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Cephalometric norms among a sample of the Lebanese population

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Research Article

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Abstract

Background

Cephalometric analysis is fundamental to orthodontic diagnosis and treatment planning, yet most established norms derive from Caucasian populations.

Objectives

This study aimed to establish comprehensive cephalometric norms for the Lebanese adult population using three classical analytical systems.

Methods

A cross-sectional study was conducted on 80 Lebanese adults (34 males, 46 females; aged 16–30 years) with Class I occlusion and balanced facial profiles. Lateral cephalometric radiographs were analyzed using WebCeph software, applying Downs, Steiner, and Ricketts analyses. Descriptive statistics, independent t-tests for gender comparisons, and one-sample t-tests against Caucasian norms were performed.

Results

Lebanese subjects demonstrated a substantially flatter mandibular plane angle (Go-Gn/SN: 28.70° ± 4.98°) compared to Caucasian (32°) and Moroccan (35.35°) norms, indicating horizontal growth patterns. The ANB angle (males: 2.75° ± 2.59°; females: 3.58° ± 1.97°) suggested a mild Class II skeletal tendency. Significant sexual dimorphism was observed, with males showing greater SNB values (81.28° vs. 79.31°, p = 0.023) and females demonstrating increased lower incisor proclination (L1–NB: 29.42° vs. 25.52°, p = 0.008) and reduced interincisal angles (124.98° vs. 129.69°, p = 0.020).

Conclusion

Lebanese adults exhibit distinctive cephalometric characteristics that differ from Caucasian standards, most notably a significantly flatter mandibular plane. These population-specific norms provide clinicians with appropriate diagnostic references for Lebanese patients, potentially improving diagnostic accuracy and treatment planning outcomes.

Introduction

Cephalometric analysis remains a foundational tool in orthodontic diagnosis and treatment planning, offering a standardized, reproducible, and quantitative appraisal of craniofacial morphology using lateral cephalometric radiographs. Since Broadbent's pioneering introduction of lateral cephalometry in the early 20th century, this modality has enabled clinicians to objectively assess skeletal and dental relationships through precise angular and linear measurements, supporting clinical decisions across

diverse patient populations[1]. Over subsequent decades, numerous analytical frameworks have been developed. Among the most influential are those introduced by Downs[2] (1948), Steiner [3](1953), and Ricketts[4] (1960), which collectively underpin much of modern clinical orthodontics.

Although these classical analyses were originally derived from predominantly Caucasian samples, a growing body of contemporary research indicates that cephalometric norms vary significantly across different ethnic and racial groups. Therefore, reliance on traditional Western-derived standards may lead to diagnostic inaccuracies when applied universally. Systematic reviews and normative studies have documented such differences in cephalometric values across diverse populations, highlighting the importance of population-specific standards. For example, variations in craniofacial parameters have been observed among Arab, African, and other non-Caucasian samples, emphasizing ethnic and regional distinctions in skeletal and soft-tissue morphology[5]. In the Middle East and Arab region, several studies have investigated cephalometric characteristics, demonstrating notable deviations from classical Caucasian standards. Recent research exploring cephalometric parameters in Arab cohorts underscores the necessity of considering ethnicity, age, and sex in diagnosis and treatment planning [(6,7)].

Despite increasing interest in Middle Eastern populations, data on the Lebanese population remain limited. Saadeh et al. (2025) [8] addressed this gap by establishing cephalometric norms for both hard and soft tissues in Lebanese adults with balanced facial profiles and normal occlusion. Their findings indicated that, compared to established Caucasian standards, Lebanese individuals generally present with smaller, more retrognathic jaws and a more obtuse nasolabial angle. Additionally, significant gender-related differences were identified across several skeletal and soft-tissue parameters, underscoring the importance of population-specific reference values to ensure accurate clinical evaluation and orthodontic treatment planning.

Given these findings and the documented inter-ethnic variability in cephalometric patterns, it is clear that developing normative data for specific populations is essential for optimal orthodontic care. While most Arab countries have established localized cephalometric standards, there remains a paucity of comprehensive norms for the Lebanese population that integrate conventional analyses (Downs, Steiner, Ricketts) with contemporary clinical requirements. Therefore, the present study aims to establish specific cephalometric norms for a pure Lebanese ethnic group using established analytical methods a reference that will enhance diagnostic accuracy and improve individualized treatment planning for Lebanese orthodontic patients.

Materials and Methods

This study employed a descriptive cross-sectional study design. The approval was obtained from the research ethical committee of Beirut Arab University. Each patient signed a written informed consent to participate in this study (IRB number: 2025-H0182-D-M-0872). The study sample consisted of lateral cephalometric radiographs selected from existing records at the Outpatient Clinics of the Department of Orthodontics, Beirut Arab University, Lebanon, during the period from August 2024 to August 2025. The

targeted population was young Lebanese adults who had undergone routine dental and orthodontic assessment, with radiographs obtained as part of standard diagnostic procedures.

Sample size calculation was performed using 80% power of the study with sample size estimation conducted via http://www.raosoft.com/samplesize, assuming a confidence level of 95% and study power of 80%. The calculated minimum sample size was 80 lateral cephalograms. The study sample consisted of 80 lateral cephalograms meeting all inclusion criteria; [9] patient aged 16–30 years with Lebanese heritage for three generations (participant and both parents of Lebanese origin), Angle Class I molar and canine relationships, Less than 3 mm of total arch length discrepancy, presence of full permanent dentition and with balanced profile representing esthetically Lebanese facial characteristics. Finally patients had no history of previous or current orthodontic treatment and absence of Craniofacial Anomalies.

