BRIDGING THE GAP IN CEPHALOMETRIC NORMS: A POPULATION-SPECIFIC HARD TISSUE STUDY IN THE NORTH INDIAN,SUNAM COMMUNITY

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ABSTRACT

Introduction: The cranial base constitutes a fundamental component of the craniofacial complex, providing the structural and developmental foundation for maxillomandibular alignment and spatial orientation. Variability in cranial base morphology has been extensively documented across different ethnicities, racial groups, and sexes, underscoring its significance in orthodontic diagnosis and treatment planning. Ethnic-specific differences in cranial base length, angle, and flexure can affect cephalometric analyses and skeletal classifications, thereby necessitating the use of population-specific normative data. In the context of India's heterogeneous demographic composition, a uniform application of cephalometric standards derived from other populations may result in diagnostic inaccuracies and suboptimal treatment outcomes.

Aim and Objectives: To establish normative values for anterior cranial base length, posterior cranial base length, anterior facial height, posterior facial height, maxillary length, and mandibular length among adult males and females from Punjab.

Materials and Method: A total of 100 pre-treatment lateral cephalograms from adults (aged 18–30 years) reporting to the Department of Orthodontics, Guru Nanak Dev Dental College and Research Institute, Sunam, were analyzed.

Result and Conclusion: Statistically significant differences were observed in anterior cranial base length, maxillary base length, and mandibular base length compared to Caucasian standards, with smaller values in the Punjabi population. This reinforces the need for region-specific cephalometric norms.

Keywords: Cephalometry; Anterior cranial base length; Maxillary base length; Mandibular base length; Punjab population.

INTRODUCTION

The concept of beauty has evolved through centuries and varies across cultures and ethnicities. Cephalometric standards, developed for different populations, often reflect these differences. Numerous studies have confirmed that cranial and facial structures exhibit significant variations among ethnic and racial groups[1].

The cranial base functions as a fundamental scaffold for craniofacial growth and development, exerting a decisive influence on the anteroposterior positioning of the maxilla and mandible. Structurally, it comprises anterior and posterior segments that articulate with surrounding craniofacial structures, thereby guiding the spatial orientation and relational harmony of the facial skeleton. Morphological deviations in cranial base length, angulation, or flexure can substantially affect sagittal skeletal relationships, often contributing to malocclusion patterns. In light of the inherent variability and subjectivity associated with clinical assessments, cephalometric analysis remains an essential and standardized diagnostic tool in

orthodontics. It facilitates precise skeletal evaluation and supports the formulation of individualized, evidence-based treatment strategies[2].

Growth of the cranial base is inherently linked to maxillary and mandibular development. Variations in growth direction or magnitude can affect facial symmetry and occlusal relationships[3]. As cephalometric norms vary across populations, a universal standard may not suffice. This study was therefore undertaken to determine region-specific values in the Punjabi population.

AIM AND OBJECTIVE

To determine mean norms for anterior and posterior cranial base length, anterior and posterior facial height, maxillary length, and mandibular length among adult males and females from Sunam, Punjab,india.

MATERIALS AND METHOD:

A cross-sectional observational study was conducted using 100 pre-treatment lateral cephalograms from adult patients reported to the Department of Orthodontics and Dentofacial Orthopaedics, Guru Nanak Dev Dental College and Research Institute, Sunam.

Inclusion Criteria:

- Native residents of Punjab,india.
- Patients between 18–30 years age group.
- Skeletal Class I malocclusion (ANB 2+2).
- Normodivergentgrowth pattern (FMA 22˚–28˚).

Exclusion Criteria

- Individuals with craniofacial anomalies or history of trauma/surgery.
- Those who undergone previous orthodontic treatment.

Cephalometric Tracing Protocol

All lateral cephalograms were manually traced using high-quality acetate matte tracing paper and a sharpened 3H pencil under uniform illumination provided by a standardized X-ray viewer. Anatomical landmarks were identified based on established cephalometric conventions and transferred with precision to the tracing medium. To ensure consistency and minimize observational error, all tracings were performed by a single calibrated examiner under identical environmental conditions.

