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Original article

Impact of the Articular Angle on Skeletal Class II Division 1 Malocclusion in Libyan Patients: A Retrospective Cephalometric Analysis

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Abstract
The articular angle (S-Ar-Go) is one of the important cephalometric parameters influencing mandibular growth direction, rotation, and overall skeletal morphology. This study aims to assess the relationship between the articular angle and Class II Division 1 malocclusion in Libyan patients, evaluating its role in mandibular retrusion and skeletal disharmony. A total of 116 lateral cephalometric radiographs of Libyan white population patients diagnosed with Class II Division 1 malocclusion (SNA≥ 4) and proclined upper incisors, i.e., overjet > 3 mm) were analyzed using Dr. Ceph software. Measurements included the articular angle (S-Ar-Go), ANB angle, SNB angle, and mandibular plane angle (SN-MP). Statistical analysis was performed using SPSS 12.0 software, employing Pearson correlation analysis and independent t-tests to determine the significance of articular angle variations. A significantly larger articular angle was observed in Class II Division 1 Libyan patients compared to normal Libyan cephalometric values ($p < 0.01$). The articular angle exhibited a strong positive correlation with ANB ($r = 0.312$, $p = 0.001$) and a negative correlation with SNB ($r = -0.285$, $p = 0.002$). Additionally, increased articular angles were associated with clockwise mandibular rotation and a steeper mandibular plane. This study confirms that an increased articular angle contributes to skeletal Class II malocclusion by influencing mandibular growth and posterior positioning of the mandible. The findings emphasize the necessity of considering the articular angle in cephalometric diagnosis and treatment planning, particularly in cases requiring orthopedic interventions in growing patients or camouflaging or orthognathic surgery of non-growing patients.
Keywords. *Cephalometrics, Articular Angle, Class II Div 1 Malocclusion, Mandibular Growth, Skeletal Morphology.*

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Introduction
Skeletal Class II malocclusion is often associated with mandibular retrusion, maxillary prognathism, or a combination of both [1]. The articular angle (S-Ar-Go) plays a significant role in determining mandibular growth direction and is a key indicator of posterior mandibular positioning and rotation [2]. This parameter reflects the morphology of the cranial base and the temporo-mandibular joint [3]. A larger articular angle is often observed in high-angle Class II patients and is linked to a more obtuse mandibular posture, leading to increased lower anterior facial height and clockwise rotation [4,5]. Studies have demonstrated that changes in the articular angle influence mandibular plane inclination, which exacerbates Class II skeletal discrepancies [4,6].
This study is the second in a series of studies aimed at analyzing the influence of different parameters on skeletal Class II division 1 malocclusion in Libyan patients. In a previous study on Libyan patients [7], we evaluated the effects of gonial angle on skeletal class division 1. The present study builds upon these findings by investigating the role of the articular angle. This part aims to evaluate the impact of the articular angle on skeletal Class II Division 1 malocclusion in Libyan patients to better understand its contribution to mandibular retrusion and treatment implications for better understanding for Libyan orthodontists.

Method
This retrospective cephalometric study was conducted at the Althager Orthodontic Center, Misurata, Libya. The study included 116 lateral cephalometric radiographs for patients diagnosed with Class II Division 1 malocclusion (ANB ≥ 4). A total of 116 lateral cephalometric radiographs for patients with Class II Div 1 malocclusion, 56 males (Mean age: 18.5 ± 5.0 years) and 60 females (Mean age: 19.2 ± 5.4 years). Inclusion criteria include: Libyan white patient with Class II Division 1 malocclusion, ANB ≥4, proclined upper incisors (Over-jet > 3mm), presence of all permanent teeth through first molars, and no previous orthodontic treatment. The exclusion criteria include: Previous orthodontic treatment, poor quality raidographs and the presence of syndromic conditions. Radiographs were made by the author using Strato X 2000(Villa Medical Systems –Italy) with teeth in centric occlusion. Digital cephalometric analysis was done using Dr.Ceph cephalometric software (Fytek Co.USA), and the following angles with their representative landmarks were

