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ORIGINAL ARTICLE

Sella Turcica Morphometry in Skeletal Malocclusions: A Cephalometric Evaluation in a Cambodian Cohort

Na Chihan[1], Gowri Sivaramakrishnan[2], Akhilanand Chaurasia[3], Hoang Viet[4], Pannapat Chanmanee[5], Arofi Kurniawan[6], Prasad Mandava[7], Rakhi Issrani[8], Mohammad Khursheed Alam[8], Anand Marya[6,9]

[1]Faculty of Dentistry, University of Puthisastra, Phnom Penh, Cambodia.
[2]Specialty Dental Residency Program, Primary Healthcare Centers, Manama, Bahrain.
[3]Department of Oral Medicine and Radiology, King George's Medical University, Lucknow, India.
[4]Department of Orthodontics & Pedodontics, Faculty of Dentistry, Van Lang University, Ho Chi Minh, Vietnam.
[5]Orthodontic Section, Department of Preventive Dentistry, Faculty of Dentistry, Prince of Songkla University, Songkhla, Thailand.
[6]Department of Forensic Odontology, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia.
[7]Department of Orthodontics, Narayana Dental College, Nellore, Andhra Pradesh, India.
[8]Department of Preventive Dentistry, College of Dentistry, Jouf University, Sakaka, Kingdom of Saudi Arabia.
[9]Department of Orthodontics, Faculty of Dentistry, University of Puthisastra, Phnom Penh, Cambodia.

Corresponding author: Anand Marya **E-mail:** amarya@puthisastra.edu.kh

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ABSTRACT
Objective: To measure the linear dimensions of the Sella Turcica (ST) and assess its morphological characteristics across different age groups, genders, and skeletal malocclusion classes within a Cambodian population sample. **Material and Methods:** A total of 150 archived cephalometric radiographs comprising 50 each from skeletal Class I, Class II, and Class III malocclusion groups were retrospectively selected from patient records at the UP Dental Hospital and traced to measure the ANB angle (A point–Nasion–B point), ST length, depth, anteroposterior diameter, and Cp–Ca distance in millimeters. **Results:** Age showed a significant positive relationship with the ANB angle ($r = 0.415$, $p < 0.001$), AP diameter ($r = 0.314$, $p < 0.001$), and Cp-Ca ($r = 0.269$, $p = 0.001$). Females had a higher mean ANB angle and depth compared to males, whereas males had a higher mean length, AP diameter, and Cp-Ca compared to females. Class III exhibited significantly lower mean length, AP diameter, and Cp-Ca than Class I and Class II. At the same time, Class II demonstrated a significantly greater mean depth than Class I. **Conclusion:** This study highlights significant variations in the linear dimensions of the ST across different skeletal malocclusion classes in a Cambodian population. Class III individuals exhibited smaller ST dimensions compared to Class I and II, while Class II showed greater ST depth.

Keywords: Malocclusion; Cephalometry; Sella Turcica.

Introduction

The sella turcica (ST) is a saddle-shaped anatomical structure that is clearly visible on lateral cephalograms, which are routinely used for orthodontic diagnosis. It is located in the middle cranial fossa on the intracranial surface of the sphenoid bone [1]. Typically, it measures 4 to 12 mm vertically and 5 to 16 mm in the anteroposterior dimension [2,3]. The wide variation in measurements is likely due to differences in landmarks, radiographic techniques, and the degree of radiographic enlargement reported in the literature [3]. Since the ST encloses the pituitary gland, abnormalities in its development can lead to changes in the ST's size and shape, detectable on radiographs [2,3]. Larger STs are usually associated with adenomas, mucocele, meningioma, primary hypothyroidism, prolactinoma, gigantism, acromegaly, empty sella syndrome, and Nelson's syndrome. In contrast, smaller STs are rare and associated with primary hypopituitarism and Sheehan's syndrome [4].

The five abnormal shapes found on radiographs, as described by Axelsson et al. [5], include a double contour of the floor, an irregular dorsum sella, an oblique anterior wall, a pyramidal shape, and ST bridging. Evidence indicates that ST bridging is commonly associated with Class III malocclusion, syndromes involving the craniofacial region, tooth transposition, hypodontia, impacted teeth, etc. [6]. A recent study by Kaya et al. [7] on the dimensions of ST in patients with various dental anomalies showed a decrease in ST length and diameter in patients with transposition. Additional findings include increased frequency of type III (complete) bridging in patients with 3rd molar agenesis and increased calcification of the Class III (complete) ponticulus posticus in patients with palatally impacted canines, transposition, and 3rd molar agenesis [7].

