GMR

The Original

ASSESSMENT OF VERTICAL SKELETAL DISCREPANCIES BY ESTABLISHING R ANGLE VALUE

Dr Sushma Sonawane[1], Dr Sameer Narkhede[2], Dr Nitin Gadhiya[3], Dr Tanya Gupta[4], Dr Rakesh Singh[5], Dr Swati Gotmare[6], Dr Keval Shroff[7]

[1]Professor and PHD Scholar in The Department of Orthodontics and Dentofacial Orthopedic
sushma.sonawane@dypatil.edu
[2]Professor and Head of The Department of Orthodontics and Dentofacial Orthopedic
sameer.narkhede@dypatil.edu
[3]Professor in The Department of Orthodontics and Dentofacial Orthopedic, nitin.gadhiya@dypatil.edu
[4]1st year MDS Student in Orthodontics and Dentofacial Orthopedic, tanyagupta068@gmail.com
[5]Professor in The Department of Orthodontics and Dentofacial Orthopedic, rakeshKumar.singh@dypatil.edu
[6]Professor in The Department of Oral and Maxillofacial Pathology, swati.gotmare@dypatil.edu
[7]Lecturer in The Department of Orthodontics and Dentofacial Orthopedic shroffkeval@yahoo.com

ABSTRACT
Orthodontic diagnosis, treatment planning, and long-term treatment stability are all significantly impacted by vertical skeletal abnormalities. This study assessed the R angle's concordance with standard cephalometric measures and its efficacy as a cephalometric parameter for evaluating vertical skeletal discrepancies. Two hundred seventy lateral cephalometric radiographs of orthodontic patients between the ages of eighteen and thirty from the Department of Orthodontics and Dentofacial Orthopaedics at the D. Y. Patil University School of Dentistry in Navi Mumbai were examined. The R angle's value as an additional tool for assessing vertical skeletal discrepancies and helping orthodontists evaluate vertical skeletal patterns was supported by statistically strong correlations with established cephalometric parameters.

KEYWORDS: Lateral cephalograms, skeletal discrepancies, orthodontics, and malocclusions

INTRODUCTION
Due to their aetiology, diagnosis, treatment planning, and propensity to recur after treatment, malocclusions resulting fr bom vertical discrepancies have generated a great deal of attention in the field of orthodontics[1]. Because it directly affects facial aesthetics, treatment planning, treatment mechanics, and long-term stability, an accurate assessment of the vertical skeletal pattern is a crucial part of orthodontic diagnosis. Because they regularly impact both functional occlusion and facial attractiveness and are frequently linked to a higher risk of relapse after treatment, vertical skeletal discrepancies are among the most difficult orthodontic issues[1]. Therefore, developing a suitable treatment plan requires a thorough grasp of facial growth and the variables affecting vertical development.
The relationship between the maxilla and mandible is greatly impacted by the dynamic process of vertical facial growth, which lasts for a long time. Rakosi[2] claims that subsequent mandibular development could exacerbate malocclusion by widening already-existing vertical disparities. Vertical malocclusions are caused by a variety of factors, including soft tissue function, environmental factors, tooth eruption, and skeletal growth. While differences in mandibular growth direction are strongly linked to deep bite and long-face skeletal patterns, habits such thumb sucking, altered tongue posture, and excessive vertical facial development may contribute to anterior open bite [3–5]. As a result, precise evaluation of vertical growth is still essential for diagnosis and therapy planning.
To assess vertical skeletal differences, several cephalometric analyses have been proposed. The Frankfort Mandibular Plane Angle (FMA), Y-axis angle, GoGn-SN angle, facial axis angle, and Jarabak ratio are frequently used metrics [8–12]. Because they offer useful information on skeletal relationships and craniofacial growth patterns, these measurements have gained widespread acceptance in orthodontic practice. However, because each measure is dependent on particular anatomical landmarks and reference planes, there may be differences when identifying landmarks, which could compromise the consistency of the diagnosis.
When recognizing landmarks like Porion, Orbitale, and Gnathion, the FMA and Y-axis measurements are prone to inaccuracies because they rely on the Frankfort horizontal plane[13]. Similar to this, changes in the anterior cranial base and mandibular landmarks may have an impact on the GoGn-SN angle, but the facial axis angle depends on precisely locating the Basion and Pterygomaxillary landmarks[13]. The Jarabak ratio does not only analyze vertical skeletal discrepancies, but also is effective for evaluating facial proportions. Consequently, a thorough evaluation of vertical skeletal relationships might not be possible if only one cephalometric value is used.
Rizwan and Mascarenhas developed the R angle in 2013 as a cephalometric parameter for assessing vertical skeletal discrepancies in order to get around some of these restrictions[14]. Three skeletal landmarks Nasion (N), the condyle center (C), and Menton (Me) are joined by the angle created at the condyle center to generate the R angle. The R angle

