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Tomographic Evaluation of the Nasal Floor and the Anterior Maxillary Region in Relation to Skeletal Class, Facial Profile, and Sex

Evaluación Tomográfica del Piso Nasal y de la Región Anterior del Maxilar en Relación con la Clase Esqueletal, el Perfil Facial y el Sexo

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SUMMARY: This study analyzed morphometric variations of the nasal floor and the anterior maxillary region using cone-beam computed tomography (CBCT), evaluating their relationship with skeletal class, facial profile, and sex. The methodology consisted of the analysis of 540 CBCT scans distributed according to skeletal class (I, II, and III), facial profile (straight, convex, and concave), and sex, with 30 subjects in each group combination. In each study, measurements of middle nasal thickness, incisor bone thickness at 3 mm, 6 mm, and 9 mm rom the alveolar crest, anterior bone height, alveolar inclination, distance from the nasal surface to the anterior buccal cortical plate, palatal-nasal height, and nasopalatine canal length were performed. The results showed that incisor bone thickness, alveolar inclination, palatal-nasal height, and nasopalatine canal length were the variables that exhibited the most consistent behavior among groups, whereas middle nasal thickness and anterior bone height showed greater variability. In general, several linear values were higher in men than in women, particularly in some class III subgroups, whereas the most marked differences among skeletal classes and facial profiles tended to be observed in concave profiles and in certain class II and III subgroups. These findings highlight the importance of considering skeletal class, facial profile, and sex in the morphometric evaluation of the nasal floor and the anterior maxillary region, since its analysis by CBCT may provide useful information for more accurate diagnostic and therapeutic planning in the premaxillary region.

KEY WORDS: Nasal floor; Anterior maxilla; Skeletal class; Facial profile; Cone-beam computed tomography.

INTRODUCTION

The anterior maxillary region is an area of considerable anatomical and clinical interest, as it contains structures that are essential for implant, orthodontic, and surgical planning, including the nasal floor, the alveolar process, the buccal cortical plate, and the nasopalatine canal. The morphology and spatial arrangement of these elements may influence the amount of available bone, the trajectory of implant placement, tooth movement, and the safety of various procedures performed in the premaxillary region. In this regard, cone-beam computed tomography (CBCT) has proven to be a useful tool for the three-dimensional evaluation of this region, as it allows precise analysis of bone anatomy and its individual morphometric variability (Milanovic & Vasiljevic, 2021; Özeren Kes¸kek *et al*., 2022; Chatzipetros *et al*., 2023).

Recent studies have documented that the nasopalatine canal and the anterior maxillary bone exhibit morphological and dimensional variations associated with factors such as sex, age, and local anatomical pattern. Milanovic and Vasiljevic (2021), observed sex-related differences in the anatomical and morphometric characteristics of the nasopalatine canal and the anterior maxillary bone, whereas Arnaut *et al*. (2021), reported that canal shape may be a relevant factor in planning orthodontic movement of the anterior teeth. Complementarily, Vasiljevic *et al*. (2021), described the presence of accessory canals in the anterior maxilla and their relationship with nasopalatine canal type, thereby expanding the anatomical complexity of this region and reinforcing the need for detailed tomographic assessment prior to any clinical intervention.

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Subsequently, Özeren Keskek *et al.* (2022), confirmed by CBCT that the anatomy and dimensions of the nasopalatine canal show considerable variability across different planes of observation, whereas Bermúdez-Pérez *et al*. (2023), evaluated the incisive canal and related osseous structures, such as the length and width of the bone anterior to the canal, revealing important differences that may affect bone availability in the anterior region. Similarly, Kuc *et al*. (2023), analyzed the anatomical variability of the incisive canal and its relationship with age, sex, and the position of the maxillary central incisors, highlighting the diagnostic importance of this structure in orthodontic and maxillofacial contexts.

In 2023, Chatzipetros *et al*., simultaneously evaluated the morphology of the nasopalatine canal and the adjacent buccal cortical plate in a consecutive series of patients, finding that certain dimensions were greater in men and that dental status could also modify the local anatomy. Likewise, Alasmari (2023), reported that anatomical and morphological variations of the nasopalatine canal were associated with sex- and age-related differences in a retrospectively assessed CBCT sample. More recently, Firincioglulari and Orhan (2024), showed that nasopalatine canal morphology is related to the thickness of the anterior maxillary buccal bone, reinforcing the idea that analysis of this region should consider both the canal and the surrounding bone.

