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RESEARCH ARTICLE

THREE-DIMENSIONAL EVALUATION OF THE FIRST CERVICAL VERTEBRAL MORPHOLOGY IN SKELETAL CLASS I AND III MALOCCLUSIONS IN YEMENI PATIENTS

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Abstract

Introduction: The shape of the cervical vertebrae is known to be of great importance in the field of orthodontics, as it can be used to assess skeletal maturity. This study aimed to evaluate the shape of the cervical vertebrae in individuals with class I and III skeletal malocclusion.

Methods: The research data were collected from the orthodontic patient records by analyzing cone beam computed tomography of the selected individuals before treatment (n=52) this study was conducted between January 2022 and January 2023. The individuals were divided into two groups based on the ANB angle: class I group (n=26, male=12, female=14) and class III group (n=26, male=9, female=17). The ages ranged from 18 to 30 years, and they were all Yemeni.

Results: The shape of the cervical vertebrae differs among individuals with different anteroposterior skeletal patterns. Cone beam radiographs of 52 patients were evaluated to assess the morphology of the first cervical vertebra in both Class I and Class III. Eight linear variables and one angular variable were compared in both groups, and there were significant differences between HOTDC1, LOAPC1, dorsal arch, HOTDC1, H1APC1, FOTDC1, and superior surface among individuals with different anteroposterior skeletal patterns.

Conclusion: The morphology of the cervical vertebrae was found to be influenced by the anteroposterior relationship of the maxilla to the mandible.

Keywords: Cervical vertebrae, Cone-beam computed tomography (CBCT), orthodontics, Yemen.

INTRODUCTION

The assessment of the patient's skeletal age is very important to determine the appropriate treatment plan for orthodontic patients[1]. There are seven vertebrae in the cervical spine, which support the head. In addition, research has been conducted on the relationship between C1 dimensions and skull and neck position. The length of the mandible and neck position has shown a correlation; longer mandibles were associated with more cervical columns tilted toward the true horizontal[2]. Class I, II, and III skeletal malocclusions can be identified by the anteroposterior relationship of the base[3]. Class III malocclusions may be manifested by skeletal and dental features, including mandibular skeletal protrusion, maxillary skeletal recession, or a combination of the two. Alveolar protrusions such as retroclined mandibular incisors and proclined maxillary incisors are common dental features[4]. Orthodontics is one of the medical specialties that has widely used 3D technologies. The use of these technologies has changed the way orthodontists and maxillofacial surgeons diagnose, plan treatment, monitor condition, and evaluate outcomes. These technologies accurately visualize 3D anatomy by reproducing anatomical structures[5,6]. Several biological indicators, such as cervical vertebral morphology and hand and wrist X-rays, can be used to determine a patient's growth stage[7,8]. For facial and skull imaging, cone-beam computed tomography (CBCT) is superior to medical CT due to its variable field of view (FOV), fast scanning speed, very high resolution of patient radiation exposure, isotropic units, rapid image analysis, and image enhancement[9]. With the development of cone-beam computed tomography (CBCT) technology, many authors have used it to evaluate the morphology of the cervical vertebrae because it gives more accurate three-dimensional images and shows any abnormalities in the cervical vertebrae[10].

Recently, there has been a revolution in Yemen to know many dental standards, including "the reliability of modern dental age estimation methods using X-rays among Yemeni children[11], dental caries and treatment needs among children with physical disabilities[12], the effect of dental implants on increasing the colonization rate of aerobic bacteria in the oral cavity[13], the effect of dental implants on the colonization of aerobic bacteria in the oral cavity, the antibiotic profile of common isolated aerobic bacteria[14], temporomandibular dystonia: prevalence, clinical and demographic data[15], and results of treatment strategies for hundreds of patients, radiographic evaluation of prominent fillings using cone beam computed tomography[16], factor resolution, and the pattern of permanent tooth extraction[17], the prevalence of signs of temporo-mandibular joint disorders in healthy edentulous individuals[18], and the validity of Tanaka and Johnston's mixed dentition among Yemeni adults[19]. However, a comprehensive evaluation of the shape of the cervical vertebrae in cases of Class I and III malocclusion in the Yemeni population has not been performed. Therefore, the aim of this study was to investigate the shape of the cervical vertebrae in cases of Class I and III malocclusion using CT imaging technique.