has been suggested as a substitute metric for assessing vertical skeletal patterns since these landmarks are comparatively stable and less impacted by modifications in traditional reference planes. However, cephalometric standards may change among various ethnic and geographic groups, and the initial study was carried out in a South Indian population.
Before the R angle's routine clinical application can be advised, additional validation in various groups is required due to the potential impact of population-specific craniofacial traits. In order to analyze the R angle, ascertain its correlation with recognized cephalometric parameters, and appraise its utility in assessing vertical skeletal discrepancies, the current study was conducted.

2. MATERIALS AND METHODS

270 orthodontic patients between the ages of 18 and 30 had their lateral cephalometric radiographs used in this study. The radiographs came from the Department of Orthodontics and Dentofacial Orthopaedics' archival records at the D. Y. Patil University School of Dentistry in Navi Mumbai.
The study only included patients without any transverse or vertical facial or skeletal abnormalities and with a Class I skeletal pattern. To exclude the impact of treatment-related alterations on cephalometric measurements, people who had previously received orthodontic treatment were eliminated.
A minimal sample size of roughly 89 participants was deemed adequate to provide sufficient external validity based on the study design. However, a total of 270 patients were included in the current study in order to increase the findings' dependability and generalizability.

2.1 Method

All lateral cephalometric radiographs were manually traced on 8 × 10-inch acetate matte paper using standard cephalometric tracing procedures.
To ensure consistency and minimize inter-examiner variability, all tracings and measurements were performed by a single examiner.
Each cephalogram was evaluated to obtain the cephalometric parameters required for assessing the vertical skeletal pattern. The parameters included Frankfort Mandibular Plane Angle (FMA), Y-axis angle, GoGn-SN angle, Facial axis angle, Jarabak ratio, and the R angle.
Based on the cephalometric measurements, each subject was classified into one of three skeletal growth pattern groups. Classification was determined using FMA, GoGn-SN angle, Y-axis angle, Facial axis angle, and Jarabak ratio. A subject was assigned to a particular skeletal pattern when at least three of the five parameters indicated the same growth pattern. Accordingly, the study population was divided into the following groups:
Low-angle group (90 patients)
Average-angle group (90 patients)
High-angle group (90 patients)
After classification, the R angle was measured for every subject. Mean R angle values were calculated for each group, and the relationship of the R angle with established cephalometric parameters was analyzed to determine its usefulness in assessing vertical skeletal discrepancies.

Angular and Ratio Parameters

Frankfort mandibular plane angle (FMA)
Y axis
GoGn-SN angle
Facial axis angle
Jarabak ratio
R angle