Landmarks

- Sella (S)- The geometric center of pituitary fossa.
- Nasion (N)- The most anterior point on the fronto-nasal suture in the midsagittal plane.
- Articulate (Ar)-A point at the junction of the posterior border of the ramus and the inferior border of the posterior cranial base.
- Menton (Me)- The most inferior point on the contour of the mandibular symphysis, as projected on the lateral cephalometric radiograph.
- Gonion (Go)- A point on the curvature of the angle of the mandible located by bisecting the angle formed by lines tangent to the posterior ramus and the inferior border of the mandible.
- Pogonion (Pog)-The most anterior point on the chin.
- Anterior nasal spine (ANS)-The most anterior, superiorly positioned point at the tip of the anterior nasal spine of the maxilla, located at the median plane.
- Posterior nasal spine (PNS)-The posterior spine of the palatine bone constituting hard palate
- Point A: Sub-spinale – The most posterior midline point in the concavity between ANS and prosthion (the most inferior point on the alveolar bone overlying the maxillary incisor).
- Palatal plane- Line connecting anterior nasal spine and posterior nasal spine.
- Frankfort -mandibular plane angle (FMA): Formed by the intersection of Frankfort horizontal plane and the mandibular plane.

Parameters used in the study [Fig. 1]

- Anterior cranial base length: (N-S) Line connecting sella and nasion.
- Posterior cranial base length:(S-Ar) The linear distance between Sella (S)—the midpoint of the sella turcica—and
- Articulare (Ar)—the point of intersection between the posterior border of the mandibular ramus and the base of the skull.
- Anterior facial height: (N-Me) Line connecting nasion and menton.
- Posterior facial height:(S-Go) Line connecting sella and gonion.
- Maxillary length: Line connecting PNS – point A perpendicular to palatal plane.
- Mandibular base length:(Go-Pog) Line connecting gonion and pogonion.

Reference tables:

Parameter	Average value
Anterior cranial length (N-S)	75.4mm
Posterior cranial length (S-Ar)	32-35 mm
Anterior facial height (N-Me)	114.0 +- 6.1 mm
Posterior facial height (S- Go)	72.2 +- 4.6 mm
Maxillary length (PNS-PP)	53.9 mm
Mandibular length (Go-Pog)	82mm

Table No.1: Average values of Caucasian Adult Males

Parameter	Average value
Anterior cranial length (N-S)	70.1mm
Posterior cranial length (S-Ar)	32-35 mm
Anterior facial height (N-Me)	110.8 +- 6.4 mm
Posterior facial height (S- Go)	69.9 +- 4.5 mm
Maxillary length (PNS-PP)	51.1 mm
Mandibular length (Go-Pog)	77.8mm

Table No.2: Average values ofCaucasian Adult Females

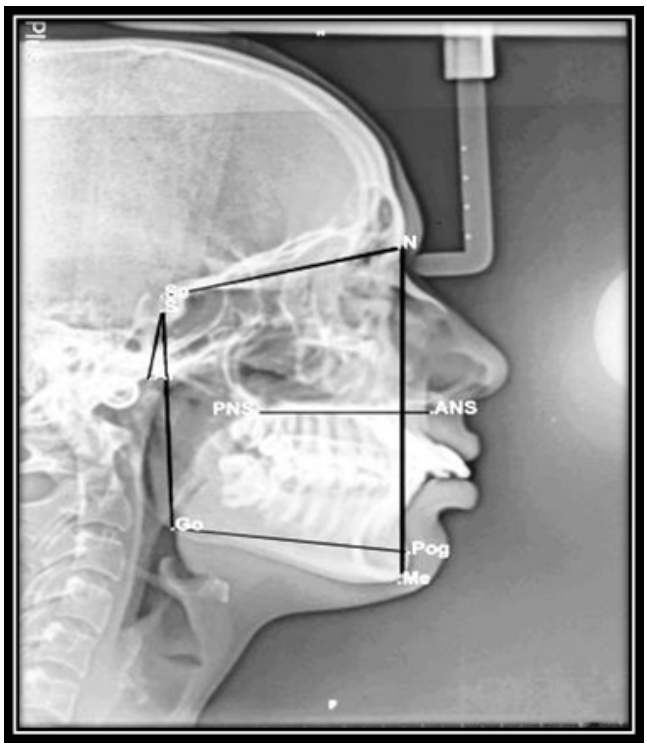


Figure No.1: Parameters traced on lateral Cephalogram

Measured Parameters (As Shown In Fig. 1):