used: Articular Angle (S-Ar-Go): Angle between the cranial base and the posterior mandible. ANB Angle: Sagittal discrepancy between the maxilla and mandible. SNB Angle: Mandibular position relative to the cranial base. Mandibular Plane Angle (SN-MP): Rotation and vertical growth direction. To test inter-reliability, 25 radiographs were randomly chosen and analyzed twice at two-week intervals, and the difference was tested using a paired t-test, which showed a statistically non-significant difference (t=1.078, P>0.05). These measurements were compared to normal values for Libyans as established by Elfaituri et al [7]. Pearson correlation analysis and independent t-tests were performed using SPSS 12.0 software to assess the relationship between the articular angle and other cephalometric parameters.

Results and discussion

The present study evaluated the relationship between the articular angle (S–Ar–Go) and skeletal Class II Division 1 malocclusion in a Libyan sample. The findings demonstrated a statistically significant increase in the articular angle among Class II subjects (147.2° ± 5.3°) compared to normative values (143.5° ± 4.1°; p < 0.01). In addition, Class II subjects exhibited increased ANB and decreased SNB values, along with a significantly steeper mandibular plane (SN–MP), indicating a combined sagittal and vertical skeletal discrepancy. These findings are consistent with classical descriptions of Class II malocclusion as a multifactorial condition involving both mandibular retrusion and vertical dysplasia [1–5]. The articular angle reflects the spatial relationship between the cranial base and the posterior mandibular ramus, and thus serves as an indirect indicator of mandibular growth direction and cranial base morphology. The increased values observed in this study suggest a posteriorly positioned condyle and a tendency toward clockwise mandibular rotation. This interpretation is supported by early cephalometric analyses and growth theories that emphasized angular relationships in craniofacial development [6,9-12].

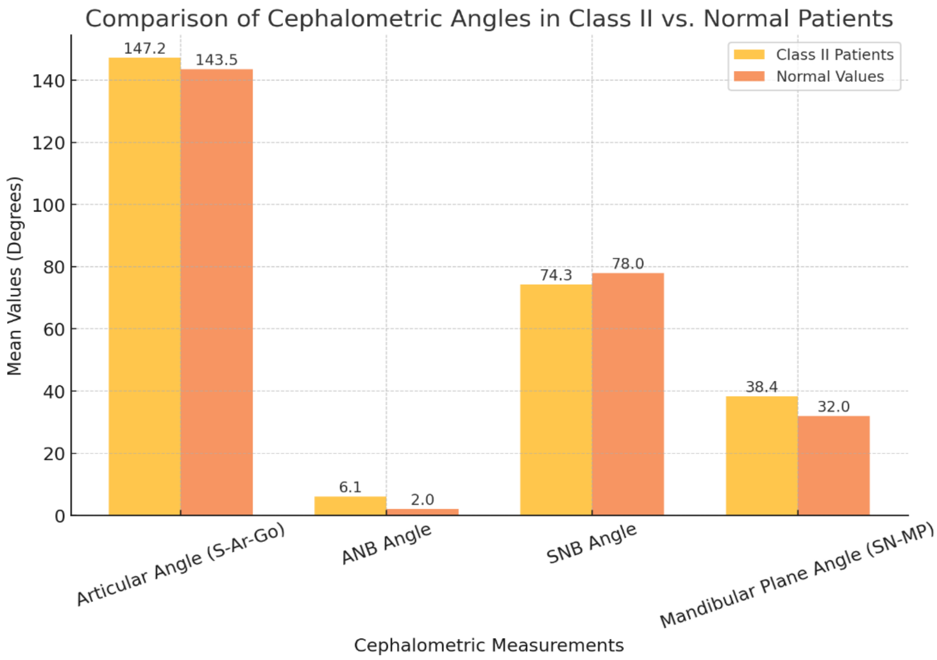

Figure 1. Comparison of cephalometric angles in class II v. normal patients

Table 1. Mean cephalometric values in class II patients vs. normal values

Measurement	Class II Patients (Mean±SD)	Normal Values (Mean±SD)	P-Value
S-Ar-Go Angle	147.2±5.3	143.5±4.1	<0.01
ANB Angle	6.1±1.3	2.0±1.5	<0.001
SNB Angle	74.3±3.2	78.6±2.5	<0.01
SN-MP Angle	38.4±4.7	32.0±3.8	<0.01

