ORIGINAL STUDY

Pneumatization of the inferior turbinate - imaging study

Vasilica Baldea[1], **M. D. Cobzeanu**[2], **Mihaela Moscalu**[3]

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

[2]University of Medicine and Pharmacy Iasi, ENT Departament, "Sfantu Spiridon" Emergency Hospital, Iasi, Romania

[3]University of Medicine and Pharmacy, Department of Medical Informatics and Biostatistics, Iasi, Romania

ABSTRACT

BACKGROUND. Pneumatization of the inferior turbinate is a very rare intranasal, extrasinusal anatomic variant, usually discovered by imaging. The pneumatization of the inferior turbinates implies the presence of a well-defined aerated cavity, with variable shape and dimensions. Therapeutic attitude depends on symptoms and the relationship between the pneumatization and paranasal sinuses.

MATERIAL AND METHOD. We conducted a retrospective anatomo-imagistic study, for a period of 2 years, on 205 CT scans having as target organ the face sinuses region, in symptomatic adult patients, aged between 18 and 91 years, out of which 97 were women (47,32%), and 108 men (52,68%). The cranio-facial CT scans were made with a spiral, multiplan, high resolution technique.

RESULTS. The research found 10 cases with inferior turbinate pneumatization, with a prevalence of 4.88% , out of which 6 women (2.92%) and 4 men (1.95%). Statistical analysis showed that there is a slight predisposition of females for inferior turbinate pneumatization (RR=1.67). Most of the subjects presented more extrasinusal pneumatizations, anatomic variants of the endoscopic surgical landmarks involved in a possible etiology of rhino-sinusitis or of increased surgical risk. Given its rarity and sporadic reports in the literature, we will describe, by means of a suggestive iconography, all identified cases of inferior turbinate pneumatization.

CONCLUSIONS. Inferior turbinate pneumatization is a rare anatomic variant present in both sexes, with drainage into the inferior meatus, that may or may not communicate with the ipsilateral maxillary sinus. It can be unilateral or bilateral, isolated or associated with pneumatization of one or more nasal turbinates, with other extrasinusal pneumatizations or sinusal hyperpneumatizations of the rhino-sinusal structures and its diagnosis is entirely imagistic, best on coronal CT.

INTRODUCTION

Pneumatization of the inferior turbinate is a very rare intranasal, extrasinusal anatomic variant, usually discovered by imaging, when an etiologic review of a nasal respiratory failure or of a recurrent chronic rhino-sinusitis is performed.

The inferior turbinate, a triangular bone independent of the ethmoid, inserted into the turbinal crest of the upper jaw through its upper edge, laterally delineates the inferior meatus; it represents an important anatomic landmark for the lacrimonasal duct, which has the nasal opening in the anterior meatal part[1]. With a mucosa having a cavernous-type vascular tissue, it is involved in the respiratory physiology, while through its anterior section, it takes part in the formation of the nasal valve, the narrowest region of the nasal passage[2].

Cranio-facial CT scans reveal the inferior turbinate, on its coronal slices, like a comma with tissue density, centered by a bone lamella, on both sides of the nasal septum; the axial slices are like two elongated ellipses, along the external wall of the nasal fossae, with various degrees of hypertrophy, with tissue density, centered by a bone column.

Pneumatization of the inferior turbinates implies the presence of a well-defined aerated cavity, with variable shape and dimensions, which can communicate

Corresponding author: Vasilica Baldea
email: etabaldea@yahoo.com

with the maxillary sinus when it is found in the middle section[3-7] and presents its own ostium. Otherwise, there is no such communication[8-9].

From a pathogenic point of view, pneumatization of the inferior turbinates can result by means of two mechanisms:

a) invagination and loculation of a fragment of embedded intraturbinal epithelium („vase clos") in the turbinate and isolated by ossification of the lamellas that represent the inferior turbinate[10];

b) extension of the pneumatization in the inferior turbinate starting from the insertion root on the maxillary, or alterations of the adjacent sinus ventilation (maxillary)[11].

Pneumatization can be unilateral or bilateral, isolated or associated with other turbinate and/or extrasinusal pneumatizations or other rhino-sinusal anomalies.

The diagnostic key is represented by the cranio-facial CT, coronal slices[12], that reveals pneumatization as a cavity with a well-defined contour, of airy density, rounded or having the shape of a comma with a thicker infero-internal end, and of variable dimensions. The pneumatization can be limited or extensive, with a single cell or multicellular, unilateral or bilateral[7]. Using the sagital reconstruction, one can observe the extent of the pneumatic cavities as compared to the turbinate as a whole. All three research plans emphasize its isolated character or multiple extrasinusal pneumatizations (middle turbinate, superior turbinate, crista galli apophysis)[13].

For the pneumatization of the inferior turbinate, Ozturc and collaborators[14] mention a prevalence of 1/250.

Therapeutic attitude depends on symptoms and the relationship between the pneumatization and paranasal sinuses[15,11]. If there are no clinical features, refraining from surgery is the rule[16].

AIM OF THE STUDY

In a retrospective imagistic study including 205 CT scans of the face sinuses region for ENT symptomatic patients, the research had the following objectives:

1. determining the prevalence of the inferior turbinate pneumatization;
2. the correlation between rhino-sinusitis and the inferior turbinate pneumatization;
3. identification of other extrasinusal pneumatizations or of certain anatomic variants of interest for the rhino-sinusal endoscopy.

MATERIAL AND METHOD

We conducted a retrospective anatomo-imagistic study, for a period of 2 years and 6 months (January 2008 - June 2010), on 205 CT scans having as target organ the face sinuses region, in symptomatic adult patients; they presented for an ENT consultation at the "N. Titulescu" Ambulatory, at the emergency room of the Buzau County Hospital or at the ENT Clinic of "Sf. Spiridon" Iasi Hospital and they performed this preoperative imagistic review in the profile centers from the counties of Buzau, Bucharest or Iasi.

We evaluated adult patients, aged between 18 and 91 years (with an average age of 47.61 years), out of which 97 were women (47,32%), and 108 men (52,68%). The results refer to a segment of the population (symptomatic ENT patients) and not to the general one.

For accurate images, the cranio-facial CT scans were made with a spiral, multiplan, high resolution technique, which allows complex bone reconstructions in 3 planes: the coronal plane perpendicular to the hard palate, the axial slices parallel to the hard palate, and the coronal slices perpendicular to the same previously mentioned landmark.

We considered inferior turbinate pneumatization the presence of any aerated cell at this level, regardless of size or location.

RESULTS

The present research found 10 cases with inferior turbinate pneumatization, in the 205 patients, with a prevalence of 4.88% (Table 1, Figure 1), out of which 6 women (6/205, with a percentage of 2.92%) and 4

Table 1
Case distribution according to the presence of inferior turbinate pneumatization

Cranio-facial CT scan	Case no.	%
Presence of inferior turbinate pneumatization	10	4.88%
Absence of inferior turbinate pneumatization	195	95.12%
Total	205	

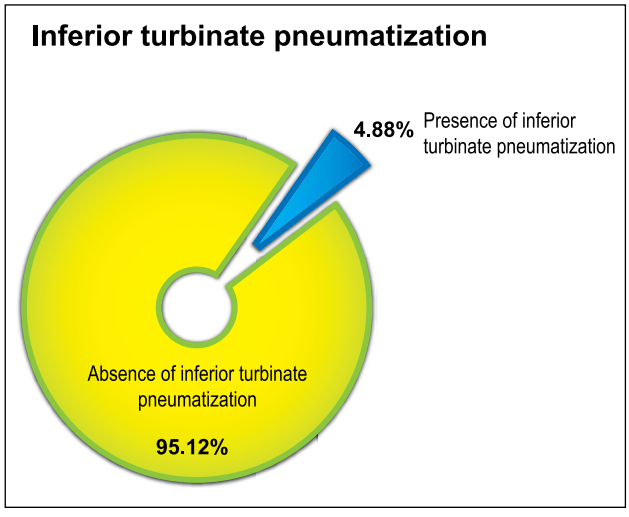

Figure 1 Case distribution according to the presence of inferior turbinate pneumatization

men (4/205, with a percentage of 1.95%) (Table 2, Figure 2).

Statistical analysis (Table 3, Table 4) showed that there is a slight predisposition of females for inferior turbinate pneumatization (RR=1.67), but one cannot consider that there is a significant association between this anatomic variant and females ($\chi 2$=0.687, p=0.4101, 95% CI).

Unilateral types were represented by 6 cases (2.93%), and the bilateral ones by 4 cases (1.95%) (Table 5, Figure 3).

Statistical indicators of the age of patients with inferior turbinate pneumatization are illustrated in Table 6.

The average age of patients with nasal inferior turbinate pneumatization (Table 7, Figure 4) was 42.1 years ± 19. Statistical indicators of the sex of patients presenting this anatomic variant are described in Tables 2-4 and in Figure 2, while indica-

Table 2
Case distribution according to the presence of inferior turbinate pneumatization vs. patients' sex

Patients	Inferior turbinate pneumatization		Total
	present	absent	
female	6	91	97
%	6.19%	93.81%	
male	4	104	108
%	3.70%	96.30%	
Total	10	195	205

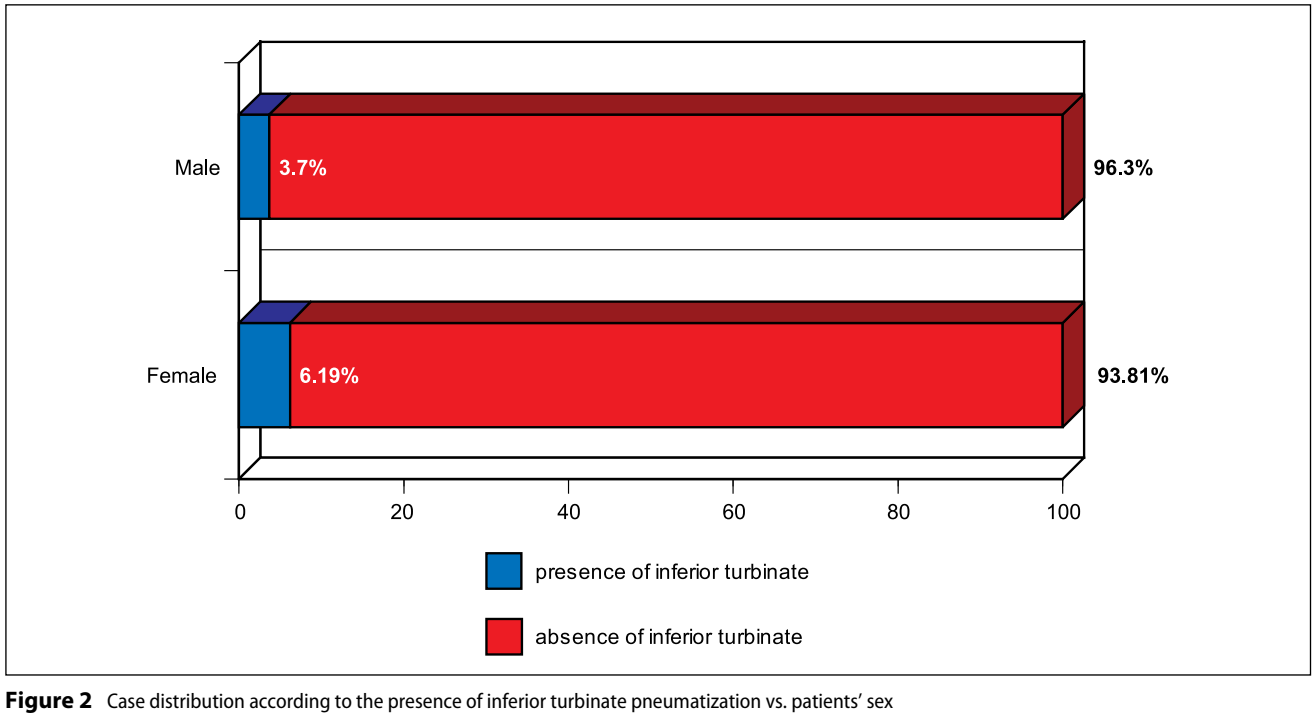

Figure 2 Case distribution according to the presence of inferior turbinate pneumatization vs. patients' sex