SUBJECTS AND METHODS

Sample size: The study by Watanabe *et al.* 2 reported a dorsal arch measurement of 8.3+1.1 mm in skeletal class II against 9.9+2.6 mm in skeletal class III. The sample size was calculated using G*power 3.0.10 software with an alpha value of 0.05 and a power of 80%. A minimum sample size of 26 participants was determined via power analysis. Between January 2022 and January 2023, the sample was taken from the orthodontic patients' records using their pre-treatment CBCT (N=52). Subjects of this study were selected from the different Skeletal Classes (Class l and Class III). Patients were considered Skeletal Class I pattern when (ANB = 3+1º), Skeletal Class III pattern when (ANB<1º)[11]. Two gender-based subgroups were created from each study group: Class I group (n=26, males=12, females=14). Group Class III (n=26; 9 males, 17 females). Cone beam CT scans are used for orthodontic diagnosis and treatment planning, and the records used in this study were gathered from Sana'a University's Faculty of Dentistry. All of the volunteers were Yemeni and ranged in age from 18 to 30. There were no congenital maxillofacial abnormalities among the individuals.

Reliability: For accuracy, a well-trained assessor was used on the E-A scanner (Ez3Dplus2009; Ewoosoft, Co., Ltd., Hwaseong, Korea) and the analysis and reading were performed twice within a two-week period to eliminate measurement errors.

Measurements: This study measures eight linear measurements and one angular measurement to assess the morphology of cervical vertebrae with different sagittal skeletal patterns. Those measurements were as follows:

1. Horizontal outer anteroposterior (AP) diameter of the first cervical vertebra (C1) (mm) (HOAPCI) (Figure 1).
2. Horizontal inner anteroposterior diameter of C1 (mm) (HIAPCI) (Figure 1).
3. Horizontal outer transverse diameter of C1 (mm) (HOTDCI) (Figure 1).
4. Distance between outer margin of transverse foramen and outer margin of lateral mass (mm) (outer margin) (Figure 1).
5. AP diameter of the superior surface of the C1 anterior arch (mm) (superior surface) as in Figure 1.
6. Lateral outer AP diameter of Cl (mm) (LOAPC1) (Figure 2).
7. Height of the atlas dorsal arch (mm) (dorsal arch) (Figure 2).
8. Frontal outer transverse diameter of Cl (mm) (FOTDCI) (Figure 3).
9. Angle along the axis line of the dens to the occlusal plane (dens angle (degrees) as in Figure 4).

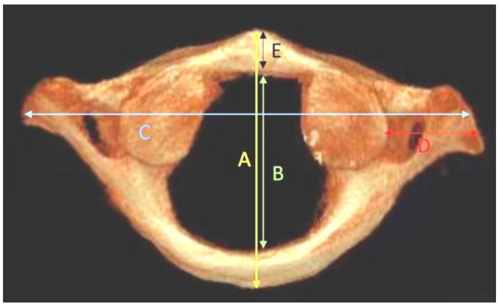

Figure 1: Axial view of cervical vertebra.
(1) Horizontal outer anteroposterior (AP) diameter of the first cervical vertebra (C1) (mm) (HOAPC1(. (2) Horizontal inner anteroposterior diameter of C1 (mm) (HIAPC1). (3) Horizontal outer transverse diameter of C1 (mm) (HOTDC1). (4) Distance between outer margin of transverse foramen and outer margin of lateral mass (mm) (outer margin). (5) AP diameter of superior surface of C1 anterior arch (mm) (superior surface).

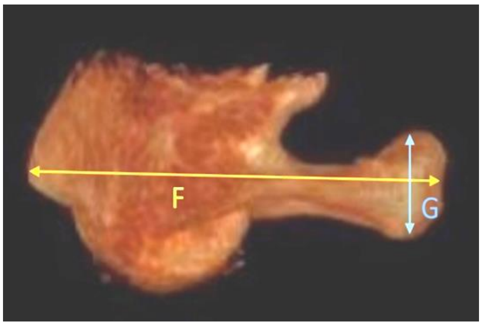

Figure 2: Lateral view of second cervical vertebra.
No. (6)=the lateral outer AP diameter of C1 (mm) (LOAPC1). No. (7)=Height of the atlas dorsal arch (mm) (dorsal arch).

