Clinical significance of sella turcica morphologies and
dimensions in relation to different skeletal patterns and
skeletal maturity assessment

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ABSTRACT
Background: Sella turcica is a saddle-like structure based on the roof of the sphenoid bone and has an important role in orthodontic diagnosis and treatment planning. The aims of the study were to assess sella shape and size in an adolescent Iraqi sample in different skeletal classes and to verify the possibility of clinical application of sella turcica in skeletal maturity estimation.

Materials and Methods: The study sample composed of (140) Iraqi adolescent subjects aged 10-16 years (91 females, 49 males); every subject had true lateral cephalometric radiograph. The sample was subjected to 2 classifications: the 1st included three skeletal classes according to ANB angle, and the 2nd included accelerative and decelerative groups according to maturity indicators of cervical vertebrae seen radiographically. In each classification, sella size was measured using three linear measurements (S.length, S.depth, and S.diameter).

Results: Most of sella turcica measurements were not different statistically among the skeletal classes, and that specific sella turcica linear measurements can not be obtained for each specific skeletal class throughout the pubertal period. Normal sella was the predominant over the other morphological aberrations in both classification systems, while these morphologies occurred more frequently in class II and III. Sella depth and diameter were significantly higher in the decelerative than accelerative group, while non significant difference was found concerning sella shapes between the two groups.

Conclusions: It was concluded that Sella depth and sella diameter measurements can be utilized clinically for pubertal growth phase determination, while sella morphology can not be diagnostic for the accelerative and decelerative pubertal growth phases.

Keywords: Sella Turcica, Pubertal growth, Skeletal Maturity. (J Bagh Coll Dentistry 2012;24(2):120-126).

INTRODUCTION
Several landmarks within the cranium have been determined to act as reference points when tracing cephalometric radiographs. These landmarks are used to measure positions of structures (such as the maxilla or mandible) in relation to the cranium, or to themselves. The benefits gained from studying these structures serve: in assisting the orthodontist during diagnosis, as a tool to study growth, and in evaluation of orthodontic treatment results. (1)

One of the most commonly used cranial landmarks for cephalometric tracing is sella point. This point is located in the centre of the sella turcica, with the turcica housing and protecting the pituitary gland in the cranial base. (2)

Any abnormality or pathology in the gland could manifest from an altered shape of the sella turcica and/or a disturbance in the regulation of secretion of glandular hormones. (3-6) The anatomy of the sella turcica has been described as being variable. (7) Morphologically, three basic types—oval, round, and flat—have been classified, the oval and round types being the most common. During embryological development, the sella turcica area is a key point for the migration of the neural crest cells to the frontonasal and maxillary developmental fields. (8)

For this reason, it is very important to study the effect of puberty (a period of significant body changes) on the normal morphology of this landmark clearly in a young sample, as it is studied in an adult sample, since this has a great importance in orthodontic diagnosis and treatment planning.

Previously, when studying the sella turcica size (length, depth and diameter) and its relation to different skeletal patterns, no statistically significant correlation between facial type and the mean sella turcica area of the pituitary fossa had been presented. (9) However, Alkofide (1) when evaluated skeletal type and linear dimensions of sella turcica, a significant difference was found. When comparing skeletal class II and class III subjects, a significant difference was observed between the diameter of the sella turcica in both skeletal classes which may be attributed to genetic factors.

Although the morphology and dimensions of sella turcica have been studied by previous researchers on adult Iraqi samples (10,11), until now no Iraqi study has been done to evaluate the linear dimensions and morphological structure of sella turcica in an adolescent Iraqi sample. Although no significant differences had been obtained between males and females in terms of mean linear dimensions of the sella turcica, previous studies (1,12,13) found a significant effect of age on

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sella turcica dimensions. So the present study was the first Iraqi study that evaluated the linear dimensions and morphological structure of sella turcica in an adolescent Iraqi sample, and their relationship to different skeletal patterns. Furthermore, this study was (for the 1st time) attempted to test the possibility of clinical employment of Sella Turcica in pubertal growth estimation.

