Prevalence of Skeletal Anteroposterior Malocclusions in Skeletally Mature Patients in Puerto Rico: A Pilot Study

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Objective: To estimate the prevalence of skeletal anteroposterior malocclusions and their associated components in orthodontic patients living in Puerto Rico.

Methods: A cross-sectional study was conducted with 50 normodivergent patients (cervical vertebral maturation stages 4–6) from the Orthodontic Graduate Program (2012–2014) of the University of Puerto Rico, Medical Sciences Campus. A calibrated examiner obtained five measurements (Frankfort Horizontal–Sella–Nasion, Sella–Nasion–Gonion–Gnathion, Sella–Nasion–A point, Sella–Nasion–B point, and A point–Nasion–B point) from patients' initial cephalometric x-rays using Dolphin Imaging software, version 11.7, to determine the presence and distribution of skeletal jaw discrepancies. Sex-based differences were explored using the Mann-Whitney and Fisher's exact tests. $P < .05$ was considered statistically significant.

Results: The prevalence of skeletal discrepancies was 78%. The most common skeletal malocclusion was Class II (54%), followed by Class I (34%) and Class III (12%). Class II malocclusions were associated with maxillary prognathism (59%), whereas Class III malocclusions were attributed to mandibular prognathism (83%). Most Class I patients did not present a discrepancy (65%); however, we observed bimaxillary prognathism in 24% of Class I patients, and a low position of Sella was detected in 54% of the sample. No significant sex-based differences were observed in the five cephalometric x-ray measurements ($P > .05$) .

Conclusion: A high percentage of patients presented with a skeletal malocclusion. Class II skeletal malocclusions due to maxillary prognathism predominated; no sex-based differences were found for skeletal jaw discrepancies; a low Sella position was frequently observed.

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Key words: Skeletal, Malocclusion, Cephalometry, Prevalence

Facial skeletal patterns are determined by the mandibular and maxillary bones (1). Skeletal malocclusion, therefore, occurs because of alterations in maxillary and/or mandibular development and can affect the positioning, alignment, and health of the primary and permanent teeth (2). Thus, untreated patients with severe skeletal malocclusions may present with dental deformities, bruxism, dental crowding, caries, dental trauma, trismus, mastication difficulties, airway obstruction, and digestive disturbances. In addition, skeletal malocclusion has been reported to have adverse effects on intellectual well-being, social skills, and economic levels and psychological status (2). Recognizing skeletal disharmonies in patients is important for orthodontists, as these may have a significant effect on treatment planning and prognosis (3). Thus, identifying these skeletal growth patterns provides the opportunity for the early detection of unfavorable skeletal disharmony and for advising patients on possible treatment outcomes.

Malocclusion was defined by Dr. Edward H. Angle in 1899 as a disharmony between the positions of the upper and lower first molars (4). Currently, cephalometric radiographs remain the gold standard for the diagnosis of skeletal malocclusion. This is because cephalometric radiographs allow angular measurements, which, in turn, permit the assessment of the anteroposterior (A-P) relationship between the maxilla and mandible. Steiner analysis is the most common cephalometric analysis used in Orthodontics, owing to its simplicity (5). This analysis is based on a reference line drawn from the anatomical landmarks Sella and Nasion (S-N) and the position of the maxilla (Sella–Nasion–A point [SNA]) and mandible (Sella–Nasion–B point [SNB]). The Steiner analysis also accounts for differences among these angular measurements, which themselves define the A-P relationship of the jaws, measured as A point–Nasion–B point [ANB]. In addition, the analysis provides valuable information on the type of skeletal A-P malocclusion being presented by a given orthodontic patient. It is important to mention that values and norms for these angles vary according to age, sex, and ethnicity.

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The prevalence of malocclusions varies with age. Owing to high variation among patients in the timing of the pubertal growth spurt, chronological age and dental development indicators are unreliable predictors of skeletal maturity (6). A more accurate way to determine individual skeletal maturation is the cervical vertebral maturation (CVM) method, which can be useful in predicting the peak mandibular growth (7). Mandibular growth plays an important role in the development of skeletal malocclusions and their severity. It can also dictate treatment alternatives and possible treatment outcomes.

