

Assessing Cervical Spine Curvature in Skeletal Malocclusion using a Modified Cephalometric Angle

Dr. Sharvari Vijay Kadhare¹, Dr. Sumeet Ghonmode², Dr. Suryakant Powar³,
Dr. Wasundhara A. Bhad (Patil)⁴, Dr. Amal B J⁵, Dr. Sejal Sandip Naikwadi⁶, Dr. Anisha Rajan CM⁷

¹Post Graduate Student, Government Dental College and Hospital, Mumbai
Corresponding Authors Email: kadhresharvari@gmail.com

²Associate Professor, Government Dental College and Hospital, Mumbai
Email- sumeet_ghonmode@yahoo.com

³Professor and Head of Department, Government Dental College and Hospital, Mumbai
Email- suryakant.powar@gmail.com

⁴Professor and Dean, Government Dental College and Hospital, Mumbai
Email- [wasundharabhad\[at\]gmail.com](mailto:wasundharabhad[at]gmail.com)

⁵Post Graduate Student, Government Dental College and Hospital, Mumbai
Email- [Amal.bj007\[at\]gmail.com](mailto:Amal.bj007[at]gmail.com)

⁶Post Graduate Student, Government Dental College and Hospital, Mumbai
Email- [Sej99naik\[at\]gmail.com](mailto:Sej99naik[at]gmail.com)

⁷Post Graduate Student, Government Dental College and Hospital, Mumbai
Email: [anisharajancm2\[at\]gmail.com](mailto:anisharajancm2[at]gmail.com)

Abstract: *This study investigates the relationship between and skeletal malocclusion using a modified cephalometric angle. A total of 215 subjects were categorized into skeletal Class I, Class II, and Class III malocclusions. Lateral cephalograms were traced manually, and a cervical angle was measured between the cranial base and cervical vertebrae. Results showed Class II patients had reduced cervical curvature, while Class III showed increased lordosis. A statistically significant correlation was found between the cervical spine posture and skeletal malocclusion. These findings underscore the clinical value of incorporating cervical posture analysis into orthodontic assessment and treatment planning.*

Keywords: Cervical spine curvature; cephalometric analysis; skeletal malocclusion; cranio-cervical posture; orthodontic diagnosis

1. Introduction

The alignment and posture of the cervical spine have long been recognized as crucial factors in the development and function of the craniofacial complex. Cervical lordosis—a natural anterior curvature of the cervical spine—is essential for maintaining postural balance and enabling optimal neuromuscular coordination between the head and neck. Deviations from normal curvature can disrupt musculoskeletal balance but also affect dental occlusion and craniofacial growth patterns.¹

It is well established that poor posture of the head and neck is a major contributing factor to myofunctional disorders in the craniofacial region. During the critical stages of growth, especially adolescence, abnormal cervical posture can disrupt normal craniofacial development.² This disruption is due to the biomechanical and anatomical connections between the neck muscles, vertebrae, and the structures of the face and jaw. The cervical spine, especially its upper segments (C1 and C2), develops in close association with cranial structures and differs embryologically from the lower vertebral column. Such developmental proximity underscores the potential for

structural changes in the cervical region to influence craniofacial morphology.³

Epidemiological data supports this anatomical relationship. Several studies have shown a higher prevalence of craniomandibular disorders (CMD) in patients suffering from cervical spine issues. These patients often exhibit clinical signs of malocclusion, further suggesting a functional and anatomical correlation between cervical spine posture and the positioning of the jaws. For example, Festa et al. demonstrated a negative correlation between cervical lordosis and mandibular length in Class II malocclusion patients. This finding suggests that compensatory mechanisms in the cervical spine may develop in response to sagittal skeletal discrepancies of the jaws.⁴

Solow and Tallgren have extensively reported on the interplay between craniocervical posture and facial morphology. Their studies identified a set of associations between increased craniocervical angulation and specific craniofacial traits, such as a steeper mandibular plane angle, increased lower anterior facial height, and mandibular retrognathism. These associations were more strongly related to the head's position in relation to the cervical column than to the true vertical

plane. Such evidence indicates that cervical posture may not merely accompany but actively influence craniofacial growth trajectories.⁵

