

ORIGINAL STUDY

Some radiological and clinical aspects of the sinus crista galli

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ABSTRACT

The advantages of CT scanning of the paranasal sinuses enabled otorhinolaryngologists to observe some anatomical entities in the patients, which in previous times were impossible to realize. Besides the well-known fact about the pneumatized middle turbinate and the perpendicular septal plate, the pneumatization of crista galli has been quite bashfully and scarcely recognized on CT scans since the very beginning of the use of this radiological method. On the other side, it seems that the incidence of pneumatization of crista galli is not that low. The so far published CT scans studies report on its incidence of 12-13.9%. We found this number higher: even 37.5%. We are the first to report on the inner dimensions of the crista galli pneumatization, i.e. the dimensions of the cavity within it, in both anterior-posterior direction (range 5.1-12.4 millimeters) and lateral-lateral direction (range 3.1 to 7.1 millimeters). No correlation between the lateral-lateral dimensions and Keros types of the olfactory fossa slope 1, 2 and 3 was found. Also, no correlation was found between Hajjioannou types of crista galli base position 1, 2 and 3 and the dimensions of pneumatization. No clear signs that would suggest that pneumatized crista galli is just an additional compartment of the frontal sinus have been proven either. This anatomical entity seems to be a separate, real paranasal sinus: sinus cristae galli.

KEYWORDS: crista galli, pneumatization, sinus cristae galli, Keros classification, Hajjioannou classification

INTRODUCTION

The advantages of CT scanning of the paranasal sinuses enabled otorhinolaryngologists to observe some anatomical entities in the patients which in previous times were impossible to realize. The fact that the middle turbinate can be pneumatized (concha bullosa) has been known for decades from the surgical experiences, but the facts on its incidence in man have been collected only after studying a large number of patients and their CT scans^{1,2}. The incidence of this radiological finding can reach even 67.5%³. It has also been known for almost fifty years that the perpendicular lamina of the nasal septum or even sphenoid bone rostrum could be pneumatized in some persons as well. This cavity within the bony septal skeleton has been named *sinus septi nasi*. Nowadays, owing to CT-scanning, it is well known that this entity is not that rare: the sinus septi nasi can even be found in 27% of the population^{4,5,6}. Contrary to that, the pneumatization of crista galli has been quite bashfully and scarcely recognized on CT scans since the very beginning of the use of this radiological method. It seems to be generally neglected. The occurrence of this anatomical

entity has attracted the attention of only few radiologists and rhinologists until the recent years. Because of that, the pneumatization and related pathological processes within the pneumatized crista galli have not been connected to the patients' complaints and the clinical picture they showed. There are, however, some notable exceptions: congenital midline nasal defects, including nasal dermoids, have been seen to track from, through or near the pneumatized crista galli⁷. Some authors reported on the fact that obstruction of the way of communication of pneumatized crista galli with other paranasal chambers can lead directly to the chronic inflammation⁸. Mucocele development has also been seen to be located within the pneumatized crista galli⁹.

It seems that the incidence of pneumatization of crista galli is not that low. The most recent report comes from Kim et al¹⁰. The incidence of this entity on a large amount of CT studies (N=818) was found to be 12.2% in the population that included not only adults, but also children from 7 to 18 years of age, and 13.2% in adults solely. Som et al¹¹ found similar result (13%), whereas Al-Qudah⁴ found pneumatized crista galli in even 28% of patients!

Since we noticed in our patients that CT images have highlighted a great variety of the dimensions and the shape of crista galli, and particularly of the degree of its pneumatization (Figure 1 A,B; Figure 2 A,B), a retrospective observational study on the presence and morphological characteristics of the pneumatized crista galli was undertaken on the coronal and axial CT scans of CRS patients gripping the period between November 2009 and January 2013.

