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Post-natal size and morphology of the sella turcica. Longitudinal cephalometric standards for Norwegians between 6 and 21 years of age

Stefan Axelsson*, Kari Storhaug** and Inger Kjær***

*Department of Orthodontics, Faculty of Dentistry, University of Oslo, Norway **TAKO-Centre, Resource Centre for Oral Health in Rare Medical Conditions, Oslo, Norway and ***Department of Orthodontics, Faculty of Health Sciences, University of Copenhagen, Denmark

SUMMARY The purpose of this study was to establish normative longitudinal cephalometric standards of size and to describe the morphology of the sella turcica in Norwegian males and females between 6 and 21 years of age using standardized lateral radiographic cephalograms. The subjects comprised 35 males and 37 females from the Oslo University Craniofacial Growth Archive. All were healthy Caucasians, with an Angle Class I molar and canine relationship with no apparent facial disharmony. None had undergone orthodontic therapy.

The length, depth, and diameter of the sella turcica was measured and the mean values were analysed longitudinally. Comparisons between the dimensions of the sella turcica of males and females in each age group were performed using a Student's *t*-test.

The length of the sella turcica was almost constant throughout the observation period and the depth and diameter increased with age. No differences between males and females were detected for the depth and diameter of the sella turcica, but the length was larger in males throughout the observation period.

The morphology of the sella turcica was assessed and five different morphological aberration types were identified: 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. The female subjects had slightly more sella turcicas with aberrant morphology.

These reference standards for the dimensions of the sella turcica can be used in the study of growth and development of individuals with craniofacial aberrations and syndromes.

Introduction

In cephalometric analyses of the dentofacial and neurocranial morphology, the sella point (the midpoint of the sella turcica) constitutes an important reference point. A number of studies in the orthodontic literature have illustrated the changes in sella turcica shape during growth (Björk, 1955; Melsen, 1974; Björk and Skieller, 1983). In a comprehensive study of growth patterns of the different parts of the cranial base, Melsen (1974) found that apposition of bone on the anterior part of the interior surface of the sella turcica ceased at an early age, whereas resorption on the distal part of the sella floor and on the posterior wall continued for a longer period. Apposition of bone was observed at the turberculum sellae and resorption at the posterior boundary of the sella turcica up to the age of 16–18 years (Björk, 1955; Melsen, 1974; Björk and Skieller, 1983). The reference point sella would thus be displaced backwards and downwards during growth and development (Figure 1).

The morphology of the sella turcica is of importance for the cephalometric position of the reference point sella, not only when evaluating cranial morphology, but also when growth changes and orthodontic treatment results are to be evaluated.

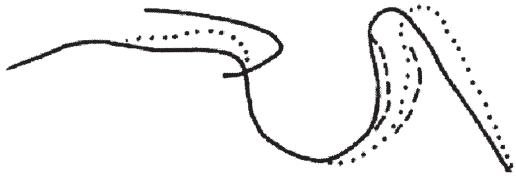

Figure 1 The contour of normal sella turcica morphology analysed from profile radiographs (anterior to the left), from childhood (solid line) to adulthood (dotted line). The upper contour of the anterior wall of the sella turcica appears to be perpendicular and unchanged during the normal course of development. The increasing size of the sella turcica under normal conditions is a result of resorption and apposition processes on the dorsum sellae. Redrawn with permission from Björk and Skieller (1983).

There is an increasing interest in the study of human craniofacial dysmorphology, but there are few cephalometric standards available on normal growth and development of the sella turcica (e.g. Silverman, 1957; Choi *et al.*, 2001). Normal standards are essential for describing abnormal morphology in various craniofacial aberrations and syndromes.

The purpose of this study was to analyse the size and describe the morphology of the sella turcica on standardized lateral cephalograms of Norwegian males and females between 6 and 21 years of age. Longitudinal normative data on sella turcica size and morphology can be useful in the scientific evaluation of abnormal craniofacial and neurocranial development in different craniofacial abnormalities.

Subjects and methods

Study population

The data were derived from serial lateral cephalometric radiographs from the Oslo University Craniofacial Growth Archive. This longitudinal reference material has been described in detail previously (El-Batouti *et al.*, 1994; Axelsson *et al.*, 2003).

The material comprised 72 individuals (35 males and 37 females) who had lateral cephalometric radiographs taken every third year from 6 to 18 years. In addition, lateral cephalometric radiographs were available for 34 of the same subjects at 21 years of age (19 males and 15 females). The age distribution for both sexes is presented in Table 1.