A recent study by Jankowski et al. [8] reported a 16.98% prevalence of ST abnormalities in patients with dental anomalies. The authors also reported a higher prevalence of dental anomalies in abnormal ST types [8]. Hence, any abnormalities in the shape and size of ST can be considered a good predictor of dental anomalies. While there are many similar studies from various geographic locations, it is necessary to understand the morphological types of ST prevalent in Cambodia to draw inferences on this topic applicable to this population. Therefore, the present study aimed to measure the linear dimensions (length, depth, anteroposterior diameter, Cp-Ca) of the ST and to assess its morphological characteristics across different age groups, genders, and skeletal malocclusion classes within a Cambodian population sample.

Material and Methods

Ethics, Study Design, and Setting

This study was a retrospective audit of 150 pre-existing cephalometric radiographs collected over 10 months from patients who had previously undergone orthodontic assessment and treatment at the UP Dental Clinic. Data were collected over 10 months. The University of Puthisastra Research Ethics Committee approved the study protocol with the reference number 006IR24. The present study is presented according to STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines [9]. Since this study involved a retrospective audit of records, formal patient consent was not required.

Inclusion and Exclusion Criteria

A total of 150 cephalograms were selected; the sampling was retrospective and based on the availability of complete, high-quality radiographs, with 50 cephalograms in each of the Class I, Class II, and Class III categories, defined by the ANB angle (A–Nasion–B). An ANB angle of 0-4° was classified as skeletal Class I, an angle over 4° was classified as skeletal Class II, and an angle of less than 0° was classified as skeletal Class III.

Good-quality cephalograms in which the ST was clearly visible and the ANB could be measured were included. Exclusion criteria included cephalograms with poor image quality or unclear visualization of the sella turcica region, patients with a history of craniofacial trauma, syndromes, or congenital anomalies (e.g., cleft lip/palate), individuals with systemic endocrine disorders affecting pituitary function, those who had undergone prior or ongoing orthodontic treatment, and patients below 15 years of age to ensure skeletal maturity and measurement consistency.

Study Measurement

The ST was traced on acetate paper from the cephalograms, and its shape and dimensions were subsequently recorded. The dimensions were measured using a ruler in millimeters. The length, the depth, the antero-posterior (AP) diameter, and Cp-Ca were measured. The AP diameter of the sella turcica was measured as the linear distance between the tuberculum sellae and the dorsum sellae on lateral cephalograms [2,5]. The length of ST was measured from the tip of Tuberculum sella to the tip of dorsum sella. The depth of ST was measured by drawing a line perpendicular to the length of ST to the deepest point. The Cp-Ca was measured from the Cp point (the deepest point of the posterior wall of ST) to the Ca point (the deepest point of the anterior wall of ST).

Observer Calibration and Reliability Assessment

To ensure measurement accuracy and reproducibility, observer calibration was conducted before data analysis. A total of 30 cephalograms (10 from each skeletal class) were randomly selected and used for reliability assessment. A single trained orthodontist initially performed all cephalometric tracings and measurements. To evaluate intra-rater reliability, the same observer repeated the tracings and measurements after a two-week interval. Additionally, inter-rater reliability was assessed by having a second experienced orthodontist independently trace and measure the same set of 30 cephalograms. The ICC was calculated for all four sella turcica parameters: length, depth, AP diameter, and Cp–Ca distance. ICC values for both intra- and inter-rater assessments demonstrated excellent agreement, ranging from 0.81 to 0.93 (Table 1).

Table 1. Observer Calibration and Reliability Assessment for Sella Turcica Measurements.

Parameter	Intra-Class Correlation Coefficient		Interpretation
	Observer 1	Observer 2	
Length (mm)	0.88	0.84	Excellent
Depth (mm)	0.91	0.86	Excellent
AP Diameter (mm)	0.86	0.81	Excellent
Cp–Ca Distance (mm)	0.93	0.90	Excellent

Values ≥ 0.75 are considered good; ≥ 0.85, excellent; Analysis based on 30 randomly selected cephalograms independently evaluated by two calibrated observers.

