Cervical vertebrae staging in pre-orthodontic patients in Benin City, Nigeria

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Abstract

Objective: To determine the prevalence of the various stages of skeletal maturation of the cervical vertebrae in pre-orthodontic patients in Benin City, Nigeria.
Method: The first six cervical vertebrae of 105 untreated orthodontic patients attending the clinic of the University of Benin Teaching Hospital were assessed on the cephalometric radiograph to determine the stages of maturation. Correlations between age, gender, type of malocclusion and skeletal maturation stages were determined using the software SPSS (version 16). Significant values of P<0.05 were applied were applicable.
Result: The average age of participants was 14±1.5 years with an almost equal gender distribution. Cervical vertebrae maturation (CVM) stage 3 was the most frequently occurring with 26.7% of the sample population. This was also seen mostly in the 11-year-old age group. The least frequently reported was CVM stage 1 with 5.7%. According to dento-skeletal patterns, CVM stage 3 was most prevalent in bimaxillary proclination with (29.3%). Others include mandibular retrusion, maxillary protrusion and skeletal 2 with 26.3%, 25% and 17.2% respectively. Males showed a higher distribution in the CVM stage 3 than females. There was also a significant association between age and Cervical maturation, P<0.05.
Conclusion: Cervical Maturation stages 1-6 were identified in pre-orthodontic patients aged 7-21-years. Stage 3 was the most frequently occurring.CVM stage and is seen more in 11-year-old-males. Females demonstrated a higher number in CVM stages 4 and 5. The correlation coefficient between age and CVM was 0.86 (P<0.05) for stage 3.

Key words: Cervical vertebrae, staging, orthodontics

Introduction

Skeletal maturation can be determined by the degree of maturation of the cervical vertebrae and this has been closely related with the onset of puberty[1-4]. Orthodontic patients routinely have cephalometric radiographs taken to determine the type of malocclusion present and in treatment planning1. The advantage of this single investigative tool is that it can be used to determine the orthodontic problem and as an indicator of the stage of skeletal maturity by assessing and analyzing the second to the sixth cervical vertebrae in one film[1-4].
Children with malocclusion who undergo orthodontic treatment especially during the active period of growth or puberty have been shown to have a significant improvement in the skeletal problem when compared with adults[1,2]. There however appear to be no differences in growth rate between sexes until around 9-10-years of age when girls start puberty about 2years earlier than boys. The pubertal growth spurt for boys however tends to last longer for boys than for girls and chronological age does not always correlate with developmental age[1-3]. This has been shown to be as a result of variations in growth as due to various factors which include genetic, hereditary and environmental which are more significant in children and adolescents[3]. Environmental factors such as the nutritional status, the degree of physical activity, and health or illness may also significantly affect growth[2-3]. However, growth is also the result of a continuing interaction between environmental, genetic and hereditary factors and this could also influence the stage of skeletal maturity for various individuals[1,4].
Also the timing of orthodontic treatment and the degree to which various skeletal changes occur vary at different ages and between groups of individuals, between sexes, or between ethnic groups[2,5]. In our environment, orthodontic treatment is carried out in all age groups and in both sexes[6-8], but there appear to be no studies correlating timing of treatment, sex, age, ethnic groups and growth or skeletal maturity.
Numerous studies have described various methods of assessing growth and skeletal maturity in adolescence[1-5]. These include increase in body height[9,10], skeletal maturation of the hand and wrist[11,12], dental development and eruption[13,14], menarche or voice changes[15,16] and cervical vertebrae maturation which is useful in determining mandibular growth[2,4,5,17-20]. These studies have determined that the optimal time of treatment based on the CVM method is stages 3 and 4 for different populations. However, studies are scarce in our environment correlating these parameters with different types of malocclusion. The other advantages of the cervical vertebrae maturation method is that it is a good tool in

assessing the optimal time of dentofacial treatment, and also in assessment of the peak period of mandibular growth[2,4,5,17-20]. Numerous cephalometric studies have been carried out in our environment[21,23], but there appear to be no study correlating the age, gender, type of malocclusion and the skeletal maturation in our environment.

This study aims to determine the various stages of cervical vertebral maturation in untreated orthodontic patients in Benin City, Nigeria.