- Anterior cranial base length (N-S)
- Posterior cranial base length (S-Ar)
- Anterior facial height (N-Me)
- Posterior facial height (S-Go)
- Maxillary length (PNS-PP)
- Mandibular base length (Go-Pog)

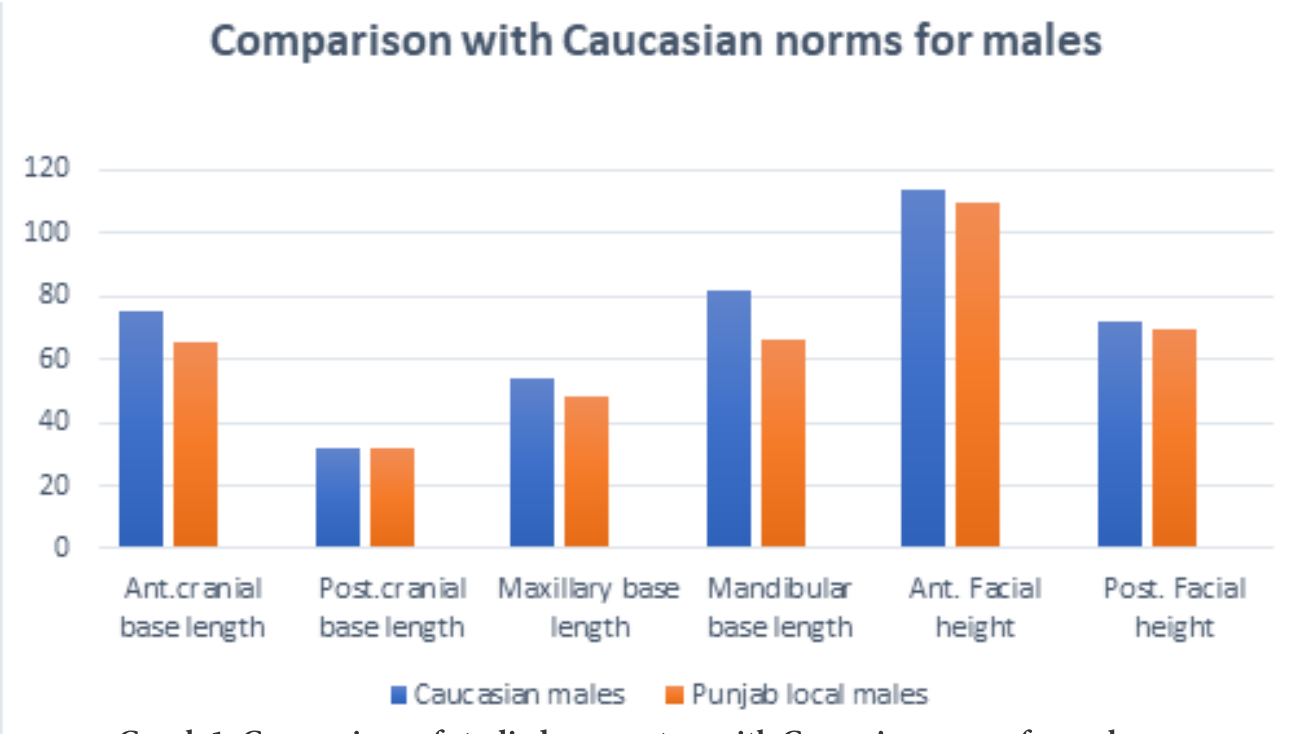
RESULTS

The Punjab population (Sunam) showed significantly reduced values for anterior cranial base length, maxillary base length, and mandibular base length when compared with Caucasian norms.(Table 3 & 4) and (Graph 1& 2). There was no significant difference for value of posterior cranial base length, anterior facial height and posterior facial height among Sunam and Caucasian norms. It was reported in this study that males had significantly higher value of maxillary base length and anterior cranial base length as compared to female of Sunam population (Table 5 and Graph 3).