Despite these advances, most recent evidence has focused primarily on the morphology of the nasopalatine canal, its relationship with the anterior buccal bone, or isolated demographic variables such as sex, age, or dental status. Studies simultaneously integrating the analysis of the nasal floor, bone thickness at different levels of the incisor, anterior bone height, alveolar inclination, the distance from the nasal surface to the anterior buccal cortical plate, palatal-nasal height, and nasopalatine canal length, while also considering their possible relationship with skeletal class, facial profile, and sex, are less frequent. This limitation justifies the development of studies aimed at a broader morphometric characterization of the anterior maxillary region, as this type of information may contribute to more accurate diagnostic and therapeutic planning in procedures performed in the premaxillary area.

Therefore, the aim of the present study was to perform a tomographic evaluation of the nasal floor and the anterior maxillary region in relation to skeletal class, facial profile, and sex using cone-beam computed tomography.

MATERIAL AND METHOD

An observational, retrospective, comparative, and cross-sectional study was conducted through the analysis of cone-beam computed tomography (CBCT) scans obtained from the database of patients treated at the Faculty of Stomatology, Autonomous University of San Luis Potosí. The sample consisted of 540 tomographic studies distributed according to skeletal class (I, II, and III), facial profile (straight, convex, and concave), and sex (female and male), with 30 subjects in each group combination.

The images corresponded to diagnostically acquired scans archived institutionally and were analyzed using BlueSky Plan® software (Blue Sky Bio, Grayslake, IL, USA), which allows multiplanar reconstructions in the axial, coronal, and sagittal planes, as well as linear and angular measurements of craniofacial structures. Prior to measurement, all tomographic images were standardized in the three spatial planes to obtain a homogeneous orientation of the anterior maxillary region and the nasal floor, thereby reducing errors derived from volume positioning.

In each tomographic scan, the anterior maxillary region was identified and the following morphometric variables were recorded: middle nasal thickness (ENM); incisor bone thickness at 3 mm, 6 mm, and 9 mm from the alveolar crest (EOI-3, EOI-6, and EOI-9); anterior bone height (AOA); alveolar inclination (IA); distance from the nasal surface to the anterior buccal cortical plate (DNCA); palatal-nasal height (APN); and nasopalatine canal length (LCN). Linear measurements were recorded in millimeters (mm), and the angular measurement was recorded in degrees (°). The location of reference points and planes was established uniformly in all images to ensure comparability among groups.

Only tomographic scans with adequate image quality, clearly identifiable anatomical structures in the anterior maxillary region, permanent dentition in the area of interest, and sufficient cephalometric records to determine both skeletal class and facial profile were included. Scans with artifacts, distortions, a history of surgery in the anterior maxillary region, tooth loss in the evaluated area, bone lesions, or any condition compromising measurement accuracy were excluded.

Skeletal class was determined using the ANB angle, formed by Nasion, Point A, and Point B. Subjects were classified as Class I when the ANB angle ranged from 0° to 4°, Class II when the ANB angle was greater than 4°, and Class III when the ANB angle was lower than 0° (Fig. 1). Facial profile was classified according to the soft tissue facial contour as straight, convex, or concave (Fig. 2). All measurements were performed under standardized conditions by a previously calibrated observer. To assess reproducibility, a subsample of tomographic scans was

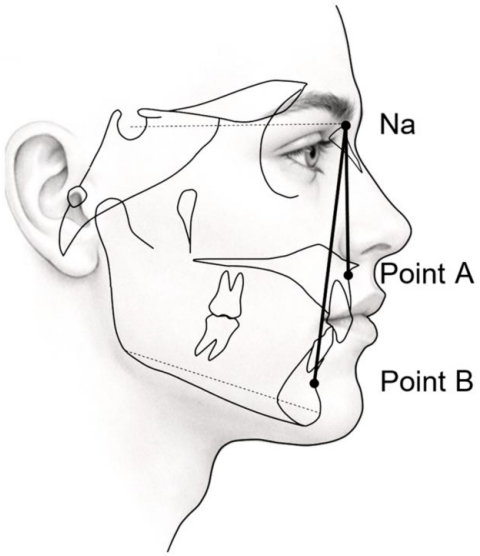


Fig. 1. Cephalometric landmarks used for skeletal class determination. Nasion (Na), Point A, and Point B are shown as reference points for sagittal skeletal evaluation through the ANB relationship.

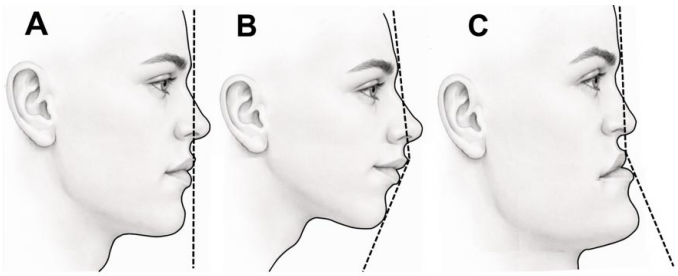


Fig. 2. Facial profile classification according to the soft tissue contour. (A) Straight profile, (B) convex profile, and (C) concave profile.