Materials and method

The total sample consisted of 105 cephalometric radiographs of untreated orthodontic patients attending the University of Benin Teaching Hospital. All the cephalometric radiographs from January 2009 to January 2010 (n=253) were included. Only those with clear diagnostic value were selected for visual and cephalometric analysis. Of this number only 238 met the required criteria and were entered randomly into an x-ray register. Systematic random sampling was then carried out and every 2nd name on the x-ray register was selected to give a total sample size of 105. Maturation stages were determined by the method described by Hassel and Farman[4]. Visual analysis consisted of viewing the morphology of the 2nd to 6th cervical vertebrae (C2, C3 C4, C5 and C6 – **Figures 1 and 2)** by one investigator under the same conditions and at two different intervals. The kappa value of 0.88 obtained gave a good intra-examiner interpretation. The most posterior, anterior and deepest parts of the lower border of the bodies of C2, C3 C4, C5 and C6 were traced on the radiograph and examined for the presence or absence of a concavity at the lower border of the bodies. They were also examined for the following shapes: trapezoid, wedge shaped C3 and nearly rectangular C4, rectangular horizontal, square and rectangular vertical to help in identifying the various CVM stages **(Figure 2).**

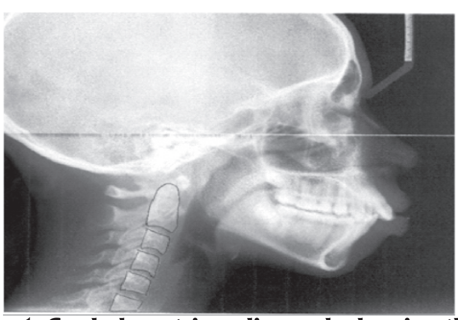


Figure 1. Cephalometric radiograph showing the 2nd to 6th cervical vertebrae

Cephalometric analysis was carried out also to determine skeletal problems (SNA, SNB, ANB and interincisal angle were assessed) using the Steiner analysis[1,22].

SNA- Sella –nasion- A point (the innermost and concave part of the bony maxilla) to determine maxillary prognathism or retrognathism

Nigerian values[21] of 82-89ş were regarded as a normal maxilla

Values of < 81ş were regarded as a retrusive maxilla and >90ş as maxillary

Prognathism[21]

SNB- Sella –nasion- B point (the innermost and concave part of the bony mandible) to determine mandibular prognathism or retrognathism Nigerian values of 79.5 - 85.9şwere regarded as a normal mandible

Values of < 79.4ş were regarded as a retrusive mandible and >86ş as mandibular prognathism[21]

ANB- Point A to nasion to point B representing the skeletal pattern

Nigerian values of 2-4şrepresent skeletal pattern I <1ş skeletal pattern III and >5ş skeletal pattern II[21]

Interincisal angle- being the angle formed between the upper and lower incisors

Nigerian values of 108-116ş were regarded as normal Values of < 107ş were regarded as bimaxillary protrusion and >117ş as maxillary prognathism[21]

All tracings were done on 0.003' matte acetate paper under good lighting by the same investigator. Twenty randomly selected radiographs were retraced after a two week interval and the kappa test carried out giving a value of 0.82 indicating good agreement.

Statistical analysis were performed using SPSS for windows (version 16.0 Chicago IL). The chi-squared test was used to determine significance of the correlation

Result

A total of 105 participants aged 7-21-years-of age were included in the study.

The female to male ratio was almost 1:1. There was an equal distribution of 11, 13 and 16-year-olds 13(12.4%) in the study. The 9-year-old age group had the least number of subjects 1(0.9%) in the study **(Figure 3)**.

Cervical stages 1-6 were identified in this study with CVM stage 3 demonstrated in the highest frequency in 28(26.7%).

Figures 2- 4 demonstrate the six different CVM stages and the various frequencies respectively.

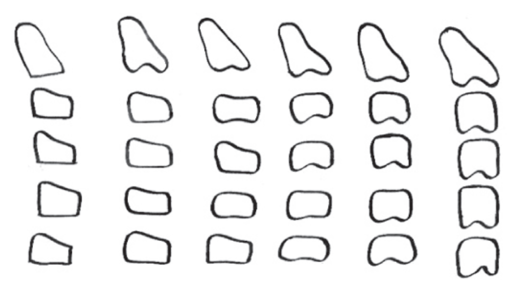
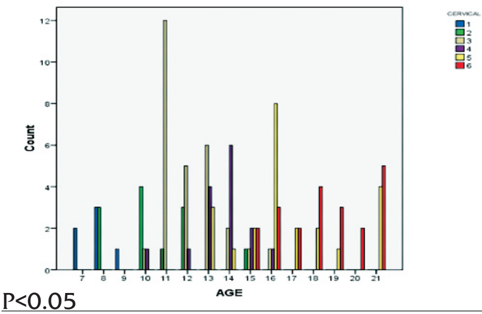


Figure 2: Diagrammatic representation of the 6 stages of cervical vertebral maturation as traced from cephalometric radiographs