MATERIALS AND METHODS

The sample

The sample of this study consisted of radiographs for patients who were attending the preventive and orthodontic clinics at the teaching hospital of the College of Dentistry – Baghdad University seeking paedodontic and orthodontic treatments. The sample was all of Iraqi origin, with an age ranging between 10-16 years. Out of 185 subjects examined, only 140 subjects (49 males and 91 females) met the inclusion criteria including no history of systemic disease (clinically healthy patient) or trauma in the craniofacial complex, no syndromes (clefts of the lips and palate), and no history of previous orthodontic treatment. Every subject has to be free from any congenital or acquired malformations of the cervical vertebrae (seen radiographically). (14)

The sample has been subjected to two classification systems. 1st, according to ANB angle (15-17) into skeletal class I (13 males, 38 females), class II (20 males, 20 females), and class III (16 males, 33 females). 2nd, according to Maturity Indicators of Cervical Vertebrae (CVMI) (14) into accelerative (56) and decelerative (43) groups respectively.

In the 2nd classification system, by excluding the easily recognized skeletal (I and VI) stages at the extremes of pubertal growth stages from the total radiographs, the total sample (140) became (99) radiograph.

METHOD

Cephalometric Analyses

All Lateral Cephalometric Images were analyzed by an AutoCAD program (version 2007) to measure the ANB angle and to calculate the linear measurements of Sella Turcica.

Size of Sella Turcica

According to Silverman (18) and Kisling (19) the following lines were measured to determine the size of the Sella Turcica, all the reference lines used were situated in the midsagittal plane (figure 1):

\[ A) \text{ The length of the Sella Turcica:} \text{ Was measured as the distance from the Tuberculum Sellae (TS) to the tip of Dorsum Sellae (DS).} \]

\[ B) \text{ The depth of Sella Turcica:} \text{ Was measured as a perpendicular from the line mentioned above to the deepest point on the floor of the fossa (BPF).} \]

\[ C) \text{ The anteroposterior greatest diameter of the Sella Turcica:} \text{ Was measured from the Tuberculum Sellae (TS) to the furthest point on the posterior inner wall of the fossa (SP).} \]

Shape of Sella Turcica

For the assessment of the morphological aberrations of the sella turcica (after enlargement of its view), in addition to the normal morphology of sella turcica traced in (figure 2); the different morphological appearances of the sella turcica described by Axelsson et al. (13,20) (figure 2), were used to classify sella shapes in the current study. The six morphological variations that are rated as normal included oblique anterior wall, sella turcica bridging, double contour of the floor, irregularity (notching) in the posterior part of the dorsum sellae, extremely low sella turcica, and pyramidal shape of the dorsum sellae.

Skeletal Maturation Assessment

The second part of the study has concerned with verifying the possibility of using the sella turcica for pubertal growth estimation by depending on a method of skeletal maturation assessment using the Maturity Indicators of Cervical Vertebrae. This method has been developed by Hassel and Farman (14) (CVMI). They described certain criteria for assessing maturational changes on the second, third, and fourth cervical vertebrae, which can be visualized on the lateral cephalograms even if a thyroid protective collar has been worn during radiation exposure.

The two skeletal stages (stages I and VI) represent the extremes of the pubertal growth period, which can be very easily diagnosed clinically by the orthodontist. Greater efforts were, therefore, done to concentrate on subjects at the skeletal stages which require certain maturity indicators for their determination, specially skeletal stages III and IV. For more facility and practicality, the six pubertal growth stages have been condensed only into two growth phases or stages (accelerative and decelerative), i.e., by excluding the two skeletal stages (stages I and VI) at the extremes of the pubertal growth period, the two accelerative (stages II and III) and the two decelerative (stages IV and V) were combined to represent the accelerative and decelerative groups, respectively. (14,21,22)

Furthermore, since males and females pass during puberty through the same physiological sequence, i.e., both progress towards skeletal...
maturity with advancement of age and growth; therefore, the total sample has been classified into accelerative and decelerative groups without male and female classification.

**Statistical Analysis**

The statistical analysis included:

*I. Descriptive Statistics:* Including (Mean value, Standard deviation, Number and Percentage, and Statistical tables).