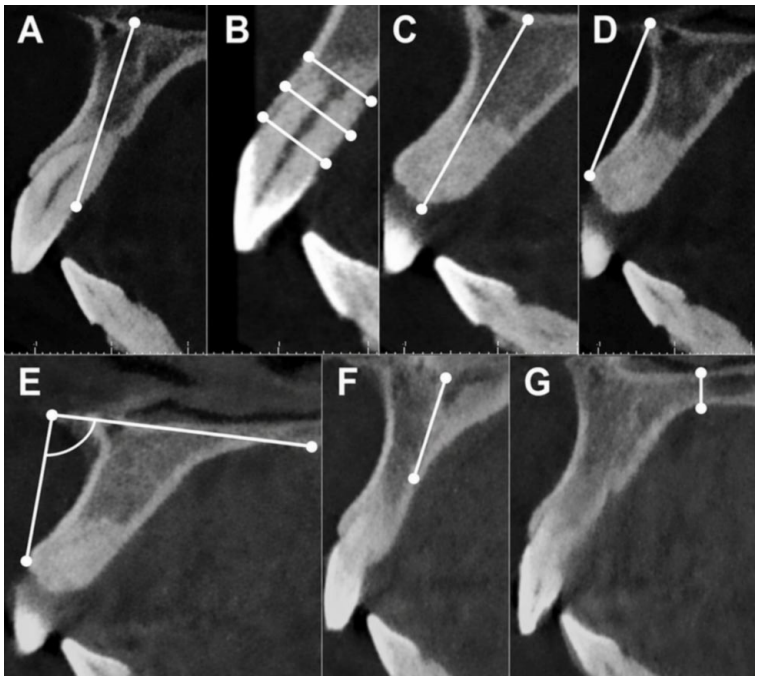


Fig. 3. Tomographic measurements performed in the anterior maxillary region on sagittal CBCT sections. (A) Middle nasal thickness (ENM). (B) Incisor bone thickness measured at 3, 6, and 9 mm from the alveolar crest (EOI-3, EOI-6, and EOI-9). (C) Anterior bone height (AOA). (D) Distance from the nasal surface to the anterior buccal cortical plate (DNCA). (E) Alveolar inclination (IA). (F) Nasopalatine canal length (LCN). (G) Palatal-nasal height (APN).

measured again at two different time points. Intraobserver and interobserver agreement were determined using the intraclass correlation coefficient (ICC). The ICC values demonstrated excellent reproducibility, with intraobserver and interobserver agreement values of 0.95 and 0.91, respectively. (Fig. 3).Fig. 2. Facial profile classification according to the soft tissue contour. (A) Straight profile, (B) convex profile, and (C) concave profile.

Statistical analysis was performed using MINITAB Statistical Software, version 17 (Minitab Inc., State College, PA, USA). Data normality was assessed using the Shapiro-Wilk test. Descriptive statistics were obtained for each group and expressed as mean ± standard deviation. Comparisons among facial profiles within each skeletal class and among skeletal classes within each facial profile were performed using parametric or nonparametric tests according to data distribution. For variables with normal distribution, one-way ANOVA followed by post hoc comparisons was used; for variables without normal distribution, the Kruskal-Wallis test and pairwise comparisons were applied as appropriate. For comparisons between females and males within the same skeletal class and facial profile, the independent-samples Student's t test or the Mann-Whitney U test was used according to the distribution of each variable. Statistical significance was set at $p \leq 0.05$.

RESULTS

Descriptive statistics were obtained for the morphometric variables evaluated in the nasal floor and anterior maxillary region, including middle nasal thickness, incisor bone thickness at 3 mm, 6 mm, and 9 mm from the alveolar crest, anterior bone height, alveolar inclination, distance from the nasal surface to the anterior buccal cortical plate, palatal-nasal height, and nasopalatine canal length (Table I). In general, the highest values for several linear variables were observed in the male groups, particularly in skeletal class III with a straight profile, in which middle nasal thickness, anterior bone height,

Table I. Descriptive statistics.

