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Relationship between dental age, chronological age and cervical vertebral maturation in children and adolescents from Bucaramanga, Colombia.

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Abstract: Objective: To determine the relationship between chronological age and dental age using Demirjian's method and Baccetti's method of cervical vertebral maturation in radiographs of children and adolescents aged 5 to 16 years in the city of Bucaramanga, Colombia. Methods: An analytical observational cross-sectional study was performed in 1385 cephalometric and panoramic radiographs of 775 females and 610 males. Sex, dental age according to the Demirjian's method, chronological age and degree of maturation of the cervical vertebrae according to Baccetti's method were analyzed. The univariate analysis included the calculation of measures of central tendency for quantitative variables, and frequencies and proportions for qualitative variables. Spearman correlation coefficients were calculated in the bivariate analysis. In the multivariate analysis a multiple linear regression was performed. A value of $p<0.05$ was considered statistically significant. Results: The mean chronological age was 10.8±3.3 years [Median: 11; 95% CI:10.6-10.6]. There was no statistically significant difference according to sex ($p=0.3409$). The mean of the differences between dental age and chronological age was 0.60±1.44 years. There was a strong and positive correlation between dental age and chronological age with each stage of maturation. Females reached skeletal maturity at an earlier age. Conclusions: Chronological age shows a direct and positive relationship with dental age and stages of skeletal maturation in a Colombian population.

Keywords: growth; permanent dentition; child; adolescent.

INTRODUCTION.

The study of craniofacial growth using indicators such as dental age and skeletal maturation is relevant because of its clinical implication in treating children and adolescents at their optimal growth peaks, in order to achieve greater effectiveness.[1,2] Anthropometric studies, molecular biology, and lateral cephalometric radiographs, used in the Baccetti's method, have been used to determine skeletal development, as well as panoramic radiographs, in which the stage of dental calcification is established.[3-5] Studies that determine the optimal skeletal age to perform orthodontic treatment have had great acceptance due to the clinical implications, and have been replicated in different populations.[6,7] The same happens with studies that assess dental age involving other variables.[8]

Each population has a particular growth model and although there are some shared characteristics, growth is individual and no patient grows as the same rate as another.[9] The Colombian population has a tri-hybrid origin, in which White-Europeans, Afro-Colombians and Indigenous Colombians melded. It has been classified as a mestizo population, and it is difficult to point out conventional craniofacial traits given that these vary according to geographical areas.[10,11] Thus, as a result of miscegenation, Colombia is recognized as a country with an ethnic and cultural diversity.

It is fundamental to determine the relationship between skeletal maturation, chronological age and dental age in specific population since standards and reference parameters commonly used are based on other populations, mostly Caucasian.[2] Such standards and parameters do not account for the racial backgrounds found in Latin American countries. Additionally, it is known that eating habits and geographical locations are factors that modify growth.[12,13]

The aim of this study is to define standards that may characterize the Colombian population more accurately so that they could be used to identify if a patient has a normal pattern of dental calcification in relation to their bone maturation and to identify any alteration. The objective is to describe the degree of skeletal maturation and its relationship with chronological age and dental age in subjects aged 5 to 16 years in the city of Bucaramanga, Colombia.

MATERIALS AND METHODS.

An analytical observational cross-sectional study was carried out. A total of 2770 radiographs, 1385 lateral cephalometric radiographs and 1385 panoramic radiographs of children and adolescents between 5 and 16 years of age, living in the city of Bucaramanga, Colombia, were examined. The radiographs had been requested as requirement for dental or orthodontic treatments at the School of Dentistry at Universidad Santo Tomás, from 2013 to 2015. Poor quality radiographs, with dental anomalies and with radiolucent lesions consistent with dental caries were excluded. Sampling was done at convenience.

The analyzed variables were sex, chronological age, dental age and stage of maturation. The stages of maturation were determined by the cervical vertebral maturation method based on the shape and the lower edges of the second, third and fourth cervical vertebra (C2, C3, C4, respectively), which can be classified into five stages of maturation: stage 1, 2, 3, 4 and 5 (CVM1, CVM2, CVM3, CVM4, CVM5)[4,5]. Clinical variables were not evaluated.