Size of the sella turcica

Cephalometric analyses. The calculated variables, length, depth, and diameter of the sella turcica, are illustrated in Figure 2. The definitions of the variables are in accordance with Silverman (1957) and Kisling (1966). All reference lines used are situated in the midsagittal plane.

The sella turcica was measured by tracing the contour of the pituitary fossa from the tip of the dorsum sellae to the turberculum sella and then following a straight line from the turberculum sella back to the origin. This straight line corresponded to the position of the diaphragma sellae. The length of the sella turcica was measured as the distance from the turberculum sella to the tip of the dorsum sellae, and the depth of the sella turcica was measured perpendicular to this line to the deepest point on the floor. The antero-posterior greatest diameter of the sella turcica was measured from the turberculum sella to a point on the posterior inner wall of the pituitary fossa furthest from the turberculum sella (Figure 2).

Table 1 Subject characteristics.

	Number	Mean age	SD	Minimum	Maximum
Male					
6 year group	35	6.0	0.3	5.4	6.7
9 year group	35	8.9	0.4	8.3	9.7
12 year group	35	11.9	0.4	11.3	12.7
15 year group	35	14.9	0.4	14.3	16.0
18 year group	35	18.2	0.4	17.4	18.8
21 year group	19	21.3	0.4	20.5	22.2
Female					
6 year group	37	6.0	0.4	5.1	6.7
9 year group	37	8.9	0.4	8.1	9.6
12 year group	37	11.9	0.4	11.1	12.7
15 year group	37	14.9	0.4	14.1	15.7
18 year group	37	18.1	0.4	17.3	18.9
21 year group	15	21.3	0.6	20.4	22.4

SD, standard deviation.

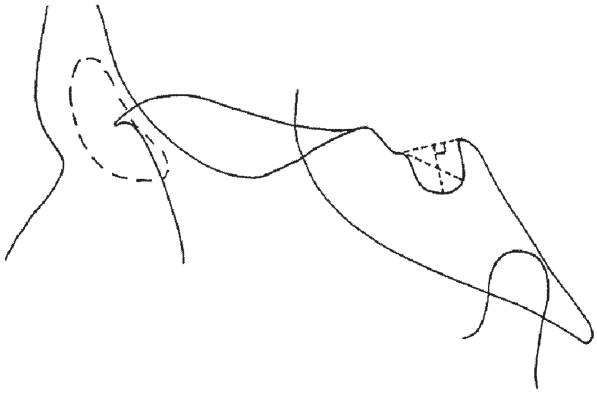

Figure 2 The reference lines used in the analysis of the sella turcica.

The reference points were traced, digitized and processed using the Dentofacial Planner® computer program (Dentofacial Software Inc., Toronto, Ontario, Canada). The measurements were calculated to the nearest 0.1 mm. The radiographic magnification factor of 5.6 per cent was corrected by the computer software program.

Assessing the errors of the methods. Twenty radiographs chosen at random were traced and digitized by the same investigator (SA) on two separate occasions at least 2 weeks apart. Measurement errors were estimated according to Dahlberg (1940). The coefficient of reliability and the variance of the duplicate measurements were also calculated, as recommended by Houston (1983).

The error of the duplicate measurement groups was generally small. The range was 0.0–0.4 mm. The largest variation found was for the diameter of the sella turcica. The results from the error analyses are given in Table 2.

Statistical analyses

Data from all measurements were transferred to a scientific statistical program (SPSS® Base 10.0, SPSS Inc., Chicago, Illinois, USA). The statistical differences between the arithmetic means of the measurements in the male and female age groups were compared using the Student's *t*-test for independent data, with a significance level of 5 per cent ($P < 0.05$).

Table 2 Error of the method assessed from duplicate tracings of 20 radiographs.

Variables	Dahlberg's calculation	Houston's coefficient of reliability (%)	Variance of the difference between duplicate measurements
Length	0.13	99.98	0.01
Depth	0.13	99.94	0.02
Diameter	0.17	99.97	0.02

Morphology of the sella turcica

The entire contour of the sella turcica was traced on to thin acetate paper under optimal illumination. For comparison, the normal sella turcica morphology reported by Björk and Skieller (1983) was used (Figure 1).

