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The shape and size of the sella turcica in skeletal Class I, Class II, and Class III Saudi subjects

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SUMMARY The purpose of this study was to describe the shape and measure the size of the sella turcica in Saudi subjects with different skeletal types. Lateral cephalometric radiographs of 180 individuals (90 males and 90 females) with an age range of 11–26 years were taken and distributed according to skeletal classification; 60 Class I, 60 Class II, and 60 Class III. The sella turcica on each radiograph was analysed and measured to determine the shape of the sella, in addition to the linear dimensions of length, depth, and diameter. A Student's *t*-test was used to calculate differences in linear dimensions, while a one-way analysis of variance was performed to study the relationship between skeletal type and sella size.

The results show that the sella turcica presented with a normal morphology in the majority of subjects (67 per cent). No significant differences in linear dimensions between genders could be found. When age was evaluated, significant differences were found between the older (15 years or more) and the younger (11–14 years) age groups at the 0.01 and 0.001 levels for length, depth, and diameter. Sella size of the older age group was larger than in the younger age group. When skeletal type was compared with sella size, a significant difference was found in the diameter of sella between the Class II and Class III subjects ($P < 0.01$). Larger diameter values were present in the skeletal Class III subjects, while smaller diameter sizes were apparent in Class II subjects (multiple comparison tests). When gender, age, and skeletal type were all compared with the size of the sella (regression analyses), age was significantly related to a change of length ($P < 0.01$) and diameter ($P < 0.001$).

Sella shape and dimensions reported in the current study can be used as reference standards for further investigations involving the sella turcica area in Saudi subjects.

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 range from assisting the orthodontist during diagnosis, as a tool to study growth in an individual through superimposition of structures on a longitudinal basis, and during evaluation of orthodontic treatment results.

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 the pituitary gland in the cranial base. This gland lies within the pituitary fossa and consists of the anterior lobe (adenohypophysis), the intermediate lobe, and the posterior lobe (neurohypophysis; Pisaneschi and Kapoor, 2005). Any abnormality or pathology in the gland could manifest from an altered shape of the sella turcica, to a disturbance in the regulation of secretion of glandular hormones; prolactin, growth hormones, thyroid-stimulating hormone, follicular stimulating hormone, etc. (Elster, 1993a,b; Pisaneschi and Kapoor, 2005). These disturbances can in turn lead to growth problems such as acromegaly or gigantism, Cushing's disease, hyperthyroidism, amenorrhea and galactorrhea, and menstrual disturbances (Elster, 1993a,b). Cephalometric radiographs of subjects with these conditions may, in some instances, show an abnormal sella region, or *vice versa;* subjects with an abnormal sella turcica may in fact have an undetected underlying disease (Weisberg *et al.*, 1976; Friedland and Meazzini, 1996; Alkofide, 2001).

Several studies conducted on the shape of sella turcica have concluded that the morphological appearance of the sella turcica is established in the early embryonic structure. Profile radiographs of 16 children born with myelomeningocele revealed an altered shape of sella present during foetal life (Kjær *et al.*, 1998). Kjær *et al.* (2002) found, in a foetus with holoprosencephaly, that the area of the sella turcica also displayed malformations. In children with fragile X and Down syndrome, a change of sella shape was evident pre-natally and continued post-natally (Russell and Kjær, 1999; Kjær *et al*., 2001b).

In order to determine if the sella region presents with any unusual appearance, one must study the normal morphology of the sella turcica. Morphology may vary from individual to individual, and the establishment of normal standards will aid in the process of eliminating any abnormality in such an important region. Therefore, the purpose of this study was to analyse the morphological shape and measure the linear dimensions of sella turcica to determine if

differences exist due to gender or age or if in subjects with different skeletal patterns.

Subjects and methods

This investigation was a prospective study of patients seeking orthodontic treatment at King Saud University, College of Dentistry, Riyadh, Saudi Arabia. No individuals with major illnesses or medical conditions were included in the study. Diagnostic records, including upper and lower study models, bitewing panoranic and cephalometric radiographs were obtained. The cephalometric radiographs of 180 patients (90 males and 90 females) aged 10–26 years were used in this study. The Planmeca PM 2002 CC Proline Cephalostat (Instrumentarium Corp. Imaging Division, Tuusula, Finland) machine was used. Radiographs were taken by trained radiographic technicians in a standardized manner using the same cepholstat. Only radiographs that had the clearest reproduction of the sella turcica area were selected. The midsaggital enlargement was 110 per cent and all linear measurements were corrected for magnification differences prior to the statistical analyses.