All lateral cephalometric radiographs were obtained using standardized digital cephalometric equipment at the Department of Orthodontics, Beirut Arab University. The radiographic technique employed conventional lateral cephalometric projection with standardized parameters. These standardized radiographic parameters ensured consistency in image quality and geometric accuracy across all subjects, permitting reliable landmark identification and measurement reproducibility. All radiographs were obtained by experienced radiographic technicians following standardized protocols to minimize positioning errors and ensure diagnostic quality. Patients were positioned in the cephalostat with precise standardization to ensure reproducibility with Head Positioned Midsagittal plane positioned perpendicular to the X-ray beam and parallel to the image receptor Frankfort horizontal plane (Porion to Orbitale) oriented parallel to the floor, representing natural head position as described by Moorrees and Kean (1958) [10]

All measurements were performed using WebCeph software (https://web-ceph.com), a web-based cephalometric analysis platform. The software provides automated calculation of angular and linear measurements following standardized geometric definitions for each analysis (Downs, Steiner, Ricketts).

The following cephalometric landmarks were systematically identified on each lateral cephalogram in accordance with standardized definitions established in the orthodontic literature (Downs, 1948; Steiner, 1953; Ricketts, 1960). All landmark identifications followed these standardized definitions to ensure consistency with published norms and facilitate valid comparisons with reference populations.

Table 1: Cephalometric Landmarks:	
Landmark	**Definition**
Skeletal Landmarks	
Nasion (N)	Craniometric point where the midsagittal plane intersects the most anterior point of the nasofrontal suture.
Sella Turcica (S)	The geometric center of the sella turcica (pituitary fossa).
Basion (Ba)	The most inferior point on the anterior margin of the foramen magnum in the midsagittal plane.
Orbitale (Or)	The lowest point on the inferior rim of the bony orbit. When bilateral images were present, the two orbitales were averaged.
Porion (Po)	The uppermost and outermost point on the external auditory meatus. Bilateral images were averaged to establish the Frankfort horizontal.
Point Po (Downs)	The orthogonal projection of Pogonion onto the mandibular plane as specifically defined by Downs.
Anterior Nasal Spine (ANS)	The tip of the bony anterior nasal spine at the most anterior point of the maxilla.
Point A (Subspinale)	The deepest point on the curve of the maxilla between the anterior nasal spine and the dental alveolus, representing the anterior limit of the maxillary basal bone.
Point B (Supramentale)	The deepest midline point on the mandibular symphysis between infradentale and pogonion, representing the anterior limit of the mandibular basal bone.
Pogonion (Pog)	The most anterior point on the bony symphysis of the mandible in the midsagittal plane.
Gnathion (Gn)	The midpoint between the most anterior and most inferior points of the bony chin symphysis.
Menton (Me)	The most inferior point on the bony symphysis of the mandible in the midsagittal plane.
Gonion (Go)	The equidistant point between the most posterior and the most inferior points on the mandibular angle. Bilateral gonial angles were traced and averaged when double images were present.
Point Xi	The geometric center of the ramus of the mandible, determined by constructing the intersection of the anteroposterior and superoinferior bisectors of the ramus outline (used in Ricketts analysis).
Point Pm (Protuberance Menti)	The inflection point of the outline of the symphysis between Pogonion and Point B (used in Ricketts analysis).
Dental Landmarks	
Maxillary Incisal Edge (UI)	The incisal tip of the most anterior maxillary central incisor.

Table 1: Cephalometric Landmarks:	
Maxillary Incisor Apex (U1 apex)	The root apex of the most prominent maxillary central incisor.
Mandibular Incisal Edge (LI)	The incisal tip of the most anterior mandibular central incisor.
Mandibular Incisor Apex (L1 apex)	The root apex of the most prominent mandibular central incisor.
Maxillary First Molar (U6)	The distal contact point of the maxillary first molar crown (used for U6-PTV measurement in Ricketts analysis).

Three classical cephalometric analytical systems were applied to each lateral cephalogram using WebCeph software (WebCeph, Korea). Digital calibration was performed using the integrated ruler reference on each radiograph to ensure measurement accuracy.

The following measurements from Ricketts' comprehensive cephalometric analysis were evaluated (Ricketts, 1960, 1972): [4,11]

