The Morphology of the Sella Turcica in Monozygotic Twins

Mette T. Brock-Jacobsen,[1] Carsten Pallisgaard,[2] and Inger Kjær[1]

[1] *Department of Orthodontics, Institute of Odontology, University of Copenhagen, Denmark*

[2] *Clinic of Orthodontics, Aalborg Community Dental Service, Aalborg, Denmark*

The purpose was to compare the sella turcica morphology of individuals within pairs of monozygotic twins with normal karyotype and to analyze the similarity between the observed morphology and the morphology of non-twins at the same age with normal karyotype. Profile radiographs from 84 individuals of 42 twin pairs (18 male and 24 female pairs, aged 18–23 years) comprised the material. Sella turcica measurements from non-twins aged 6–21 years were used as normal reference. Length, depth and diameter of the sella turcica were measured and controlled by re-measurements. Pearson's correlation coefficient was used for comparison of individuals within twin pairs. For comparison of twins and non-twins, normal standard values for length, depth and diameter were subtracted from the twin values. For the mean values of these differences, confidence limits *p* values and *t* values were calculated. The study showed that the size of the sella turcica may be partly similar and partly dissimilar within the pair of monozygotic twins. Statistical evaluation of the data showed correlations between length, depth and diameter of the sella turcica between the two twin individuals in the same twin pair. Differences in sizes are observed between individuals in the twin material and individuals in the non-twin material. As a conclusion, the twin males were more similar within the twin pair, but deviated more from the non-twin material than the females. Female twins had more discrepancy within the twin pair, but deviated less from the non-twin material than the males.

Keywords: Sella turcica, twins, genetics, morphology, radiology

The location, size and morphology of the sella turcica have a decisive influence on the cephalometric analyses of craniofacial morphology and growth. Therefore, the sella turcica and the location of the reference point S (sella) in the center of the inner curvature of the sella turcica have been the focus of many years of scientific studies (Björk, 1955; Björk & Skieller, 1983; Riolo et al., 1974). These studies showed that the contour of the anterior wall of the sella turcica seen on a profile radiograph is stable after six years of age. This anterior structure is used as a superimposing structure in cephalometric growth analyses (Björk & Skieller, 1983). In the bottom and dorsal wall of the sella turcica resorption processes continue until age 16–17 years for boys and age 14–15 years for girls (Melsen, 1974). Due to these changes in size and morphology the S point moves downwards and backwards during childhood and puberty (Björk & Skieller, 1983).

In 2004 Axelsson et al. performed a study describing the variations in size and morphology of the sella turcica during childhood and puberty (Axelsson et al., 2004). The purpose of this study was to establish a reference material for cephalometric standards according to age and gender. Axelsson et al. (2004) measured the size of the sella turcica in 72 individuals, of whom profile radiographs had been taken every third year between the ages of 6 and 21 years. The lengths, depths and diameters of the sella turcicas were measured.

Axelsson et al.'s method of measuring the sella turcica (Axelsson et al., 2004) is in agreement with the methods by Silverman (1957) and Kisling (1966). Axelsson et al. (2004) found increasing values for length, depth and diameter concurrently with increasing age, but no significant gender differences in the values regarding depth and diameter in all age groups. However, Axelsson's study found that the length of the sella turcica was significantly larger in boys than girls in the age groups 12, 15 and 18 years (Axelsson et al., 2004). As part of the cephalometric diagnostics it is important to be able to distinguish normal from pathological development. Axelsson's study from 2004 presented an adequate reference material, useful for diagnosing abnormal morphology.

The normal and pathological development of the prenatal pituitary gland has been analyzed (Kjær & Hansen, 2000) and a series of studies have focused on the pathological sella after birth (Becktor et al., 2000; 2001; 2005; Kjær et al., 1998; 2001; Kjær & Niebuhr, 1999; Russell et al., 1999).

Received 18 March, 2009; accepted 29 September, 2009.

