Original Article

A Study to Evaluate and Compare Morphology of Cervical Vertebrae (C1, C2, C3, and C4) with Different Sagittal Craniofacial Patterns on Lateral Cephalographs

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Abstract

Introduction: Evaluation of craniofacial growth is very important for treatment planning in individuals with skeletal orthodontic anomalies. Maturity status helps to identify the growth status of an individual. Cervical vertebral maturity indicators are more commonly used. Their growth completes before the growth of the jaws. If any correlation exists between the change in morphology of cervical vertebrae and developing sagittal skeletal malocclusion, interceptive measures would become easy and efficient as a treatment. This study aims at any correlation present between the change in morphology of cervical vertebrae and developing skeletal sagittal malocclusion. **Materials and Methods**: A cross-sectional study was conducted on 103 subjects, divided into three groups, on the basis of ANB angle which was measured on lateral cephalometric radiographs. Parameters including concavity depth at the lower border of the 2nd, 3rd, and 4th cervical vertebrae and base length, upper border length, body length, posterior height, anterior height, and body height of the 3rd and 4th cervical vertebrae bodies were measured. One-way analysis of variance was used for between-group comparisons. **Results:** There was no statistically significant difference between the mean chronological ages of the individuals among study groups, in the body height, body width, upper border length, vertebral base length, anterior height, posterior height, and concavity depth at the lower border of the 4th cervical vertebrae between groups ($P > 0.05$). **Conclusion:** The results of this study support that morphological development of cervical vertebrae is a separate entity and has no correlation with sagittal skeletal development of face.

Keywords: Cephalometrics, Cervical vertebrae, Different malocclusions, Growth and development, Sagittal growth

Introduction

Van Loon of Holland was probably the first to introduce the cephalometrics into orthodontics.[1] Paccini in 1922 standardized the radiographic head images. In 1931, Broadbent of the USA and Hofrath of Germany simultaneously but separately developed a device called cephalostat, which further standardized cephalometric technique.[1]

Cephalometrics can be used to assess the spatial relationships:
- Relationships between the cranium and jaws
- Relationships between the jaws themselves
- Relationships between the different structures seen on lateral cephalographs
- Relationships between the skeletal and dental structures of craniofacial region.

Cervical vertebrae (C1, C2, C3, and C4) are seen very clearly on lateral cephalograph very commonly along with other dental and cranial structures.

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The main function of the cervical spine is to support the weight of the head. There are seven cervical vertebrae, numbered C1–C7. [2,3]

There are two specialized vertebrae that connect to the skull. The first vertebra (C1) is the ring-shaped atlas that connects directly to the skull. This joint allows for the nodding or "yes" motion of the head.

The second vertebra (C2) is the peg-shaped axis, which has a projection called the odontoid that the atlas pivots around.

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This joint allows for the side to side or "no" motion of the head.[4]

Hassel and Farman reported changes in dimension of cervical vertebrae during pubertal growth and classified them into various stages.[5-10]

Morphological variations in cervical vertebrae have also been reported in various diseases such as cervical kyphosis or Klippel-Feil syndrome.

The growth of vertebrae completes before the growth of the jaws. If a correlation exists between the morphology of cervical vertebrae and developing sagittal skeletal malocclusion, interceptive measures would become easy and efficient.[11,12]

This study intends to check for any correlation between the change in cervical vertebrae and developing skeletal sagittal malocclusion.

Materials and Methods

A cross-sectional study was planned. Ethical approval was granted from the Ethical Committee of CSMSS Dental College and Hospital, Aurangabad, Maharashtra.

A total of 103 subjects ranging from 17 to 30 years of age with various sagittal skeletal malocclusion and those with no previous orthodontic or orthopedic or surgical treatment were enrolled in this study.

Subjects with systemic disease affecting bone metabolism such as osteoporosis and Paget's disease were excluded from the study.

Lateral cephalogram collected from these 103 subjects was divided into three groups, on the basis of ANB angle which was measured on lateral cephalometric radiographs, to the sagittal skeletal pattern: Class I (ANB; 0°–4°), Class II (ANB; >4°), and Class III (ANB; <0°).