Several studies have evaluated the prevalence of malocclusions in different ethnic populations. However, these investigations did not distinguish between dental and skeletal malocclusions. In Middle Eastern and European populations, the estimated prevalences of Class I and II are, overall, greater than are those of Class III (2, 9–11). However, a higher prevalence of Class III malocclusions has been reported in an ethnic Chinese population (8).

Etiological analysis of skeletal malocclusions shows that, in the United States, 60% of Class II cases are associated with mandibular skeletal retrusion, whereas only 10 to 15% are due to maxillary protrusion (12). Yet, interestingly, a comparative Class III study of native Japanese and Americans of European ancestry reported that maxillary skeletal retrusion occurred more frequently in Japanese individuals than their American counterparts, whereas mandibular prognathism was more commonly seen in those of European–American ancestry (13).

Although the prevalence of skeletal malocclusions varies by ethnicity and Hispanics are the largest minority group in the United States, information on malocclusion in this population is limited. Puerto Rico is a United States territory, its population composed mostly of Hispanics with a multiracial background of European, African, and Taino Indian ancestry. Therefore, studies on Puerto Ricans could provide insight into specific skeletal traits that have yet to be characterized. To date, only two studies have addressed skeletal traits in Puerto Rican populations. Nonetheless, these cephalometric studies relied mainly on the esthetic opinions of laypersons for sample selection, which may have introduced a selection bias. The findings of these studies suggest more convex profiles and increased maxillary prognathism compared to cephalometric norms, which are based on Caucasian standards (14, 15).

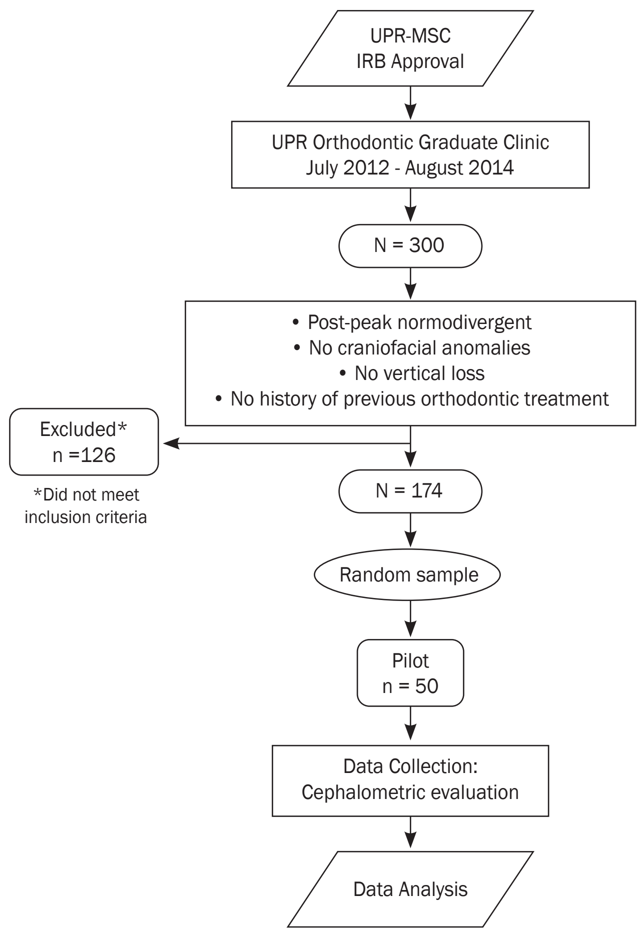
The aim of this study was to estimate the prevalence of skeletal A-P malocclusions in a group of normodivergent post-peak orthodontic patients in Puerto Rico and determine whether there were sex-based differences in these discrepancies.

The findings of the present study will provide valuable information to guide more individualized clinical assessment and treatment planning in a Hispanic population. Furthermore, identifying skeletal problems and the components of malocclusion allows the development of tailored orthodontic interventions and protocols for reducing dentoskeletal discrepancies (16).