Address for correspondence: Professor Inger Kjær, Department of Orthodontics, Institute of Odontology, Faculty of Health Sciences, University of Copenhagen, 20 Nørre Alle, DK-2200 Copenhagen N, Denmark. E-mail: ik@odont.ku.dk

The purpose of this study was to:

- clarify whether the morphology of the sella turcica is phenotypically alike in two individuals in a pair of monozygotic twins with normal karyotype
- compare the sella turcica morphology observed in twins with the morphology observed in a group of non-twins, both groups with normal karyotype.

Material and Methods

The Twin Material

Profile radiographs from 84 individuals of 42 pairs of monozygotic twins, 18 male and 24 female pairs, comprised the present study. The ages varied from 18 to 23 years, i.e. adults.

The profile radiographs were taken in a cephalostat at the Department of Radiology, Århus Dental College, Denmark. The linear enlargement factor in the midsagittal plane was 5.6 %.

The monozygocity of the twins was diagnosed according to methods by the Danish Twin Register including three blood type identifications and a tissue type identification (Grymer et al., 1991). Records of medical history were available providing information on nose and facial trauma and respiratory problems. Thirty individuals had experienced nose trauma during childhood. These were all untreated (Grymer et al., 1991). The twin material was collected by Specialist in Orthodontics Carsten Pallisgaard, Municipal Dental Service Aalborg, Denmark, and comprised 42 pairs of monozygotic twins (Gryner et al., 1991).

In the present study twin individuals were identified by consecutive numbers, an odd and even number respectively. Each twin pair thus comprised one twin individual with an odd number and one twin individual with an even number; the odd number was always lower than the even number. For example, 'Males 1–2' constituted two male individuals in a monozygotic twin pair and 'Females 3–4' constituted two female individuals in another monozygotic twin pair.

The twins were anonymous, and the designation of the twins in each twin pair as 'odd' or 'even' served a practical purpose and was completely random. The designation was considered of no significance for the elucidation of data in the following.

The Normal Material

In order to compare the parameters of the twins with parameters of individuals who are not twins, standard measurements described by Axelsson et al. (2004) were used. Axelsson et al.'s (2004) normal material of the size of the sella turcica was created based on 72 Norwegian individuals. These individuals were followed from 6 to 18 years of age with profile radiographs every third year. Thirty four of these individuals, 15 females and 19 males, were followed up with profile radiographs at 21 years of age. The profile radiographs that form the basis of the normal material are from the Oslo Craniofacial Growth Archive, Norway. In this material the sella turcica measurements length, depth and diameter are detailed based on gender and age.

Cephalometric Method

In this study the sella turcica was measured on profile radiographs according to the method by Silverman (1957), Kisling (1966) and Axelsson et al. (2004). Length, depth and diameter of the sella turcica were measured, partly for comparison of individuals within twin pairs and partly for comparison of the twin material with the non-twin material.

The contour of the sella turcica was drawn on tracing paper. The sella turcica was drawn from the tuberculum sella to the tip of the dorsum sella. The length was measured from the tuberculum sellae to the tip of the dorsum sella and the depth as the length of a line perpendicular to the length measurement to the deepest point in the structure. The diameter was expressed as the length of the largest anterior-posterior diameter of the sella turcica and was measured from the tuberculum sella to the point farthest away from the tuberculum sella at the posterior interior contour of the sella turcica. All distances were measured in mm to the nearest 0.1 mm. The distances measured in the sella turcica are shown in Figure 1. In all measurements a digital calliper, tracing paper and lead pencil 0.5 were used.

Statistical Methods

Method Error

Twenty profile radiographs were remeasured with 1-month interval. In the first 10 females and the first 10 males the length, depth and diameter of the sella turcica were measured. The remeasurements were compared with the first measurements by calculating any percentage deviations.

