identified land marks on every cephalometric radiograph

| | |
|---|---|
| 1 | Nasion |
| 2 | Sella |
| 3 | Point A |
| 4 | Point B |
| 5 | Gnathion |
| 6 | Orbitale |
| 7 | Porion |
| 8 | Gonion |
| 9 | Menton |
| 10 | Odontoid process |
| 11 | Cervical vertebra |
| 12 | Cv2tg |
| 13 | Cv2ip |
| 14 | Cv4ip |

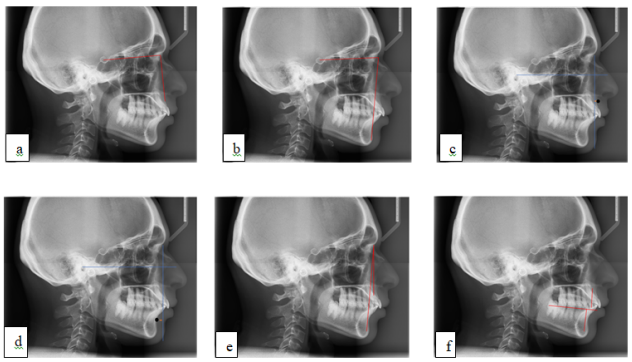


**Figure 1: a.** SNA **b.** SNB **c.** NA linear **d.** NB linear **e.** ANB **f.**Wits appraisal

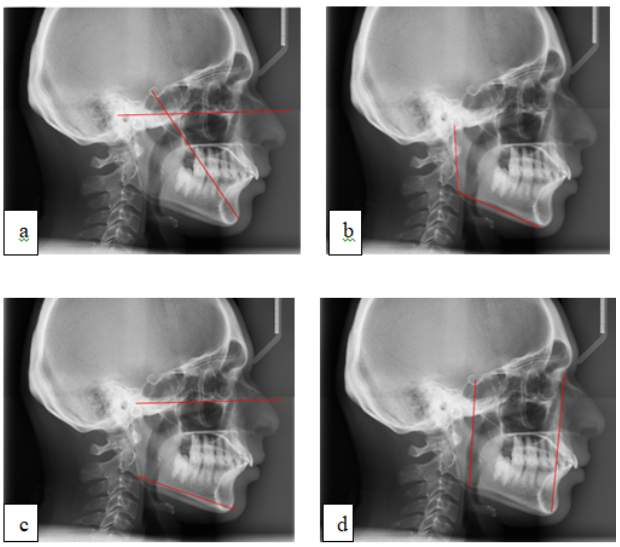


**Figure 2: a.** Y axis **b.** Gonialangle **c.** FMPA **d.** Jarabak's ratio

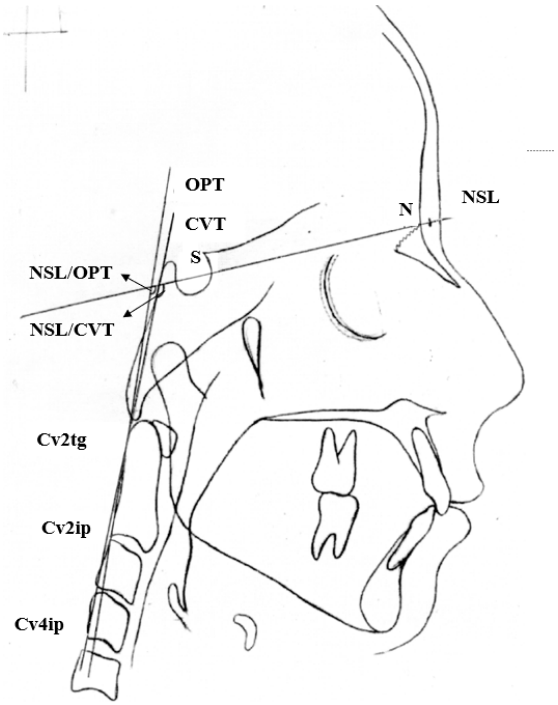


**Figure 3:** Head and cervical postural variables

## 5. Discussion

The current study investigated the connection between sagittal skeletal discrepancies, posture, and craniocervical morphology in the Indian population. The lateral