Further studies reinforce these findings. A study by Hosseinzadeh Nik and Janbaz Aciyabar introduced a practical method of evaluating cervical curvature using modified constructed angles in cephalometric analysis, finding a significant correlation between cervical posture and sagittal jaw position, particularly in Class II malocclusions. Likewise, Tecco et al. emphasized the importance of evaluating cervical angles in subjects with temporomandibular dysfunction (TMD), noting that altered mandibular position can influence cervical curvature and potentially contribute to cervical discomfort or pathology.⁵

Although these studies support the link between cervical posture and malocclusion, the nature of this relationship—whether causal, compensatory, or bidirectional—remains debated. Some authors argue that altered cervical posture may precede malocclusion, whereas others suggest that skeletal jaw discrepancies may lead to postural adaptations in the cervical spine.⁶ Regardless of the direction of causality, the association has significant implications for orthodontic diagnosis and treatment planning. Evaluating cervical posture, particularly using simplified and reproducible angles such as the modified cervical angle, can enhance the clinician's understanding of each patient's unique craniofacial and postural dynamics.⁷

In light of this, the present study seeks to compare the modified cervical angle across patients with skeletal Class I, II, and III malocclusions. By evaluating pre- and postoperative changes in this angle, we aim to investigate how cervical spine curvature correlates with different sagittal skeletal patterns and assess whether orthodontic or orthognathic interventions lead to measurable changes in cervical posture. The modified cervical angle employed in this study offers a practical, reproducible approach to quantifying lordotic curvature on standard lateral cephalograms, allowing its application in routine clinical settings. This study aims to assess the relationship between cervical spine curvature and skeletal malocclusion using a modified cephalometric method, comparing Class I, II and III malocclusion. This research highlights the importance of integrating postural assessment into orthodontic diagnosis. It contributes to evolving perspectives on how cervical alignment affects or reflects craniofacial morphology and treatment outcomes.

2. Materials and Methods

Study Design and Sample Selection

This study was conducted as a cross-sectional cephalometric analysis. A total of 215 patients were included, each classified into skeletal Class I, Class II, or Class III malocclusion groups based on standard cephalometric criteria (primarily ANB angle and Wits appraisal). Subjects included both males and females with completed craniofacial growth, no prior orthodontic or surgical treatment, and no systemic or craniofacial syndromes.

Inclusion Criteria

- Fully erupted permanent dentition
- Completed craniofacial skeletal growth (ages 18–30)
- Clear lateral cephalometric radiographs taken in natural head position (NHP)
- No prior orthodontic, orthognathic, or orthopedic treatment

Exclusion Criteria

- Presence of craniofacial syndromes or deformities
- Temporomandibular joint disorders (TMD)
- History of trauma to head or neck
- Evidence of upper airway obstruction or adenoid pathology

Cephalometric Measurements

Lateral cephalograms were obtained in standardized conditions using a cephalostat, with the patient in natural head posture. All radiographs were traced manually by the principal investigator to ensure uniformity. The maxillomandibular skeletal relationships were assessed using traditional and postural cephalometric landmarks.

Landmarks and Planes Used:

- **Nasion (N):** Anterior point of the frontonasal suture
- **Sella (S):** Center of the sella turcica
- **Point A (A):** Deepest point on the contour of the premaxilla
- **Point B (B):** Deepest point on the anterior contour of the mandible
- **Posterior border of the foramen magnum**
- **Midpoints of inferior borders of cervical vertebrae (typically C2 to C4)**
- **Perpendicular bisector** of the line connecting the anterior and posterior border of the foramen magnum

Modified Cervical Angle Measurement:

To evaluate the cervical curvature, a **modified cervical angle** was constructed by:

- 1) Drawing a reference line along the base of the skull at the entrance to the foramen magnum.
- 2) Constructing a second line connecting the midpoints of the inferior borders of cervical vertebrae (C2–C4).
- 3) Measuring the angle formed between these two lines—representing the **inclination of the cervical column relative to the cranial base**.



This modified approach was adapted from the methods described by Hosseinzadeh et al. and Solow et al., with minor

refinements to enhance reliability and simplicity for clinical use.