**II. Inferential Statistics:** Including (ANOVA test, LSD test, Independent t-test, and Likelihood Ratio test (Lx^2))

**RESULTS AND DISCUSSION**

The literature involves different age ranges, with the puberty may begin as early as 9 or 10 years, and may end as late as 18 or 19 years of age. By selecting the 10-16 years age range, therefore, reconciliation of the different findings about the pubertal timing has been done. (22,23) Size measurements of the sella turcica have, to-date, almost solely been used as a diagnostic tool concerning expanding tumors or tumor-like processes in the pituitary gland. (1,2,4,25)

Statistically, there were non significant gender differences in all sella turcica linear measurements (S. length, S. depth and S. diameter) in skeletal class II and III, while the two measurements (S. depth and S. diameter) were significantly higher in females than in males dealing with skeletal class I (table 1). This may be explained by: 1st, The explicit discrepancy in gender distribution in this skeletal pattern. 2nd, The earlier pubertal growth spurt in females which may influence their sella measurements.

Genetic factors most likely play a leading role in male-female growth differences. The marked advancement of girls over boys in the rate of maturation is attributed to the delaying action of the Y chromosome in males. By delaying growth, the Y chromosome allows males to grow over a longer period of time than females, therefore making possible greater overall growth. (26)

On the other hand, non significant gender mean difference was found concerning the sella length in class I. This may be attributed to a greater pubertal growth influence on the vertical than on the anteroposterior (Sella length) dimension. By comparing the subjects’ linear dimensions of sella turcica with normative data from the literature, the former result was in agreement with Alkofide (1) and Yassir et al. (10), while the latter result was in agreement with Silverman (13), Chilton et al. (27), and Elster et al. (28) who revealed that the pituitary fossa of males tended to be larger than that of females during childhood. After that, due to the pubertal growth spurt in females which begins 2 years earlier than males, a significant change in pituitary fossa size occurs in females from 11 to 14 years of age. Thereafter, the late growth acceleration in males, which is usually about 2 years later than females, results in an approximate equalization in sella area in both genders.

On the other hand, by comparing sella measurements among the skeletal classes, it was found that the sella depth was significantly higher in class I than in class II (table 1). This finding may be attributed to genetically determined growth factors. According to this study result, specific sella turcica linear measurements can not be obtained for each specific skeletal class throughout the pubertal period.

In comparison with adult studies Meyer-Marcotty (6), Yassir et al. (10), and Al-Ani (11), it could be demonstrated that the length, depth, and diameter of the sella turcica region of all examined patients in this study tended to be smaller, a finding that confirms the effect of age on sella measurements.

Investigations concerning the sella turcica have not only focused on size, but also on morphology. (1,2,6,10,11,13,20,29) No previous studies concerning sella morphology have mentioned the gender difference in each skeletal class separately during pubertal period alone, rather previous studies have either compared between males and females as a total sample (Yassir et al. (10) and Axelsson et al. (13,20)) or they compared between the classes (as a total in each class) without giving gender difference (Meyer-Marcotty et al. (6); Yassir et al. (10); Abdel-Kader (30)). Furthermore, these studies used the frequency and percentage as a baseline for comparison, i.e. descriptive statistics only, and they did not use inferential statistical analyses between genders and among the classes.

Normal sella turcica was the predominant shape over the other morphological variations in all skeletal classes (table 2). This predominance can be attributed to growth and development basis. Sella turcica is expected to become oval to more round (i.e normal) with craniofacial growth progression. This is true if we follow the normal growth and development of sella turcica, as it appears as a shallow-like depression at the fetal stage, while as the growth of the cranium proceeds it becomes slightly oval to round at the permanent dentition stage (at adolescence). This result comes to be in agreement with (Alkofide (1); Yassir et al. (10), Al-Ani (11) and Axelsson et al. (13,20)) their results showed that a normal sella turcica morphology was seen in two-thirds of the subjects, while the remainder showed dysmorphic appearances.
Any deviation from the above mentioned sella growth and development map can account for the occurrence of these shapes. Statistically, only in class III, Likelihood Ratio test showed significant difference between males and females for the different shapes of sella turcica. Skeletal class III can be considered as a type of craniofacial deviation in which growth pattern is abnormal. Furthermore, greater percentages of males are affected by this type of malocclusion than females. So, if we consider morphological sellar aberrations as a deviation from the normal development of sella turcica, abnormal sella may occur more frequently in this class and mostly in males.