The radiographs were distributed according to skeletal Class and gender; 60 Class I, 60 Class II, and 60 Class III cases were collected with an equal distribution between males and females in each class (30 males and 30 females). The radiographs were divided into two groups according to the subject's age: pre-pubertal (10–14 years), during or post-pubertal (15 years or more). The division was made for the following reasons: previous reports that the morphology of sella turcica does not change significantly after 12 years of age (Björk, 1955; Melsen, 1974); females at approximately 15 years of age have finished their pubertal growth; sella turcica size in younger adult males and females have been reported to be almost the same, except during pregnancy (Israel, 1970; Pisaneschi and Kapoor, 2005). Table 1 shows the distribution of Classes and genders.

Classification of skeletal type into Class I, Class II, or Class III was based on the ANB angle (SNA and SNB). The ANB angle indicates the magnitude of the skeletal jaw discrepancy, regardless of which jaw is at fault. Skeletal base Class was categorized as follows: angles ± 2 degrees Class I skeletal base; angles more than 4 degrees Class II, and angles less than 0 degrees Class III. In addition, to overcome the limitations of the ANB angle and to further describe jaw severity/discrepancy, the Wits analysis was used.

Table 1 Subjects grouped according to gender, age, and skeletal Class.

Skeletal Class	Males		Females	
	10–14 years	15–26 years	10–14 years	15–26 years
Class I	16	14	14	16
Class II	19	11	15	15
Class III	11	19	14	16
Total	46	44	43	47

Cephalometric tracing of sella turcica

The sella turcica on each cephalometric radiograph was traced on thin acetate paper under optimal illumination by the author. This tracing was superimposed on graph paper marked in square millimetres to calculate the sella area (Silverman, 1957), and measurements were made to the nearest 0.1 mm. The configuration of the sella turcica, which consisted of the tuberculum sella, the sella turcica floor, the dorsum sellae, and both anterior and posterior clinoid processes, was drawn.

Shape of the sella turcica

To determine the variations in shapes of the sella turcica, the different morphological appearances of sella (Axelsson *et al.*, 2004) were used and compared with the current study. Axelsson *et al.* (2004), in addition to the normal morphology of sella turcica shape, described five morphological variations which included oblique anterior wall, sella turcica bridging, double contour of the floor, irregularity (notching) in the posterior part of the dorsum sellae, and pyramidal shape of the dorsum sellae.

Size of the sella turcica

The linear dimensions of sella turcica were measured using the methods of Silverman (1957) and Kisling (1966). All reference lines used in the current study were located in the midsaggital plane. The length of sella turcica was measured as the distance from the tuberculum sella to the tip of the dorsum sellae. The depth of the sella turcica was measured as a perpendicular from the line above to the deepest point on the floor. A line was also drawn from the tuberculum sella to the furthest point on the posterior inner wall of the fossa. This was considered as the antero-posterior diameter of sella turcica (Figure 1).

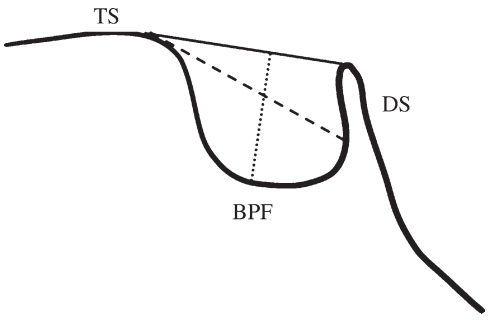

Figure 1 Normal sella turcica morphology and reference lines used for measuring sella size: TS, tuberculum sella; DS, dorsum sella; BPF, base of the pituitary fossa; black line, length of sella; dashed line, diameter of sella; dotted line, depth of sella.

Reliability of measurements

In order to reduce errors due to intra-operator variability, 20 lateral cephalometric radiographs were chosen at random and retraced after an interval of 3 weeks under identical conditions. The one-way random effects analysis of variance (ANOVA) model was used to extract estimates of variance components. The intraclass correlation coefficient (ICC), which is a function of these components, is a widely accepted index of measurement reliability. The ICC was used in this study to evaluate the reproducibility of the readings (Shoukri, 2004). The reliability measurements were between 0.86 and 1.00, which shows good reproducibility of the retraced radiographs.

Statistical analyses

Data were analysed using the Statistical Package for Social Sciences version 13.0 for Windows (SPSS Inc., Chicago, Illinois, USA). A Student's *t*-test was used to calculate the mean differences in sella turcica linear dimensions between males and females, and between the different age groups (significance level 0.01). To study the relationship between skeletal type and sella turcica size, a one-way ANOVA test was performed, and a multiple comparison test was used to further distinguish which skeletal Class showed the most significant difference in diameter size. Regression analyses were also used to test the interrelationship of the variables of gender, age, and skeletal type, with the linear dimensions of sella turcica (significance was calculated at the 0.01 level).