All tracings and angle measurements were performed twice, two weeks apart, to assess intra-observer reliability. The average of the two readings was used for statistical analysis.

Data Analysis:

Data was analyzed using SPSS version 19.0 (Statistical Package for Social Sciences Chicago Inc). Descriptive statistics were computed for all variables. One way ANOVA was used to compare correlation between skeletal malocclusion and cervical spine curvature using a modified cephalometric measurement technique in different skeletal groups. Correlation of cervical posture with different skeletal malocclusions was tested using Pearson's correlation. Level of significance was set at $p \leq 0.05$.

3. Results

There were 215 patients in the entire sample which were divided into Skeletal Class I, Skeletal Class II, and Skeletal Class III based on the angle ANB angle and Wits appraisal.

Table 1: Shows a Correlation between Malocclusion and point X and Y

Malocclusion	R	P
Point X	0.38	0.02
Point Y	-0.36	0.03

Test applied Spearman's Correlation
Level of significance set at $p \leq 0.05^*$

Eligibility Criteria

All studies were assessed for eligibility using the PICO model, which stands for:

- (P) Patients diagnosed with malocclusion without a history of orthodontic treatment were included.
- (I) Not applicable.
- (C) The control group consisted of individuals with Class I malocclusion (normal sagittal jaw relationship) to evaluate the association of cranio-cervical posture with Class II and III malocclusion.
- (O) Outcome measures included craniovertical angles, cervicohorizontal angles, craniocervical angles, and cervical curvature obtained through cephalometric analysis.

Table 2: Shows the intergroup comparison of points. Table 1 presents a comparison of points X and Y and cervical posture in the different skeletal groups. Cervical curvature was found to differ in the three classes of malocclusion, namely skeletal Class I, II and III.

		N	Mean	Std. Deviation	f-Value	p-Value
X	Class 1	71	150.4085	9.13795	31.53	0.01*
	Class 2	74	149.5811	9.26476		
	Class 3	70	158.8000	2.08931		
Y	Class 1	71	28.4930	10.71431	24.44	0.01*
	Class 2	74	30.4189	9.26476		
	Class 3	70	21.2000	2.08931		
SNA	Class 1	71	81.6056	2.48699	3.02	0.01*
	Class 2	74	82.2297	2.06436		
	Class 3	70	81.3571	2.02188		
SNB	Class 1	71	78.9014	2.74203	84.05	0.01*

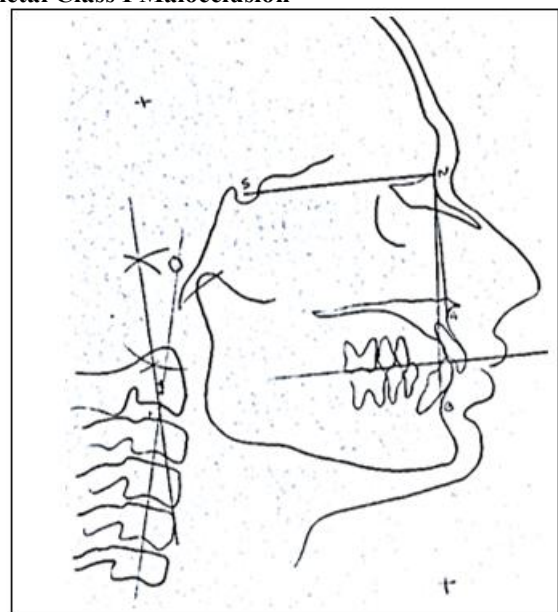
ANB	Class 2	74	78.8784	2.02012	18.14	0.01*
	Class 3	70	84.0429	3.31197		
	Class 1	71	2.7183	.88128		
	Class 2	74	3.8649	1.31716		
	Class 3	70	3.6286	1.35317		