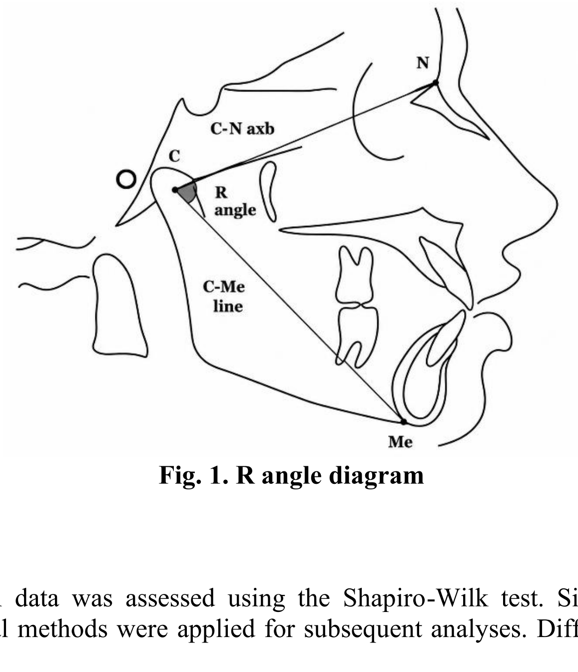

Fig. 1. R angle diagram

2.3 Statistics

The normality of the numerical data was assessed using the Shapiro-Wilk test. Since the data followed a normal distribution, parametric statistical methods were applied for subsequent analyses. Differences among the three skeletal

growth pattern groups were evaluated using one-way analysis of variance (ANOVA), followed by pairwise post hoc comparisons wherever appropriate.
The relationship between the R angle and the established cephalometric parameters was analyzed using Pearson's correlation coefficient.
Agreement between the R angle and the existing cephalometric parameters was assessed using Cohen's Kappa statistic.
The association between categorical variables was evaluated using the Chi-square test. A p-value of less than 0.05 was considered statistically significant for all statistical analyses.

3. RESULTS

Table 1 summarizes the descriptive statistics of the R angle for the three skeletal growth pattern groups. The mean R angle (± SD) was 69.40 ± 1.977° for the low-angle group, 74.63 ± 2.077° for the average-angle group, and 80.27 ± 2.056° for the high-angle group. One-way ANOVA demonstrated a statistically significant difference among the three groups ($F = 712.976$, $p < 0.001$).
Table 2 presents the pairwise comparison of skeletal growth patterns following one-way ANOVA. Significant differences were observed between the low- and high-angle groups ($p = 0.01$), as well as between the average- and high-angle groups ($p = 0.01$).
Table 3 illustrates the receiver operating characteristic (ROC) analysis used to differentiate low-angle cases from average-angle cases. A statistically significant difference was observed between the two groups ($p < 0.01$). The ROC analysis identified an R angle greater than 70.5° as the optimal threshold for distinguishing low-angle cases, with a sensitivity of 95.56% and a specificity of 93.33%.
Table 4 presents the ROC analysis performed to differentiate average-angle cases from high-angle cases. The comparison between the two groups was statistically significant ($p < 0.01$). An R angle greater than or equal to 75.5° demonstrated a sensitivity of 92.00% for identifying high-angle cases.
Table 6 presents Pearson's correlation coefficients describing the relationship between the R angle and the established cephalometric parameters.
Pearson correlation analysis demonstrated a statistically significant very strong positive correlation between the R angle and FMA ($r = 0.845$, $p < 0.001$), indicating that higher FMA values were associated with higher R angle values.
A statistically significant strong negative correlation was observed between the R angle and the Jarabak ratio ($r = –0.765$, $p < 0.001$), suggesting that an increase in the Jarabak ratio corresponded to a decrease in the R angle.
A statistically significant strong positive correlation was identified between the R angle and the GoGn-SN angle ($r = 0.784$, $p < 0.001$), indicating that both parameters increased together.
The R angle also demonstrated a statistically significant very strong positive correlation with the Y-axis angle ($r = 0.806$, $p < 0.001$), reflecting a direct relationship between these two measurements.
A statistically significant strong negative correlation was found between the R angle and the Facial axis angle ($r = –0.675$, $p < 0.001$), indicating an inverse relationship between the two variables.
To evaluate the agreement of the R angle with established cephalometric parameters, Chi-square and Cohen's Kappa analyses were performed. The findings are summarized in Tables 7–11.
Table 7 demonstrated a statistically significant association between the R angle and FMA classifications across the three skeletal growth pattern groups ($\chi^2 = 141.016$, $p < 0.001$). Cohen's Kappa analysis indicated substantial agreement between the two parameters ($\kappa = 0.456$), and the agreement was statistically significant ($p < 0.001$).
Table 8 demonstrated a statistically significant association between the R angle and Jarabak ratio classifications across the three groups ($\chi^2 = 130.126$, $p < 0.001$). Cohen's Kappa analysis revealed a moderate level of agreement ($\kappa = 0.419$), which was also statistically significant ($p < 0.001$).
Table 9 showed a statistically significant association between the R angle and GoGn-SN classifications among the three skeletal growth pattern groups ($\chi^2 = 173.816$, $p < 0.001$). Cohen's Kappa analysis demonstrated a moderate level of agreement ($\kappa = 0.511$), and the agreement was statistically significant ($p < 0.001$).
Table 10 demonstrated a statistically significant association between the R angle and Y-axis classifications across the three skeletal growth pattern groups ($\chi^2 = 68.548$, $p < 0.001$). Cohen's Kappa analysis indicated substantial agreement between these two parameters ($\kappa = 0.281$), and the observed agreement was statistically significant ($p < 0.001$).
Table 11 demonstrated a statistically significant association between the R angle and Facial axis angle classifications among the three skeletal growth pattern groups ($\chi^2 = 100.030$, $p < 0.001$). Cohen's Kappa analysis revealed a fair level of agreement ($\kappa = 0.363$), and this agreement was statistically significant ($p < 0.001$).

