Original Article

A novel diagnostic tool for sagittal jaw relationship: The P angle

ABSTRACT

Aim: To introduce a new cephalometric measurement called P-angle using three skeletal landmarks—point S, point Gn, and point A, to evaluate the sagittal relationship between the maxilla and mandible.

Materials and Methods: A total of 130 pretreatment lateral cephalograms were selected and segregated into skeletal Class I, II, and III groups based on W-angle and ANB angle. It included 50 Class I (25 males and 25 females), 50 Class II (25 males and 25 females), and 30 Class III (13 males and 17 females) skeletal pattern patients. The *P* angle was formed between the line from point A perpendicular to the S-Gn line and line A-Gn. The P-angle and W-angle were measured in each patient. Data was entered in MS Excel sheet and analyzed by using SPSS software 24.0 version IBM USA. The mean and standard deviation of P-angle and W-angle was calculated and were compared using an unpaired *t*-test.

Results: The unpaired *t*-test results showed that there is no significant difference between P-angle and W-angle in Class I, Class II, and Class III skeletal pattern.

Conclusion: *P*-angle can be used as an adjunct for W-angle during pretreatment cephalometric tracing.

Keywords: *P*-angle, sagittal jaw relationship, w-angle

INTRODUCTION

In orthodontic diagnosis and treatment planning, it is very important to cephalometrically measure the anteroposterior (AP) jaw relationship. Several authors have assessed the sagittal skeletal relationship using various landmarks, starting from Riedel[1] (ANB angle), Jacobson[2] (Wits analysis), Nanda and Merrill[3] (App-Bpp), Baik and Ververidou[4] (β angle), Kim and Vietas[5] anteroposterior dysplasia indicator, Neela *et al*.[6] (YEN angle), Bhad *et al*.[7] (W angle), Kumar *et al*.[8] (Pi analysis), etc., The ANB angle and Wits appraisal are still one of the most commonly used measurements in assessing sagittal relation, although there is not a single cephalometric measurement that has been accepted to be used as the gold standard for defining Class I, Class II, or Class III skeletal patterns.[9-12] Accurate location of the cephalometric landmarks, growth changes, and orthodontic treatment may cause difficulty in the accurate assessment of the sagittal skeletal discrepancy. Hence, create confusion regarding the reliability of these parameters to assess AP jaw discrepancy.[13]

W-angle, Yen angle, and Pi analysis uses more stable cephalometric landmarks hence found to be more reliable. However, they require tracing nonconventional landmark

Received: 15-Feb-2021 **Revised:** 10-Jun-2021
Accepted: 28-Jun-2021 **Published:** 04-Aug-2021

Access this article online	
Website: www.orthodrehab.org	Quick Response Code
DOI: 10.4103/ijor.ijor_6_21	

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How to cite this article: Singh PR, Ambekar AS, Kangane SK. A novel diagnostic tool for sagittal jaw relationship: The P angle. Int J Orthod Rehabil 2021;12:58-63.

point G and point M using the template of concentric circles, which is not easy and time-consuming.[7] The template used in it is not easily available everywhere. It needs to accurately identify and trace the contour of the premaxilla and mandibular symphysis. The outline of the circle either exceeds or remains deficient to one out of the three surface landmark borders of the premaxilla and mandibular symphysis, i.e., it is not always tangent to all the three surfaces [Figure 1]. The largest best-fit circle size for one examiner may not be the same for another examiner, as the premaxilla, and the mandibular symphysis are not circular structures, which may lead to inter-operator bias. The remodeling of the anterior surface of the premaxilla after orthodontic treatment has a direct effect on point A,[14,15] but it should also indirectly affect the position of point M as it forms the anterior limit of the circle.

The purpose of this study was to introduce a new angle, the "P" angle, which measures the sagittal relationship of jaws accurately using conventional cephalometric landmarks and can be used as an adjunct to w angle to ease its measurement and to eliminate its methodological error and possible inter-operator bias to an extent. This study also determines the relationship between the G-Axis (S-G point) of Braun *et al*.[16] and the Y-axis (S-Gn) of Downs.[17]

The P angle

The P angle is a new measurement comprising of conventional cephalometric landmarks and is used for assessing the skeletal mal-relationship of jaws sagittally. It comprises of three skeletal landmarks-point S, point Gn, point A, i.e.,

- Point S-midpoint or center of sella turcica
- Point Gn-the most anterior inferior point of the bony chin or the midpoint between pogonion and menton or the point located perpendicular on mandibular symphysis, midway between the Pogonion and Menton points
- Point A (subnasale)-it is the deepest midline point on the anterior outer contour of the maxillary alveolar process.