Table 2
Ricketts identification anatomical landmarks

Landmark	Definition
Facial Axis Angle (Ba-Na to Pt-Gn)	The angle formed by the intersection of the Basion- Nasion line and the Facial Axis (from Pterygoid point through Gnathion). Normal: 90° ± 3°. This measurement indicates the general direction of facial growth and facial height characteristics.
Facial Depth Angle (N-Pog to FH):	The angle formed by the intersection of the facial plane (Nasion-Pogonion) and the Frankfort horizontal plane. Normal: 87° ± 3°. This indicates the anteroposterior position of the mandible (Pogonion).
Mandibular Plane Angle (Go-Gn to FH	The angle formed by the intersection of the mandibular plane (Gonion-Gnathion) and the Frankfort horizontal plane. Normal: 26° ± 4°. This angle indicates the cant of the mandibular corpus and reflects vertical growth pattern.
Convexity at Point A (N-Pog to A)	The perpendicular distance in millimeters from Point A (Subspinale) to the facial plane (Nasion-Pogonion). Normal: 2 mm ± 2 mm. This represents the anterior limit of the maxilla and indicates middle face convexity.
Lower Incisor to A-Pog (degrees)	The angular measurement between the long axis of the lower incisor and the A-Pogonion plane. Normal: 22° ± 4°. This indicates lower incisor procumbency or uprighting relative to the denture bases.
Lower Incisor to A-Pog (mm)	The linear measurement indicating the anteroposterior position of the mandibular incisor incisal edge relative to the A-Pogonion line. Normal: +1.0 mm ± 2.5 mm.
Upper Molar to Pterygoid Vertical (U6-PTV)	The distance in millimeters from the pterygoid vertical to the distal surface of the upper first molar. Normal: Age + 3.0 mm. This assists in determining molar position and extraction decisions.
Lower Facial Height (ANS-Xi-Pm)	The angle formed between Anterior Nasal Spine to Xi (geometric center of the ramus) to Pm (Protuberance Menti). Normal: 47° ± 4°. This angle describes the divergence of the lower face and vertical jaw relationships.

The complete Steiner analysis was performed, including the following skeletal and dental measurements (Steiner, 1953, 1959, 1960):[3,12,13]

Table 3
Steiner identification anatomical landmarks

Landmark	Definition
SNA	The angle is formed by SN plane and point A. This angle is suggestive of relation of maxilla to cranial base. Increased angle is indicative of prognathic maxilla while reduction in the value of this angle is suggestive of retro positioned maxilla.
SNB	The angle is formed by SN plane and point B. This angle is suggestive of relation of mandible to cranial base. Increased angle is indicative of prognathic mandible while reduction in the value of this angle is suggestive of retro positioned mandible.
ANB	The angle is formed by point A-N-B. The angle gives measure of the skeletal pattern of the individual. Increased or positive angle is suggestive of class II profile while negative angle, point B ahead of point A indicates class III skeletal profile.
Mandibular plane (Go-Gn to Sn)	This angle is suggestive of relation between mandibular plane (Go-Gn- Sn) to the Sn plane. The angle provides essential information regarding growth pattern of the individual.
U1 to NA (degrees and mm)	This parameter gives measure of inclination of upper incisors with respect to bony bases point N and A.
Lo1 to NB (degrees and mm)	This parameter gives measure of inclination of lower incisors with respect to bony bases point N and B.
Interincisal angle (U1-L1)	The angle is formed by the long axis of incisors. The angle suggests proclination of incisors.
Occlusal plane to SN plane	This angle gives a measure of slope of occlusal plane relative to the SN plane. The value increases in downward or clockwise tipped occlusal planes mostly in vertical growers, whereas the decreased value is suggestive of anticlockwise tip of the occlusal plane often appreciated in the horizontal growers.

The Downs analysis was applied to evaluate skeletal and dental patterns through the following measurements (Downs, 1948, 1952, 1956): [2,14,15]

Table 4
Downs identification anatomical landmarks

Landmark	Definition
Facial angle (in degrees)	Facial angle is ideally used in Down's to measure the degree of retrusion and protrusion of the lower jaw.
AB plane angle (in degrees)	This angle is suggestive of maxilla-mandibular relationship to the facial plane. Standard values lie in the range of -9° to 0° with mean value of -4.6°.
Y-axis (in degrees)	The angle formed between the S-pog and frankfort plane. It is suggestive of growth pattern in relation to the cranial base with the Frankfort horizontal plane with an average value of 59°.
Cant to occl. plane	This angle gives a measure of slope of occlusal plane relative to the FH plane.
Incisors to occlusal plane angle (in degrees)	This is the inside inferior angle formed by the intersection between the long axis of lower central incisor and the occlusal plane and is read as a plus or minus deviation from a right angle.
Incisor to mandibular plane angle	This angel is formed by intersection of the long axis of the lower incisor and the mandibular plane.
U1 to A-Pog linear (in mm)	This is a linear measurement between the incisal edge of the maxillary central incisor and the line joining point A to pogonion.

Statistical analysis:

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov normality tests, descriptive statistics, independent samples t-tests, one-sample t-tests, and effect size calculations were conducted using SPSS analytical procedures. Graphical representations of data distributions were generated using Microsoft Excel 2019. The Kolmogorov-Smirnov test was performed to assess normality of distribution for each cephalometric variable. Variables demonstrating non-normal distribution ($p < 0.05$) were evaluated for transformation or analyzed using non-parametric alternatives.

Results

This study analyzed lateral cephalometric radiographs from 80 Lebanese young adults aged 16–30 years (mean age 21.60 ± 2.89 years). The sample comprised 34 males (age range 16– 29 years, mean 21.06 ± 2.50 years) and 46 females (age range 16–30 years, mean 22.00 ± 3.11 years), providing a female-to-male ratio of 1.35:1. The mean values, standard deviations, and results of the statistical comparisons between genders were summarized in Tables 5–7.