Results

Data from the cephalometric measurements of the sella turcica for males and females divided into six age groups, with arithmetic means, standard deviations, maximum and minimum values, number of individuals, and the level of statistical significance between males and females are presented in Table 3.

There were no significant differences between males and females regarding the mean values for the depth and diameter of the sella turcica in any of the age groups. The length of the sella turcica was larger in the male group throughout the observation period, but reached a significant difference only for the 12 ($P < 0.05$), 15 ($P < 0.05$), and 18 ($P < 0.01$) year old age groups (Table 3, Figure 3a–c).

In the assessment of the morphological aberrations of the sella turcica, five distinct morphological types were found: 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. The different types of sella turcica dysmorphology, including the normal sella turcica, are illustrated as tracings of the sella turcica and with enlargements from the lateral cephalometric radiographs in Figure 4a–f.

A normal morphology of the sella turcica was found in 71 per cent of the male group and in 65 per cent of the female group. An oblique anterior wall was more common in the male group, while sella turcica bridging and irregularities of the posterior part of the dorsum sellae were more common in the female group. Only one female individual had more than one morphological aberration trait of the sella turcica (Table 4).

Table 3 Sella turcica dimensions (in mm) in males and females from the Oslo University Craniofacial Growth Archive.

	Male (n = 35)					Female (n = 37)					Significance
	Mean	SD	Minimum	Maximum	n	Mean	SD	Minimum	Maximum	n	
6 years											
Length	8.8	1.5	5.3	13.2	35	8.5	1.3	5.7	11.0	37	ns
Depth	6.3	0.8	4.5	8.1	35	6.4	0.8	5.1	8.2	37	ns
Diameter	10.0	1.3	8.2	14.1	35	9.8	1.3	7.8	12.6	37	ns
9 years											
Length	8.7	1.3	6.1	12.2	35	8.2	1.4	5.1	10.7	37	ns
Depth	6.7	0.9	4.5	8.6	35	6.6	0.7	5.0	8.1	37	ns
Diameter	10.1	1.1	8.1	12.8	35	10.2	1.3	6.9	12.4	37	ns
12 years											
Length	8.6	1.2	5.9	10.9	35	7.9	1.6	4.1	11.6	37	*
Depth	6.7	1.1	4.6	9.7	35	6.7	1.1	2.9	8.9	37	ns
Diameter	10.6	1.2	7.7	12.8	35	10.5	1.2	7.3	12.8	37	ns
15 years											
Length	8.7	1.2	5.4	11.4	35	7.9	1.4	5.1	11.4	37	*
Depth	7.1	1.2	4.6	9.7	35	7.2	1.0	5.3	9.2	37	ns
Diameter	11.0	1.0	8.6	13.3	35	11.1	1.1	8.6	12.9	37	ns
18 years											
Length	9.0	1.3	6.2	12.1	35	8.1	1.3	5.0	10.0	37	**
Depth	7.4	1.2	4.9	9.6	35	7.1	1.1	4.5	8.9	37	ns
Diameter	11.5	1.1	9.0	13.5	35	11.4	1.0	9.3	14.0	37	ns
21 years											
Length	8.9	0.9	7.4	10.7	19	8.4	1.6	5.0	11.2	15	ns
Depth	7.3	1.1	5.3	9.6	19	7.2	1.2	4.8	9.3	15	ns
Diameter	11.3	1.1	8.4	13.2	19	11.7	1.1	10.1	13.2	15	ns

SD, standard deviation.
ns, not significant; *significant at $P < 0.05$; **significant at $P < 0.01$.