Table 1. Estimation of R angle for low, average and high angle cases 95% confidence interval for mean

Parameter	GP	N	Mean	SD	SE	CI Lower	CI Upper	Minimum	Maximum	F value	p-value

FMA	Low	90	21.36	5.318	0.561	20.25	22.47	11	39	59.779	<0.001
	Average	90	27.33	3.271	0.345	26.65	28.01	21	39		
	High	90	31.16	4.167	0.439	30.29	32.03	18	40		
JARABAK RATIO	Low	90	70.84	4.147	0.437	69.97	71.71	65	86	67.345	<0.001
	Average	90	65.18	3.163	0.333	64.52	65.84	58	75		
	High	90	62.19	3.509	0.37	61.46	62.92	54	73		
GoGn-SN	Low	90	23.99	4.686	0.494	23.01	24.97	10	31	100.217	<0.001
	Average	90	31.42	4.218	0.445	30.54	32.3	22	45		
	High	90	36.53	3.721	0.392	35.75	37.31	28	44		
Y-axis	Low	90	57.64	3.944	0.416	56.82	58.46	51	70	24.192	<0.001
	Average	90	61.33	4.172	0.44	60.46	62.2	53	72		
	High	90	63.96	4.81	0.507	62.96	64.96	53	76		
Facial axis angle	Low	90	92.07	2.31	0.244	91.59	92.55	86	98	14.663	<0.001
	Average	90	90.13	2.492	0.263	89.61	90.65	85	94		
	High	90	89.4	2.435	0.257	88.89	89.91	82	94		
R angle value	Low	90	66.98	2.848	0.3	66.38	67.58	61	73	229.842	<0.001
	Average	90	72.82	1.862	0.196	72.43	73.21	70	76		
	High	90	78.22	2.645	0.279	77.67	78.77	75	87		

Table 2. Inter group pair wise comparison with growth pattern using post Hoc Test

Growth pattern	Average	Low	Total
R	6	86	92
R	84	4	88

Table 3. Chi-square comparison between low and average angle groups

	Value	Df	P value
Chi-square	142.292	1	0.000*

Table 4. Classification of R angle between average- and high-angle skeletal pattern groups

Growth pattern	Average	High	Total
R	84	12	96

R	6	78	84

Table 5. Chi-square comparison between average and high angle groups

	Value	Df	P value
Chi-square	115.714	1	0.000*

Table 6. Values of Pearson's Co-efficient 'r' and Its Significance between R angle and other parameters