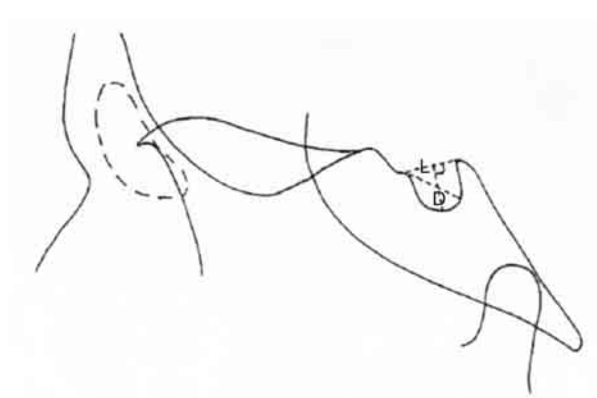

Figure 1

Schematic drawing of the osseous contours in the cranial base. In the sella turcica three dotted lines are indicated of which L marks the length, D the depth and the unmarked line the diameter of the sella turcica.

Table 1

Deviations According to Remeasurements

Response	No. observations	Mean value	Min	Max	*t* value	Pr > |t|
Sella length	20	0.000	–0.300	0.300	0.00	1.0000
Sella depth	20	–0.090	–0.600	0.200	–2.07	0.0523
Sella diameter	20	–0.140	–0.400	0.100	–4.27	0.0004

Note: The table shows the deviations between the first and second measurement of the sella turcica. It can be concluded that for the diameter of the sella there is a small discrepancy between the measurements as the values of the re-measurements are slightly different than the values of the first measurements.

For the purpose of calculating measurement uncertainty, mean value, minimum and maximum as well as *t* test were used.

For the purpose of clarifying whether the sella turcicas of individuals within pairs of monozygotic twins were phenotypically alike, Pearson's correlation coefficient was used. For the purpose of comparing the twin values with non-twin values, normal standard values were subtracted from the twin values. For the mean values of these differences confidence limits *p* values and *t* values were calculated.

Results

Comparison of Sella Turcica Sizes Between the Two Individuals Within Each Twin Pair

The results of the present study showed that the size of the sella turcica may be partly similar and partly dissimilar within the pair of monozygotic twins.

Statistical evaluation of the data showed correlations between length, depth and diameter of the sella turcica between the two twin individuals in the same twin pair. The largest correlation in the males was observed in the length of the sella turcica with a correlation of 0.85. In the males, the correlation for depth was 0.61 and for diameter 0.65. In the females, the correlation for depth was 0.47, 0.50 for diameter and 0.39 for length.

Examples of similar and dissimilar sella turcica lengths within the same twin pair are illustrated in Figures 2 and 3. These figures show that the sella turcica lengths may be similar or dissimilar within a pair. The same is observed for depth and diameter. Figure 4 shows an example of similar sella turcica morphology in a male monozygotic twin pair, aged 18 years. Figure 5 shows an example of dissimilar sella turcica morphology in a male monozygotic twin pair, aged 18 years.

Similarities Between Twin Individuals and Non-Twin Individuals

Differences in sizes are observed in individuals in the twin material and individuals in the normal material. If the material is evaluated at a 95% significance level, deviation was seen in the length of the sella turcica in the males. Examples are shown in Figures 2 and 3. Thus, the present study shows that the length of the sella turcica in the males deviates more than is acceptable at a 95% significance level.

As a conclusion, the twin males are more similar within the twin pair, but deviate more from the non-twin material than the females. Female twins have more discrepancy within the twin pair, but deviate less from the non-twin material than the males.

Control of Measurements

The deviations of the re-measurements are shown in Table 1. Except for few observations, minor average deviations in measurements are observed. The average deviations are of a small percentage, at most 7%, even though some dispersion is seen in the deviations.

Discussion

Many odontological studies have focused on the similarities and differences in monozygotic twins. In 1986 Proffit described how genetic factors affect the prevalence of malocclusion. Malocclusion is not a modern phenomenon as fossils reveal occurrences of malocclusion including crowding. Still, an increase in the occurrence of malocclusions has occurred. This increase may be explained by different theories. The increase may be caused by evolutionary reduction of jaw size and tooth size. Another explanation is that reproduction based on humans with different ethnic backgrounds and with different characteristic facial features causes a mix of different genetic potentials with different dental and facial characteristics. Proffit (1986) stated that studies comparing monozygotic twins with non-monozygotic twins provide an opportunity to evaluate the percentage of variability, which is caused by genetic factors (Proffit, 1986).