Variable	Values for Sunam population		Caucasian Norms		p- value
	Mean	SD	Mean	SD	
Ant.Cranial base length	64.23	3.30	75.4	-	<0.01*
Post. Cranial base length	31.92	3.68	32	-	0.85
Maxillary base length	51.92	5.17	53.9	-	0.19
Mandibular base length	66.05	4.33	82	-	<0.01*
Ant. Facial height	105.31	4.19	114	6.1	0.009*
Post.facial height	72.69	6.01	72.2	4.6	0.77

* Statistically significant (p <.05), NS- Non Significant (p < 0.05)

Table 3: Comparison of studied parameters with Caucasian norms for males

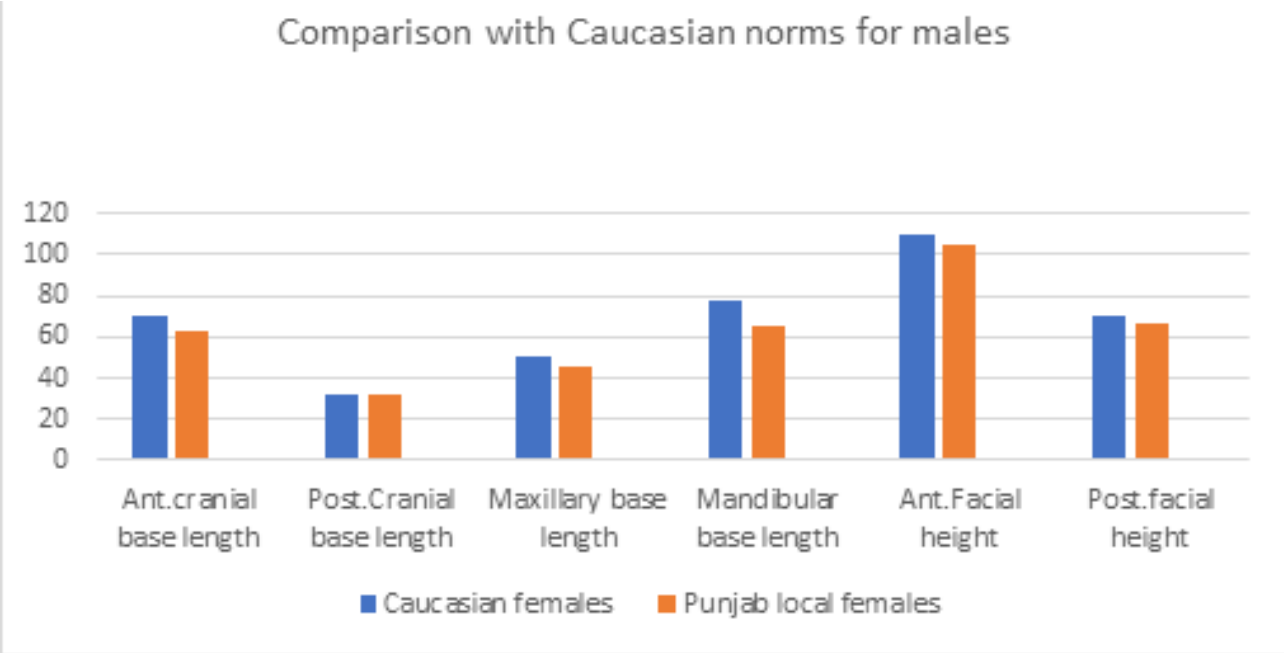


Graph 1: Comparison of studied parameters with Caucasian norms for males

Variable	Values for Sunam population		Caucasian Norms		p- value
	Mean	SD	Mean	SD	
Ant.Cranial base length	61.47	4.84	70.1	-	0.002*
Post. Cranial base length	29.12	3.04	32	-	0.38
Maxillary base length	48.88	4.70	51.1	-	0.13
Mandibular base length	66.06	5.52	77.8	-	<0.01*
Ant. Facial height	103.06	8.69	110.8	6.4	0.011*
Post.facial height	65.14	6.21	69.9	4.5	0.08

* statistically significant (p <.05), NS- Non Significant (p < 0.05)

