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A new parameter for assessing vertical skeletal discrepancies: The R angle

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Abstract

Aim- The purpose of this study is to evaluate, the reliability of R angle (Nasion - Center of the condyle - Menton) in assessing the vertical skeletal discrepancies.

Methods - In this study, 80 patients aged between 18-26 years were selected, all patients were of South Indian origin who visited the Department of Orthodontics and Dentofacial Orthopaedics, seeking orthodontic treatment.

Based on the existing parameters subjects were divided into three groups - Low angle, Average angle and High angle cases. Next, the R angle was individually constructed, measured and compared for each of the three skeletal patterns (High, Average and Low angle). The values of the R angle obtained were statistically analyzed.

Results - R angle below 70.50 indicate Low angle cases, between 70.5 - 75.50 indicate Average angle cases and above 75.50 indicate High angle cases.

Conclusion - The newly introduced R angle is clinically and statistically significant in assessing skeletal discrepancies in the vertical direction.

Keywords: R angle, Skeletal pattern, Low angle, Average angle, High angle, C-N axis C-Me axis.

Introduction:

An accurate assessment of a patient's facial skeletal pattern in vertical, sagittal and transverse direction is

paramount in orthodontic diagnosis and treatment planning. Many angular and linear measurements have evolved over time with the continued untiring effort of various researchers trying to locate the most stable and reliable landmarks to assess the skeletal discrepancies in different directions.

The existing parameters used to assess vertical skeletal discrepancies are FMA¹, Y axis angle², SN-GoGn³, Facial axis angle⁴ and Jarabak ratio⁵.

In Tweeds analysis¹ the angle formed by the intersection of Frankfort Horizontal plane and the Mandibular Plane (FMA) is used to assess the vertical skeletal discrepancy. A mean value of 250 is considered normal, higher value indicates a high angle case and a lower value indicates a low angle case.

In Down's analysis³ Y axis is used to assess the vertical skeletal discrepancies. This angle is formed at the intersection of sella-gnathion line with the Frankfort Horizontal Plane. Larger angles indicate high angle cases as seen in Class II facial patterns, acute angles are seen in low angle cases mostly Class III facial patterns and a mean angle of about 59.40 is seen in average facial patterns.

In Steiner's analysis³ the angle formed by the intersection of S-N plane and Mandibular plane (SN-GoGn angle) is used to assess the vertical skeletal pattern. In a well balanced face the angle is 320, an increased angle is seen in High angle cases and decreased angle in Low angle cases.

In McNamara analysis⁴ the Facial axis angle formed by the intersection of basion - nasion line and pterygomaxillare - gnathion line is used to assess the vertical skeletal discrepancy. In a balanced face the facial axis angle is perpendicular to the basion-nasion line i.e. 900. A negative value, ie, 900 subtracted from the measured angle suggests excessive vertical development of the face. Deficient vertical development of the face is indicated by positive values. The higher the value greater the vertical deficiency of the face, or vice versa.

The Jarabak ratio⁵ determines the percentage of the anterior and posterior facial proportions. This ratio is obtained by the formula posterior facial height / anterior facial height x 100. Anterior facial height is measured from nasion to menton and the posterior facial height is measured from sella to gonion. Values between 62-65% indicate a well balanced face, a higher percentage is seen in low angle cases, whereas lower percentage is suggestive of high angle cases.

The C axis angle⁶ is the angle formed at sella by connecting nasion - sella - Point M (Point M as proposed by Nanda and Merrill, is defined as the centre of the largest circle, that is tangent to the superior, anterior and palatal surfaces of the maxilla as seen in sagittal plane). G axis angle⁷ is the angle formed at sella by connecting nasion - sella - G-point (The G-point is defined as a point representing the centre of the largest circle that is tangent to the internal inferior, anterior, and posterior surfaces of the mandibular symphyseal region as seen on a lateral cephalogram), both these angles determine the direction of vertical growth of maxilla and mandible independently, but do not assess the overall vertical skeletal pattern of the face.

These existing parameters which assess vertical skeletal discrepancies present with certain shortcomings. To overcome these shortcomings an attempt has been made to develop a new parameter to assess skeletal pattern in vertical direction, which is both clinically and statistically significant.