Ricketts Analysis:

As demonstrated in table (5), males and females showed largely comparable values across most skeletal and dental parameters measured by Ricketts analysis. However, females exhibited significantly greater convexity of the facial profile, as reflected by the facial convexity measurement (N-Pog' A: 2.09 ± 2.49 mm vs. 0.57 ± 3.03 mm, p = 0.020). In addition, females had significantly higher values for lower incisor position relative to the A-Pog line (A-Pog; LI in mm: 2.70 ± 2.00 mm vs. 1.46 ± 1.58 mm, p = 0.003), indicating greater labial positioning of the lower incisors. The other measurements showed no statistically significant gender differences.

Table 5
Ricketts Cephalometric Measurements (Males vs. Females)

Variable	Males (n = 34) Mean ± SD	Females (n = 46) Mean ± SD	P-value
Ba-Na, Pt-Gn (°)	90.10 ± 3.95	89.29 ± 3.41	0.339
N-Pog, frank (°)	90.32 ± 3.26	89.45 ± 2.28	0.184
Go-Gn, frank (°)	19.40 ± 4.85	21.29 ± 3.47	0.058
N-Pog' A (mm)	0.57 ± 3.03	2.09 ± 2.49	0.020*
A-Pog; LI (°)	26.09 ± 4.03	27.08 ± 3.98	0.277
Up.Mo-Pt.v (mm)	15.32 ± 4.67	14.12 ± 4.32	0.248
A-Pog; LI (mm)	1.46 ± 1.58	2.70 ± 2.00	0.003*
ANS-XiPm (mm)	42.12 ± 3.41	42.18 ± 2.82	0.939

*Independent samples t-test; * p < 0.05 considered statistically significant.*

Steiner Analysis:

As shown in table (6), Significant gender-related differences were observed in three parameters of the Steiner analysis. Males demonstrated a higher SNB angle (81.28 ± 3.83° vs. 79.31 ± 3.61°, p = 0.023), reflecting greater mandibular prognathism. Conversely, females presented with a significantly larger L1 to NB angle (29.42 ± 5.42° vs. 25.52 ± 6.88°, p = 0.008), suggesting increased proclination of the lower incisors. The interincisal angle was also significantly smaller in females compared to males (124.98 ± 7.93° vs. 129.69 ± 9.24°, p = 0.020), consistent with greater incisor proclination. No significant differences were noted for SNA, ANB, Go-Gn to SN, U1–NA (both degrees and mm), L1–NB (mm), or occlusal plane to SN.

Table 6
Steiner Cephalometric Measurements (Males vs. Females)

Variable	Males (n = 34) Mean ± SD	Females (n = 46) Mean ± SD	P-value
SNA (°)	83.47 ± 4.30	82.99 ± 4.29	0.621
SNB (°)	81.28 ± 3.83	79.31 ± 3.61	0.023*
ANB (°)	2.75 ± 2.59	3.58 ± 1.97	0.121
Go-GN to SN (°)	27.71 ± 6.01	29.43 ± 3.97	0.153
U1–NA (°)	22.07 ± 5.73	21.96 ± 6.49	0.931
U1–NA (mm)	4.23 ± 2.41	4.15 ± 2.39	0.872
L1–NB (°)	25.52 ± 6.88	29.42 ± 5.42	0.008*
L1–NB (mm)	4.93 ± 2.71	6.00 ± 1.87	0.053
Interincisal angle (°)	129.69 ± 9.24	124.98 ± 7.93	0.020*
Occl to SN (°)	14.36 ± 4.47	15.70 ± 4.31	0.186

*Independent samples t-test; * $p < 0.05$ considered statistically significant.*

Downs Analysis:

In table (7), most parameters of the Downs analysis did not show significant differences between genders. However, two notable exceptions were identified. Females displayed significantly higher values for the AB plane angle (N-Pog; AB: 4.38 ± 2.79° vs. 2.04 ± 2.79°, p = 0.001), indicating greater maxillomandibular skeletal discrepancy. Additionally, females demonstrated a significantly steeper occlusal plane cant (Cant to Occl: 5.78 ± 2.85° vs. 4.31 ± 2.85°, p = 0.015). The other variables, including facial angle (N-Pog; fk), Y-axis (S-Pog; fk), mandibular plane inclination (Li-occlusal), incisor mandibular plane angle (IMPA), and upper incisor to A-Pog (Ui; A-Pog), were similar in both groups.

Table 7
Downs Cephalometric Measurements (Males vs. Females)

Variable	Males (n = 34) Mean ± SD	Females (n = 46) Mean ± SD	P-value
N-Pog; fk (°)	91.07 ± 3.64	89.56 ± 3.62	0.056
N-Pog; AB (°)	2.04 ± 2.79	4.38 ± 2.79	0.001*
S-Pog; fk (°)	55.10 ± 2.90	55.94 ± 2.94	0.229
Cant to Occl (°)	4.31 ± 2.85	5.78 ± 2.85	0.015*
Li-occlusal (mm)	67.71 ± 6.95	67.32 ± 6.95	0.785
IMPA (°)	97.42 ± 5.83	97.82 ± 5.83	0.765
Ui; A-Pog (mm)	4.02 ± 1.92	4.51 ± 1.92	0.265

*Independent samples t-test; * p < 0.05 considered statistically significant.*

Discussion

The majority of conventional cephalometric analyses have been developed using normative data derived primarily from Caucasian populations. Consequently, direct application of these standards to Lebanese individuals may lead to inaccurate diagnosis and treatment planning. Ethnic variations in the sagittal and vertical positioning of the maxilla and mandible could significantly influence facial proportions and occlusal relationships thereby affecting clinical interpretation of the different malocclusion patterns. Despite the clinical importance of ethnicity specific standards, only a small number of investigations have evaluated the cephalometric norms in the Lebanese individuals. This study established Lebanese cephalometric norms using three classical analytical systems (Steiner, Ricketts, and Downs) in a sample of 80 subjects (34 males and 46 females) aged 16–30 years.