On the other hand, evaluation of dental maturation was carried out using Demirjian's method, which consists of comparing the radiological development of the left lower teeth (31, 32, 33, 34, 35, 36, 37), based on a scale of maturation defined in eight stages from A to H. Dental age is obtained from the sum of these scores.[14]

Inter-examiner calibration of dental age and maturation stages was performed, and a Kappa coefficient of 0.76 and 0.80 was obtained, respectively. Subsequently, a pilot study consisting of sixty lateral cephalometric radiographs and sixty panoramic radiographs was carried out to evaluate the data collection instrument, logistics and the statistical tests that would be used in the study.

Data obtained through radiographic observation were recorded in an instrument designed for that purpose. Typing was carried out in duplicate and databases were validated before being exported to the statistical package Stata I/C version 12.0.

Proportions and frequencies were calculated using qualitative variables and measures of central tendency and dispersion using quantitative ones. Distribution of quantitative variables was evaluated and correlation coefficients (Pearson or Spearman, as appropriate) were analyzed. Additionally, Bland and Altman agreement limits between dental age and chronological age were established. A multiple linear regression was performed and a posteriori assumptions were evaluated. A value of $p<0.05$ was considered statistically significant.

The present study complied with scientific, technical and administrative standards for health research in Colombia according to resolution 008430 of October 4, 1993. This studied was classified as *"risk-free research"*. The Board of Dental Clinics at Universidad Santo Tomás provided inform consent and gave permission to use the radiographs from the clinical histories. Confidentiality of the data was kept at all steps of the research.

Table 1 Frequency of the radiographs of the participants according to their age, chronology and sex.

Chronological age (Years old)	Total n (%)	Female n (%)	Male n (%)
5	17 (1.2)	16 (94.1)	1 (5.9)
6	107 (7.7)	58 (54.2)	49 (45.8)
7	182 (13.1)	107 (58.8)	75 (41.2)
8	177 (12.8)	96 (54.2)	81 (45.8)
9	105 (7.6)	57 (54.2)	48 (45.8)
10	85 (6.1)	53 (62.3)	32 (37.7)
11	82 (5.9)	38 (46.3)	44 (43.7)
12	123 (8.9)	67 (54.5)	56 (45.5)
13	134 (9.7)	74 (55.3)	60 (44.7)
14	128 (9.2)	81 (63.2)	47 (36.8)
15	132 (9.5)	68 (51.5)	64 (48.5)
16	113 (8.2)	60 (53.1)	53 (46.9)
Total	1385 (100.0)	775 (56.0)	610 (44.0)

Table 2. Mean and standard deviation of the chronological age (CA) and dental age (DA) in each stage of maturation (ME) according to sex.

ME	Female			Male		
	n (%)	CA	DA	n (%)	CA	DA
1	148 (19.1)	7.5±2.0	8.6 ±1.7	121 (19.8)	8.4±2.4	9.2±1.8
2	203 (26.2)	8.6±1.9	9.7±1.9	189 (31.0)	9.2±2.4	10.2±2.2
3	181 (23.4)	11.1±2.5	11.9±2.4	149 (24.4)	11.3±2.6	12.0±2.4
4	165 (21.3)	13.7±1.8	13.4±1.5	95 (15.6)	14.0±1.6	13.9±1.6
5	78 (10.1)	14.9±1.3	14.5±1.5	56 (9.2)	15.3±1.1	15.1±1.4
Total	775 (100)	10.7±3.3	11.3±2.8	610 (100)	10.9±3.3	11.5±2.8

Table 3. Correlation coefficients between chronological age (CA) and dental age (DA) in each maturation stage (MS) according to sex.

MS	Female		Male	
	rho	*p*-value	rho	*p*-value
1	0.7479	<0.0001	0.7817	<0.0001
2	0.8103	<0.0001	0.8746	<0.0001
3	0.8450	<0.0001	0.8887	<0.0001
4	0.4448	<0.0001	0.5076	<0.0001
5	0.4619	<0.0001	0.6850	<0.0001

rho: Spearman

Table 4. Coefficients of the multiple linear regression model of the explanatory variables evaluated.