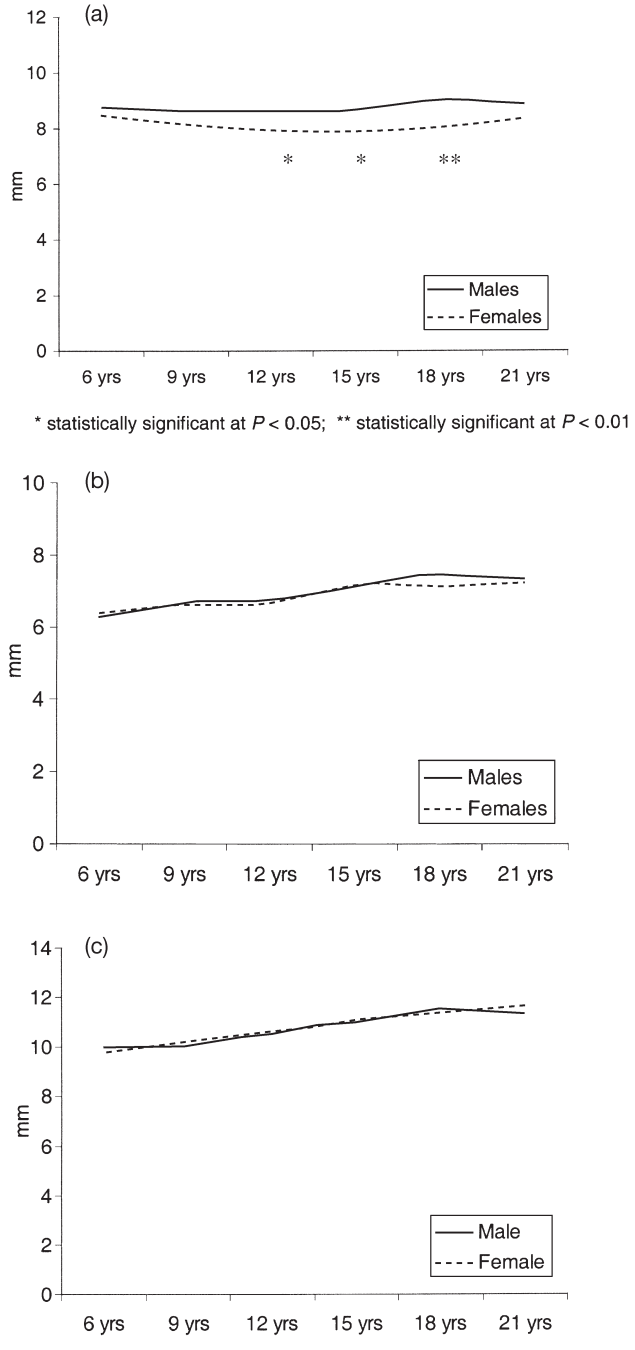

Figure 3 Graphical illustrations of (a) the length, (b) the depth, and (c) the diameter of the sella turcica for males and females from the Oslo University Craniofacial Growth Archive.

It is interesting to note that in two of the six female subjects with bridging of the sella turcica, the aberration was evident at 6 years of age. In the remaining four cases, the sella turcica bridge developed over time and was clearly evident at 15 years of age. In the two male subjects classified as having a sella turcica bridge, the malformation was clearly evident at 6 years of age. All other morphological aberrations were apparent at 6 years of age and persisted throughout the observation period.

Discussion

In this study, the size and morphological aberrations of the sella turcica were investigated longitudinally in a population of healthy Norwegian males and females with a normal facial appearance and normal occlusion. A study of this type does not appear to have been performed previously.

The pre-natal formation and post-natal development of the sella turcica and the pituitary gland are complex processes. The two structures are located in a boundary region, separating tissues of different origin and development. The anterior part is believed to develop mainly from neural crest cells that are not directly dependent upon the notochord, while the posterior part develops from the para-axial mesoderm, which is closely related to notochordal induction (Kjær and Fischer-Hansen, 1995; Müller and O'Rahilly, 1980, Kjær *et al.*, 1999; Lieberman *et al.*, 2000).

Measurements of the sella turcica and appraisal of its morphology are valuable in the assessment of pathology in the pituitary gland. Studies of sella turcica size on radiographs have been based either on linear (Gordon and Bell, 1922; Camp, 1924; Martin, 1941; Silverman, 1957), various methods of area (e.g. Davenport and Renfoe, 1940; Haas 1954; Silverman, 1957), and volume (DiChiro and Nelson, 1962; McLachlan *et al.*, 1968; Underwood *et al.*, 1976; Chilton *et al.*, 1983) measurements.

The central position of the sella turcica in the cranial base and the association with disease or pathology in the pituitary gland with alterations in size and shape may explain the numerous scientific reports published. As a result, a great number of measurements exist representing, according to each author, the normal dimensions of the sella turcica. The great discrepancies between the various measurements are probably due to the use of different landmarks, radiographic techniques, and degree of radiographic enlargement, most often not compensated for in previous investigations.

Most authors of longitudinal studies of the sella turcica agree that growth decreases rapidly after the first years of life, that there is an increased growth rate at the time of puberty, and that growth slows down and ceases in the late teens or early adulthood (Melsen, 1974).