Several papers dealing with this issue have been published in the recent years^{12,13,14,15,16}. None of them, however, offered the data specifically addressed to the dimensions of the cavity within the pneumatized crista galli, both in anterior-posterior (length) and lateral-lateral direction (width), neither on the relationship

between the depths of the olfactory fossa slope according to Keros classification.

Hypothetically, our team had a general impression and presumption that the deep slope of the olfactory fossa (Keros type 3) will not “allow” the wide lateral-lateral enlargement, i.e. pneumatization of crista, while the shallow slope, like Keros type 1, for instance, will allow its full development.

The aim of this paper, therefore, is to present our results regarding the general incidence of pneumatized crista galli in patients suffering from chronic rhinosinusitis (CRS), an average of lateral-lateral and anterior-posterior dimensions of the pneumatization and the relationship to the morphology of the olfactory fossa, i.e. the depth of its slope. We also studied

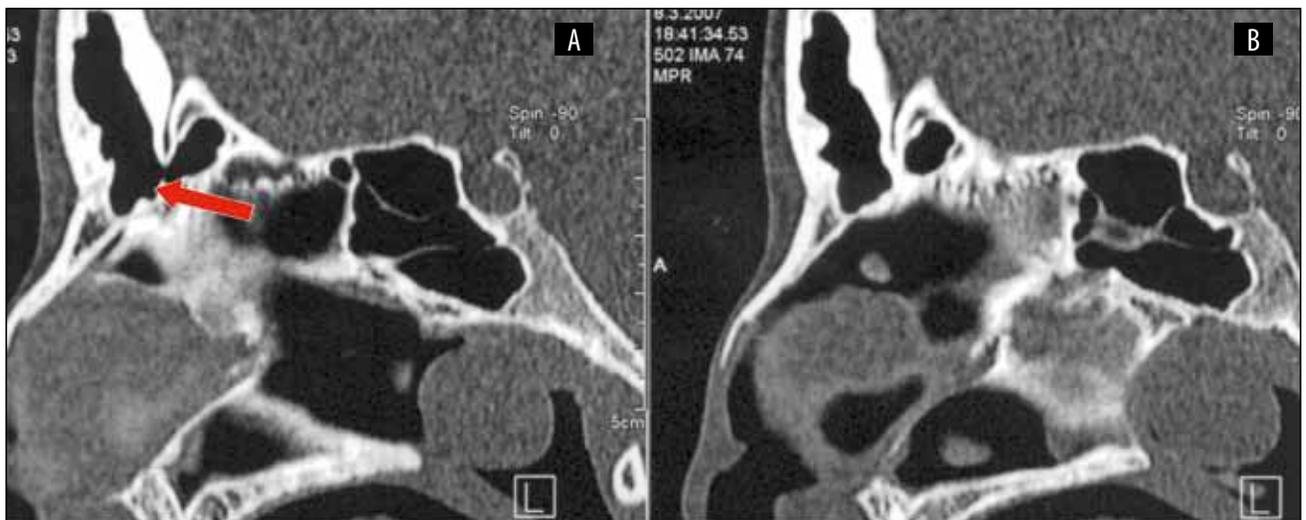


Figure 1 A sagittal CT scan at the level of the nasal septum (A) showing that there is a short, small connection between the air chamber within the crista galli and frontal sinus itself (red arrow) and just 2 millimeters more laterally (B)

