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Research Article

Comparison And Evaluation of Colombian Mestizo Population Aged 5 to 13 Years Using Mcnamara's Cephalometric Norms

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Abstract

Background: Craniofacial structure is influenced by the evolutionary process of populations, which produces variations depending on ethnicities and regions. Employing cephalometry, standards have been determined for Class I patients, by age ranges and sex, but the same definition is lacking for Class III. This paper aims to characterize a Colombian mestizo population aged 5 to 13 years using McNamara's analysis measures in lateral cephalometric radiographs and to compare them with Caucasian Class I and Class III patients.

Materials and Methods: A total of 1626 lateral cephalometric radiographs of patients who have not received previous treatment (851 males and 775 females; aged 5 to 13 years) were analyzed.

Results: Measurements increase with age, are lower in the female sex, and only SN-PM decreases with age. Vertical measures (ANS-Me, Na-Me, S-Go, SN-PM) and sagittal measures (Go-Gn, S-N) in mestizo people differ more from the Caucasian Class I and Class III population. Maxillomandibular differential in all ages displays significant differences when compared to the Class III group with the Colombian sample and Caucasian Class I.

Conclusions: In most measurements, the sample of mestizos shows to be significantly different from Caucasians. Skeletal Class III malocclusion differs from all malocclusions from an early age in its maxillary and mandibular components.

Keywords: Colombian Mestizo; Population; Mcnamara's

Introduction

The craniofacial region can be considered as a complex system that grows and reshapes following an intricate network of auxological forces, distorting processes or compensatory mechanisms [1,2]. A complex system is considered a dynamic system that possesses the ability to self-organize a large number of elements interacting in a non-linear manner. However, to understand the function of a biological organization, it is often useful to conceptualize it as a system of elements that interact and simultaneously define the components' dynamic behavior [3,4]. Therefore, the behavior of the craniofacial region cannot be explained solely based on a single physical law, or by the behavior of individual elements. Element's cooperation determines the overall behavior and provides properties that can be totally alien to the system's individual components. In consequence, the system must be analyzed as a whole, as a coherent unit [5-7]. in order to determine the behavior of various craniofacial region measurements in a mestizo population.

In recent times, it has been widely accepted that both genetic inheritance and environmental factors contribute to Class III malocclusion presence [8,9]. Different loci and potential genes have been associated with this malocclusion with the help of linkage analysis and association studies [9,10]. Although the findings are revealing, these studies have limitations such as having non-probabilistic sample sizes, the exclusion of environmental factors, lack of a systematic estimate of genetic variants associated with the disease, and, most importantly, limited phenotypes that cannot comprise the complexities of Class III malocclusion [11]. On the other hand, limited knowledge of the condition underlying etiologies contributes to the fact that diagnosing and treating this type of malocclusion remains a challenge for dentists [12].

Craniofacial development is also influenced by the evolutionary process of populations [13]. This implies a facial features reconfiguration in which both linear and angular cephalometric variations occur in soft and hard tissues [7,14]. Hence, main studies in cephalometry have been able to determine standards for Class I patients according to age range [15], yet they are not as well defined for Class III patients.

Several studies have reported the prevalence of different malocclusions, which represents an opportunity to understand the frequency and phenotypic characteristics of these malocclusions according to ethnic groups. This demonstrates how genetics, in addition to function, can influence the presence of malocclusion. Class II malocclusion prevalence varies among different racial groups: in Caucasians, it ranges from 1% to 4% depending on the method used in the study and the evaluated age group. In Asian populations, Class III malocclusion prevalence varies among different regions, with high values including China (4-12%) [20-23], Japan (2.3-13%) [24,25], and Korea (9-19%) [26]. Similarly, a relatively high prevalence of Class III malocclusion has been observed in other countries such as Saudi Arabia (9.4%) [27] and Sweden (6%) [28]. In contrast, in people of northern European descent, this value ranges between 0.8 and 4.2% [29-31], in European Americans is 0.8% [13,16]. and in African Americans between 0.6 and 1.2% [32,33]. Such phenotypes, however, still need to be evaluated in the Colombian population. Accordingly, this paper aims to characterize a Colombian mestizo population aged 5 to 13 years using McNamara's analysis measures [7]. in lateral cephalometric radiographs by performing a comparative analysis with Class I and Class III patient measurements from a sample of Caucasian patients.

Methodology

A descriptive cross-sectional study was carried out with a sample size of 1626 mestizo patients aged between 5 and 13 years, who had not received any type of previous treatment. This sample was taken from the Center for Craniofacial Growth and Development of the Faculty of Dentistry of the Universidad de Antioquia.

Radiographs were processed following the protocol described in a previous study [34] and the cephalometric measurements obtained are described in figure 1.

The sample of this study was compared with the published results of Guyer., *et al.* research in 1986 [35]. They evaluated 109 Class III malocclusion patients and 96 Class I patients from the Broadbent sample derived from the Bolton-Brush Growth Study at Western Reserve University [36]. See table 1.