Table 4: Comparison of studied parameters with Caucasian norms for females

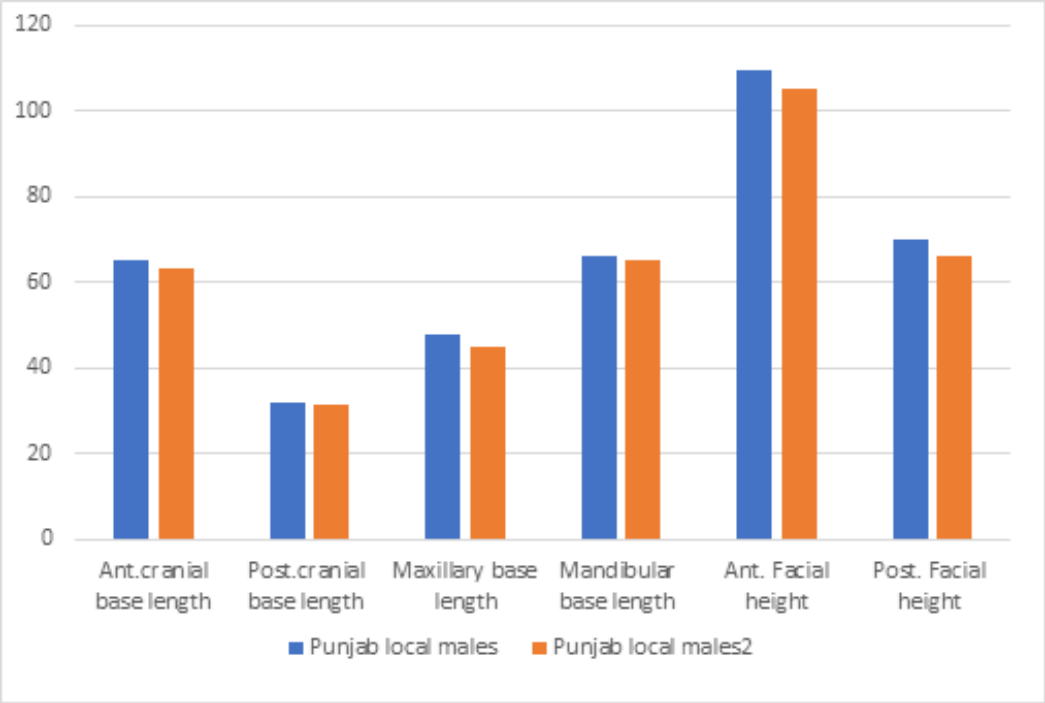


Graph 2: Comparison of studied parameters with Caucasian norms for females

Variable	Sunam Male		Sunam Female		p- value
	Mean	SD	Mean	SD	
Ant.Cranial base length	64.23	3.30	61.47	4.84	0.074
Post. Cranial base length	31.92	3.68	29.12	3.04	0.036*
Maxillary base length	51.92	5.17	48.88	4.70	0.110
Mandibular base length	66.05	4.33	66.06	5.52	0.533
Ant. Facial height	105.31	4.19	103.06	8.69	0.375
Post.facial height	72.69	6.01	65.14	6.21	0.003*

* statistically significant (p <.05), NS- Non Significant (p < 0.05)

Table5: Comparison of parameter values between male and female of Sunam population



Graph 3: Comparison of parameter values between male and female of Sunam population

DISCUSSION

Lateral cephalometry remains a cornerstone in orthodontic diagnosis, enabling precise evaluation of craniofacial morphology and growth. Since its introduction by Broadbent in 1931[1], cephalometry has played a critical role in identifying skeletal discrepancies and guiding treatment planning. Among various anatomical landmarks, the cranial base exerts significant influence on the positioning of the maxilla and mandible, ultimately determining the skeletal pattern and facial harmony[2].

However, the cephalometric standards widely adopted in orthodontics have been predominantly derived from Caucasian populations. Given the established ethnic variation in craniofacial structures, applying these generalized norms across diverse populations may lead to diagnostic inaccuracies. This has led to increasing advocacy for population-specific cephalometric standards. The present study was thus conducted to assess cranial and facial skeletal dimensions in a representative Punjabi adult population, with an emphasis on establishing normative values for anterior and posterior cranial base lengths, maxillary and mandibular base lengths, and vertical facial heights.

