Beta angle in a sample of Iraqi adults with Class I skeletal and dental relations and its correlation with other craniofacial measurements

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ABSTRACT
Background: This study aimed to determine the value of Beta angle for a sample of Iraqi adults with class I skeletal and dental relations and to verify the existence of sexual dimorphism and to find out the relation between this angle and other craniofacial measurements.

Materials and Methods: Sixty dental students (23 males and 37 females) with an age ranged between 20-31 years old and having class I skeletal and dental relations were chosen for this study. Each student was subjected to clinical examination and digital true lateral cephalometric radiograph. The radiographs were analyzed using AutoCAD 2007 computer program to measure the angular and linear variables. Descriptive statistics were obtained for the measurements for both genders and total sample; independent samples t-test was performed to evaluate the gender difference and Pearson's correlation coefficient test used to detect the relation between the Beta angle and other measurements.

Results and Conclusions: The value of Beta angle in this study was 32.63°±2.57°. When the Beta angle is less than 27°, the case is class II and when it is more than 38°, the case is class III. There is no genders difference regarding the Beta angle and this angle correlated significantly and positively with the mandibular length and articular angle and negatively with ANB and saddle angles.

Key words: Sagittal jaw relation, Beta angle.

INTRODUCTION
Freeman (1) stated that, even before Edward H. Angle introduced his classification of malocclusion to the profession in the early 1900's, the anteroposterior relation of mandible to maxilla was a most important diagnostic criterion. This relationship can be determined from clinical observation to some degree, but it can be much more accurately evaluated from a lateral radiograph. Broadbent's (2) introduction of his cephalometer in 1931 made such films available, although they were used primarily for research and growth studies until the late 1940's.

From 1947 till 2009, many methods (3-39) had been developed to assess the anteroposterior (sagittal) jaw relationship. For every method, there are many advantages and disadvantages, but still the ANB angle (7) is the most popular one.

In 2004, Baik and Ververidou (37) established a new cephalometric measurement, named the Beta angle, to assess the sagittal jaw relationship with accuracy and reproducibility. In this angle, three skeletal landmarks- point A, point B, and the apparent axis of the condyle- were used to measure an angle that indicated the severity and the type of skeletal dysplasia in the sagittal dimension. They found that subjects with a Beta angle between 27° and 35° had a Class I skeletal pattern, a Beta angle less than 27° indicated a Class II skeletal pattern, a Beta angle greater than 35° indicated a Class III skeletal pattern and there was no statistically significant difference between mean Beta angle values of males and females.

Kamalamma (40) carried out a lateral cephalometric study in the natural head position on Indian adults to determine the norms for Beta angle and Wits appraisal and also to correlate Beta angle with the Wits appraisal and ANB angle. The results indicated that there was no significant difference in the norms for males and females. Beta angle showed a negative linear correlation with ANB angle and Wits appraisal.

This study aimed to determine the value of Beta angle for a sample of Iraqi adults with class I skeletal and dental relations and to verify the existence of sexual dimorphism and to find out the relation between this angle and other craniofacial measurements.

MATERIALS AND METHODS
Sample
Out of 80 clinically examined under and postgraduate students in the College of Dentistry, University of Baghdad with an age ranged between 20-31 years, 60 students (23 males and 37 females) were selected having normal occlusion, full permanent dentition regardless the third molars, and ANB angle equals to 2°±2° and MP-SN angle equals to 32°±5° (7).

Methods
Each individual was examined clinically and subjected to the digital true lateral cephalometric radiograph using the Planmeca ProMax X-ray unit. The individual was positioned within the
cephalostat with the sagittal plane of the head vertical, the Frankfort plane horizontal, and the teeth were in centric occlusion. Every lateral cephalometric radiograph was analyzed by AutoCAD program 2007 to calculate the angular and linear measurements. Once the picture was imported to the AutoCAD program, it will appear in the master sheet on which the points and planes were determined, and then the measurements were obtained. The angles were measured directly as they were not affected by magnification while the linear measurements were divided by scale (the ruler in the nasal rod) for each picture to overcome the magnification.