It consists of three lines:

- Line connecting point S and point Gn
- Line connecting point Gn and point A
- Line from the point A perpendicular to S-Gn line
- The P angle is the angle formed between the line from point A perpendicular to the S-Gn line and line A-Gn [Figure 2].

MATERIALS AND METHODS

To assign samples to the Classes I, II, III skeletal pattern groups, the pretreatment records were screened of the patients treated in the Department of Orthodontics in a college setup.

Lateral cephalograms of 130 patients were traced by different investigators and then again traced by the same investigators after a 2-week interval. It included 50 Class I (25 male and 25 female), 50 Class II (25 male and 25 female), and 30 Class III (13 male and 17 female) skeletal pattern patients based on W-angle and ANB angle. The sample size for each group was derived using the mean and standard deviation (SD) of W-angle by using the formula $n = (Z_1)^2 \times S^2/d^2$ [Tables 1-3]. P-angle and w-angle were constructed [Figure 1] and measured in all the sample patients and then were compared statistically. Angle S-G-Gn was measured in all patients, and also parallelism of line G-M and line Gn-A was checked by measuring the distance between two lines at their starting and endpoint.

While constructing w angle, points M and G were located as suggested by Nanda and Merrill[3] and Braun *et al*.[16] and a template with concentric circles whose diameters increased in 1 mm increments was used.

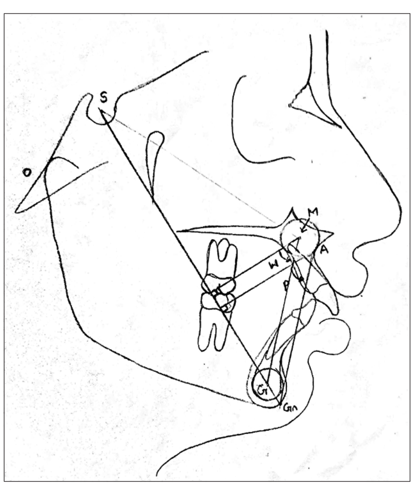

Figure 1: Relationship between P-angle and w-angle

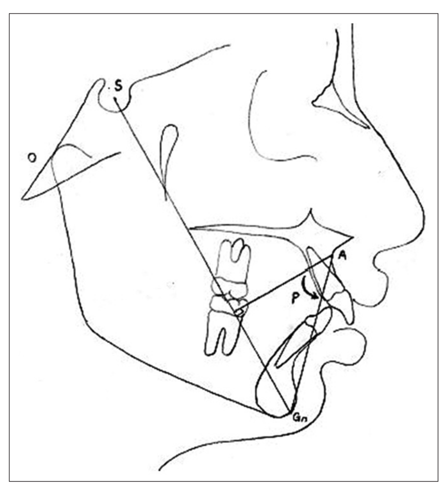

Figure 2: The construction of P-angle

P angle and W angle were measured by two operators, and the mean value was taken of each. To measure the method error using Dahlberg's formula, the same procedure was repeated after 2 weeks, and it was found to be 0.5° for P angle and 0.7° for w angle.

Statistical analysis and methods

Data were collected using a structure pro forma. Data thus were entered in the MS Excel sheet and analyzed using Statistical Package for Social Sciences (version 24.0, IBM Corp, Armonk, NY, USA).

Quantitative data were expressed in terms of mean and SD.

A comparison of mean and SD between the independent groups was made using an unpaired *t*-test to assess whether the mean difference between groups is significant or not.

Descriptive statistics of each variable were presented in terms of mean, SD, standard error of the mean.

A $P < 0.05$ was considered statistically significant, whereas a $P < 0.001$ was considered highly significant.

RESULTS

The mean value for the *P* angle in the Class I skeletal pattern group was 53.7° with an SD of 1.86, whereas the mean values in the Classes II and III skeletal pattern groups were 47.92 and 58.8° with an SD of 1.51 and 1.9, respectively [Table 4].

Similarly, the mean value for the w angle in the Class I skeletal pattern group was 53.74° with a SD of 1.87, whereas the mean values in the Classes II and III skeletal pattern groups were 48.02 and 59° with an SD of 1.56 and 2.1, respectively [Table 4].

When these values were compared using an unpaired *t*-test, no significant difference was found between values of *P* angle and w angle. Angle S-G-Gn was consistently 180° in almost all patients, and the distance between line G-M and line A-Gn at its starting and endpoint was equal with an insignificant difference in all the patients [Tables 5-7].