Model	Beta Coefficient	Standard error	*p*-value	95% CI	
Sex (Male)	0.0529	0,0724	0.465	-0.09	0.20
Dental Age (DA)	0.8773	0,0181	<0.0001	0.84	0.91
Maturation Stage(MS)	0.5947	0,0406	<0.0001	0.51	0.67
Constant	-0.8430	0,1558	<0.0001	-1.15	-0.54

CI: Confidence interval

Figure 1 Maturation stages and their relationship with chronological age.

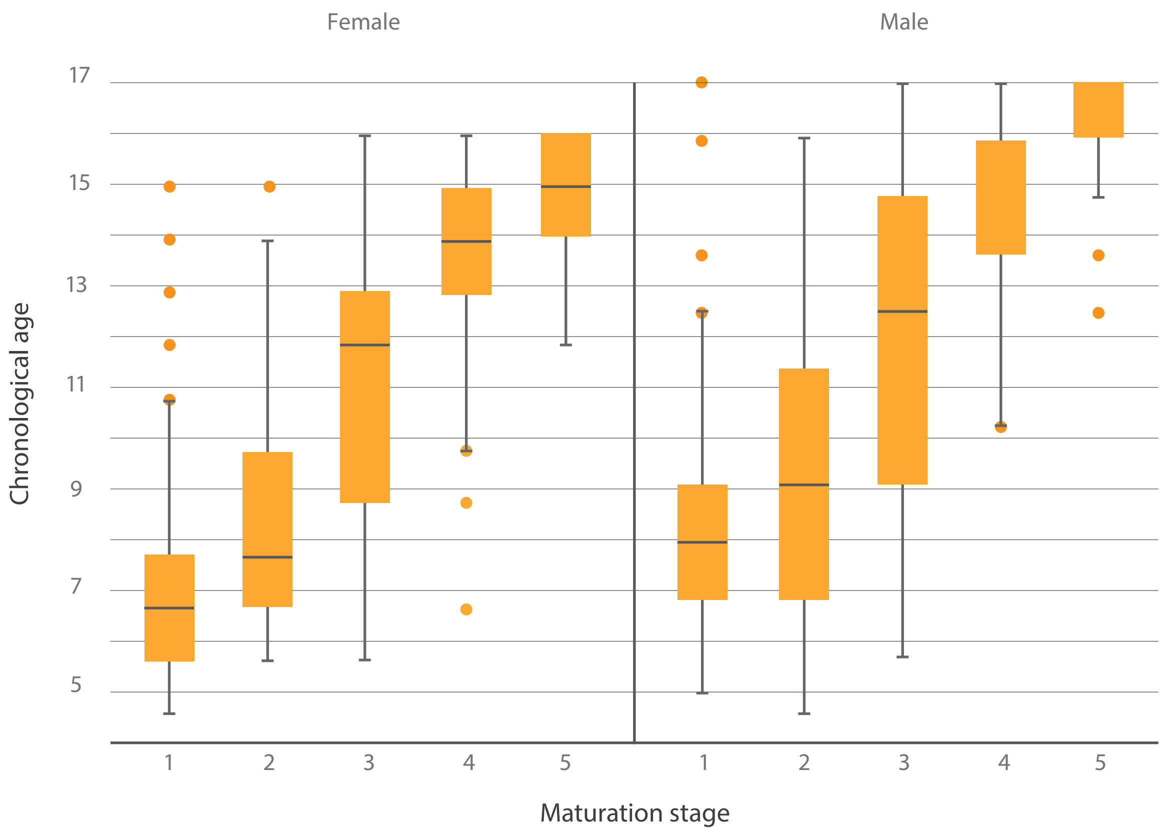


Figure 2. Maturation stages and their relationship with dental age.