In 1984 Lundstrøm published a study on the relation between heredity and environment in connection with a clarification of causes of dentofacial variation and malocclusions (Lundstrøm, 1984).

In 2001 Hughes evaluated the variation in the occlusion of the primary dentition in Australian twins aged 3–7 years. The study included 70 monozygotic twin pairs, 79 dizygotic twin pairs and, for comparison, 114 single individuals, comprising 56 girls and 58 boys. Space, horizontal overbite and vertical overbite were examined (Hughes et al., 2001). The results of this study showed that space was primarily affected by environmental factors. Horizontal and vertical overbite

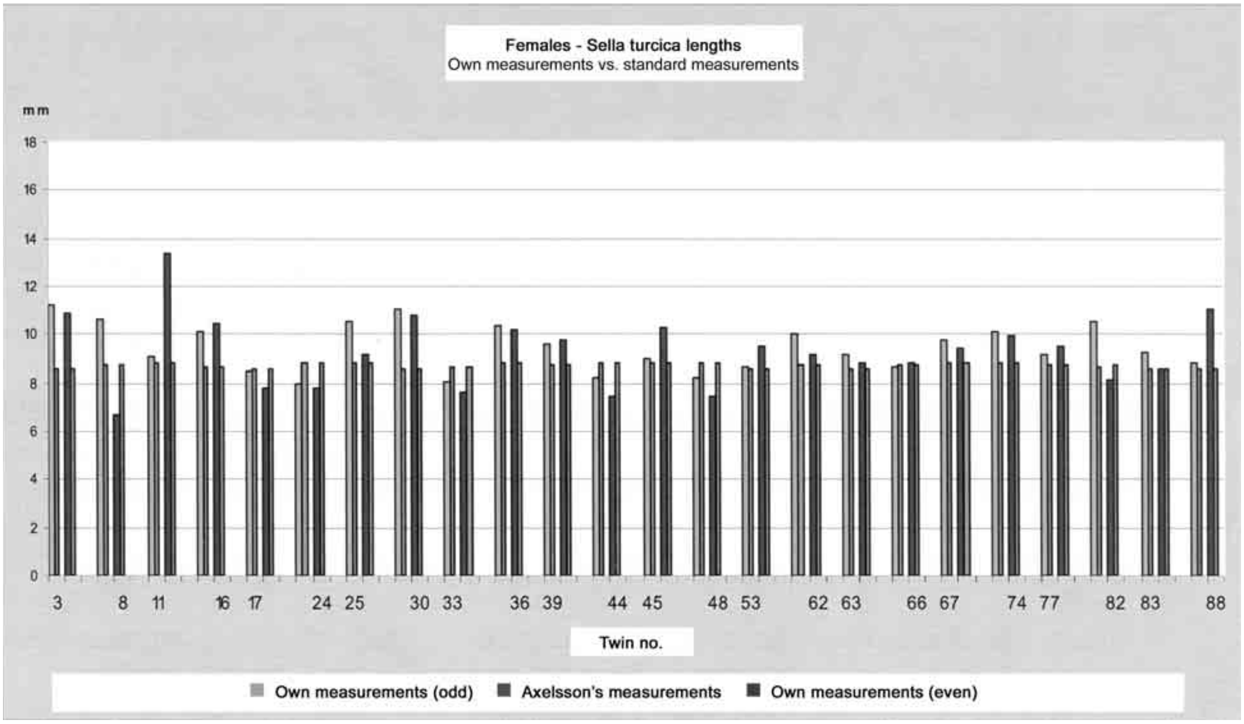

Figure 2

Diagram illustrating the sella turcica lengths of the individuals in each of the female twin pairs. The individuals in each twin pair has an odd and an even number. For comparison, standard references (Axelsson et al., 2004) of sella turcica lengths in females are included.

