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Anatomical Variations of the Human Nasal Osteomeatal Complex, Studied by CT

By

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ABSTRACT

Background: Precise information of the anatomical variants of the osteomeatal complex is critical for clinicians, especially with the advent of functional endoscopic sinus surgery. This study aimed to determine the incidence and morphology of these variations in adult Saudi patients, using computed tomography (CT).

Methods: The anatomical variations of the osteomeatal complex were studied in one hundred adult Saudi patients with clinical suspicion of sinusitis, using oblique CT scan. They were explored in the radio-diagnostic department of Al-Majma'ah, King Khalid Hospital, K.S.A.

Results: There was a great number of variations in the anatomy of studied part of the nasal region. Deviated nasal septum was the most common type of variations (78%), followed by pneumatized middle concha (38%). These variations were frequently accompanied with reduction of the osteomeatal complex.

Conclusions: Oblique CT scan is a good method to evaluate the osteomeatal complex. This region shows a wide prevalence of anatomical variations. Determination of these variations aids in providing a better surgical orientation and avoiding or minimizing the possible complications.

Key Words: Osteomeatal complex, Computed tomography, Anatomical variations.

INTRODUCTION

Osteomeatal complex is a term, referring to the maxillary sinus ostium, ethmoidal infundibulum, hiatus semilunaris and frontal recess[(1)]. It comprises the region of the middle meatus with the anterior air cells[(2)]. It represents the final common pathway for drainage of the frontal, maxillary and anterior ethmoidal sinuses. A patent osteomeatal complex is essential for the improvement of patients with sinus disease[(3)].

An accurate knowledge of the anatomy of this region is essential in order to understand the patho-physiology of diseases affecting sinuses and their subsequent management[(2)]. Moreover, the revolutionary changes in the surgical treatment of sinusitis in the recent years, particularly in nasal endoscopic surgery, require the clinicians to have precise information of the large numbers of the anatomical variants of this region, many of which are

detectable only by the use of CT[4]. Very small air cells may be missed during anatomical dissections but not at CT[5].

The aim of the present study is to determine the incidence and morphology of the anatomical variations of the region of osteomeatal complex in adult Saudi patients, using computed tomography (CT). This is also a trial to assess the possible role of these changes in sinusitis and describe them in a comprehensible way for the clinicians.

MATERIAL AND METHODS

CT scan studies of patients evaluated for clinical suspicion of sinusitis were analyzed. Cases with nose or paranasal sinus tumours, surgery or injury were excluded. Then the study included 100 CT scans of the nasal sinus region in adults (50 males and 50 females). Their ages ranged from 18 to 78 years, mean age 32. They were explored in the radio-diagnostic department of Al-Majma'ah, King Khalid Hospital, K.S.A. between April 2006 and December 2008. Oblique coronal slices were taken, with 2-5mm in thickness. Taking the hard palate as a reference, the plane of section was taken at an oblique angle of about 45 degrees with it (Fig. 1). Each CT scan was analyzed separately. Anatomic variations considered in this study were that of nasal septum, middle concha, anterior ethmoidal sinus and uncinate process. The selected CT scans were photographed. The data were then collected, reported and discussed.

RESULTS

There were many variations in the anatomy of studied part of the nasal region. There was no significant difference in the incidence of variations between males and females. Deviated nasal septum was the most common type of variation (78%), followed by pneumatized middle concha (38%). Other variations included agger nasi, pneumatization of bony portion of nasal septum, paradoxical middle concha, Haller cells, hypoplastic middle concha, bony spurs of nasal septum, overpneumatized ethmoidal bulla "great bulla ethmoidalis" and uncinate process deviation (Table 1 and Graphic 1).

The defined anatomic variations were classified into four groups according to the involved structures; nasal septum, middle concha, ethmoidal air cells and uncinate process.