Only subjects aged 18 years and above were included in this study to ensure that growth-related changes had largely ceased. This criterion was informed by Björk[4], who reported cessation of cranial base growth by approximately 12 years of age, and Nanda[5], who noted that most facial skeletal development concludes before the age of 18.

Anterior Cranial Base Length

The findings of the present study revealed that anterior cranial base length was shorter in the Punjabi population when compared to established Caucasian norms. This observation aligns with previous reports from various Indian populations. Bhattacharya et al.[7] noted reduced anterior cranial base length in the West Indian population, while Tikku et al.[8] reported similar findings in North Indians. Kamak et al.[9] and Kumari et al.[10] observed the same trend in populations from Haryana and Central India, respectively.

Moreover, sexual dimorphism was evident in the current sample, with males showing consistently greater

anterior cranial base lengths than females. These findings are comparable to those reported by Bibby[6] in a Scottish cohort, where males exhibited larger craniofacial dimensions. The current data further reinforce the notion that gender-related variations must be considered when interpreting cephalometric values.

Maxillary Base Length

The maxillary base length was also found to be reduced in the Punjabi population relative to Caucasian standards. This is consistent with the results reported by Yadav et al.[11] for the Central Indian population and Tikku et al.[8] for North Indians. As in the anterior cranial base measurements, maxillary dimensions were greater in males, reflecting a consistent pattern of sexual dimorphism across craniofacial parameters.

Mandibular Base Length

A similar trend was observed in mandibular base length. The present study revealed reduced Go–Pog length in Punjabi subjects compared to Caucasian references. These findings corroborate those of Syam Kumar[12], who documented decreased mandibular length in South Indian subjects, and Tikku et al.[8], who reported similar outcomes in North Indian females. The observed gender difference, with males showing longer mandibular bases, aligns with known anthropometric patterns of male skeletal robustness.

Overall Craniofacial Trends and Clinical Implications

Across all measured parameters—anterior cranial base, maxillary length, mandibular length, and vertical facial heights (anterior and posterior)—Punjabi subjects consistently demonstrated smaller dimensions than those reported in Caucasian norms. These differences emphasize the importance of developing population-specific cephalometric standards to improve the accuracy of diagnosis and the precision of orthodontic treatment planning.

Failure to account for these ethnically driven variations may result in misinterpretation of skeletal relationships, potentially leading to suboptimal treatment outcomes. Hence, clinicians practicing in ethnically diverse settings must consider localized normative data to ensure tailored, evidence-based care.

CONCLUSION

Sexual dimorphism was clearly evident in this study, with male subjects exhibiting larger cranial and facial dimensions compared to females. The female subjects consistently demonstrated comparatively shorter measurements across multiple parameters. When benchmarked against established Caucasian norms, both male and female subjects in the Punjabi population exhibited reduced mean values for anterior cranial base length, maxillary base length, and mandibular base length. Interestingly, posterior cranial height, anterior facial height, and posterior facial height were largely comparable to Caucasian standards. These findings underscore the necessity of establishing population- and gender-specific cephalometric norms to enhance the accuracy of diagnosis and the efficacy of individualized orthodontic treatment planning

LIMITATIONS

This study has certain limitations that warrant consideration. Firstly, the use of two-dimensional imaging via lateral cephalograms introduces inherent drawbacks such as image distortion, magnification errors, and superimposition of anatomical structures. These factors may affect the precision of linear and angular measurements, despite efforts to standardize head positioning and apply consistent calibration protocols. The limitations of projection geometry in 2D imaging cannot be entirely mitigated and may influence measurement accuracy.

Secondly, the study sample was confined to a specific age group (18–30 years) and a localized population (North Indian, specifically Punjabi subjects). While this enhances population-specific relevance, it may limit the

generalizability of the findings to other age brackets and ethnic groups. Further studies involving diverse populations and three-dimensional imaging modalities would provide a more comprehensive understanding of craniofacial morphology.

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Conflict of Interest

The authors declare no conflict of interest with respect to the authorship, research, or publication of this article.

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