Parameter	Statistic	FMA	JARABAK RATIO	GoGn-SN	Y axis	Facial axis angle	R angle
FMA	Pearson Correlation	1	-.616**	.664**	.615**	-.302**	.620**
	Sig. (2-tailed)	-	0	0	0	0	0
	N	270	270	270	270	270	270
JARABAK RATIO	Pearson Correlation	-.616**	1	-.869**	-.311**	.237**	-.645**
	Sig. (2-tailed)	0	-	0	0	0.006	0
	N	270	270	270	270	270	270
GoGn-SN	Pearson Correlation	.664**	-.869**	1	.473**	-.351**	.744**
	Sig. (2-tailed)	0	0	-	0	0	0
	N	270	270	270	270	270	270
Y axis	Pearson Correlation	.615**	-.311**	.473**	1	-.574**	.519**
	Sig. (2-tailed)	0	0	0	-	0	0
	N	270	270	270	270	270	270
Facial axis angle	Pearson Correlation	-.302**	.237**	-.351**	-.574**	1	-.459**
	Sig. (2-tailed)	0	0.006	0	0	-	0
	N	270	270	270	270	270	270
R angle value	Pearson Correlation	.620**	-.645**	.744**	.519**	-.459**	1
	Sig. (2-tailed)	0	0	0	0	0	-
	N	270	270	270	270	270	270

***. Correlation is significant at the 0.01 level (2-tailed)*
**. Correlation is significant at the 0.05 level (2-tailed)*

Table 7. Comparison of frequencies of R angle and FMA

	FMA			
R	**Average**	**High**	**Low**	**Total**
Average	48	32	14	94
High	22	56	6	84
Low	22	2	68	92
Total	92	90	88	270

	Value	Df	P value
Chi-square	141.016	4	0.000*

		Value	Approx. Std. Error	Approx. T	P value
Measure of Agreement	Kappa	0.456	0.044	10.59	0

Table 8. Comparison of frequencies of R angle and Jaraback ratio

	Jarabak Ratio			
R	**Average**	**High**	**Low**	**Total**
Average	40	18	36	94
High	32	38	14	84
Low	4	0	88	92
Total	76	56	138	270

	Value	Df	P value
Chi-square	130.126	4	0.000*

		Value	Approx. Std. Error	Approx. T	P value
Measure of Agreement	Kappa	0.419	0.042	9.98	0

Table 9. Comparison of frequencies of R angle and GoGn-SN angle

	GoGn-SN			
R	**Average**	**High**	**Low**	**Total**
Average	32	18	44	94
High	16	60	8	84
Low	2	0	90	92
Total	50	78	142	270

	Value	Df	P value
Chi-square	173.816	4	0.000*

		Value	Approx. Std. Error	Approx. T	P value
Measure of Agreement	Kappa	0.511	0.04	12.78	0

Table 10. Comparison of frequencies of R angle and Y axis

	Y axis			
R	**Average**	**High**	**Low**	**Total**
Average	18	42	34	94
High	16	54	14	84
Low	14	10	68	92
Total	48	106	116	270

	Value	Df	P value
Chi-square	68.548	4	0.000*

		Value	Approx. Std. Error	Approx. T	P value
Measure of Agreement	Kappa	0.281	0.042	6.69	0

Table 11. Comparison of frequencies of R angle and facial axis angle

	Facial axis angle			
R	**Average**	**High**	**Low**	**Total**
Average	58	12	24	94
High	30	48	6	84

Low	38	4	50	92
Total	126	64	80	270

	Value	Df	P value
Chi-Square	100.03	4	0.000*

		Value	Approx. Std. Error	Approx. T	P value
Measure of Agreement	Kappa	0.363	0.046	7.89	0

4. DISCUSSION

Achieving harmonized face aesthetics and functional occlusion requires balanced vertical facial growth[15]. Changes in vertical skeletal development are common during orthodontic diagnosis and might result in discernible changes in facial proportions. While less vertical growth may lead to a short facial look, deep bite, and limited incisor display, excessive vertical growth is frequently linked to characteristics like increased lower facial height, gingival display, lip incompetence, and anterior open bite[16,17]. Accurate detection of these variances is therapeutically significant because they impact not only the appearance of the face but also therapy planning and long-term treatment stability[18]. While orthognathic surgery is frequently necessary for significant skeletal abnormalities in adults, growing individuals may benefit from growth adjustment using functional orthopaedic appliances.