Nasal Septum Variations

Deviation of nasal septum was found in 78 cases (78%). It included any midline deviation and varied from slight deviation (45%), without other nasal variations to marked deviation (33%) associated with other variations. The slight deviation of nasal septum was seen to be accompanied with normal osteomeatal unit (Figs. 2 and 3).

However, the marked deviation was accompanied with other anatomical variations, including reduction of the other side of the nasal cavity (Fig. 4). The bony portion of the nasal septum was observed to be pneumatized in 20 cases (20%) (Fig. 5). The anatomic variation included septal bony spurs in 7 cases (7%). These cases were mostly seen to be associated with narrowing of the affected middle meatus and lateral deviation of the uncinate process (Fig. 6).

Middle Concha (Turbinate) Variations

Pneumatization of the middle concha was detected in 38 cases (38%). It was unilateral in 28 cases and bilateral in 10 cases. This pneumatization was small without association with other variations in 20 cases (20%) (Fig. 7). However, extensive pneumatization forming concha bullosa was observed in 18 cases (18%). Concha bullosa was associated with reduction of the nasal cavity and deviation of the nasal septum (Fig. 8). It was seen to be communicated with the ethmoidal sinus (Fig. 9). Other middle concha variations included paradoxical concha in 16 cases (16%) (Fig. 10). In this case the convexity of the concha was directed toward the lateral wall (Figs.10 and 11). Also, hypoplastic middle concha was seen in 8 cases (8%) (Fig. 3).

Ethmoidal Variations

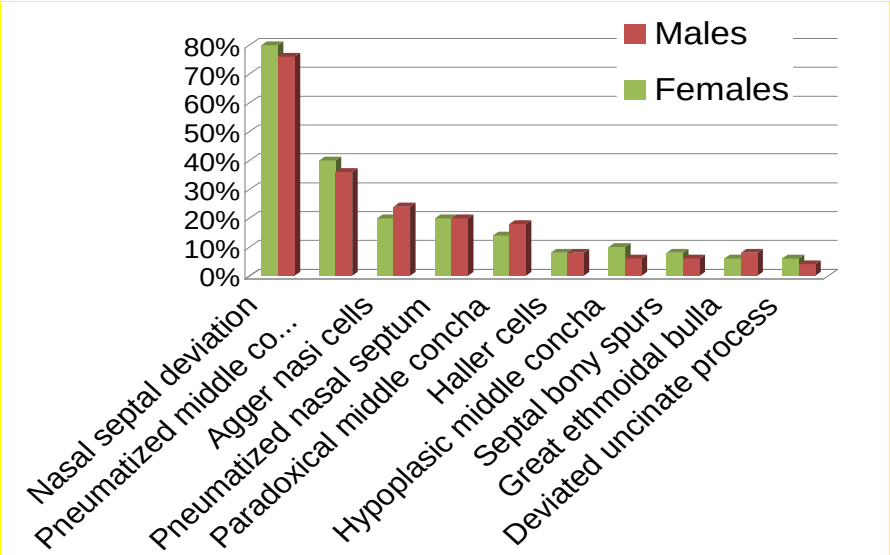
Agger nasi cells were present in 22 cases (22%). They were situated below the frontal sinus (Fig. 12). Also, Haller cells were seen in 8 cases (8%). Great ethmoidal bulla were detected in 7 cases (7%) (Fig. 11). No cases with Onodi cells were encountered.

Uncinate Process Variations

There were some anatomical variations in the direction and attachment of the uncinate process. Its deviations were observed in five cases (5%); three cases laterally and two medially. It was attached to the middle concha in one case (Fig. 8) and to the ethmoidal floor in another case (Fig. 13). No cases of pneumatization or absence of the uncinate process were encountered in the examined CT images.

Anatomical Variations	In Males	In Females
Nasal septal deviation	38	40
Pneumatized middle concha	18	20
Agger nasi cells	12	10
Pneumatized nasal septum	10	10
Paradoxical middle concha	9	7
Haller cells	4	4
Hypoplasic middle concha	3	5
Septal bony spurs	3	4
Great ethmoidal bulla	4	3
Deviated uncinate process	2	3

Table (1): Numbers of the anatomic variations of the osteomeatal complex in both males and females.



