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Original Research Article

MPP-DPP metrics: A novel diagnostic tool for sagittal dysplasia assessment

Sreejit Saha[1]*, Chandrashekar BS[1], Mahendra S[2], Nishan Ansari[2], Narayana Iyer Ramana Ramya Shree[2]

[1]*Dept. of Orthodontics, Krishnadevaraya College of Dental sciences and Hospital, Bangalore, Karnataka, India*
[2]*Dept. of Orthodontics and Dentofacial Orthopedics, Krishnadevaraya College of Dental sciences and Hospital, Bangalore, Karnataka, India*

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ABSTRACT

Aim and Objectives: The aim of the study is to establish a correlations between MPP-DPP metrics, ANB angle and Witts appraisal, as well as to determine whether perpendicular drawn from the centroids of the premaxilla(M) and mandibular symphysis(D) to the palatal plane can be utilised for identifying sagittal dysplasia in lateral cephalometric radiographs.
Background: Orthodontic diagnoses has relied heavily on radiographic cephalometry. The limited validity of current assessment techniques, vertical jaw relationships, and growth-related jaw rotations have made evaluating sagittal jaw relationships difficult and also they are less vulnerable to factors that could compromise accuracy and have a reduced measurement error, linear measurements have clear advantages over angular measurements.
Materials and Methods: lateral cephalometric radiographs of 90 individuals were included in this study and were divided into 3 groups based on their sagittal relationship,(Class 1, class 2, class 3). A perpendicular was drawn from point M(centroid of premaxilla) and point D(centroid of mandibular symphysis) to the palatal plane and the linear distance measured was compared to ANB and Witts appraisal.
Results: The mean MPP -DPP values in Class I subjects was 3.222 ± 1.435, Class II subjects was 8.672 ± 2.443, and in Class III subjects was -6.410 ± 2.535 and this mean difference between 3 Skeletal classes was statistically significant at p<0.001. Additionally, the study showed a positive correlation between M-PP/D-PP metrics, ANB and Witts appraisal.
Conclusion: This study showcases the promise of MPP-DPP metrics as supplementary indicators in orthodontic diagnosis and treatment planning. The strong positive correlations identified between MPP-DPP, ANB, and Wits appraisal underscore their value in evaluating sagittal jaw relationships.

1. Introduction

Radiographic cephalometry, introduced by Broadbent.[1] in 1931, has been a cornerstone in orthodontic diagnostics. However, assessing sagittal jaw relationships has remained a challenge due to growth-related jaw rotations, vertical jaw relationships, and the limited validity of existing assessment methods.

Linear measurements offer distinct advantages over angular measurements, being less susceptible to variables affecting accuracy and exhibiting lower measurement error. Several authors have developed numerous cephalometric analyses to deduce sagittal jaw relationships, primarily relying on the relationship of the maxilla and mandible to the cranial base or other planes such as Frankfort, palatal, and occlusal planes.[2–16]

* *Corresponding author*.
E-mail address: sreejitsaha.27@gmail.com (S. Saha).

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In this study, the occlusal plane is replaced with a skeletal plane to improve precision and consistency in its location. The palatal plane has emerged as a discernible and reliable reference for determining the base of the maxilla.[4] The objective of this investigation is to establish correlations between MPP-DPP, ANB, and Witts appraisal, examining whether perpendicular drawn from the centroids of the premaxilla(M) and mandibular symphysis(D) to the palatal place can serve as indicators of sagittal dysplasia in lateral cephalometric radiographs. The focus is specifically on measuring the sagittal maxilla-mandibular relationship.

2. Materials and Methods

The current study is a non-interventional observational descriptive investigation utilizing secondary data. It was conducted at the Department of Orthodontics and Dentofacial Orthopedics, Krishnadevaraya College of Dental Sciences and Hospital in Bangalore, India, spanning from December 2023 to January 2024. The sample was categorized into three distinct groups(Class 1, Class 2, Class 3) based on the skeletal base, addressing three aspects of the investigation. For this study, a cohort of 90 non-growing adults with well-balanced facial features, normal occlusion, and no history of orthodontic treatment or orthognathic surgery was selected, adhering to the inclusion criteria. This selection aimed to establish norms by averaging skeletal parameters projected onto the palatal plane. A perpendicular line was drawn from the palatal plane to points M(Centroid of pre-maxilla) and D(Centroid of mandibular symphysis). The linear distance was measured and compared with Wits and Steiner's ANB(Figure 1).

2.1. Inclusion criteria

1. Subjects aged between 18-30 years.
2. Must have full complement of teeth(excluding third molars).
3. High quality lateral cephalograms.