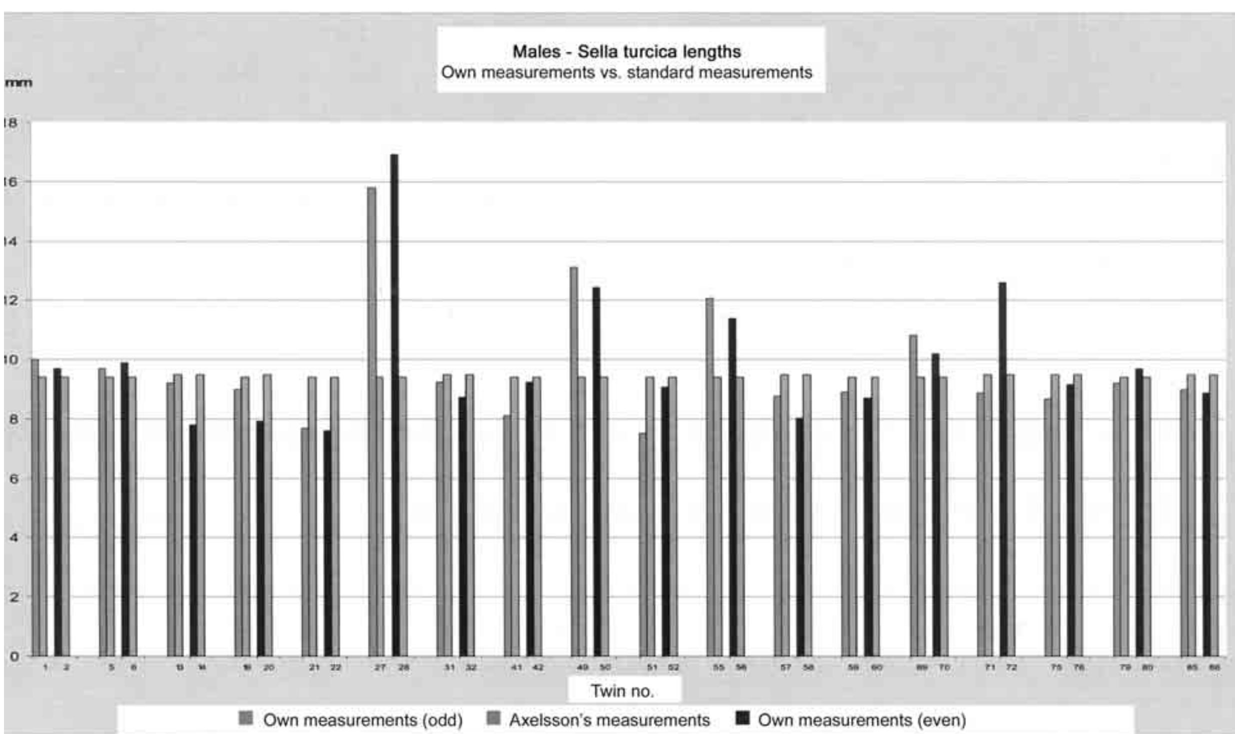

Figure 3

Diagram illustrating the sella turcica lengths of the individuals in each of the male twin pairs. The individuals in each twin pair have an odd and an even number. For comparison, standard references (Axelsson et al., 2004) of sella turcica lengths in males are included. Twin pair number 13–14 is illustrated in Figure 4 and twin pair 71–71 is illustrated in Figure 5.