In an extensive longitudinal radiographic investigation of 320 individuals from 1 month to 18 years, Silverman (1957) reported the mean values for the area of the sella turcica according to gender and age. It is noticeable from that study that the sella turcica in males tended to be larger than that in females, except during puberty, as this occurred about 2 years earlier and was more pronounced in females than in males. These results were also in part verified by Chilton *et al.* (1983), but differ in some respect from those reported by Francis (1948), who found that the size of the sella turcica in females was greater than in males.

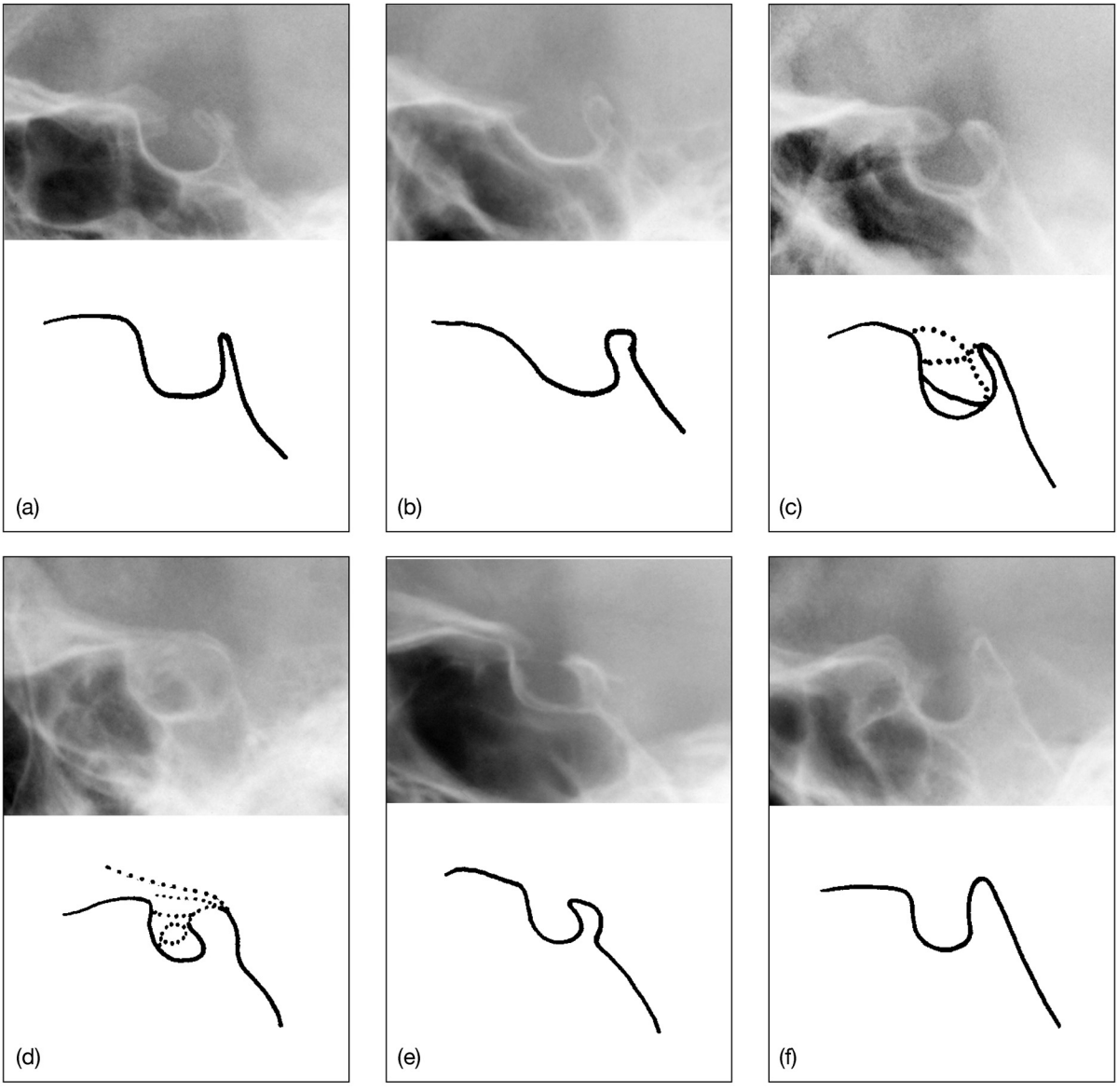

Figure 4 Tracings and details from lateral cephalograms of the different morphological types of sella turcica: (a) normal sella turcica, (b) oblique anterior wall, (c) double contour of the floor, (d) sella turcica bridge, (e) irregularity (notching) in the posterior part of the sella turcica, (f) pyramidal shape of the dorsum sellae.