Graphic (1): Percentages of the anatomic variation incidence of the osteomeatal complex in males and females.

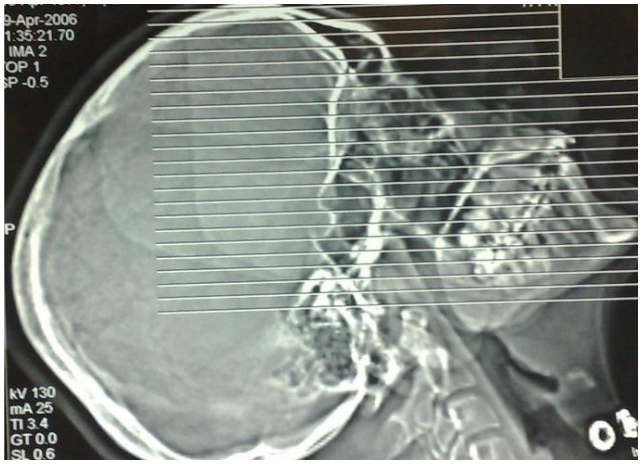


Fig. 1: showing planes of oblique CT scan

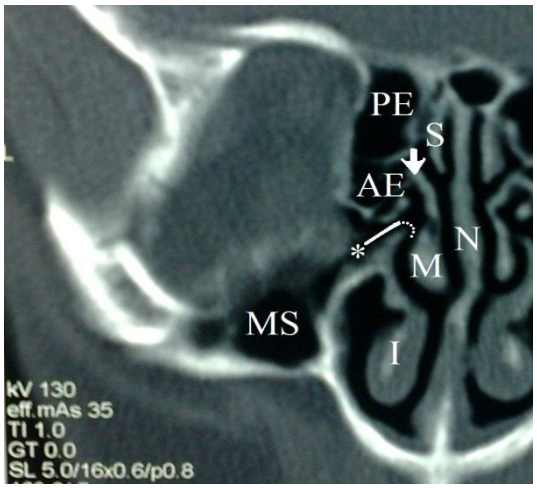


Fig. 2

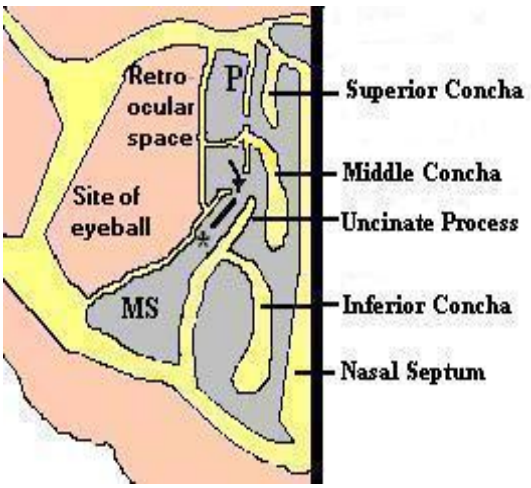


Fig. 3

Fig. 2: Oblique CT scan shows a slight deviation of the nasal septum (N) with normal osteomeatal unit; maxillary sinus ostium (asterisk), ethmoidal infundibulum (straight line), hiatus semilunaris (dots). The anterior ethmoidal (AE) and posterior ethmoidal (PE) sinuses are separated from each other at the attachment of the basal lamella (arrow) of the middle concha (M). Superior (S) and inferior (I) conchae and maxillary sinus (MS) are shown.

Fig. 3: Diagram of an oblique CT scan shows a normal osteomeatal unit. The ostium (asterisk) of maxillary sinus (MS) and opening of anterior ethmoidal sinus (curved arrow) into ethmoidal infundibulum (straight line) is marked.