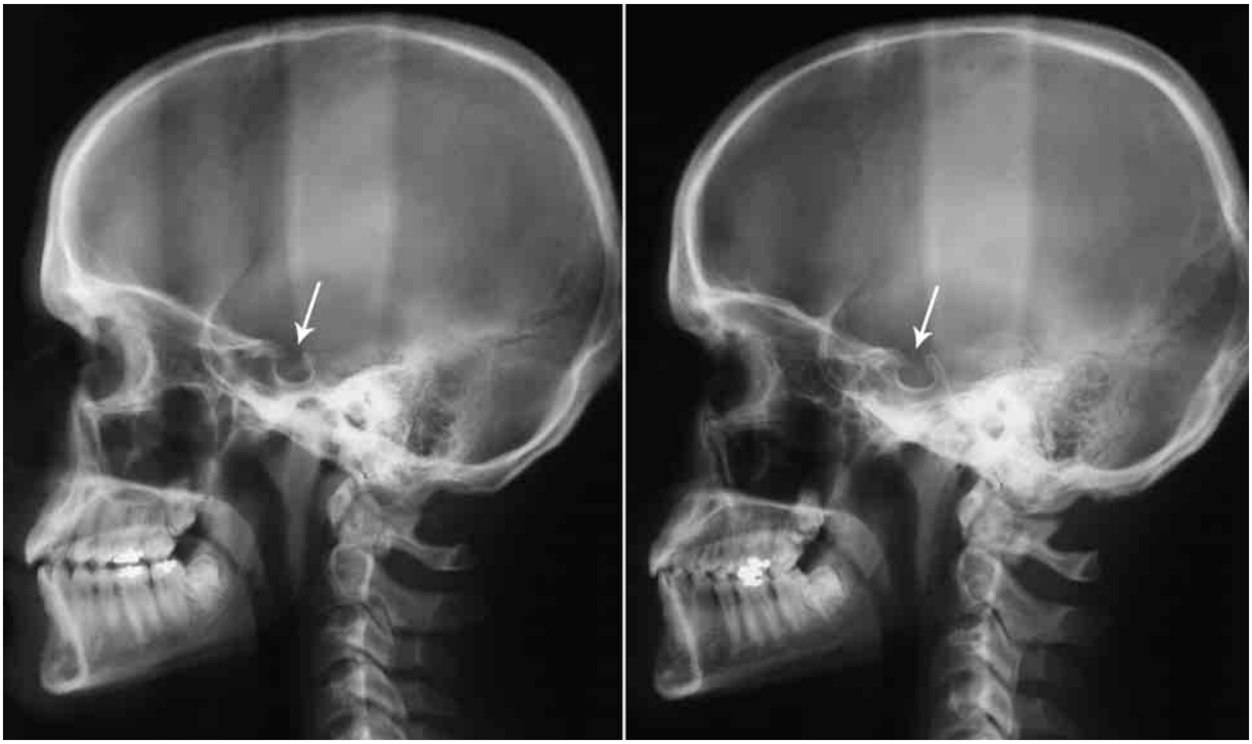

Figure 4

Profile radiographs of a pair of male monozygotic twins, aged 18 years. The morphologies of the sella turcicas (marked by white arrows) are close to identical. Differences in lengths of the sella turcicas are visualized in Figure 3.

were affected both by environmental and genetic factors (Hughes et al., 2001).

Concerning the dentition, Townsend et al. (2005) studied the variation in the prevalence of agenesis (maxillary lateral incisor and premolars) and supernumerary teeth (mesiodens) in the permanent dentition in Australian monozygotic twin pairs. The study comprised 278 monozygotic twins. The results showed that 24 of the 278 pairs had agenesis of at least one or more teeth. Of these 24 pairs, the individuals in 21 pairs had agenesis of different tooth types, and the individuals in three pairs had agenesis of the same tooth types. Nine pairs of the studied 278 pairs had occurrence of one or more mesiodens. The individuals in eight pairs of these nine had different occurrence of number of mesiodens. Townsend et al. concluded that in monozygotic twins different occurrences of agenesis and supernumerary teeth can be observed (Townsend et al., 2005).

In 1977 Becker studied the similarities of monozygotic twins in a detailed case report. He examined the two individuals in the same twin pair. Besides evaluating fingerprints and hair structure, the study also included dental investigations (Becker, 1977). The first mandibular incisor of both individuals in a twin pair erupted at age eight months at exactly the same day. Length and width of the palate were measured, and were exactly the same in both twins. The mesio-distal and bucco-lingual sizes were measured. The differences in tooth sizes of individuals within the same twin pair were of the same degree as the differences between the left and right side teeth in each twin individual. In this case report, Becker found that the differences in this monozygotic twin pair were very few (Becker, 1977).

In a case report in 2003 Leonardi examined ectopic canines in both individuals in one monozygotic twin pair (Leonardi et al., 2003). In this case report both monozygotic twins had bilaterally palatally located ectopic canines, accordingly a condition which is supposed to be inherited (Leonardi et al., 2003).