Ethical approval

This study was designed according to STROBE guidelines and conducted in accordance with the Declaration of Helsinki. The study protocol was approved by the Ethical Committee of the Faculty of Dentistry, Sana'a University, Yemen.

Statistical analysis

The statistical software tool SPSS (Statistical Tool for the Social Sciences) version 25 for Windows was used to enter and analyze the data. Means, standard deviations, chi-square and t-tests were calculated at 95% statistical significance level and a *p* value less than 0.05 was considered statistically significant.

RESULTS

The sample included 21 males and 31 females with no statistical significant difference between gender and both skeletal groups (*p*>0.05) (Table 1). Statistically significant differences were investigated between the first and third class groups. There was no statistically significant difference in the outer margin and dense angles (*p*>0.05). The variables HOAPC1, HIAPC1, HOTDC1, upper, LOAPC1, dorsal arch, and FOTDC1 showed statistically significant differences between the first class and the third class (*p*<0.05), and the highest mean value was found in the third class (Table 2).

DISCUSSION

Several previous studies have evaluated the maturity and shape of the cervical vertebrae using 3D imaging, but there has been insufficient research to evaluate the shape of the cervical vertebrae in Yemen and the Class I and III malocclusion patients. The majority of studies that used cone-beam CT were based on the evaluation of small samples due to the high cost despite the high accuracy of this method compared to 3D imaging[1,20]. In this study, 52 patients were evaluated using cone-beam CT to determine the shape of the first cervical vertebrae in class I and III malocclusion in Yemen. This research study evaluated 52 patients with different skeletal patterns "class I and III," which were analyzed based on gender. This was the same as that of Baydas *et al.*[21], who evaluated the morphology of the cervical vertebrae of 90 patients (45 males and 45 females) with different skeletal classes. Furthermore, Gunduz *et al.*[22], who examined the hyoid bone and C1 atlas morphology in patients with different skeletal classes, found that there was a statistically significant difference between genders.

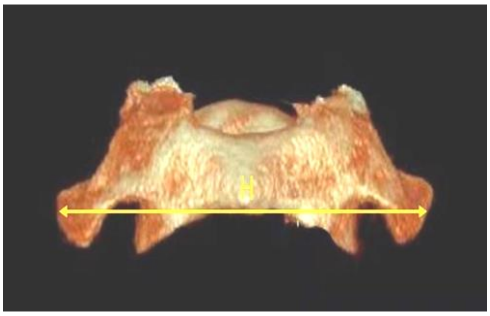

Figure 3: Frontal view of second cervical vertebra.

No. (8)=the frontal outer transverse diameter of C1 (mm) (FOTDC1).

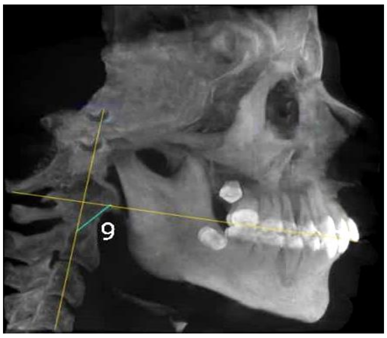

Figure 4: The angle along axis line of the dens to occlusal plane (dens angle [degrees]).

Table 1: The relation between gender and skeletal groups.

Categories		Gender F	Gender M	Total
Skeletal	Class I	14	12	26
		53.8%	46.2%	100.0%
	Class III	17	9	26
		65.4%	34.6%	100.0%
Total		31	21	52
		59.6%	40.4%	100.0%
p-value		0.719 (0.397)		

p: Probability; *: significance ≤0.05; Test used: Chi-Square test

Table 2: The mean value of cervical vertebra measurements in Class I and Class III groups.