Materials and Methods

To fulfill the aim of this study, we conducted a cross-sectional pilot study of patients accepted for treatment by the residents of the University of Puerto Rico (UPR) Orthodontic Graduate Program from July 2012 through August 2014 (Figure 1). The study included patients who had an initial lateral cephalometric x-ray available on the medical chart and, and each patient presented a normodivergent vertical growth pattern on the cephalometric x-ray and had a CVM stage of 4, 5, or 6 (300 patients). Subjects were excluded from the analysis if they had (1) a previous history of orthodontic treatment or (2) a history of craniofacial anomalies/deformities.

Figure 1. Study Flow Chart



A total of 126 patients did not meet the inclusion or exclusion criteria. Thus, the sampling frame comprised 174 patients. Of these, 50 were randomly selected for inclusion in the pilot study. Simple random selection was performed using the random-number-generation function in Microsoft Excel, version 2011.

Data Collection Procedures and Instruments

Cephalometric x-rays were digitally traced and then analyzed using Dolphin Imaging software, version 11.7. Each patient's skeletal maturation was determined by utilizing the CVM method (7). This method consists of six stages (CVM 1–6) based on the morphology of cervical vertebrae C2, C3, and C4. Stages 1, 2, and 3 in the CVM method correspond to the growth spurt during adolescence, whereas CVM stages 4, 5, and 6 are considered post-peak stages (mature stages). In this pilot study, skeletal maturation (as measured by the CVM method) was used as a study inclusion criterion.

Normodivergence was also verified by tracing vertical angular measurements of the Sella–Nasion–Gonion–Gnathion (SN-GoGn) and the Frankfort Horizontal–Sella–Nasion (FH-SN). As needed, a correction of the Sella position within the cranial base was undertaken (17). Since the A-P malocclusions were measured from the Sella-Nasion line, it was important to determine that both the Sella and the Nasion were in adequate vertical positions. If the angulation between the SN and FH planes was outside the normal range (7°–9°), a correction of the Sella position was made. Subsequently, a single examiner (LR) determined the A-P angular measurements to identify the A-P position of both the maxilla (SNA) and the mandible (SNB) and to assess the relationship (ANB) between them. Figure 2 displays all anatomical landmarks used in the assessment. Skeletal malocclusion categories and the components of the malocclusions were defined according to the Steiner analysis (5). Bimaxillary prognathism was defined as the anterior displacement of both the maxillary and mandibular skeletal bases (18). Patients were classified as having bimaxillary retrognathism when both skeletal bases were located posterior to their normal reference positions.

Calibration Procedures

Training and calibration exercises were performed utilizing cephalometric x-rays selected from the UPR Orthodontic Graduate Program Clinic following the same inclusion and exclusion criteria in the study. Prior to undergoing the calibration procedure, both examiners (LR and JO) participated in a training session. A total of 20 cephalometric x-rays were used to conduct the calibration exercise.

Cohen's kappa coefficients (for the malocclusion variable) and weighted kappa coefficients (for the CVM-stage variable) were calculated to evaluate the intra- and inter-examiner reliability of categorical measurements. For continuous measurements (FH-SN, SN-GoGn, ANB, SNA, and SNB), intraclass correlation coefficients (ICCs) were reported. Cohen's kappa values and ICCs greater than or equal to 0.75 were deemed acceptable (Table 1).

Statistical Analyses

Absolute and relative frequencies were computed for sex, skeletal discrepancy, type of skeletal malocclusion (Classes I, II, and III), and the components of the malocclusions presented (prognathism, retrognathism, or both). Measures of central tendency and dispersion were calculated for the angular cephalometric measurements (FH-SN, SN-GoGn, ANB, SNA, and SNB). The prevalence of skeletal malocclusion was compared to the estimated 65% prevalence in the US population (2) using a one-sample binomial test.