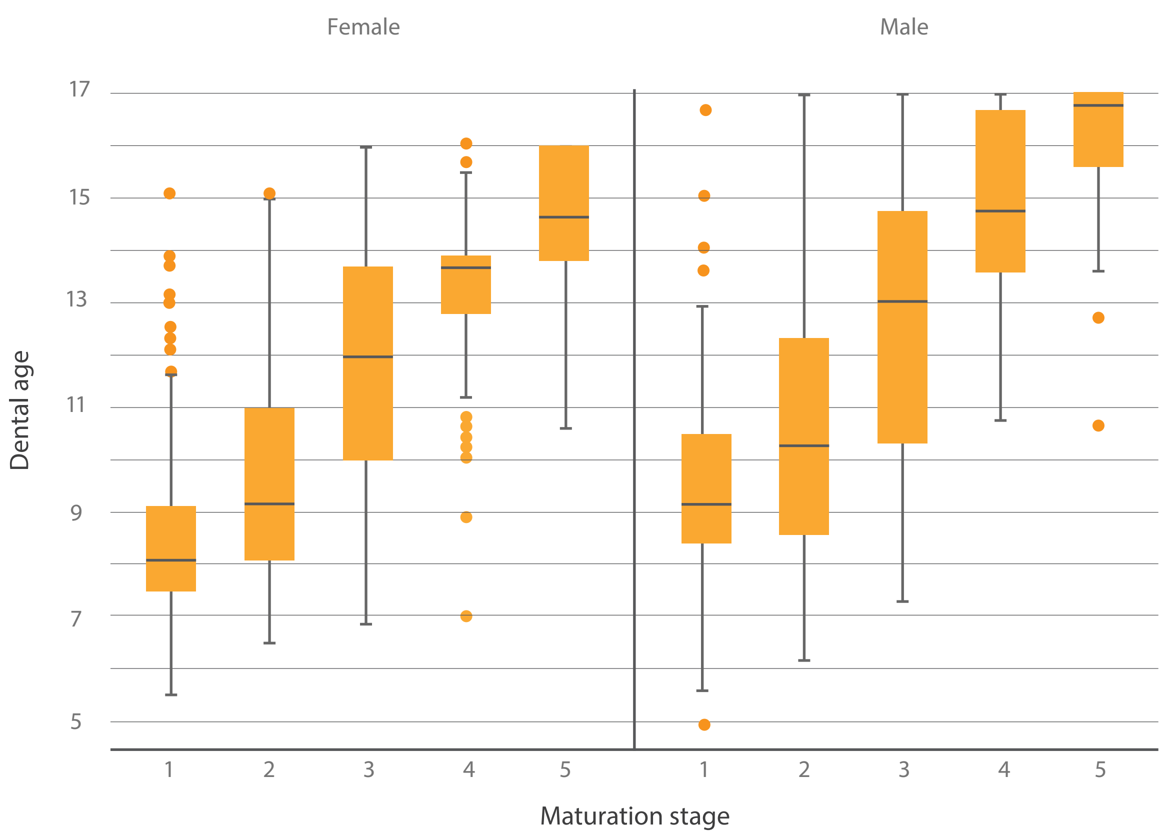
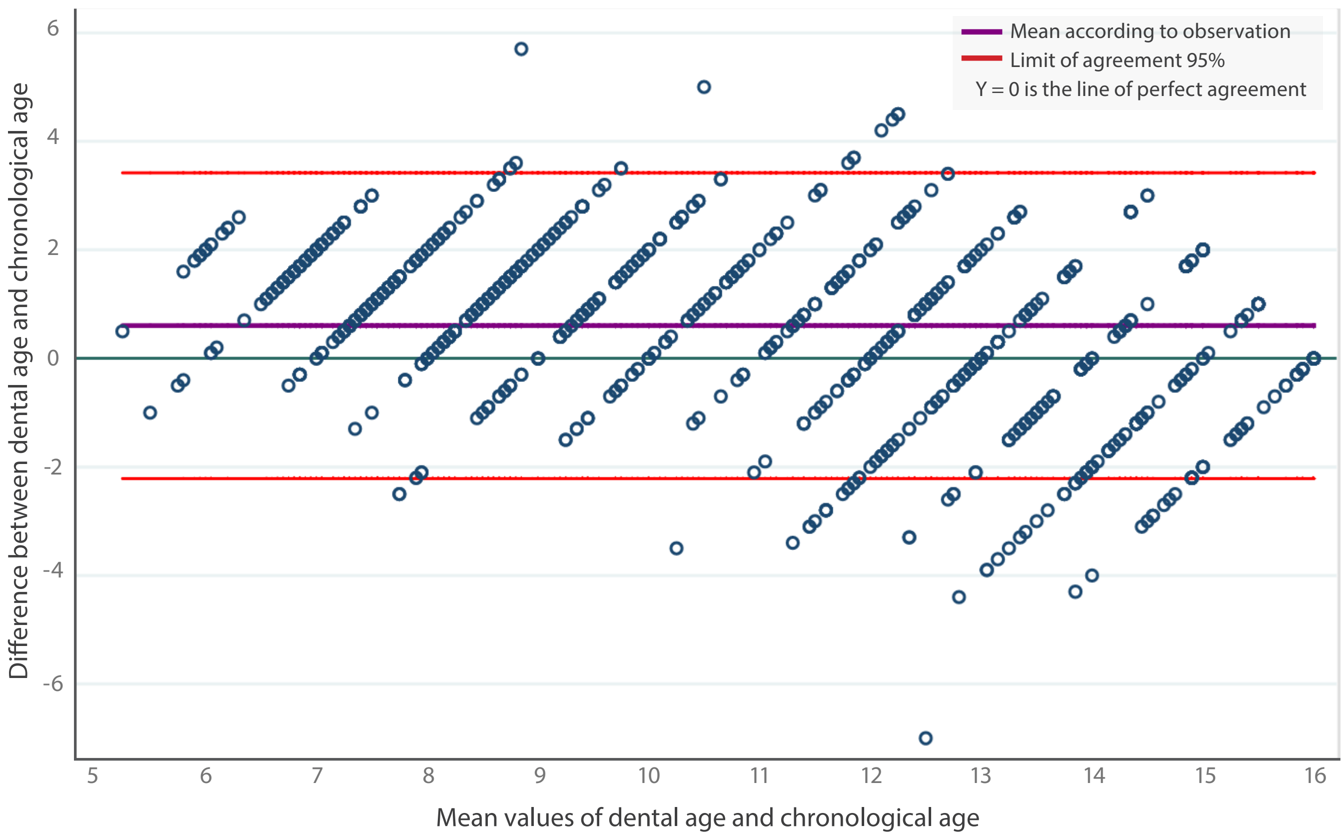