Sex	Class	Profile	ENM	EOI-3	EOI-6	EOI-9	AOA	IA	DNCA	APN	LCN
Female	I	**Straight**	21.98 ± 3.37	6.71 ± 1.28	7.26 ± 1.59	6.82 ± 1.47	20.72 ± 3.01	51.12 ± 4.45	19.80 ± 2.26	3.63 ± 1.24	11.19 ± 1.68
		Convex	20.44 ± 3.46	6.36 ± 1.62	6.84 ± 1.89	6.40 ± 1.61	19.81 ± 3.60	53.43 ± 5.41	18.16 ± 3.35	3.88 ± 0.99	11.14 ± 1.63
		Concave	14.20 ± 3.20	5.49 ± 1.30	7.26 ± 1.60	8.71 ± 1.50	14.84 ± 3.10	59.36 ± 4.80	15.93 ± 2.40	3.07 ± 1.00	9.63 ± 1.70
	II	**Straight**	21.73 ± 2.76	7.50 ± 0.94	7.03 ± 0.82	7.04 ± 1.14	21.33 ± 2.30	54.53 ± 2.30	20.20 ± 2.41	4.22 ± 1.49	12.67 ± 1.43
		Convex	21.54 ± 4.62	6.01 ± 1.25	6.16 ± 1.35	6.16 ± 1.14	20.51 ± 5.05	49.94 ± 5.94	19.71 ± 4.78	3.01 ± 1.27	11.41 ± 3.24
		Concave	21.66 ± 4.70	6.37 ± 1.10	7.26 ± 1.56	7.17 ± 1.99	20.63 ± 4.64	50.73 ± 6.07	19.73 ± 4.05	3.25 ± 0.66	12.13 ± 2.83
	III	**Straight**	22.15 ± 1.96	7.17 ± 0.65	7.44 ± 0.60	6.88 ± 1.11	21.81 ± 2.74	50.15 ± 5.11	19.01 ± 1.84	4.68 ± 0.27	11.64 ± 1.93
		Convex	19.48 ± 1.53	6.97 ± 1.04	6.75 ± 1.79	7.16 ± 1.94	19.73 ± 1.08	53.26 ± 1.31	18.18 ± 0.78	4.43 ± 1.33	10.79 ± 1.95
		Concave	18.45 ± 4.36	6.42 ± 0.34	6.81 ± 1.40	6.26 ± 1.48	18.55 ± 2.36	48.51 ± 1.67	16.31 ± 2.12	2.21 ± 0.98	9.25 ± 1.48
Male	I	**Straight**	21.43 ± 2.44	7.91 ± 2.05	7.87 ± 1.43	7.57 ± 1.42	20.94 ± 3.17	54.05 ± 5.18	18.11 ± 2.50	3.95 ± 1.31	11.93 ± 2.24
		Convex	21.38 ± 2.94	6.28 ± 0.90	7.07 ± 1.01	7.27 ± 1.25	20.57 ± 3.34	52.23 ± 6.06	19.23 ± 3.09	4.17 ± 1.10	13.69 ± 1.73
		Concave	19.69 ± 2.80	9.59 ± 1.80	8.89 ± 1.60	8.13 ± 1.50	19.27 ± 3.00	49.46 ± 4.90	17.24 ± 2.40	1.92 ± 1.10	12.30 ± 1.80
	II	**Straight**	21.76 ± 2.68	7.14 ± 1.06	7.70 ± 1.76	7.74 ± 2.18	20.96 ± 2.73	51.62 ± 3.48	19.48 ± 3.07	4.10 ± 2.07	12.34 ± 2.48
		Convex	23.12 ± 3.28	7.37 ± 0.86	7.55 ± 1.09	7.84 ± 1.04	21.73 ± 3.00	53.56 ± 4.54	19.67 ± 2.80	3.84 ± 1.23	12.86 ± 1.63
		Concave	22.20 ± 3.10	7.05 ± 1.20	7.31 ± 1.42	7.52 ± 1.35	21.30 ± 2.85	52.48 ± 4.10	19.36 ± 2.96	4.62 ± 1.16	13.41 ± 2.05
	III	**Straight**	22.84 ± 2.91	6.64 ± 0.59	7.75 ± 0.29	7.56 ± 0.42	22.72 ± 3.04	58.03 ± 0.31	20.79 ± 3.61	4.12 ± 0.71	14.95 ± 1.80
		Convex	22.41 ± 1.79	7.54 ± 0.84	7.38 ± 0.78	7.45 ± 0.48	21.45 ± 1.58	52.22 ± 2.55	19.13 ± 2.18	3.57 ± 1.04	12.46 ± 2.03
		Concave	21.09 ± 3.60	6.54 ± 2.27	6.97 ± 2.58	7.22 ± 1.78	21.22 ± 3.98	56.89 ± 3.37	20.10 ± 4.72	5.73 ± 0.68	14.07 ± 4.57

Abbreviations: ENM = middle nasal thickness; EOI-3 = incisor bone thickness at 3 mm from the alveolar crest; EOI-6 = incisor bone thickness at 6 mm from the alveolar crest; EOI-9 = incisor bone thickness at 9 mm from the alveolar crest; AOA = anterior bone height; IA = alveolar inclination; DNCA = distance from the nasal surface to the anterior buccal cortical plate; APN = palatal-nasal height; LCN = nasopalatine canal length. Data are expressed as mean ± standard deviation.

alveolar inclination, and nasopalatine canal length were especially notable. In contrast, some of the lowest values were recorded in females with a concave profile, especially in class I, where lower values of middle nasal thickness, anterior bone height, and nasopalatine canal length were observed, together with relatively greater alveolar inclination. Overall, the concave profile showed greater morphometric variability than the straight and convex profiles.