Understanding the patient's growth pattern and its anticipated evolution is just as important to the success of orthodontic therapy as determining whether a vertical skeletal discrepancy exists. Treatment results may be jeopardized and the risk of post-treatment relapse increased if the vertical component of craniofacial growth is not well managed[19]. As a result, a thorough assessment of vertical skeletal relationships is still a crucial part of orthodontic diagnosis and treatment planning[20].

A common method for evaluating vertical skeletal connections and craniofacial morphology is lateral cephalometric analysis. For this aim, a number of cephalometric parameters have been created, such as the Y-axis by Downs, the Frankfort Mandibular Plane Angle (FMA) by Tweed, the GoGn-SN angle by Steiner, and other metrics like the Jarabak ratio and face height ratio[8,9,21]. Although landmark identification, reference planes, and anatomical changes may affect the accuracy of these studies, they are nevertheless useful in orthodontic diagnosis. As a result, further cephalometric characteristics that can enhance the evaluation of vertical skeletal discrepancies are still required.

For orthodontic diagnosis and treatment planning, accurate evaluation of vertical skeletal abnormalities is essential. To assess skeletal relationships in the transverse, sagittal, and vertical dimensions, a variety of cephalometric measures have been developed over time. The Frankfort Mandibular Plane Angle (FMA), GoGn-SN angle, Y-axis angle, facial axis angle, and Jarabak ratio are some of the most commonly utilized metrics. Despite the fact that these studies are frequently employed in clinical practice, each has some drawbacks that could affect the precision of the diagnosis.

The Frankfort horizontal plane, which is created using the Porion and Orbitale landmarks, is necessary for both the FMA and Y-axis measurements. Since many cephalometric analyses rely on the machine Porion rather than the actual anatomical landmark, identifying the anatomical Porion has long been acknowledged as a potential source of inaccuracy. Measurements based on this reference plane may be impacted by variations in ear-rod placement and the external auditory meatus's structure, which can also lead to errors in the Frankfort horizontal plane's construction[22].

The location of the Gnathion landmark also affects the Y-axis measurement. Schudy[4] also pointed out problems related to the Y-axis in assessing vertical growth patterns, and Paranhos et al.[23] noted that changes in Gnathion position were required to improve the detection of vertical skeletal differences.

Likewise, the orientation of the Sella-Nasion plane determines the GoGn-SN angle. The relationship between the Sella-Nasion plane and the mandibular plane may change as a result of variations in cranial base inclination, which could affect how the vertical skeletal pattern is interpreted. Sarhan[24] showed that variations in the Sella–Nasion plane's inclination could impact cephalometric interpretation, indicating that this measurement should be evaluated cautiously.

The intersection of the Pterygomaxillary–Gnathion and Basion–Nasion lines forms the facial axis angle, as defined by McNamara analysis. However, on lateral cephalograms, it can be difficult to accurately identify Basion and Pterygomaxillary landmarks, which lowers the measurement's consistency[11].

A common tool for evaluating facial proportions is the Jarabak ratio, which measures the proportionate connection between anterior and posterior facial heights. This ratio is useful for characterizing facial morphology, but it is not a direct predictor of vertical skeletal discrepancy alone; rather, it represents overall facial proportions[12].

In 2013, Drs. Mohammed Rizwan and Rohan Mascarenhas proposed the R angle as a substitute cephalometric measure for evaluating vertical skeletal disparities[14]. It is created by connecting the angle created at the condyle's center with three skeletal landmarks: Menton (Me), the center of the condyle (C), and Nasion (N). The condyle's center is regarded as a reliable anatomical landmark and has been effectively employed in the Beta angle to assess sagittal skeletal relationships[25]. The current study tested the R angle's use because few studies have analyzed it in various ethnicities and cephalometric norms may alter with ethnicity.