Table 3
Estimated parameters in associating patients ' sex vs. presence of inferior turbinate pneumatization

(df=1)	Chi-square χ^2	p 95% confidence interval
Yates Chi-square - χ2	0.687	0.4101465
Correlation coefficient (Spearman Rank R)	0.3547	0.3544412

Table 4
Estimating the parameters of confidence - inferior turbinate pneumatization vs. patients' sex

	Estimated value	95% Confidence interval	
		Minim	Maxim
PARAMETERS: Odd - based			
Odds Ratio (OR)	1.71	0.41	7.50
PARAMETERS: Risk - based			
Risk Ratio (RR)	1.67	0.49	5.74

Table 5
Case repartition according to the type of inferior turbinate pneumatization

INFERIOR TURBINATE PNEUMATIZATION	Case no.	%
Absence of inferior turbinate pneumatization	195	95.12%
Unilateral	6	2.93%
Left	2	0.98%
Right	4	1.95%
Bilateral	4	1.95%
Total	205	

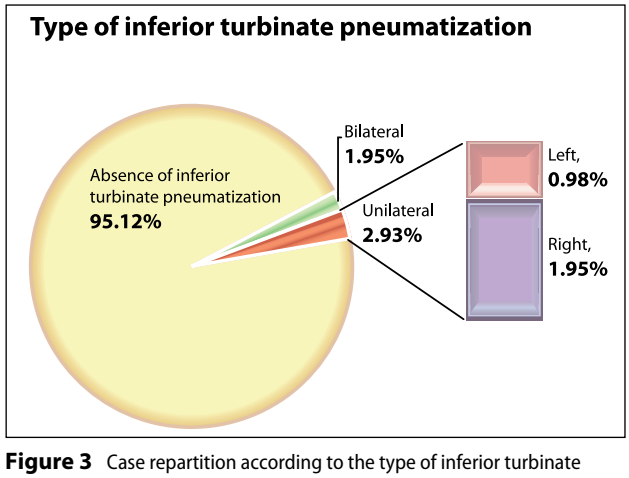

Figure 3 Case repartition according to the type of inferior turbinate pneumatization

tors of age in Tables 6-7 and in Figure 4. Communication with the maxillary sinus was found in 6 cases, with equal representation on the left vs. right side. Most of the subjects presented more extrasinusal pneumatizations to which were added other anatomic variants of the endoscopic surgical landmarks involved in a possible etiology of rhinosinusitis or of increased surgical risk.

The test for comparing average values of age vs. presence of the inferior turbinate pneumatization (Anova Test) shows that this anomaly can be identified at all ages (Table 7).

Given its rarity and sporadic reports in the literature, we will describe, by means of a suggestive iconography, all identified cases of inferior turbinate pneumatization

Table 6
Age related statistical indicators according to the inferior turbinate pneumatization

Inferior turbinate pneumatization	Mean age	Std. Dev.	Min	Max
Absent	47.7	17.6	18	91
Present	42.1	19.0	23	81
Total	47.5	17.7	18	91

Table 7
The test comparing age average values and the presence of inferior turbinate pneumatization

Age	F (95% confidence interval)	p
ANOVA test	0.666551	0.415214

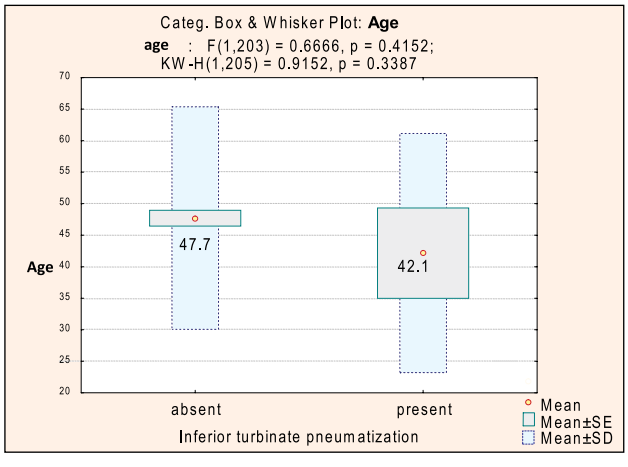

Figure 4 The mean age according with the presence of pneumatized inferior turbinate

CASE 1

It is a 48 year-old female patient (Figure 5), with right inferior turbinate pneumatization, nasal septum deviation, hypoplasia of the left inferior turbinate and deformation of the left maxillary sinus internal wall, without any other nasal turbinates pneumatizations. Other anatomic variants of clinical and therapeutic interest are associated at this level: type VII nasal septum deviation, having the septal crests situated on the left side, with the septum concavity at the level of the inferior turbinate pneumatization; hypotrophic, deformed left inferior turbinate, in contact with in the septal crest; the internal wall of the left maxillary sinus with a distorted "Z" form and an intrasinus septum. As in the concha bullosa case, inferior turbinate pneumatization may also be accompanied by a septal deviation, most often a contralateral one.

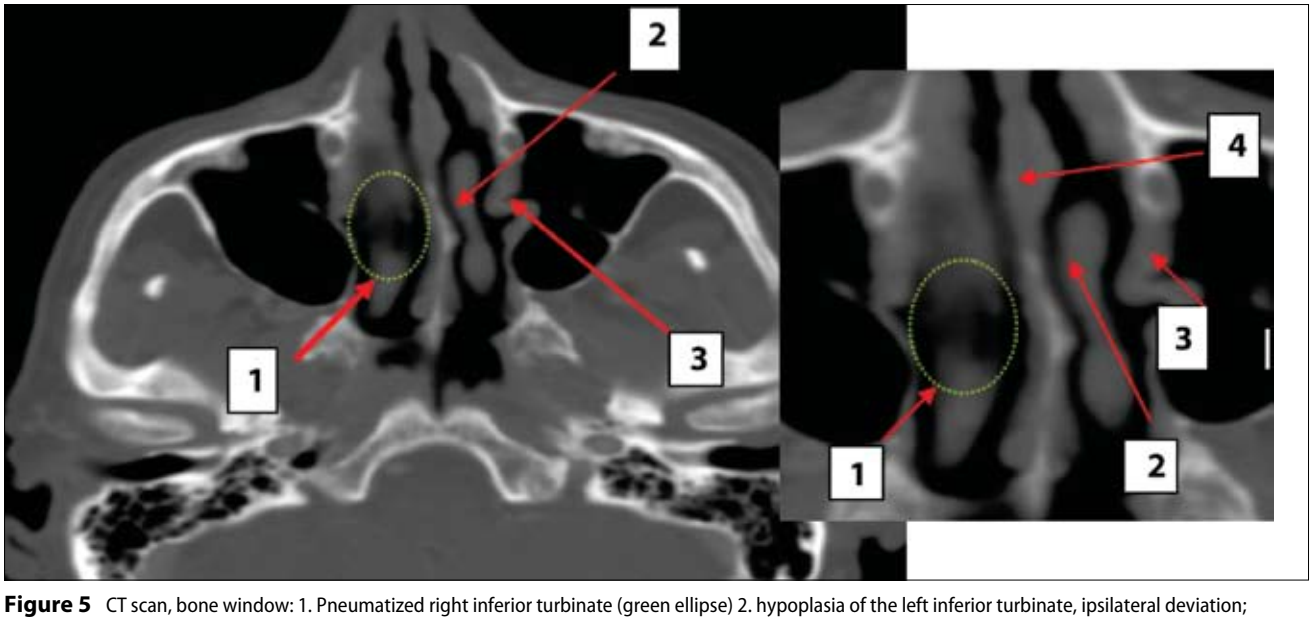

Figure 5 CT scan, bone window: 1. Pneumatized right inferior turbinate (green ellipse) 2. hypoplasia of the left inferior turbinate, ipsilateral deviation; 3."Z"deformity of the external wall of the left nasal fossa; 4. Right naterior and posterior nasal septum deviation (Type VII)

CASE 2

It is a 30 year-old female patient with a bilateral pneumatization of the inferior turbinates (Figure 6a) associated with a right concha bullosa, left type III nasal septum deviation and hypoplasia of the left middle turbinate (Figures 6b-c). Pneumatization of the left inferior turbinate communicates with the maxillary sinus (Figure 6b).

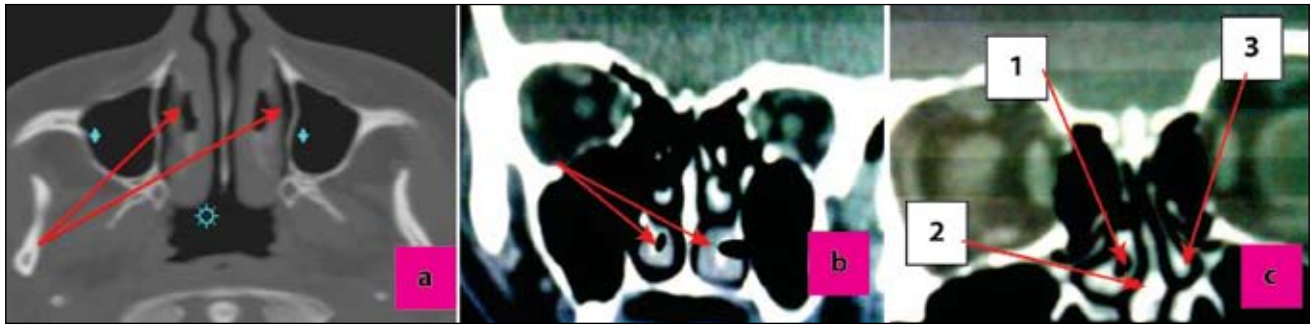

Figure 6 Cranio-facial CT scan, bone window, axial slice (a) and coronal reconstruction (b, c): a) bilateral inferior turbinate pneumatization (red arrow): on this slice, at this level can't be identified the communication with the maxillary sinus; maxillary sinus (♦); rhinopharynx (☼); b) on te coronal reconstruction (red arrow) the communication with the left maxillary sinus can be seen;the pneumatization of the right inferior turbinate remains isolated by the sinus. c) 1. Right concha bullosa; 2. Left nasal septum deviation, on the other side of the middle turbinate pneumatization; 3.hypertrophy of the left middle turbinate

CASE 3

It is a 26 year-old male patient (Figures 7-10) with the pneumatization of the left inferior, middle and superior turbinate (Figure 7), with a pathological process of the left maxillary sinus; due to the right pansinusitis, one cannot make assessments regarding the nasal fossa and the right paranasal sinuses. We have however selected the case for the interesting and rare association of the pneumatization of the three usual left nasal turbinates; this can be observed in Figure 7, in a coronal reconstruction at the level of the turbinates head. The pneumatized left superior turbinate is inserted into the lamina papyracea.