The correlation analysis provides further insight into sagittal skeletal relationships. The positive correlation between the articular angle and ANB (r = 0.312, p = 0.001) and the negative correlation with SNB (r = −0.285, p = 0.002) indicate that increased articular angle is more closely associated with mandibular retrusion than maxillary prognathism. This finding supports previous work identifying mandibular deficiency as a principal

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component of Class II malocclusion [13–15]. However, it should be noted that ANB is influenced by cranial base configuration and jaw position, which may limit its diagnostic specificity when used in isolation [16,17].

Table 2. Correlation of Articular angle to other parameters

Correlations	ANB	SNB	SN-MP
Articular angle (S-Ar-Go	r=0.312, p=0.001	r=-0.285, p=0.002	r=0.302, p=0.001

In the vertical dimension, the present study demonstrated a significant association between increased articular angle and a steeper mandibular plane SN–MP (r=0.302, p=0.001), indicating a hyperdivergent growth pattern. This is in agreement with studies that have attributed vertical skeletal discrepancies to rotational growth mechanisms rather than purely linear changes [18–20]. Additional investigations have emphasized the clinical importance of vertical control in orthodontic treatment, particularly in patients with clockwise mandibular rotation [21,22]. The present findings are consistent with both classical and contemporary literature. Foundational cephalometric analyses established the importance of craniofacial angular relationships in determining skeletal pattern and facial harmony [23–25].