2.2. Exclusion criteria

1. Subjects who have previously undergone orthodontic or dentofacial orthopedic treatment.
2. History of trauma to craniofacial region.
3. Gross craniofacial asymmetry and deformities.

2.3. Statistical analysis

Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., will be used to perform statistical analyses.

2.4. Descriptive statistics

Descriptive analysis includes expression of MPP-DPP, AO-BO & ANB values in terms of Mean & SD for each group.

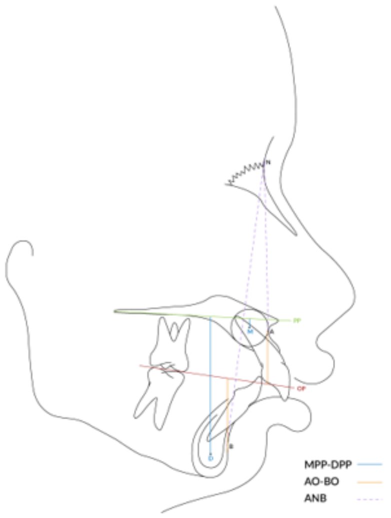

Figure 1: M- Centroid of premaxilla, D- Centroid of mandibularsymphysis, Point A, Point B, N- Hard tissue Nasion, PP- Palatal plane, OP-Occlusal plane. A perpendicular drawn from palatal plane to point M and point Dwas used in this study to determine the sagittal relationship and wascorrelated to Wit's appraisal and Steiner's ANB angle. Linear measurements, such as MPP-DPP and AO-BO, are represented by solid lines, while angular measurements, like ANB, are indicatedby dashed lines.

2.5. Inferential statistics

One-way ANOVA Test followed by Tukey's post hoc Test / Kruskal Wallis Test followed by Dunn's post hoc Test [Based on data distribution] was used to compare the mean M-PP/D-PP, AO-BO & ANB between 3 Skeletal Classes.Pearson's correlation / Spearman's Rank Correlation test was used to determine the relationship between M-PP/D-PP, AO-BO & ANB values in each Skeletal class and in overall samples.ROC Curve analysis for the M-PP/D-PP values was performed to differentiate the Skeletal bases in Class I, II & III subjects.The level of significance was set at $p<0.05$.

3. Results

Comparison of MPP-DPP to Other Measures of Sagittal Jaw Relationships:

The three methods used for comparison of skeletal base relationships were AO-BO(Wits), ANB angle, and the relationship of points M perpendicular and D perpendicular to palatal plane. Former researches have confirmed the observations that the palatal plane remains relatively stable throughout growth.[4,17–19] This stability over time validates use of the palatal plane as a reference plane for measurement.

The mean M-PP / D-PP values in

1. Class I subjects was 3.222 ± 1.435(Figure 2).

2. Class II subjects was 8.672 ± 2.443(Figure 3).
3. Class III subjects was -6.410 ± 2.535(Figure 4).

Figure 2: The average MPP-DPP values of Class 1 individuals was 3.222 mm.

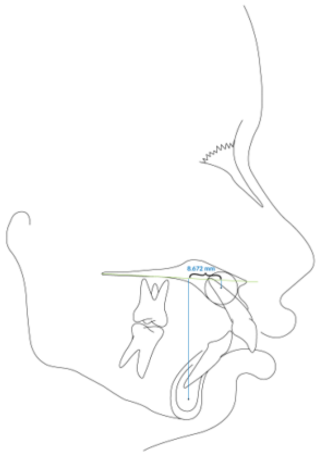

Figure 3: The average MPP-DPP values in Class 2 individuals was 8.672 mm.

The mean M-PP / D-PP values in Class I subjects was 3.222 ± 1.435, Class II subjects was 8.672 ± 2.443 and in Class III subjects was -6.410 ± 2.535 and this mean difference between 3 Skeletal classes was statistically significant at p<0.001(Table 1).

Multiple comparison of mean differences between skeletal malocclusions revealed that the mean Skeletal Class II subjects showed significantly highest M-PP / D-PP values as compared to Class I & Class III subjects and the mean differences were statistically significant at p<0.001. This was then followed next by Class I subjects who showed significantly higher mean M-PP / D-PP values as compared to Class III subjects and the mean difference was statistically significant at p<0.001. This infers that the mean M-PP / D-PP values was significantly highest in Class II Subjects, followed by Class I Subjects and least in Class III Subjects(Table 2).

