Romanian Journal of Rhinology, Vol. 2, No. 7, July - September 2012

ORIGINAL STUDY

Anatomical variants of the uncinate process – CT scan imaging study

Vasilica Baldea[1], Mihail Dan Cobzeanu[2], Florina Mihalcea[3]

[1]ENT Ambulatory Service, "N. Titulescu", Buzau, Romania

[2]ENT Department , Emergency Clinical Hospital "Sf. Spiridon" University of Medicine and Pharmacy "Grigore T. Popa" Iasi, Romania

[3]CH Hospital St Esprit Agen, Radiology Department, France

ABSTRACT

BACKGROUND. The uncinate process is the key in the bony structures of the ethmoid in the lateral nasal wall, defining the semilunar hiatus together with the ethmoid bulla. This structure presents anatomical variants that determine the rhinosinusal pathology and endoscopic approach: various degrees of angulation, pneumatization or methods of superior insertion on adjacent structures.

MATERIAL AND METHODS. The authors present an anatomo-radiologic, retrospective study on 205 CTs of the facial sinuses, in patients between 18-91 years old, 108 men and 97 women, for a period of two and a half years.

RESULTS. The study allowed to determine the prevalence of normal angulation, verticalization and horizontalization, pneumatization of the uncinate process, the superior insertion with the 3 classical variants (on the lamina papyracea, the skull base, the insertion of the middle turbinate) and the least common ones (ethmoid bulla, pneumatized superior turbinate or "through multiple joints" - multiple insertions).

CONCLUSIONS. One third of the uncinate processes are verticalized (lateralized) or medialized (horizontalized), pneumatization is a rare anatomical variant, and the superior insertion of this structure has many variants (3.41%).

KEYWORDS: uncinate process, CT scan, anatomical variants

INTRODUCTION

In the anterior ostiomeatal complex, there are different anatomical variants, isolated or associated. Most of the anatomical variants involve the middle turbinate (particularly concha bullosa and paradoxical curbature, anomalies of number and development), nasal septum deviation, pneumatization of Agger nasi cells and ethmoid bulla, presence of Haller's cells and anomalies of the uncinate process.

The uncinate process is the key in the bony structures of the ethmoid in the lateral nasal wall. Together with the ethmoid bulla, it defines the semilunar hiatus. It has the appearance of a soft bony blade that belongs to the ethmoid and merges with the ethmoid process of the inferior nasal turbinate[1].

The most common anatomical variants of this surgical landmark are represented by: angulation degree (normal, medialization, lateralization), pneumatization, superior insertion (into a less usual topographical area - lamina papyracea, skull base, insertion of the middle turbinate), deformation of the free extremity (in the shape of a hook or a cudgel), elongation with doubling of the middle turbinate contour (in this case, it participates in the formation of the double middle turbinate or duplicate turbinate). The uncinate process is an upper extension of the lateral wall of the nasal fossae and, normally, it is inserted inferiorly in the postero-medial portion of the agger nasi cells[2,3]. When it inserts itself into other structures, it can lead to obstructions.

Pneumatization of the uncinate process, with a reported prevalence of 0.4-13%[2-6] is a rare abnormality,

Corresponding author: Vasilica Baldea
e-mail: etabaldea@yahoo.com

occupying the infundibular free regions, and it creates areas of mucosal thickening. Kantarci and collaborators[7] consider that changes in the uncinate process can lead to an important functional blockage of the ostiomeatal complex: deviations from normal of the angulation (especially medialization), as well as pneumatization, may cause a close contact of this surgical landmark with the middle turbinate, being the most frequently found in chronic recurrent rhinosinusitis. When associated with other anatomical variants that cause a narrowing of the ethmoid infundibulum (Haller's cell, anomalies of the middle turbinate), the risk of rhinosinusitis is increased.

AIM OF THE STUDY

We examined 205 craniofacial CT scans, we used imagistic material from the archive of the County Emergency Hospital in Buzau, in order to reveal the various anatomical variants of the uncinate process with impact in the endoscopic rhinosinusal pathology and surgery.

The aim of the study was to determine the prevalence for:

1. Types of angulation of the uncinate process (normal, medialization, verticalization)

2. Pneumatization of the uncinate process (uncinate bulla)

3. Variants of superior insertion of the uncinate process.

MATERIAL AND METHODS

The patients, symptomatic adults, had indication for CT exploration of the facial sinuses region for diverse pathology (rhinologic, ophthalmologic, traumatologic, neurologic, OMF). The study enrolled 108 men (52.69%) and 97 women (47.3%), with a mean age of 47.61±17.71 years, prevailing subjects between 30-40 years (Figure 1). Statistical indicators of patients' age and sex are presented in Tables 1-3 and in Figure 2.

In terms of imaging protocol, we used spiral multiplan exploration with high-resolution bone reconstructions, thus having all three planes available