When facial profiles were compared within each skeletal class (Table II), statistically significant differences in class I females were identified mainly in comparisons involving the concave profile, particularly for middle nasal thickness, incisor bone thickness at 3 mm and 9 mm, anterior bone height, alveolar inclination, distance from the nasal surface to the anterior buccal cortical plate, palatal-nasal height, and nasopalatine canal length. In class II females, significant differences were observed mainly in incisor bone thickness at 3 mm, 6 mm, and 9 mm, as well as in alveolar inclination and palatal-nasal height. In class III females, the most evident differences were again concentrated in comparisons involving the concave profile, especially for middle nasal thickness, anterior bone height, alveolar inclination, distance from the nasal surface to the anterior cortical plate, palatal-nasal height, and nasopalatine canal length. In males, differences among profiles within class I were more noticeable in incisor bone thickness at 3 mm, 6 mm, and 9 mm, as well as in alveolar inclination, palatal-nasal height, and nasopalatine canal length. In class II, differences among profiles were limited and were mainly restricted to alveolar inclination. In class III, the most consistent differences were found in alveolar inclination and palatal-nasal height, especially among the straight, convex, and concave profiles.

Table II. Comparison among facial profiles within each skeletal class.

Sex	Class	Profile	ENM	EOI-3	EOI-6	EOI-9	AOA	IA	DNCA	APN	LCN
Female	**I**	**Straight *vs.* Convex**	0.18	0.29	0.44	0.21	0.25	0.07	0.08	0.39	0.91
		Straight *vs.* Concave	**<0.001***	**0.001***	0.99	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**0.005***	**<0.001***
		Convex *vs.* Concave	**<0.001***	**0.004***	0.43	**<0.001***	**<0.001***	**<0.001***	**0.002***	**0.03***	**<0.001***
	II	**Straight *vs.* Convex**	0.91	**0.003***	0.07	**0.02***	0.56	**0.02***	0.77	**<0.001***	0.18
		Straight *vs.* Concave	0.95	**0.02***	**0.04***	0.26	0.63	**0.04***	0.81	**0.001***	0.57
		Convex *vs.* Concave	0.98	0.33	**0.01***	0.10	0.95	0.61	0.99	0.46	0.39
	III	**Straight *vs.* Convex**	**0.003***	0.61	0.39	0.58	**0.01***	0.08	0.21	0.44	0.18
		Straight *vs.* Concave	**<0.001***	**0.01***	0.06	0.09	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***
		Convex *vs.* Concave	0.32	0.19	0.52	0.21	0.07	**0.004***	**0.02***	**<0.001***	**0.01***
Male	**I**	**Straight *vs.* Convex**	0.94	**0.001***	0.10	0.39	0.61	0.23	0.17	0.46	**0.001***
		Straight *vs.* Concave	0.09	**0.02***	**0.01***	0.08	0.12	**0.01***	0.34	**<0.001***	0.55
		Convex *vs.* Concave	0.11	**<0.001***	**0.02***	**0.04***	0.22	**0.03***	**0.02***	**<0.001***	0.08
	II	**Straight *vs.* Convex**	0.07	0.29	0.68	0.82	0.31	0.09	0.80	0.61	0.36
		Straight *vs.* Concave	0.18	0.11	0.24	0.31	0.15	**0.04***	0.27	0.07	0.09
		Convex *vs.* Concave	0.41	0.36	0.58	0.63	0.47	0.13	0.49	0.12	0.28
	III	**Straight *vs.* Convex**	0.11	0.08	0.39	0.66	0.19	**<0.001***	0.16	**0.001***	0.07
		Straight *vs.* Concave	0.10	0.74	0.44	0.81	0.37	**0.01***	0.28	**<0.001***	0.18
		Convex *vs.* Concave	0.30	0.21	0.63	0.74	0.55	**0.002***	0.41	**0.01***	0.29

Abbreviations: ENM = middle nasal thickness; EOI-3 = incisor bone thickness at 3 mm from the alveolar crest; EOI-6 = incisor bone thickness at 6 mm from the alveolar crest; EOI-9 = incisor bone thickness at 9 mm from the alveolar crest; AOA = anterior bone height; IA = alveolar inclination; DNCA = distance from the nasal surface to the anterior buccal cortical plate; APN = palatal-nasal height; LCN = nasopalatine canal length. Values correspond to p-values for pairwise comparisons among facial profiles within each skeletal class. Bold values indicate statistically significant differences. * $p \leq 0.05$.