The two successive axial slices (Figure 8) initially show a posterior pneumatization of the left inferior

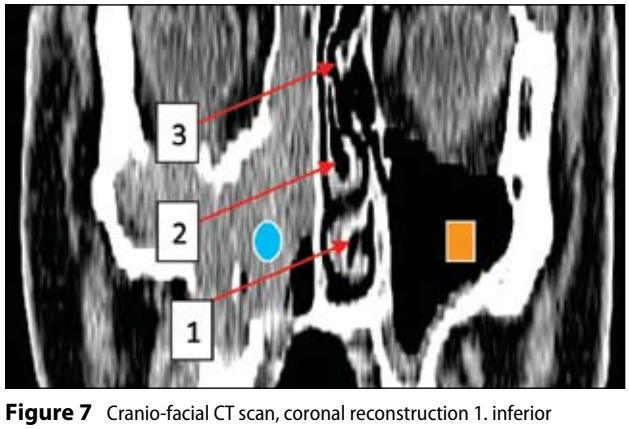

Figure 7 Cranio-facial CT scan, coronal reconstruction 1. inferior turbinate pneumatization; 2. middle turbinate pneumatization; 3. superior nasal turbinate pneumatization; left maxillary sinus (yellow square)with hypertrophyc mucosa; right pansinusitis (blue sphere)

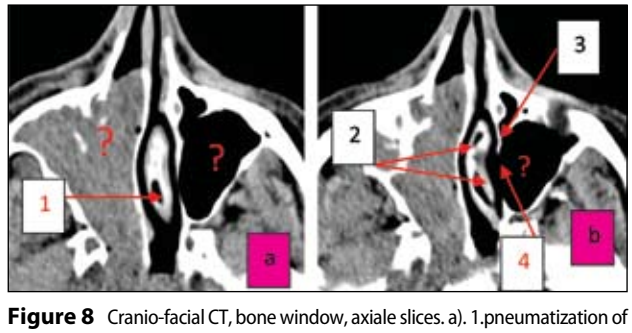

Figure 8 Cranio-facial CT, bone window, axiale slices. a). 1.pneumatization of the posterior third of the inferior turbinate - one cell; pathological right maxillary sinus (●); left maxillary sinus (▼); b 2. Pneumatization of the inferior turbinate - 2 cells; 3. Left uncinate process; 4. Communication between the pneumatized inferior turbinate and left maxillary sinus

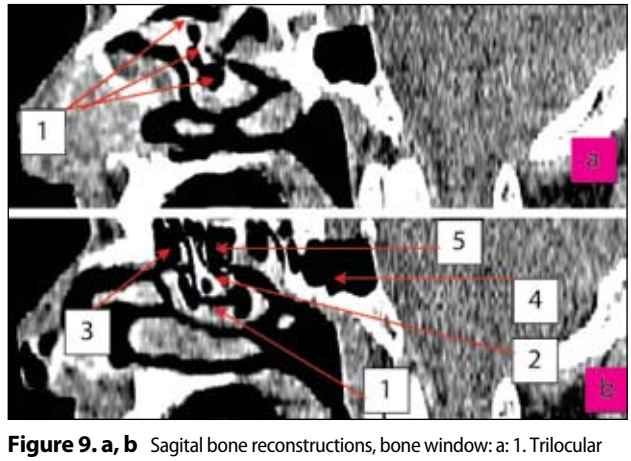

Figure 9. a, b Sagital bone reconstructions, bone window: a: 1. Trilocular concha bullosa (formed by three cells); b: 1. Trilocular concha bullosa, over which the left uncinate apophyse is projecting; 2. Pneumatized left uncinate apophyse, elongated; 3. Left agger nasi cell, hyperpneumatized; 4. Hyperpneumatization of the sphenoid sinus; 5. Pneumatization of the ethmoid bulla

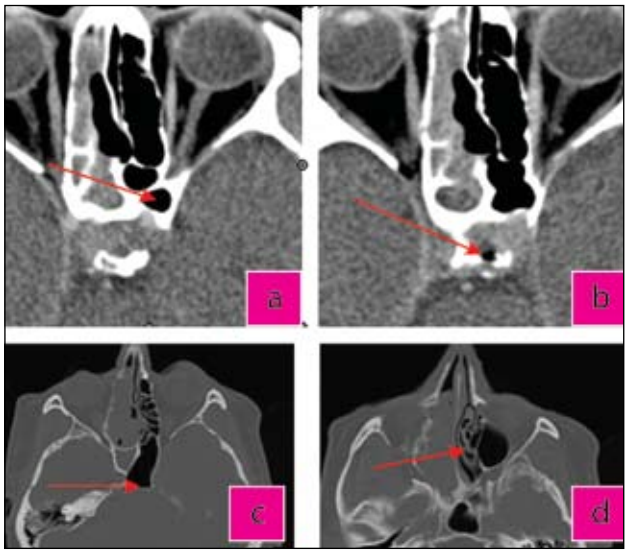

Figure 10. a, b, c, d Cranio-facial CT, axial slices. a,b: tissue window;c,d: bone window. a. Pneumatization of the left anterior clinoid process; b. partial pneumatization of dorsum sellae; c.Hyperpneumatization of the left sphenoid sinus, posterior development towards dorsum sellae; d. concha inside the left concha bullosa

turbinate, then a double pneumatization (anterior and posterior), as well as a wide communication with the homolateral maxillary sinus. The unciform apophysis is verticalized, with the distal end in the hook.

The sagittal reconstructions (Figure 9) identify the following associations: extensive trilocular left concha bullosa, left sphenoidal pneumosinus, pneumatized uncinate process.

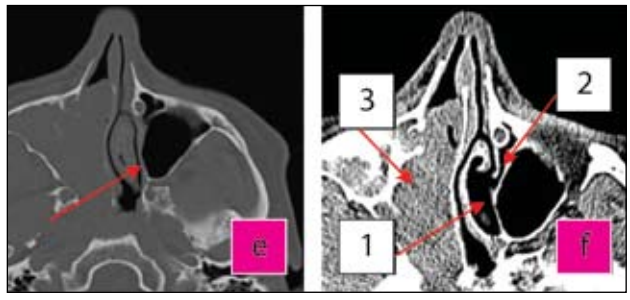

Figure 10. e, f Cranio-facial CT, axial slices; e. bone window: left inferior turbinate pneumatization (arrow); inflammatory process in the right maxillary sinus, anterior and posterior ethmoidal cells, intrasinus septum in the left maxillary sinus; f. tissue window:1.left concha bullosa opening in the middle meatus; 2. Left uncinat process in hook shape; 3. Pathologic right maxillary sinus

CASE 4

It is a 56 year-old male patient with medium third pneumatization of the left inferior turbinate associated with (Figures 11-13): contralateral type V nasal septum deviation, pneumatization of the left uncinate process, bilateral extensive concha bullosa, dorsum sellae pneumatization, hyperpneumatization of the right ethmoidal bulla, left sphenoidal pneumosinus dilatans, internal carotid arteries prolapsing bilaterally, sphenoidal intersinus septum inserted into the right internal carotid artery.

CASE 5

38 year-old male patient (Figure 14) with pneumatization of right inferior nasal turbinate, with drainage into the corresponding inferior meatus, without any opening into the maxillary sinus. It associates a bilateral pneumatization of the uncinate process.

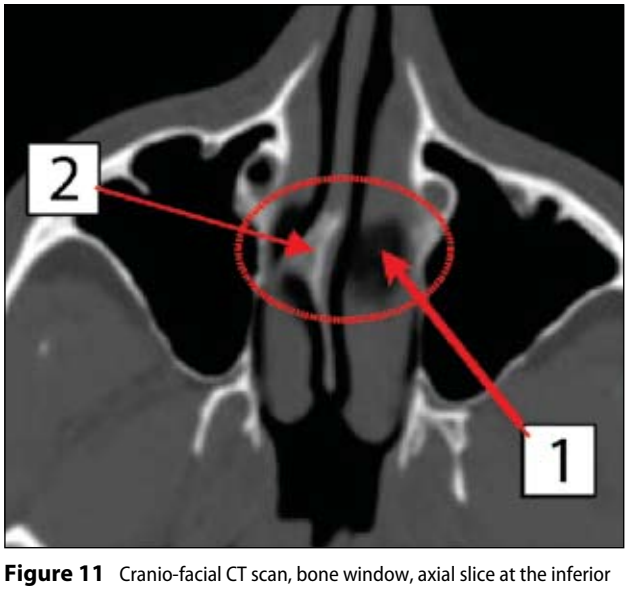

Figure 11 Cranio-facial CT scan, bone window, axial slice at the inferior turbinate level; 1.middle third pneumatization of the inferior turbinate; 2. Type V nasal septum deviation (on the other side of the pneumatized inferior turbinate)

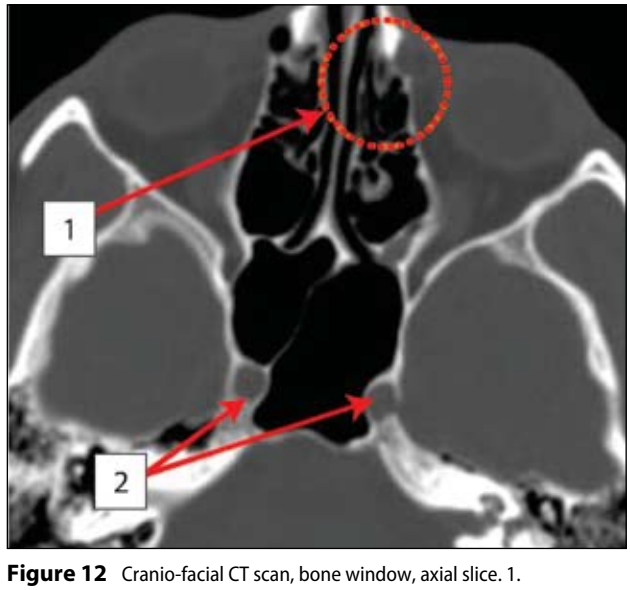

Figure 12 Cranio-facial CT scan, bone window, axial slice. 1. pneumatization of the left uncinat process and hyperpneumatization of the right ethmoid bulla; 2.the prolaps of the internal carotid arteries, with intersinusal septum inserted on the posterior wall of the artery