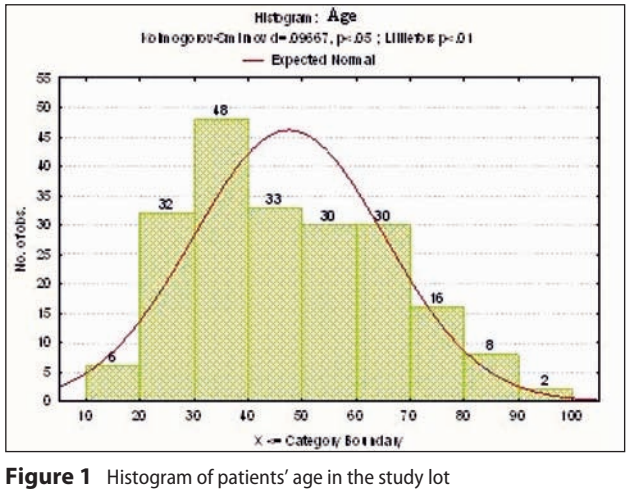

Figure 1 Histogram of patients' age in the study lot

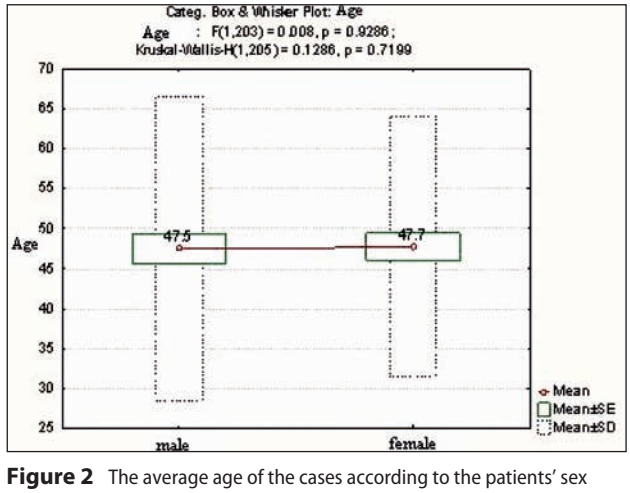

Figure 2 The average age of the cases according to the patients' sex

Table 1
Age-related statistical indicators in the study lot

	Age Mean	Mean		Std. Dev.	Std Err.	Min	Max	Q25	Median	Q75
		-95%	+95%							
Male	47.51	43.89	51.13	18.97	1.83	20.00	91.00	32.00	44.50	63.00
Female	47.73	44.45	51.02	16.29	1.65	18.00	82.00	35.00	48.00	60.00
All Groups	47.61	45.18	50.05	17.71	1.24	18.00	91.00	34.00	45.00	61.00

Table 2
The test comparing mean values vs. patients' sex

AGE	F (95% confidence interval)	p
ANOVA Test	0.008043	0.928626

Table 3
Cases distribution according to patients' sex

	No. of cases	%
Male	108	52.69%
Female	97	47.32%
Total	**205**	

(coronal, axial, sagittal), where the coronal plane is perpendicular to the palatine bone. The palatine bone was taken as the reference plane for the coronal acquisitions. For the axial plane, the orbitomeatal line has been selected as reference. Sections started from the anterior wall of the frontal sinuses to the posterior wall of the sphenoidal sinus. Coronal sections had 2 mm and axial ones 3 mm, providing accuracy in identifying the fine bone structures to be examined.

Milliamperage was between 60-100 mAs, commonly used in imaging protocols.

RESULTS

1. Type of angulation of the uncinate process

The angulation degree of the uncinate process was evaluated for the three variants, both on the left and right side (Table 1, Figure 1).

Approximately two-thirds of the uncinate processes, both on the right and left side, presented a normal angulation as compared to the sagittal plane (right prevalence of 77.56% and, respectively, 79.02% on the left).

Verticalization (lateralization) was noticed in 14/205 subjects on the left side (6.82%), versus 31/205 cases (15.12%) on the right side.

Horizontalization was dominant on the left (32/205, prevalence 15.61%) versus on the right (12/205, prevalence 6.86%).

In the studied group, all variants of angulation were present, in different degrees, most of the time asymmetric (Figures 2-5).

2. Pneumatization of the uncinate process (uncinate bulla)

Table 4
Case distribution according to angulation grade

Uncinate process angulation		No. of cases	%
Left	Normal	159	77.56%
	Vertical	14	6.83%
	Horizontal	32	15.61%
	205		
Right	Normal	162	79.02%
	Vertical	31	15.12%
	Horizontal	12	5.85%
	205		
	Total	205	

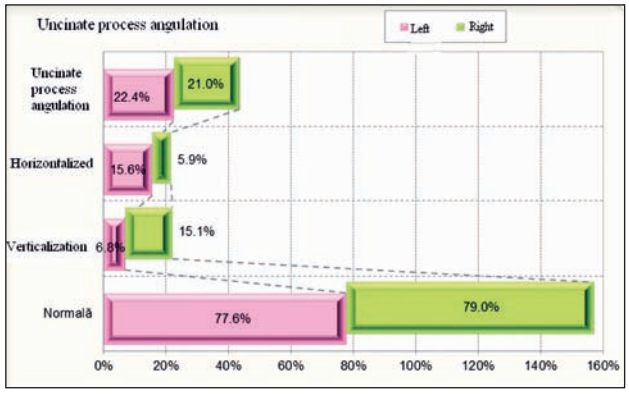

Figure 3 Case distribution according to uncinate process angulation

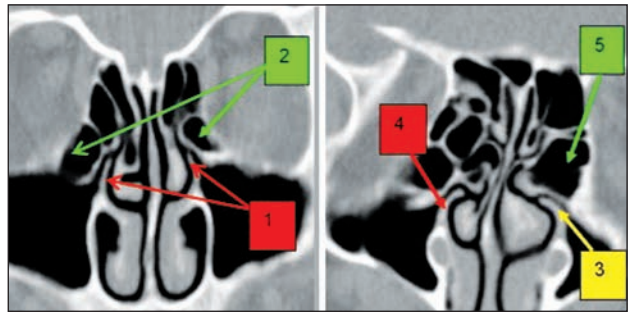

Figure 4 Paranasal sinuses CT scan, bone window, coronal slice. 1. normal angulation of the left uncinate process, right verticalization (lateralization); 2. bilateral Haller cell; 3. medialized left uncinate process (horizontalized); 4. normal angulation of the right uncinate process; 5. giant left ethmoid bulla