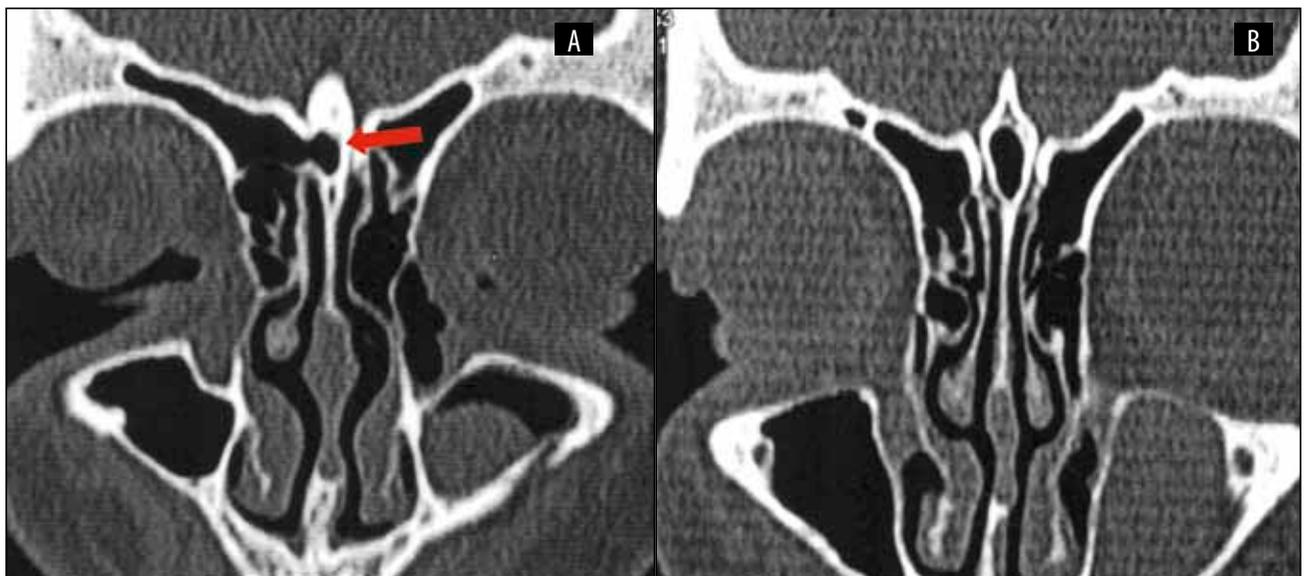


Figure 2 A. The bony integrity of crista galli has been scribed by the pneumatization process from the right frontal sinus chamber (red arrow); B. Well pneumatized, empty crista galli which seems to be healthy. A deep slope of the olfactory fossa (Type 3 after Keros), and type 1 after Hajjioannou (the base of crista does not extend below the cribriform plate)

whether or not there is any relationship between the dimensions of the pneumatization and the Hajjioannou three types of crista galli base position: over the cribriform lamina, on the halfway to the nasal cavity and deep in the nasal cavity.

The connection between the cavity within the pneumatized crista galli and the surrounding air-chambers of neighboring sinuses has been studied as well.

MATERIAL AND METHODS

A retrospective radiologic study upon 527 CT images of the chronic rhinosinusitis (CRS) patients' paranasal sinuses, both in coronal and axial projections, has been carried on at the Department for Radiology and ENT Department, Clinical Hospital Center Zagreb, Croatia. The CT examinations were performed with a 64 channel MDCT (Lightspeed VCT, GE Healthcare, Milwaukee, USA; scan parameter, 120kVp, 250mAs; scan time, 1000msec; matrix size, 512x512) without contrast enhancement. The patients were scanned in the supine position (gantry tilt, about 21 degrees through anterior margin of frontal sinus and nostril), and coronary editing of 1-mm thick slices from the front of the frontal sinus to the end of the sphenoid sinus was done. The CT scans were routinely evaluated with a window width/level of 2000/265 HU for axial scans and 2000/350 HU for coronal scans.

To assess whether or not particular crista galli was pneumatized, the radiological coefficient of tissue density was measured whenever crista was enlarged, showing dense, whitish bone margins and gray color within them (Figure 3). In that way, the distinction between edematous mucosa and just bony spongiosis within the crista was made.

The position of the crista galli base was defined after the very recently published Hajjioannou's classification¹⁴:

Type 1- the base of the crista galli is located at the level of the cribriform plate.

Type 2- less than 50% of the height of the crista galli is located below the level of the cribriform plate.