The 270 participants in the study were split equally into three groups based on their bone growth patterns: low, average, and high angle. Each subject was placed in a group when at least three of the five established cephalometric parameters FMA, GoGn-SN angle, Y-axis angle, facial axis angle, and Jarabak ratio indicated the same skeletal growth trend.
For the low-, average-, and high-angle groups in this investigation, the mean R angle values were 69.40 ± 1.977°, 74.63 ± 2.077°, and 80.27 ± 2.056°, respectively. The R angle successfully differentiated the various vertical skeletal patterns, as one-way ANOVA showed statistically significant differences between the three skeletal growth patterns ($F = 712.976$, $p < 0.001$).
The R angle's diagnostic capabilities were further illustrated by the receiver operating characteristic (ROC) study. With a sensitivity of 95.56% and specificity of 93.33%, a R angle more than 70.5° distinguished low-angle from average-angle cases. Similarly, average-angle and high-angle instances were distinguished with good diagnostic accuracy when the R angle was 75.5° or above. These results suggest that low-angle cases are represented by R angle values below 70.5°, average-angle cases by values between 70.5° and 75.5°, and high-angle skeletal patterns by values above 75.5°.
All established cephalometric parameters examined in this study showed statistically significant correlations with the R angle, according to Pearson's correlation analysis. FMA ($r = 0.845$) and the Y-axis angle ($r = 0.806$) showed very high positive correlations, but the GoGn-SN angle ($r = 0.784$) showed a strong positive correlation. On the other hand, there were significant negative associations between the R angle and the Jarabak ratio ($r = –0.765$) and the facial axis angle ($r = –0.675$). These results show that the R angle exhibits good agreement with commonly used cephalometric measurements and closely reflects vertical skeletal morphology.
In 2016, Maheen Ahmed et al.[26] assessed the diagnostic efficacy of various cephalometric measures for evaluating patterns of vertical skeletal growth. The Y-axis angle, SN-MP angle, MMA, GoGn-SN angle, FMA, R angle, and Facial Height Ratio (LAFH:TAFH) were all included in their analysis. Like the current study, they found strong correlations between the R angle and recognized cephalometric parameters, demonstrating its value as a supplementary metric for assessing vertical skeletal disparities.
The Chi-square test and Cohen's Kappa analysis were used to further assess the agreement between the R angle and the established cephalometric parameters. All skeletal growth pattern groups showed statistically significant correlations. Cohen's Kappa analysis showed moderate agreement with the Jarabak ratio ($\kappa = 0.419$) and GoGn-SN angle ($\kappa = 0.511$), fair agreement with the facial axis angle ($\kappa = 0.363$), and significant agreement between the R angle and FMA ($\kappa = 0.456$) as well as the Y-axis angle ($\kappa = 0.281$). These results suggest that for assessing vertical skeletal discrepancies, the R angle offers a degree of agreement similar to commonly used cephalometric measures.
The current study's results are consistent with those of Drs. Mohammed Rizwan and Rohan Mascarenhas[14], who first assessed the R angle in a community of South Indians. The current investigation also showed that the R angle is a clinically helpful and statistically reliable supplementary metric for assessing vertical skeletal discrepancies, notwithstanding variations in the study group.
All things considered, the results indicate that the R angle can be used as an extra cephalometric measure to evaluate vertical skeletal disparities. It offers useful information that may enhance diagnostic precision and aid in the planning of orthodontic treatment when interpreted in conjunction with recognized cephalometric analyses.

5. CONCLUSION

The following conclusions were drawn from the present study:
1. The R angle can help orthodontists diagnose and arrange treatments by acting as a helpful supplementary cephalometric measure for assessing vertical skeletal discrepancies.
2. According to the results of this study, low-angle skeletal patterns are indicated by R angle values below 70.5°, average-angle skeletal patterns are represented by values between 70.5° and 75.5°, and high-angle skeletal patterns are suggested by values larger than 75.5°.
3. The R angle's effectiveness in evaluating vertical skeletal discrepancies was supported by statistically significant agreement and correlation with established cephalometric parameters.
4. There were notable correlations found between the R angle and FMA, Y-axis angle, GoGn-SN angle, facial axis angle, and Jarabak ratio, suggesting that the R angle is congruent with accepted techniques for assessing vertical skeletal relationships.
5. The R angle is a straightforward and useful parameter for regular clinical use since it can be easily determined on lateral cephalometric radiographs using a small number of clearly defined anatomical landmarks.
6. Because the R angle is built without the use of derived or created points, there may be less chance of landmark recognition mistakes, which would increase the measurement's repeatability.