Statistical analysis

IBM-SPSS (version 23) was used for data processing. A descriptive analysis was performed for all linear and angular variables of the Colombian study. They were then summarized using the average, the standard deviation, and the confidence intervals corresponding to each gender and age group. Based on the average, standard deviation, and sample sizes results of Guyer., *et al.* and Broadbent., *et al*. studies, and because they are tertiary information sources, interval estimates were calculated. Using these results, the corresponding comparisons were made between the different age groups by sex and occlusion I and III. For each group, different super-index letters indicate that there are statistically significant differences (SSD) among the groups or in some of them, while the same super-index letters indicate that there are no SSD among the groups.

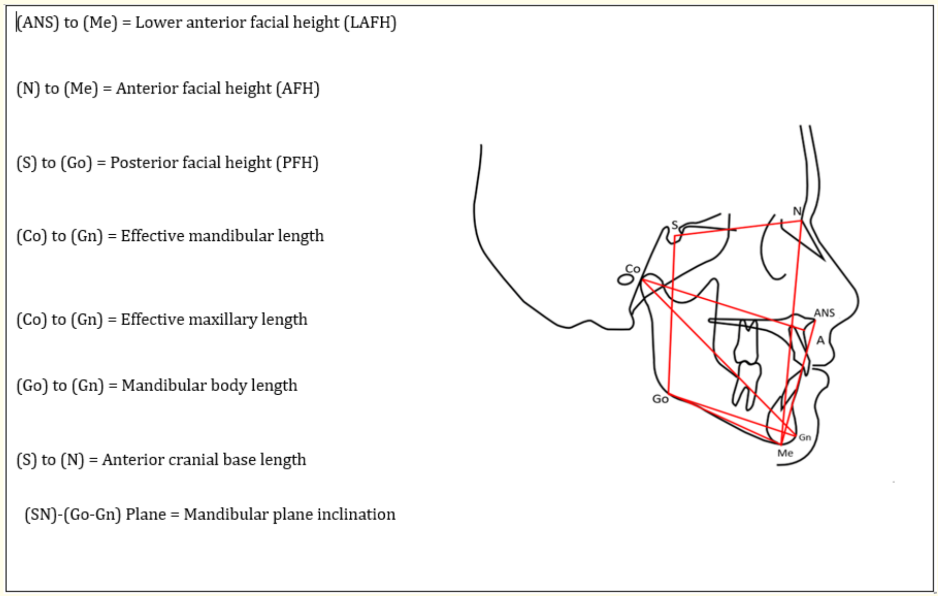

Figure 1: Anatomical landmark points used: sella (S), nasion (N), gonion (Go), gnathion (Gn), condylion (Co), A point (A), anterior nasal spine (ANS), and menton (Me).

	Mestizo		Caucasian	
Age	**Male**	**Female**	**Class III**	**Class I**
5-7	169	171	38	32
8-10	581	538	40	32
11-13	101	66	31	32

Table 1: Distribution of the number of patients by age, sex, and type of occlusion.

Results

Table 2 shows the results of longitudinal and angular measurements for 5-7, 8-10, and 11-13 age groups, respectively. Results are also compared by sex for the Colombian mestizo sample and by Class I and Class III occlusion from Guyer and Broadbent studies. In addition, Figure 2 displays the trend line graphs (a-i) for each linear and angular measurement for sex and skeletal classification in the mestizo and Caucasian population, respectively.

Cephalometric measurements generally increase with age throughout the entire sample, the values being lower in mestizo females. This trend prevails in the three age groups with significant differences in the 5-7 and 8-10 groups, but not significant in most of the 11-13 group values. Only the SN-PM angle measurement decreases with age, and it shows significant differences between the mestizo and Caucasian sample in the groups from 5 to 7 and 11 to 13 years.

Upon comparing the sample of Colombian mestizos with Class I and Class III Caucasians in the 5-7 age group, significant differences are found in the Na-Me, S-Go, SN-PM, Go-Gn, and SN measures. Regarding the maxillomandibular differential, significant differences are observed between mestizos and Class I and the Class III group. Co-Gn results are similar in mestizo and Class I Caucasian males, yet there are significant differences between them and mestizo females, and class III Caucasians. As regards mestizo females, they presented generally lower values, except in the SN-PM angle where higher values were found for the mestizo population. When evaluating only mestizos according to sex, six measures were differentiating them (ANS-Me, Na-Me, S-Go, Co-Gn, Co-A, and SN) and three similar ones (SN-PM, Go-Gn, Max-mand dif.), which suggests that sexual dimorphism occurs from an early age.

In the 8-10-years age group, significant differences were found in the ANS-Me, Na-Me, S-Go, Go-Gn, and SN measures. There are significant differences among all the groups regarding the Co-Gn measure, that is, female and male Colombian mestizos and Class I and Class III Caucasians. In the Co-A measure, mestizo males are similar to Class III males, but significant differences are identified both in mestizo females (lower value) and in Class I (higher value). As for maxillomandibular differential, statistically significant differences are observed between mestizos and Class I, and Class III group, SN-PM measure in this group is similar for all groups.