P<0.05

Figure 3: Age distribution of the various CVM stages

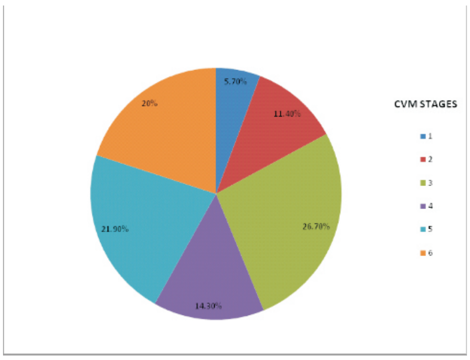


Figure 4: Frequency distribution of the various CVM stages

CVM stage 3 demonstrated a higher number of males 20(19.1%) while females were higher in CVM stage 6 in 14(13.3%) **(Table 1).**

Table 2 shows the frequency distribution of SNA and SNB with reduced, normal and increased values.

Table 2 shows the highest distribution in SNA values >90 (maxillary prognathism) in CVM stages 3 and 6 in 6 (24%) respectively; reduced SNB values (<79ş) with the highest prevalence in 10 (26.3%) in CVM stage 3 and the highest ANB values (>5ş) in skeletal pattern 2 in 17 (30.4%). Bimaxillary proclination (reduced interincisal values <107ş) was highest in 12 (29.3%) and in CVM stage 3. There was however no significant association between SNA, SNB, ANB and the interincisal angle and the 6 different CVM stages P>0.05.

Table 3 shows the correlation between the six CVM stages and age, SNA, SNB, ANB, interincisal angle and skeletal pattern.

Table 1: Cervical maturation stages according to gender

Maturation Stage	Males n %	Female n %	Total n %
1	4 (7.1)	2 (4.1)	6 (5.7)
2	7 (12.5)	(10.2)	12 (11.4)
3	20 (35.7)	8 (16.3)	28 (26.7)
4	5 (9)	10 (20.4)	15 (14.3)
5	13 (23.2)	10 (20.4)	23 (21.9)
6	7 (12.5)	14 (28.6)	21 (20)
Total	**56(100)**	**49(100)**	**105 (100)**

Table 2: Frequency distribution of SNA, SNB

Cephalometric Value	Comment	CVM 1	2	3	4	5	6	Total
	Total:	(6)	(12)	(28)	(15)	(23)	(21)	105
Interincisal Angle								
Increased (>117) Maxillary Prognathism		5	3	9	7	7	5	36
Reduced (<107)Bimax		1	7	12	4	7	10	41
Normal (108-116)		0	2	7	4	9	6	28
SNA								
Increased (>90) Maxillary Prognathism		1	4	6	4	4	6	25
Reduced (<81) Maxillary Retrusion		2	3	5	1	4	6	21
Normal (82-89)		3	5	17	10	15	9	59
SNB								
Increased (>86) Mandibular Prognathism		1	4	2	2	5	3	17
Reduced (<79) Mandibular Retrusion		1	7	10	4	7	9	38
Normal (79.5-85.9)		4	1	16	9	11	9	50
ANB								
Increased (>5) Skeletal II		3	8	17	10	10	8	56
Reduced (<1) Skeletal III		2	1	3	2	4	5	17
Normal (2-4) Skeletal I		1	3	8	3	9	8	32

P>0.05

Table 3: Correlation between age, SNA SNB ANB interincisal angle, skeletal pattern and different classes of CVM

Variable	mean	CVM stage	n=105 r	P value
Age	14.15	3.95	0.858	0.001*
SNA	85.9	3.95	-0.040	0.683
SNB	81.4	3.95	0.040	0.684
ANB	4.4	3.95	-0.107	0.277
Interincisal angle	111.7	3.95	-0.038	0.702
Skeletal pattern	1.85	3.95	-0.319	0.157

Discussion

The results of this study from a sample of untreated orthodontic patients demonstrated the various stages of skeletal maturation as seen on the cervical vertebrae in various age groups and type of malocclusion in Benin City, Nigeria.

The gender distribution in this study showed a higher number of males (19.1%) in CVM stage 3, than females who were higher, (13.3%) in CVM stage 6. This is in contrast with studies by San Roman et al9 where the most frequent stages were CVM stages 3 and 2 in girls in 24% and 23.8% respectively and stage 2 in 33.2% in boys. This could be due to the differences in sample size and a wider distribution in both genders. However, this present study and those by San Roman et al[9] utilized the same parameters as described in the staging described by Hassel and Farman[4]. CVM staging as described by Lamparski[17] and demonstrated in other studies[9] showed stage 4 as the most frequent in both males and females in 27.6% and 29.2% respectively. This difference could also be due to age and ethnic variations in the various stages of maturation as this present study was carried out on Africans, while the other study[9] was carried out on Europeans.

