Cone-beam Computed Tomography-based Investigation of Hard Palate Morphometry in Iraqi Arab and Kurdish Populations - A Retrospective Study

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Abstract

Introduction: The hard palate (HP) has clinical and anthropological significance; nevertheless, there is a paucity of cone-beam computed tomography (CBCT)-derived data for Iraqi populations. The aim of this study was to assess HP linear measurements and indices in Iraqi Arabs and Kurds while exploring gender and ethnic differences as well as the gender predictive potential. **Materials and Methods:** Four hundred CBCT scans (200 Arabs, 200 Kurds; equal distribution of males and females) were analysed for palatal length (PL), palatal breadth (PB), palatal height (PH), palatine index (PI) and palate height index (PHI). Independent *t*-tests, Chi-square testing for differences and binary logistic regression for gender prediction were selected. **Results:** Males from both ethnic groups had greater PL, PB and PH compared to females. Only PB exhibited a statistically significant difference across ethnic groups ($P = 0.000$). Leptostaphyline PI and orthostaphyline PHI were the most prevalent forms. The accuracy of gender prediction was 81% for Arabs and 70% for Kurds, with PB being the most effective predictor, reporting exact *P* values when applicable. **Discussion:** Males had larger palatal dimensions in both populations. Both groups had leptostaphyline PI and orthostaphyline PHI preponderance. Palatal measures are clinically relevant for treatment planning and supportive in forensic and anthropological examinations; however, their use in sex estimate should be considered complementary rather than definitive.

Keywords: Cone-beam computed tomography, hard palate, palatal breadth, palatal height, palatal length

Introduction

The hard palate (HP) is a part of the skull located inside the oral cavity. It is composed of the anterior section of the base, the roof of the mouth and the floor of the nose. It is formed by the maxillary palatine process and the horizontal plates of the palatine bones.[1] Morphological information about the HP is very important in many areas of medicine and dentistry, especially in maxillofacial surgery, forensic anthropology, orthodontics, prosthodontics and otolaryngology. This is especially true when looking at patients before performing nasogastric intubation, nasopharyngoscopy and uvulopalatopharyngoplasty.[2,3]

With strong support from osteological investigations of desiccated skulls, the acquired morphometric data may serve anthropological objectives, including racial and ethnic identification of crania.[2-4] Numerous researchers have examined palatal morphology using various techniques, such as direct measurements of dental casts with calibrated callipers and indirect analysis of two-dimensional projections, such as photographs or X-rays. Each approach has distinct challenges, including inaccuracies and technological complications.[5-7]

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Recent studies have examined the dimensions of the HP using three-dimensional (3D) imaging techniques on patients, specifically cone-beam computed tomography (CBCT), which is favoured for evaluating palatal bone dimensions and volume due to its capacity to provide precise and reliable data regarding osseous structures and adjacent vital components.[8,9]

The literature search indicated a scarcity of credible data about the use of 3D images to assess the form of HP in Iraq. It is clinically and anthropologically relevant to compare HP morphometry between Arab and Kurdish populations because population-specific data enhance the precision of treatment planning. This comparison improves forensic interpretation by distinguishing ethnic variance from sexual dimorphism. The research aims to analyse the dimensions and classifications of the HP in an Iraqi population (Arab and Kurd) using 3D geometric morphometrics and to ascertain any ethnic and gender-specific variations.

Materials and Methods

This retrospective cross-sectional study randomly collected CBCT images of the Arabic ethnicity at GAMA Clinics in Baghdad using the Rainbow machine (Rainbow, South Korea), while images of the Kurdish ethnicity were obtained from the FOTON Maxillofacial Imaging Centre in Sulaymaniyah using the Carestream machine (Carestream Company, Germany). Both facilities used identical scanning parameters. The scanning settings included a tube voltage of 120 kVp, a tube current varying from 2 to 15 mA, an image acquisition voxel size of 0.3 mm, a slice thickness of 0.3 mm and a field of view of 16 × 17, with standard patient positioning used throughout scanning in the two CBCT machines. Analyses were mainly interpreted within each population rather than as conclusive inter-ethnic comparisons because the use of two different CBCT systems may introduce inter-device variability related to hardware design and reconstruction algorithms, even though identical scanning parameters were applied. The Radiology Department Archives performed a radiological assessment, and the study was approved by the Ethical Committee at the College of Dentistry, University of Tikrit (reference number 9/2025), issued on September 30, 2025.