Drawbacks of the existing parameters.

In Tweeds analysis¹ the angle formed by the intersection of Frankfort Horizontal plane and the Mandibular Plane (FMA) is used to assess the vertical skeletal pattern. For the construction of the Frankfort Horizontal Plane location of porion and orbitale is less readily identified⁹ and the Mandibular Plane is constructed as a tangent to the lower border of the mandible which is not a very reliable plane, therefore the reliability of FMA is questionable.

In Down's analysis² Mandibular Plane angle is formed using the Frankfort horizontal plane, as already mentioned the ease to locate porion and orbitale is questionable.⁹ In the same analysis Y axis angle is used to assess the downward, rearward or forward position of the chin in relation to the upper face.⁹ Therefore, both parameters are not very reliable in assessing skeletal patterns in the vertical direction.

In Steiner's analysis³ SN-GoGn is used to assess the vertical skeletal pattern, since S-N plane may vary if there is some underlying skeletal deformity, this plane becomes less reliable in efficiently assessing skeletal patterns.

Gnathion being an anterior landmark on the symphysis would more favorably assess the orientation of chin, depending on the position of gnathion the mandibular plane may vary, therefore making this angle less reliable in assessing skeletal patterns.

In McNamara's analysis ⁴ the Facial axis angle formed by the intersection of basion - nasion line and pterygomaxillare - gnathion line is used as a vertical skeletal dysplasia indicator. Since basion is less readily identified, ⁹ construction of basion-nasion plane is not a very reliable. The angle also uses pterygomaxillare which is less readily identified ⁹ and gnathion, which could be considered more suitable in assessing the orientation of chin instead of the skeletal patterns.

The Jarabak ratio ⁵ more than a vertical dysplasia indicator could be used to evaluate the ratio between the anterior to the posterior facial heights.

The C axis angle ⁶ is the angle formed at sella by connecting nasion - sella - Point M and G axis angle ⁷ is the angle formed at sella by connecting nasion - sella - G Point both these angles determine the direction of vertical growth of maxilla and mandible independently, but do not assess the overall skeletal pattern of the face.

Material and Methods:

In this study, 80 patients aged between 18-26 years were selected. All patients who visited the Department of Orthodontics and Dentofacial Orthopaedics, Yenepoya University, seeking orthodontic treatment.

As part of the pre-treatment (diagnostic) records, 8x10 inches lateral cephalograms were made. All lateral cephalograms were traced on 8x10 inches acetate matte paper with a 3H sharp drawing pencil. Only patients with a Class I skeletal pattern, who had never undergone any prior orthodontic treatment are considered in this study.

Once the lateral cephalograms were traced, the routinely used parameters to determine the vertical skeletal dysplasias were constructed and measured. These parameters include -:

FMA¹, Y axis angle ², SN-GoGn ³, Facial axis angle ⁴ and Jarabak ratio ⁵.

FMA is the angle formed by the intersection of Frankfort Horizontal plane and the Mandibular Plane.

Y axis is the angle formed by the intersection of sella-gnathion line with the Frankfort Horizontal Plane.

SN-GoGn angle is formed by the intersection of S-N plane and Mandibular plane.

Facial axis angle is formed by the intersection of basion - nasion line and pterygomaxillare - gnathion line.

Jarabak ratio determines the percentage of the anterior and posterior facial proportions. This ratio is obtained by the formula posterior facial height / anterior facial height x 100. Anterior facial height is measured from nasion to menton and the posterior facial height is measured from sella to gonion.

C axis angle is the angle formed at sella by connecting nasion - sella - Point M (Point M as proposed by Nanda and Merill, is defined as the centre of the largest circle, that is tangent to the superior, anterior and palatal surfaces of the maxilla as seen in sagittal plane). G axis angle is the angle formed at sella by connecting nasion - sella - G-point (The G-point is defined as a point representing the centre of the largest circle that is tangent to the internal inferior, anterior, and posterior surfaces of the mandibular symphyseal region as seen on a lateral cephalogram).

Based on the factors ratio the sample was divided into three groups - Low angle , Average angle and High angle cases.

Eventually, after the cephalometric evaluation of the entire sample i.e. 80 cases, 30 were low angle, 20 average angle and the remaining 30 high angle cases.