Results

Shape of the sella turcica

The morphology of the sella turcica appeared to be normal in shape in the majority of subjects (67 per cent), regardless of gender, age, or skeletal type (Table 2). Variation in morphological appearance was present in 33 per cent of the individuals; an irregular dorsum sella was found in 11 per cent, while an oblique anterior wall and a double-contoured sella turcica were present in 9 per cent.

Table 2 Frequency distribution of sella turcica type.

Sella type	Frequency	Percentage
Normal sella turcica	120	66.7
Oblique anterior wall	17	9.4
Sella turcica bridge	2	1.1
Double contour	16	8.9
Irregular dorsum sella	20	11.1
Pyramidal shape	5	2.8
Total	180	100.0

Size of the sella turcica

The linear dimensions of the sella turcica located in the midsaggital plane area are presented in Table 3. The average length, depth, and diameter of the sella turcica for both females and males are shown. When comparing linear dimensions of sella turcica between genders, no significant differences between females or males in terms of length, depth, or diameter size could be found. On the other hand, when linear dimensions were compared with age, there were significant differences between the older and the younger age groups ($P < 0.01$, $P < 0.001$; Table 4) for all three linear dimensions. It was noted that sella turcica in the older group was consistently larger than that in the younger age group.

In order to determine if subjects with different skeletal patterns presented with different linear dimensions of the sella turcica, irrespective of age or gender, a one-way ANOVA test was performed. A significant difference was found between skeletal Class and the diameter of the sella turcica ($P < 0.01$; Table 5). Scheffe's multiple comparison analysis revealed a significant difference between skeletal Class II and Class III subjects (Table 6). The mean difference was in the diameter of sella turcica, in that it appeared to be larger in Class III subjects, while smaller in Class II subjects. Table 7 demonstrates the interrelationship between the variables; gender, age, skeletal type, and size of the sella

Table 3 Sella turcica linear dimensions for females and males (in millimetres).

	Gender	*n*	Mean	Standard deviation	Standard error of the mean	*P* value
Length	Female	90	10.7	2.007	0.212	0.464
	Male	90	11.0	2.628	0.277	
Depth	Female	90	9.1	1.444	0.152	0.780
	Male	90	9.1	1.207	0.127	
Diameter	Female	90	14.0	1.777	0.187	0.848
	Male	90	13.9	2.098	0.221	

t-test, outcome by gender.

Table 4 Sella turcica linear dimensions (in millimetres) by age group.

	Age group (years)	*n*	Mean	Standard deviation	Standard error of the mean	*P* value
Length	10–14	83	10.3	1.890	0.208	*
	15–26	97	11.3	2.575	0.261	
Depth	10–14	83	8.8	1.253	0.138	*
	15–26	97	9.3	1.367	0.139	
Diameter	10–14	83	13.4	1.671	0.183	**
	15–26	97	14.5	2.006	0.204	

t-test, outcome by age.
*$P < 0.01$; **$P < 0.001$.

Table 5 One-way analysis of variance testing the effects of skeletal Class on sella linear dimensions (in millimetres).

		n	Mean	Standard deviation	Standard error	95% confidence interval for mean		Minimum	Maximum	*P* value
						Lower bound	Upper bound			
Length	Class I	60	10.7	2.033	0.262	10.2	11.3	4	15	0.090
	Class II	60	10.4	1.952	0.252	9.9	10.9	6	14	
	Class III	60	11.4	2.857	0.369	10.6	12.1	4	22	
	Total	180	10.8	2.335	0.174	10.5	11.2	4	22	
Depth	Class I	60	8.9	1.274	0.164	8.6	9.3	7	12	0.220
	Class II	60	9.0	1.334	0.172	8.7	9.4	6	14	
	Class III	60	9.3	1.361	0.176	9.0	9.7	6	13	
	Total	180	9.1	1.327	0.099	8.9	9.3	6	14	
Diameter	Class I	60	13.9	1.848	0.239	13.4	14.4	9	18	*
	Class II	60	13.4	1.687	0.218	12.9	13.8	9	19	
	Class III	60	14.6	2.084	0.269	14.1	15.2	11	20	
	Total	180	14.0	1.939	0.144	13.7	14.3	9	20	

*$P < 0.01$.

Table 6 Multiple comparison analysis (Scheffe) between Classes with diameter (in millimetres) as the dependent variable.