**Table 2:** Cephalometric reference variables

| | | |
|---|---|---|
| SNA | Sella-Nasion-Point A angle | Maxilla and cranial base relationship |
| SNB | Sella-Nasion-Point B angle | Mandible and cranial base relationship |
| ANB | Point A- Nasion-Point B angle | Anteroposterior relationship of maxillary and mandibular bases |
| NA linear | Linear measurement from Point A to the Nasion perpendicular | The relationship of maxilla to cranial base |
| NB linear | Linear measurement from Point B to the Nasion perpendicular | The relationship of mandible to cranial base |
| Wits appraisal | Linear distance on functional occlusal plane between perpendicular lines drawn from Point A and Point B | Determines anteroposterior maxillary and mandibular base relationship |
| Y axis | Angle between FH and S-Gn | Shows projection of the chin and the direction of facial growth |
| Gonial angle | Angle between Articulare-Gonion-Menton | Valuable indicator to diagnose growth pattern and determine rotation of mandible |
| FMPA | Angle between Frankfort Horizontal plane and mandibular plane | Helps to assess growth pattern |
| Jarabak's Ratio | Ratio of posterior and anterior facial heights | Helps to assess growth pattern |

**Table 3:** Cervical postural variables

| | |
|---|---|
| NSL/OPT | The angle between NSL and OPT |
| NSL/CVT | The angle between NSL and CVT |
| NL/OPT | The angle between NL and OPT |
| NL/CVT | The angle between NL and CVT |

NSL: Nasion sella line NL: Nasion line
OPT: Odontoid processtangent CVT: Cervical vertebra tangent

**Table 4:** Parameters

| Parameter | N | Minimum | Maximum | Mean | Standard deviation |
|---|---|---|---|---|---|
| SNA | 98 | 72.00 | 87.00 | 81.7273 | 3.10425 |
| SNB | 98 | 68.00 | 91.00 | 77.0455 | 4.53008 |
| ANB | 98 | 1.00 | 10.00 | 5.0455 | 2.10390 |
| WITS | 98 | 0 | 7.00 | 2.4545 | 2.06391 |
| NA LINEAR | 98 | -11.00 | 4.00 | -.8636 | 4.03904 |
| NB LINEAR | 98 | -24.00 | 1.00 | -11.0227 | 6.80070 |
| Y AXIS | 98 | 51.00 | 71.00 | 62.0000 | 4.27618 |
| GONIAL ANGLE | 98 | 110.00 | 140.00 | 124.5000 | 6.71707 |
| FMPA | 98 | 11.00 | 35.00 | 25.2273 | 5.99152 |
| JARABAK'S RATIO | 98 | 60.86 | 80.70 | 67.9332 | 5.68724 |
| NSL/OPT | 98 | 84.00 | 118.00 | 100.7273 | 8.09575 |
| NSL/CVT | 98 | 93.00 | 117.00 | 107.2273 | 6.80988 |

**Table 5:** Association between cranio-cervical parameters and sagittal discrepancies

| | | Correlations | | | | | |
|---|---|---|---|---|---|---|---|
| | | **SNA** | SNB | **ANB** | **Wits** | **NA Linear** | **NB linear** |
| NSL/OPT | Pearson's Correlation Coefficient | -.172 | -.490 | .521 | .333 | -.034 | -.335 |
| | P Value | .445 | .020 | .013 | .130 | .881 | .127 |
| | N | 98 | 98 | 98 | 98 | 98 | 98 |
| NSL/ CVT | Pearson's Correlation Coefficient | .037 | -.312 | .564 | .087 | .082 | -.132 |
| | P Value | .871 | .157 | .006 | .700 | .717 | .558 |
| | N | 98 | 98 | 98 | 98 | 98 | 98 |

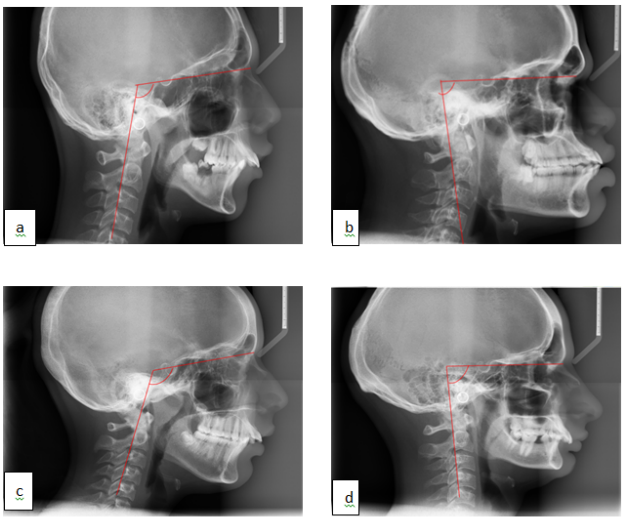


**Figure 4: a.**Craniocervical angle(NSL-OPT) increased in a patient having Class IImaxillomandibular relationship(> ANB) **b.** Craniocervical angle( NSL-OPT)decreased in a patient having prognathic jaw bases **c.** Craniocervical extensionseen in a patient with vertical growth pattern with increased FMPA and Y- Axis **d.** Craniocervical flexion seen in a patient with horizontal growth pattern.