Figure 3. Bland and Altman agreement limits between dental age and chronological age (difference mean: 0.603, and standard deviation: 1.437).



RESULTS.

Out of a total of 1385 radiographs, 775 (56.0%) were of females; mean chronological age was 10.8±3.3 years [Median: 11; 95% CI: 10.6- 10.6]. When categorizing chronological age, it was observed that 7 years old was the most prevalent age, present in 182 (13.1%) radiographs. There was no statistically significant difference in chronological age according to sex (p=0.3409). Table 1 shows the absolute and relative frequencies of the categorized age of the included radiographs according to sex.

Figures 1 and 2 show the relationship between chronological age and dental age with Baccetti's stages of maturation. An earlier maturation onset and termination was observed in females.

It was also observed that both chronological age and dental age increase with an increasing degree of dental maturation (Table 2). When evaluating Bland and Altman agreement limits between dental age and chronological age, the mean of the differences was 0.60±1.44 years (Figure 3), which is considered good as it is close to zero; when sex was taken into account, it was found that dental age increases on average 0.58±1.48 years in females and males. This increase was on average 0.63±1.38 years for all stages of maturation.

When evaluating the correlation between chronological age and stages of maturation, a Spearman coefficient of 0.7390 was found (p<0.0001), and reviewing the correlation between dental age and stages of maturation resulted in a similar value (rho: 0.7016 p<0.0001). There was a strong correlation between chronological age and dental age in males and females in stages 2 and 3 (p<0.0001), but there was a lower correlation in stage 4 in both sexes, although there was a statistically significant difference (Table 3).

The multiple linear regression model shows that explanatory variables (sex, dental age, and stages of maturation) accounted for 83.7% of chronological age. A statistically significant difference was observed in the coefficients of these variables with the exception of sex (Table 4).

The analysis of the *a posteriori* assumptions showed that the residuals of the model complied with the assumption of homogeneity of variances (p=0.9790) and of linearity. As such, the model is as follows: Chronological age=-0.8430+0.0529 sex +0.8773 dental age +0.5947 stages of maturation. It can be suggested that, for each increase in the stage of maturation, the chronological age increases on average 0.5947, provided all other variables remain constant.