Type 3- more than 50% of the height of the crista galli is located below the level of the cribriform plate

During the observation of the CT scans, particular attention was paid to six main points:

1. The existence of crista galli pneumatization or not;
2. Anterior-posterior dimension of the cavity within crista;
3. Lateral-lateral dimension of the same;
4. Keros type of the olfactory fossa slope according to the original classification, in which type 1 has a depth of 1-3 mm (26.3% of population), type 2 has a depth of 4-7 mm (73.3% of population)

and type 3 has a depth of 8-16 mm (0.5% of population);

5. The position of the pneumatized crista galli base according to Hajjioannou's classification;
6. The possibly visible and detectable connection of the cavity within the crista galli with the adjacent sinuses (frontal or ethmoid sinus).

The numerical values were recorded as precisely as up to the first decimal.

RESULTS

There were 198 out of 527 subjects whose CT scans showed at least a certain degree of pneumatized crista galli (37.5%). There were 106 males (53.53%) and 92 females (46.46%). The age range was from 19 to 72 years.

The term "at least a certain degree of pneumatization" means here more than 5.0 millimeters in anterior-posterior direction and more than 3.0 millimeters in lateral-lateral direction. The values of the antero-posterior dimensions of the cavity within the crista ranged between 5.4 up to 12.4 millimeters in males and 5.1 up to 10.6 millimeters in females. The values of the latero-lateral dimensions of the cavity within the crista ranged between 3.3 to 7.1 millimeters (an average 6.4 mm) in males and 3.1 to 6.8 millimeters (an average 5.5 mm) in females.



Figure 3 A coronal CT scan showing typical Keros 2 type of olfactory slope depth (up to 7 millimeters). Again, type 1 after Hajjioannou. The crista galli is somewhat irregularly shaped, oblique, following the irregularity of the anterior skull base (right half of the skull base is lower than left one). The cavity within the crista seems to be fulfilled with the contents identical to those in ethmoid cells. The radiological coefficient suggested a mucosal edema rather than spongiosis here. An emphasized pneumatization of both middle turbinates is also visible.

Among those with pneumatized crista galli, there were 49 patients who carried Keros type 3 olfactory slope (20.9%), 132 patients with Keros type 2 (56.4%) and 53 patients (22.6%) with Keros type 1.

Contrary to our expectations, no relationship between the depth of the olfactory fossa slope, as classified by Keros system, and the width of the crista galli pneumatization was found. No relationship between Hajiloannou types of crista galli base positioning and the dimensions of the cavity within the crista was found either.

The connection between the cavity within the crista galli and adjacent air-spaces was clearly seen in 24 out of 198 of them carrying the pneumatized crista galli (12.1%). All of them showed an obvious connection to the frontal sinus.

DISCUSSIONS

The general incidence of pneumatized crista galli in our study reaching up to 37.5% showed to be higher than in previous studies. For instance, Basic et al.¹² found in 1999 the incidence of 2.4% only. Ten years later, Som et al.¹¹ reported 13%. Other authors demonstrated similar results. Kim et al.¹⁰ showed the incidence of 12.2% in the large group of even 818 patients, but this group included also children. After analyzing the results of two age groups separately, the incidence in the subjects aged 7 to 18 years was only 2.7%, whereas the rest showed an incidence of 13.2%. Some other authors found a higher incidence^{13,15}. Al Qudah found even 28% of pneumatizations⁴! Our results seem to be, at the very first sight, surprisingly high, i.e. 37.5%. We believe that this is the result of our very strict criteria to assess whether some cristae galli were pneumatized or not. First of all, we took into consideration as pneumatized crista galli all those cases in which radiological coefficient for the grayish content within the clear, bony margins of crista, suggested mucosal swelling instead of soft, spongy bony tissue. Then, we also counted even those cases in which crista galli has been minimally, but still pneumatized. The term “minimally” meant more than 5.0 millimeters in anterior-posterior direction and more than 3.0 millimeters in lateral-lateral direction of the cavity within the crista itself.