Cephalometric Landmarks, Lines, and Measurements

Cephalometric Landmarks
1. Point S (Sella): The midpoint of the hypophysial fossa (41).
2. Point N (Nasion): The most anterior point on the nasofrontal suture in the median plane (41).
3. Point A (Subspina): The deepest midline point on the premaxilla between the Anterior Nasal Spine and Prosthion (6).
4. Point B (Supramentale): The deepest midline point on the mandible between Infradentale and Pogonion (6).
5. Point Me (Menton): The lowest point on the symphyseal shadow of the mandible seen on a lateral cephalogram (42).
6. Point Go (Gonion): A point on the curvature of the angle of the mandible located by bisecting the angle formed by the lines tangent to the posterior border of the ramus and inferior border of the mandible (42).
7. Point C: The center of the condyle (37).
8. Point ANS (Anterior Nasal Spine): It is the tip of the bony anterior nasal spine in the median plane (41).
9. Point PNS (Posterior Nasal Spine): This is a constructed radiological point, the intersection of a continuation of the anterior wall of the pterygopalatine fossa and the floor of the nose. It marks the dorsal limit of the maxilla (41).
10. Point Ar (Articulare): The point of intersection of the external dorsal contour of the mandibular condyle and the temporal bone (41).

Cephalometric Lines
1. Sella-Nasion (SN) line: It is the anteroposterior extent of anterior cranial base (41).
2. Mandibular plane (MP): Formed by a line joining Gonion and Menton (42).
3. N-A line: Formed by a line joining Nasion and point A (6).
4. N-B line: Formed by a line joining Nasion and point B (6).
5. C-B line: A line connecting the center of the condyle C with B point (37).
6. A-B line: A line connecting A and B points (6).
7. A line from point A perpendicular to the C-B line (37).
8. Sella- Articulare (S-Ar) line: A line from Sella to Articulare (41).
9. Palatal plane (PP): A line joining between anterior nasal spine and posterior nasal spine (41).
10. Articulare- Gonion (Ar- Go) line: A line joining between Articulare and Gonion (41).

Cephalometric Measurements
1. ANB angle: The angle between lines N-A and N-B. It represents the difference between SNA and SNB angles or it may be measured directly as the angle ANB (7).
2. Beta angle: It is the angle between the line from point A perpendicular to the C-B line and the A-B line (37).
3. SN plane- Mandibular plane angle (SN-MP): The angle between the S-N plane and the mandibular plane (41).
4. Gonial angle (Ar-Go-Me): The angle between the posterior border of the ramus and the mandibular plane (41).
5. Saddle angle (N-S-Ar): The angle between the anterior and the posterior cranial base. This angle formed at the point of intersection of the S-N plane and the S-Ar plane (41).
6. Articular angle (S-Ar-Go): This angle formed at the point of intersection of the S-Ar plane and the Ar-Go plane (41).
7. Basal plane angle (PP-MP): This defines the angle of inclination of the mandible to the maxillary base (41).
11. Mandibular length: It represents the distance from Gonion to Menton (43).
12. Ramus length: The distance between Ar and Go (41).
14. Upper anterior facial height (UFH): It’s measured from N to ANS (42).
15. Lower anterior facial height (LFH): It’s measured from ANS to Me (42).
16. Posterior facial height (PFH): It’s measured from S to Go (41).
Statistical Analyses
All the data of the sample were subjected to computerized statistical analysis using SPSS version 15 (2006) computer program. The statistical analysis included:
1. Descriptive Statistics: Means, standard deviations, standard errors, minimum, maximum and statistical tables.
2. Inferential Statistics: Independent-samples t-test for the comparison between both genders and Pearson’s correlation coefficient test to detect the relation between the Beta angle and other measurements.

In the statistical evaluation, the following levels of significance are used:
- Non-significant (NS) P > 0.05
- Significant * 0.05 ≥ P > 0.01
- Highly significant ** 0.01 ≥ P > 0.001
- Very highly significant *** P ≤ 0.001

RESULTS AND DISCUSSION
In this study, the normal value of the Beta angle had been determined for a sample of Iraqi adults with class I dental and skeletal relations with its relation to different craniofacial measurements.