DISCUSSION.

The study of craniofacial growth and development remains a very important issue due to all its clinical implications for the patient. The present study shows the relationship between skeletal maturation according to cervical vertebrae, Baccetti's method and its relationship with chronological and dental age in a population of 1,385 Colombian individuals.

The dental assessment method according to the degrees of calcification, proposed by Demirjian,[14] is considered a valid method and a world reference that can be used to compare data from different studies on this matter.[8,15,16] In the present study the mean of the differences between dental and chronological age was found to be 0.60±.44 in both sexes. Results by sex were 0.58±1.48 years in females and 0.63±1.38 years in males. This figure is similar to that observed by Jayaraman *et al.,* who reported an overestimation of 0.65 in females and 0.60 in males.[2]

However, Różyło-Kalinowska *et al.,* reported a mean of the differences of 1.10±1.18 and 0.99±1.25 years for females and males, respectively, after evaluating 718 radiographs of Polish children and adolescents between 6 and 17 years of age.[17] In this regard, it is important to mention that the authors considered the stage of maturation.[6]

Differences between populations were not significantly large, which could prove the validity of this method and simultaneously illustrate how environmental factors influence the process of tooth eruption, explaining why each population has different dental age patterns.[18,19]

Although introduced in 1972 by Lamparski, the study of cervical vertebrae as a method to assess skeletal maturation was only adopted in orthodontics after the studies of Baccetti, Franchi and McNamara.[4,5] Nowadays, it is considered useful as a biological indicator of skeletal maturity, although its validity and reproducibility is controversial according to many authors. Santiago *et al.,* concluded that there were methodological flaws in the studies using skeletal maturation, since adequate reproducibility and correlation analysis to allow the proper calibration of the examiners was not present.[20] On the other hand, Cericato *et al.,* suggested that skeletal assessment using cervical vertebrae is reliable and that better reproducibility values can be found in females, when compared to Baccetti's, by using the Hassel and Farman method.[21]

In the present study, an average chronological age of 7.9±2.2 years and an average dental age of 8.9±1.8 years in the maturation stage 1 for both sexes were observed. Rivas *et al.,* 2009 found this stage of maturation between 8 and 9 years of age in a sample of 324 Chilean patients.[22] On the other hand, in 2011 Różyło-Kalinowska *et al.,* reported that, in girls, this peak of maturation occurs at a chronological age of 10.8±1.5 years and at a dental age of 12.0±1.5, whereas in boys it occurs at a chronological age of 11.1±1.6 years and at a dental age of 12.0±1.9 years.[17] It is observed that this stage of maturation is reached at a later chronological and dental age.

Bedoya *et al.* evaluated 130 radiographs of Colombian children living in the southwestern region of the country and found a mean chronological age of 9.3±1.7 years for both sexes for the stage 1 of maturation.[23] In another study conducted in a population of Colombian children and adolescents, a chronological age of 7 to 9 years was observed at the same stage of maturation.[24]

It should be noted that this work included radiographs of people with and without cleft lip and/or cleft palate.

It is important to note that stage 1 of cervical maturation is the ideal time to perform interceptive treatments such as maxillary expansion, when the peak of mandibular growth has not yet started; at this stage the growth is yet to be completed in 85% to 90%.[22]

The present study showed that maturation stage 2 was reached at a mean chronological age of 8.9±2.2 and at a dental age of 10.0±2.1 years, and it also occurred earlier in females than in males. The mean chronological age found by Bedoya *et al.* in this stage was 10.1±1.623. Studies show that it takes in average one year to reach the peak of mandibular growth at this stage of maturation.[24,25]

Maturation stages 3 and 4, related to the maximum peak of growth and greater craniofacial growth,[26] occurs between the chronological ages of 11 and 14 years (11.2±2.6 years for stage 3 of maturation, and 13.8±1.7 for stage 4 of maturation). Studies carried out in other populations have reported a greater variation, although the early development of females with respect to males remains constant.[27,28] It is at these ages when the best results will be obtained in interceptive treatments for the management of sagittal problems related to mandibular growth.[29,30]