Table III. Comparison among skeletal classes within each facial profile.

Sex	Profile	Class	ENM	EOI-3	EOI-6	EOI-9	AOA	IA	DNCA	APN	LCN
Female	**Straight**	**I *vs.* II**	0.81	**0.01***	0.63	0.96	0.54	**0.01***	0.61	**0.01***	**0.02***
		I *vs.* III	0.78	**0.004***	0.88	0.84	0.36	0.41	0.48	**0.01***	0.63
		II *vs.* III	0.92	0.39	0.57	0.71	0.68	**0.02***	0.77	0.17	0.11
	Convex	**Clase I *vs.* II**	0.34	**0.02***	0.29	0.44	0.56	**0.003***	0.41	**0.001***	0.26
		Clase I *vs.* III	0.20	0.97	0.94	0.17	0.39	0.89	0.99	0.28	0.58
		Clase II *vs.* III	0.15	0.09	0.20	0.32	0.63	**0.01***	0.52	**0.004***	0.41
	Concave	**Clase I *vs.* II**	**0.01***	0.27	0.95	0.18	**0.03***	**<0.001***	0.08	0.07	0.11
		Clase I *vs.* III	**0.02***	0.43	0.77	0.10	**0.04***	**<0.001***	0.05	0.06	**0.04***
		Clase II *vs.* III	0.77	0.69	0.62	0.54	0.69	**0.004***	0.19	0.29	0.09
Male	**Straight**	**Clase I *vs.* II**	0.61	0.19	0.92	0.78	0.98	0.07	0.36	0.84	0.73
		Clase I *vs.* III	0.17	**0.003***	0.81	0.69	0.12	**<0.001***	0.14	0.53	**0.01***
		Clase II *vs.* III	0.28	**0.01***	0.73	0.84	0.21	**0.001***	0.32	0.48	**0.02***
	Convex	**Clase I *vs.* II**	0.09	**<0.001***	0.18	0.28	0.24	0.57	0.88	0.09	0.22
		Clase I *vs.* III	0.11	**0.001***	0.22	0.33	0.41	0.60	0.69	0.06	0.31
		Clase II *vs.* III	0.42	0.78	0.49	0.70	0.62	0.76	0.74	0.27	0.57
	Concave	**Clase I *vs.* II**	0.26	0.08	0.11	0.33	0.41	0.06	0.21	0.07	0.42
		Clase I *vs.* III	0.22	**0.01***	**0.01***	0.18	0.21	**0.003***	0.08	**<0.001***	0.31
		Clase II *vs.* III	0.31	**0.04***	**0.03***	0.29	0.36	**0.02***	0.17	**0.004***	0.38

Abbreviations: ENM = middle nasal thickness; EOI-3 = incisor bone thickness at 3 mm from the alveolar crest; EOI-6 = incisor bone thickness at 6 mm from the alveolar crest; EOI-9 = incisor bone thickness at 9 mm from the alveolar crest; AOA = anterior bone height; IA = alveolar inclination; DNCA = distance from the nasal surface to the anterior buccal cortical plate; APN = palatal-nasal height; LCN = nasopalatine canal length. Values correspond to p-values for pairwise comparisons among skeletal classes within each facial profile. Bold values indicate statistically significant differences. * $p \leq 0.05$.

When skeletal classes were compared within each facial profile (Table III), significant differences were observed in females with a straight profile for incisor bone thickness at 3 mm, alveolar inclination, palatal-nasal height, and nasopalatine canal length. In the convex profile, differences were concentrated mainly in incisor bone thickness at 3 mm, alveolar inclination, and palatal-nasal height. In the concave profile, the variables showing the clearest differences were middle nasal thickness, anterior bone height, and alveolar inclination. In males with a straight profile, differences among classes were identified mainly in incisor bone thickness at 3 mm, alveolar inclination, and nasopalatine canal length, particularly when comparing class I with class III and class II with class III. In the convex profile, incisor bone thickness at 3 mm was the variable showing the most consistent behavior among classes. In the concave profile, differences were concentrated in incisor bone thickness at 3 mm and 6 mm, alveolar inclination, and palatal-nasal height, suggesting that this profile may be more sensitive to skeletal variations in the anterior maxillary region.