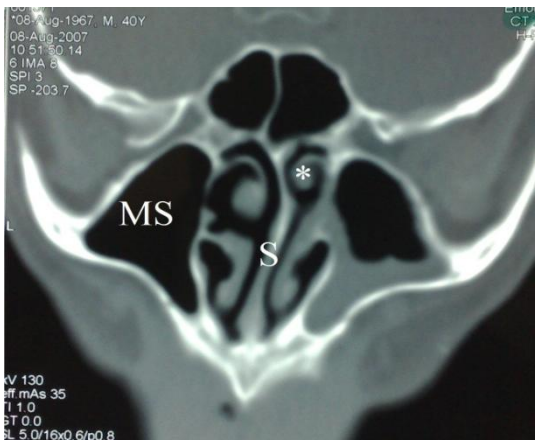


Fig. 4

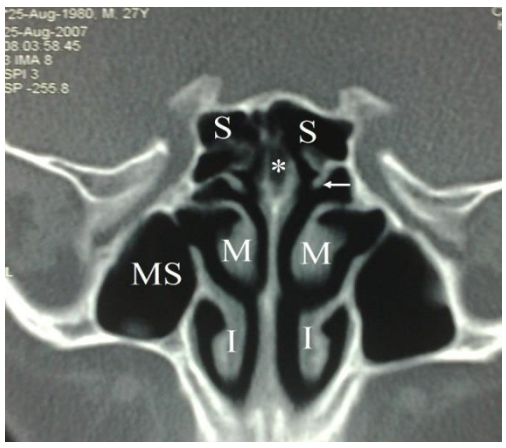
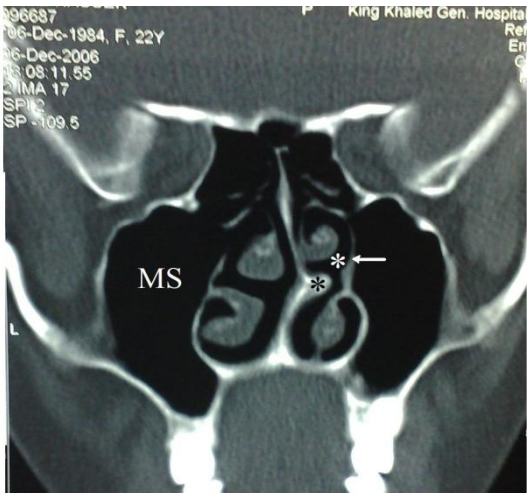


Fig. 5

Fig. 4: Oblique CT scan shows a marked right deviation of the nasal septum (S) associated with reduction of the right side of the nasal cavity and hyperplasia of the right middle concha (asterisk).

Fig. 5: Oblique CT scan shows a pneumatized bony portion (asterisk) of the nasal septum. The sphenoid (S) and maxillary (MS) sinuses and the three pairs of conchae; superior concha (arrow), middle concha (M) and inferior concha (I) are shown.



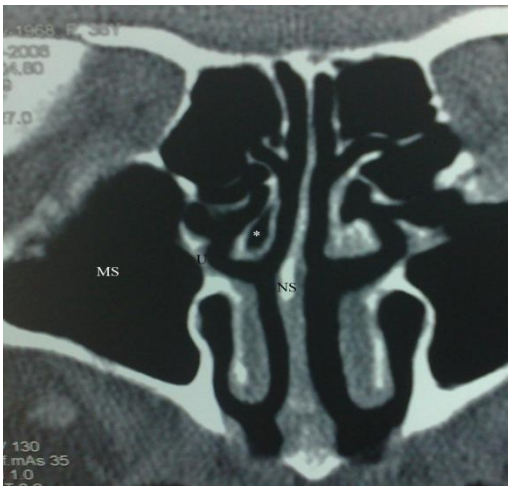
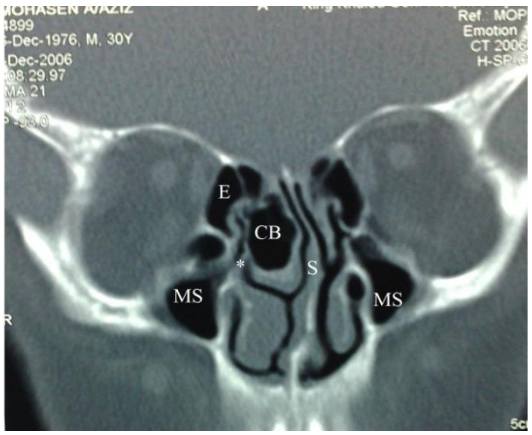