Still, as to the differences in the incidence of pneumatization, be it of perpendicular septal plate, uncinate process, middle turbinate or crista galli, not only the technical issues, but also the ethnical differences should be taken into account.

It is not quite clear whether or not the pneumatized crista galli is just a compartment of the frontal sinus, or it is a sinus per se. The radiological study is the only tool at the moment to judge whether or not there is

some visible, detectable ostium, tunnel or whichever other type of communication between the frontal sinus and the cavity in the crista galli. We did not succeed to identify these connections very frequently, i.e. we found them in only 12.1%. Despite all attempts to perform the slices as thin as possible, the connection between the frontal sinus and the sinus cristae galli remained not detectable at all (Figure 3, 4).

In our opinion, the fact that in some cases, like in those presented in the figures 1A and 2A, the connection is quite visible, it does not mean automatically that the cavity within the crista galli is just an additional compartment of the neighboring “big brother”, the frontal sinus. For instance, there are well-documented cases with a large sphenoidal recess, with a large, easily recognizable sphenoid ostium, but this still does not mean that the cavity in the sphenoid bone is just an additional compartment of the nasal cavity. It's a sphenoid sinus per se. The same can be applied here regarding the cavity in the crista galli. In our clinic we use to call it just sinus cristae galli and this article will probably promote this term to be accepted among the endoscopic surgeons of the paranasal sinuses and skull base. The future will show whether or not we do have to start thinking of the phenomenon of pneumatized crista galli as a clinical, not anatomical entity at all.

The correlation between the depth of the olfactory fossa slope and the degree of crista galli lateral-lateral pneumatization, even if it was expected, has not been found. Moreover, pneumatization was also found in both typical cases of Keros types 1 and 2 (Figure 3, 4).

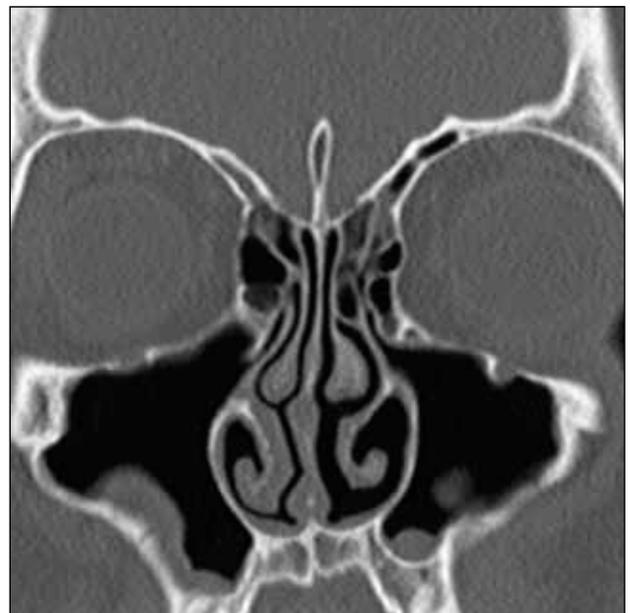


Figure 4 Thin, elegant but still pneumatized crista galli fulfilled with the edematous mucosa inside it, in the patient with the typical Keros type 1 (flat olfactory region, no slope at all!). Again, type 1 after Hajiloannou is present.

As to the position of the crista galli base, the author of the classification, Hajilannohou, found type 1 in 28.3%, type 2 in 63.6% and type 3 in 8.1%. As far as we are concerned, the percentages given by this author should be reconsidered, since no strict definition was given at which exact level of the orbit or other reliable surrounding adjacent anatomical structures should one rely when judging the crista galli base position: at the half of the bulb, at the orbital apex level, or just at the level of ground lamella. In case it would be ground lamella, it would be difficult to standardize future observations regarding this very interesting morphological entity, since the ground lamella, which is normally situated just beneath the middle part of the crista galli, is not at all easy to recognize both on the axial and coronal scans! Sagittal scans can help a lot in regards of this problem. Sagittal scans, in addition, if performed in a median plane, can give a perfect profile insight in the structure of the crista galli (see Figure 1 A and B).