When females and males were compared within the same skeletal class and facial profile (Table IV), statistically significant differences were observed in specific groups. In class I, differences were identified in the straight profile for incisor bone thickness at 3 mm and 9 mm, alveolar inclination, and distance from the nasal surface to the anterior buccal cortical plate; in the convex profile, differences were observed in incisor bone thickness at 9 mm and nasopalatine canal length; whereas in the concave profile, differences were identified in incisor bone thickness at 3 mm and palatal-nasal height. In class II, the convex profile showed the highest number of differences between sexes, particularly in incisor bone thickness at 3 mm, 6 mm, and 9 mm, alveolar inclination, palatal-nasal height, and nasopalatine canal length. In class III, the straight profile showed differences in incisor bone thickness at 9 mm, alveolar inclination, palatal-nasal height, and nasopalatine canal length; the convex profile showed differences in middle nasal thickness, anterior bone height, palatal-nasal height, and nasopalatine canal length; and the concave profile showed differences in middle nasal thickness, incisor bone thickness at 9 mm, anterior bone height, alveolar inclination, distance from the nasal surface to the anterior buccal cortical plate, palatal-nasal height, and nasopalatine canal length. Taken together, these findings indicate that the effect of sex was not uniform but rather depended on the combination of skeletal class and facial profile.

Overall, the results suggest that the variables showing the most consistent behavior across comparisons were incisor bone thickness, alveolar inclination, palatal-nasal height, and nasopalatine canal length. In contrast, some variables, such as middle nasal thickness and anterior bone height, showed a pattern that was more dependent on the specific group evaluated. In general terms, the most marked differences tended to occur in concave profiles and in certain class II and III subgroups, suggesting that the morphometry of the nasal floor and anterior maxillary region is modulated by the interaction among skeletal pattern, facial profile, and sex.

Table IV. Comparison between sexes within the same skeletal class and facial profile.

Class	Profile	ENM	EOI-3	EOI-6	EOI-9	AOA	IA	DNCA	APN	LCN
I	**Straight**	0.47	**0.01***	0.14	**0.04***	0.81	**0.02***	**0.01***	0.34	0.08
	Convex	0.33	0.77	0.40	**0.02***	0.52	0.27	0.14	0.41	**<0.001***
	Concave	0.18	**0.05***	0.11	0.37	0.16	0.06	0.10	**0.03***	0.09
II	**Straight**	0.97	0.26	0.13	0.26	0.72	**0.01***	0.55	0.81	0.58
	Convex	0.09	**<0.001***	**<0.001***	**<0.001***	0.28	**0.01***	0.96	**0.05***	**0.03***
	Concave	0.42	0.19	0.27	0.31	0.48	0.08	0.67	**0.04***	0.21
III	**Straight**	0.52	0.11	0.17	**0.05***	0.35	**<0.001***	0.08	**0.05***	**<0.001***
	Convex	**<0.001***	0.07	0.16	0.60	**0.001***	0.45	0.13	**<0.001***	**0.003***
	Concave	**0.02***	0.80	0.73	**0.04***	**0.006***	**<0.001***	**0.002***	**<0.001***	**0.004***

Abbreviations: ENM = middle nasal thickness; EOI-3 = incisor bone thickness at 3 mm from the alveolar crest; EOI-6 = incisor bone thickness at 6 mm from the alveolar crest; EOI-9 = incisor bone thickness at 9 mm from the alveolar crest; AOA = anterior bone height; IA = alveolar inclination; DNCA = distance from the nasal surface to the anterior buccal cortical plate; APN = palatal-nasal height; LCN = nasopalatine canal length. Values correspond to p-values for comparisons between females and males within the same skeletal class and facial profile. Bold values indicate statistically significant differences. * $p \leq 0.05$.*

DISCUSSION

The present study morphometrically evaluated the nasal floor and the anterior maxillary region in relation to skeletal class, facial profile, and sex. In general, the results showed that incisor bone thickness, alveolar inclination, palatal-nasal height, and nasopalatine canal length were the variables that displayed the most consistent differences among groups, whereas middle nasal thickness and anterior bone height showed a more variable pattern. These findings are in agreement with recent studies indicating that the anterior maxillary region presents important anatomical variations according to craniofacial pattern, sex, and local morphology, even when the specific structures evaluated are not exactly the same as those analyzed in the present study (Akkoca & Yes¸ilova, 2023; AlAli *et al*., 2023; Abdul *et al*., 2024; Özarslantürk *et al*., 2025).

Differences among skeletal classes were more evident in certain profiles, particularly in the concave profile and, to a lesser extent, in the straight profile. This pattern supports the notion that the sagittal configuration of the craniofacial complex may influence the morphological expression of the anterior alveolar bone and adjacent structures. Tang *et al*. (2023), reported relevant three-dimensional changes in alveolar bone in subjects with class II open bite, whereas Tunca *et al*. (2025), observed variations in anterior bone thickness and in the presence of bone defects according to malocclusion type. Taken together, these findings suggest that the morphology of the anterior maxillary region may be expressed differently depending on the combination of skeletal class and facial pattern.

