ORIGINAL ARTICLE

Eur. J. Anat. 17 (3): 142-145 (2013)

Anatomy of the adult foramen caecum

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SUMMARY

The foramen caecum is a hitherto not fully described structure of the base of the anterior cranial fossa. The surroundings of its route are routinely the site of surgical interventions which are preceded by a computer tomography scan. The examination and comparison of the adult foramen caecum anatomy are found in anatomical specimens and in computer tomography images. The measurements of foramen caecum were done using computer tomography images. The anonymous images of 18 adult patients were used, as well as 15 cranium anatomical specimens. Only skulls with an intact foramen caecum region were examined. Tools available in the Clear Canvas Workstation 2,0SP1 were used to conduct measurements of the CT images, while a millimeter scale and a probe inserted into the foramen caecum were used to conduct measurements of the anatomical specimens. The foramen caecum was present in all investigated skulls but with the wide range of proper dimensions. The highest (15 mm) and the lowest depth (4 mm) were found in anatomical specimens. It has been ascertained that the foramen caecum inside bone structure takes the form of a short canal leading to the frontal sinus. The comparison of the results of the measurements of CT images and anatomical specimens revealed that the dimensions of the foramen caecum vary. The examination of each CT image resulted in identification of the foramen caecum.

Key words: Cribriform plate – Crista galli – Ethmoid bone – Frontal bone – Anterior cranial fossa

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INTRODUCTION

The foramen caecum is located in front of the cribriform plate of the ethmoid bone and behind the frontal bone, within the frontoethmoidal suture. The information on the foramen caecum available in anatomical literature (Goss, 1956; Standring, 2004) usually details only the aforementioned location. Some researchers (Hedlund, 2006) describe the location of the foramen caecum more accurately. According to them, the anterior of the foramen caecum is limited by the frontal bone, while its posterior by the anterior part of the crista galli, and lateral margins are limited by the ethmoid ala. Other researchers (Lowe et al., 2000) also provide numerous examples of anomalies in children and detail the course of this region's embryogenesis. These anomalies include, for example: crista galli bifidation (Kim et al., 2003), choanal atresia, the so-called "persistent" foramen caecum – the route for frontal meningoencephalocoele (Kanowitz and Bernstein, 2006), lack of the crista galli, and lack of the perpendicular plate and of the cribriform plate of the ethmoid bone (Branovan et al., 1997; Lowe et al., 2000). As mentioned by Hedlund (2006), the most frequent type of pathologies of this region which are correlated with the anomalies of the foramen caecum include: nasal dermal sinus, anterior cephalocele, and nasal glioma. The foramen caecum is frequently explored during anterior cranial fossa surgical procedures when the dura is separated and elevated from the cranial floor and crista galli (Rogelio and Dolci, 1997; Branovan et al., 1997; Burhardt and Tobon, 1999). Therefore the question of the foramen caecum's route should be thoroughly explored in

Submitted: 4 November, 2012. *Accepted:* 27 March, 2013.

the context of surgical procedures in the area.

This study's aim is the examination of foramen caecum occurrences and morphology in computer tomography images of adults and in the Department's of Descriptive and Clinical Anatomy (DDCA's) collection of human cranial anatomical specimens.

The foramen caecum is located within the frontoethmoidal suture. This study aims to present the diversity of the foramen caecum's dimensions and to attempt to ascertain its proper dimensions. Hedlund (2006) defines the dimension of the foramen caecum in three- to five-year old children. The dimension of the foramen caecum infrequently exceeds 3 mm. During his analysis of over 200 human skulls Boyd (1930) found 2 skulls in which the foramina caecum led through the nasal bone, and a single skull where the foramen caecum led into the nasal cavity. The importance of the foramen caecum and its vein is not clear in children (Thewissen, 1989). On the other hand, Kaplan et al. (1973) reported that they were not able to confirm the presence of the vein in any of the 201 examined foramina caeca. Lack of any anomalies observable with the employed methods in the foramen caecum's area was the criterion used to determine the proper dimensions.

MATERIALS AND METHODS

In order to characterise the foramen caecum, an analysis of 18 cranial computer tomography images was carried out. These belong to patients who were diagnosed in the Department of Clinical Radiology of the Warsaw Medical University Trauma Centre Child Jesus Memorial Clinical Hospital for reasons unrelated to morphological cranial malformation. The patients were 11 males aged 23 to 70 and 7 females aged 23 to 75.

A group of 15 specimens without bone defects in the investigated region was selected from the DDCA's osteological collection. The aim of the analysis was an examination of local bone structures. Therefore the methods best suited to such an analysis were used.

The measurements of the CT scans were conducted via an analysis of CT images with the Clear Canvas Workstation 2,0SP1 program. The measurements of the skulls were performed on photographs of each specimen using Adobe Photoshop computer software millimeter scale tool. The depth of the foramen was investigated with a probe. All patients were Caucasian, and all specimens came from Caucasian populace.