In the 11-13-year-old age group, significant differences were found between the two samples in the ANS-Me, Na-Me, S-Go, Co-Gn, Co-A, SN-PM, Go-Gn, and SN measures. Maxillomandibular differentia measure had the same behavior as in the previous groups, the Class III group being the highest value with statistically significant differences. Much similarity is found in the sample of Caucasians Class I and Class III in this age group, except for the Co-Gn measure and maxillomandibular differential which is found to be higher for the Class III group. Differences between the Caucasian and mestizo populations are also evident.

Variables		Mestizo		Caucasian	
		Male	Female	Class I	Class III
	Age	Mean [95% CI]	Mean [95% CI]	Mean [95% CI]	Mean [95% CI]
ANS-Me (mm)	5-7	56.7 (56.0 ; 57.3)[a]	54.5 (53.8 ; 55.2) [b]	56.8 (55.7 ; 57.9) [a]	58.4 (56.5 ; 60.3)[a]
	8-10	57.6 (57.3 ; 58.0) [a]	55.8 (55.4 ; 56.2) [b]	59.3 (58.2 ; 60.4) [c]	61.2 (59.6 ; 62.8) [c]
	11-13	59.5 (58.5; 60.4) [a]	57.3 (56.2 ; 58.4) [b]	62.2 (60.8 ; 63.6) [c]	64.5 (62.5 ; 66.5) [c]
Na-Me (mm)	5-7	95.9 (94.9 ; 96.9) [a]	92.9 (91.9 ; 93.9) [b]	99.1 (97.7 ; 100.5) [c]	102.5 (99.4 ; 105.6) [c]
	8-10	99.2 (98.6 ; 99.8) [a]	96.6 (96.0 ; 97.2) [b]	106.3 (104.8; 107.8) [c]	108.8 (106.6 ; 111.0) [c]
	11-13	102.8 (101.3 ; 104.2) [a]	100.2 (98.5 ; 101.8) [a]	112.7 (111.0 ; 114.4) [b]	115.0 (112.3 ; 117.7) [b]
S-Go (mm)	5-7	60.7 (60.0 ; 61.4) [a]	58.8 (58.0 ; 59.5) [b]	64.4 (63.3 ; 65.5) [c]	65.7 (62.9 ; 68.5) [c]
	8-10	63.7 (63.3 ; 64.1) [a]	61.8 (61.4 ;62.3) [b]	70.3 (69.0 ; 71.6) [c]	67.6 (66.1 ; 69.1) [c]
	11-13	66.6 (65.4 ; 67.7) [a]	64.4 (63.2 ; 65.7) [a]	75.1 (73.6 ; 76.6) [b]	74.4 (72.6 ; 76.2) [b]
Co-Gn (mm)	5-7	95.7 (94.8 ; 96.6)[a]	93.3 (92.3 ; 94.2) [b]	96.1 (94.9 ; 97.3) [a]	103.3 (100.9 ; 105.7) [c]
	8-10	99.3 (98.8 ; 99.8)[a]	97.2 (96.7 ; 97.7) [b]	104.6 (103.3; 105.9) [c]	107.8 (106.0 ; 109.6) [d]
	11-13	103.7 (102.2; 105.2) [a]	100.5 (98.8 ; 102.2)[a]	111.5 (110.1 ; 112.9) [b]	117.2 (114.8 ; 119.6) [c]
Co-A (mm)	5-7	77.9 (77.2 ; 78.6) [a]	75.8 (75.1 ; 76.6)[b]	78.8 (77.8 ; 79.8) [a]	79.8 (78.2 ; 81.4)[a]
	8-10	79.8 (79.4 ; 80.1) [a]	78.1 (77.7 ; 78.5) [b]	84.4 (83.2 ; 85.6) [c]	81.2 (79.9 ; 82.5)[a]
	11-13	82.1 (81.0 ; 83.1) [a]	79.7 (78.2 ; 81.1) [a]	89.1 (87.9 ; 90.3) [b]	86.2 (83.8 ; 88.6) [b]
SN-PM (°)	5-7	35.6 (34.9 ; 36.4) [a]	35.3 (34.5 ; 36.1) [a]	31.8 (30.7 ; 32.9) [b]	32.8 (31.2 ; 34.4) [b]
	8-10	34.2 (33.8 ; 34.6) [a]	34.2 (33.8 ; 34.7)[a]	30.6 (29.5 ; 31.7) [a]	35.6 (33.9 ; 37.3)[a]
	11-13	33.4 (32.4 ; 34.4) [a]	33.8 (32.6 ; 35.0) [a]	30.4 (29.3 ; 31.5) [a]	33.1 (30.9 ; 35.3) [ab]
Go-Gn (mm)	5-7	62.4 (61.7 ; 63.2) [a]	61.0 (60.3 ; 61.7)[a]	65.1 (64.2 ; 66.0) [b]	68.4 (66.3 ; 70.5) [b]
	8-10	65.3 (64.9 ; 65.7) [a]	64.3 (63.8 ; 64.7) [b]	71.7 (70.6 ; 72.8) [c]	71.7 (70.2 ; 73.2) [c]
	11-13	68,5 (67,4; 69,6)[a]	66.4 (65.1 ; 67.7)[a]	75.9 (74.7 ; 77.1) [b]	76.8 (74.9 ; 78.7) [b]
SN (mm)	5-7	60.2 (59.6 ; 60.8) [a]	58.1 (57.5 ; 58.6) [b]	66.3 (65.4 ; 67.2) [c]	68.4 (67.1 ; 69.7) [c]
	8-10	61.2 (60.9 ; 61.6)[a]	59.1 (58.8 ; 59.4) [b]	69.0 (68.0 ; 70.0) [c]	68.3 (67.1 ; 69.5)[c]
	11-13	62.5 (61.7 ; 63.3) [a]	61.0 (60.0 ; 61.9)[a]	71.7 (70.7 ; 72.7) [b]	70.8 (69.2 ; 72.4) [b]
Max-mand. dif. (mm)	5-7	17.8 (17.3 ; 18.3) [a]	17.4 (16.9 ; 17.9) [a]	17.3 (16.6 ; 18.0) [a]	23.4 (22.3 ; 24.5) [b]
	8-10	19.6 (19.3 ; 19.9) [a]	19.1 (18.8 ; 19.4) [a]	20.2 (17.7 ; 22.7)[a]	26.6 (25.5 ; 27.7) [b]
	11-13	21.6 (20.7 ; 22.5) [a]	20.8 (19.9 ; 21.7) [a]	22.4 (21.4; 23.4) [a]	31.0 (29.6 ; 32.4) [a]