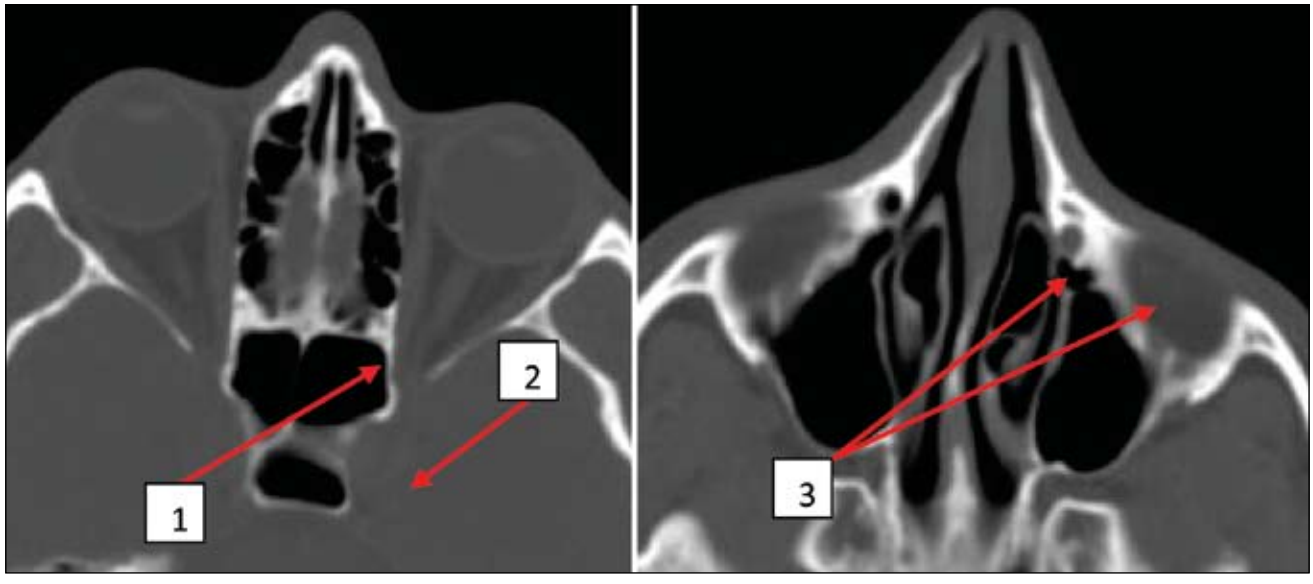

Figure 13 Cranio-facial CT scan: 1. Hyperpneumatization of the sphenoid sinuses; 2. Pneumatization of dorsum sellae; 3. Bilateral extensive concha bullosa

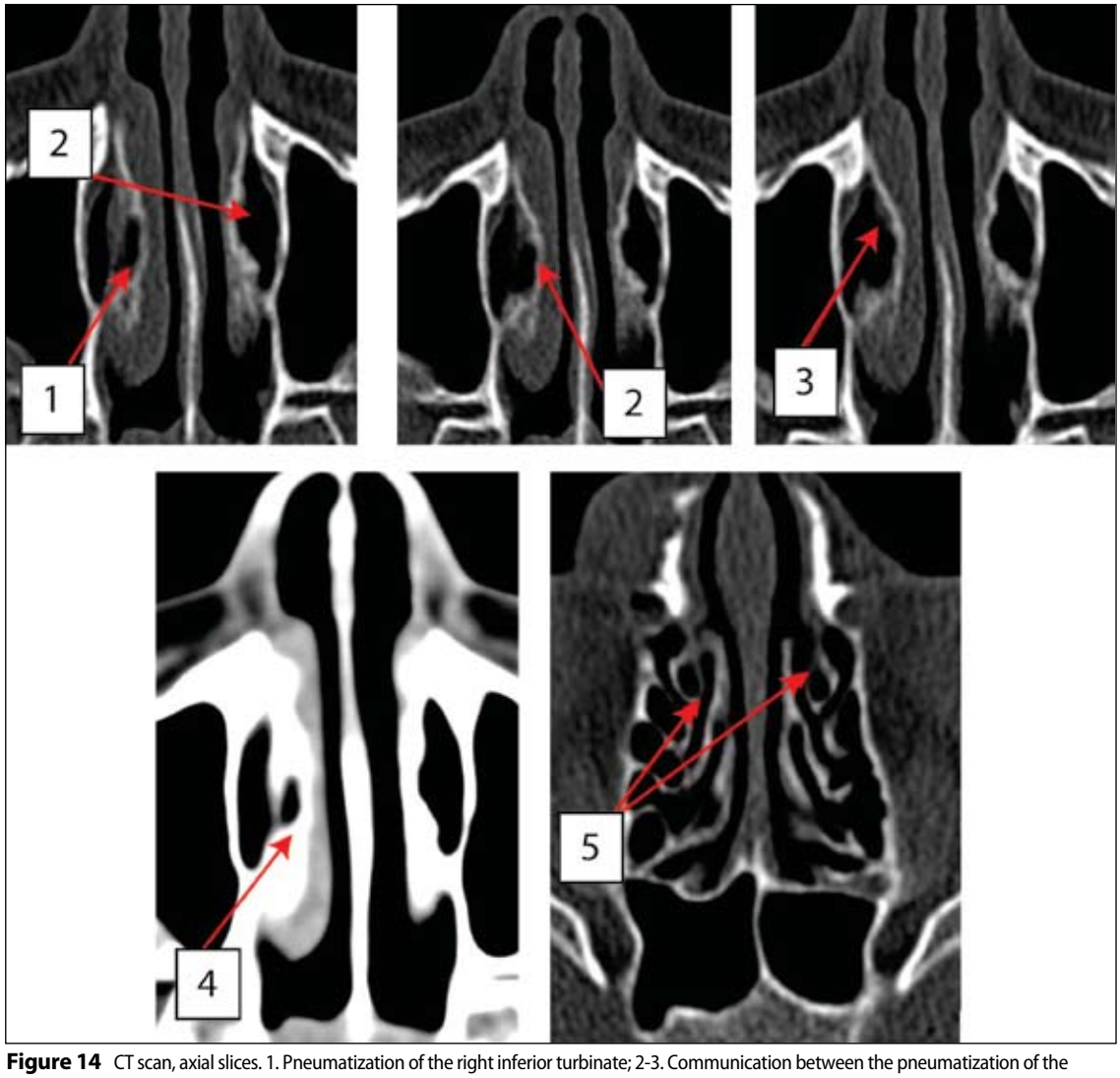

Figure 14 CT scan, axial slices. 1. Pneumatization of the right inferior turbinate; 2-3. Communication between the pneumatization of the inferior turbinate and middle meatus; 4. Pneumatization of the right inferior turbinate; 5. Bilateral pneumatization of the uncinat process

CASE 6

It is a 23 year-old male patient (Figures 15-16) with pneumatization of all nasal turbinates, visible on different slices. Pneumatization of the inferior turbinate is bilaterally situated in the medium third, while on the left side it communicates with the maxillary sinus (Figure 15). This anatomic variant associates: bilateral extensive concha bullosa, extensively pneumatized superior turbinates of small dimensions, bilateral supreme turbinate, left hyperpneumatized ethmoidal bulla, type IV nasal septum deviation, accessory ostium of the right maxillary sinus, inflammatory process of the left maxillary sinus (liquid level), supreme right turbinate (Figures 16 a-b).

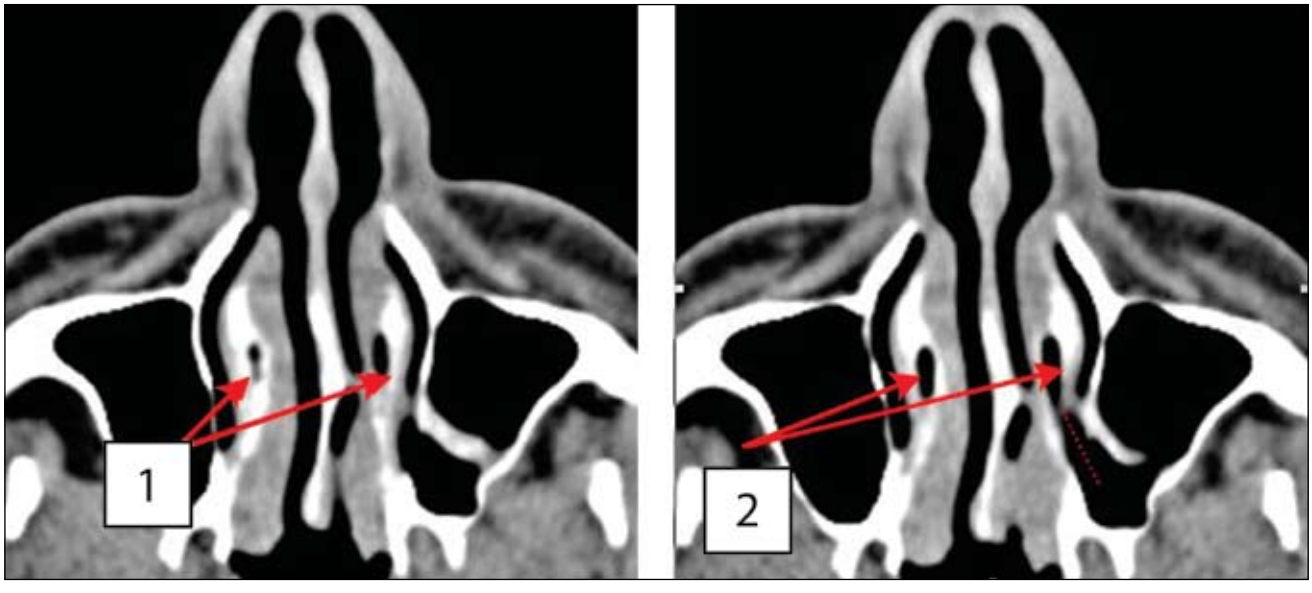

Figure 15 Cranio-facial CT scan, bone window, axial slice. 1.bilateral pneumatization of the inferior turbinate; 2.right - no communication with the maxillary sinus; left - the drainage of the pneumatized inferior turbinate into the maxillary sinus.