P angle was found to be equal to that of w angle in all three sagittal relationships of jaws, i.e., Class I, Class II, or Class III.

DISCUSSION

This investigation has introduced a new cephalometric variable to assess AP skeletal pattern, the P angle. It utilizes the conventional skeletal landmark point S, point A, and point Gn. The need to introduce this angle was due to difficulty in accurately tracing the point M and point G used in Yen angle, W angle, and Pi analysis.[6-8] It needs to accurately identify and trace the contour of the premaxilla and mandibular symphysis and use template of concentric circles to locate the point M and G, respectively.[7] This extra armamentarium is not easily available. The largest best-fit circle should be drawn tangent to the anterior, superior, and palatal surfaces of the premaxilla for point M and tangent to the internal anterior, inferior, and

Table 1: Minimum sample size calculation for skeletal class I malocclusion group

Formula Symbols	Formula Parameters	Calculated Values
M	Your guess of population mean	53.70
S	Standard deviation of mean	2.00
1-α	Set level of confidence (value<1.0)	0.95
Z1	*Z* value associated with confidence	1.96
D	Absolute precision	1
N	Minimum sample size	16

Table 2: Minimum sample size calculation for skeletal class II malocclusion group

Formula Symbols	Formula Parameters	Calculated Values
M	Your guess of population mean	48.90
S	Standard deviation of mean	2.10
1-α	Set level of confidence (value<1.0)	0.95
Z1	*Z* value associated with confidence	1.96
D	Absolute precision	1
N	Minimum sample size	17

Table 3: Minimum sample size calculation for skeletal class III malocclusion group

Formula Symbols	Formula Parameters	Calculated Values
M	Your guess of population mean	58.70
S	Standard deviation of mean	3.2
1-α	Set level of confidence (value<1.0)	0.95
Z1	*Z* value associated with confidence	1.96
D	Absolute precision	1.2
N	Minimum sample size	28

Table 4: Mean, standard deviation and *t*-test values of *P*-and W-angle in class I, class II and, class III groups

	n	Mean	SD	*t*	*P*	Inference
Class I						
Angle W	50	53.74	1.87	1.42	0.15 (>0.05)	NS
Angle P	50	53.70	1.86			
Class II						
Angle W	50	48.02	1.56	1.69	0.07 (>0.05)	NS
Angle P	50	47.92	1.51			
Class III						
Angle W	30	59.00	2.10	1.64	0.11 (>0.05)	NS
Angle P	30	58.80	1.90			

SD: Standard deviation, NS: Not significant

Table 5: Mean, standard deviation and standard error in skeletal class I group

Class I	*n*	Mean	SD	SE	Range	Minimum	Maximum
Age	50	18.24	2.66	0.38	11	14	25
W angle	50	53.74	1.87	0.26	6	51	57
P angle	50	53.7	1.86	0.26	6	51	57
Angle S-G-Gn	50	179.92	0.27	0.04	1	179	180
Difference between line G-M and line Gn-A at their starting and end point	50	0.04	0.14	0.02	0.5	0.0	0.5

SD: Standard deviation, SE: Standard error

Table 6: Mean, standard deviation and standard error in skeletal class II group

Class II	*n*	Mean	SD	SE	Range	Minimum	Maximum
W angle	50	48.02	1.56	0.22	5	46	51
P angle	50	47.92	1.51	0.21	5	46	51
Angle S-G-Gn	50	179.90	0.42	0.06	2	178	180
Difference between line G-M and line Gn-A at their starting and end point	50	0.05	0.21	0.03	1.0	0.0	1.0

SD: Standard deviation, SE: Standard error

Table 7: Mean, standard deviation and standard error in skeletal class III group

Class III	*n*	Mean	SD	SE	Range	Minimum	Maximum
Age	30	18.47	2.75	0.50	11	14	25
W angle	30	59.00	2.10	0.38	7	56	63
P angle	30	58.80	1.90	0.35	7	56	63
Angle S-G-Gn	30	179.83	0.53	0.10	2	178	180
Difference between line G-M and line Gn-A at their starting and end point	30	0.08	0.27	0.05	1.0	0.0	1.0

SD: Standard deviation, SE: Standard error

posterior surfaces of the mandibular symphysis for point G.[6-8] The outline of the circle is usually found to either exceed or remains deficient to one out of the three surface landmark borders of the premaxilla and mandibular symphysis, i.e., it is not always tangent to all three surfaces. For example in the patient shown in [Figure 1], the circle is touching the anterior and palatal surface of premaxilla but exceeding the boundary of the superior surface. Similarly in the patient shown in [Figure 1] the largest possible circle touches the internal posterior and inferior surface of mandibular symphysis but exceeds the anterior surface. The largest best-fit circle size for one examiner may not be the same for another examiner, as the premaxilla, and the mandibular symphysis is not circular structures, which may lead to inter-operator bias. As *P* angle is equal to w angle and it uses routinely used cephalometric landmarks hence could be used as an adjunct to w-angle in assessing the skeletal relationship more accurately.