Table 2: Average and confidence intervals of linear and angular variables by age groups and sex in the Colombian sample, and by Class III cases of the Guyer study sample [35] and Class I of the Broadbent study [36].

For each age group, different super-index letters indicate that there are statistically significant differences (SSD) among the groups or in some of them (columns), while the same super-index letters indicate that there are no SSD among the groups.

Discussion

Dentistry has always been concerned with the craniofacial complex growth and has examined which craniofacial complex structure is involved in Class III malocclusion: the maxilla, mandible, or

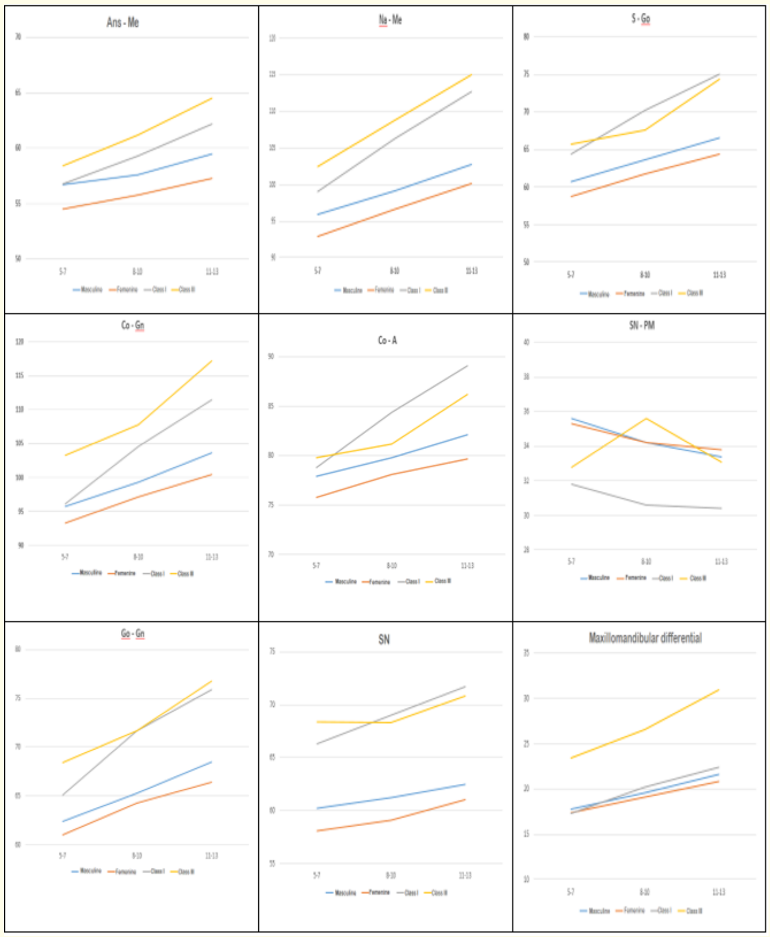

Figure 2: Trend line graphs (a-i) of the averages of linear and angular variables by age and sex in the sample of mestizos, and by Class III cases of the Guyer study and Class I of the Broadbent study.