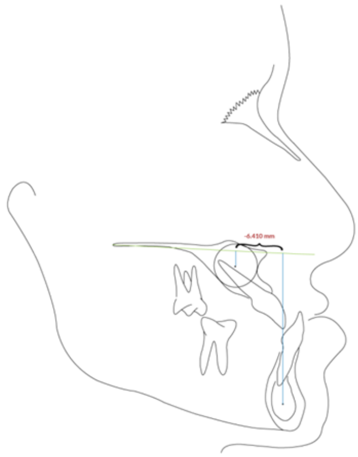

Figure 4: The average MPP-DPP values in class 3 individuals was -6.410 mm.

The mean AO-BO values in Class I subjects was 2.966 ± 1.622, Class II subjects was 8.959 ± 2.421 and in Class III subjects was -4.141 ± 1.957 and this mean difference between 3 Skeletal classes was statistically significant at p<0.001(Table 3).

Multiple comparison of mean differences between Skeletal malocclusions revealed that the mean Skeletal Class II subjects showed significantly highest AO-BO values as compared to Class I & Class III subjects and the mean differences were statistically significant at p<0.001(Table 4). This was then followed next by Class I subjects who showed significantly higher mean AO-BO values as compared to Class III subjects and the mean difference was statistically significant at p<0.001. This infers that the mean AO-BO values was significantly highest in Class II Subjects, followed by Class I Subjects and least in Class III Subjects.

Themean ANB values in Class I subjects was 1.95 ± 0.85, Class II subjects was 6.67± 1.60 and in Class III subjects was -3.14 ± 2.56 and this mean differencebetween 3 Skeletal classes was statistically significant at p<0.001(Table 5).

Multiple comparison of mean differences between Skeletal malocclusions revealed that the mean Skeletal Class II subjects showed significantly highest ANB values as compared to Class I & Class III subjects and the mean differences were statistically significant at p<0.001. This was then followed next by Class I subjects who showed significantly higher mean ANB values as compared to Class III subjects and the mean difference was statistically significant at p<0.001. This infers that the mean ANB values was significantly highest in Class II Subjects, followed by Class I Subjects and least in Class III Subjects(Table 6).

Table 1: Comparison of mean MPP-DPP values between 3 skeletal classes using One-way ANOVA test.

Parameters	Classes		Mean	SD	Min	Max	p-value
M-PP / D-PP	Class I	28	3.222	1.435	0.20	5.10	<0.001*
	Class II	28	8.672	2.443	5.16	15.50	
	Class III	28	-6.410	2.535	-10.67	-1.69	

* - Statistically significant

Table 2: Multiple comparison of mean difference in MPP-DPP values between skeletal classes using Tukey's post hoc test.

Parameter	(I) Groups	(J) Groups	Mean Diff.(I-J)	95% CI for the Diff.		P-value
				Lower	Upper	
M-PP / D-PP	Class I	Class II	-5.450	-6.851	-4.050	<0.001*
		Class III	9.632	8.232	11.033	<0.001*
	Class II	Class III	15.083	13.682	16.483	<0.001*

* - Statistically significant

Table 3: Comparisonof mean AO-BO values between 3 skeletal classes using one-way ANOVA test.

Parameters	Classes		Mean	SD	Min	Max	p-value
AO-BO	Class I	28	2.966	1.622	0.20	5.90	<0.001*
	Class II	28	8.959	2.421	5.10	15.02	
	Class III	28	-4.141	1.957	-7.86	-0.52	

* -Statistically significant

Table 4: Multiple comparison of mean difference in AO-BO values between skeletal classes using Tukey's post hoc test.

Parameter	(I) Groups	(J) Groups	Mean Diff.(I-J)	95% CI for the Diff.		p-value
				Lower	Upper	
AO-BO	Class I	Class II	-5.993	-7.286	-4.700	<0.001*
		Class III	7.107	5.814	8.400	<0.001*
	Class II	Class III	13.100	11.807	14.393	<0.001*

* - Statistically significant

Table 5: Comparison of mean ANB values between 3 skeletal classes using Kruskal Wallis Test.

Parameters	Classes		Mean	SD	Min	Max	p-value
ANB	Class I	28	1.95	0.85	0.5	3.4	<0.001*
	Class II	28	6.67	1.60	5.0	11.7	
	Class III	28	-3.14	2.56	-10.2	-0.2	

* - Statistically significant

Table 6: Multiple comparison of mean difference in ANB values between skeletal classes using Dunn's post hoc test.

Parameter	(I) Groups	(J) Groups	Mean Diff.(I-J)	95% CI for the Diff.		p-value
				Lower	Upper	
ANB	Class I	Class II	-4.72	-5.87	-3.57	<0.001*
		Class III	5.09	3.94	6.24	<0.001*
	Class II	Class III	9.81	8.65	10.96	<0.001*

* - Statistically significant

Table 7: Pearson's/Spearman's Rank correlation test was used to determine the relationship between MPP-DPP, AO-BO and ANB in 90 samples and in each skeletal malocclusions.

