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The incidence of pneumatised inferior turbinate and relation to close anatomic structures

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Background: *Pneumatisation of the inferior turbinate (PIT) is a rare abnormality of the paranasal sinus. It is very difficult to differentiate from the hypertrophia of the inferior turbinate clinically. Thus, it is important to be considered, especially in cases with no response to medical treatments. We aimed to investigate the presence and the frequency of PIT by computed tomography (CT).*

Materials and methods: *A total of 2905 cases (1381 female, 1524 male) with an age range between 16 and 84 were included.*

Results: *The pneumatisation of the inferior turbinate was observed in 1.72% of the cases with a percentage of 1.88% in women and 1.57% in men. In PIT (+) cases the bilaterality was found in 54% of them. According to the subtypes, 70% was lamellar, 28% was bullous and 2% was extensive. No statistically significant difference was found for age distribution. The most commonly associated variations were the pneumatisation of the middle and upper turbinate and the septal deviation.*

Conclusions: *The pneumatisation of the inferior turbinate is a rare variation with a similar frequency among men and women. It is diagnosed by CT and when symptomatic, the optimal treatment is surgery.* (Folia Morphol 2019; 78, 3: 621–625)

Key words: inferior turbinate, pneumatisation, coronal computed tomography, paranasal sinus region, anatomic variations

INTRODUCTION

Three turbinates are located bulging along the lateral wall of the nasal cavity. Upper and middle turbinates are the parts of the ethmoid bone whilst inferior turbinate is an independent bone of the splanchnocranium. These structures, which are lined by mucosa and known as intranasal conchae, have role in humidification and filtration of the air, thermoregulation and sniffing. Inferior turbinate with a triangular shape is an anatomical landmark of the nasolacrimal channel.

Concha bullosa defines the pneumatisation of the turbinates with air balloons in the concha and generally seen in the middle turbinate. The pneumatisation of the inferior turbinate (PIT) is an extremely rare variation which is needed to be kept in mind in functional endoscopic sinus surgery. Pneumatisation can be seen as an isolated abnormality with unilateral or bilateral localisation; however, PIT can also be associated with different abnormalities such as intra and/or extrasinusal pneumatisation and other rhinosinusal abnormalities [1]. It is difficult to differentiate between PIT and hypertrophia of the inferior concha clinically and endoscopically. The most effective method to differentiate these two entities is the computed tomography (CT) of the paranasal sinuses.

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The aim of this study is to define the presence and the frequency of the pneumatised inferior turbinate in CT. PIT should be kept in mind as a variation by radiologists and clinicians in order to explain the bulging of the inferior turbinate into the nasal cavity.

MATERIALS AND METHODS

Our retrospective study was designed as the observation of the CTs performed to 3099 patients (1652 male, 1447 female) between January 2012 and December 2016 in the Department of Radiology, Muğla Sıtkı Koçman University with a local ethical committee approval.

Patients with an age under 16 or who had paranasal surgical procedure were excluded in addition to the patients whose paranasal anatomy was unable to determine. After exclusion 2905 cases with an age range of 16 to 84 were included in the study. The age distribution was found between 16 and 84 in men (1524 cases; 52.46%) and 16 and 81 in women (1381 cases; 47.54%). The mean age of the male patients was 36.64 ± 14.64, whereas the mean age of the female patients was 37.09 ± 13.85.

The sections of CT was obtained from 16 sliced (Siemens, Somatom Emotion, Germany) and double tubed — 256 sliced (Siemens, Somatom Definition Flash, Germany) MDBT operators. The sections of the paranasal sinus CT were measured as 3 mm thickness, 1 pitch, 110 Kv and 70 mAs. CT images in coronal and reformatted axial plane were evaluated.

The patients were grouped according to gender and the images were evaluated for the presence of PIT. PIT was then subgrouped as bullous type (pneumatisation was located in the lower part or the bullous part of the turbinate), lamellar type (pneumatisation was located in the vertical lamellar part) and extensive type (pneumatisation was located in both parts) according to the classification of Bolger et al [3]. In cases with PIT, associated paranasal sinus abnormalities were also noted.

Ethical approval

Ethical approval was taken from the ethical committee of the clinical investigations of Muğla Sıtkı Koçman University with grant number of 08.02.2016 / 7.

RESULTS

The pneumatisation of the inferior turbinate was observed in 50 of 2905 cases (1.72%). Twenty six of these 50 cases were female. The age ranges of the PIT (+) female and male patients were 16–69 and 17–62, respectively. The mean age of the female patients was 30.73 ± 12.72 whilst in male patients it was 29.75 ± ± 9.28. PIT was unilateral in 23 (46%) cases and bilateral in 27 (54%) cases. Fourteen (52%) of 27 unilateral PIT (+) cases was located in the right nasal cavity whereas 13 (48%) showed left localisation (Fig. 1). According to the classification of Bolger et al. [3], 35 (70%) cases were lamellar type, 14 (28%) were bullous type and 1 (2%) case was extensive type (Fig. 2, Tables 1–3). In bilateral cases, the same type of pneumatisation was observed and noted in the same group.