The predominance of non significant sella morphology differences between genders enabled dealing with the subjects as a total sample within each skeletal class. Although multiple comparisons were made among the classes, a significant difference only was present between class II and III (table 3). Genetically determined growth factors may have a role. Formation and development of the sella turcica and dental structures share, in common, the involvement of neural crest cells. In fact, the anterior part of the sella turcica is believed to develop mainly from neural crest cells, (31,32) so any structural deviations in the anterior wall are believed to be associated with specific deviations in the facial skeleton. (33) Moreover, During embryological development, the sella turcica area is a key point for the migration of the neural crest cells to the frontonasal and maxillary developmental fields. (8)

The majority of normal sella turcica appeared to be present in skeletal class I followed by class III and then by class II. This may be attributed to structural adaptation phenomenon. The sella turcica structural development is influenced by growth and development of the surrounding structures (i.e. anterior and posterior cranial bases, brain, and nasomaxillary complex). Normal and harmonious growth behavior of these structures would result in a normal sella shape, while any deviation from this harmonious growth might lead to sella turcica morphological aberrations which occurred mostly in class III.

Determining the pubertal growth phase (accelerative or decelerative) is an important aim clinically, irrespective of the specific stage of that phase. Dealing with (table 4) there was non significant difference of sella mean length between the accelerative and decelerative groups. Conversely, the other two measurements (S. depth and S. diameter) were higher in the decelerative than accelerative group. Statistically, there were significant and highly significant differences in the mean values of sella (depth and diameter) between groups, respectively.

This finding may be related to growth and age progression background. Bone apposition on the anterior part of the interior surface of the sella turcica is ceased at an early age, whereas resorption is continued for a long time on the distal part of the sella floor and on the posterior wall. (35-38) Furthermore, the anterior wall of the sella turcica reaches stability at 5-6 years of age and the tuberculum sella and the posterior wall of the sella turcica stop growing at ages of 18 years in males and 16 years in females (at the ends of pubertal growth). (39) This can give us two important findings. First, the reference point 'sella' would, therefore, with growth and age progression, be displaced backwards and downwards. Second, Sella depth and diameter would be increased with age and at specific time females are having higher sella measurements than males.

Related previous studies, (1,2,9,12,13,18,27,29,40) have dealt with the age factor, rather than pubertal growth spurt. They mostly confirmed two findings: 1 st, sella size increases significantly with age; 2 nd, sella depth and diameter are the most influenced linear measurements by the age factor in comparison with sella length.

According to this study result, sella depth and sella diameter measurements can be utilized clinically for pubertal growth phase determination. This requires larger sample collection so that cut-off points and intervals (ranges) can be estimated for the accelerative and decelerative stages.

REFERENCES

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Clinical significance of sella

Table 1: Descriptive and Inferential Statistics for Sella measurements in (mms).

<table>
<thead>
<tr>
<th>sk. class</th>
<th>Sella length</th>
<th>Sella depth</th>
<th>Sella diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sex</td>
<td>n</td>
<td>Mean</td>
</tr>
<tr>
<td>cl. I</td>
<td></td>
<td>13</td>
<td>6.94</td>
</tr>
<tr>
<td></td>
<td>♀</td>
<td>38</td>
<td>6.54</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>51</td>
<td>6.64</td>
</tr>
<tr>
<td>cl. II</td>
<td></td>
<td>20</td>
<td>7.08</td>
</tr>
<tr>
<td></td>
<td>♀</td>
<td>20</td>
<td>6.88</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>40</td>
<td>6.98</td>
</tr>
<tr>
<td>cl. III</td>
<td></td>
<td>16</td>
<td>6.42</td>
</tr>
<tr>
<td></td>
<td>♀</td>
<td>33</td>
<td>7.17</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>49</td>
<td>6.99</td>
</tr>
</tbody>
</table>

ANOVA 0.46 (NS) ANOVA 0.041* ANOVA 0.37 (NS)

Table 2: Number distribution and percentage of Sella shape in skeletal classes with gender difference.