Interpretation of Skeletal Sagittal Relationships:

Relative to Steiner's Caucasian norm, our Lebanese sample showed comparable SNA values and SNB values in males, indicating an orthognathic jaw position consistent with Caucasian standards. However, the ANB angle (males: 2.75°; females: 3.58°) slightly exceeded the Caucasian norm of 2°, revealing a mild Class II skeletal tendency particularly in females. In agreement with our finding, Hussien et al. (2010) [16] assessed Palestinian subjects through Steiner's analysis which showed distinct SNA, SNB, and ANB values relative to Caucasian norms. There was no gender-stratified data were reported in comparable format to allow direct angular comparison.

Ousehal et al. (2012) [9] evaluated Moroccan subjects and reported SNA of 80.59° ± 3.8° and SNB of 77.68° ± 3.55°, both lower than our Lebanese values (SNA: 83.19° overall; SNB: 80.19° overall), suggesting the Lebanese jaws are positioned more anteriorly relative to the cranial base. Their ANB of

3.11° ± 1.68° was comparable to our overall ANB of 3.23°, indicating both populations share a mild Class II tendency. However, our female subjects showed a slightly more pronounced skeletal discrepancy (3.58°) compared to both our males (2.75°) and the Moroccan mean. Lower incisor proclination exceeded Steiner's norm in both populations, confirming a shared dentoalveolar compensation pattern across Mediterranean Arab groups.

Moreover, Darazé et al.(2017) [17] reported generally retrusive SNA and SNB values relative to Caucasian references, which contrasts with the present study's findings of SNA values comparable to Steiner's norm. This discrepancy is attributable to their inclusion of mixed malocclusion types, which precludes direct normative comparison. The female tendency toward greater facial convexity reported by Darazé et al. is, however, consistent with our finding of a significantly higher ANB in Lebanese females (3.58° vs. 2.75° in males, $p > 0.05$) and greater N-Pog' A in females on Ricketts analysis (2.09 mm vs. 0.57 mm, $P = 0.020$).

Hashim et al. (2020) [18] assessed Qatari females who exhibited higher sagittal cephalometric values than Caucasian norms, a direction of difference opposite to the pattern seen in our Lebanese females, who show ANB values only mildly above the Caucasian norm. This suggests greater maxillomandibular sagittal prominence in the Qatari population compared to Lebanese subjects.

Saadeh et al. (2025) [8] reported SNA values (males: 81.39°; females: 81.28°) and SNB values (males: 79.39°; females: 79.18°) slightly lower than our findings, while their ANB (males: 2.00°; females: 2.10°) closely approximates the Caucasian norm of 2° and falls below our values. Both studies agree on the orthognathic jaw position in Lebanese adults; the mild ANB difference likely reflects sample heterogeneity and differences in measurement software (Dolphin Imaging vs. WebCeph). Their L1–NB angles (males: 24.31°; females: 24.96°) are lower than ours (males: 25.52°; females: 29.42°), particularly for females, suggesting our female subjects exhibit more pronounced lower incisor proclination as compensation for the slightly larger Class II tendency.

Vertical Pattern and Mandibular Plane Inclination

The vertical pattern, as expressed by the mandibular plane angle in the current study, was substantially lower than Steiner's norm of 32° (Go-Gn/SN: males 27.71°; females 29.43°). This hypodivergent pattern was confirmed independently across all three analyses: Ricketts mandibular plane to Frankfort horizontal (19.40°/21.29° vs. norm 26°), lower facial height (42.12°/42.18° vs. norm 47°), Downs Y-axis (mean 55.52° vs. norm 59.4°), and occlusal plane cant (mean 5.17° vs. norm 9.3°). Accordingly, Lebanese adults were consistently more hypodivergent than the Caucasian reference across all analytical systems.

The Moroccan sample (Ousehal et al., 2012) [9] demonstrated a Go-Gn/SN of 35.35° ± 5.65°, which exceeded both Steiner's Caucasian norm (32°) and our Lebanese mean (28.70°) by 3.35° and 6.65°, respectively. This was the most pronounced inter-Arab regional difference identified in the present study:

while Moroccans are hyperdivergent relative to Caucasians, Lebanese adults are hypodivergent, representing fundamentally different vertical facial types within the Arab world.

Yemeni subjects (Daer and Abuaffan, 2016) [19] demonstrated hypodivergent vertical relationships, a direction consistent with the present Lebanese findings. Both populations present with flatter mandibular planes than Caucasian norms, suggesting that hypodivergent growth may characterize certain Arab subgroups independently of their geographic proximity.

Saadeh et al. (2025) [8] reported mandibular plane angles (PP-MP: males 25.51°; females 24.50°) that, while measured using a different reference plane, similarly indicate a normodivergent to mildly hypodivergent pattern. Despite both studies targeting Lebanese adults with normal occlusion, differences in measurement protocols (Go-Gn/SN vs. PP-MP) and software may contribute to the inter-study variation, underscoring the importance of methodological standardization in normative research.