Fisher's exact test was used to associate sex with the type of skeletal malocclusion and the CVM stage. Due to deviations from normal distribution (detected by the Shapiro–Wilk test), cephalometric measurements were compared between male

Figure 2. Cephalometric Landmarks: Sella (S), Nasion (N), Porion (Po), Orbitale (Or), Point A (A), Point B (B), Gonion (Go), Gnathion (Gn), and the Frankfort Horizontal (FH) plane.

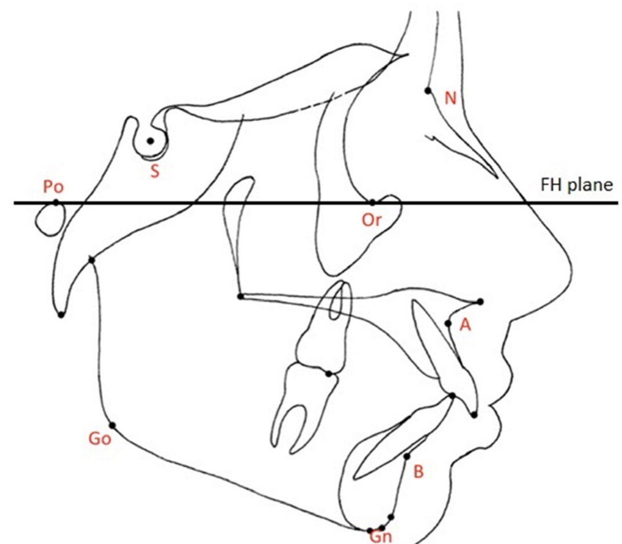


Table 1. Reliability of repeated skeletal measurements taken by the main examiner (intra-examiner) and by the main and gold standard examiner (inter-examiner reliability)

Measure	Intra-examiner reliability (2 measurements by the main examiner)		Inter-examiner reliability (Main examiner vs. Gold Standard)	
	Cohen's kappa coefficient (95% CI)	ICC	Cohen's kappa coefficient (95% CI)	ICC
CVM stage* (4, 5, 6)	0.94 (0.82-1.00)	----	0.76 (0.52-0.99)	----
Skeletal classification of malocclusion (I, II, III)	0.90 (0.71-1.00)	----	0.90 (0.71-1.00)	----
Skeletal components (5 categories)	1.00 (1.00-1.00)	----	0.93 (0.80-1.00)	----
Angular measurements				
SNA		0.96		0.97
SNB		0.98		0.98
ANB		0.99		0.99
FH-SN		0.97		0.98
SN-GoGn		0.98		0.96

*Due to ordinal nature of this variable, weighted kappa coefficient was calculated
Abbreviations: ANB, A point–Nasion–B point; CVM, cervical vertebral maturation; FH-SN, Frankfort Horizontal–Sella–Nasion; ICC, intraclass correlation coefficient; SN-GoGn, Sella–Nasion–Gonion–Gnathion; SNA, Sella–Nasion–A point; SNB, Sella–Nasion–B point.

and female patients using the Mann–Whitney test. A *P* value less than .05 was considered statistically significant, and the data were analyzed using SAS statistical software v. 9.3 (SAS Institute, Cary, NC). In accordance with the Declaration of Helsinki, the protocol described herein was submitted to and approved by the Institutional Review Board of the UPR Medical Sciences Campus.

Results

As described in Table 2, the majority of the patients were female (56%) and had a CVM stage of 6 (52%), i.e., were considered skeletally mature; CVM stage distribution was different in male vs. female patients (*P* = .04). Twenty-seven of 50 measurements made (54%) were adjusted for the position of Sella using the FH line as a reference . All these corrections were carried out because of the low position of this anatomical landmark.

Measures of central tendency and dispersion (means [SDs]) for all angular cephalometric measurements were as follows: 9.1 (SD, 2.3) for FH-SN, 31.3 (SD, 2.8) for SN-GoGn, 4.3 (SD, 3.0) for ANB, 85.1 (SD, 3.7) for SNA, and 80.8 (SD, 3.9) for SNB (Table 3). None of these measurements differed by sex (*P* > .05).