Next, the R angle was individually constructed and measured on all the lateral cephalograms for each of the three groups (Low, Average and High angles). The values of the R angle obtained in each of the three groups were

statistically analyzed to determine their significance.

R angle construction

The R angle is an anterior angle formed for assessing the vertical skeletal discrepancies. It uses three skeletal landmarks - Nasion (N), Center of the condyle (C) and Menton (Me). The angle formed at the Center of the condyle is the R angle.

Landmarks

Nasion (N) - is the most anterior point on the frontonasal suture in the midsagittal plane.

Center of the condyle (C) - is the center of the condyle, found by tracing the head of the condyle and approximating its center.⁸

Menton (Me) - is the lowest point on the symphyseal shadow of the mandible seen on the lateral cephalogram.

C-N axis - center of the condyle (C) to nasion (N).

C-Me axis - a line connecting center of the condyle (C) to menton (Me).

The angle formed at center of the condyle (C) by the intersection of C-N axis and C-Me axis represents the R angle. (Figure. 1)

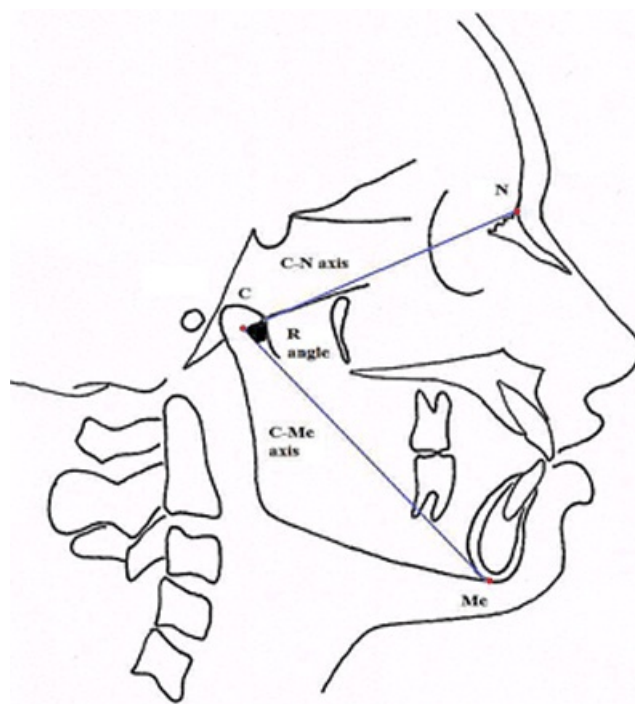


Figure 1
R angle

Results:

Microsoft Excel was used to compile the data. The means and standard deviations of the R angle were obtained using the Oneway ANOVA test. Students Newman-keuls post hoc test was done to determine whether there was a significant difference among the three groups. P value less than 0.0005 was considered statistically significant.

Receiver operator characteristic (ROC) curves were constructed to examine the sensitivity and specificity of the R

angle to discriminate among the three skeletal patterns.

The mean values and standard deviation of the R angle for all the three skeletal patterns were obtained with the Oneway ANOVA test. (Tabulated in Table 1).

The R angle values as examined by the Students Newman-Keuls post hoc test showed that the three skeletal patterns being examined are different. (Tabulated in Table 2).

Receiver operating characteristic curves inferred that, R angle > 70.50 had 81.6% sensitivity and 70% specificity in discriminating the low angle cases from average angle cases and R angle > 75.50 had 90% sensitivity and 77.8% specificity in discriminating the average angle cases from high angle cases. (Tabulated in Table 3 and 4).

Therefore, values below 70.50 indicate low angle cases, values between 70.5 -75.50 indicate average angle cases and values above 75.50 indicate high angle cases.

Table 1
Mean value and standard deviation of R angle in Low, Average and High angle cases.

Skeletal Pattern	Mean	Std. Deviation	Minimum	Maximum
Low angle	68.8684	2.62185	63.00	73.00
High angle	78.5185	3.15461	74.00	83.00
Average angle	72.5000	1.84089	70.00	76.00

F=97.4 P=.0005

Table 2
Students Newman - Keuls post hoc test, shows that the R angle values for three skeletal patterns are different.