Variables	Class I Mean	Class I Std	Class III Mean	Class III Std	t test	*p*-value	ICC Class I	ICC Class III
HOAPC1	37.35	3.35	40.08	2.57	-3.290	0.002**	0.95	0.96
HIAPC1	27.36	2.24	28.59	0.95	-2.557	0.015*	0.98	0.97
HOTDC1	68.00	3.19	72.53	3.40	-4.958	0.000**	0.94	0.95
Outer margin	13.33	1.76	13.36	1.74	-0.063	0.950	0.97	0.94
Superior surface	5.92	1.02	6.73	1.18	-2.672	0.010*	0.94	0.96
LOAPC1	37.99	2.95	40.14	2.63	-2.767	0.008**	0.93	0.94
DORSAL arch	7.74	1.38	8.65	1.04	-2.657	0.011*	0.90	0.91
FOTDC1	67.03	2.88	72.33	3.56	-6.384	0.000**	0.95	0.96
Dens Angle	-0.08	0.27	0	0	-1.443	0.161	0.98	0.97

HOAPC1: horizontal outer anteroposterior diameter of C1; HIAPC1: horizontal inner anteroposterior diameter of C1; HOTDC1: horizontal outer transverse diameter of C1; LOAPC1: lateral outer anteroposterior diameter of C1; FOTDC1: frontal outer transverse diameter of C1; SD: standard deviation, P: Probability; *: significance ≤0.05; Test used: Student's t-test unpaired

With the development of 3D imaging, it was found to be more reliable and accurate in detecting minor changes and evaluating cervical vertebrae than the previously used 2D imaging techniques. This was confirmed by Patcas *et al.*[23], who suggested that CBCT images are needed for a more accurate diagnosis and location of the deviations. In this study, CBCT images were evaluated for 52 patients from different skeletal classes to assess cervical vertebral morphology; this was the same as Watanabe *et al.*[2], and Ghazy *et al.*[24], who described the morphology of cervical vertebrae in different skeletal classes using CBCT. In this study, specific measurements were used to evaluate the morphology of the cervical vertebrae. The morphology of the cervical vertebrae was assessed using nine linear measurements and one angle assessment. It was discovered that patients from different skeletal classes did not differ statistically significantly in the outer margin and dense angles. This was in line with the findings of Ghazi *et al.*[24], who used the same methodology to examine the cervical vertebral morphology in patients with skeletal classes I and II, and Watanabe *et al.*[2], who examined the cervical vertebral morphology in patients with skeletal classes II and III. The variables in this study that demonstrated a statistically significant difference between Class I and Class III were HOAPC1, HIAPC1, HOTDC1, Superior, LOAPC 1, Dorsal arch, and FOTDC1. According to Watanabe *et al.*[22], there were no appreciable changes between Class II and Class III patients' "HOTDC1," LOAPC1, FOTDC1, or "Dense Angle," but there was a notable difference between Class II and Class III patients' atlas "dorsal arch" heights. Given that the latter examined the morphology of the cervical vertebrae in Japanese patients, whereas this study focused on Yemeni patients, the disparity could be explained by the different heritages of the two groups. Additionally, this study contrasted Class III with Class I malocclusions, whereas their study contrasted Class III with Class II.

Limitations of the study

The limitations of this study include a small sample size because of CBCT cost and its limited use for orthodontic patients; Class II subjects were not included; current study focused on Class III and Class I because they are considered the most common among the Yemeni people, and Class II has been studied in previous research, and patients were not subdivided on their vertical skeletal patterns. For future studies, we recommend comparing the cervical vertebrae morphology in the different heritages all over the world.

CONCLUSIONS

This study confirmed previous findings that individuals with Class III and Class I malocclusions and different anteroposterior skeletal patterns had differences in cervical vertebral shape. No statistically significant difference was observed in the outer margin and dense angles, while HOAPC1, HIAPC1, HOTDC1, superior surface, LOAPC1, dorsal arch, and FOTDC1 showed statistically significant differences between individuals with different anteroposterior skeletal patterns. The measured parameters were found to be significantly increased in Class III patients compared to Class I.

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AUTHOR'S CONTRIBUTION

Al-Ghola E: writing original draft, methodology, investigation. **Al-Harazi G:** formal analysis, data curation, conceptualization. **Al-Shamahy HA:** editing, methodology. Final manuscript was checked and approved by all authors.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

None to declare.

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