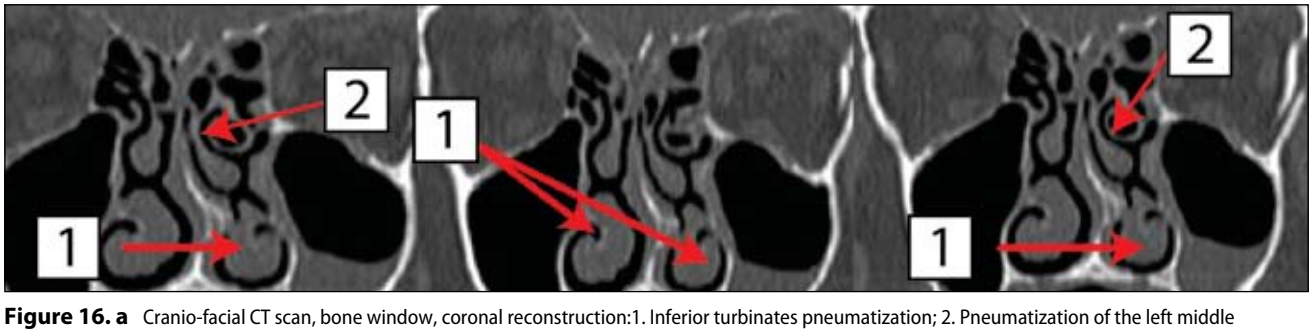

Figure 16. a Cranio-facial CT scan, bone window, coronal reconstruction:1. Inferior turbinates pneumatization; 2. Pneumatization of the left middle turbinate; 3. Blateral lamillar concha bullosa

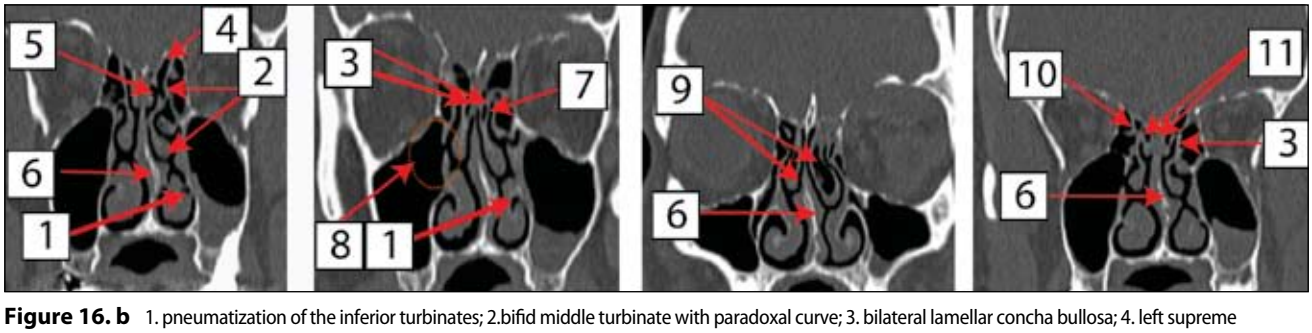

Figure 16. b 1. pneumatization of the inferior turbinates; 2.bifid middle turbinate with paradoxal curve; 3. bilateral lamellar concha bullosa; 4. left supreme turbinate; 5. drainage of the superior turbinate concha bullosa; 6. nasal septum deviation (type IV); 7. hyperpneumatized left ethmoidal bulla; 8. accessory right maxillary sinus ostium; 9. bilateral extensive concha bullosa of the middle turbinate; 10. right supreme turbinate; 11. bilateral pneumatization of the superior turbinate

CASE 7

81 year-old female patient (Figures 17-21) with pneumatization of the right inferior turbinate and it associates: bilateral hyperpneumatization of supreme turbinate of type C, sinusal hyperpneumatizations (left frontal pneumatocel and right frontal hypersinus, sphenoidal pneumosinus dilatans) and extrasinusal hyperpneumatizations: pneumatization of the right inferior and left superior turbinates, dorsum sellae pneumatization, anterior clinoid processes, vomer, a hyperpneumatized left Onodi cell, bilaterally hyperpneumatized ethmoidal bulla, as well as paradoxical incurvation of the left superior turbinate.

Hyperpneumatization of the supreme turbinate bilaterally generates a mucosal contact (synechiae) with the supreme turbinate, and also with the nasal septum on the left side (by developing this type of concha bullosa between the nasal septum and the superior turbinate). Hyperpneumatization of the frontal and sphenoidal sinuses might be caused by the pneumatization of the superior and supreme turbinate through sinus drainage disorders. There are physiopathological conditions for an inflammatory process of the anterior sinuses, but imaging provides minimal change in this aspect (thickening of mucus).

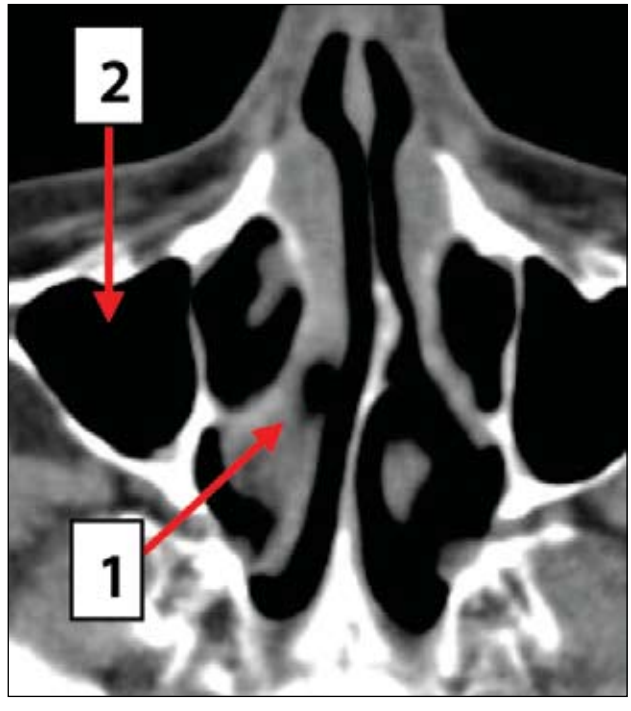

Figure 17 Cranio-facial CT scan. 1) pneumatization of the right inferior turbinate without communication with the maxillary sinus; 2) right maxillary sinus

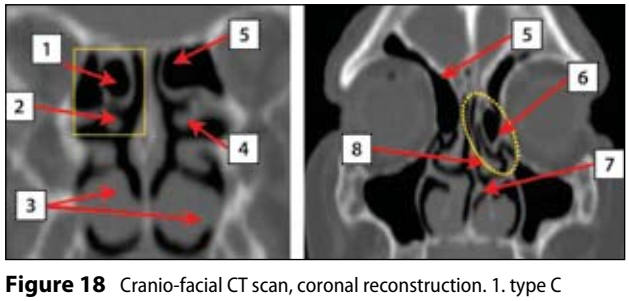

Figure 18 Cranio-facial CT scan, coronal reconstruction. 1. type C supreme turbinate with hyperpneumatization; 2. right superior turbinate; 3. hypertrophic inferior turbinates; 4. paradoxically incurved left superior turbinate; 5. hyperpneumatized type C supreme turbinate with sphenoid sinus communication; 6. hyperpneumatization of the left superior turbinate; 7. type V left nasal septum deviation; 8. hypertrophic middle turbinate; 9. bilateral hypertrophic maxillary sinus mucosa

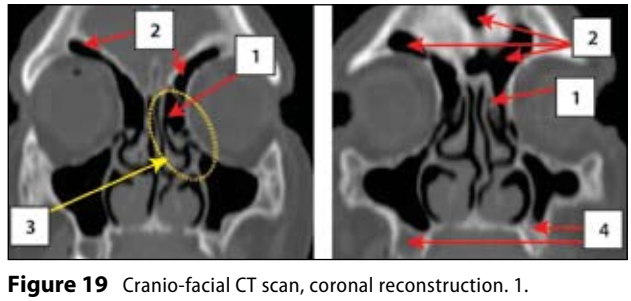

Figure 19 Cranio-facial CT scan, coronal reconstruction. 1. hyperpneumatization of the left superior turbinate; 2. hyperpneumatization of the frontal sinuses (left - pneumatocel, right - hypersinus); 3. small middle turbinate, elongated; 4. bilateral inflammation of the maxillary sinus

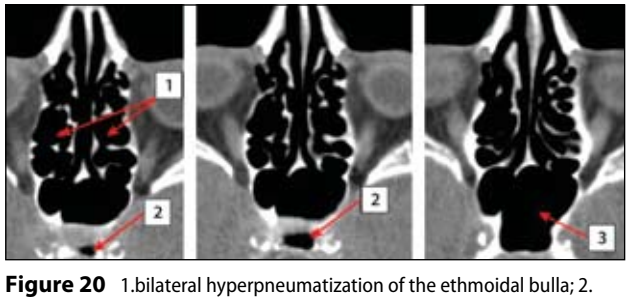

Figure 20 1.bilateral hyperpneumatization of the ethmoidal bulla; 2. pneumatization of dorsum sellae; 3. hyperpneumatized sphenoid sinus (pneumosinus dilatans), without intersinusal septum

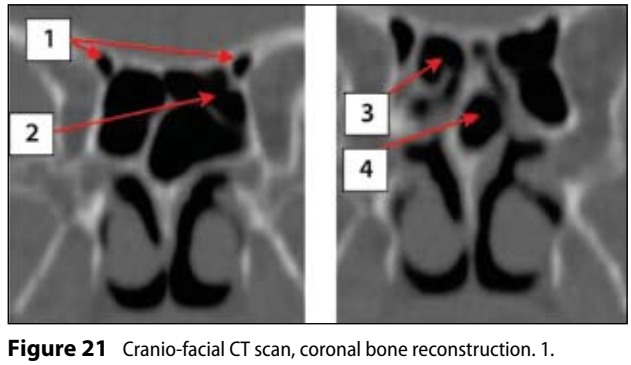

Figure 21 Cranio-facial CT scan, coronal bone reconstruction. 1. pneumatization of the anterior clinoid process; 2. left hyperpneumatized Onodi cell; 3. hyperpneumatization of the right supreme turbinate - concha bullosa drainage in sphenoid sinus; 4. pneumatization of the vomer

CASE 8

64 year-old female patient presenting pneumatization of the right inferior turbinate in the anterior third, with drainage into the right inferior meatus and communication in the homolateral maxillary sinus (Figure 22). It associates only sinusal hyperpneumatizations (frontal, bilateral posterior ethmoidal and sphenoidal). Study of medical documents reveals complaints of headache and nasal obstruction, while anterior rhinoscopy revealed hypertrophyc inferior turbinates. The cause of this increase in volume has been the pneumatization of the inferior turbinate, essentially discovered radiologically.

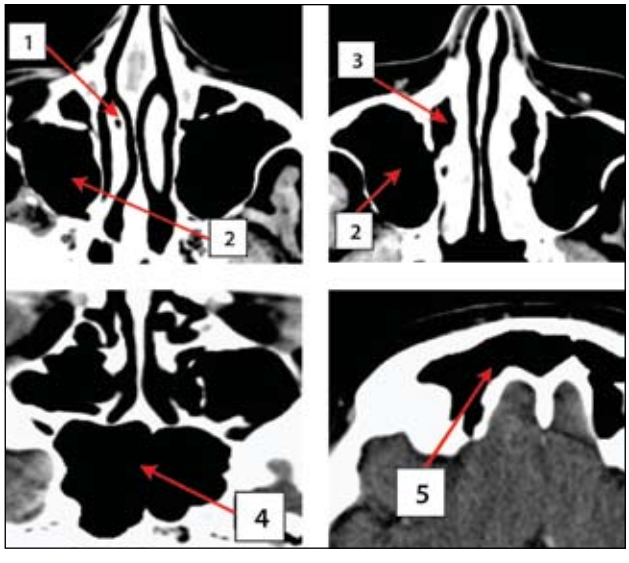

Figure 22 Cranio-facial CT scan, bone window, axial slices 1. pneumatization of the right inferior turbinate; 2. right maxillary sinus; 3. right inferior turbinate pneumatization with middle meatus drainage and right maxillary sinus communication; 4. sphenoidal pneumosinus dilatans with no intersinusal septum; 5. bilateral frontal pneumosinus dilatans

CASE 9

30 year-old female patient with bilateral pneumatization of the inferior nasal turbinate without communication with the maxillary sinus, drainage being made into the inferior meatus (Figure 23). This anatomic variant also associates: hyperpneumatizations of the paranasal sinuses (bilateral frontal pneumosinus dilatans and sphenoidal hypersinus) and of the extrasinusal ones: pneumatization of the superior nasal turbinates, of the right supreme turbinate of type C, bilocular bilateral concha bullosa, hyperpneumatization of the right agger nasi cell, of the right ethmoidal bulla, hyperpneumatized right Onodi cell (Figures 24-26).