One of the most consistent findings of the present study was the behavior of incisor bone thickness and alveolar inclination, variables that showed repeated differences among profiles, among classes, and, in some subgroups, also between sexes. From a clinical point of view, this is relevant because both variables may influence bone availability, implant insertion direction, and the limits of tooth movement. Abdul *et al*. (2024), showed that the sagittal root position of anterior teeth is related to the alveolar cortical plate, whereas Calin *et al*. (2025), indicated that the characteristics of the incisive canal and anterior cortical region may condition the possibility of safe anchorage in the anterior maxilla. These antecedents support the importance of interpreting the anterior alveolar bone as a three-dimensional structure closely linked to facial and skeletal morphology.

The comparison between females and males revealed more evident differences in some class II and III subgroups, especially in variables such as incisor bone thickness, alveolar inclination, palatal-nasal height, and nasopalatine canal length. This pattern is consistent with studies reporting sexual dimorphism in anterior maxillary structures. AlAli *et al*. (2023), observed differences in anterior buccal bone thickness, whereas Piskórz *et al*. (2024), reported sex-related variations in the dimensions of the incisive canal and adjacent bone. Similarly, Özarslantürk *et al*. (2025), found that the dimensions of the nasopalatine canal and associated alveolar bone may vary in patients scheduled for anterior implants. Together, these studies support the notion that sex constitutes a relevant anatomical covariable in the morphometric evaluation of the anterior maxilla.

From a clinical perspective, the results of the present study reinforce the importance of individualized tomographic evaluation of the nasal floor and anterior maxillary region. The observed differences in bone thickness, alveolar inclination, palatal-nasal height, and nasopalatine canal length may influence the planning of implantological, orthodontic, and surgical procedures in the premaxillary region. Among the limitations of the present study, it should be considered that this was a cross-sectional morphometric evaluation based on CBCT; therefore, longitudinal changes cannot be established, nor can it be determined to what extent the differences found are exclusively due to skeletal pattern or to functional and adaptive factors. Nevertheless, the findings of the present study provide useful information for understanding the anatomical variability of the anterior maxillary region and its possible clinical relevance.

CONCLUSION

Morphometric variations of the nasal floor and anterior maxillary region were influenced by the combined effect of skeletal class, facial profile, and sex. The most consistent differences were observed in incisor bone thickness, alveolar inclination, palatal-nasal height, and nasopalatine canal length. Evaluation by cone-beam computed tomography may provide relevant information for clinical planning in the anterior maxillary region.

Conflicts of interest. The authors declare that there are no potential conflicts of interest related to the research, authorship, and/or publication of this article.

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RESUMEN: Este estudio analizó las variaciones morfométricas del piso nasal y de la región anterior del maxilar mediante tomografía computarizada de haz cónico (CBCT),

evaluando su relación con la clase esqueletal, el perfil facial y el sexo. La metodología consistió en el análisis de 540 tomografías distribuidas según clase esqueletal (I, II y III), perfil facial (recto, convexo y cóncavo) y sexo, con 30 sujetos en cada combinación de grupo. En cada estudio se realizaron mediciones de espesor nasal medio, espesor óseo en incisivo a 3 mm, 6 mm y 9 mm desde la cresta alveolar, altura ósea anterior, inclinación alveolar, distancia desde la superficie nasal hasta la tabla vestibular anterior, altura palatino-nasal y longitud del canal nasopalatino. Los resultados mostraron que el espesor óseo en incisivo, la inclinación alveolar, la altura palatino-nasal y la longitud del canal nasopalatino fueron las variables que presentaron el comportamiento más consistente entre grupos, mientras que el espesor nasal medio y la altura ósea anterior mostraron una mayor variabilidad. En general, varios valores lineales fueron mayores en hombres que en mujeres, particularmente en algunos subgrupos de clase III, mientras que las diferencias más marcadas entre clases esqueletales y perfiles faciales tendieron a observarse en los perfiles cóncavos y en ciertos subgrupos de clase II y III. Estos hallazgos resaltan la importancia de considerar la clase esqueletal, el perfil facial y el sexo en la evaluación morfométrica del piso nasal y de la región anterior del maxilar, ya que su análisis mediante CBCT puede aportar información útil para una planeación diagnóstica y terapéutica más precisa en el sector premaxilar.

PALABRAS CLAVE: Piso nasal; Maxilar anterior; Clase esqueletal; Perfil facial; Tomografía computarizada de haz cónico.

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