Skeletal Pattern	Subset for alpha = .05		
	1	2	3
Low angle	68.8684	72.5000	78.5185
Average angle			
High angle			
Significance	1.000	1.000	1.000

Table 3
ROC to discriminate Low angle from Average angle cases.

			Skeletal Pattern		Total
			Low angle	Average angle	
Cutoff value	<71.5	Count	21	15	36
		% within group	81.6%	30.0%	70.8%
	≥71.5	Count	9	5	14
		% within group	18.4%	70.0%	29.2%
Total	Count		30	15	50
	% within group		100.0%	100.0%	100.0%

Table 4
ROC to discriminate Average angle from High angle cases.

			Skeletal Pattern		Total
			Average angle	High angle	
Cutoff value	<75.5	Count	9	6	15
		% within group	90.0%	22.2%	40.5%
	≥ 75.5	Count	1	21	22
		% within group	10.0%	77.8%	59.5%
Total	Count			10	37
	% within group		100.0%	100.0%	100.0%

Discussion:

An accurate assessment of vertical skeletal discrepancy is important in orthodontic diagnosis and treatment planning. Several cephalometric analysis have been proposed by various researchers, to assess skeletal discrepancies in different directions.

The most commonly used parameters are FMA, SN-GoGn angle, Y-axis angle, Facial axis angle and Jarabak ratio.

Subjects are grouped into Low, Average and High angle cases based on FMA, SN-GoGn angle, Y-axis angle, Facial axis angle and Jarabak ratio, when atleast three out of the five parameters indicated a specific skeletal pattern.

Through this study an attempt has been made to evaluate the efficiency of R angle in assessing vertical skeletal discrepancies by comparing with the already existing vertical skeletal discrepancy indicators.

So far, most of the existing vertical dysplasia indicators rely on angles formed by the intersection of two planes or ratio of the anterior and posterior facial heights.

The R angle is based on axial measurements where vertical skeletal pattern is assessed by an angle formed at the Center of condyle (C) by the intersection of C-N axis and C-Me axis.

In this study, Center of Condyle (C) is being used, as it represents a central landmark in the posterior aspect of the face. Since, it is a central landmark of the condyle which is least effected by growth and remodeling changes even as the condyle continues to grow. It is a stable landmark, easy to locate, reliable and has been effectively used in a previous study (Beta angle) ⁸ to assess sagittal skeletal patterns as well. Sella has not been considered in this study, since location of sella varies in different individuals, the and especially in conditions where underlying skeletal deformities exists they directly influence the S-N plane thereby leading to erroneous interpretations of the skeletal patterns. Therefore, the center of the condyle can also be used in assessing growth in vertical direction.

Nasion is being used, as it represents the anterior and superior-most skeletal midline landmark of the face and Menton is used as it represents the anterior and inferior-most skeletal midline landmark of the face. Neither gnathion nor pogonion were considered in this study as both would better describe the orientation of the chin in sagittal plane.

Drawbacks of the existing parameters. In Tweeds analysis ¹ the angle formed by the intersection of Frankfort Horizontal plane and the Mandibular Plane (FMA) is used to assess the vertical skeletal pattern. For the construction of the Frankfort Horizontal Plane location of porion and orbitale is less readily identified ⁹ and the Mandibular Plane is constructed as a tangent to the lower border of the mandible which is not a very reliable plane, therefore the reliability of FMA is questionable.

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Conclusion:

1. This new vertical discrepancy indicator enables clinicians to assess vertical skeletal discrepancy efficiently, thereby aiding in accurate diagnosis and treatment planning.
2. The R angle is constructed with minimal cephalometric landmarks, which can be easily and accurately located on digital lateral cephalograms.
3. R angle is constructed using only fixed skeletal landmarks and no constructed points or landmarks, thereby minimizing operator error.
4. The R angle uses the C-N and C-Me axis to assess the vertical skeletal dysplasia, considering the center of condyle as the central landmark in the posterior aspect of the face.
5. The C-N and C-Me axis are more stable compared to the currently used unstable planes.

6. Cephalometric evaluation of young adults shows that, R angle below 70.5 degrees indicates low angle, between 70.5 -75.5 degrees indicates average angle and above 75.5 degrees indicates high angle cases.

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