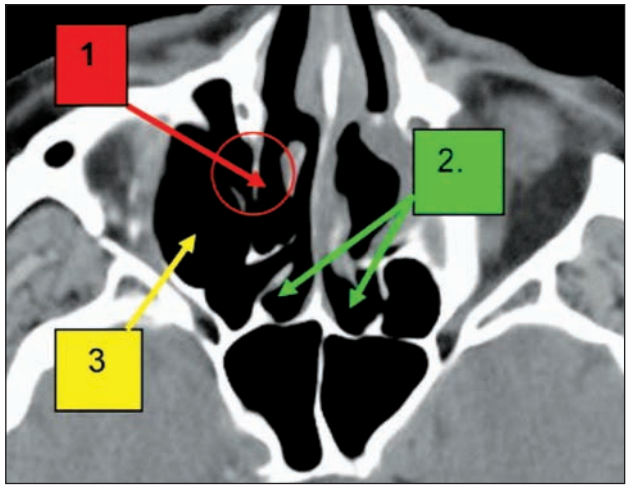

Figure 5 Paranasal sinuses CT scan, bone window, axial slice. 1. verticalization (lateralization) of the right uncinate process; 2. right posterior ethmoid sinus; 3. right maxillary sinus

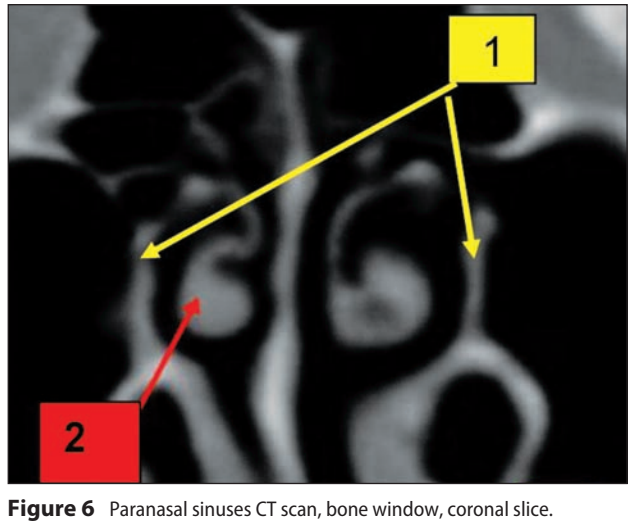

Figure 6 Paranasal sinuses CT scan, bone window, coronal slice. 1. Bilateral verticalization (lateralization) of the uncinate process; 2. Paradoxical curvature of the middle turbinate

Table 5
Case distribution according to the presence of the uncinate process pneumatization

Cranio-facial CT scan	No. of cases	%
Uncinate process pneumatization	7	3.41%
No pneumatisation of the uncinate process	198	96.59%
Total	**205**	

Pneumatization of the uncinate process (Tables 5-6, Figure 7) is another anatomical variant of this surgical landmark, possibly associated with decreased sinus ventilation[3,8,9,10], especially for the anterior ethmoid, the region of the ethmoidal infundibulum and of the frontal recess. The research identified the pneumatization of the uncinate process in 7/205 cases (prevalence of 3.41%), 4 men (1.95%) and 3 women (1.46%). Bilateral pneumatization of the uncinate process was present in 3/205 subjects (1.46%) and the unilateral variant in 4/205 cases (1.95%). In the studied group, the cases of unilaterally pneumatized unci-

Table 6
Case repartition according to the uncinate process pneumatisation type

UNCINATE PROCESS PNEUMATIZATION	No. of cases	%
No pneumatisation of the uncinate process	198	96.59%
Unilateral	4	1.95%
Left	4	1.95%
Right	-	-
Bilateral	3	1.46%
Total	**205**	

Table 7
Age-related statistical indicators according to the uncinate process pneumatization

Uncinate process pneumatization	Age Mean	Std. Dev.	Min	Max
Absent	34.50	16.52	18.00	56.00
Present	45.67	26.39	28.00	76.00
Total in the study lot	**39.29**	**20.11**	**18.00**	**76.00**