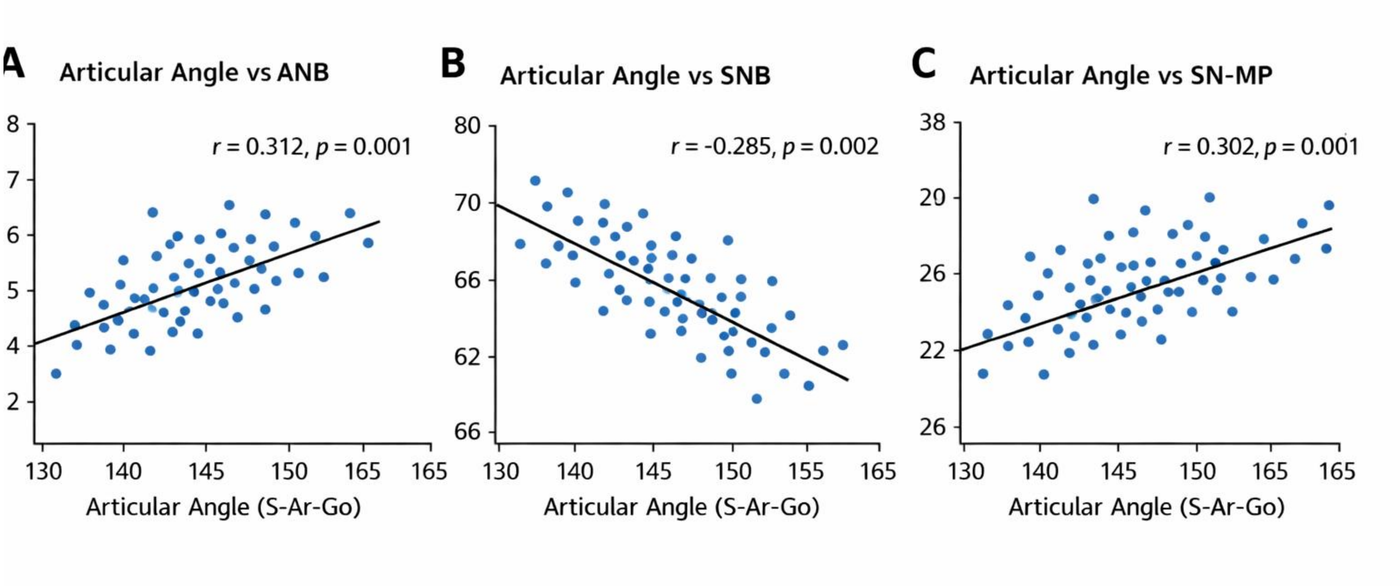

Fig 2. Scattered plot of different correlations

More recent studies, including those utilizing three-dimensional imaging, have confirmed that mandibular position in Class II patients is closely related to cranial base morphology and condylar orientation [26]. From a clinical perspective, the articular angle may serve as a useful adjunct in diagnosis and treatment planning. In growing patients, increased values may indicate a tendency toward vertical growth and clockwise mandibular rotation, which can influence the selection and timing of functional treatment approaches [27]. However, the effectiveness of growth modification is influenced by multiple factors, including growth potential and patient compliance, and therefore cannot be predicted solely by cephalometric parameters.

In non-growing patients, increased articular angle values are often associated with vertical skeletal patterns that complicate orthodontic camouflage and may require advanced biomechanical strategies or surgical intervention. Comprehensive treatment planning should therefore integrate skeletal, dental, and soft tissue considerations rather than relying on isolated angular measurements. An important contribution of this study is its focus on a Libyan population, which remains underrepresented in orthodontic research. Most cephalometric norms are derived from non-Libyan populations, and their direct application may lead to diagnostic inaccuracies. The findings of this study highlight the need for population-specific reference values to improve diagnostic precision and treatment outcomes.

Despite these contributions, several limitations should be acknowledged. The retrospective design introduces potential selection bias, and the use of two-dimensional cephalometry limits the evaluation of three-dimensional craniofacial structures. Furthermore, the absence of longitudinal data restricts the ability to assess growth changes over time. Future studies incorporating longitudinal designs and advanced imaging modalities are recommended to further elucidate the role of the articular angle in craniofacial development. Overall, the findings support the relevance of the articular angle as a parameter associated with both sagittal and vertical components of skeletal Class II malocclusion. However, it should be interpreted within a multifactorial framework rather than as an independent diagnostic determinant.

Conclusion

From this study, the articular angle (S–Ar–Go) was found to be significantly increased in skeletal Class II Division 1 subjects and demonstrated meaningful associations with both sagittal and vertical cephalometric parameters. The observed correlations—specifically the positive relationship with ANB and the negative relationship with SNB—indicate that an increased articular angle is closely linked to mandibular retrusion and contributes to the sagittal discrepancy characteristic of Class II malocclusion. In addition, its association with an increased mandibular plane angle (SN–MP) supports its relevance in identifying vertical growth tendencies, particularly clockwise mandibular rotation. These findings reinforce the concept that the articular angle is not just a descriptive measurement, but a clinically relevant parameter reflecting underlying craniofacial growth. Its incorporation into routine cephalometric analysis may enhance diagnostic precision, particularly in differentiating mandibular deficiency from maxillary excess and in anticipating vertical growth patterns that influence treatment mechanics. From a clinical standpoint, early recognition of increased articular angle values may aid in optimizing treatment timing and modality selection in growing patients, while in non-growing individuals, it may inform the complexity of orthodontic camouflage or the need for surgical intervention. Importantly, the present study provides population-specific data for the Libyan sample, highlighting the necessity of establishing localized cephalometric norms rather than relying solely on conventional standards derived from other populations. Future research incorporating longitudinal designs, three-dimensional imaging, and growth maturity indicators is recommended to further elucidate the dynamic role of the articular angle and to strengthen its application in evidence-based orthodontic practice.

Conflict of interest. Nil

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