A priori power analysis (G*Power 3.1, Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) suggested that with $\alpha = 0.05$, 80% power, odds ratio = 1.6, $Pr(Y = 1 \mid X = 0) = 0.5$ and $R^2 = 0.2$, a minimum of $N = 198$ individuals would be needed (10), the final sample size of 400 CBCT scans (200 Arabs and 200 Kurds) therefore substantially exceeded the minimum required sample, ensuring robust statistical power for the analyses. The sample of 400 CBCT images from individuals (200 Arabs and 200 Kurds, evenly distributed by gender) therefore offered enough power for binary logistic regression (BLR) analysis. Inclusion criteria included Individuals of both genders and both ethnicities between ages 21-65 and individuals with complete dentition (excluding third molars) or missing only one or two teeth that did not interfere with measurements. Exclusion criteria included fully or partially edentulous patients, a history of major medical conditions, trauma or surgery affecting the HP, presence of dental anomalies or the presence of crown and bridge work.[10]

The RadiAnt Imaging viewer programme (Medixant, Poland) version 2025.1 was used for calculating the distance. The measurements were standardised using CBCT scans aligned in the axial view, ensuring that bilateral zygomatic structures were positioned at identical angles and elevations. The bilateral infraorbital foramina were oriented perpendicular to the horizontal axis in the coronal view. In the sagittal view, the Frankfort plane functioned as the true horizontal axis [Figure 1]. To minimise measurement error, all measurements were conducted twice, 1 week apart. The intraclass correlation coefficient (ICC) test was used to assess intra-rater reliability, yielding the following ICC values for average assessments of palatal length (PL), palatal breadth (PB) and palatal height (PH): the ICC values indicated high to exceptional reliability for the three measurements: PL 0.97 (95% confidence interval [CI] range: 0.019–0.995), PB 0.950 (95% CI range: 0.009–0.990) and PH 0.875 (95% CI range: 0.007–0.986).

According to the research conducted by Premkumar in 2011 and Sarilita and Soames in 2015,[11,12] the measurements were carried out as follows:

- The PL was measured from the Orale (the exact midpoint in the line joining the posterior socket borders of both upper central incisors) anterior to the staphylion (a point situated at the base of the posterior nasal spine) posteriorly [Figure 2]
- The PB was measured as the distance obtained between the inner borders of sockets of the upper second molars (endomolar)
- The PH was obtained as the maximum arching of the palate to the level of line drawn between the endomolar points [Figure 3].

The PI was calculated as ‘the palatine breadth-to-length ratio expressed as a percentage (palatine breadth/palatine length) ×100’. In contrast, the PHI was calculated as ‘the palatine height-to-breadth ratio expressed as a percentage (palatine height/palatine breadth) * 100’.[10,11] According to a study by Premkumar in 2011,[11] the PI, palates can be classified as leptostaphyline (narrow palate: <80%), mesostaphyline (intermediate type: 80%–84.9%) and brachystaphyline (wide palate: ≥ 85%). The PHI enables the identification of the arching of the palate. Accordingly, the palate can be classified as chamestaphyline (low palate: <28%), orthostaphyline (intermediate type: 28%–39.9%) and hypsistaphyline (40% or more)’.[10,11]

A descriptive statistical analysis, including mean and standard deviation for the measurements of PL, PB and PH, was conducted. The assessment of data distribution was performed using histograms, Q–Q plots, skewness and