a combination of both. Bui obtained data indicating a 35% mandible involvement, 48.8% maxilla, and 16.2% combination of both, while another study found the values to be 49% mandible, 26% maxilla, and 6% combination [38]. This demonstrates that there is no consensus on the issue, currently existing multiple factors that interact in the establishment of this malocclusion. Likewise, variations in Class III malocclusion incidence in different ethnicities may reflect a variation in the genes or types of genes that contribute to the general phenotype. In Colombia, reports are showing a decrease in the prevalence of Class II and an increase of Class III during the passing from mixed to permanent dentition at the growth peak [39]. Also, the national study shows that Class III appears in a higher proportion at age 15 (4.5%) than at 12 (2.6%) [40]. This comes to prove how malocclusion tends to increase over the years. In the Class III Caucasian patients sample used in the present study, we found that both structures are modified, that is, there is a decrease in maxillary size and an increase in mandibular size. These results could appear to show how the possible influence of environmental and genetic factors displays itself in particular ways in some populations in Class III. This conclusion; however, is largely based on mere observations.

Cephalometric radiographs of the sample represent a collection with all possible variations such as craniofacial conformations, age, ethnicities, sex, offspring, and racial mixtures established in a country. When comparing McNamara's analysis measures between the mestizo sample, and Class III and Class I patients of Caucasian descent, dissimilar values are found. This is in line with previous studies showing ethnic differences in cephalometric measures and how craniofacial growth and development in Class III is established at an early age.

When evaluating the structures compromising craniofacial development, the cranial base has been defined as a dynamic component, which modifies the conformation of different skeletal classifications [41]. Previous reports have associated the presence of malocclusion of Class III and Class II patients [42] with changes in the size and angulation of the cranial base. On the contrary, others do not report having found any kind of association with the previous findings [43,44]. It has whereas been established that the cranial base behavior has a high genetic involvement-provided its origin from primary cartilage-and it has also been determined how this can affect the relationship with the maxilla and mandible. The anterior cranial base has been evaluated in different populations [45] both its size [46] and flexion [47] and it has been established that it can determine the position of the mandible [48] and the maxilla [49]. In this study, when comparing the mestizo and Caucasian samples, we found that both Class III and Class I have a larger anterior cranial base size. Mestizos having a smaller-sized anterior cranial base may result in prognathism appearing at early ages [50].

Anthropology has studied mandible conformation in ancestor populations and found that size and shape change during evolution [51]. Evolution influences mandibular sizes in every ethnic group, and primarily the mandibular branch is affected. This may explain the differences in vertical facial measurements found in our study between the different ethnicities and the differences between Class III and Class I patients in their vertical component. A study evaluating craniofacial growth and development in patients aged six to sixteen years shows that maxillae anteroposterior difference worsens with age in Class III patients. In this study the effective mandibular length (Co-Gn) increases from age 5 until age 13, more in the Class I group (15.4 mm), then in Class III (13.9 mm), followed by mestizo sample male individuals (8 mm) and female individuals being at the smaller end of that measure (7.9 mm). When evaluating the maxillomandibular differential, it is observed that the values are always higher in Class III, and the mestizo sample is very similar to Caucasian Class I. This may suggest that class III malocclusion is established at an early age, worsens with age, and manifests itself in the maxillomandibular differential.

It is considered that the anterior vertical facial growth must be proportional to posterior growth. When comparing this proportion in the samples, we found that the Colombian mestizo population does not maintain it in the early years of life, which shows an imbalance. Class I Caucasians best preserve the anterior facial height (Na-Me) to posterior facial height (S-Go) proportion [54]. Additionally, Class III Caucasian sample displays higher variance in all age groups.

Maxillary length in the Class III Caucasian group has a lower value than in Class I, it is similar to male mestizos, and although it later presents a growth peak at age 8 to 10, remains lower than Class I. This measure has lower values in some subclassifications of Class III patients [55] and the mestizo population being, in general, smaller sized than the Caucasian one may be the reason why the size of the maxilla are similar in Class III Caucasian and mestizos. Thus, Class III malocclusion does not only have a mandibular component but is indeed a combination of maxillary and mandibular modification [56].

Measurement of the mandibular plane (SN-PM) angle in the mestizo sample and Class I presents a decrease, as reported in the literature [57]. Class III Caucasians present an increase during the period between 5-7 and 8-10 years, later markedly decreasing and the vertical components being established at an early age [59], which proves to be typical of Class III [58]. Some authors describe it as a factor to be taken into account during the permanent molar's eruption and vertical growth [1,60]. This measurement is one of the most consistent throughout different groups.

The mandibular body is the result of the transverse, sagittal, and vertical changes of the entire mandibular growth [61]. When comparing the mestizo sample with the Caucasians, we found that Caucasians have a larger mandibular body size-Class III has a bigger size than Class I- although there are no significant differences. This could suggest that sagittal development is reflected in the mandibular body size, being generally smaller in the mestizo sample. The comparison between mestizo males and females exhibits similarities in the age of 5-7 and 11-13 and differences in the age of 8-10. This shows that size behaves very differently from branch evaluation, which is a response to changes in the condyle.