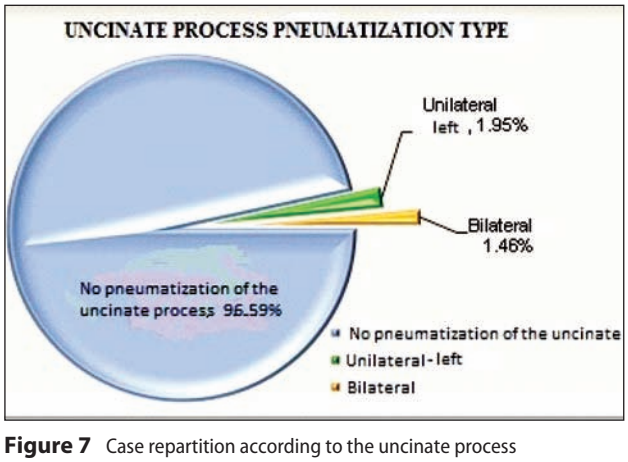

Figure 7 Case repartition according to the uncinate process pneumatisation type

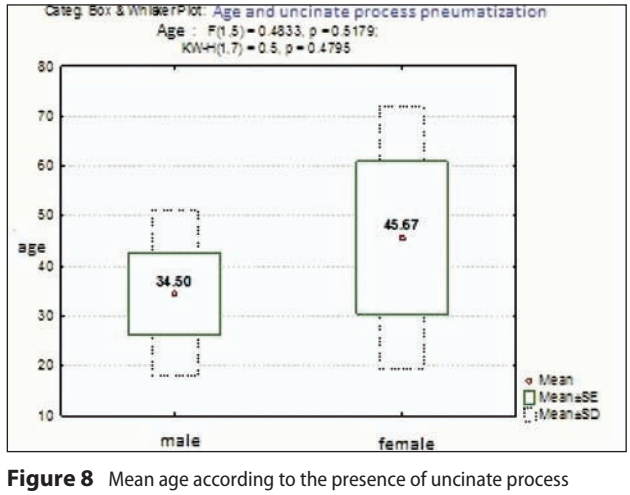

Figure 8 Mean age according to the presence of uncinate process pneumatization

Table 8
The test comparing the mean age values vs. presence of the uncinate process pneumatization

AGE	F (95% confidence interval)	p
ANOVA test	3.483260	0.0417925

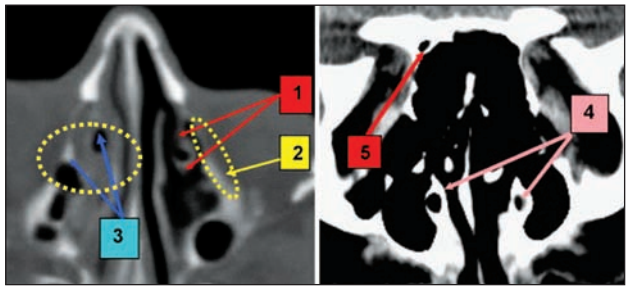

Figure 9 Paranasal sinuses CT scan: 1. pneumatised left uncinate process, adherent to the lamina papyracea; 2. lamina papyracea; 3. inflammatory process in the right anterior ethmoidal cells; 4. bilateral pneumatization of the uncinate process, verticalization; 5. pneumatization of the clinoid process

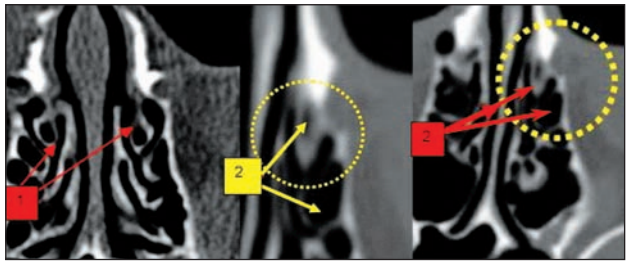

Figure 11 Paranasal sinuses CT scan, bone window, axial slices: 1. bilateral pneumatization of the uncinate process; 2. pneumatized left uncinate process associated with giant left ethmoid bulla

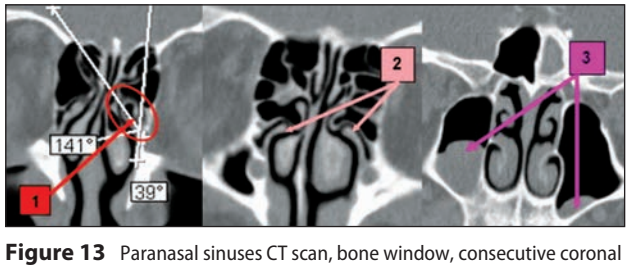

Figure 13 Paranasal sinuses CT scan, bone window, consecutive coronal slices: 1. uncinate process pneumatisation, medialization (39° angle); 2. bilateral medialization of the uncinate process inserted on a giant ethmoid bulla; 3. bilateral maxillary sinus inflammatory process

nate process were exclusively on the left. Figures 9-13 reveal various imagistic aspects of this anatomical variant.

3. Variants of superior insertion of the uncinate process

Study results of the different types of superior insertion of the uncinate process are presented in Table 9.

Figures14-22 present different anatomical variants of superior insertion of the uncinate process.

4. Deformation of the extremity of the uncinate process

The free extremity of the uncinate process may present deformations in the shape of a "hook" or a "cudgel", a bifid appearance, also revealed by images in Figures 23-25 form the group casuistry.

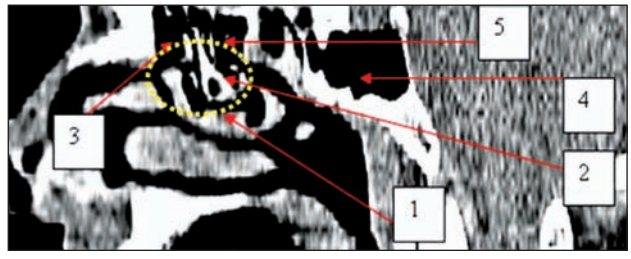

Figure 10 Paranasal sinuses CT scan, left sagittal reconstruction: 1. trilocular concha bullosa; 2. pneumatization of the uncinate process, elongated; 3. Agger nasi cell; 4. hype-pneumatization of the sphenoid sinus; 5. ethmoidal bulla

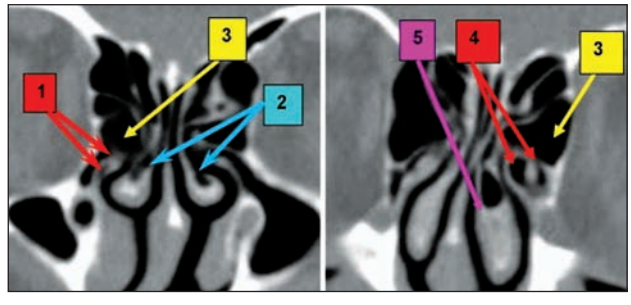

Figure 12 Paranasal sinuses CT scan, bone window, consecutive coronal slices: 1. right uncinate process pneumatization, adherent to the ethmoid bulla; 2. bilateral concha bullosa; 3. giant right ethmoid bulla; 4. left uncinate process pneumatization, adherent to giant ethmoid bulla; 5. left concha bullosa. N.B. Corroborating data from this case show a bilateral pneumatization of the uncinate process and bilateral concha bullosa, but at different levels