Statistical Analysis

Descriptive statistics were used to analyze the demographic data. The Kolmogorov-Smirnov test was used to assess the normality of the distributions of the variables. Since the data were not normally distributed, the Mann-Whitney and Kruskal-Wallis tests were used to assess mean differences in ST size by gender and skeletal pattern. Pearson's correlation was used to assess the relationship between ST size and age. A p-value of < 0.05 was considered statistically significant.

Results

The mean age of the study sample was 23.76 ± 5.63 years. The mean ANB angle of the study sample was 0.51 ± 5.91. 102 cephalograms belonged to females, and 48 belonged to males. The mean ANB angle in males was -0.51 ± 6.19 and in females was 0.99 ± 5.74. The mean ANB angle in Class I, II, and III skeletal patterns is 1.52 ± 1.33, 6.33 ± 2.17, and -6.44 ± -6.44, respectively. There was a significant difference in the mean ANB angle between the skeletal patterns.

The mean dimensions of ST in the study sample are presented in Table 2. There was a significant relationship between age and both the mean AP diameter and the Cp-Ca measurements in ST. Age showed a significant, positive relationship with ANB ($r = 0.415$, $p < 0.001$), AP diameter ($r = 0.314$, $p < 0.001$), and Cp-Ca ($r = 0.269$, $p = 0.001$). (Table 3) The Pearson correlation values in Table 3 indicate that for each additional year in the age of the study participants, ANB increases by 0.415, the AP diameter of ST increases by 0.314, and Cp-Ca increases by 0.269.

Table 2. Mean dimensions of ST on cephalograms.

Parameter	Mean ± Standard Deviation (mm)	Range (mm)
Length	6.79 ± 2.49	0.50 – 13.50
Depth	8.54 ± 5.68	0.50 – 75.00
AP diameter	9.88 ± 1.83	4.45 – 15.00
Cp-Ca	8.96 ± 1.22	6.00 – 12.50

Table 3. Comparison of ST dimensions with age.

Parameters	Pearson Correlation (°)	Significance
Age and ANB	0.415	< 0.001
Age and Length	0.106	0.196
Age and Depth	-0.051	0.533
Age and AP diameter	0.314	< 0.001
Age and Cp-Ca	0.269	0.001

Females had a higher mean ST depth than males. At the same time, males had higher mean length, AP diameter, and Cp-Ca than females. The mean dimensions of ST in males and females are presented in Table 4.

Table 4. Mean dimensions of ST in males and females.

	Gender	N	Mean ± Standard Deviation (mm)	p-value
Length	Female	102	6.67 ± 2.46	0.289
	Male	48	7.05 ± 2.56	
Depth	Female	102	8.68 ± 6.82	0.894
	Male	48	8.23 ± 1.31	
AP Diameter	Female	102	9.86 ± 1.86	0.872
	Male	48	9.92 ± 1.79	
Cp-Ca	Female	102	8.90 ± 1.16	0.491
	Male	48	9.09 ± 1.33	

The mean ST dimensions in Class I, II, and III skeletal patterns are presented in Table 5. There was a significant difference in ST dimensions between the skeletal patterns. A post-hoc analysis with multiple pairwise comparisons showed significant differences in mean length, depth, AP diameter, and Cp-Ca values for different classes.

Class III exhibited a significantly lower mean length compared to both Class I (MD = 1.03, $p = 0.014$) and Class II (MD = 1.22, $p = 0.005$). Regarding depth, Class II demonstrated a significantly greater mean depth than Class I (MD = -0.62, $p = 0.030$), while Class I had a significantly higher mean depth compared to Class III

(MD = 0.60, p = 0.008). In terms of AP diameter, Class III showed a significantly reduced mean AP diameter in comparison to Class I (MD = 0.81, p = 0.007) and Class II (MD = 0.75, p = 0.028). For Cp-Ca, Class III displayed a significantly lower mean Cp-Ca than both Class I (MD = 0.50, p = 0.025) and Class II (MD = 0.61, p = 0.009).

For ANB, Class II possesses a significantly higher mean ANB compared to Class I (MD = -4.81, p < 0.001) and Class III (MD = 12.76, p < 0.001), and Class I possesses a significantly higher mean ANB compared to Class III (MD = 7.96, p < 0.001).

Table 5. Comparison of ANB Angle and ST Dimensions Among Skeletal Class I, II, and III Patterns.