The maturation stage 5, related to the end of growth and in which the final 5% to 10% vertical growth of the individual is still to be completed, was reached at a mean chronological age of 15.1±1.2 years. In the present study, radiographs of subjects up to the age of 16 were examined, so maturation stage 6 was not observed. It should be noted that meta-analyses showing the validity of this method emphasize that it is difficult to differentiate between stages 5 and 6.[20,21]

One relevant aspect is the strong correlation between chronological age and dental age in both sexes at the maturation stages 2 and 3 (rho:810 and rho:845 in females, respectively; rho:0.874 and rho:0.889 in males, respectively). Różyło-Kalinowska *et al.,* reported higher values of correlation in the stage of cervical maturation.[17]

One of the limitations of the present study was the use of convenience sampling, as it does not allow the results to be applied to populations other than the one included in the study. In addition, personal, family or clinical characteristics of participants were not considered because only their radiographic records were used. However, as this is the first study of this kind conducted in a Colombian population, it can be seen as a significant contribution.

These findings suggest that maturation stages 3 and 4 are related to the maximum craniofacial growth, which was established between 11 and 14 years of age, with wide individual variation. Females were found to reach skeletal maturation at an earlier age, as evaluated through the study of the maturation stages of the cervical vertebrae and from the dental age estimated by Demirjian's method, compared to males.

Dental age as measured by Demirjian's method shows a strong correlation (rho: 0.8996 p<0.0001) with the chronological age in children and adolescents from 5 to 16 years of age in the city of Bucaramanga, Colombia. Chronological age has a direct and positive relationship with dental age and with the maturation stages of the cervical vertebrae.

To date, indicators that accurately determine craniofacial growth have not yet been developed. It is recognized as an individual process involving multiple factors that hinder its measurement.

REFERENCES.

1. Rongo R, D'Antò V, Bucci R, Polito I, Martina R, Michelotti A. Skeletal and dental effects of Class III orthopaedic treatment: a systematic review and meta-analysis. J Oral Rehabil. 2017;44(7):545–62.
2. Jayaraman J, Wong HM, King NM, Roberts GJ. The French-Canadian data set of Demirjian for dental age estimation: a systematic review and meta-analysis. J Forensic Leg Med. 2013;20(5):373–81.
3. Krishan K, Kanchan T, Menezes RG, Ghosh A. Forensic anthropology casework-essential methodological considerations in stature estimation. J Forensic Nurs. 2012;8(1):45–50. [PubMed]
4. Baccetti T, Franchi L, McNamara JA Jr. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. Angle Orthod. 2002;72(4):316–23.
5. Baccetti T, Franchi L, McNamara JA Jr. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Semin Orthod. 2005;11:119–9.
6. Brons S, van Beusichem ME, Bronkhorst EM, Draaisma JM, Bergé SJ, Schols JG, Kuijpers-Jagtman AM. Methods to quantify soft tissue-based cranial growth and treatment outcomes in children: a systematic review. PLoS One. 2014;9(2):e89602.
7. Castaldo G, Cerritelli F. Craniofacial growth: evolving paradigms. Cranio. 2015;33(1):23–31.
8. Lewis JM, Senn DR. Forensic Dental Age Estimation: An Overview. J Calif Dent Assoc. 2015;43(6):315–9.
9. Thilander B, Pena L, Infante C, Parada SS, de Mayorga C. Prevalence of malocclusion and orthodontic treatment need in children and adolescents in Bogota, Colombia. An epidemiological study related to different stages of dental development. Eur J Orthod. 2001;23(2):153–67.
10. Departamento Administrativo Nacional de Estadística (DANE) Proyecciones Nacionales y Departamentales de población 2005-2020. 7th Ed. Bogotá, Colombia: Estudios Postcensales; 2009.
11. Asociación Probienestar de la Familia Colombiana (Profamilia); Ministerio de la Protección Social (MPS); USAID. Encuesta Nacional de Demografía y Salud (ENDS 2010) 5th Ed.