DISCUSSIONS

A. Degree of angulation

Depending on the degree of angulation in the sagittal plane, the uncinate process has three anatomical variants:

1. normal angulation: between 100-300;

2. medialization – angulation <300: when it incurves medially and becomes horizontalized, the angle increases over 300, and the uncinate process participates in forming a variant of the middle turbinate - the double turbinate - and may block mucociliary drainage, thereby affecting the ostiomeatal complex. It can be a predisposing factor for recurrent rhino-sinusitis, especially anterior ones;

3. lateralization or verticalization – angulation <100.

Saunders CN, Martin A., Birchall AM, Susan J. Armstrong, Killingback N, Singh DG[9] make morphometric research in order to reveal the role of morphology of the paranasal sinuses in the pathogenesis of chronic rhinosinusitis. They perform a multivariate analysis of 8 landmarks of the ostiomeatal complex (the left and right supraorbital margins, the junction of the ethmoi-

Table 9
Case distribution according to the different types of superior insertion of the uncinate process

	Superior insertion of the uncinate process	No. of cases	%
Left	Into the lamina papyracea	52	25.37%
	Into the middle turbinate	34	16.59%
	Into the skull base	12	5.85%
	Multiple insertions	7	3.41%
	Other insertions (superior turbinate, ethmoid bulla)	5	2.44%
Right	Into the lamina papyracea	48	23.41%
	Into the middle turbinate	20	9.76%
	Into the skull base	10	4.88%
	Multiple insertions	5	2.44%
	Onther insertions (superior turbinate, ethmoid bulla)	3	1.46%

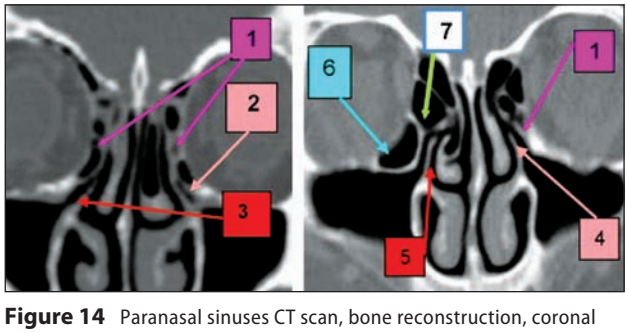

Figure 14 Paranasal sinuses CT scan, bone reconstruction, coronal slices: 1. left lamina papyracea; 2. left uncinate process inserted into the lamina papyracea, adherent to the external nasal wall with maxillary sinus ostium obstruction; 3. right uncinate process inserted into the lamina papyracea; 4. left uncinate process inserted into the lamina papyracea; 5. right uncinate process inserted into the ethmoid bulla; 6. Haller cell; 7. ethmoid bulla

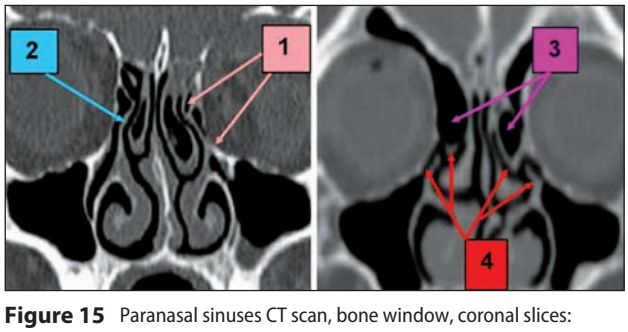

Figure 15 Paranasal sinuses CT scan, bone window, coronal slices: 1. superior insertion of the left uncinate process into the pneumatized superior turbinate and lamina papyracea; 2. superior insertion on the right uncinate process into the lamina papyracea; 3. bilateral pneumatization of the superior turbinate; 4. bilateral superior insertion of the uncinate process into the pneumatized superior turbinate and lamina papyracea

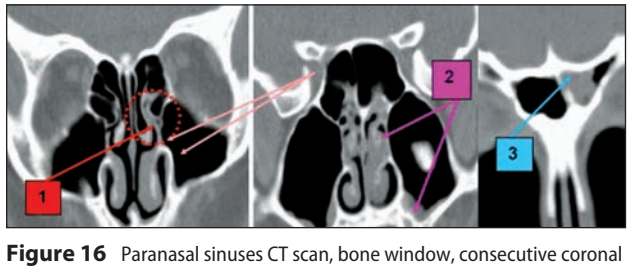

Figure 16 Paranasal sinuses CT scan, bone window, consecutive coronal slices: 1. pneumatized left uncinate process inserted into concha bullosa and ethmoid bulla, with narrowed uncinate sulcus; 2. left maxillary sinus and bilateral ethmoid sinus inflammatory process; 3. left frontal sinus inflammatory process