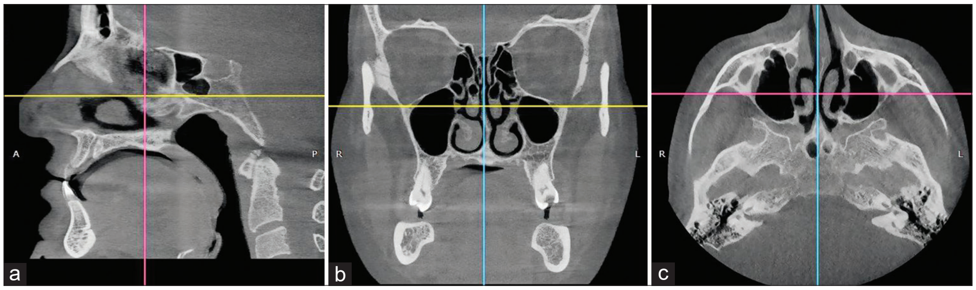

Figure 1: Cone-beam computed tomography (CBCT) images demonstrating standard head orientation across three planes: (a) sagittal view showing the Frankfort horizontal plane aligned as the true horizontal reference; (b) coronal view illustrating that the bilateral infraorbital foramina are symmetrically positioned perpendicular to the horizontal axis; and (c) axial view confirming that the bilateral zygomatic structures are aligned at equivalent angles and elevations, indicating proper head positioning

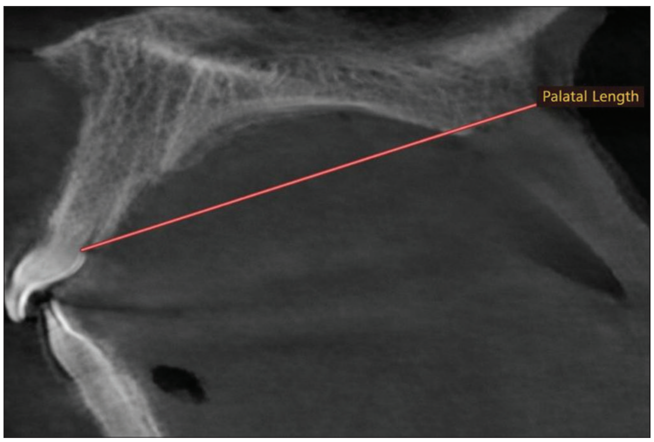

Figure 2: Cone-beam computed tomography sagittal view showing the linear distance measurement of palatal length

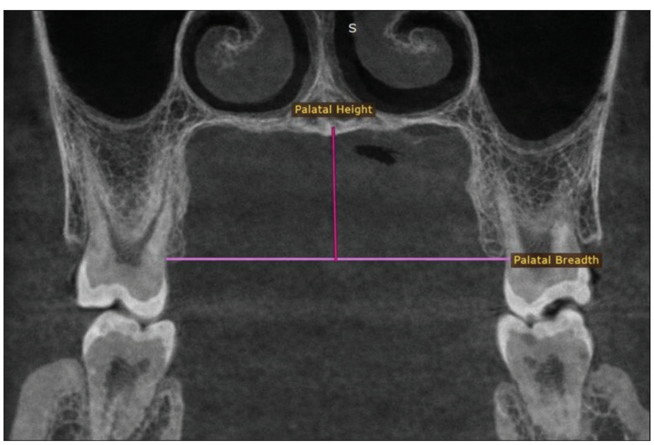

Figure 3: Coronal view showing the linear distance measurements of palatal breadth and palatal height

kurtosis statistics and the Shapiro–Wilk test. The skewness and kurtosis values were within ± 1, indicating approximate normality. Furthermore, because of the substantial sample size (*n* = 400), parametric analysis was conducted despite the significant findings of the Shapiro–Wilk test. An independent *t*-test was used to assess the differences between the Arabic and Kurdish populations, as well as the genders within each group. A Chi-square test was used to demonstrate the differences between the two ethnicities and genders for the categorical variables (PI and PHI).