Skeletal Class	I (mean = 13.9)	II (mean = 13.4)	III (mean = 14.6)
I	—	—	—
II	0.301	—	—
III	0.116	*	—

*$P < 0.01$.

turcica. The results revealed that age was significantly related to length ($P < 0.01$) and diameter ($P < 0.001$).

Discussion

This prospective study describes the morphological appearance and linear dimensions of the sella turcica in Saudi subjects with different skeletal types. Shape variation in the sella turcica has long been reported by many researchers (Gordon and Bell, 1922; Camp, 1924; Teal, 1977; Kantor and Norton, 1987; Tetradis and Kantor, 1999). Gordon and Bell (1922) examined the radiographs of children 1–12 years of age and classified the sella turcica into circular, oval, and flattened, or saucer shaped. They concluded that most of the subjects had either a circular or oval-shaped sella, and noted that even with this broad classification, difficulty was found in placing some cases into one of the three categories. Davidoff and Epstein (1950) used the term 'J-shaped sella', while 'omega sella' was introduced by Fournier and Denizet (1965). These definitions were later termed radiological myths by Kier (1969), who advised disregarding both since they were used to characterize abnormal pathology as well as normal developmental patterns. Other descriptions of the sella turcica have been proposed based on the appearance of flatness or concavity of the contours of the sella floor, the angles made by the contours of the tuberculum sella, the contours of the anterior and posterior clinoid processes, and the fusion of both processes in what is termed a 'sella turcica bridge' (Camp, 1924; Becktor *et al.*, 2000; Choi *et al.*, 2001).

In a recent study (Axelsson *et al.*, 2004), the shape of the sella turcica was categorized into six main types; normal sella turcica, oblique anterior wall, double-contoured sella, sella turcica bridge, irregularity (notching) in the posterior part of the sella, and pyramidal shape of the dorsum sellae. Their results show that a normal sella turcica morphology was seen in two-thirds of the subjects, while the remainder showed dysmorphological appearances. An alteration in the shape of the sella turcica can be misleading since it may be present in 'normal' subjects (Camp, 1924; Kantor and Norton, 1987; Tetradis and Kantor, 1999), as well as in medically compromised subjects such as those with spina bifida (Kjær *et al.*, 1998) and craniofacial deviations (Becktor *et al.*, 2000; Kjær *et al.*, 2001a,b).

In the current study, approximately 67 per cent of the subjects appeared to have a normal shaped sella turcica, while 33 per cent presented with different aberrations. This is in agreement with Axelsson *et al.* (2004). The finding of an irregular notching of the dorsum sella was the same for both studies (11 per cent), while a pyramidal shape of the dorsum was reported more frequently in the former investigation. A doubled contour floor was present in 9 per cent of the subjects of the current study, which is higher than that reported by Axelsson *et al.* (2004).

The presence of a sella turcica bridge in normal individuals is not uncommon and has been shown to occur in 5.5–22 per cent of subjects (Camp, 1924; Kantor and Norton, 1987; Tetradis and Kantor, 1999; Axelsson *et al.*, 2004), with an increase in occurrence in patients with craniofacial

Table 7 Regression analysis for variables (age group, gender, and skeletal type) and linear dimensions.

	Length			Depth			Diameter		
	B	Standard error	Significance	B	Standard error	Significance	B	Standard error	Significance
Age group	0.910	0.348	*	0.366	0.201	0.070	0.978	0.278	**
Gender	0.245	0.340	0.472	0.051	0.197	0.794	−0.066	0.272	0.808
D1	0.526	0.418	0.210	0.363	0.242	0.134	0.619	0.335	0.066
D2	−0.179	0.419	0.670	0.132	0.242	0.586	−0.403	0.336	0.232
R^2		0.066			0.036			0.132	

D1, Class II reference to Class I; D2, Class III reference to Class I; B, regression coefficient.
*$P < 0.01$; **$P < 0.001$.

deviations (Becktor *et al.*, 2000). In the current study, a sella bridge was found in only 1.1 per cent of the subjects which is much lower than that previously reported. An oblique anterior wall has also been documented in normal (Axelsson *et al.*, 2004), and medically compromised subjects such as children with lumbosacral myelomeningocele and Seckel syndrome (Kjær *et al.*, 1998; 2001a,b). The current study showed only 9.4 per cent of subjects with an oblique anterior wall compared with 26 per cent found by Axelsson *et al.* (2004).