The cervical vertebrae were traced on lateral cephalographs on thin acetate paper under ideal light illumination by the same operator to avoid the interoperator errors.

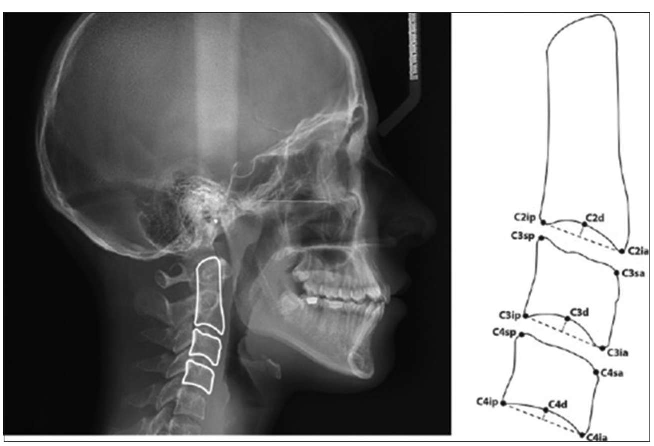


Figure 1: The points marked on the bodies of the 2nd, 3rd and 4th cervical vertebrae

The points presented at Figure 1 were marked on the bodies of the 2nd, 3rd, and 4th cervical vertebrae. The distance between these points, which are shown in Table 1, was measured in mm.

All measurements were performed on the lateral cephalometric radiographs.

Method of data analysis

Statistical analysis was performed using Statistical Package for the Social Sciences version of 21 for Windows (Armonk, NY: IBM Corp.).

Descriptive quantitative data were expressed in mean and standard deviation, respectively. Data normality was checked using Shapiro–Wilk test.

Confidence interval is set at 95% and probability of alpha error (level of significance) set at 5%. Power of study is set at 80%.

Analysis was done by one-way analysis of variance f test for the comparison of age and gender and comparison of different measurements of 2nd cervical vertebrae (C2), 3rd cervical vertebrae (C3), and 4th cervical vertebrae (C4) among different malocclusion groups in males and females. A pairwise comparison between any two malocclusion groups using Tukey's *post hoc* test.

Results

It was found that there was no statistically significant difference between the mean chronological ages of the individuals among the study groups ($P > 0.05$).

There was also no statistically significant difference in the body height, body width, upper border length, vertebral base length, anterior height, posterior height, and concavity depth at the lower border of the 4th cervical vertebrae between groups ($P > 0.05$) (Tables 2-4).

Discussion

Increase in vertical height,[13-15] horizontal width,[13-15] and lower border concavity depth[13,15] of body of cervical vertebrae during skeletal maturation are under the influence of environmental and genetic factors.[16-18] It has been demonstrated in the

Table 1: Measurements performed on cephalometric radiographs

Measurements	Explanations
Length of upper border	Distance between the points sp and sa
Length of vertebral base	Distance between ip and ia points
Vertebral body width	Width of the vertebral body measured from the middle
Anterior height	Distance between the points sa and ia
Posterior height	Distance between the points sp and ip
Height of the vertebral body	Height of the vertebral body measured from the middle
Concavity depth at the lower border	Perpendicular distance of point D to the points ip and ia

SP: Superior posterior, SA: Superior anterior, IP: Inferior posterior, IA: Inferior anterior