As regards the pneumatization of the supreme turbinate, coronal slices show a double size as compared to the homolateral superior turbinate, thus fitting in type C; it anteriorly insinuates between the right supreme turbinate that is paradoxically incurved and the nasal septum, causing mucosal contact (both at the level of the septum and of the superior turbinate). This situation theoretically leads to potential drainage difficulties of the posterior sinuses and modifications of the ostiomeatal complex. In this case however, one cannot observe by imaging a clear inflammatory reaction in the posterior nasal sinuses. There are nevertheless inflammatory changes (retention cyst) in the right maxillary sinus.

CASE 10

33 year-old female patient with bilateral pneumatization of the inferior turbinate that communicates on the left side with the maxillary sinus (Figure 27). The case associates: pneumatization of vomer, superior and supreme left turbinate, left uncinate process, right anterior clinoid process, left extensive and right linear concha bullosa, bilateral paradoxical incurvation of the middle turbinate.

Table 8 presents the association of other sinusal or extrasinusal pneumatizations, of rhino-sinusitis, of other anatomic variants of interest, in the cases identified with pneumatization of the inferior turbinate:

Study of the correlation of the nasal inferior turbinate pneumatization with rhino-sinusitis is emphasized in Tables 9-11 and in Figure 30.

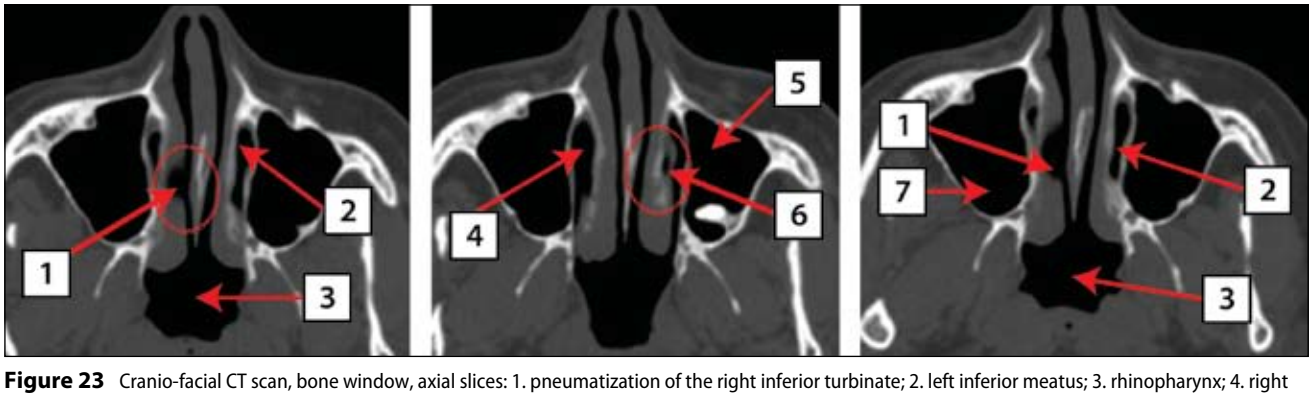

Figure 23 Cranio-facial CT scan, bone window, axial slices: 1. pneumatization of the right inferior turbinate; 2. left inferior meatus; 3. rhinopharynx; 4. right inferior meatus; 5. inflammatory process (polyp) of the left maxillary sinus; 6. pneumatization of the left inferior turbinate; 7. right maxillary sinus

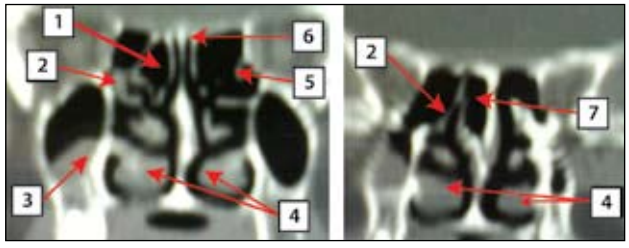

Figure 24 Cranio-facial CT scan, coronal reconstruction: 1. type C, hyperpneumatized right supreme turbinate; 2. paradoxically incurved right superior turbinate; 3. inflammatory process (retention cyst) in the right maxillary sinus; 4. bilateral inferior turbinate hypertrophy; 5. left supreme turbinate; 6. left superior turbinate; 7. pneumatization of the vomer

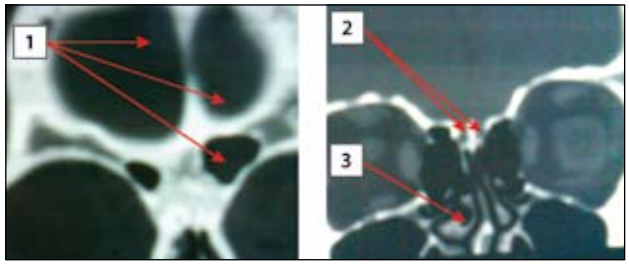

Figure 25 Cranio-facial CT scan, coronal reconstruction. 1. frontal sinus (bilateral pneumosinus); 2. Keros type II (6.9 and 6.5 mm) variant of the ethmoid roof; 3. right concha bullosa

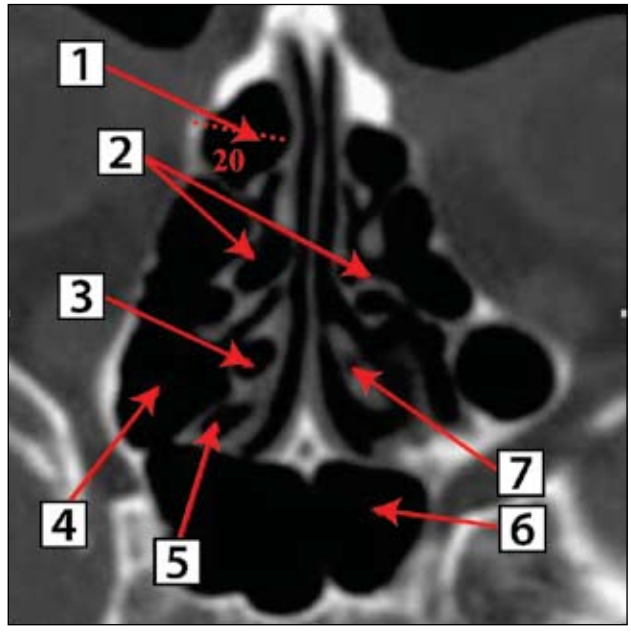

Figure 26 Cranio-facial CT scan, bone window, axial slice: 1. hyperpneumatization of the right Agger nasi; 2. bilateral bilocular pneumatization of the middle turbinate (two cells); 3. pneumatization of the right superior turbinate; 4. right Onodi cell; 5. pneumatization of the right supreme turbinate; 6. hyperpneumatization of the sphenoid sinus, with no intersinusal septum; 7. pneumatization of the left superior turbinate

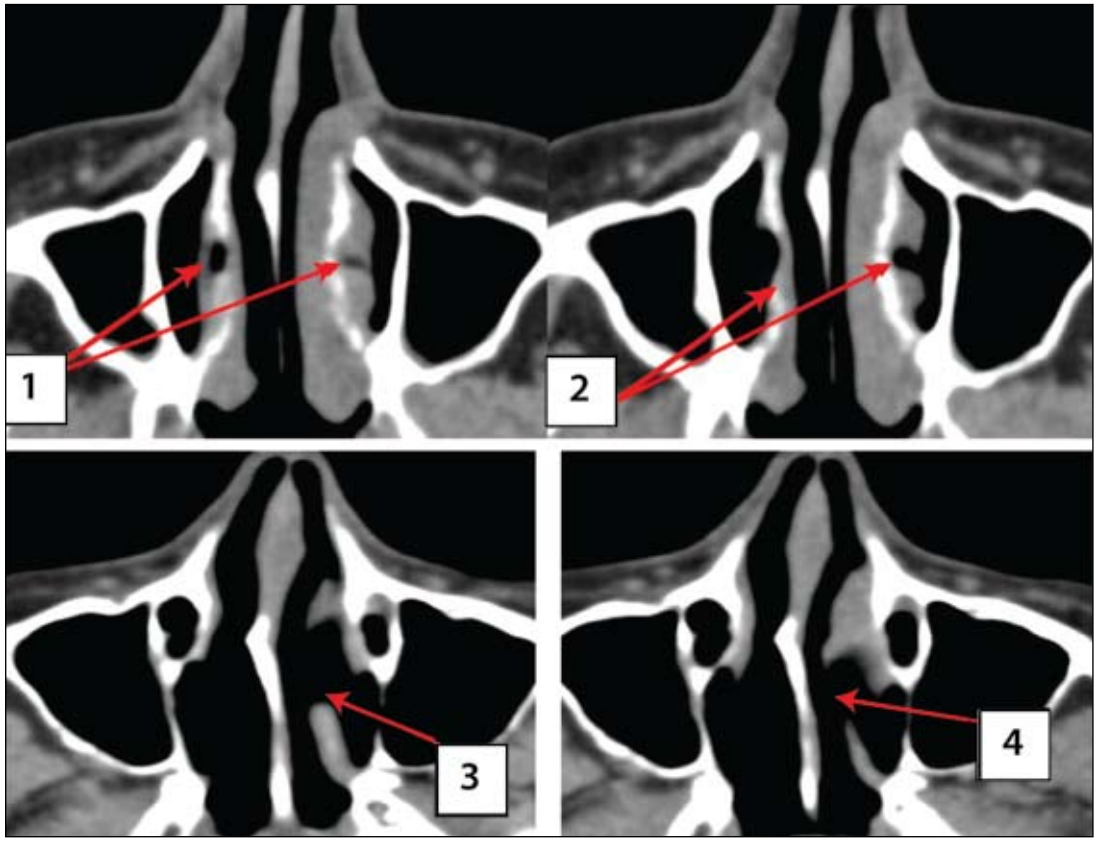

Figure 27 Cranio-facial CT scan, bone window, axial slices: 1. bilateral pneumatization of the inferior turbinate (middle part); 2,3. pneumatization of the inferior turbinate with inferior meatus drainage; 4. communication with the left maxillary sinus (red line)