Dentoalveolar Characteristics:

The assessment of the dental protrusion revealed that upper incisor inclination (U1–NA: males 22.07°; females 21.96°) and upper incisor protrusion (U1–NA: males 4.23 mm; females 4.15 mm) were virtually identical to Steiner's norms (22° and 4 mm). In contrast, lower incisor proclination exceeded norms across all three analyses: L1–NB angle in females (29.42°) and males (25.52°) both surpass the norm of 25°; IMPA averaged 97.42° (males) and 97.82° (females) against Downs' norm of 91.4°; and lower incisor inclination to A-Pog (26.09°/27.08°) exceeded Ricketts' norm of 22° by 4–5°. The interincisal angle (males: 129.69°; females: 124.98°) fell below Steiner's norm of 131°, consistent with the increased lower incisor proclination.

In agreement with our Lebanese findings, Moroccan subjects [9] similarly showed lower incisor to NB values exceeding Steiner's norms in both degrees (28.17° ± 5.29° vs. norm 25°) and millimeters (6.64 ± 2.23 mm vs. norm 4 mm). Both populations share compensatory lower incisor proclination despite their differing vertical patterns, suggesting this dentoalveolar adaptation is a common response to mild Class II skeletal tendency in Mediterranean Arab groups.

Also, El Hayeck et al. (2016) [20] reported greater lip prominence in Lebanese adults relative to Western standards. This soft-tissue finding is directly consistent with the lower incisor proclination documented in the present study, as more labially inclined incisors support fuller lip posture, providing cross-analytical convergent validity for the dentoalveolar pattern identified here.

Moreover, Saadeh et al. (2025) 8 reported L1–NB angles of 24.31° (males) and 24.96° (females), lower than our values (25.52° and 29.42°, respectively). Agreement exists for males, where the difference was marginal (1.21°). The more substantial female discrepancy (4.46°) suggests that our female subjects exhibited greater lower incisor proclination, consistent with their larger ANB angle and the compensatory dentoalveolar mechanism it implies.

Gender Dimorphism:

Gender dimorphism in the present study was limited to specific parameters; males showed significantly greater SNB (81.28° vs. 79.31°, p = 0.023); females showed significantly greater L1–NB angle (29.42° vs. 25.52°, p = 0.008), smaller interincisal angle (124.98° vs. 129.69°, p = 0.020), greater facial convexity on Ricketts (N-Pog' A: 2.09 mm vs. 0.57 mm, p = 0.020), and greater lower incisor protrusion on Ricketts (A-Pog/LI: 2.70 mm vs. 1.46 mm, p = 0.003). On the Downs analysis, females displayed a significantly larger AB plane angle (N-Pog; AB: 4.38° vs. 2.04°, p = 0.001) and a steeper occlusal plane cant (5.78° vs. 4.31°, p = 0.015). No gender differences exist in the classical Caucasian normative values for these parameters, confirming that gender dimorphism is a population-specific characteristic of the Lebanese sample.

Ousehal et al. (2012) [9] reported sex-stratified Steiner values for Moroccan subjects, similarly identifying no statistically significant sex differences in dentoalveolar parameters. Darazé et al. (2017) 17 and Saadeh et al. (2025) [8] both confirmed that Lebanese females exhibit greater facial convexity and more prominent soft-tissue profiles, in agreement with the present findings.

Ayoub et al. (2008, 2009) [21,22] established the existence of significant craniofacial gender dimorphism in Lebanese adults at the population level, providing the earliest corroboration of this pattern.

Collectively, the consistent finding of sex-differentiated dentoalveolar and convexity parameters across Lebanese studies argues for gender-specific normative reference values as standard practice in Lebanese orthodontic diagnosis.

Conclusion

The Lebanese sample demonstrated overall skeletal relationships that are close to classical Steiner norms, with a mild Class II tendency reflected by the ANB angle. Males exhibited significantly greater mandibular prominence compared to females, although the overall sagittal discrepancy did not differ significantly between genders. The mandibular plane angle indicated a more horizontal pattern than both Caucasian norms. Gender dimorphism exists in the Lebanese population, with males showing greater mandibular prominence and females demonstrating greater lower incisor proclination and facial profile convexity.

Declarations

Ethics approval and consent to participate The approval was obtained from the research ethical committee of Beirut Arab University. Each patient signed a written informed consent to participate in this study (IRB number: 2025-H0182-D-M-0872).

Author contributions

Doha al dujeili: Conceptualization, Methodology, Investigation, Writing – Original Draft, Visualization.

Aly Osman: Supervision, Project Administration, Resources, Funding Acquisition, Writing – Review & Editing.