Nevertheless, owing to the navigational computer systems developed in recent years, the surgery of the pneumatized crista galli has become more acceptable as an idea. Rare authors of today perform this type of surgery with an enviable degree of ease and assurance¹⁶. Therefore, it seems more accurate to operate in this region under the computer guidance, which enables the surgeon to control the tip of the instrument all the time (Figure 5).

CONCLUSIONS

1. The general incidence of pneumatized crista galli in our material was 37.5%
2. No statistically significant difference was found between males and females
3. No statistically significant difference was found regarding the age
4. No statistically significant correlation between the Keros type of the olfactory slope and the extend of the crista galli pneumatization was found either
5. The antero-posterior dimensions of the cavity within the crista range between 5.1 up to 12.4 millimeters
6. The values of the lateral-lateral dimensions of the cavity within the crista range between 3.1 to 7.1 millimeters
7. There is no correlation between the depth of the olfactory fossa slope and the degree of crista galli latero-lateral pneumatization
8. There is no correlation between the position of the crista galli base and lateral-lateral dimension of its pneumatization
9. No clear signs that would suggest that pneumatized crista galli is just an additional compartment of the frontal sinus have been found. Thus,
10. We consider this anatomical entity a real sinus, named sinus cristae galli

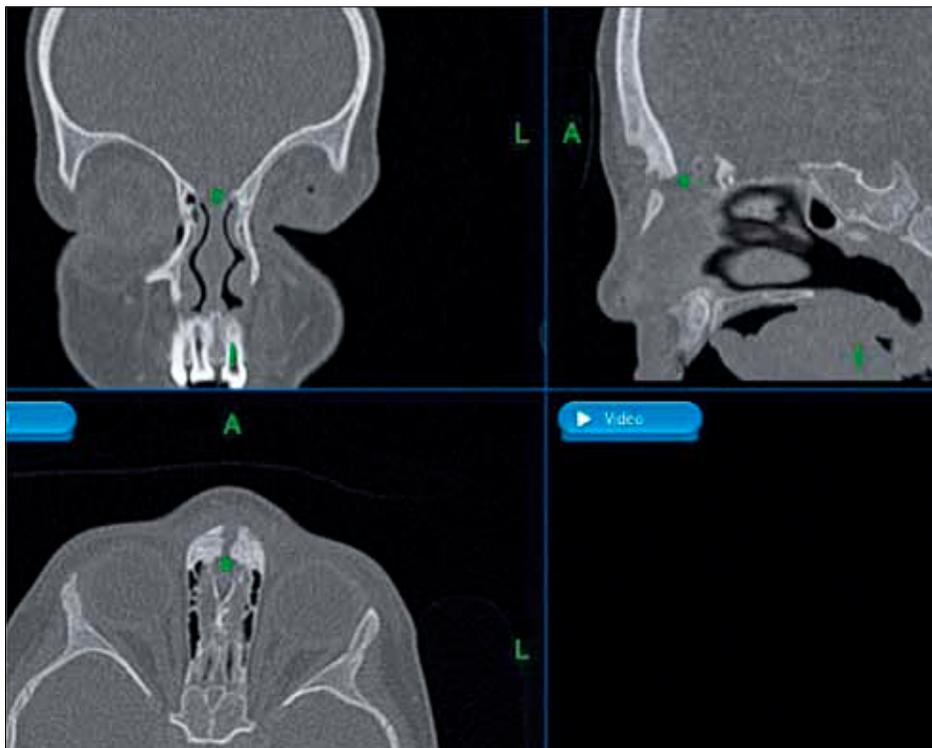


Figure 5 Snapshot during the surgery of the nasal dorsal fistula in an 18-month-old boy. The main pathological process was a dermoid cyst in the sinus cristae galli!

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