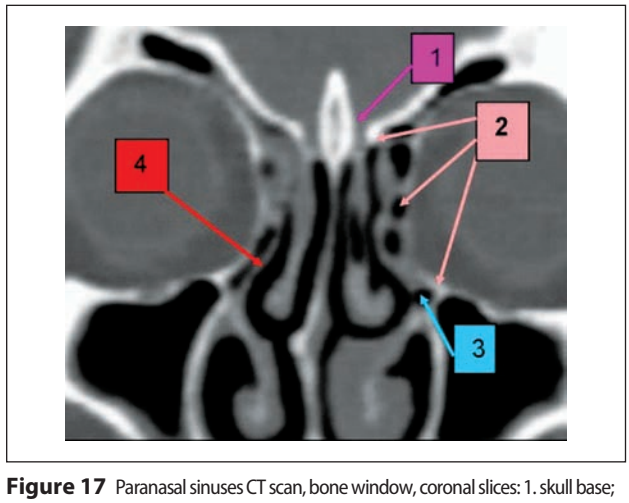

Figure 17 Paranasal sinuses CT scan, bone window, coronal slices: 1. skull base; 2. left uncinate process inserted on skull base, lamina papyracea, Haller cell, being adherent to the internal wall of the maxillary sinus; 3. left Haller cell; 4. right uncinate process inserted on lamina papyracea, narrowing the etmoidal infundibulum

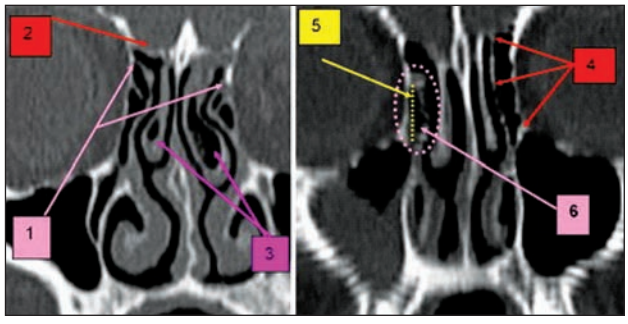

Figure 18 Paranasal sinuses CT scan: 1. bilateral uncinateprocess insertion into lamina papyracea; 2. skull base; 3. bilateral concha bullosa; 4. left uncinate process inserted on skull base, adherent to lamina papyracea; 5. lamina papyracea; 6. right uncinate process insertion on lamina papyracea

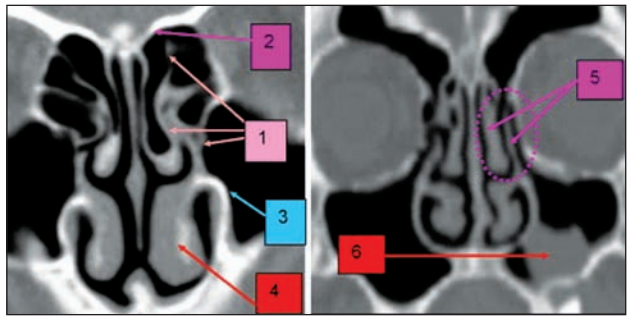

Figure 19 Paranasal sinuses CT scan, bone window, coronal slices: 1. left uncinate process multiple insertion into the middle turbinate, skull base, external wall of the nasal fossa; 2. skull base; 3. maxillary sinus; 4. hypertrophy of the left inferior turbinate; 5. left uncinate process insertion into the lamina papyracea, as part of the double turbinate (duplicate); 6. left maxillary sinus inflammatory process

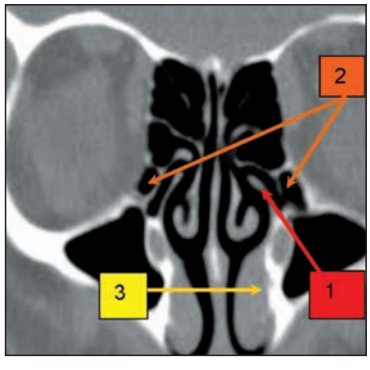

Figure 20 Paranasal sinuses CT scan, bone window, coronal slice: 1. Left uncinate process adherent to a Haller cell, with insertion into the ethmoid bulla; 2. bilateral Haller cell; 3. hypertrophy of the left inferior turbinate

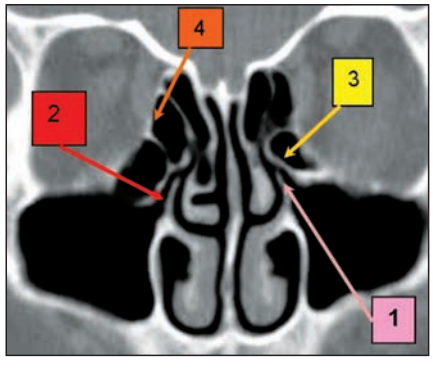

Figure 21 Paranasal sinuses CT scan, bone window, coronal slice: 1. Hyperpneumatization of Haller cell; 2. right uncinate process inserted into the giant ethmoid bulla; 3. left Haller cell; 4. left giant ethmoid bulla

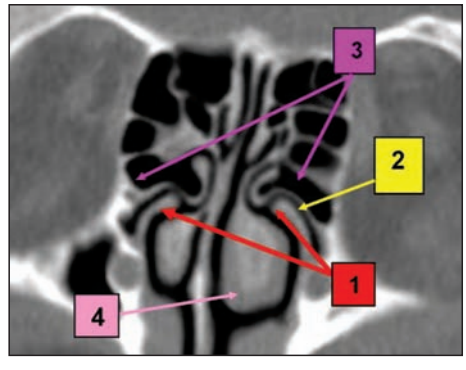

Figure 22 Paranasal sinuses CT scan, bone window, coronal slice: 1. bilateral curved uncinate process, medialized, inserted superior into the ethmoid bulla; 2. left narrowed uncinate sulcus; 3. hypertrophic, deformed ethmoid bulla; 4. important hypertrophy of the left middle turbinate