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Figures

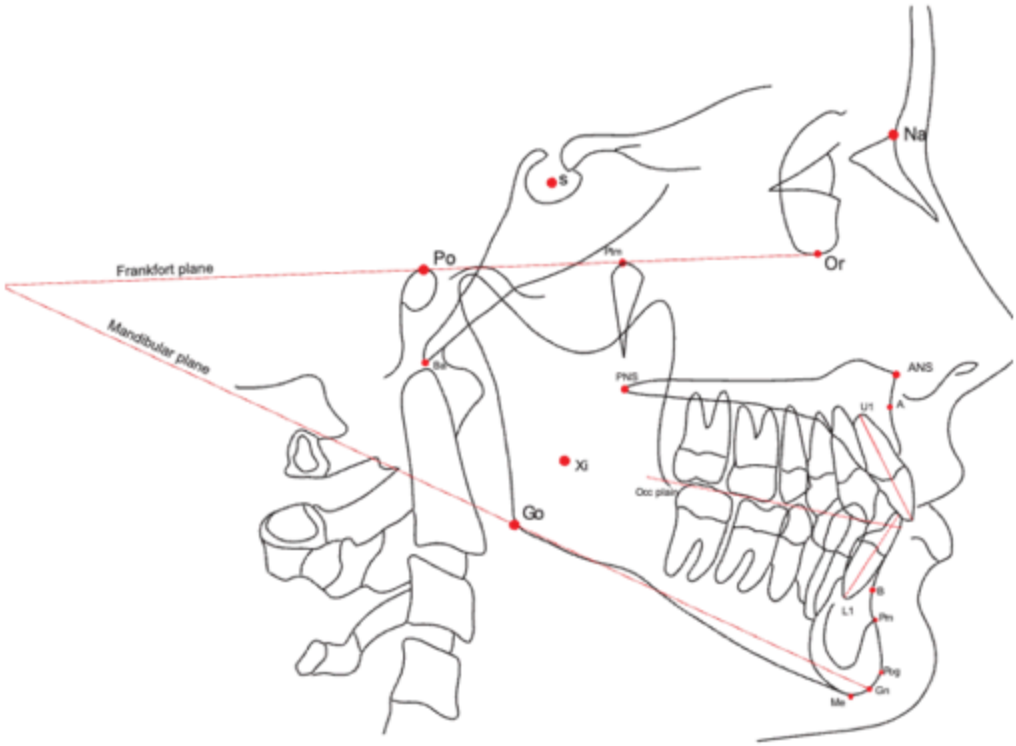


Figure 1

Lateral cephalometric radiograph illustrating the hard tissue landmarks used in Downs, Steiner, and Ricketts analyses in the present study.

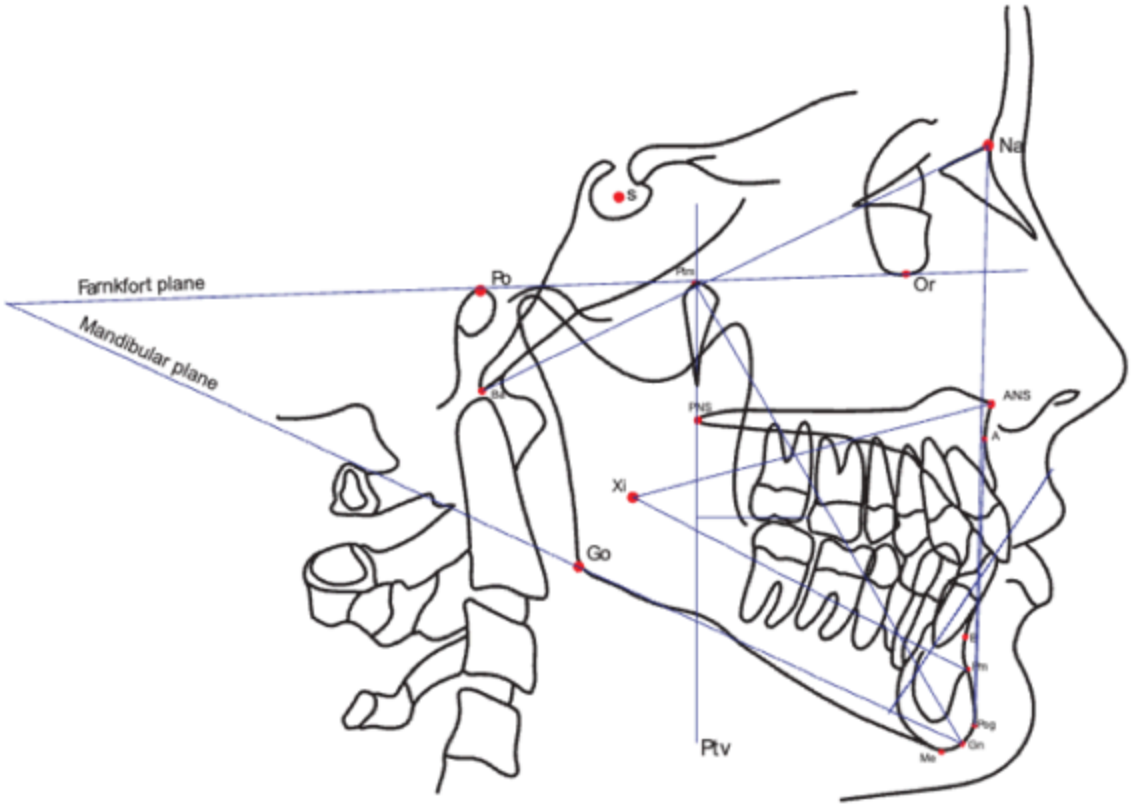


Figure 2

Lateral cephalometric diagram illustrating the hard tissue landmarks used Ricketts analyses in the present study.

