



Original Research Article

A novel indicator for assessing sagittal dysplasia: CAP1 angle

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Abstract

Objective: To introduce a novel perspective known as the CAP1 angle using Point W, M and G, which effectively assesses the sagittal skeletal interrelation between the maxilla and mandible, without being influenced by alterations in the vertical dimension.

Materials and Methods: In this orthodontic study, lateral cephalograms of 250 patients were examined to evaluate sagittal discrepancies. One investigator measured parameters like the ANB angle, Wit's appraisal, and Beta angle. For Categorical Data Frequency and Percentage were obtained, For Continuous data Mean and SD was obtained. To compare categorical data Cross Tabulation with Chi Square test of proportion was applied, and to compare the continuous data ANOVA with Post Hoc Tukey's was used. All the statistical analysis was performed keeping the confidence interval at 95% and ($p < 0.05$) was considered statistically significant. After applying inclusion and exclusion criteria, 150 cephalograms were chosen and categorized into Class I, Class II, and Class III skeletal groups.

Results: CAP1 angles between 19° and 25° , $>25^\circ$ and $<19^\circ$ suggest skeletal class I, II, and III malocclusions, respectively.

Conclusion: CAP1 angle thus helps assessing the sagittal skeletal malocclusion without being altered by changes in vertical dimensions and age.

Keywords: Point M, Point G, Point W, CAP1 Angle, Skeletal disharmony

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1. Introduction

Cephalometric analysis is a cornerstone in orthodontic diagnostics and treatment planning, pivotal for resolving discrepancies in the anteroposterior and vertical dimensions of the maxillary and mandibular bases. Essential qualities of any diagnostic tool include precision, reliability, and reproducibility. However, traditional parameters like the ANB angle face challenges due to jaw rotation induced by growth or orthodontic interventions and variations in cranial base length.^{1,2} It has been noted in prior investigations that the position of the nasion undergoes alterations as an individual grows, hence impacting the ANB angle.³⁻⁶

The Beta angle⁷ using points A and B, is prone to alteration due to regional remodelling,^{8,9} and locating point C on lateral cephalograms is challenging.^{10,11} The Yen¹² and W angles¹³ were introduced to address these issues. However, the Yen angle's accuracy may suffer from jaw rotation, while the W angle relies on the unstable landmark of Point S.^{14,15}

It has long been known that the tuberculum sella (T) and wing (W) points, located at the middle cranial base, are highly stable.^{16,17} Arat ZM's research underscores the remarkable stability of the tuberculum sella (T) and wing (W) points, situated at the middle cranial base. Their study illuminates these points as the most steadfast within the cranial base. Utilizing the T point along the T-W line for superimposition emerges as a robust method for evaluating comprehensive facial feature changes during active growth phases and prolonged monitoring.¹⁸

In this context, our study introduces a novel perspective—the CAP1 angle. This parameter, independent of vertical dimension alterations, relies on three robust anatomical landmarks: Point W, at the intersection of the ala major contour and the jugum sphenoidale; Point M,¹⁹ the center of the largest circle tangent to the maxilla's frontal, upper, and palatal surfaces; and Point G²⁰ the focal point of the largest circle tangent to the mandibular symphysis's inner

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frontal, posterior, and lower edges. The CAP1 angle, defined by lines connecting W-G and M-G points, offers a fresh approach to assessing sagittal skeletal interrelation (**Figure 1**).

Our study's primary objective is to establish the mean value of the CAP1 angle across three distinct skeletal malocclusions in the Konkan population. Thus, aiming to contribute valuable insights into orthodontic diagnosis and treatment planning, offering a more precise and reliable tool for clinicians in the field.

2. Materials and Methods

In this orthodontic study, 250 patients' pre-treatment records were assessed using optimum-quality lateral cephalograms where-in the landmarks were visible. The researchers analyzed sagittal discrepancies by measuring parameters such as the ANB angle, Wit's appraisal, and Beta angle. To ensure data accuracy, a single investigator conducted all measurements. Out of the initial 250 cephalograms, 150 were selected based on inclusion and exclusion criteria. (**Table 1**). These 150 were categorized into three skeletal groups: Class I, Class II, and Class III (**Table 2**).