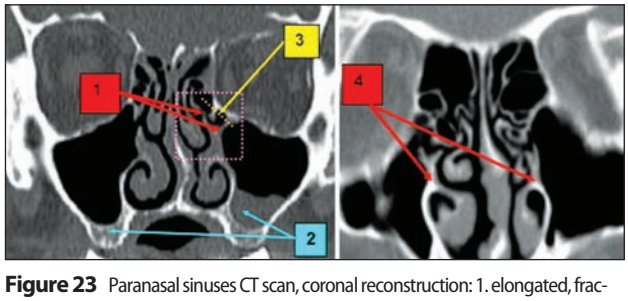

Figure 23 Paranasal sinuses CT scan, coronal reconstruction: 1. elongated, fractured, left uncinate process, inserted into the lamina papyracea; 2. pathologic process in the maxillary sinuses; 3. lamina papyracea; 4. bilateral bifid uncinate process

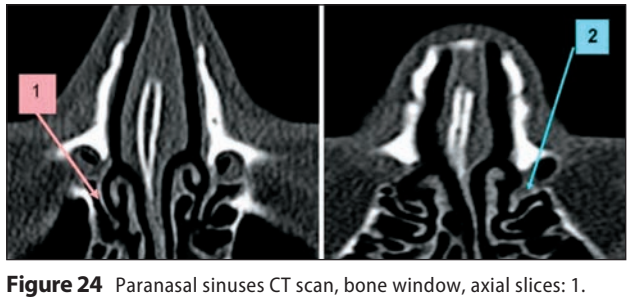

Figure 24 Paranasal sinuses CT scan, bone window, axial slices: 1. curved uncinate process, with "hook" extremity deformation; 2. deformation and thickening of the the left uncinate process

dal bulla and the lamina papyracea, the margin of the ethmoidal bulla opposite the uncinate process, the inferior margin of the middle turbinate, the point where the uncinate process inserts into the inferior turbinate, the lateral side of the middle turbinate opposite the uncinate process) and the tip of the uncinate process. Their first results show that there are no anatomical differences within the ostiomeatal complex between patients with and without rhinosinusitis. Nevertheless, those who develop rhinosinusitis present a significantly lateralized uncinate process. The results obtained are consistent with those of Stammberger[10], who considers that lateral placement of the uncinate process can cause narrowing of the maxillary sinus ostium and leads to mucociliary contact, which predispose to the blockage of sinus drainage.

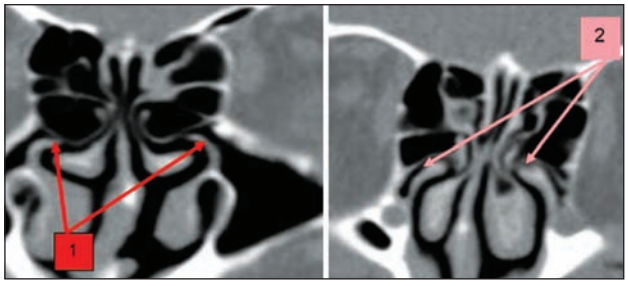

Figure 25 Paranasal sinuses CT scan, coronal bone reconstruction. Free margin deformity of the uncinate process: 1. "hook"shape; 2. "cudgel" shape

In the series of patients studied, about two-thirds of the uncinate processes, both on the right and left side, presented a normal angulation as compared to the sagittal plane (right prevalence of 77.56% and, respectively, 79.02% on the left).

Verticalization (lateralization), in 14 subjects, had a prevalence of 6.82% on the left side versus 15.12% on the right side, while medialization (horizontalization) was more frequent on the left, having been identified in 32 patients, with a prevalence of 15.61%, versus on the right, in 12 patients and a prevalence of 6.86%.

We found that, in most of the cases, lateralization of the uncinate process led to abnormal development of the ethmoidal bulla, which became gigantic, obstructing the middle meatus and the ethmoidal infundibulum.

B. Pneumatization of the uncinate process

Imaging studies performed with accuracy suggest that pneumatization of the uncinate process occurs due to hyperpneumatization of the agger nasi cell in its postero-superior portion (that is in the antero-superior region of the uncinate process).

The lowest value of 2.5% is given by Bolger and colleagues[5], in 202 patients. Arslan and colleagues[11] found a percentage of 4 in 200 patients, Earwaker[2] of 9.1 in the largest group of 800 patients; Riello and Boasquevisque[5] mention a prevalence of 13% in 200 patients. In the studied group, pneumatization was found in 7 patients, with a value of 3.41%, left forms being predominant.

C. Variants of superior insertion of the uncinate process

There are several variants described of superior insertion of the uncinate process.

Three possibilities are classically accepted, listed in descending order of frequency:

1. on the papyracea lamina;
2. on the skull base;
3. in the middle turbinate insertion.

There are also various combinations of the aforementioned situations or other variants less revealed by different studies (for example, on a concha bullosa of the superior turbinate).

All classical anatomical variants of superior insertion of the uncinate process, as well as combinations of these, were found.

In a study conducted on 800 cases, Earwaker[2,11] provides a detailed description of the variants of superior insertion of the uncinate process, by classifying them according to the association with other variants of the ostiomeatal complex (ethmoid bulla, middle turbinate, septal deviation, degrees of angulation of the uncinate process). When the uncinate process inserts into the papyracea lamina, maxillary sinus drainage may be affected[2,12].