The images below depict distinctive points used in cranial measurements. Measurement sections as determined by the points:

A, B - Bone point pterion. C, D - The highest longitudinal dimension of the right and left sections of the cribriform plate of the ethmoid bone. E, F - The highest transverse dimension of the right and left sections of the cribriform plate of the ethmoid bone.

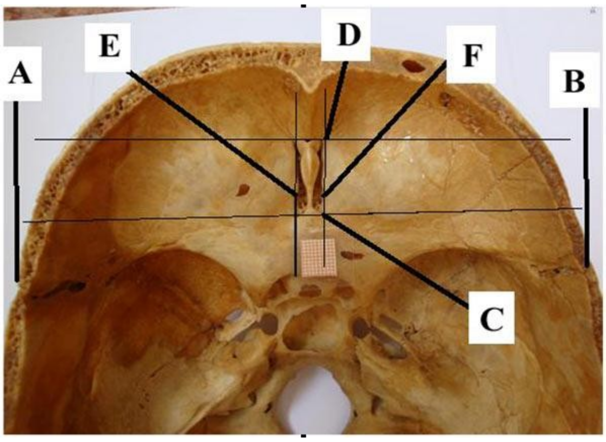

Fig. 1. Measurement points used on anatomical specimens and during analysis of CT scans depicted on a specimen.

RESULTS

The foramen caecum was present in all investigated skulls. It was also identified in all CT cases. There were no discernable anomalies.

The table below depicts arithmetic mean, standard deviation, maximum and minimum of measurement section. Sections: AB, CD, EF (Fig. 1)

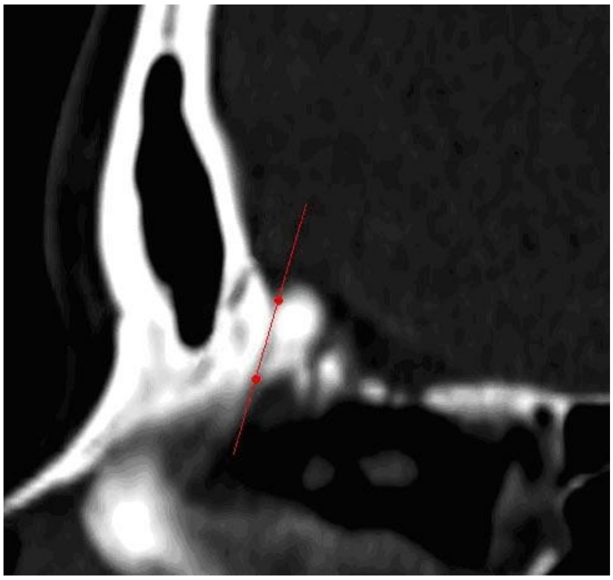

Fig. 2. The foramen caecum's depth (longitudinal dimension in the sagittal cross-section) measurement on a CT scan.

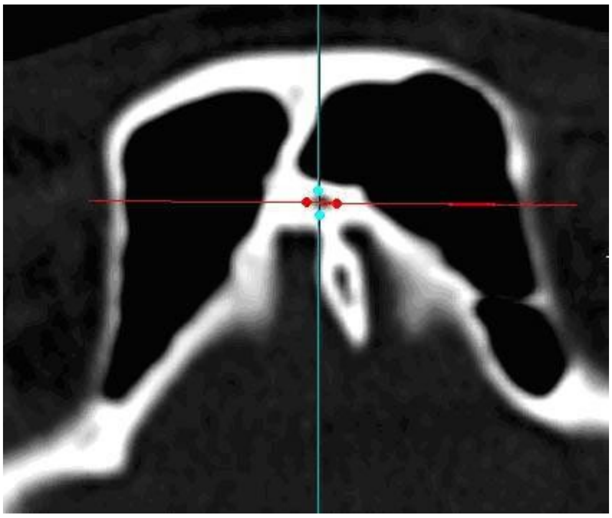

Fig. 3. The foramen caecum's width (transverse dimension in the horizontal cross-section) and length (sagittal dimension in the horizontal cross-section) measurement on CT.

and depth were measured during specimen analysis. Sections: AB, CD, EF, depth (Fig. 2), width and length (Fig 3) were measured during CT scan study. The highest (15 mm) and the lowest depth (4 mm) were found in anatomical specimens. The foramen caecum's length and width were measured only on CT scans due to their greater accuracy. The extreme length dimensions were 1.67 mm and 0.24 mm. The extreme width dimensions were 1.83 mm and 0.26 mm. This indicates that foramen caecum is a structure with the wide range of proper dimensions (Fig. 4).