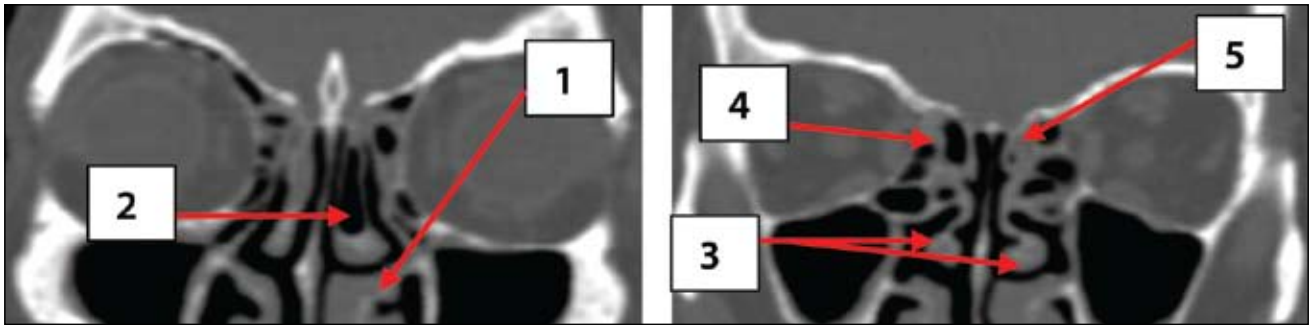

Figure 28 Cranio-facial CT scan, coronal reconstruction: 1. pneumatization of the left inferior turbinate; 2. extensive left concha bullosa; 3. paradoxically incurved middle turbinate; 4. pneumatization of the right supreme turbinate

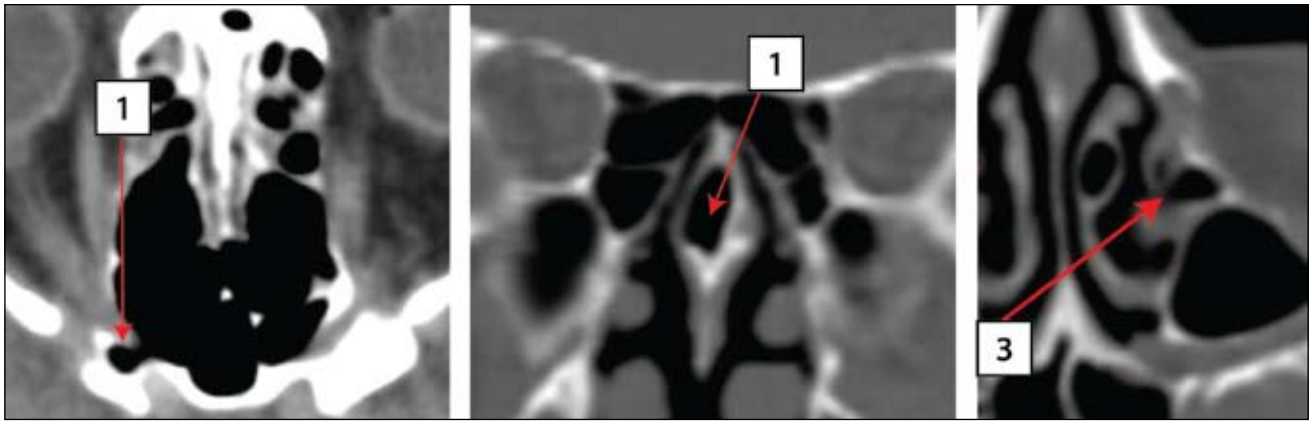

Figure 29 Cranio-facial CT scan, bone coronal reconstruction: 1. pneumatization of the left anterior clinoid process; 2. pneumatization of vomerului; 3. pneumatization of the left uncinat process

Table 8
Association of other anatomic variants with pneumatizations of the inferior turbinate

No.	Age (years)	Sex	Other extrasinusal/sinusal pneumatizations	Other anatomic variants of the surgical landmarks	Association of anterior sinusitis
1	48	F	-	nasal septal deviation, middle turbinate hypoplasia, deformation of the sinus internal wall	+
2	30	F	right middle turbinate concha bullosa	nasal septal deviation, middle turbinate hypoplasia	+
3	26	M	middle turbinate, superior turbinate, posterior clinoid, dorsum sellae	-	+
4	56	M	bilateral middle turbinate concha bullosa, posterior clinoid, dorsum sellae, ethmoidal bulla	nasal septal deviation, prolapsing internal carotid arteries, sphenoidal intersinus septum inserted in the vessel	+
5	38	M	bilateral uncinate process, bilateral agger nasi	-	-
6	23	M	bilateral middle turbinate concha bullosa, ethmoidal bulla	bifurcate middle turbinate, supreme turbinates, septal deviation, accessory ostium of the maxillary sinus	+
7	81	F	bilateral supreme and superior turbinate	-	+
8	64	F	hyperpneumatizations of the ethmoid, sphenoid and frontal sinus	maxillary intrasinus septum, medialized uncinate process	-
9	30	F	right supreme turbinate, middle turbinate concha bullosa, agger nasi, ethmoidal bulla, Onodi cell	paradoxically incurved superior turbinate	+
10	33	F	middle turbinate concha bullosa, vomer, superior turbinate, uncinate process, crista galli, clinoid process	paradoxical incurvation of the middle turbinate, right supreme turbinate	+

Table 9
Case repartition according to the presence of the inferior turbinate pneumatization vs. anterior sinusitis

Anterior sinusitis	Inferior turbinate pneumatization		Total
	present	absent	
Present	8	104	112
%	80.00%	53.33%	
Absent	2	91	93
%	20.00%	46.67%	
Total	10	195	205

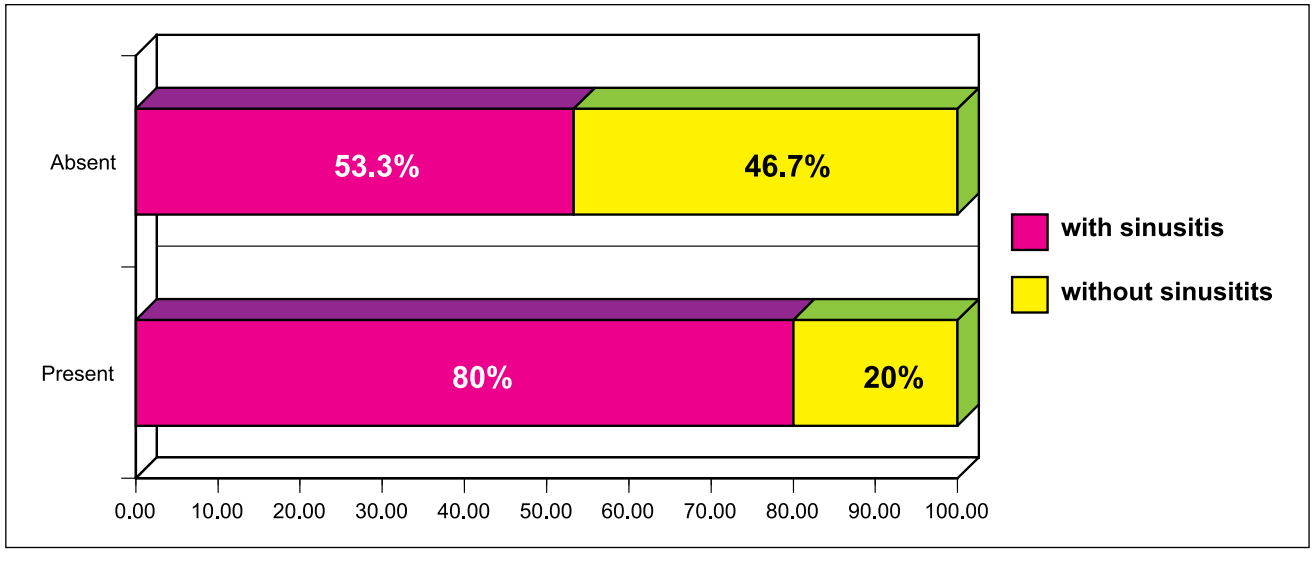

Figure 30 Case repartition according to the presence of the inferior turbinate pneumatization vs. anterior sinusitis

Table 10
Estimated parameters in the association anterior sinusitis vs. presence of inferior turbinate pneumatization

(df=1)	Chi-square χ^2	p 95% confidence interval
Yates Chi-square - χ2	3.76	0.018471
Correlation coeficient (Spearman Rank R)	0.4356	0.030547

Table 11
Estimating the parameters of confidence - anterior sinusitis vs. inferior turbinate pneumatization

	Estimated value	95% confidence interval	
		Minim	Maxim
PARAMETERS: Odd - based			
Odds ratio (OR)	3.50	0.66	24.52
PARAMETERS: Risk - based			
Risk ratio (RR)	3.32	0.72	15.26

In the studied group, there is a significant statistical association between the presence of the inferior turbinate pneumatization and the presence of the anterior rhino-sinusitis (Yates' Chi-square - $\chi 2=3.76$; $p=0.018471$ and Spearman Rank $R=0.4356$; $p=0.030547$), while estimation of odd and risk parameters shows the following: chance of rhino-sinusitis is 3.5 times higher in patients with inferior turbinate pneumatization vs. patients without this anatomic variant (OR=3,50; RR=3,32 - Table 11).

DISCUSSIONS

From the first description of inferior turbinate pneumatization made in 1988 by Zinreich and collaborators[7], cases of this anatomic variant have been reported quite rarely. In 2003, Ingram[10], Richardson and Brynn[17] reported a patient each. The last mentioned call into question the case of a 38 year-old woman with rhino-sinusitis and allergic manifestations. Until 2003, only 10 published studies presented this topic.

The prevalence of this anomaly in the studied group was 4.87%, predominantly women (60%), while by type, left unilateral forms prevailed. It is a slightly increased value as compared to Ozturc's studies[18]. In 2005, the latter performed a radiological analysis extended on a number of 250 CT scans and identified 10 cases (1/250, that is 0.4%), without any significant difference between sexes or age groups (since it can be found at all ages).

Regarding communication with the maxillary sinus, there were only unilateral forms, 3 on the right and 3 on the left, all these cases presenting a localization of pneumatization in the middle section of the inferior turbinate. Most of the cases (9/10) had associations of other extrasinusal pneumatizations, some of them unusual (pneumatization of the uncinate process, of the anterior and posterior clinoid processes), or of other anatomic variants worthy of consideration in a rhino-sinusal imagistic review (paradoxical incurvation of middle or superior turbinates, middle turbinate hypoplasia, significant deviation of nasal septum). Also, there were associations of sphenoidal, frontal or posterior ethmoidal sinus hyperpneumatizations. A single case showed no extrasinusal pneumatizations, but hyperpneumatization of the frontal and sphenoidal sinus was present. Nasal inferior turbinate pneumatization associated in several subjects pneumatization of the other turbinates in different combinations.

Concerning rhino-sinusal inflammatory reactions, 8 out of 10 patients with inferior turbinate pneumatization presented signs of rhino-sinusitis. We cannot exactly quantify only the role of this anatomic variant because 8 out of 10 cases presented at least 2 extrasinusal pneumatizations (one of the subjects had 5, another even 7 such pneumatizations). To these we add a number of other variants of surgical landmarks that are important for the therapeutic plan or the surgical approach (between 2 and 5 variants in each case). In this research, the average age of patients presenting inferior turbinate concha bullosa was 42.9 years.