The potency of palatal measures to predict sex (male = 0, female = 1) was enhanced by BLR. PL, PB and PH functioned as the continuous predictors. PI and PHI are categorical (3 levels each) and were entered into the logistic regression using dummy variables with the first category as reference. For PI: PI (1) =1 if mesostaphyline, 0 otherwise; PI (2) =1 if brachystaphyline, 0 otherwise; reference = leptostaphyline. For PHI: PHI (1) =1 if orthostaphyline, 0 otherwise; PHI (2) =1 if hypsistaphyline, 0 otherwise; reference = chamestaphyline.

Results

The findings indicated a substantial disparity in PL, PB and PH across genders across both ethnic groups, with a more pronounced effect seen in males. The measurements of PB exhibited a substantial variation between the two ethnic groups; however, given the use of different CBCT systems, this finding should be interpreted as exploratory. Although several gender differences reached statistical significance, effect size analysis revealed that PB and PH demonstrated moderate-to-large clinical relevance, whereas PL showed only small-to-moderate effects, as shown in Tables 1-3. The outcomes of PI and PHI are presented in Tables 4 and 5.

Table 6 shows that the BLR fit the data well for both Arabic and Kurdish populations, as the Hosmer–Lemeshow test was not significant in both groups. The model explains more variation in the Kurdish population than in the Arabic population, based on the higher Nagelkerke R^2 value (0.485 in Arabs and 0.624 in Kurds). The Kurdish model also shows better overall performance, with higher classification accuracy (78.5% in Arabs and 84% in Kurds), sensitivity (76% in Arabs and 83% in Kurds) and specificity (81% in Arabs and 85% in Kurds). In both populations, the models can correctly identify most positive and negative cases. There was no multicollinearity among predictors, indicating stable results. The ROC curves above the diagonal further confirm that both models have good ability to distinguish between outcome groups, with better performance observed in the Kurdish population. In the Arabic population, BLR indicated that PB was a significant predictor of gender (B = −0.435, *P* = 0.001), with higher PB levels

Table 1: Comparison of the linear measurements of the palate in Arab population

Measurements	Arab	Mean±SD	*P*	Effect sizes (Cohen's *d*)
PL	Male	51.27±3.89	0.005	0.39
	Female	49.99±2.38		
PB	Male	42.30±3.03	0.000	0.79
	Female	39.89±3.06		
PH	Male	14.82±2.61	0.000	1.05
	Female	12.32±2.06		

Independent *t*-test for difference *P*<0.05=significant difference. Effect sizes were interpreted using Cohen's criteria: *d*≈0.20=small effect, *d*≈0.50=moderate effect and *d* ≥0.80=large effect. SD: Standard deviation, PL: Palatal length, PB: Palatal breadth, PH: Palatal height

Table 2: Comparison of the linear measurements of the palate in Kurdish populations

Measurements	Kurd	Mean±SD	*P*	Effective sizes (Cohen's *d*)
PL	Male	50.94±4.30	0.000	0.64
	Female	48.41±3.49		
PB	Male	40.31±2.94	0.000	0.75
	Female	38.09±2.98		
PH	Male	14.39±2.37	0.000	0.64
	Female	12.79±2.62		

Independent *t*-test for difference *P*<0.05=significant difference. Effect sizes were interpreted using Cohen's criteria: *d*≈0.20=small effect, *d*≈0.50=moderate effect and *d* ≥0.80=large effect. SD: Standard deviation, PL: Palatal length, PB: Palatal breadth, PH: Palatal height

Table 3: Comparison of the linear measurements of the palate in Arab population and Kurdish populations

Measurements	Arab and Kurd	Mean±SD	*P*	Effective sizes (Cohen's *d*)
PL	Arab	50.62±3.28	0.11	0.26
	Kurd	49.67±4.10		
PB	Arab	41.10±3.27	0.000	0.59
	Kurd	39.20±3.15		
PH	Arab	13.57±2.66	0.942	0.01
	Kurd	13.59±2.62		

Independent *t*-test for difference *P*<0.05=significant difference. Effect sizes were interpreted using Cohen's criteria: *d*≈0.20=small effect, *d*≈0.50=moderate effect and *d* ≥0.80=large effect. SD: Standard deviation, PL: Palatal length, PB: Palatal breadth, PH: Palatal height

correlating with reduced probabilities of being female (Exp (B) =0.647; 95% CI: 0.497–0.843). PL and PH were not significant predictors ($P > 0.05$).