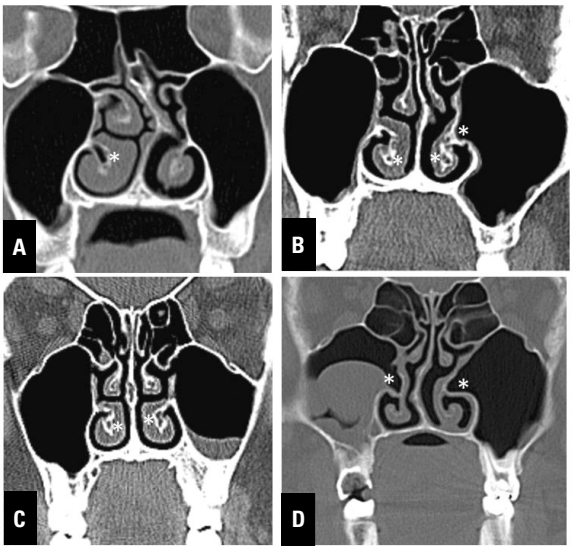

Figure 1. Different types of inferior turbinate pneumatisation; **A.** Bullous type on the right side in a 17-year-old female; **B.** Bullous type on the right side with extensive type on the left side in a 21-year-old female; **C.** Bilateral bullous type in a 20-year-old female; **D.** Bilateral lamellar type in a 17-year-old male.

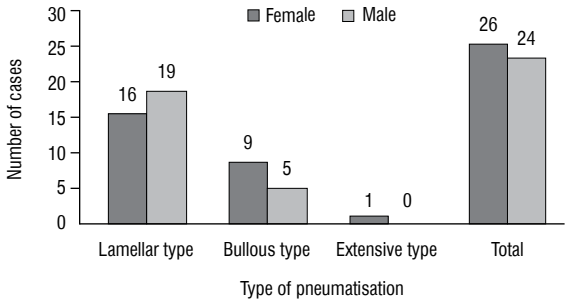

Figure 2. The frequency of the types of the pneumatisation of the inferior turbinate according to gender.

The percentage of PIT was 1.88% (n = 26) in women and 1.57% (n = 24) in men. No statistically significant difference in frequency of PIT between men and women was found despite the predominance in women (χ^2 = 0.406, p = 0.5239).

Table 1. The frequency and the distribution of the pneumatisation of the inferior turbinate according to gender

	Number of cases	Total	Lamellar	Bullous	Extensive
Female	1381	26 (52%)	16 (32%)	9 (18%)	1 (2%)
Male	1524	24 (48%)	19 (38%)	5 (10%)	0 (0%)
Total	2905	50 (100%)	35 (70%)	14 (28%)	1 (2%)

Table 2. The pneumatisation of the inferior turbinate according to gender and localisation

	Lamellar type			Bullous type			Extensive type			Total
	Right	Left	Bilateral	Right	Left	Bilateral	Right	Left	Bilateral	
Female	5	7	4	2	0	7	0	1	0	26
Male	7	5	7	0	0	5	0	0	0	24
Total	12	12	11	2	0	12	0	1	0	50

Table 3. Other paranasal variations associated with the pneumatisation of the inferior turbinate

	Female	Male	Total
Pneumatisation of the middle turbinate	18	14	32
Onoidi cell	10	11	21
Pneumatisation of the upper turbinate	10	9	19
Septal deviation	8	11	19
Haller cell	5	8	13
Pneumatisation of the crista galli	8	2	10
Paradoxical middle turbinate	1	1	2
Uncinate bulla	1	1	2
Paradoxical inferior turbinate	1	0	1

The lamellar type of pneumatisation was the most common type and the bullous type was the second most common type in both genders. The extensive type was seen in only 1 woman (Tables 1 and 2).

The abnormalities of the paranasal sinus associated with pneumatisation are given in Table 3. The most common abnormality associated with PIT was the pneumatisation of middle concha (64%) (Table 3).

DISCUSSION

Inferior turbinate lined by cavernous vascular rich mucosa and developed independently from the lateral wall of the nasal cavity is the largest of the conchae play important role in the regulation, heating and filtration of the air flow [1, 3, 10]. Changes in the skeleton of the inferior turbinate which is involved in the formation of the nasal valve and the narrowest region of the nasal passage, or the increased volume of the mucosa, may affect nasal patency.

Pneumatisation of the superior and middle turbinates is relatively common variation seen in paranasal sinus tomographies. However, pneumatisation of the inferior turbinate (PIT) is rare [4, 17]. The ventilation of the turbinates was firstly described by Santorini in the middle turbinate in 1793. PIT was firstly described by Zinreich et al. [17] in 1988. Surgical interventional procedures were mostly located in the middle meatus and surrounding area and the delayed diagnosis of PIT due to asymptomatic presentation are the most common reasons of the limited number of studies and few case reports in the literature [16].