As Richardson and Brynn[17] reported the case of a woman with manifestations of allergic rhino-sinusitis, among the subjects presented for inferior turbinate pneumatization (case 3), we have identified a patient who had symptoms of a recurrent rhino-sinusitis and a clinical aspect of inferior and middle turbinate hypertrophy. The case required an imagistic CT review. This investigation revealed a right pansinusitis which was operated. On CT slices, we identified pneumatization of the three nasal turbinates on the left side. Symptoms corroborated with data provided by imagistic investigation have allowed complete diagnostic with an appropriate therapeutic plan. Nasal obstruction on the left side might benefit from decongestant drug treatment, with local corticoids, and surgical treatment (septoplasty for nasal septum deviation and removal of the middle and inferior turbinate concha bullosa, left uncinectomy for the uncinate apophysis pneumatization; for the inferior turbinate pneumatization the option would be to refrain from surgical attempt).

In 2003 Braun H. and Stammberger H.[3] published an unusual case of turbinates pneumatization associated with hyperpneumatization of the paranasal sinuses. The authors reported pneumatization in 5 out of 6 nasal turbinates (only the pneumatization of an inferior turbinate was missing), crista galli apophysis, posterior section of the nasal septum associated with a Haller cell and hyperpneumatization of the frontal and sphenoidal sinus. The studied imaging revealed one case that had all the turbinates pneumatized on the left side (case 3).

Most of the cases identified (7/10, that is 70%) presented significant nasal septum deviation, in agreement with various authors who also report in cases with inferior turbinate pneumatization an association of septum deviation. In 2004, Uzun and Birol Ugur[18] describe a case of unilateral pneumatization of the inferior turbinate associated with a septum deviation and maxillary retention cyst in a 25 year-old man with nasal obstruction.

Case 2 described in our personal study, a 30 year-old woman with bilateral pneumatization of the inferior turbinates associated with a right concha bullosa, left nasal septal deviation of type III

and left middle turbinate hypotrophy, who presented symptoms of a persistent nasal obstruction, rhinorrhea and headache, resembles as type of naso-sinusal anatomic variants one of the three cases of inferior turbinate pneumatization published in 2004 by Yanaqisawa and Eiji[19]. Related to age and sex, these authors just like Unlu[6], Kantarci and Murat[20], find no significant differences between sexes, and this anatomic variant reveals it at all ages. In 2008, Eweiss, Khatwa and Yeitoun[21] described an unusual anatomic variant of pneumatized inferior turbinate associated with a trifurcate middle turbinate; it is actually the first case reported in the literature of a middle turbinate split into three parts. In the studied group, we revealed a bifurcation of left middle turbinate, with pneumatization of one of them. Another unusual association of inferior turbinate pneumatization is reported by Sagit, Saka, Kuran and Akin[22] who present a case of pneumatization of all the six turbinates in a 17 year-old young man: anterior rhinoscopy only revealed a bilateral hypertrophy of the left middle turbinate and inferior turbinates, associated with a septum deviation. CT scan showed a pneumatization of all six nasal turbinates, the case representing a purely imagistic diagnostic. In our personal group also, we could find a patient, a 23 year-old young man (case 6), with all 6 nasal turbinates pneumatized. He also presents 2 variants of the number of turbinates: a left bifid middle turbinate (in which one of the components is pneumatized) and a right supreme turbinate.

Yang and Chong[23] make a 12-year retrospection by studying inferior turbinate pneumatization on CT. They used Bolger's classification, according to which turbinate pneumatization is of three kinds: bulbous, lamellar and extensive, and they identify a number of 16 cases (14 unilateral, 2 bilateral). In our personal study unilateral cases prevailed too.

Communication of the pneumatized inferior turbinate with the maxillary sinus was present in 6 cases, representing 60% of these (3 on the left side, 3 on the right side), as compared to 8 cases, representing 44%, reported by Yang and Chong[23].

Existence of a concha bullosa can be clearly identified on CT, imaging being able to enlighten the clinician when differentiating between an inferior turbinate pneumatization and other hypertrophies. Data from the literature show a right prevalence[24,25]. In our personal research too, the number of registered cases show a right prevalence: 8 right vs. 5 left pneumatizations. Careful imagistic evaluation should provide a differential diagnosis of this anatomic variant with a "pseudo pneumatization of the inferior turbinate", resulting from the contact of the inferior turbinate edge with the external wall of the nasal cavity. In this case, the external limit of the pneumatic cavity cannot be identified (Figure 31).

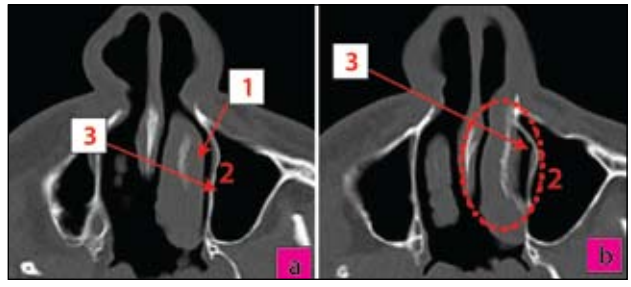

Figure 31 Cranio-facial CT scan: Pseudopneumatization of the left inferior turbinate: **a.** 1. Left inferior turbinate hypertrophy; 2. Left maxillary sinus; 3.wall of the left maxillary sinus; **b.** 2) the contact of the inferior turbinate lateral edge with the internal wall of the maxillary sinus giving the ideea of a pseudo-pneumatization of the inferior turbinate

The cell that pneumatizes the inferior turbinate may present an inflammatory process (mucocele or "inferior turbinate sinusitis") through a chronic inflammation caused by ventilation disorders. Such a case is reported in the literature by the Turkish authors, Göçmen H. and collaborators[26]. In the investigated casuistry, no inferior turbinate pneumatization presented an inflammatory process.

Inferior turbinate pneumatization does not usually present a particular evolutionary profile, except for the cases where there is a functional disturbance of the ostiomeatal complex.

CONCLUSIONS

Inferior turbinate pneumatization is a rare anatomic variant (prevalence of 4.87%), present in both sexes, with drainage into the inferior meatus, that may or may not communicate with the ipsilateral maxillary sinus.

It can be unilateral or bilateral, isolated or associated with pneumatization of one or more nasal turbinates, with other extrasinusal pneumatizations or sinusal hyperpneumatizations or other anatomic variants of the rhino-sinusal structures.

The inferior turbinate pneumatization diagnosis is entirely imagistic, best on coronal CT.

There is a significantly statistical association between the presence of rhino-sinusitis and the presence of inferior turbinate pneumatization (Yates Chi-square - $\chi 2=3.76$; $p=0.018471$ and Spearman Rank $R=0.4356$; $p=0.030547$;OR=3,50; RR=3,32).

There is a slight predisposition of females for inferior turbinate pneumatizations (RR=1.67), but it cannot be said that there is a significant association between this anatomic variant and females ($\chi 2=0.687$, $p=0.4101$, 95% CI).

REFERENCES

1. Hollinshead W.H., The Head And Neck. In: Hollinshead W H. Anatomz For Surgeons. Philadelphia: Harper And Row, 1982.
2. Ewans P. H., Anatomy Of The Nose And Paranasal Sinuses. In. Kerr A. G., Ed. Scott Brown S Otolaryngology. Boston: Butterworth-Heinemann, 1987.
3. Braun H., Stammberger H., Pneumatization of Turbinates. Laryngoscope, 2003; 113(4): 668-672.
4. Dogru H., Doner F., Uygur K. et al., Pneumatizet Inferior Turbinate. Am J Otolaringol., 2002; 31:62-4.
5. Ingram W.A., Richardson B.E., Concha Bullosa of An Inferior Turbinate. E Dawlaty. Inferior Concha Bullosa - A Radiological and Clinical Rarity. Rhinology., 1999; 37: 133-5.
6. Unlu H.H., Altuntas A., Aslan A., et al. - Inferior Concha Bullosa. J Otolarzngol., 2002; 31:62-4.
7. Zinreich S.J., Mattox De, Kennedy Dw. et al., Concha Bullosa: Ct Evaluation. J Comput Assist Tomogr,. 1988;12:778-84.
8. Dawlaty E.E., Inferior Concha Bullosa - A Radiological And Clinical Rarity. Rhinology, 1999; 37:133-5.
9. Ozcan C., Gorur K., Duce M., Massive Bilateral Inferior Concha Bullosa. Ann Otol RhinolLaryngol, 2002; 111: 100-1.
10. Ingram Wa., Rhichardson Be., Concha Bullosa of An Inferior Turbinate. Ear Nose Throat Journal, Aug.1, 2003; 82(8): 605-607.
11. Dogru H., Doner F., Uygur K. et al., Pneumatized Inferior Turbinate. Am J Otolaryngology, 1999; 20:139-141.
12. Har E.G., Slavit Dh., Turbinoplasty for Concha Bullosa. A Non Synechiae Forming Alternative to Middle Turbinectomy. Rhinology, 1996; 34:54-56. 440.
13. Ariyurek Om., Balkanci F., Aydingoz U., Onerci M., Pneumatized Superior Turbinate: A Commun Anatomic Variation? Surg Radiol Anat, 1996; 18: 137- 139.
14. Zturk A., Alatas N., Ozturk E., San I., Sirmatel O., Kat N., Pneumatization Of The Inferior Turbinates Incidence And Radiologic Appearance. J Comput Assist Tomogr, 2005; 29 (3): 311-314.
15. Aydin O., Ustundag E., Ciftc E., Keskin I.G., Pneumatization of the Inferior Turbinate. Auris Nasus Larynx, 2001; 28:361-363.
16. Kharoubi S., Pneumatisation Du Cornet Inferieur À Propos D'Une Observatoion. Journal Tunisien D. Orl Et Chirurgie Cervico-Faciale. Décembre 2006; Nr.17, 63-65, 1737-7803.
17. Richardson B., Brynn E., Concha Bullosa Of An Inferior Turbinate. Ear, Nose And Throat Journal, Aug.1, 2003.
18. Uzun L., Ugur B.M., Savranlar A., Pneumatisation of the Inferior Turbinate. European Journal Of Radiology Extra, Vol. 51, Issue 3, September 2004; 99-101.
19. Yanaqisawa E., Pneumatizet Inferior Turbinate. Ear, Nose And Throat Journal, Mar 1, 2004.
20. 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.
21. Eweiss A., Khatwa M.M., Zeitoun H., Trifurcate Middle Turbinate; An Unusual Anatomical Variation. Rhinology. North Wales, United Kingdom, 2008 Sep; 46(3): 246-8.
22. Sagit M., Saka C., Kuran G., Akin I., An Unusual Pneumatisation Of Turbinates. B- Ent. 2008; 4(2): 101-3.
23. Yang Bt., Chong V.F.H., Wang Y.C., Xian J.F., CT Appearance Of Pneumatized Inferior Turbinate Clinical Radyology, August 2008; Volume 63, Issue 8, 901-905.
24. Dawlaty E.E., Inferior Concha Bullosa - A Radiological And Clinical Rarity. Rhinology, 1999; 37:133-5.
25. Demey A. Jr., Merell R., Mirante J., Ianagisawa E., Pneumatized Inferior Turbinate: Report Of Three Cases. Ent Journal. 2005.
26. Hakan G., Haldun O., Kűrşat C., Erdal S., Infected Inferior Turbinate Pneumatization. European Archives Of Oto-Rhino-Laryngology. Berlin/ Neidelberg; Dec. 2005; Vol 262, Nr 12.