Concerning craniofacial development, the prevalence of cleft lip (CL), cleft palate (CP) and combined cleft lip and palate (CLP) in monozygotic twins has also been studied, e.g. by Christensen & Fogh-Andersen (1993). The material comprised twins with CL, CP and CLP, born in Denmark between 31 December 1969 and 1 January 1991. Syndrome patients with clefts were not included in the study. The study comprised 39 twin pairs, 14 monozygotic pairs, 19 dizygotic pairs and six twin pairs with unknown zygocity. Eight of the 14 monozygotic twin pairs had no similarity, while six of the 14 monozygotic twin pairs had identical cleft types.

https://doi.org/10.1375/twin.12.6.598 Published online by Cambridge University Press

Figure 5

Profile radiographs of a pair of male monozygotic twins, aged 18 years. The morphologies of the sella turcicas (marked by white arrows) are different. Differences in lengths of the sella turcicas are visualized in Figure 3.

The present study showed that the size of the sella turcica varies in the individuals within the monozygotic twin pairs examined. The size of the sella turcica can therefore not only be genetically determined but is also environmentally determined (e.g. changes due to illness etc.). In future cephalometric studies it would be interesting to focus on the size of the sella turcica and relate this to other measurements in the cephalometric investigation and to general body height. In the present study it was not possible to evaluate whether nose trauma, noted in the medical reports of the individual twins, had any influence on the sella turcica morphology since the age at which the trauma had occurred was not stated. In the present study, similar and dissimilar sella turcica morphologies were observed in the twin pairs. In this study, as in the study by Grymer et al. (1991), different lengths of craniofacial structures were found. The results of these two studies showed that some structures are close to identical when the two individuals within a pair were compared, while other structures varied significantly. It is assumed that different structures are affected differently by environmental factors which may explain these results. The measurements of length, depth and diameter, used as normal material for comparison with the twin material, are average measurements. In Axelsson et al.'s study the minimum and maximum measurements and average measurements were presented (Axelsson et al., 2004). Great variations were seen of length, depth and diameter in both males and females in Axelsson et al.'s material.

It could be presumed that twin pairs with normal chromosomes express the same phenotypic conditions as non-twins with normal chromosomes. This was not confirmed in this study. The present twin material consisted of Danes aged 18–23 years. Axelsson et al.'s sella turcica study (2004) on normal material was performed as a longitudinal study on a Norwegian population. The material comprised children and adolescents aged 2–21 years. The age span of the present material from 18 to 23 years makes it easy to compare with the normal materials when ages must be congruent as the age span in the normal and twin materials are alike. The ethnicity of the individuals in the two materials of this study was not given.

In a recent study by Sonnesen et al. (2008) performed on the same twin profile radiographs as used in the present study, the interrelation between cervical column morphology and craniofacial morphology was elucidated. Sonnesen et al. (2008) confirmed that cervical vertebral fusions and craniofacial morphology analyzed on profile radiographs may be interrelated in twins. The study also documented that differences in cervical column morphology can occur in individuals within a pair of monozygotic twins. The study illustrated that differences in craniofacial

https://doi.org/10.1375/twin.12.6.598 Published online by Cambridge University Press

morphology between individuals within a pair of monozygotic twins can be associated with cervical vertebral fusion. This and the present studies, performed on the same radiographs, elucidate new aspects in craniofacial development of monozygotic twins. Still, the well-known findings of differences between individuals in the same pair of monozygotic twins are confirmed.

Acknowledgments

The IMK Foundation is acknowledged for financial support. Maria Kvetny, MA, is acknowledged for linguistic support and manuscript preparation.

References

Axelsson, S., Storhaug, K., & Kjær, I. (2004). Postnatal size and morphology of the sella turcica. Longitudinal cephalometric standards for Norwegians between 6 and 21 years of age. *European Journal of Orthodontics, 26,* 597–604.

Becker, A. (1977). Monozygosity in twins: A detailed investigation. *American Journal of Orthodontics*, 72, 65–75.