Samples	Parameter	values	AO-BO	ANB
Class I	M-PP/D-PP	r	0.69	0.57
		p-value	<0.001*	0.002*
Class II	M-PP/D-PP	r	0.88	0.83
		p-value	<0.001*	<0.001*
Class III	M-PP/D-PP	rho	0.75	0.70
		p-value	<0.001*	<0.001*
Overall	M-PP/D-PP	rho	0.97	0.96
		p-value	<0.001*	<0.001*

Pearson's / Spearman's Rank correlation test was used to determine the relationship b/w M-PP/D-PP, AO-BO & ANB in overall samples and in each Skeletal Class .

Table 8: ROC Curve analysis for MPP-DPP parameter in differentiating the skeletal bases inClass I, Class II and Class III subjects.

Skeletal Classes	AUC	Std. Error	95% Conf. Interval		p-value	Cut off	Sn (%)	Sp (%)
			Lower	Upper				
I vs II	1.00	0.01	0.94	1.00	<0.001*	> 5.1	100.00	100.00
I vs III	1.00	0.01	0.94	1.00	<0.001*	≤ - 1.69	100.00	100.00
II vs III	1.00	0.01	0.94	1.00	<0.001*	≤ - 1.69	100.00	100.00

* - Statistically significant

The test results demonstrate that M-PP/D-PP shows a significant strong positive correlation with AO-BO [r = 0.69 & rho = 0.75] among Class I subjects & III subjects, whereas a very strong positive correlation was observed [r = 0.88 & rho = 0.97] among Class II & Overall samples. The findings were statistically significant at p<0.001. Similarly, M-PP/D-PP shows a significant moderate positive correlation with ANB [r = 0.57] among Class I subjects & a significant strong positive correlation [rho = 0.70] among III subjects which was statistically significant at p=0.002 & p<0.001 respectively, whereas a very strong positive correlation was observed [r = 0.83 & rho = 0.96] among Class II & Overall samples. The findings were statistically significant at p<0.001 as shown(Table 7).

The ROC [Receiver Operator Characteristic] Curve analysis revealed that the M-PP/D-PP value demonstrated a cut off value of 5.1 to differentiate the Skeletal base between Class I & II subjects with Sensitivity and Specificity of 100%. Similarly, a cut off value of - 1.69 to differentiate the Skeletal base between Class I & III subjects and also between Class II & Class III subjects with Sensitivity and Specificity of 100%(Table 8).

4. Discussion

Patients presenting with sagittal dysplasias are a common sight in any orthodontic clinical practice. Mere clinical observation is insufficient for accurate diagnosis in such cases. Radiographic adjuncts are a valuable resource, providing us insight to accurately diagnose and plan treatment in such scenarios. Numerous sagittal dysplasia indicators have been proposed over the years by several authors; each with its own list of pros and cons. Despite inherent flaws, many of them are still widely used due to their ease in application and universal applicability. The orthodontic fraternity have been constantly in the pursuit of improving and adopting better methods for sagittal dysplasia indication.

Numerous indicators of sagittal dysplasia have been documented in the literature over the years. Among these, the ANB angle, first introduced by Riedel[20] in 1948, has emerged as the most prevalent and commonly employed method. In the context of this study, the mean ANB angle values closely adhere to Riedel's established standards and demonstrate notable correlations with other variables in class I samples. The ANB angle, though a key metric in orthodontics, is subject to a multitude of influences and can frequently lead to misinterpretation. Its accuracy hinges on a range of factors, including the patient's age, the rotational growth of their jaws, vertical growth patterns, and the length of the anterior cranial base(specifically, the AP position of N).[21] This complexity underscores the need for a nuanced understanding when interpreting this angle, as it is not a standalone indicator but rather a composite of various interrelated elements.

The Wits' appraisal, a method introduced by Jacobson [5], circumvents the use of point N and reduces the rotational effects of jaw growth. While the Wits appraisal is not influenced by landmarks or jaw rotations, it grapples with the challenge of accurately pinpointing the functional occlusal plane, a task that can prove daunting, particularly in mixed dentition scenarios. Moreover, fluctuations in the Wits measurement during orthodontic interventions may not solely signify sagittal changes in the jaws but could also mirror alterations in the functional occlusal plane. The average values of this measurement demonstrate a significant correlation with the ANB angle across all classes and with APP-BPP in class I alone, which can be attributed to the typical inclinations of the palatal and occlusal planes in class I samples.