The categorical variables PLI ($P = 0.002$) and PHI ($P = 0.005$) were statistically significant overall. In comparison to the reference group, PLI(1) (Exp(B) = 0.254; $P = 0.030$), PHI(1) (Exp(B) 0.123; $P = 0.006$) and PHI (2) (Exp(B) = 0.011; $P = 0.001$) exhibited considerably decreased chances of being female, although PLI(2) was not statistically significant. In the Kurdish population, BLR revealed that PB was the only significant predictor of gender (B = −0.304, $P = 0.002$), with elevated PB levels correlating with decreased probability of being female (Exp(B) = 0.738; 95% CI: 0.608–0.894). PL and PH were not significant predictors ($P > 0.05$).

The categorical variables PLI ($P = 0.031$) and PHI ($P = 0.149$) were not significant at the category level, but PHI (2) exhibited a borderline correlation ($P = 0.061$). As shown in Tables 7 and 8, the predictive equations for each population were as follows:

For the Arabic population:

Logit(P) = 15.290 + 0.121 (PL) – 0.435 (PB) – 0.109–1.372 (PLI [1]) – 0.616 (PLI [2]) – 2.094 (PHI [1]) – 4.497 (PHI [2])

For the Kurdish population:

Logit(p) = 16.526–0.73 (PL) – 0.3049 (PB) +0.18 (PH) – 0.702 (PLI [1]) +0.629 (PLI[2]) –0.966 (PHI [1]) – 2.319 (PHI [2])

Discussion

A comprehensive understanding of HP morphology has considerable clinical importance. It is involved in 'passive articulation in speech, the management of sleep apnoea syndrome, the planning of maxillofacial and orthopaedic surgeries for individuals with Down syndrome, the execution of cleft palate surgery, the formulation of orthodontic treatment and the design and fabrication of dentures for edentulous patients'.[13-15] The measurements of HP morphometry in Iraqi Arab and Kurdish populations were carried out by measuring the PL, PB, PH, PI and PHI. These measurements were performed according to previously conducted research.[10-12] The distribution of PI types varied across genders in both ethnic groups, which concurs with the findings of Araby *et al*. in 2023,[10] which showed a substantial difference in Arab cases and a non-significant difference in Kurd cases.

The leptostaphyline type of PI was the most prevalent in our study; this aligns with the findings of studies of Kulkarni in 2016,[13] Sarilita and Soames in 2015[12] and Araby *et al*. in 2023.[10] Conversely, the findings from the study by D'Souza in 2025[13] indicated that 40% of cases were brachystaphylline, 37.5% leptostaphylline and 22.5% mesostaphylline. Additionally, studies[13-16] revealed that 86.9% of palates were brachystaphylline (broad palate) across 86.9% of skulls. The results of these investigations contradicted our observations, demonstrating that the length of the palate was less than its width. These diverse findings may aid in distinguishing cranial differences across races, thereby benefiting forensic anthropology. The PHI confirmed that the orthostaphyline type was the predominant kind in both groups. This corresponds with the research conducted by Araby *et al*. in 2023,[10] which found no significant differences between genders in Kurdish cases alone; this may be ascribed to population variance.