In the study, 78% of patients presented malocclusions; however, this prevalence was not statistically significantly different from the US population estimate of 65% (*P* = .05) (2). The distribution of skeletal classification and its associated components is reported in Table 4. The most frequent skeletal pattern found was Class II (54%), with skeletal maxillary prognathism present in 59% of these patients. This was followed by Class I (34% of patients), 65% of whom had no skeletal discrepancy Bimaxillary prognathism was observed in 24% of Skeletal Class I patients, whereas only 11% had bimaxillary retrognathism. At 12%, the least common skeletal pattern was Class III, with 83% of these patients exhibiting mandibular skeletal prognathism. No associations were found between sex and either skeletal malocclusion (*P* values > .05).

Table 2. Number and percentage of patients by Cervical Vertebral Maturation (CVM) stage, among all and by sex

CVM stage	Overall (n=50)	Females (n=28)	Males (n=22)	Chi-square *P* value
4	15 (30%)	5 (18%)	10 (45%)	
5	9 (18%)	4 (14%)	5 (23%)	0.04
6	26 (52%)	19 (68%)	7 (32%)	

Discussion

The aim of this study was to estimate the prevalence and distribution of skeletal facial patterns in patients accepted for treatment at the Orthodontic Graduate Program. We found that the prevalence of malocclusion was 78%, which was higher than was reported on the US mainland, where 65% of the population was estimated to show some degree of malocclusion (2). The differences between these two studies could be attributed to ethnicity, registration methods, and variations in the definition of malocclusions (19).

In addition, to verify normodivergence in this study sample, the position of Sella was corrected as needed. A low position of Sella was found in 54% of the patients; however, no significant differences were found between sexes. These results are in accordance with those of Evanko et al. (1997), who did not find any sex differences in a sample of Puerto Ricans (15).

As to the mean estimates of the angular measurements in the study, these were similar to those reported in the other studies with Puerto Rican samples. The values of the SNA and ANB angles appear to be closer to the African American norms (85° and 4°) (20). Puerto Ricans are a mixed ethnic group with African heritage; therefore, the angular measurements obtained in this study may reflect this ethnic admixture. Nevertheless, while this study provides valuable cephalometric data, we must be careful in

Table 3. Measures of central tendency and dispersion of angular cephalometric measurements, overall (n=50) and by sex

Cephalometric Measurement	Overall (n=50)		Females (n=28)		Males (n=22)		Mann-Whitney test
	Mean ± SD	Median (Min – Max)	Mean ± SD	Median (Min – Max)	Mean ± SD	Median (Min – Max)	*P* value
FH-SN (6° ± 3°)	9.1 ± 2.3	9.0 (4.1 – 14.0)	9.5 ± 1.9	9.2 (4.2 - 13.6)	8.7 ± 2.7	8.7 (4.1 – 14.0)	.19
SN-GoGn (32° ± 5°)	31.3 ± 2.8	30.8 (26.9 – 36.8)	30.9 ± 3.1	30.8 (26.9 - 36.8)	31.7 ± 2.5	31.0 (27.0-35.5)	.28
ANB (2° ± 2°)	4.3 ± 3.0	4.6 (-2.0 – 11.3)	3.9 ± 3.3	3.7 (-2.0 - 9.6)	4.83 ± 2.6	4.6 (1.2 – 11.3)	.42
SNA (82° ± 3°)	85.1 ± 3.7	85.0 (74.9 – 92.4)	85.1 ± 4.1	85.3 (74.9 – 92.2)	85.1 ± 3.1	85.0 (78.6 – 92.4)	.81
SNB (80° ± 3°)	80.8 ± 3.9	80.9 (72.3 – 91.0)	81.2 ± 4.5	81.8 (72.3 – 91.0)	80.3 ± 3.0	80.7 (74.0 – 86.4)	.43

establishing comparisons with other studies because of differences in study design.