Table 4 Morphological types of aberration in the sella turcica in individuals in the Oslo University Craniofacial Growth Archive.

	Males (n = 35)		Females (n = 37)		95% confidence interval for females
	n	%	n	%	
Normal sella turcica	25	71	24	65	49–80
Oblique anterior wall	8	23	1	3	0–8
Sella turcica bridge	2	6	6	16	4–28
Double contour of the floor	0	0	1	3	0–8
Irregularities of the posterior part of the dorsum sella	0	0	4	11	1–21
Pyramidal shape of the dorsum sella	0	0	2	5	0–13
More than one type	0	0	1	3	0–8

A recently published study by Choi *et al.* (2001) reported the size and shape of the normal sella turcica in 200 Korean orthodontic patients with an age range of 6–42 years. The reported dimensions of the sella turcica are not comparable with the present investigation due to different measuring techniques and definitions of landmarks. The dimensional changes in the sella turcica, according to age, had a significant positive linear trend to length, depth, and width until 25 years of age. After 26 years of age, no significant increase was found in the sella turcica dimensions. Especially, sella turcica length had a more proportional increase than sella turcica depth and width.

In the present study, the length of the sella turcica was larger in males throughout the observation period, while the depth and greatest diameter were almost similar for both sexes. A clear increase in sella turcica dimensions during puberty, calculated by means of growth rate increments, could also be detected in the longitudinal material for depth and greatest diameter, but not for length. This compares favourably with the trends reported by Silverman (1957).

Few authors have reported the linear dimensions of the sella turcica separately for males and females at different ages during growth. Camp (1924) measured the mean dimensions of the normal sella turcica in 500 healthy, mostly adult, individuals, without giving ages, sex, type of radiograph, enlargement factor, or landmark identification, to be 10.6 mm in the antero-posterior direction and 8.1 mm in depth. These measurements coincide almost exactly with those the author obtained by direct measurements of anatomic specimens in an autopsy study (Camp, 1923). Tetradis and Kantor (1999) measured the length and depth of the sella turcica in 325 orthodontic patients between 6 and 21 years of age and older. The material was divided into four age groups, but not according to sex, and the material was multiracial, with about 18 per cent non-Caucasians. The values for the different dimensions of the sella turcica given by Camp (1924) and Tetradis and Kantor (1999) are larger than those in the present study.

The results of the current investigation have shown a great variation in sella turcica size in normal individuals, which is in agreement with Silverman (1957), and Tetradis and Kantor (1999). It is believed that the normal growth material presented provides a method of evaluating the size of the sella turcica within a wide range of normal variation.

Investigations concerning the sella turcica have not only focused on size, but also on morphology. Normal anatomical variation of the sella turcica must be considered, as it may vary greatly in normal adult individuals (Gordon and Bell, 1922; Camp, 1924).

Numerous variations in the shape of the normal sella turcica have been observed and attempts have been made to classify these normal variants. Camp (1924) classified the normal sella turcica into three types: circular, oval, and flat. The oval type was the most frequent, the flat type the least frequent. Teal (1977) used the same classification of the normal morphology variants of the sella turcica, and emphasized that studies of the morphology of the sella turcica should be divided into three segments: the anterior wall, the floor, and the posterior wall including the dorsum sellae. Tetradis and Kantor (1999), in an investigation of normal skeletal variants seen on cephalometric radiographs, divided the morphological types of the sella turcica into shallow, J-shaped, double contour of the floor, and presence of a middle clinoid process.