Table 2: Mean age

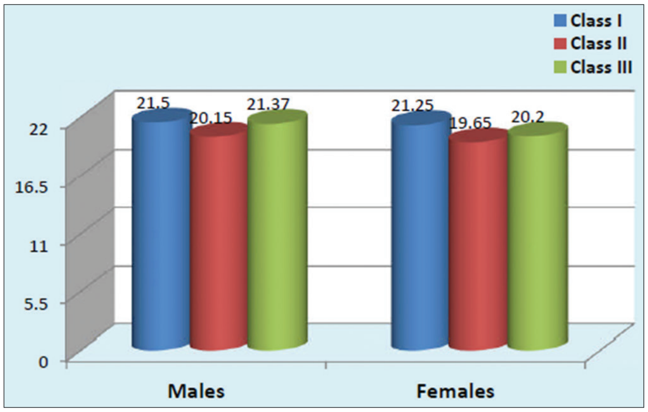
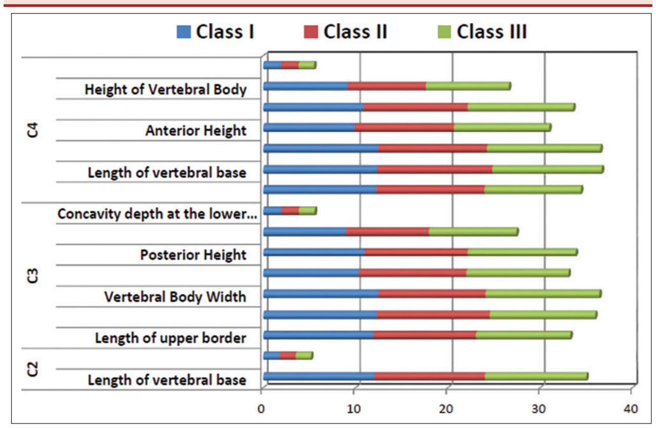


Table 3: Comparison of mean age between different malocclusion in males and females

Different malocculsions	Males mean (SD)	Females mean (SD)
Class I	21.5 (4.82)	21.25 (3.86)
Class II	20.15 (3.57)	19.65 (2.41)
Class III	21.37 (3.82)	20.2 (3.66)
P-value#	*P*=0.567	*P*=0.318
Class I versus Class II^	*P*=0.570	*P*=0.294
Class I versus Class III^	*P*=0.997	*P*=0.631
Class II versus Class III^	*P*=0.766	*P*=0.881

#*P*-value for overall comparison using one-way ANOVA F test ^*P*-value for pairwise comparison between any two malocclusion groups using Tukey's *post hoc* test, SD: Standard deviation

Table 4: Comparison of different dimensions of cervical vertebrae performed on cephalometric radiographs of different malocclusion



literature that there are significant differences between head and cervical postures among different craniofacial configurations.

The length of the upper border and vertebral base, and posterior and anterior height of the 3rd and 4th cervical vertebrae bodies are some of the determinants of cervical vertebral maturation (CVM) method, developed by Baccetti *et al*.[3] There were no statistically significant differences between the groups in any of these parameters. The other determinant of this method is the concavity depths at the lower border of the 2nd, 3rd, and 4th cervical vertebrae. No statistically significant differences were observed between the groups at these parameters as well. These results support the reliability of visual examination-based CVM methods among patients with different sagittal skeletal patterns.

In the regression formula developed by Mito *et al*., it was reported that bone age can be calculated more objectively using the parameters related to vertebral bodies. The method was developed by utilizing a cross-sectional study and validated on the records of 66 female patients without considering their skeletal patterns.

However, the results of the present study showed that there were no statistically significant differences between sagittal patterns in terms of width, anterior height, and posterior height of the third cervical vertebra body and width, body height, and anterior or posterior height of the fourth cervical vertebral body, which are among the parameters used in these regression formulas.

The results of this study should be interpreted with caution. The limitations of this study mostly arose from its cross-sectional design. More robust evidence can be gained from longitudinal diagnostic material from both genders and different hand-wrist skeletal maturation stages. Another limitation of this study is the ANB angle that was used to assign patients into sagittal patterns. Although ANB angle is a practical and commonly used cephalometric measurement, it has certain limitations. Assessment of this same hypothesis using shape analysis methods to group patients into craniofacial patterns could be a beneficial approach to overcome this particular limitation.

Conclusion

No statistically significant difference was determined in the parameters related to the bodies of 2nd, 3rd, and 4th cervical vertebrae for skeletal maturity with different sagittal skeletal growth and development patterns. The results of this study support that morphological development of cervical vertebrae is a separate entity and has no correlation with sagittal skeletal development of face.

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