Bogotá, Colombia: Printex Impresores Ltda; 1990.
12. Bhattacharya PT, Misra SR, Hussain M. Nutritional Aspects of Essential Trace Elements in Oral Health and Disease: An Extensive Review. Scientifica. 2016;2016:5464373.
13. Moss ML. The functional matrix hypothesis revisited. 3. The genomic thesis. Am J Orthod Dentofacial Orthop. 1997;112(3):338–42.
14. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973;45(2):211–27.
15. Litsas G, Lucchese A. Dental and Chronological Ages as Determinants of Peak Growth Period and Its Relationship with Dental Calcification Stages. Open Dent J. 2016;10:99–108.
16. Cadenas I, Celis C, Hidalgo A. Método de Demirjian para estimación de edad dentaria en base a estadios de mineralización. Anv Soc Radiol Oral Maxilo Facial de Chile. 2010;13:13–23.
17. Różyło-Kalinowska I, Kolasa--Rączka A, Kalinowski P. Relationship between dental age according to Demirjian and cervical vertebrae maturity in Polish children. Eur J Orthod. 2011;33(1):75–83.
18. Maycas M, Esbrit P, Gortázar AR. Molecular mechanisms in bone mechanotransduction. Histol Histopathol. 2017;32(8):751–60.
19. Espina Á, Fereira J, Céspedes M, Barrios F, Ortega A, Maldonado Y. Empleo de la edad dental y la edad ósea para el cálculo de la edad cronológica con fines forenses, en niños escolares con valores de talla y peso no acordes con su edad y sexo, en Maracaibo, Estado Zulia. Estudio preliminar. Acta Odontol Venez. 2007;45(3):1–9.
20. Santiago RC, de Miranda Costa LF, Vitral RW, Fraga MR, Bolognese AM, Maia LC. Cervical vertebral maturation as a biologic indicator of skeletal maturity. Angle Orthod. 2012;86(6):1123–31.
21. Cericato GO, Bittencourt MA, Paranhos LR. Validity of the assessment method of skeletal maturation by cervical vertebrae: a systematic review and meta-analysis. Dentomaxillofac Radiol. 2015;44(4):20140270.
22. Rivas C, Avaria C, Guzmán CL. Correlación entre edad cronológica y maduración ósea en vértebras cervicales en adolescentes chilenos para determinar peak de crecimiento puberal. Rev Dent Chile. 2009;100(3):4–11.
23. Bedoya A, Osorio JC, Tamayo JA. Edad cronológica y maduración ósea cervical en niños y adolescentes. Rev Cubana Estomatol. 2016;51(1):43–53.
24. González MC, Martínez CM, Mora I, Bautista GR, Palmet S. Estado de maduración ósea de las vértebras cervicales en una población colombiana con y sin labio y paladar fisurado. Univ Odontol. 2014;33(70):41–50.
25. Perinetti G, Contardo L, Gabrieli P, Baccetti T, Di Lenarda R. Diagnostic performance of dental maturity for identification of skeletal maturation phase. Eur J Orthod. 2012;34(4):487–92.
26. Tatsumi H, Hideshima K, Kanno T, Hashimoto R, Matsumoto A, Otani H, Sekine J. Effect of ageing on healing of bilateral mandibular condyle fractures in a rat model. Int J Oral Maxillofac Surg. 2014;43(2):185–93.
27. Alexander AE, McNamara JA Jr, Franchi L, Baccetti T. Semilongitudinal cephalometric study of craniofacial growth in untreated Class III malocclusion. Am J Orthod Dentofacial Orthop. 2009;135(6):700.e1-14.
28. Aissaoui A, Salem NH, Mougou M, Maatouk F, Chadly A. Dental age assessment among Tunisian children using the Demirjian method. J Forensic Dent Sci. 2016;8(1):47–51.
29. Tausche E, Luck O, Harzer W. Prevalence of malocclusions in the early mixed dentition and orthodontic treatment need. Eur J Orthod. 2004;26(3):237–44.
30. Elkordy SA, Aboelnaga AA, Fayed MM, AboulFotouh MH, Abouelezz AM. Can the use of skeletal anchors in conjunction with fixed functional appliances promote skeletal changes? A systematic review and meta-analysis. Eur J Orthod. 2016;38(5):532–45.