In Saxony, Germany, a prevalence of 59.3% was reported for mandibular retrognathism and distal jaw relationships (11). Additionally, studies in Pakistan and Iran reported prevalences of 47% and 70% for Class II skeletal patterns, respectively (9, 10). Our results agree with those of these studies; 54% of the patients in our sample had skeletal Class II malocclusions, while 34% and 12% had Class I and Class III malocclusions, respectively. However, our findings disagree with the estimated prevalence of skeletal Class II (18.8%) malocclusion in an ethnic Chinese population (8).

As reported by McNamara (12), mandibular retrognathism (60% of the cases) has been associated with Class II skeletal patterns in Caucasian populations. However, the present study found maxillary skeletal prognathism to be the primary cause of Class II skeletal patterns in this sample of orthodontic patients. This discrepancy can be attributed to the fact that McNamara's study assessed 8- to 10-year-old patients, most of whom had hyperdivergent facial patterns (12). Nevertheless, the findings of this study are consistent with those of other cephalometric studies conducted in Puerto Rican populations (14, 15).

Table 4. Distribution of skeletal classification of malocclusions and skeletal components, overall and by sex

Skeletal Classification	Skeletal Components	Overall (N=50)	By sex		Fisher's exact test *P* value
			Male (N=22)	Female (N=28)	
Class I		17 (34%)	8 (36%)	9 (32%)	
Class II		27 (54%)	14 (64%)	13 (46%)	.06
Class III		6 (12%)	0 (0%)	6 (21%)	
By skeletal classification of malocclusion					
Class I	No Jaw Discrepancy	11 (65%)	7 (88%)	4 (44%)	.16
	Bimaxillary Prognathism	4 (24%)	1 (12%)	3 (33%)	
	Bimaxillary Retrognathism	2 (11%)	0 (0%)	2 (22%)	
Class II	Maxillary Prognathism	16 (59%)	9 (64%)	7 (54%)	.84
	Mandibular Retrognathism	9 (33%)	4 (29%)	5 (38%)	
	Combination Maxillary Prognathism/Mandibular Retrognathism	2 (8%)	1 (7%)	1 (8%)	
Class III	Maxillary Retrognathism	0 (0%)	0 (0%)	0 (0%)	---*
	Mandibular Prognathism	5 (83%)	0 (0%)	5 (83%)	
	Combination Maxillary Retrognathism/Mandibular Prognathism	1 (17%)	0 (0%)	1 (17%)	

**P* value could not be obtained due to lack of variability in the sex variable.

Regarding Class III malocclusion, we found a higher prevalence of this condition in our sample than has been reported in prior studies (21). In addition, all the patients with Class III malocclusions were female and had mandibular prognathism. These findings concur with those reported for European Class III skeletal patterns, which are mainly linked to mandibular prognathism, but differ from those in Japanese populations, in which maxillary retrognathism is the leading cause (13).

Our research presents some limitations. For instance, the sample for this pilot was obtained solely from the UPR Orthodontic Graduate Program; we did not include patients with skeletal discrepancies treated elsewhere or those not seeking orthodontic treatment. Patients who seek treatment in a clinical setting are usually aware that they have some form of malocclusion (self-selection bias); therefore, we may be overestimating the prevalence of skeletal discrepancies. However, this study provides valuable estimates for future research without any additional burden on participants since the cephalometric x-rays would be part of the initial evaluation of the patients. The present study has several additional strengths, including high intra- and inter-examiner reliability (kappa and ICC > 75%) for skeletal measurements, indicating high internal validity. Moreover, the homogeneity of the sample in terms of ethnicity, skeletal maturity, and the normodivergence of the vertical facial patterns helped control confounders that might otherwise have affected the study results.

Future studies are warranted to confirm our results. These should be population-based studies with probabilistic samples. If such investigations were to confirm our findings, they could aid in the development of orthodontic interventions tailored to each patient's ethnicity. These tailored interventions could reduce the burden of the condition and, in turn, decrease associated problems such as facial deformities, bruxism, crowding, caries, trauma, trismus, mastication difficulties, airway obstruction, and digestive disturbances, as well as broader adverse outcomes such as intellectual, psychological, social, and economic impairments.