Test applied One WAY ANOVA Test

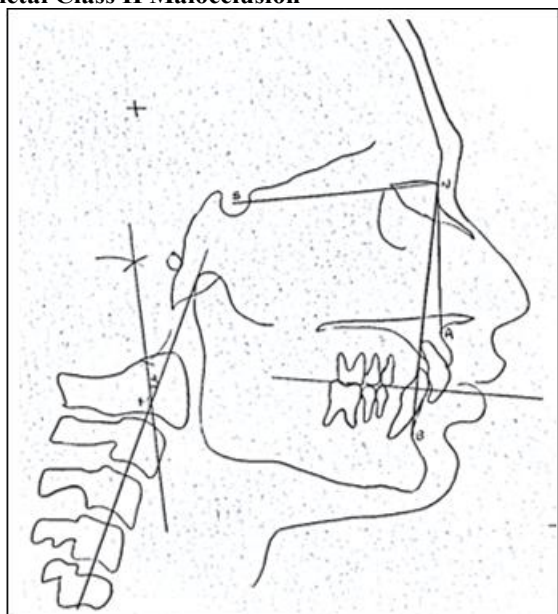
Level of significance set at $p \leq 0.05^*$

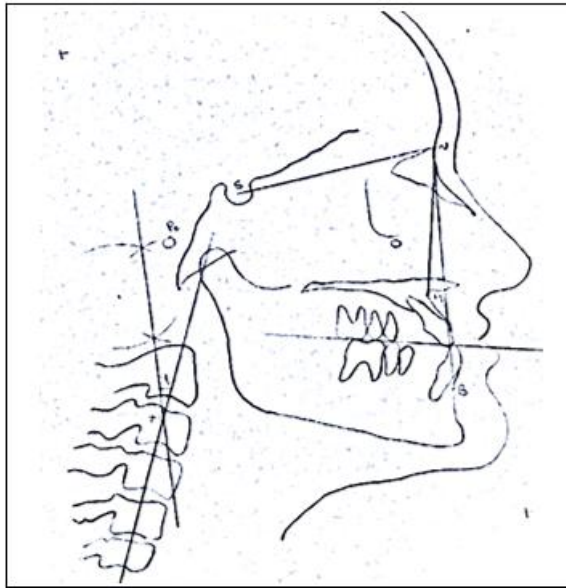
Skeletal class I, class II, and class III malocclusion subjects exhibit different body postures, and there is a favorable link between cervical spine curvature and skeletal malocclusion in these subjects. Cervical curvature in subjects with Skeletal Class I base was found to be significantly different from that of Class II and Class III. Statistically significant difference was seen between cervical curvature of skeletal Class I, skeletal Class II and skeletal Class III. Skeletal class presented a weak but significant correlation with only cervical spine curvature.

Skeletal Class I Malocclusion



Skeletal Class II Malocclusion



Skeletal Class III Malocclusion**4. Discussion**

The current study was conducted in order to discover whether there was a correlation between cervical spine curvature and sagittal skeletal relation. The current study used quantitative cephalometric data to identify cervical spine curvature, in contrast to other research by Solow B and Deda MR that only used visual assessment of cervical posture. As a result, the outcomes were more accurate and dependable.

According to our study's descriptive findings, skeletal Class II patients often exhibited smaller modified cervical angles than skeletal Class I and skeletal class III subjects. This suggested that the cervical spine curvature was inclined forward. Conversely, skeletal Class III participants exhibited relatively wider modified cervical angles, which are indicative of a cervical spine curvature that is inclined backward. However, a statistically significant difference was discovered when the cephalometric measures for cervical inclinations in various malocclusions were compared.

The first writers to show a positive association between body posture and craniofacial shape were Solow and Tallgren⁵. This school of thought gained a new dimension in 1977 when Solow and Kreinborg⁸ proposed the soft tissue stretch theory. According to the biomechanical concept hypothesis of postural collapse,⁹ the dentition serves as the primary structural component that supports the skull. Any harm to this dental unit may cause a number of changes that ultimately lead to the collapse of the postural system.