When the linear dimensions of length, depth, and diameter of the sella turcica in the present study were compared with other investigations (Quakinine and Hardy, 1987; Axelsson *et al.*, 2004), a difference between measurements was noted. Quakinine and Hardy (1987) performed a microsurgical anatomical study on 250 sphenoidal blocks obtained from cadavers of different ages. They found that the average transverse width of the sella turcica was 12 mm, the length (antero-posterior diameter) 8 mm, and the average height (vertical diameter) 6 mm. When compared with the current study (Table 3), all mean dimensions were on average 1.07–2.97 mm smaller than those in the Saudi sample. Those authors advised that when measuring sella turcica size, the height of the gland was usually 2 mm shorter than the actual depth of the sella (the gland does not fill the whole volume of the sella turcica), and that this should be taken into consideration during measurements. Similar results were also found in a Norwegian sample (Axelsson *et al.*, 2004). The linear dimensions in this Saudi sample were on average 2.02–2.73 mm larger than those in the Norwegian subjects.

When determining if any differences existed in the present study between males and females in terms of sella turcica size, no significant gender differences were found. Similar findings were reported by Israel (1970) who concluded that sella turcica size in young adult males and females were almost the same, although he noted that sella turcica size may increase in males with age. In a study by Silverman (1957) of radiographs of 320 individuals, 1 month to 18 years of age, the mean sella area was calculated (length and depth). The findings revealed that the pituitary fossa of males tended to be larger than that of females from about 1–13 years of age. 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 15 years of age. Thereafter, the late growth acceleration in males, which is usually 2–3 years later than that in females, results in an approximate equalization in sella area in both genders. On the other hand, Haas (1954) compared the mean size in square millimeters of the sella area of boys and girls aged 3–17 years and found some differences due to gender. He reported that the sella turcica of boys was greater than girls, but after 17 years of age, the sella of females were slightly larger than that of males.

When the effect of age on sella turcica size was studied, the sella sizes of the older age group in the present investigation were consistently larger than the younger group. Similar findings were reported by Preston (1979) who found a close correlation between the area of sella and age. His findings on 182 lateral radiographs of individuals aged 5–17 years revealed that the pituitary fossa increased in size with age, which reflects the adolescent growth spurt of females that occurs at an earlier age. Choi *et al.* (2001) also concluded that the linear dimensions of sella turcica had a positive linear tendency until 25 years of age. After 26 years of age, no significant increase could be found in sella turcica size. Contrary to these findings, Elster *et al.* (1990), in a magnetic resonance imaging study of 169 patients aged 1–30 years, found that during childhood there was no difference between males and females, but that dramatic changes took place during puberty with swelling of the gland. Pituitary gland height was 7–10 mm in females while in males it was 7 mm, both being larger than in childhood or young adulthood. They also concluded that young adults had slightly but significantly smaller glands than adolescents of the same gender.

Few studies have compared the skeletal type of individuals with their sella turcica size to determine if a

relationship exists. Preston (1979) divided cephalometric radiographs of subjects into three groups according to age 5–9, 10–14, and 15–17 years, and according to their skeletal/facial type: Class I, Class II, and Class III. His findings showed no statistically significant correlation between facial type and the mean sella area of the pituitary fossa. However, contrary to the current study in which linear dimensions were used, the mean sella area was measured by Preston (1979). In the present study, when skeletal type and linear dimensions of sella turcica were evaluated, 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 Classes. An increase in diameter size appears to be more common in Class III subjects, while a reduced diameter size is more prevalent in Class II individuals.

When studying the affects of gender, age, and skeletal type, on the size of the sella turcica, the results show that age was significantly related to the length and diameter of sella, which were larger in older subjects, irrespective of gender or skeletal type. No similar studies comparing these three factors with sella size could be found in the literature.

The linear dimensions obtained from the current study can be used to approximate the size of the pituitary gland, and may aid the clinician when confronted with an abnormally large sella area on lateral cephalograms. The orthodontist should also be familiar with the different shapes of the sella area, in order to help distinguish pathology from normal developmental patterns.

Conclusions

1. Approximately 67 per cent of the investigated subjects had a normal sella shape.
2. No significant differences in size of the sella could be found between genders.
3. Significant differences in sella size between the older (15 years or more) and younger (11–14 years) age groups were found for all three linear dimensions (length, depth, and diameter). Sella sizes in the older age subjects were larger.
4. When sella size was compared with skeletal type, a significant difference was found in diameter size between Class II and Class III subjects. Larger diameter values were present in skeletal Class III subjects, while smaller diameter sizes were apparent in Class II subjects.
5. Age was significantly correlated with the length and diameter of sella, when all three variables, gender, age, and skeletal type, were compared with sella size.
6. The results of the present study of sella shape and size may be used as reference standards for Saudi subjects when studying sella turcica morphology.

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