cephalograms of ninety-eight Indian patients were examined. With the patient in the Natural Head Position(NHP), all radiographs were acquired using a standard focus-film distance and a distance from the film to the medial plane. Cooke et al.,(1990)[15] and Lundstrom et al.,(1995)[16] demonstrated the better stability and reproducibility of NHP. The study examined subjects with Class I, Class II, and Class III skeletal patterns that showed average, horizontal, and vertical growth patterns. Only participants who had reached stage 6 of the CVMI, or skeletal growth, as defined by Hassel and Farman[17], were included in the study. A total of six angular, three linear and one ratio was analysed as part of this study for evaluation of growth pattern and sagittal discrepancies. The head and postural variables NSL/OPT, NSL/CVT, NL/OPT, and NL/CVT were examined. Sonessen and Solow's investigation yielded credible and repeatable results for these variables.[7] The association between head posture and the various kinds of malocclusion has been discussed in earlier research. In one study, 61 children with poor neck posture were compared to their controls. The results showed that the children with poor posture had longer faces and a higher prevalence of Angle's Class II malocclusion. In a study conducted by Balters, it was also shown that Class II malocclusion and head posture are related. Class II individuals had more severe spine issues than those in other classes of malocclusion. It has previously been shown that there are correlations between head position and upper airway obstruction in patients with OSA as well as between craniofacial morphology and head posture. Recent research has demonstrated correlations between head posture and cervical vertebral column fusion, between patients with OSA and cervical vertebral column fusion, and between craniofacial morphology, especially the cranial base.

In the current investigation, variations in craniocervical angles were observed among participants with Class I, Class II, and Class III malocclusion. A negative correlation was found between NSL/OPT and SNA, SNB, NA Linear, and NB Linear values, while a positive correlation was found between NSL/OPT with ANB and Wits in the link between Cranio-cervical Parameters and Sagittal Discrepancies.

The correlation between NSL/OPT and ANB was found to be statistically significant. When NSL/CVT was attempted to be linked to sagittal discrepancies, it was shown that NSL/CVT and ANB were positively correlated, as were NSL/CVT-SNA, NSL/CVT-ANB, NSL/CVT-Wits, and NSL/CVT-NA Linear. This relationship between NSL/CVT and ANB was statistically significant. The correlation between cranio-cervical characteristics and growth patterns showed that NSL/OPT-FMPA, NSL/OPT-Y-Axis, and NSL/OPT-Gonial angle were negatively correlated with each other, whereas NSL/OPT-Jarabak's Ratio was positively correlated. This link, however, did not reach statistical significance($p>0.05$). Though this relationship was statistically significant($p>0.05$), there was a negative association between NSL/CVT-Gonial angle and NSL/CVT-Jarabak's Ratio and a positive association between NSL/CVT-Y-Axis and NSL/CVT-FMPA. Patients presenting with a Class II maxillomandibular connection showed larger cranio-cervical angulation. Maxillary and mandibular prognathism increased with a decrease in craniocervical angles. Referring to (Figure 4), there was a more forward head position and a straighter cervical spine curve in Class III subjects compared to Class I. Huggare and Harkness's(1991)[6] conclusions were consistent with these, but they contradicted those put out by Schwartz(1926)[5] and Rocabado et al.,(1982).[18] Racial differences and differences in sample makeup could be the cause of the disparate results observed in these researches. In contrast to growth patterns, the craniocervical angles increased as the Jarabak's ratio fell, suggesting that patients with vertical growth patterns are more likely to exhibit an extended head posture. As the FMA and Y-axis grew, so did the craniocervical angles. To extrapolate these results to larger populations, more research needs to be done. Further research should consider the significant influence that racial and ethnic diversity have on cephalometric norms.

## 6. Conclusion

The following observations were made while examining the connection between sagittal skeletal discrepancies and head posture in the Indian population:

1. Postural variable means were different from those of European subjects previously reported.
2. Craniocervical extension was associated with Class II maxillomandibular relation.
3. Cervical spine flexion was seen to be associated with horizontal growers and more erect spine was seen in vertical growers.

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None.

## 8. Conflict of interest

None.

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