By the technological developments of CT, the anatomical variations of paranasal sinuses and bones are started to be diagnosed more [4, 10]. PIT which is a rare variation is generally diagnosed incidentally by imaging studies [10, 13].

There were studies focusing on the pathogenetic mechanisms of PIT; however, no certain etiological reason was found. The most commonly accepted hypothesis of the pathogenetic mechanisms are associated with embriological development of the inferior turbinate. Inferior turbinate develops from prochordal plaque at the 6–8th embryonal weeks on the lateral wall of the nose [9, 14]. Two chondral lamellas and 2 separate ossification centres are seen on the inferior concha at 5–7th months [5] and the development continues after birth [2]. The invagination of the epithelium into the double lamellar tissue is thought to be one of the aetiological reasons of the pneumatised concha [10]. The secondary theory focuses on the possible role of the maxillary sinus disease and its close relation to the traction zone of the inferior turbinate [7]. The third theory suggests that the extension of the ventilation of the maxillary sinus to the inferior concha in the foetal life may result in PIT [11, 15].

The incidence of PIT was reported as 0.03–4.88% in the studies performed by CT [1, 8, 15, 16]. We

found the incidence of PIT at 1.72% in our study. The lamellar type pneumatisation is the most common type according to the classification of Bolger et al. [3]. Thirty five of 50 (70%) patients had lamellar type, 14 had bullous type (28%) and 1 case had extensive type of pneumatisation (2%). Twenty-three (46%) cases were bilateral whilst 27 (54%) were unilateral.

The frequency of the pneumatisation of the middle concha was higher in females [13]. But the same data for the inferior turbinate was limited. Öztürk et al. [9] reported that PIT is similar in both genders; however, Baldea et al. [1] suggested the slight predominance among women, but no significant difference was found. We also found that pneumatisation is more common in females, similar to the study of Baldea et al. [1]; however, no significant difference was found ($p = 0.5239$).

Variations are common in paranasal sinus region. In the study of Baldea et al. [1], with 250 cases, 10 cases of pneumatisation were detected and 9 of these cases also had extrasinusal or sinusal pneumatisation. In addition to that, 7 of these 10 cases had various anatomical variations [1]. Braun and Stammberger [4] reported cases of pneumatisation in 5 conchae except the inferior turbinate. In our study, the following associated paranasal sinus abnormalities with pneumatisation were found: ventilation of the middle turbinate in 64.0% ($n = 32$), Onoidi cells in 42.0% ($n = 21$), ventilation of the superior turbinate in 38% ($n = 19$) and septal deviation in 38% ($n = 19$).

Depending on the similarity of the epithelium in the air gaps between the conchae and other sinusal cavities, similar inflammatory diseases may accompany pneumatisation [3]. In addition to that, over-ventilated conchae may form mass effect and cause the obstruction in the nasal cavity and sinus infections by affecting osteomeatal drainage [11]. In the study of Baldea et al. [1], 8 of 10 pneumatised cases had symptoms of rhinosinusal infection. The authors stated that in these cases the effect of PIT could not be fully demonstrated due to the presence of other extra-pneumatisations.

The pneumatisation of the inferior turbinate may cause runny nose, sneeze and headache, depending on its degree [10, 13]. Nasal congestion due to PIT is rare; however, may affect quality of life. Especially extensive PIT may cause epiphora because of the contraction of the nasolacrimal duct [6]. The differentiation between the hypertrophia of the inferior turbinate and PIT is almost impossible [10]. Clinically, in patients diagnosed with hypertrophia of the inferior turbinate, PIT should be kept in mind when medical treatments are ineffective [10]. The final diagnosis can be established based on paranasal sinus CT. The treatment for PIT is only indicated when the patient is symptomatic [12]. Medications such as nasal steroids can be given, but generally they are ineffective and surgery is needed [10]. When surgery is necessary, partial resection is preferred rather than total turbinectomy, preventing from atrophic rhinitis and aiming to widen the airway to maximum, preserve the function of the nasal mucosa and minimise the complications [17].

We aimed to give more accurate ratios for the frequency of PIT by coronal CT images in our study. The images were analysed considering that inferior turbinate may be confused with extended nasolacrimal duct or can be misinterpreted with extreme folding of the bone or mucosa of the inferior turbinate as Braun et al. reported [4, 16].

CONCLUSIONS

The pneumatisation of the inferior turbinate is an anatomical variation which can be seen in any age of both genders unilateral or bilateral. Other conchal pneumatisations and septal deviation may accompany. The final diagnosis is given upon CT images. Because of the presence of the anatomical variations of the paranasal region, it may complicate surgical procedures; radiologists and surgeons working around this region should remember about PIT in order to prevent complications.

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