Variations in the size and shape of the clinoid processes are numerous. On lateral cephalograms, the anterior clinoid processes vary in height and length, and may be seen normally as short blunt structures anterior to the anterior wall of the sella turcica, or as elongated processes extending posteriorly towards the posterior clinoid processes with which they occasionally unite. The anterior and posterior clinoid processes may overlap on lateral cephalograms and the sella turcica appears to be bridged by a union between the bony processes. Using autopsy material, Camp (1924) was able to demonstrate the presence of a true bony union between the anterior and posterior clinoid processes in 5.5 per cent of normal anatomic specimens studied. In other autopsy studies, the occurrence of a true sella turcica bridge varied between 2 and 6 per cent (for review, see Becktor *et al.*, 2000). The occurrence of a sella turcica bridge assessed on lateral radiographs is reported to be somewhat higher as it is difficult to distinguish between a true sella turcica bridge and a pseudo-bridge. In individuals referred for combined orthodontic and surgical treatment, Becktor *et al.* (2000) found a true sella turcica bridge in 5.6 per cent and a pseudo-bridge in 13.0 per cent by assessing lateral cephalograms. In the present study, the occurrence of a sella turcica bridge was somewhat higher in the female group. A prevalence of 11 per cent is higher than that reported in the literature, but in agreement with Kantor and Norton (1987) and Tetradis and Kantor (1999), who found a sella turcica bridge in 12 and 11 per cent, respectively. A clear distinction between a true bony union of the anterior and posterior clinoid processes and radiographic overlapping is, however, difficult to determine on lateral cephalograms. In this longitudinal study, all radiographs between 6 and 18 years of age (in some cases to 21 years of age) were assessed, and in four individuals (two males and two females) out of eight (two males and six females) a sella turcica bridge was present at 6 years of age. In the remaining individuals the bridge progressively developed over time, but was evident at 12 years of age. One would assume that a sella turcica bridge present at an early age represents true bony union and the other a pseudo-bridge. Applying this view on the sella turcica bridge, the incidence was calculated

to be 5.6 per cent, which is in agreement with Camp (1924) and Becktor *et al.* (2000).

Sella turcica morphology has been studied in a group of children with lumbosacral myelomeningocele using profile skull radiographs. In all cases the anterior wall of the sella turcica differed from normal morphology (Kjær *et al.*, 1998). Sella turcicas with an oblique anterior wall were also described in two female subjects with Seckel syndrome (Kjær *et al.*, 2001). With the exception of these two reports, this morphological type has not been described previously in the literature. However, it can be seen in radiographic illustrations in other reports on sella turcica morphology, but has not been commented on (e.g. Tetradis and Kantor, 1999; Choi *et al.*, 2001). The anterior wall of the sella turcica is formed pre-natally by the influence of the onset of hormone production in the adenopituitary gland (Kjær and Fischer Hansen, 1995; Kjær *et al.*, 1996).

The other morphological aberrations of the sella turcica assessed in this study, especially irregularity (notching) in the posterior part of the dorsum sellae and pyramidal shape of the dorsum sellae, do not appear to have been previously described.

It is apparent from the literature that radiographic methods have contributed much information on the development of the sella turcica in growing individuals, but the morphological aberrations have been described to a lesser extent. This may be of importance when comparing this reference material with patients with craniofacial aberrations and syndromes.

Conclusions

The results presented in this study have shown that the sella turcica is enlarged in depth and diameter from 6 to 21 years of age, but only small changes occur in length. The study offers longitudinal dimensional data for the sella turcica specified for age and gender throughout the growth period.

There is great variation in morphology in the sella turcica in the normal population. Approximately two-thirds of sella turcicas were rated as normal and a variety of dysmorphological types were detected in this normal population.

The results can be used in future studies as normal reference standards in the description of the sella turcica in craniofacial aberrations and syndromes.

Address for correspondence

Stefan Axelsson
Department of Orthodontics
Faculty of Dentistry
University of Oslo
P.O. Box 1109 Blindern
N-0317 Oslo
Norway

References

Axelsson S, Bjørnland T, Kjær I, Heiberg A, Storhaug K 2003 Longitudinal cephalometric standards for the neurocranium in Norwegians from 6 to 21 years of age. European Journal of Orthodontics 25: 185–198

Becktor J P, Einersen S, Kjær I 2000 A sella turcica bridge in subjects with severe craniofacial deviations. European Journal of Orthodontics 22: 69–74

Björk A 1955 Cranial base development. American Journal of Orthodontics 41: 198–225

Björk A, Skieller V 1983 Normal and abnormal growth of the mandible. A synthesis of longitudinal cephalometric implant studies over a period of 25 years. European Journal of Orthodontics 5: 1–46

Camp J D 1923 I. The normal and pathologic anatomy of the sella turcica as revealed at necropsy. Radiology i: 65–73

Camp J D 1924 II. The normal and pathological anatomy of the sella turcica as revealed by roentgenograms. American Journal of Roentgenology 12: 143–156