Mandibular prognathism is a facial disorder with a prevalence varying according to ethnicity and age. In the Asian population, prevalence could be as high as 8% to 40%, in the African population from 3% to 8%, while individuals from Europe had a much lower frequency, such as 0.48% to 4% [16]. Mandibular prognathism prevalence is 0.5% to 0.27% in childhood and 2% to 4% in adulthood when all somatic growth of the patient has already been established [63]. These world epidemiology findings confirm the ethnic differences of malocclusions. During the evaluation of effective mandibular length (Co-Gn), differences were found when contrasting Colombian sample males and females, when comparing Caucasian and mestizo samples, and likewise when examining the Class III and Class I Caucasian sample against each other at all ages, which reveals a larger mandibular size for males and Class III.

Previous longitudinal studies that have modeled mandibular growth using polynomial regressions indicate that branch height follows a linear pattern of increasing in size, while the body and total mandibular length show curvilinear and slowed growth patterns throughout the age. This work analyses report significant size differences between sexes. Body length growth rate is also significantly higher in males. Sexual dimorphism is observed in the total mandibular length growth. Branch height shows no variation between male and female nor in the size or speed of growth [64], which concurs with the findings on the differences between the mestizo sample, and Class III and Class I Caucasian samples.

Data mining and machine learning are mathematical procedures focused on developing algorithms and logical statements that can learn from data, and based on these, elaborate further predictions [65]. In the craniofacial prediction when comparing two populations there are differences in the growth peak [66] and patterns of good and bad growers can be found [67]. It would be fundamental to define which measures can characterize and predict a Class III patient as a good or bad grower, differentiate between Class III and other malocclusions groups, as well as classify [68] Class III patients based on cephalometric measures in the manner it can be seen when comparing these two samples.

Conclusions

Measurements increase with age, except for the SN-PM angle, and the mestizo female group values are smaller in the groups of 5-7 and 8-10 years. When comparing the sample of mestizos with Class I and Class III Caucasians, significant differences were found in most measures as they were lower for the mestizo sample. This shows that it is a generally smaller population than the Caucasian, except for the SN-PM angle where higher values are found for the Colombian mestizo population, which is closer to Class III Caucasians, which evinces a tendency to the posterior rotation of the jaw. Significant differences are observed in the maxillomandibular differential at all ages between the Class III group and the rest of the groups. This displays one of the anatomical characteristics of Class III patients, whose maxilla and mandible sagittal sizes display greater differences. In Co-Gn, which represents the mandible total length, mestizo sample and Class I Caucasian patients show initially similar values, but throughout age there starts to be a difference between them, and Class III presents the highest mandibular values, displaying the mandibular component of this malocclusion. It should be noted that this difference occurs at all ages. The maxillary length (Co-A) presents more similar values between Caucasian males and Class III in early years, the mestizo population being smaller than the Caucasian possibly being the reason for them to be similar.

Conflict of Interest

The authors declare that there is no conflict of interest involved in this research and subsequent publication.

Bibliography

1. Solow B. "The dentoalveolar compensatory mechanism: background and clinical implications". *British Journal of Orthodontics* 7.3 (1980): 145-161.

2. Caldarelli G. "Scale-Free Networks: Complex Webs in Nature and Technology". Oxford: Oxford Univ Press (2007).

3. Albert R. "Network inference, analysis, and modeling in systems biology". *Plant Cell* 19.11 (2007): 3327-3338.

4. Hiroaki Kitano. “Systems Biology: A Brief Overview”. *Science* (80-) 295.5560 (2002): 1662-1664.

5. Caldarelli Guido BM. “A networked world”. *Physics World* 23 (2010): 22-24.

6. Zhu X., *et al.* “Getting connected: Analysis and principles of biological networks”. *Genes and Development* 21.9 (2007): 1010-1024.

7. McNamara JA. “A method of cephalometric evaluation”. *American Journal of Orthodontics* 86.6 (1984): 449-469.

8. Ricardo Machado Cruz., *et al.* “Major Gene and Multifactorial Inheritance of Mandibular Prognathism”. *American Journal of Human Genetics* 146A.1 (2016): 71-77.

9. Yamaguchi T., *et al.* “Genome-wide linkage analysis of mandibular prognathism in Korean and Japanese patients”. *Journal of Dental Research* 84.3 (2005): 255-259.

10. He S., *et al.* “Association between CYP19A1 genotype and pubertal sagittal jaw growth”. *American Journal of Orthodontics and Dentofacial Orthopedics* 142.5 (2012): 662-670.

11. Moreno Uribe LM., *et al.* “Phenotypic diversity in white adults with moderate to severe Class II malocclusion”. *American Journal of Orthodontics and Dentofacial Orthopedics* 145.3 (2014): 305-316.

12. Sugawara J and Mitani H. “Facial growth of skeletal Class III malocclusion and the effects, limitations, and long-term dentofacial adaptations to chincap therapy”. *Seminars in Orthodontics* 3.4 (1977): 244-254.

13. Pinhasi R and Eshed VSP. “Evolutionary changes in the masticatory complex following the transition to farming in the southern Levant”. *American Journal of Physical Anthropology* 135.2 (2008): 36-148.