In conclusion, a high prevalence of skeletal malocclusion was found in this study group, highlighting the need for orthodontic treatment. For the most part, Class II skeletal malocclusion was related to maxillary prognathism. Interestingly, a low Sella position was frequently observed. No sex-based differences were observed in any skeletal jaw discrepancies.

Further studies utilizing A-P points that use references other than the Sella–Nasion line may be needed to minimize the influence of the vertical position of Sella.

Resumen

Objetivos: Estimar la prevalencia de maloclusiones anteroposteriores esqueletales y sus componentes asociados en pacientes ortodónticos puertorriqueños. Métodos: Se llevó a cabo un estudio transversal con 50 pacientes normodivergentes en etapa de maduración de vértebras cervicales 4, 5 y 6. Los pacientes fueron seleccionados aleatoriamente del Programa Graduado de Ortodoncia (2012–2014) de la Universidad de Puerto Rico, Recinto de Ciencias Médicas. Un dentista previamente calibrado obtuvo cinco medidas cefalométricas (Frankfort Horizontal–Sella–Nasión, Sella–Nasión–Gonion–Gnathion, Sella–Nasión–punto A, Sella–Nasión–punto B, and punto A–Nasión–punto B) de radiografías cefalométricas iniciales usando el programa Dolphin Imaging (versión 11.7) para determinar la presencia y distribución de discrepancias esqueletales mandibulares. Comparaciones por género fueron realizadas utilizando las pruebas Mann- Whitney y Fisher. Un valor de p menor de 0.05 se consideró estadísticamente significativo. Resultados: La prevalencia de discrepancias esqueletales fue 78%. La maloclusión esqueletal más común fue Clase II (54%), seguida de Clase I (34%) y Clase III (12%). Las maloclusiones Clase II fueron asociadas con prognatismo maxilar (59%), mientras que las maloclusiones Clase III fueron atribuidas a prognatismo mandibular (83%). La mayoría de los pacientes con patrones esqueletales Clase I no presentaron discrepancia (65%), sin embargo, el prognatismo bimaxilar se observó en 24% de los pacientes con Clase I. Una posición baja de Sella fue encontrada en 54% de esta muestra. Cuando se evaluó por género, no hubo diferencia estadísticamente significativa para ninguna variable ($p>0.05$). Conclusiones: Se observó un porcentaje elevado de maloclusión esqueletal. La maloclusión esqueletal Clase II debida a prognatismo maxilar fue más prevalente y no hubo diferencias por género para ninguna discrepancia esqueletal mandibular. Una baja posición de Sella se observó con alta frecuencia.