LIMITATIONS AND FUTURE

The results of this study may not be as applicable to other groups because it was limited to a single institutional sample of 270 participants. It is advised that larger and more varied people from various regional and ethnic origins participate in future research to confirm the R angle's clinical usefulness. The data supporting its regular usage in orthodontic practice would also be strengthened by additional studies assessing its diagnostic performance in various skeletal malocclusion patterns and age groups.

CONSENT

Written informed consent was obtained from all participants prior to their inclusion in the study. The consent forms have been collected and preserved by the authors in accordance with institutional and international ethical guidelines.

ETHICAL APPROVAL

The Institutional Ethics Committee of D. Y. Patil University School of Dentistry, Navi Mumbai, examined and approved the study methodology. Before the study began, ethical approval was acquired, and all procedures were followed in compliance with established ethical standards and institutional norms.

COMPETING INTERESTS

The authors declare that they have no competing interests related to this study.

REFERENCES

1. Kumar SK, Padmavati R, Shoba T. Vertical Discrepancies in Orthodontics-A Review. Indian Journal of Public Health Research & Development. 2019;10(12):2428-34.
2. Graber T, Rakosi A. Dentofacial orthopedics with functional appliances; 1997.
3. Nielsen IL. Vertical malocclusions: etiology, development, diagnosis and some aspects of treatment. The Angle Orthodontist. 1991;61(4):247-60.
4. Moss MSL, Salentij L. Differences between the functional matrices in anterior open-bite and in deep overbite. American Journal of Orthodontics. 1971;60(3):264-80.
5. Nanda SK. Patterns of vertical growth in the face. American Journal of Orthodontics and Dentofacial Orthopedics. 1988;93(2):103-10.
6. Tweed CH. The Frankfort-mandibular plane angle in orthodontic diagnosis, classification, treatment planning, and prognosis. American Journal of Orthodontics and Oral Surgery. 1946;32(4):175-230.
7. Downs WB. Variations in facial relationships: their significance in treatment and prognosis. American Journal of Orthodontics. 1948;34(10):812-40.
8. Steiner CC. Cephalometrics for you and me. American Journal of Orthodontics. 1953;39(10):729-55.
9. McNamara Jr JA. A method of cephalometric evaluation. American Journal of Orthodontics. 1984;86(6):449-69.
10. Jarabak JR, Fizzell JA. Technique and treatment with light-wire edgewise appliances. CV Mosby Company; 1972.
11. Rizwan M, Mascarenhas R. A new parameter for assessing vertical skeletal discrepancies: R angle. Rev Latinoam Ortodon Odontopediatr. 2013;16:1-7.
12. Janson GR, Metaxas A, Woodside DG. Variation in maxillary and mandibular molar and incisor vertical dimensions in 12-year-old subjects with excess, normal, and short lower anterior face height. American Journal of Orthodontics and Dentofacial Orthopedics. 1994;106(4):409-16.
13. Schudy FF. Vertical growth versus anteroposterior growth has related to function and treatment. The Angle Orthodontist. 1964;34(2):75-93.
14. Ahmed M, Shaikh A, Fida M. Reliability of various skeletal indicators in assessing vertical facial soft tissue pattern. Journal of Ayub Medical College Abbottabad. 2016;28(1):7-13.
15. Janson GR, Metaxas A, Woodside DG. Variation in maxillary and mandibular molar and incisor vertical dimensions in 12-year-old subjects with excess, normal, and short lower anterior face height. American Journal of Orthodontics and Dentofacial Orthopedics. 1994;106(4):409-18.
16. Opdebeeck H, Bell WH. The short face syndrome. American Journal of Orthodontics. 1978;73(5):499-511.
17. Bishara SE, Jakobsen JR. Changes in overbite and face height from 5 to 45 years of age in normal subjects. The Angle Orthodontist. 1998;68(3):209-16.
18. Stabrun AE, Danielsen K. Precision in cephalometric landmark identification. The European Journal of Orthodontics. 1982;4(3):185-96