Chilton L A, Dorst J P, Garn S M 1983 The volume of the sella turcica in children: new standards. American Journal of Roentgenology 140: 797–801

Choi W J, Hwang E H, Lee S E 2001 The study of shape and size of normal sella turcica in cephalometric radiographs. Korean Journal of Oral and Maxillofacial Radiology 31: 43–49

Dahlberg G 1940 Statistical methods for medical and biological students. Allen & Unwin, London

Davenport C B, Renfoe O 1940 Adolescent development of the sella turcica and the frontal sinus based on consecutive roentgenograms. American Journal of Roentgenology 44: 665–679

DiChiro G, Nelson K B 1962 Volume of the sella turcica. American Journal of Roentgenology 87: 989–1008

El-Batouti A, Øgaard B, Bishara S 1994 Longitudinal cephalometric standards for Norwegians between the ages of 6 and 18 years. European Journal of Orthodontics 16: 501–509

Francis C C 1948 Growth of the human pituitary fossa. Human Biology 20: 1–20

Gordon M B, Bell A L 1922 A roentgenographic study of the sella turcica in normal children. New York State Journal of Medicine 22: 54–59

Haas L L 1954 The size of the sella turcica by age and sex. American Journal of Roentgenology 72: 754–761

Houston W J B 1983 The analysis of errors in orthodontic measurements. American Journal of Orthodontics 83: 382–390

Kantor M L, Norton L A 1987 Normal radiographic anatomy and common anomalies seen in cephalometric films. American Journal of Orthodontics and Dentofacial Orthopedics 91: 414–426

Kisling E 1966 Cranial morphology in Down's syndrome. A comparative roentgencephalometric study in adult males. Thesis, Munksgaard, Copenhagen

Kjær I, Fischer-Hansen B 1995 The adenohypophysis and the cranial base in early human development. Journal of Craniofacial Genetics and Developmental Biology 15: 157–161

Kjær I, Hansen B F, Keeling J W 1996 Axial skeleton and pituitary gland in human fetuses with spina bifida and cranial encephalocele. Pediatric Pathology and Laboratory Medicine 16: 909–926

Kjær I, Wagner A, Madsen P, Blichfeldt S, Rasmussen K, Russell B 1998 The sella turcica in children with lubosacral myelomeningocele. European Journal of Orthodontics 20: 443–448

Kjær K W, Hansen B F, Keeling J W, Nolting D, Kjær I 1999 Malformations of cranial base structures and pituitary gland in prenatal Meckel syndrome. APMIS 107: 937–944

Kjær I, Hansen N, Becktor K B, Birkebaek N, Balslev T 2001 Craniofacial morphology, dentition, and skeletal maturity in four

siblings with Seckel syndrome. Cleft Palate-Craniofacial Journal 38: 645–651

Lieberman D E, Ross C F, Ravosa M J 2000 The primate cranial base: ontogeny, function and integration. Yearbook of Physical Anthropology 43: 117–169

Martin H O 1941 Sella turcica und Konstitution. Versuch einer Sellagrössen- und Formdeutung innerhalb konstitutionsmediziner Gefüge. George Thieme Verlag, Leipzig, pp.74–84

McLachlan M S, Williams E D, Fortt R W, Doyle F H 1968 Estimation of pituitary gland dimensions from radiographs of the sella turcica. A post-mortem study. British Journal of Radiology 41: 323–330

Melsen B 1974 The cranial base. The postnatal development of the cranial base studied historically on human autopsy material. Acta Odontologica Scandinavica 32 (Supplement 62): 57–71

Müller F, O'Rahilly R 1980 The human chondrocranium at the end of the embryonic period proper with particular reference to the nervous system. American Journal of Anatomy 159: 33–58

Silverman F N 1957 Roentgen standards for size of the pituitary fossa from infancy through adolescence. American Journal of Roentgenology 78: 451–460

Teal J S 1977 Radiology of the adult sella turcica. Bulletin of the Los Angeles Neurological Society 42: 111–174

Tetradis S, Kantor M L 1999 Prevalence of skeletal and dental anomalies and normal variants seen in cephalometric and other radiographs of orthodontic patients. American Journal of Orthodontics and Dentofacial Orthopedics 116: 572–577

Underwood L E, Radcliffe W B, Guinto F C 1976 New standards for the assessment of sella turcica volume in children. Radiology 119: 651–654