2.1. Statistical analysis

The measurements (CAP1 Angle, ANB Angle, Wits Appraisal) were calculated on the Dolphin Imaging 3D Software. The data was then entered into Microsoft Excel Version 13. The data was subjected to Statistical Analysis using IBM SPSS Version 21. For Categorical Data Frequency and Percentage were obtained, For Continuous data Mean and SD was obtained. To compare categorical data Cross Tabulation with Chi Square test of proportion was

applied, to compare the continuous data ANOVA with Post Hoc Tukey's was applied. All the statistical analysis was performed keeping the confidence interval at 95% and ($p<0.05$) was considered to be statistically significant. The Distribution of Participants Depending upon Skeletal Relationship depicted that there were equal number of Class I, Class II and Class III participants present in the study 50(33.3%) ($p>0.05$). (**Table 2**). The Mean CAP1 of Study participants in Class I Class II and Class III was 23.27 ± 2.31 , 29.51 ± 1.60 and 16.26 ± 3.08 respectively and the comparison between the Mean CAP1 between Class I, Class II and Class III depicted to be statistically significant ($p<0.05$). (**Table 3**). When Pairwise comparison of the CAP1 of the Participants among Class I, Class II and Class III was performed it was observed that Mean CAP between Class I and Class II, Class I and Class III and Class II and Class III depicted to have statistically significant difference in Mean ($p<0.05$). (**Table 4**)

3. Results

The sensitivity and specificity of the CAP1 angle was examined by the ROC curves as a test to differentiate between the three different skeletal pattern groups. To differentiate Class I from Class II, the CAP 1 angle 25.5 and less is depicted to have a sensitivity of 98% and specificity 90%. The Area under the Curve was found to be 0.956. To differentiate Class I with Class III, the CAP 1 angle 18.50 and less, the sensitivity of 100% and specificity is 80%. The Area under the Curve was found to be .989. To differentiate Class II with Class III, the CAP 1 angle 19.50 and less, the sensitivity is 98% and the specificity was 92%. The Area under the Curve was found to be .997 (**Figure 2,Figure 3 and Figure 4**)

Table 1: Inclusion and exclusion criteria

Inclusion Criteria		Exclusion Criteria	
1. Class I: ANB angle 1°–4°, WITS appraisal 0–4 mm, and Beta angle 27–35° 2. Class II: ANB angle >4°, WITS appraisal >4 mm, and Beta angle < 27° 3. Class III: ANB angle ≤0°, WITS appraisal Beta angle >27° 4. Permanent dentition with no missing teeth. 5. Patients with age group between 15 and 40 years.		1. Patients subjected to prior orthodontic treatment. 2. Patients with cranial or facial malformation and history of craniofacial trauma. 3. Poor quality of cephalograms	

Table 2: Distribution of study participants according to Gender in Class I, Class II, Class III

			Skeletal relationship			Total	P Value
			Class I	Class II	Class III		
Sex	Male	N	16	16	19	51	0.734
		%	33.3%	33.3%	37.3%	100.0%	
	Female	N	34	34	31	99	
		%	34.3%	34.3%	31.3%	100.0%	
Total		N	50	50	50	150	
		%	33.3%	33.3%	33.3%	100.0%	

Table 3: Comparison of CAP1 between Class I, Class II, Class III by ANOVA test

CAP1 Angle							
	N	Minimum	Maximum	Mean	Std. Deviation	F	Sig.
Class I	50	19.00	29.00	23.2745	2.31584	372.791	.000
Class II	50	27.00	33.00	29.5102	1.60886		
Class III	50	9.00	20.00	16.2600	3.08260		

Table 4: Pairwise Comparison of CAP1 between Class I, Class II, Class III

Multiple Comparisons			
Dependent Variable:			
Tukey HSD			
(I) Skeletal relationship		Mean Difference (I-J)	Sig.
	Class II	-6.23569	.000
	Class III	7.01451	.000
Class II	Class III	13.25020	.000

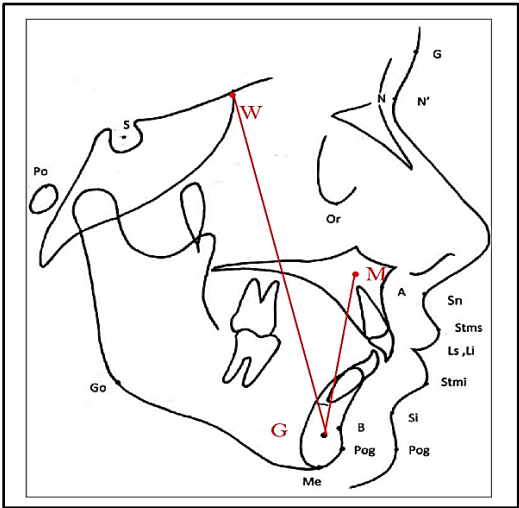


Figure 1: CAP1 Angle

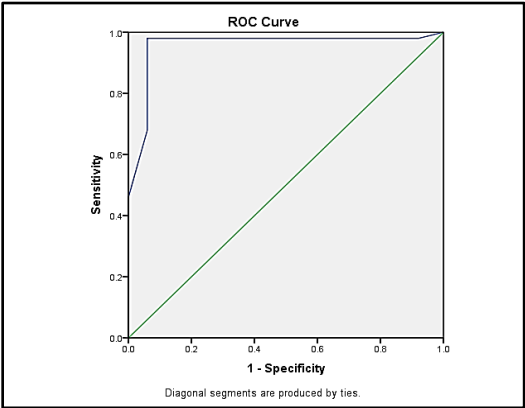


Figure 2: To differentiate Class I with Class II, the CAP 1 angle 25.5 and less depicted to have the sensitivity of 98% and specificity 90%. The Area under the Curve was found to be 0.956.