The cervical posture of adolescents with class I, II, and III malocclusions was assessed by Garcia et al¹⁰ in 2012, and they discovered a significant difference between the three classes. The cranium's angle with respect to the cervical spine is represented by the posterior inferior angle, which typically ranges from 101° on average to 5° with extension and extension. In the present study the posterior inferior angle was found to be within the normal limits for subjects in class I. But in class II, the angle was found to be smaller, indicating that the subjects posed with their necks extended forward. Class III patients had a rearward extension of the neck in their stance,

as evidenced by an increase in the posterior inferior angle relative to the normal. This was consistent with the Rocabado et al investigation.^{11,12}

Compared to class I subjects, it was found that the cervical curvature was lower in skeletal class III individuals and higher in class II skeletal basis subjects. This was consistent with earlier research by Nobili et al. and D'Attilio,^{13,14} which found that individuals with class III skeletal malocclusions exhibited a backward posture whereas those with class II malocclusions had a forward posture.

The chain theory provides an explanation for the class II malocclusion group's forward sway and the class III malocclusion group's backward sway. This hypothesis divides the entire body system into three rings. The head, neck, and TMJ muscles made up the upper ring, the back and vertebrae muscles made up the middle ring, and the foot, ankle, and leg muscles made up the lower ring. The three rings must be in perfect harmony and synchronization for a body to function. Modifications in the other two rings would result from any disruption in one of the rings. In a similar vein, individuals with class III malocclusion had a backward head posture, which caused the first ring to be positioned backward. This caused the second ring to move more forward, and the third ring to go backward.¹⁶

The soft tissue stretching hypothesis, put forth by Solow and Kreinborg in 1998, offers yet another explanation for the relationship between malocclusion and posture⁹. D'Attilio et al¹⁵ assessed the cervical posture of 120 kids and found that the two main factors causing the posture change were mandibular size and position. These two elements then affect the neural-muscular system, which alters neck posture and, ultimately, body posture. Research assessing postural alterations following orthognathic surgery has shown that there is a lasting postural change; nevertheless, within a year, the neck posture returned to its pre-operative state.¹⁷ This raises the question of whether malocclusion affects posture.

The cervical spine may be uprighting or straightening if the middle cervical inclination increases and the higher cervical inclination decreases. Studies by Kamal and Fida,¹⁸ Krishna et al¹⁹ and Smailiene et al²⁰ that documented cervical spine uprighting using a Twin Block appliance, corroborated this. In terms of anatomy, the middle and lower cervical spines encircle the oropharynx and hypopharynx, while the upper cervical spine borders the nasopharynx. The slight alterations in nasopharyngeal airway observed with functional appliance treatment are associated with a decrease in upper cervical inclination. According to other systematic reviews, the increase in oropharynx and hypopharynx with functional appliance treatment is associated with the increase in middle cervical inclination observed in the review by Murali S.²¹

It's critical to comprehend how a functional appliance affects the cervical spine. Cervical hyperlordosis can be managed with the use of functional appliances when the cervical lordosis angle decreases as a result of treatment. Although mouth appliances have been used to treat orofacial discomfort and obstructive sleep apnea, their potential for treating postural disorders of the cervical spine has not yet been investigated. The systematic review by Murali S emphasized

the possible use of functional appliances in the treatment of cervical spine alignment and hyperlordosis²¹.

This study found that the cervical spine curvature of the subjects with class I malocclusion were normal. It was discovered that the forward cervical position were present in subjects with class II malocclusion. And also subjects with class III skeletal malocclusion exhibited a backward cervical position.

Changes in posture can result in a number of issues. Patients with postural collapse have been known to experience persistent headaches, back discomfort, nerve compressions, and other symptoms.²²The biomechanical concept theory of postural collapse explains the mechanism by which malocclusion causes postural collapse²³. This also explains the necessity of correcting any postural changes as soon as possible, most likely in the younger age group, in order to prevent further deformations, maximize the use of the musculoskeletal system's existing functional efficiency, and take advantage of physiological growth spurts.

5. Conclusion

This study confirms a correlation between cervical spine curvature and skeletal malocclusion classes. Class I individuals displayed near-normal posture, while class II subjects exhibited forward cervical inclination and class III subjects showed posterior tilting. These variations highlight the relevance of cervical assessment in orthodontic diagnosis. Early intervention addressing both malocclusion and posture could improve treatment outcomes and overall musculoskeletal harmony.

Acknowledgements: Nil

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