Regarding the measurements of PL, PB and PH, our findings indicated a considerable gender disparity in both ethnic groups,

Table 4: Comparison of the palatal classification according to the palatine index of the palate in the Arab and Kurdish populations

Measurements	Leptostaphyline (narrow palate)	Mesostaphyline (intermediate)	Brachystaphyline (wide)	*P*
Arab				
Male	36 (18)	31 (15.5)	33 (16.5)	0.015
Female	55 (27.5)	17 (8.5)	28 (14)	
Total	91 (45.5)	48 (24)	61 (30.5)	
Kurd				
Male	51 (25.5)	31 (15.5)	18 (9)	0.34
Female	53 (26.5)	22 (11)	23 (11.5)	
Total	104 (52)	53 (26.5)	41 (20.5)	
Arab and Kurd				
Arab	91 (22.75)	48 (12)	61 (15.25)	0.081
Kurd	104 (26)	53 (13.25)	41 (10.25)	
Total	195 (48.75)	101 (25.25)	102 (25.5)	

Chi-square for difference, $P<0.05$=significant difference

Table 5: Comparison of the palatal classification according to the palate height index of the palate in the Arab and Kurdish populations

Measurements	Chamestaphyline (low palate), *n* (%)	Orthostaphyline (intermediate), *n* (%)	Hypsistaphyline (high), *n* (%)	*P*
Arab				
Male	9 (4.5)	66 (33)	25 (12.5)	0.000
Female	35 (17.5)	58 (29)	5 (1.25)	
Total	44 (22)	124 (62)	30 (13.75)	
Kurd				
Male	7 (3.5)	63 (31.5)	28 (14)	0.001
Female	26 (13)	59 (29.5)	15 (7.5)	
Total	33 (16.5)	122 (61)	43 (21.5)	
Arab and Kurd				
Arab	44 (11)	124 (31)	30 (7.5)	0.142
Kurd	33 (8.25)	122 (30.5)	43 (10.75)	
Total	77 (19.25)	246 (61.5)	73 (18.25)	

Chi-square for difference $P<0.05$=significant difference

Table 6: Logistic regression model performance by population

Statistic	Arabic population	Kurdish population
Hosmer–Lemeshow χ^2 (df=8), *P* value	χ^2=13.427, *P*=0.098	χ^2=12.165, *P*=0.144
Model fit interpretation	Good fit ($P>0.05$)	Good fit ($P>0.05$)
Nagelkerke R^2	0.485	0.624
Baseline accuracy (majority class) (%)	81.0	85.0
Model classification accuracy (overall %)	78.5	84.0
Sensitivity (% correctly identified positives*)	76.0	83.0
Specificity (% correctly identified negatives*)	81.0	85.0
Multicollinearity (VIF)	<1.0 (no multicollinearity)	<1.0 (no multicollinearity)
ROC curve	0.837 (good discrimination)	0.728 (good discrimination)

ROC: Receiver operating characteristic, VIF: Variance inflation factor

more pronounced in males; this is consistent with the research conducted by Araby *et al*., (2023) D'Souza *et al*., (2012) and Bühling *et al*. (2025),[10,13,14] used distinct landmarks but arrived at the same conclusions, indicating that the dimensions of the HP are greater in males than in females; this difference can be attributed to the influence of genetics and hormones.[13] The PL was larger in Arab cases than in Kurds with a non-significant difference, while the PB was significantly larger in Arab cases compared to Kurds; however, given the use of different CBCT systems, this finding should be interpreted as exploratory, which is ascribed to ethnic disparities. The overall differences between the ethnic groups can occur due to genetics, and biological factors such as prolonged mouth breathing or specific tongue posture can reduce the PB and volume.[13]

Table 7: Binary logistic regression test to predict the gender from the measurements of palate in Arab population

Measurements	*B*	*P*	Exp(*B*)	95% CI for Exp(*B*)		VIF
				Lower	Upper	
PL	0.121	0.270	1.128	0.911	1.397	3.803
PB	−0.435	0.001	0.647	0.497	0.843	3.547
PH	−0.109	0.497	0.897	0.655	1.228	5.192
PLI		0.002				
PLI (1)	−1.372	0.030	0.254	0.073	0.877	2.165
PLI (2)	0.616	0.478	1.852	0.338	10.161	3.642
PHI		0.005				
PHI (1)	−2.094	0.006	0.123	0.028	0.550	4.363
PHI (2)	−4.497	0.001	0.011	0.001	0.163	9.481
Constant	15.290	0.000	4,367,692.983			