Over the years, every anteroposterior parameter introduced has been influenced by a range of factors, including the patient's age, jaw rotations, the challenge of reproducibility in landmark identification, shifts in reference planes due to growth, and changes arising from orthodontic interventions.

To minimize the impact of growth-related fluctuations on the consistency and accuracy of reference points and measurements, this study exclusively enrolled adult participants aged eighteen and above, all of whom possessed a complete set of permanent teeth and had not undergone any prior orthodontic treatment.[20]

The majority of measurements used to assess sagittal jaw relations rely on points and planes within the cranium. Points A and B, as defined by Downs[22], have been widely employed due to their representation of the apical base limit in both jaws. However, the determination of these points presents challenges, and their positions may be influenced by growth and orthodontic treatment. Consequently, researchers have explored alternative stable points.[23] Cephalometric planes can significantly impact the assessment of sagittal jaw relations, with variable inclinations influenced by anatomical variations in points, soft tissue factors, differences in vertical jaw relations, and dento-alveolar compensation effects on dental arches and teeth alignment despite skeletal discrepancies.

This investigation eliminated the use of occlusal plane and substituted it with the palatal plane. The palatal plane is a skeletal plane that can be located with greater precision and consistency. It is preferred over the functional occlusal plane because the occlusal plane undergo changes in inclination during growth and with orthodontic treatment.[13] The Wits appraisal[5] changes significantly with shift in the angulation of the functional occlusal plane, which will alter appreciably during the growth period. The proximity of palatal plane to the dentitions and their apical bases in both the maxilla and the mandible allowed an evaluation of the maxillomandibular complex by relating the mandible to the maxillary and not by how the maxilla and the mandible related to nasion, cranial base, functional occlusal plane, or any other distant reference point. To serve these objectives, the palatal plane was seen to be a discernible and reliable plane that determines the base of the maxilla. Since the tooth-bearing areas of the maxilla and the mandible can be related to each other on the palatal plane, it provides a useful tool to measure anteroposterior jaw relationships. Palatal plane was also selected because it is stable throughout life. This was shown in this investigation and agrees with the findings of other investigators.[4,17,19]

4.1. The advantages of using palatal plane are

1. Growth changes of point N do not influence the result,
2. Rotation of the jaws does not influence the result,
3. Inclination of the occlusal plane by dental effects is excluded, and
4. Vertical effects of points A and B are decreased in comparison to other methods of analysis.

Broadbent[17] wrote that the palatal plane appeared to maintain a parallel relation over the growth range in the population he studied. Brodie[18] found from studying longitudinal records that the palatal plane maintained a constant angular relationship with the anterior cranial base. Riolo et al.,[4] in their longitudinal study found only a slight increase in the angulation of palatal plane to the anterior cranial base and to the pterygomaxillary vertical plane. Bjork using implants found that the inclination of the palatal plane to the cranial base was maintained throughout growth.[19]

The utilization of linear measurements presents distinct advantages over angular measurements.[24] Linear measurements are inherently less susceptible to the influence of variables that could potentially compromise their accuracy, thereby reducing the likelihood of errors. In contrast, angular measurements are inherently more complex due to the involvement of the positions of three points in any angular measurement. Furthermore, the impact of angular changes is magnified as one moves away from the vertex of the angle being measured. Consequently, in light of these considerations, it was determined that linear measurements would be the preferred method of measurement in this study.

Cephalometrics, while a valuable diagnostic tool, is not without its limitations. Relying solely on angular and linear measurements can be restrictive, as these parameters may not fully capture the complexity of skeletal relationships. The MPP-DPP method, however, offers a significant enhancement in assessing the anteroposterior jaw relationship. By incorporating this method alongside other diagnostic parameters, clinicians can achieve a more comprehensive understanding of a patient's condition, leading to more precise treatment planning and improved outcomes.

5. Conclusion

This study showcases the promise of MPP-DPP metrics as supplementary indicators in orthodontic diagnosis and treatment planning. The strong positive correlations identified between MPP-DPP, ANB, and Wits appraisal underscore their value in evaluating sagittal jaw relationships. However, a thorough assessment of sagittal jaw relations should take into account the intricacies of different measurements and planes employed, ensuring a more precise orthodontic evaluation.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Author's biography

Sreejit Saha, Post Graduate Student https://orcid.org/0009-0000-0523-8251

Chandrashekar BS, Professor

Mahendra S , Reader

Nishan Ansari, Senior lecturer

Narayana Iyer Ramana Ramya Shree, Senior Lecturer

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