Becktor, K. B., Einersen, S., & Kjær, I. (2000). A sella turcica bridge in subjects with severe craniofacial deviations. *European Journal of Orthodontics, 22,* 69–74.

Becktor, K. B., Sverrild L., Pallisgaard C., Burhøj J., & Kjær I. (2001). Eruption of the central incisor, the intermaxillary suture, and maxillary growth in patients with a single median maxillary central incisor, SMMCI. *Acta Odontologica Scandinavica, 59,* 361–366.

Björk, A. (1955). Cranial base development. *American Journal of Orthodontics, 41,* 198–225.

Björk, A., & Skjeller, V. (1983). Normal and abnormal growth of the mandible. *European Journal of* Orthod*ontics, 5,* 1–46.

Christensen, K. & Fogh-Andersen, P. (1993). Cleft lip (± cleft palate) in Danish twins 1970–1990. *American Journal of Medical Genetics, 47,* 910–916.

Grymer, L. F., Pallisgaard, C., & Melsen, B. (1991). The nasal septum in relation to the development of the nasomaxillary complex: A study in identical twins. *Laryngoscope*, *101*, 863–868.

Hughes, T., Thomas, C., Richards, L., & Townsend, G. (2001). A study of occlusal variation in the primary dentition of Australian twins and singletons. *Archives of Oral Biology, 46,* 875–864.

Kisling, E. (1966). *Cranial morphology in Down syndrome. A comparative roentgencephalometric study in adult males*. Copenhagen: Munksgaard.

Kjær, I., & Niebuhr, E. (1999). Studies of the cranial base in 23 patients with Cri-du-Chat syndrome suggest a developmental field involved in the condition. *American Journal of medical Genetics, 82,* 6–14.

Kjær, I., & Hansen, B. F. (2000). The prenatal pituitary gland — hidden and forgotten. *Pediatric Neurology, 22,* 155–156.

Kjær, I., Wagner, Aa., Madsen, P., Blichfeldt, S., Rasmussen, K., & Russell, B. G. (1998). The sella turcica in children with lumbosacral myelomeningocele. *European Journal of Orthodontics, 20,* 443–448.

Kjær, I., Hjalgrim, H, & Russell, B. G. (2001). Cranial and hand skeleton in Fragile X syndrome. *American Journal of Medical Genetics, 100,* 156–161.

Leonardi, R., Peck, S., Caltabiano, M., & Barbato, E. (2003). Palatally displaced canine anomaly in monozygotic twins. *Angle Orthodontist, 73,* 466–470.

Lundström, A. (1984). Nature versus nurture in dentofacial variation. *European Journal of Orthodontics, 6,* 77–91.

Melsen, B. (1974). The cranial base. *Acta Odontologica Scandinavica, 62,* 1–126.

Nielsen, B. W., Mølsted, K., & Kjær, I. (2005). Maxillary and sella turcica morphology in newborns with cleft lip and palate. *Cleft Palate-Craniofacial Journal, 42,* 610–617.

Proffit, W. R. (1986). On the aetiology of malocclusion. *British Journal of Orthodonntics, 13,* 1–11.

Riolo, L. M., Moyers, R. E., McNamara, J. A. jr., & Hunter, W. S. (1974). *An atlas of craniofacial growth*. Ann Arbor: Center for Human Growth and Development, University of Michigan.

Russell, B. G., & Kjær, I. (1999). Postnatal structure of the sella turcica in Down syndrome. *American Journal of Medical Genetics, 87,* 183–188.

Silverman, F. N. (1957). Roentgen standards for size of the pituitary fossa from infancy through adolescence. *The American Journal of Roentgenology, Radium Therapy, and Nuclear Medicine, 78,* 451–60.

Sonnesen, L., Pallisgaard, C., & Kjær, I. (2008). Cervical column morphology and craniofacial profiles in monozygotic twins. *Twin Research and Human Genetics, 11,* 84–92.

Townsend, G. S., Richards, L., Hughes, T., Pinkerton, S., & Schwerdt, W. (2005). Epigenetic influences may explain dental differences in monozygotic twin pairs. *Australian Dental Journal, 50,* 95–100.