This study showed a wide age distribution for the six different CVM stages and included children and adults between the ages of 7-21-years of age. Other studies on CVM have included ages from 9-16-years-of age in Mexicans[3], 10-15-years of age in Spanish children[9], 9-18-years-of age in Canadian children[19], and 5-11-years of age in Brazilian children[24,28]. Studies by Armond et al also show that children of the same chronological age demonstrate different skeletal ages and different stages of cervical vertebral maturation[28]. These studies[3,19,24,28,29] have demonstrated the various stages of CVM maturation in each age group with other studies demonstrating that growth potentials exist even beyond 15-years-of-age[9]. This shows that different CVM stages are exhibited in different age groups. The wide age range of 7-21-years was carried out in this present study to get a wide range of maturation as there appears to be no previous studies on CVM in Nigerians.

This present study showed the most prevalent CVM stage as 3 in 26.7%. Other studies have identified CVM stages 3 and 4 as the average occurrence of pubertal growth peak in Europeans[2,26] and Chinese[25]. This present study also demonstrated that CVM stage 3 was the highest in the 11-year-old age group and in males with 19.1%. Other studies[2,19] have demonstrated that the optimal time to treat various categories of malocclusion is during the pubertal growth spurt which has been identified in stages [3 and 4].

This study demonstrated that majority of patients had a normal maxilla with SNA values ranging from 82ş-89ş. Pared sample statistics from this study also demonstrated a mean SNA of 85.8ş for CVM stage 3 which is close to the values obtained by Farias et al[27], who demonstrated SNA values of 82.79±2.08 as the mean in CVM stage 1. This is consistent with findings from other studies where majority of the population exhibit normal SNA values as determined by the different races[21,22]. However, this present study demonstrated an equal prevalence in CVM stages 3 and 6 with increased SNA values >90ş (maxillary prognathism) and decreased values <81ş (maxillary retrusion) for CVM stage 6 respectively.

This is probably due to the fact that these patients are untreated orthodontic patients and presented for management with various dento-skeletal problems at different ages.

This study demonstrated a normal mandible with a mean SNB value of 81.39ş in stage 3 and when also compared with findings by Farias et al[27], normal SNB values were also recorded in CVM stages 1 and 2. However, their study[27] was limited to a smaller sample size with a mean age of 8-years and 6months resulting in only stages 1 and 2 observed. This is also consistent with findings from other studies where majority of the population exhibit normal SNB values as determined by the different races[21,22]. This study also demonstrated a decreased SNB value <79ş (mandibular retrusion) as being most prevalent in CVM stage[3].

This study demonstrated that skeletal pattern 2 was highest in CVM stage 3 in 30.4% and skeletal Class 3 was also highest in CVM stage 6 in 29.4%. These two classes represent challenging problems which would achieve more effective results if corrected at the optimal time[2,26,27]. Studies by Baccetti et al[2] have demonstrated that skeletal class II treatment is most effective during the peak in mandibular growth (CVM stages 3 and 4), while skeletal Class 3 treatment is effective in correcting maxillary retrusion when performed at CVM stages 1 and 2. Treatment in Class III patients who had passed puberty (CVM stages 5 and 6) resulted in more of a camouflage than a craniofacial change[26,27].

Bimaxillary proclination as demonstrated by interincisal angles <107ş was also shown to be highest in this present study in CVM stage 3. Most orthodontic patients present earlier[3,9,19,27,28] for treatment and stages 3 and 4 have been identified as the pubertal growth spurt for different ethnicities and this could be why the highest number of cranio-skeletal and dento-facial changes are seen in this stage.

A correlation between variables from this study showed a significant relationship between CVM stage 4 and 14-year-olds. When compared with other studies[28], the mean CVM stage at 14-years-of-age was between 5 and 6. A higher correlation was also found in relatively younger age groups[24], but this study did not demonstrate any correlation between skeletal classes 1, 2 and 3 and the 6 CVM stages, SNA and SNB. This is consistent to the results of other studies[24,29] where the mean CVM stage at 14-years-of-age was between 5 and 6 and despite the fact that these studies[24,28,29] utilized the improved version of evaluating cervical vertebral maturation by Baccetti et al[5]; and this study utilized the same parameters as described in the staging described by Hassel and Farman[4].

Conclusion

Based on our findings, we conclude that cervical vertebral maturation stages 1-6 exist in untreated orthodontic patients in the various age groups, and gender, in Benin City, Nigeria. Stages 3 and 4 may constitute the ideal time of onset of orthodontic treatment. Orthodontic treatment may yield better results if practitioners are encouraged to utilize the CVM method using the cephalometric radiograph prior to the onset of treatment to determine the optimal time for treatment.

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