Variables	Skeletal Class	N	Mean ± Standard Deviation (°)	p-value	Pairwise Comparison	p-value	Mean Difference
ANB	Class I	50	1.52 ± 1.33	< 0.001	Class I – Class II	< 0.001	-4.81
	Class II	50	6.33 ± 2.17		Class I – Class III	< 0.001	7.96
	Class III	50	-6.44 ± -6.44		Class II – Class III	< 0.001	12.76
Length	Class I	50	7.07 ± 2.71	0.009	Class I – Class II	0.747	-0.19
	Class II	50	7.26 ± 2.65		Class I – Class III	0.014	1.03
	Class III	50	6.04 ± 1.92		Class II – Class III	0.005	1.22
Depth	Class I	50	8.53 ± 1.69	0.019	Class I – Class II	0.030	-0.62
	Class II	50	9.15 ± 9.58		Class I – Class III	0.008	0.60
	Class III	50	7.93 ± 1.20		Class II – Class III	0.625	1.22
AP Diameter	Class I	50	10.17 ± 1.92	0.016	Class I – Class II	0.607	0.06
	Class II	50	10.11 ± 1.93		Class I – Class III	0.007	0.81
	Class III	50	9.36 ± 1.54		Class II – Class III	0.028	0.75
Cp-Ca	Class I	50	9.09 ± 1.29	0.019	Class I – Class II	0.723	-0.11
	Class II	50	9.20 ± 1.23		Class I – Class III	0.025	0.50
	Class III	50	8.59 ± 1.06		Class II – Class III	0.009	0.61

Discussion

The present study aimed to evaluate the dimensions of ST in a sample of the Cambodian population. A sample of 150 cephalograms was included, with 50 cephalograms each in the Class I, Class II, and Class III categories based on the ANB angle. Results from the present study showed that Class III exhibited significantly lower mean length, AP diameter, and Cp-Ca than Class I and Class II, while Class II demonstrated a significantly higher mean depth than Class I. Class I had a significantly greater mean depth than Class III. This study demonstrated a strong relationship between variations in the dimensions of the ST and dental malocclusion.

The ST, a saddle-shaped depression located at the base of the skull, houses the pituitary gland and serves as a crucial anatomical landmark in craniofacial morphology studies. Its dimensions, including length, width, depth, and morphology, can vary among individuals and populations [3]. Understanding these variations is essential for clinicians and researchers, as abnormalities in ST dimensions can indicate certain endocrine disorders or craniofacial anomalies [10]. Studies investigating ST dimensions often use imaging techniques such as cephalometry, computed tomography (CT), or magnetic resonance imaging (MRI) to accurately measure their parameters [3]. Moreover, population-specific studies, such as those focusing on the Cambodian population, provide valuable insights into the diversity of ST morphology across ethnic groups, aiding clinical diagnosis and treatment planning.

The findings of our study revealed a statistically significant decrease in ST length, AP diameter, and the Cp–Ca distance in individuals of Class III compared with Class I and Class II. These findings are consistent with previous reports [11,12] that found the size of ST is smaller in patients with Class III malocclusion, concluding that there are variations in cranial base parameters related to the types of malocclusion. Axelsson et al. [5] similarly showed ST size varied with age and skeletal class, being generally smaller in individuals with skeletal discrepancies.

The depth of ST was significantly greater in Class II as compared to Class I and Class III. The results are consistent with Prarthna et al. [13] and Silveira et al. [14], who reported that Class II individuals had larger ST depths, consistent with increased anterior cranial base inclination. These skeletal variations may be influenced by complex underlying developmental and genetic pathways that govern craniofacial growth and the positioning of the maxilla and mandible on the cranial base.

The relationship between age and ST dimensions was also evaluated in the present study, in which both the Cp–Ca distance and the ANB angle showed a statistically significant positive correlation with age. As the sample tested is mainly young adults (mean age 23.76 ± 5.63 years), modifications in craniofacial morphology can still occur after puberty through skeletal and dentoalveolar remodelling, especially in cases of malocclusion [10]. This trend may be driven by subtle changes in cranial base measurements over time, due to postural or functional factors.

Regarding gender differences, males had slightly higher mean ST dimensions (length, AP diameter, Cp–Ca) than females, whereas the females exhibited a somewhat deeper mean ST depth. However, these were not statistically different across all variables. These results are consistent with studies by Önal et al. [3] and Kucia et al. [15], which show that males have overall larger cranial base structures; however, differences within the ST dimensions often did not reach statistical significance due to inter-individual variability.