No correlation between the width of the skull and the dimensions of the foramen caecum has been found. Likewise, the impact of the longitudinal dimension of the cribriform plate of the ethmoid bone on the foramen caecum's dimensions turned out to be minimal. On the other hand, we have ascertained that the greater the transverse dimension of the cribriform plate of the ethmoid bone, the more oval the foramen caecum is.

Each skull's dimensions were found to be proper, therefore it is assumed that the observed wide diversity of the foramen caecum's dimensions is also proper. Furthermore the lack of anomalies commonly found alongside pathological foramen caecum in the analysed specimens and CT images also indicates the analysed foramina were all proper.

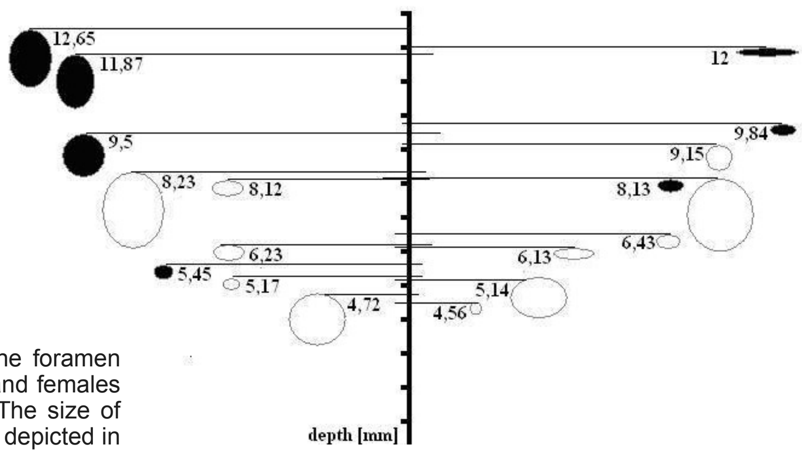

Fig. 4. The depiction of distribution of the foramen caecum's depth in males (white circles) and females (black circles) found in the CT images. The size of the foramen caecum (length and width) is depicted in scale (ten millimeters to one millimeter).

Table 1. The arithmetical means, standard deviations, maximum and minimum of the CT image analyzed section and specimen measurement section (in millimeters)

Sections	Maximum	Minimum	Mean ± SD
AB	157	140	148,66±4,52
CD	33,5	15	22,23±5,20
EF	14,67	7,89	11,59±1,87
Depth	15	4	7,85±2,58
Length	1,67	0,24	0,74±0,56
Width	1,83	0,26	0,93±0,41

DISCUSSION

The investigated region was characterized by skull width (AB) and sagittal (CD) and transverse diameter (EF) of cribriform plate. The skull width did not display greater variability, while the latter two dimensions proved more variable. The dimensions of these sections are similar to results procured by other authors (Bach-Perersen and Kjaer, 1993; Friede, 1981; Hayashi, 2003). Hedlund (2006) reported that the size of the foramen caecum rarely exceeds 3 mm. He did not, however, specify the projection of this diameter. Other authors (Kaplan et al., 1973; Thewissen, 1989) doubt the presence and importance of the vein traversing the foramen caecum.

Some authors (Hsu et al., 2002; Hedlund, 2006) reported that magnetic resonance is the best diagnostic method as far as this region is concerned. They recommend it on grounds of the fact that it allows one to differentiate normal fat found within the crista galii of six- to eight-month old children from local cartilaginous structures. However we focused on adult cases, and our CT diagnostics have indicated full ossification of the area and no presence of normal fat. Therefore CT was sufficient for the scope of our study.

After an analysis of 18 human cranial CT images and 15 human cranial anatomical specimens it has been ascertained that the dimensions of the foramen caecum, especially its depth, vary greatly.

It is thought that the greatest observed depths might result from the lack of soft tissues in the analysed specimens. Another possible explanation is that a bony tip of foramen caecum was damaged. The methods of analysis permit the assumption that the tip of the foramen caecum may be formed from soft tissues or thin bone structure. Considering that hypothesis, one must keep in mind the possibility of mechanical penetration through the foramen caecum during surgical procedures in this area.

On CT the interpretation of the existence of the foramen caecum might be limited due to the presence of the soft tissue. Nonetheless it seems that the measurement of the foramen caecum's depth in CT images yielded more accurate results. None of the examined anatomical specimens displayed any morphological malformations in the foramen caecum's area. Neither did any of the CT images. Therefore all the examined foramina caeca are considered to be anatomically proper. This implies that adults display a great variety of the foramen caecum's dimensions, especially when regarding its depth.

The examination of the foramen caecum's depth in CT scans and anatomical specimens seems to indicate that there is no connection between the superior sagittal sinus and the nasal cavity. The chosen methods of analysis indicate the foramen caecum reaches the frontal sinus at most. It should be noted, however, that the scope of this study did not include the analysis of vessels and soft tissues and the chosen methods of analysis reflect that.

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