14. Mamandras AH. “Linear changes of the maxillary and mandibular lips”. *American Journal of Orthodontics and Dentofacial Orthopedics* 94.5 (1988): 405-410.

15. McNamara-JA., *et al.* “An atlas of craneofacial Growth Cephalometric standards from the University School Growth Study”. University Michigan (1974).

16. Emrich RE and Brodie AG BJ. “Prevalence of Class 1, Class 2, and Class 3 malocclusions (Angle) in an urban population. An epidemiological study”. *Journal of Dental Research* 44.5 (1965): 947-953.

17. Thilander BMN. “The prevalence of malocclusion in Swedish schoolchildren”. *Scandinavian Journal of Dental Research* 81.1 (1973): 12-21.

18. TE M. “An epidemiologic study of occlusal anomalies in relation to development of the dentition in Icelandic children”. *Community Dentistry and Oral Epidemiology* 4.3 (1976): 121-128.

19. Tschill P., *et al.* “Malocclusion in the deciduous dentition of Caucasian children”. *Eur J Orthod* 19.4 (1997): 361-367.

20. GK C. “Class 3 malocclusion in Chinese (Cantonese): etiology and treatment”. *American Journal of Orthodontics* 65.2 (1974): 152-157.

21. Lew KKFW. “Horizontal skeletal typing in an ethnic Chinese population with true Class III malocclusions”. *British Journal of Orthodontics* 20.1 (1993): 19-23.

22. WH AW and B “A survey of handicapping dentofacial anomalies among Chinese in Hong Kong”. *International Journal of Dentistry* 14 (1964): 505-519.

23. JJ L. “Prevalence of malocclusion in Chinese children age 9-15”. *Clinical Dentistry* 5 (1985): 57-65.

24. Endo T. “[An epidemiological study of reversed occlusion. I. Incidence of reversed occlusion in children 6 to 14 years old]”. *Nihon Kyosei Shika Gakkai Zasshi* 30.1 (1971): 73-77.

25. Susami R., *et al.* “Prevalence of malocclusion in Japanese school children. 4. The frequency of mandibular overjet]”. *Nihon Kyosei Shika Gakkai Zasshi* 31.2 (1972): 319-324.

26. Baik HS., *et al.* “Cephalometric characteristics of Korean Class III surgical patients and their relationship to plans for surgical treatment”. *The International Journal of Adult Orthodontics and Orthognathic Surgery* 15.2 (2000): 119-128.

27. Toms AP. "Class III malocclusion: a cephalometric study of Saudi Arabians". *British Journal of Orthodontics*16.3 (1986): 201-206.

28. Ingervall B., *et al.* "Prevalence and awareness of malocclusion in Swedish men". *Community Dentistry and Oral Epidemiology* 6.6 (1978): 308-314.

29. Altemus LA. "Frequency Of The Incidence Of Malocclusion In American Negro Children Aged Twelve To Sixteen". *Angle Orthodontist* 29.4 (1959): 189-200.

30. Foster TD and Day AJ. "A survey of malocclusion and the need for orthodontic treatment in a Shropshire school population". *British Journal of Orthodontics* 1.3 (1974): 73-78.

31. Hannuksela A. "The prevalence of malocclusion and the need for orthodontic treatment in 9-year old Finnish schoolchildren". *Proceedings of the Finnish Dental Society* 73.1 (1977): 21-26.

32. Kelly JE., *et al.* "An assessment of the occlusion of the teeth of children". *Vital and Health Statistics* 11.130 (1973).

33. Kelly JE and Harvey CR. "An assessment of the occlusion of the teeth of youths 12-17 yr in the United States". *Vital and Health Statistics* 11 (1977).

34. Salcedo-Ospina OB and Jaramillo-Vallejo PM. "Cephalometric assessment of Colombia's mestizo population aged 6 to 12 years". *Revista Facultad de Odontología Universidad de Antioquia* 32.2 (2020): 18-32.

35. Guyer EC., *et al.* "Components of class III malocclusion in juveniles and adolescents". *The Angle Orthodontist* 56.1 (1986): 7-300.

36. Broadbent B., *et al.* "Bolton standards of dentofacial developmental growth". St Louis, Mo: Mosby (1975).

37. Bui C., *et al.* "Phenotypic characterization of Class III patients". *The Angle Orthodontist* 76.4 (2006): 564-569.

38. Jacobson A., *et al.* "Mandibular prognathism". *American Journal of Orthodontics* 66.2 (1974): 140-171.

39. Thilander B., *et al.* "Prevalence of malocclusion and orthodontic treatment need in children and adolescents in Bogota, Colombia". *European Journal of Orthodontics* 23.2 (2001): 153-167.

40. Ministerio de Salud y Protección Social, MINSALUD. "IV Estudio Nacional De Salud Bucal - ENSAB IV". Bogotá, Colomb 3 (2014): 381.

41. Singh GD., *et al.* "Morphometry of the cranial base in subjects with Class III malocclusion". *Journal of Dental Research* 76.2 (1997): 694-703.