EXP(B)=Exponentiated regression coefficient (Odds Ratio), *P*=*P*-value, B=log odds. PL: Palatal length, PB: Palatal breadth, PH: Palatal height, PHI: PH index, PLI: PL index, CI: Confidence interval, VIF: Variance inflation factor

Table 8: Binary logistic regression test to predict the gender from the measurements of palate in Kurd population

Measurements	*B*	*P*	Exp(*B*)	95% CI for Exp(*B*)		VIF
				Lower	Upper	
PL	−0.073	0.331	0.929	0.801	1.077	3.803
PB	−0.304	0.002	0.738	0.608	0.894	3.547
PH	0.018	0.895	1.018	0.777	1.336	5.192
PLI		0.031				
PLI (1)	−0.704	0.190	0.495	0.172	1.419	2.165
PLI (2)	0.629	0.411	1.875	0.419	8.398	3.642
PHI		0.149				
PHI (1)	−0.966	0.186	0.381	0.091	1.593	4.363
PHI (2)	−2.319	0.061	0.098	0.009	1.118	9.481
Constant	16.526	0.000	15,037,581.391			

EXP(B)=Exponentiated regression coefficient (Odds Ratio), *P*=*P*-value, B=log odds. PL: Palatal length, PB: Palatal breadth, PH: Palatal height, PHI: PH index, PLI: PL index, CI: Confidence interval, VIF: Variance inflation factor

Employing a BLR of the values of PL, PB, PH, PI and PH, declared that the measurements conducted on the HP could predict gender, consistent with the findings of D'Souza *et al*., (2012) and Bühling *et al*. (2025).[13,14] This research indicated that the PB has moderate discriminatory ability for sex estimation, reducing by 0.435 times in Arab females and by 0.304 times in Kurdish females. The previously mentioned studies used various landmarks and demographics and, nevertheless, showed that the dimensions of HP may be utilised in forensic dentistry to predict gender.[17-22] This retrospective cross-sectional study is subject to selection bias inherent to the use of archived CBCT scans. Although similar acquisition parameters were applied, the use of two distinct CBCT systems for the Arab and Kurdish samples is a significant methodological limitation of the current study. Systematic measurement variability that cannot be completely controlled by matching acquisition parameters alone may arise from variations in detector technology, reconstruction algorithms and system calibration.[23] Direct quantitative comparisons between ethnic groups should be interpreted cautiously because inter-device validation data were not available. The study's main analytical focus was on within-population assessments, especially gender-based differences, which are still internally valid, in order to lessen this limitation. Ethnic comparisons were therefore viewed as exploratory rather than confirmatory, and they are offered to produce hypotheses for further research employing single-device designs or harmonised imaging protocols. To the best of the authors' knowledge, this study is the first to report PI and PHI values in an Iraqi sample and one of the first studies comparing HP measurements between Arab and Kurdish Iraqi populations. These results could support population-based craniofacial assessment in forensic anthropology.

Conclusion

The morphometry HP showed clear differences between the genders in both populations, with males consistently demonstrating larger palatal dimensions, while ethnic differences were limited. The predominance of leptostaphyline PI and orthostaphyline PHI was observed in both groups. These findings highlight the clinical relevance of palatal measurements for treatment planning and their supportive role in forensic and anthropological assessments, while emphasising that their application in sex estimation should be interpreted as adjunctive rather than definitive.