P angle considers point A in its measurement. The remodeling of the anterior surface of the premaxilla after orthodontic treatment has a direct effect on point A.[14,15] Each 10° change in the maxillary incisor inclination results in the displacement of point A by 0.4 mm in the horizontal plane.[18] As the anterior surface of the premaxilla forms the anterior limit of the circle it should also affect the position of point M. However, the study by Al-Abdwani *et al*.[18] concluded that the effect of incisal inclination changes due to orthodontic treatment is of no clinical relevance to the position of points A.

A meta-analysis conducted by Trpkova *et al*.[19] reported point A and S to be reliable for cephalometric analysis of lateral films. Inter-observer differences in landmark localization of point G was found to be not significant along the X-axis and one percent significant along the Y-axis.[20]

This study also determined the relationship between the G-Axis (S-G point) of Braun *et al*.[16] and the Y-axis (S-Gn) of Downs.[17] As Point S, point G and point Gn coincided on the same line, the G-axis and Y-axis also found to be coinciding with each other.

The most popular parameter for assessing the sagittal jaw relationship still is the ANB angle, but it is found to be affected by patient's age, growth rotation of the jaws, vertical growth, and the length of the anterior cranial base, hence makes the interpretation of this angle complex and can be misleading.[2] To overcome these problems, the Wits analysis was introduced.[2] Although it is not affected by landmarks or jaw rotations still has the problem of correctly identifying the functional occlusal plane which is difficult to assess in mixed dentition. *P* angle is independent of cranial base length and also remains stable even if the jaws are rotated. This is a result of the rotation of the S–Gn line along with jaw rotation, which carries the perpendicular from point A with it. Because the A–Gn line is also rotating in the same direction, the *P* angle remains relatively stable.

A popular alternative beta angle is not affected by jaw rotations as it avoids the use of the functional plane and uses point A and point B.[4] It has a drawback that point A and point B is unstable which can be remodeled by orthodontic treatment and growth.[21,22] Furthermore the reproducibility of the location of condylion on mouth-closed lateral head cephalogram is found to be limited.[23,24] W-angle, Yen angle, and Pi analysis uses more stable cephalometric landmarks hence found to be more reliable. However, they require to locate nonconventional landmark point M and point G, which is not easy due to methodological error and scope of inter-operator bias.

To overcome this problem to an extent a new measurement, P-angle, is developed using routinely used landmarks. Its value was found to be equal to the w-angle in all patients irrespective of different skeletal patterns, i.e., Class I, Class II, and Class III. Hence, P angle can be used as an adjunct to W angle in assessing the skeletal relationship more accurately.

The concept behind P angle similar to w angle is as follows:
1. Point G was consistently found to coincide on S-Gn line
2. Line GM consistently found to parallel to line Gn-A
3. Perpendicular from point M and perpendicular from point A were consistently formed on the coinciding lines of S-G and S-Gn, and hence parallel to each other [Figure 1].

Limitations
- It cannot determine which jaw is prognathic or retrognathic
- It may not be very accurate to evaluate treatment progress as the stability of point A is questionable after orthodontic treatment.[14,15] A further study is required to assess the relationship between the w-angle and *P* angle after the orthodontic treatment
- Point Gn can be affected with growth changes[25,26] and after genioplasty.

CONCLUSION
1. A new angle, P angle can be used as a diagnostic tool to evaluate sagittal jaw relationship
2. Point S, point G, and point Gn coincide on the same line, as a result, the G-axis and the Y-axis also coincide with each other
3. Line Gn-A and Line G-M are parallel to each other
4. P-angle and W-angle are equal in all three types of the sagittal skeletal relationships of jaws i.e., Class I, Class II, and Class III
5. P-angle can be used as an adjunct for w-angle during pretreatment cephalometric tracing by taking an average of w-angle and p-angle. Nevertheless, a clinician should be aware of the importance of other cephalometric measurements in orthodontic treatment planning.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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