The clinical relevance of these findings is considerable, as ST is widely accepted as a stable cephalometric reference. ST is the earliest developed cephalometric structure and the morphology of the segment that can be used validly to compare skeletal patterns due to little or no changes thereafter after puberty [1]. Differences in ST morphometry between skeletal classes may serve as a supplementary indicator in orthodontic diagnosis and treatment planning, especially for analyzing growth patterns, cranial base morphology, and related traits.

Moreover, by deriving ST morphometric norms in a Cambodian population, the study provides region-specific craniofacial data to address a gap in the literature. Ethnic variations in craniofacial morphology suggest that population-specific standards are mandatory for precise diagnosis and personalized treatment strategies [2,5].

Several studies, including those by Sathyanarayana et al. [1] and Axelsson et al. [5], have highlighted the utility of ST dimensions in understanding craniofacial growth trends, particularly when used in conjunction with other skeletal and dental parameters. While it is not suggested that ST morphology directly dictates treatment decisions, it may provide supportive anatomical information, especially in cases involving cranial base anomalies or complex skeletal discrepancies.

The classification of skeletal malocclusion in this study was based on the ANB angle, as described in the literature, where an ANB angle between 0° and 4° indicates Class I, greater than 4° indicates Class II, and less than 0° indicates Class III malocclusion [16]. In addition, enlargement of the sella turcica may result from a range of physiological and pathological factors, including pituitary adenomas, primary hypothyroidism, prolactinomas, and conditions such as acromegaly or gigantism, where excessive growth hormone leads to structural changes in the pituitary fossa [17]. Understanding these associations is essential, as they highlight the potential of ST morphometry as an indicator not only of craniofacial growth patterns but also of underlying systemic or endocrine conditions.

This study has some limitations. The use of two-dimensional lateral cephalograms might not fully represent the three-dimensional structure of the entire ST. Additionally, the retrospective design and the skewed gender distribution (more females than males) in this study may limit generalizability. Future studies employing CBCT, more representative samples of similar size, and better-balanced gender representation might shed further light on the nature of sella turcica morphology across populations.

Conclusion

This study highlights significant variations in the linear dimensions of the sella turcica across different skeletal malocclusion classes in a Cambodian population. Class III individuals exhibited smaller sella turcica dimensions compared to Class I and II, while Class II showed greater sella turcica depth. These findings support previous research suggesting that sella turcica morphometry varies with skeletal pattern and may serve as a supplementary cephalometric parameter in craniofacial assessment. Although sella turcica morphology is not directly used in orthodontic treatment planning, understanding its variations contributes to a broader appreciation of cranial base development and may help refine diagnostic interpretations in complex skeletal cases. Further studies using advanced imaging and diverse populations are recommended to validate and expand upon these findings.

Authors' Contributions

NC	https://orcid.org/0009-0005-5470-4374	Validation, Investigation, Writing - Original Draft, and Visualization.
GS	https://orcid.org/0000-0002-5877-205X	Methodology, Formal Analysis, Data Curation, Writing - Original Draft, and Writing - Review and Editing.
AC	https://orcid.org/0000-0002-8356-9512	Software, Validation, Resources, Writing - Original Draft, Writing - Review and Editing, Visualization, and Supervision.
HV	https://orcid.org/0009-0000-5139-452X	Validation, Formal Analysis, Investigation, Writing - Original Draft, Writing - Review and Editing, and Visualization.
PC	https://orcid.org/0000-0003-3910-9807	Validation, Formal Analysis, Resources, Writing - Original Draft, Writing - Review and Editing, and Visualization.
AK	https://orcid.org/0000-0002-4698-9876	Conceptualization, Investigation, Writing - Original Draft, Writing - Review and Editing, Visualization, and Project Administration.
PM	https://orcid.org/0000-0003-3024-544X	Conceptualization, Validation, Formal Analysis, Data Curation, Writing - Original Draft, Writing - Review and Editing, and Visualization.
RI	https://orcid.org/0000-0002-0046-3529	Methodology, Validation, Investigation, Data Curation, Writing - Review and Editing, and Visualization.
MKA	https://orcid.org/0000-0001-7131-1752	Formal Analysis, Investigation, Data Curation, Writing - Original Draft, and Writing - Review and Editing.
AM	https://orcid.org/0000-0003-2009-4393	Conceptualization, Validation, Formal Analysis, Resources, Writing - Original Draft, Writing - Review and Editing, Visualization, Supervision, and Project Administration.
All authors declare that they contributed to the critical review of intellectual content and approval of the final version to be published.		

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Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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