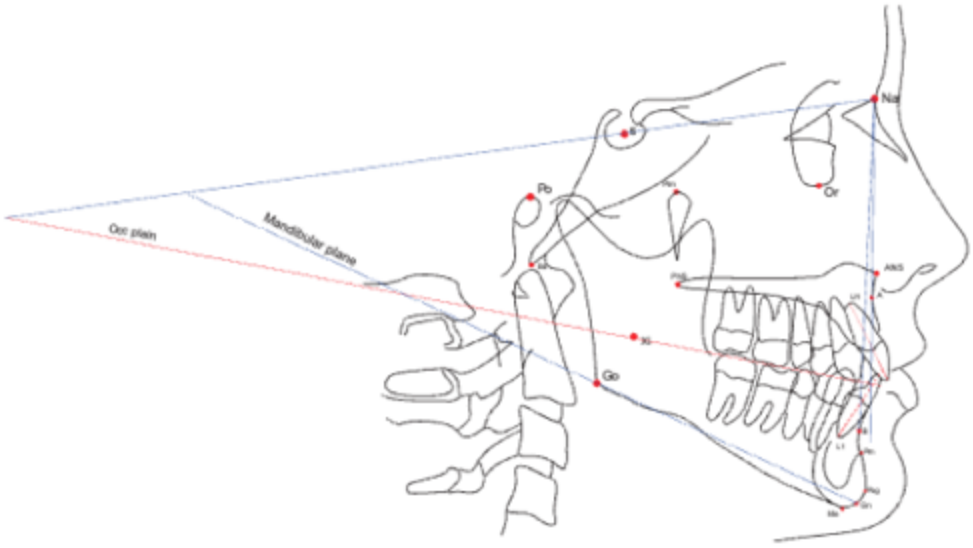


Figure 3

Lateral cephalometric diagram illustrating the hard tissue landmarks used Steiner analyses in the present study.

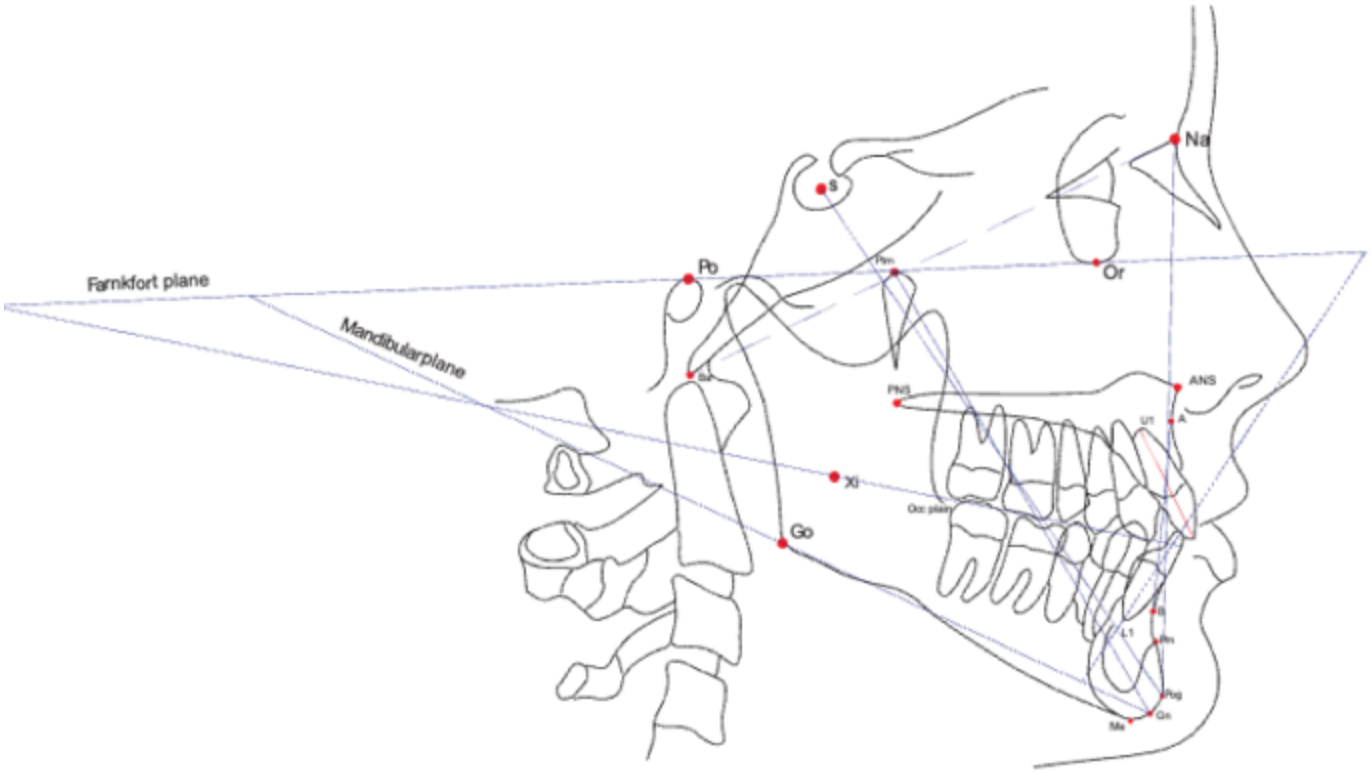


Figure 4

Lateral cephalometric diagram illustrating the hard tissue landmarks used Downs analyses in the present study.