Declaration of patient consent

In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Carstens MH, Bennun R. Pathologic anatomy of the hard palate. In: Carstens MH, editor. The Embryologic Basis of Craniofacial Structure: Developmental Anatomy, Evolutionary Design, and Clinical Applications. Cham: Springer; 2023. p. 1229-306.
2. Rani S, Sharma A, Pandit AK. A morphometric study of the hard palate in dry adult skulls and its clinical significance. Azerbaijan Pharm Pharmacother J 2025;24:13-17.
3. Kumar P, Lata P, Prasad R. Hard palate dimensions in North Indian adult skulls: A morphometric study. Azerbaijan Pharm Pharmacother J 2024;23:1-6.
4. de Rooy L. The shelf life of skulls: Anthropology and 'race' in the Vrolik craniological collection. J Hist Biol 2023;56:309-37.
5. Ferrario VF, Sforza C, Colombo A, Dellavia C, Dimaggio FR. Three-dimensional hard tissue palatal size and shape in human adolescents and adults. Clin Orthod Res 2001;4:141-7.
6. Ferrario VF, Sforza C, Schmitz JH, Colombo A. Quantitative description of the morphology of the human palate by a mathematical equation. Cleft Palate Craniofac J 1998;35:396-401.
7. Abeleira MT, Outumuro M, Diniz M, Limeres J, Ramos I, Diz P. Morphometry of the hard palate in Down's syndrome through CBCT-image analysis. Orthod Craniofac Res 2015;18:212-20.
8. Suteerapongpun P, Wattanachai T, Janhom A, Tripuwabhrut P, Jotikasthira D. Quantitative evaluation of palatal bone thickness in patients with normal and open vertical skeletal configurations using cone-beam computed tomography. Imaging Sci Dent 2018;48:51-7.
9. Kuijpers MA, Chiu YT, Nada RM, Carels CE, Fudalej PS. Three-dimensional imaging methods for quantitative analysis of facial soft tissues and skeletal morphology in patients with orofacial clefts: A systematic review. PLoS One 2014;9:e93442.
10. Araby YA, Alharbi AS, Kolarkodi SH, Almosyteer AS. Morphometric analysis of the hard palate using cone beam computed tomography in a Saudi population. Saudi Dent J 2023;35:270-4.
11. Premkumar S. Textbook of Craniofacial Growth. New Delhi: JP Medical Ltd; 2011.
12. Sarilita E, Soames R. Morphology of the hard palate: A study of dry skulls and review of the literature. Rev Argent Anat Clin 2015;7:34-43.
13. D'Souza AS, Mamatha H, Jyothi N. Morphometric analysis of hard palate in South Indian skulls. Biomed Res 2012;23:173-5.
14. Bühling S, Selge HM, Eslami S, Seifert LB, Sayahpour B, Plein N, *et al.* Impact of active and passive maxillary plates on cleft width morphology in unilateral cleft lip and palate: A prospective intervention study. Children (Basel) 2025;12:714.
15. Duan J, Li X, Zhang F, Xia W, Li B. Palatal morphology after treatment of children with obstructive sleep apnoea using the modified twin-block appliance. Int Dent J 2024;74:1120-8.
16. Mustafa AG, Tashtoush AA, Alshboul OA, Allouh MZ, Altarifi AA. Morphometric study of the hard palate and its relevance to dental and forensic sciences. Int J Dent 2019;2019:1687345.
17. Kamath V, Asif M, Shetty R, Avadhani R. Binary logistic regression analysis of hard palate dimensions for sexing human crania. Anat Cell Biol 2016;49:151-9.
18. Šidlauskienė M, Papievis V, Šidlauskas A, Šidlauskas M, Juzėnas S, Lopatienė K. Genetic and environmental impact on variation in the palatal dimensions in permanent dentition: A twin study. Sci Rep 2024;14:19785.
19. Kulkarni V. Palatometry in South Indian skulls and its clinical implications. J Anat Soc India 2016;65 Suppl 2:S103.
20. Dunn RR, Spiros MC, Kamnikar KR, Plemons AM, Hefner JT. Ancestry estimation in forensic anthropology: A review. Wiley Interdiscip Rev Forensic Sci 2020;2:e1369.
21. Yousuf SM, Jan SS, Itoo MS, Khan JA, Bhat GM. Morphometric study of hard palate and its clinical correlation. J Anat Soc India 2025;74:246-9.
22. Sumati PV, Phatak A. Determination of sex from hard palate by discriminant function analysis. Int J Basic Appl Med Sci 2012;2:243-51.
23. Gao T, Sun Y, Yuan F, Liang S. Evaluation and calibration of CBCT reconstruction models. Curr MedImaging 2023;19:1449-54.