If insertion is made into the middle turbinate or in the ethmoid riddled blade, a mechanism of sinus mucus recirculation appears, which may also affect drainage of the maxillary or frontal-homolateral sinus. This can be illustrated by the case of a 32 years old woman patient, having insertion of the left uncinate process into the aerated middle turbinate (an extensive concha bullosa with drainage into the frontal recess), while insertion of the verticalized uncinate process is made into the ethmoidal bulla. Both variants of superior insertion of the uncinate process may affect drainage of the frontal or maxillary sinus. Together with these physiopathological elements, the patient shows imaging signs of bilateral, ethmoid and left frontal maxillary rhinosinusitis.

The uncinate process may superiorly insert into the middle turbinate when it medially incurves in most of its upper portion. In these rare cases, the superior part of the uncinate process may insert in more points into three structures equally: middle turbinate, skull base, lateral nasal wall.

Among the anatomical variants of the uncinate process, according to different criteria, the most common is the insertion into an unusual topographic area and pneumatization. The uncinate process is a bone lamella that belongs to the anterior ethmoid and normally has an insertion into the postero-medial wall of the agger nasi cell[2,3]. When insertion appears into other structures, the infundibulum may take the appearance of a cul-de-sac. McLaughlin, Rehl RM, Lanza DC[12] and Earwaker[2] consider that when insertion of the uncinate process is into the papyracea lamina, this anatomical variant may affect maxillary sinus drainage. Riello and Boasquevisque[4] found such a variant with impaired sinus drainage in only one case.

In the literature, there are various reports concerning individual variations between the configuration of the ethmoid bulla or of the uncinate process[13,14].

In the studied group, the anatomical variants of superior insertion of the uncinate process, both on the left and right side, had a higher frequency into the papyracea lamina (25.36% on the left, 23.41% on the

right), followed by those into the middle turbinate (16.58% on the left, 9.75% on the right) or the skull base (5.85% on the left, 4.87% on the right), multiple insertions, insertions into the ethmoidal bulla or the superior turbinate, which registered very small percentage.

CONCLUSIONS

1. Approximately two-thirds of the uncinate processes, both on the right and left side, presented a normal angulation as compared to the sagittal plane (with a right prevalence of 77.56% and, respectively, 79.02% on the left).

2. Verticalization of the uncinate process was more frequent on the right side (15.12%) than on the left (6.82%), while medialization (horizontalization) was more frequent on the left (15.61%) versus the right side (6.86%).

3. Pneumatization of the uncinate process (uncinate bulla) is a very rare anatomical variant, with a prevalence of 3.41%, prevailing left unilateral forms.

4. Anatomical variants of superior insertion of the uncinate process had a higher frequency into the papyracea lamina (25.36% on the left, 23.41% on the right), followed by those into the middle turbinate (16.58% on the left, 9.75% on the right) or the skull base (5.85% on the left, 4.87% on the right), multiple insertions, insertions into the ethmoidal bulla or the superior turbinate, which registered very small percentage.

REFERENCES

1. Mafee M.F. Endoscopic Sinus Surgery: Role of the Radiologist. Am. J. Neuroradiol, 1991;12:855-60.
2. Earwaker J. - Anatomic variants in sinonasal CT. Radio Graphics, 1993;13:381-415.
3. Zinreich S.J., Albayram S., Benson M., et al. - The Ostiomeatal Complex And Functional Endoscopic Surgery. In: Som Pm, Curtin Hd, Editors. Head And Neck Imaging. 4th Ed. St. Louis: Mosby, 2003; 149-74.
4. De Freitas Linhares Riello A.P., Boasquevisque Me. - Anatomical Variants Of The Ostiomeatal Complex: Tomographic Findings In 200 Patients. Radiologia Brasileira Vol.41, No.3. São Paulo. May/June 2008.
5. Bolger W.E., Butzin C.A., Parsons D. S. - Paranasal Sinus Bony Anatomic Variations And Mucosal Abnormalities: CT Analysis For Endoscopic Sinussurgery. Laryngoscope, 1991;101:56-64.
6. Kennedy D.W., Zinreich Sj, - Functional Endoscopic Approach To Inflammatory Sinus Desease: Current Perspectives And Technique Modifications. Am J Rhinol., 1988; 2:89-96.
7. Kantarci M., Karasen M., R., Alper F., Onbas O., Okur A., Karaman A. - Remarkable Anatomic Variations In Paranasal Sinus Region And Their Clinical Importance. European Journal OfRadiology. 2004;50:296-302.
8. Laine F.J., Smoker W.R.K. - The ostiomeatal unit and endoscopic surgery: Anatomy,variations, and imaging findings in inflammatory diseases. American Journal of Roentgenology, 1992;159:849-857.
9. Saunders C.N., Martin A., Birchall A.M., Armstrong S.J., Killingback N., Singh D.G. - Morphometry of Paranasal Sinus Anatomyin Chronic Rhinosinusitis. Arch Otolaryngol Head Neck Surg., 1998;124:656-658.
10. Stammberger H. - Functional Endoscopic Sinus Surgery; Philadelphia: Marcel Dekker; 1991:160-169.
11. Arslan H., Aydinlioglu A., Bozkurt M., et al. - Anatomic variations ofthe paranasal sinuses: CT examination for endoscopic sinus surgery. Auris Nasus Larynx., 1999; 26:39–48.
12. Mclaughlin R.B. Jr, Rehl R.M., Lanza D.C. - Clinically Relevant Frontal Sinus Anatomy And Physiology. Otolaryngol Clin North Am., 2001;(34):1-22. 380
13. Messerklinger W. - Endoscopy of the Nose. Baltimore: Urban & Schwarzenberg, 1978.
14. Stammberger H., Wolf G. - Headaches and sinus disease: the endoscopic approach. Ann Otol Rhinol Laryngol Suppl, 1988;134:3–23.