<table>
<thead>
<tr>
<th>S. shape</th>
<th>Male</th>
<th>Female</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>7</td>
<td>29</td>
<td>0.194</td>
</tr>
<tr>
<td>Oblique</td>
<td>2</td>
<td>15.40%</td>
<td>1.260%</td>
</tr>
<tr>
<td>Bridge</td>
<td>3</td>
<td>23.10%</td>
<td>2</td>
</tr>
<tr>
<td>Notching</td>
<td>0</td>
<td>0.00%</td>
<td>2</td>
</tr>
<tr>
<td>Double</td>
<td>0</td>
<td>0.00%</td>
<td>1</td>
</tr>
<tr>
<td>Pyramidal</td>
<td>1</td>
<td>7.70%</td>
<td>3</td>
</tr>
<tr>
<td>Low</td>
<td>0</td>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>100%</td>
<td>38</td>
</tr>
</tbody>
</table>

ANOVA 0.015* 0.46 0.08 (NS) 0.46 0.08 (NS) 0.041* 0.429 7

Table 3: Number distribution and percentage of Sella shape for total sample with shape difference among skeletal classes.

<table>
<thead>
<tr>
<th>Sella shape</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
<th>Shape difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Normal</td>
<td>36</td>
<td>70%</td>
<td>23</td>
<td>57.50%</td>
</tr>
<tr>
<td>Oblique</td>
<td>3</td>
<td>5.90%</td>
<td>5</td>
<td>12.50%</td>
</tr>
<tr>
<td>Bridge</td>
<td>5</td>
<td>9.80%</td>
<td>7</td>
<td>17.50%</td>
</tr>
<tr>
<td>Notching</td>
<td>2</td>
<td>3.90%</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Double</td>
<td>1</td>
<td>2.00%</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Pyramidal</td>
<td>1</td>
<td>7.80%</td>
<td>1</td>
<td>2.50%</td>
</tr>
<tr>
<td>Low</td>
<td>0</td>
<td>0.00%</td>
<td>2</td>
<td>5.00%</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>100%</td>
<td>40</td>
<td>100%</td>
</tr>
</tbody>
</table>

ANOVA 0.46 (NS) ANOVA 0.041* ANOVA 0.37 (NS)

Table 4: Descriptive statistics of S. Turcica linear measurements for Pubertal growth stages with mean difference statistics.

<table>
<thead>
<tr>
<th>Mean difference</th>
<th>Stage of growth</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>(d.f.=97)</td>
<td>Decelerative(N=43)</td>
<td>Accelerative(N=56)</td>
</tr>
<tr>
<td>P-value</td>
<td>t-value</td>
<td>SD</td>
</tr>
<tr>
<td>0.682</td>
<td>0.41</td>
<td>1.4</td>
</tr>
<tr>
<td>(NS)</td>
<td>(NS)</td>
<td>(NS)</td>
</tr>
<tr>
<td>0.020*</td>
<td>-2.365</td>
<td>1.37</td>
</tr>
<tr>
<td>(S)</td>
<td>(S)</td>
<td>(S)</td>
</tr>
<tr>
<td>0.009**</td>
<td>-2.677</td>
<td>1.16</td>
</tr>
</tbody>
</table>

NS = P> 0.05 Non significant. * = 0.05 ≥ P > 0.01 Significant. ** = P ≤ 0.01 highly significant.
Figure 1: Normal sella turcica morphology and reference lines used for measuring sella size. TS, tuberculum sella; DS, dorsum sella; BPF, base of the pituitary fossa; SP, sella posterior; white line, length of sella; red line, diameter of sella; blue line, depth of sella.

Figure 2: Tracings and details from lateral cephalograms of the different morphological types of sella turcica: (A) Double contour of the floor, (B) extremely low sella turcica, (C) Sella turcica bridging, (D) Irregularity (notching) in the posterior part of the dorsum sellae (E) oblique anterior wall and (F) Pyramidal shape of the dorsum sellae.