In Iraq, two studies had been done using this angle as a measurement that determine the features of class II and III jaws relation (44,45) depending on the value of Baik and Ververidou (37). The variables will be discussed under two headings:

1- Descriptive statistics and gender difference

a. Angular measurements
The results showed that all of the angular measurements except MP-SN angle and saddle angle were larger in males than females with a non-significant difference. Saddle angle was larger significantly in females than males; this comes in agreement with Yassir (46) and this was considered normal as the saddle angle increased with the decreased of ANB angle (47).

The mean value of SN-MP was smaller significantly in males than females indicating that the males had a tendency towards forward rotation.

The value of Beta angle was slightly higher than Baik and Ververidou (37) and Kamalamma (40) due to the age factor in the first as they conducted their study on subjects had age between 9 and 15 years old and the head position during taking the radiograph in the second. There was non-significant genders difference and this comes in agreement with Baik and Ververidou (37) and Kamalamma (40).

b. Linear measurements
The results indicated that all the linear measurements were significantly larger in males than females. This may follow the general rule that females are slightly smaller than males in all dimensions (48).

2. Relation between Beta angle and other measurements
The results showed that Beta angle correlated significantly in negative direction with ANB and saddle angles. This comes in agreement with Kamalamma (40), while it correlated directly and significantly with the S-Ar-Go angle.

Beta angle also correlated directly and significantly with the mandibular length in so as the mandibular length increased, the Beta angle increased and this becomes obvious in Class II and III jaws relation (44,45).

On the other hand, the other linear and angular measurements had no significant correlation with Beta angle.

REFERENCES
Table 1: Descriptive statistics and genders difference

<table>
<thead>
<tr>
<th>Variables</th>
<th>Genders</th>
<th>Descriptive statistics</th>
<th>Genders difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean(S.D.) S.E.</td>
<td>Min. Max. t-test p-value</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Total</td>
</tr>
<tr>
<td>ANB°</td>
<td>2.61(1.47, 0.31)</td>
<td>2.35(1.32, 0.22)</td>
<td>2.45(1.37, 0.18)</td>
</tr>
<tr>
<td>N-S-Ar°</td>
<td>122.04(4.30, 0.90)</td>
<td>126.14(5.84, 0.96)</td>
<td>124.57(5.63, 0.73)</td>
</tr>
<tr>
<td>S-Ar-Go°</td>
<td>143.13(5.45, 1.14)</td>
<td>142.49(6.52, 1.07)</td>
<td>142.73(6.09, 0.79)</td>
</tr>
<tr>
<td>Gonial angle°</td>
<td>125.22(5.61, 1.17)</td>
<td>124.11(4.04, 0.66)</td>
<td>124.53(4.69, 0.61)</td>
</tr>
<tr>
<td>SN-MP°</td>
<td>30.65(2.74, 0.57)</td>
<td>32.62(2.89, 0.48)</td>
<td>31.87(2.97, 0.38)</td>
</tr>
<tr>
<td>PP-MP°</td>
<td>23.35(3.45, 0.72)</td>
<td>23.22(3.50, 0.57)</td>
<td>23.27(3.45, 0.45)</td>
</tr>
<tr>
<td>Beta°</td>
<td>33.17(2.71, 0.56)</td>
<td>32.30(2.46, 0.40)</td>
<td>32.63(2.57, 0.33)</td>
</tr>
<tr>
<td>S-N (mm)</td>
<td>70.45(2.52, 0.52)</td>
<td>66.83(1.94, 0.32)</td>
<td>68.22(2.79, 0.36)</td>
</tr>
<tr>
<td>S-Ar (mm)</td>
<td>36.35(2.52, 0.53)</td>
<td>32.16(2.88, 0.47)</td>
<td>33.77(3.41, 0.44)</td>
</tr>
<tr>
<td>Ar-Go (mm)</td>
<td>50.74(4.73, 0.99)</td>
<td>44.69(3.57, 0.59)</td>
<td>47.01(4.99, 0.64)</td>
</tr>
<tr>
<td>ANS-PNS (mm)</td>
<td>57.01(4.06, 0.85)</td>
<td>52.28(2.01, 0.33)</td>
<td>54.09(3.74, 0.48)</td>
</tr>
<tr>
<td>Go-Me (mm)</td>
<td>74.03(3.68, 0.77)</td>
<td>69.28(3.90, 0.64)</td>
<td>71.10(4.45, 0.57)</td>
</tr>
<tr>
<td>UAFH (mm)</td>
<td>53.19(2.80, 0.58)</td>
<td>50.62(2.52, 0.41)</td>
<td>51.60(2.89, 0.37)</td>
</tr>
<tr>
<td>LAFH (mm)</td>
<td>69.61(4.07, 0.85)</td>
<td>62.05(3.59, 0.59)</td>
<td>64.95(5.27, 0.68)</td>
</tr>
<tr>
<td>TAFH (mm)</td>
<td>121.10(4.58, 0.95)</td>
<td>111.11(3.97, 0.65)</td>
<td>114.94(6.44, 0.83)</td>
</tr>
<tr>
<td>PFH (mm)</td>
<td>82.74(4.94, 1.03)</td>
<td>72.79(3.83, 0.63)</td>
<td>76.61(6.47, 0.84)</td>
</tr>
</tbody>
</table>