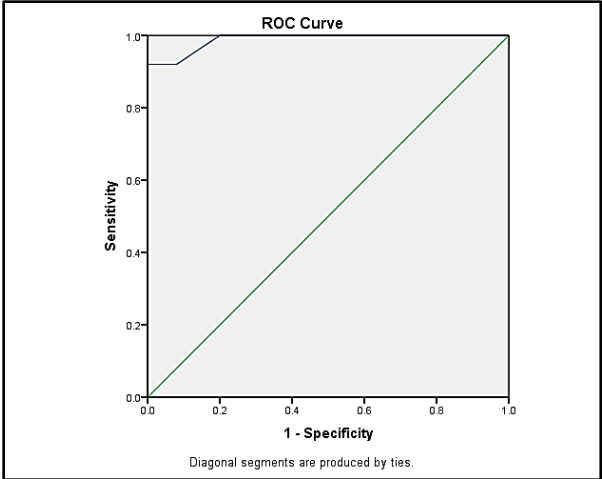


Figure 3: To differentiate Class I with Class II, the CAP 1 angle 18.50 and less, the sensitivity of 100% and specificity is 80%. The Area under the Curve was found to be .989.

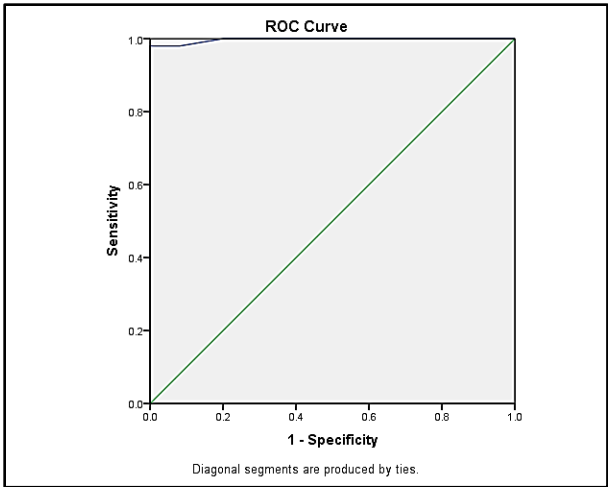


Figure 4: To differentiate Class II with Class III, the CAP 1 angle 19.50 and less, the sensitivity is 98% and specificity was 92%. The Area under the Curve was found to be .997.

4. Discussion

Accurate evaluation of sagittal relationships relies on stable landmarks determined by cephalometric parameters. Reliability is crucial for trustworthy measurements, impacting treatment decisions and patient care. Shetty et al.'s²⁰ systematic review highlighted factors like jaw rotation and variable anatomical points, necessitating the use of extracranial reference planes in assessing mandibular position relative to the maxilla.

The G and M points, advocated by researchers including Nanda and Merrill¹⁹ and later supported by Braun et al.²⁰, serve as stable skeletal landmarks denoting the mandible and maxilla. Positioned strategically, the G point lies at the center of the largest circle tangent to premaxillary surfaces, while the M point is situated on specific areas of the mandibular symphysis. Unlike points A and B, G and M points remain resistant to local remodeling induced by dental movements.

Arat et al. suggest that the middle cranial base matures earlier, likely due to its protective role for vital organs like the brain, making it an ideal research reference by age.⁸

Notably stable landmarks on this base, such as the Anterior Sella (Walker's point, W) and Wing point (w), are widely recognized and utilized by researchers for their reliability, remaining minimally susceptible to developmental changes after childhood.^{18,22}

The CAP1 angle is crucial for distinguishing between skeletal class I, II, and III malocclusions, aiding treatment planning for cases with both anteroposterior and vertical discrepancies. Complementary cephalometric measurements may be necessary for precise interpretation. Its universal applicability requires validation across diverse ethnic populations to establish norms, ensuring consistent and accurate diagnosis and treatment planning.

5. Conclusion

1. This study has illuminated the potential of the CAP1 angle as a valuable marker for evaluating jaw discrepancy, leveraging stable landmarks for its assessment.
2. The CAP1 angle in the range 19°-25° can be considered to have class I skeletal pattern.
3. The CAP1 angle more than 25° indicates Class II skeletal pattern whereas less than 19° indicates Class III skeletal pattern respectively.

6. Source of Funding

None.

7. Conflict of Interest

None.

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