42. Kerr WJ and Adams CP. "Cranial base and jaw relationship". *American Journal of Biological Anthropology* 77.2 (1998): 213-220.

43. Anderson Frank Popovich DL. "Realtion of Cranial Base Flexure to Cranial Form and Madibular Position". *American Journal of Biological Anthropology* 61 (1983): 181-187.

44. Nie X. "Cranial base in craniofacial development: Developmental features, influence on facial growth, anomaly, and molecular basis". *Acta Odontologica Scandinavica* 63.3 (2005): 127-135.

45. Gkantidis N and Halazonetis DJ. "Morphological integration between the cranial base and the face in children and adults". *Journal of Anatomy* 218.4 (2011): 426-438.

46. Anderson D and Popovich F. "Relation of cranial base flexure to cranial form and mandibular position". *American Journal of Biological Anthropology* 61.2 (1983): 181-187.

47. Klocke A., *et al.* "Role of cranial base flexure in developing sagittal jaw discrepancies". *American Journal of Orthodontics and Dentofacial Orthopedics* 122.4 (2002): 386-391.

48. Andria LM., *et al.* "Correlation of the cranial base angle and its components with other dental/skeletal variables and treatment time". *The Angle Orthodontist* 74.3 (2004): 361-366.

49. Bastir M and Rosas A. "Correlated variation between the lateral basicranium and the face: a geometric morphometric study in different human groups". *Archives of Oral Biology* 51.9 (2006): 814-824.

50. Cossio L., *et al.* "Morphological configuration of the cranial base among children aged 8 to 12 years". *BMC Research Notes* 9.1 (2016): 1-8.

51. Pokhojaev A., *et al.* "Changes in human mandibular shape during the Terminal Pleistocene-Holocene Levant". *Scientific Reports* 9.1 (2019): 1-10.

52. Wolff G., *et al.* "On the genetics of mandibular prognathism: Analysis of large European noble families". *Journal of Medical Genetics* 30.2 (1993): 112-116.

53. Williams S and Andersen CE. "The morphology of the potential Class III skeletal pattern in the growing child". *American Journal of Orthodontics* 89.4 (1985): 302-311.

54. RT S. "Differences between the facial skeletal patterns of class III malocclusion and normal occlusion". *The Angle Orthodontist* 25.4 (1955): 208-222.

55. De Frutos-Valle L., *et al.* "Subclustering in Skeletal Class III Phenotypes of Different Ethnic Origins: A Systematic Review". *Journal of Evidence-Based Dental Practice* 19.1 (2019): 34-52.

56. Macdonald KE., *et al.* "Cephalometric changes after the correction of class III malocclusion with maxillary expansion/facemask therapy". *American Journal of Orthodontics and Dentofacial Orthopedics* 116.1 (1999): 13-24.

57. Jiménez I., *et al.* "Facial growth changes in a Colombian Mestizo population: An 18-year follow-up longitudinal study using linear mixed models". *American Journal of Orthodontics and Dentofacial Orthopedics* 157.3 (2020): 365-376.

58. Chen F., *et al.* "Longitudinal intermaxillary relationships in class III malocclusions with low and high mandibular plane angles". *The Angle Orthodontist* 77.3 (2007): 397-403.

59. Tollaro I., *et al.* "Class III malocclusion in the deciduous dentition: a morphological and correlation study". *European Journal of Orthodontics* 16.5 (1994): 401-408.

60. Montasser MA. "Craniofacial growth spurt in Class I subjects". *American Journal of Orthodontics and Dentofacial Orthopedics* 155.4 (2019): 473-481.

61. Varrela J. "Effects of attritive diet on craniofacial morphology: a cephalometric analysis of a Finnish skull sample". *European Journal of Orthodontics* 12.2 (1990): 219-223.

62. Garner LD and Butt MH. "Malocclusion in black Americans and Nyeri Kenyans. An epidemiologic study". *The Angle Orthodontist* 55.2 (1985): 139-146.

63. NEWMAN GV. "Prevalence of malocclusion in children six to fourteen years of age and treatment in preventable cases". *The Journal of the American Dental Association* 52.5 (1956): 566-575.

64. Buschang PH., *et al.* "Sexual dimorphism in mandibular growth of French-Canadian children 6 to 10 years of age". *American Journal of Biological Anthropology* 71.1 (1986): 33-37.

65. Baccetti T., *et al.* "Growth in the Untreated Class III Subject". *Seminars in Orthodontics* 13.3 (2007): 130-142.

66. Mitani H., *et al.* "Growth of mandibular prognathism after pubertal growth peak". *American Journal of Orthodontics and Dentofacial Orthopedics* 104.4 (1993): 330-336.

67. Auconi P., *et al.* "Forecasting craniofacial growth in individuals with class III malocclusion by computational modelling". *European Journal of Orthodontics* 36.2 (2014): 207-216.

68. Scala A., *et al.* "Using Networks To Understand Medical Data: The Case of Class III Malocclusions". *PLoS One* 7.9 (2012): 1-8.