Males =23, Females =37, Total sample =60, d.f. = 58
Table 2: Relation between Beta angle and other variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Relation</th>
<th>Beta° Total</th>
</tr>
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<tbody>
<tr>
<td>ANB°</td>
<td>r -0.44</td>
<td>p-value 0.000 ***</td>
</tr>
<tr>
<td>N-S-Ar°</td>
<td>r -0.34</td>
<td>p-value 0.01 **</td>
</tr>
<tr>
<td>S-Ar-Go°</td>
<td>r 0.30</td>
<td>p-value 0.02 *</td>
</tr>
<tr>
<td>Gonial angle°</td>
<td>r -0.04</td>
<td>p-value 0.77 (NS)</td>
</tr>
<tr>
<td>SN-MP°</td>
<td>r -0.05</td>
<td>p-value 0.71 (NS)</td>
</tr>
<tr>
<td>PP-MP°</td>
<td>r 0.01</td>
<td>p-value 0.93 (NS)</td>
</tr>
<tr>
<td>S-N (mm)</td>
<td>r -0.06</td>
<td>p-value 0.63 (NS)</td>
</tr>
<tr>
<td>S-Ar (mm)</td>
<td>r -0.15</td>
<td>p-value 0.26 (NS)</td>
</tr>
<tr>
<td>Ar-Go (mm)</td>
<td>r 0.20</td>
<td>p-value 0.13 (NS)</td>
</tr>
<tr>
<td>ANS-PNS (mm)</td>
<td>r 0.06</td>
<td>p-value 0.63 (NS)</td>
</tr>
<tr>
<td>Go-Me (mm)</td>
<td>r 0.26</td>
<td>p-value 0.04 *</td>
</tr>
<tr>
<td>UAFH (mm)</td>
<td>r 0.02</td>
<td>p-value 0.91 (NS)</td>
</tr>
<tr>
<td>LAFH (mm)</td>
<td>r 0.14</td>
<td>p-value 0.29 (NS)</td>
</tr>
<tr>
<td>TAFH (mm)</td>
<td>r 0.14</td>
<td>p-value 0.28 (NS)</td>
</tr>
<tr>
<td>PFH (mm)</td>
<td>r 0.14</td>
<td>p-value 0.30 (NS)</td>
</tr>
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Table 3. The values of Beta angle in different studies.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Baik and Ververidou (37)</th>
<th>Kamalamma (40)</th>
<th>Present study</th>
</tr>
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<tr>
<td>Year</td>
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<td>2009</td>
<td>2013</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>9-15</td>
<td>18-25</td>
<td>20-31</td>
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<tr>
<td>Sex</td>
<td>Male Female Total</td>
<td>Male Female Total</td>
<td>Male Female Total</td>
</tr>
<tr>
<td>Mean</td>
<td>30.9 31.1 31.1</td>
<td>32.33 31.41 31.8</td>
<td>33.17 32.30 32.63</td>
</tr>
<tr>
<td>S.D.</td>
<td>2 3.73 3.46 3.57</td>
<td>2.71 2.46 2.57</td>
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<tr>
<td>Min.</td>
<td>27</td>
<td>28</td>
<td>27</td>
</tr>
<tr>
<td>Max.</td>
<td>35</td>
<td>38</td>
<td>38</td>
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