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References

1. Downs WB. Variations in facial relationships; their significance in treatment and prognosis. Am J Orthod. 1948;34(10):812-840. doi:10.1016/0002-9416(48)90015-3
2. Joshi N, Hamdan AM, Fakhouri WD. Skeletal malocclusion: a developmental disorder with a life-long morbidity. J Clin Med Res. 2014;6(6):399-408. doi:10.14740/jocmr1905w
3. Jacobson A, Jacobson RL. Radiographic Cephalometry From Basics to 3-D Imaging. 2nd ed. Chicago: Quintessence Publishing; 2006.
4. Angle, EH. Classification of Malocclusion. Dent Cosmos. 1899;41(3):248-264.
5. Steiner CC. Cephalometrics for you and me. Am J Orthod. 1953;39(10):729-755. doi:10.1016/0002-9416(53)90082-7
6. Uysal T, Ramoglu SI, Basciftci FA, Sari Z. Chronologic age and skeletal maturation of the cervical vertebrae and hand-wrist: is there a relationship?. Am J Orthod Dentofacial Orthop. 2006;130(5):622-628. doi:10.1016/j.ajodo.2005.01.031
7. 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(3):119-129.
8. Lew KK, Foong WC. Horizontal skeletal typing in an ethnic Chinese population with true Class III malocclusions. Br J Orthod. 1993;20(1):19-23. doi:10.1179/bjo.20.1.19
9. Waheedul-Hamid AS, Asad S. Prevalence of skeletal components of malocclusion using composite cephalometric analysis. Pak Oral Dent J. 2003;23(2):137-144.
10. Oshagh M, Ghaderi F, Pakshir HR, Baghmollai AM. Prevalence of malocclusions in school-age children attending the orthodontics department of Shiraz University of Medical Sciences. East Mediterr Health J. 2012;16(12):1245-1250. Published 2012 Dec 4. doi:10.26719/2010.16.12.1245
11. Reich U, Dannhauer KH. Craniofacial morphology of orthodontically untreated patients living in Saxony, Germany. J Orofac Orthop. 1996;57(4):246-258. doi:10.1007/BF02190237
12. McNamara JA Jr. Components of class II malocclusion in children 8-10 years of age. Angle Orthod. 1981;51(3):177-202. doi:10.1043/0003-3219(1981)051<0177:COCIMI>2.0.CO;2
13. Masaki F. The longitudinal study of morphological differences in the cranial base and facial structure between Japanese and American whites [in Japanese; author's transl]. Nihon Kyosei Shika Gakkai Zasshi. 1980;39(4):436-456.
14. Oliva JE. Osseous and integumental cephalometric study of the Puerto Rican ethnic group utilizing public opinion in the concept of facial esthetics [dissertation]. Los Angeles, California, USA: University of Southern California; 1983.
15. Evanko AM, Freeman K, Cisneros GJ. Mesh diagram analysis: developing a norm for Puerto Rican Americans. Angle Orthod. 1997;67(5):381-388. doi:10.1043/0003-3219(1997)067<0381:MDADAN>2.3.CO;2
16. Helm S. Malocclusion in Danish children with adolescent dentition: an epidemiologic study. Am J Orthod. 1968;54(5):352-366. doi:10.1016/0002-9416(68)90304-7
17. Moore JW. Variation of the sella-nasion plane and its effect on SNA and SNB. J Oral Surg. 1976;34(1):24-26.
18. Proffit WR, Fields H, Larson B, Sarver DM. Contemporary Orthodontics. 6th ed. St. Louis: Mosby/Elsevier; 2018.
19. Tang EL, Wei SH. Recording and measuring malocclusion: a review of the literature. Am J Orthod Dentofacial Orthop. 1993;103(4):344-351. doi:10.1016/0889-5406(93)70015-G
20. Huang WJ, Taylor RW, Dasanayake AP. Determining cephalometric norms for Caucasians and African Americans in Birmingham. Angle Orthod. 1998;68(6):503-512. doi:10.1043/0003-3219(1998)068<0503:DCNFCA>2.3.CO;2
21. Bailey LJ, Haltiwanger LH, Blakey GH, Proffit WR. Who seeks surgical-orthodontic treatment: a current review. Int J Adult Orthodon Orthognath Surg. 2001;16(4):280-292.
15. Evanko AM, Freeman K, Cisneros GJ. Mesh diagram analysis: developing a norm for Puerto Rican Americans. Angle Orthod. 1997; 67(5):381-8.
16. Helm S. Malocclusion in Danish children with adolescent dentition: an epidemiologic study. Am J Orthod. 1968; 54 (5): 352–66.
17. Moore JW. Variation of the sella-nasion plane and its effect on SNA and SNB. J Oral Surg 1976; 34: 24-26.
18. Proffit WR, Fields H, Larson B, Sarver DM. Contemporary Orthodontics. 6th ed. St. Louis: Mosby/Elsevier; 2018.
19. Tang EL, Wei SH. Recording and measuring malocclusion: a review of the literature. Am J Orthod Dentofacial Orthop. 1993; 103(4): 344–51.
20. Huang WJ, Taylor RW, Dasanayake AP.Determining cephalometric norms for Caucasians and African Americans in Birmingham. Angle Orthod 1998; 68 (6): 503–512.
21. Bailey LJ, Haltiwanger LH, Blakey GH, Proffit WR. Who seeks surgical-orthodontic treatment: a current review. Int J Adult Orthodon Orthognath Surg. 2001;16(4): 280-92.