Fig. 6 Fig. 7

Fig. 6: Oblique CT scan shows a bony spur (black asterisk) of nasal septum. It is associated with narrowing of affected middle meatus (white asterisk) with lateral deviation of the uncinate process (arrow). Maxillary sinus (MS) is shown.

Fig. 7: Oblique CT scan shows a small pneumatization of the left middle concha (asterisk). Maxillary sinus (MS) and nasal septum (NS) are marked.



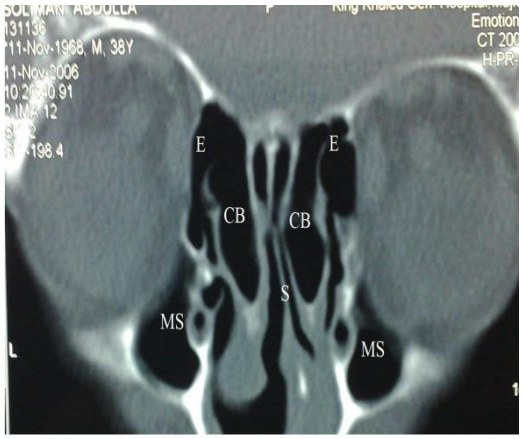


Fig. 8 Fig. 9

Fig. 8: Oblique CT scan shows middle concha bullosa, associated with deviation of the nasal septum (S). The ethmoid (E) and maxillary (MS) sinuses are shown.

Fig. 9: Oblique CT scan shows concha bullosa (CB) affecting both right and left middle conchae. They are communicated with the ethmoidal sinuses (E). Nasal septum (S) and maxillary (MS) sinuses are marked.

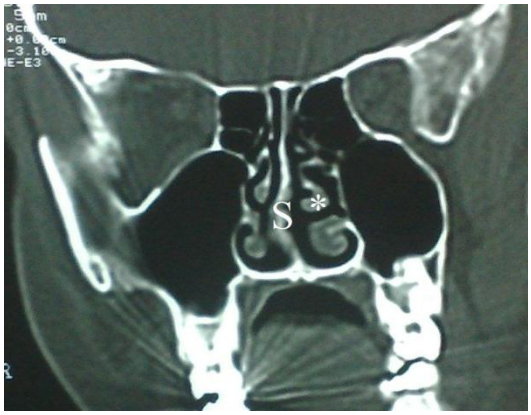


Fig. 10

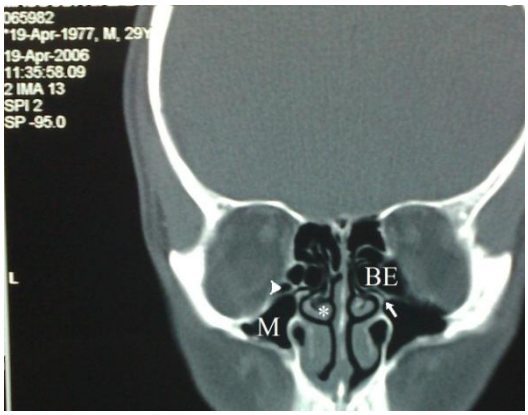


Fig. 11

Fig. 10: Oblique CT scan shows a large paradoxical middle concha (asterisk), associated with deviation of the nasal septum (S) to the other side.

Fig. 11: Oblique CT scan shows a great bulla ethmoidalis narrowing the ethmoidal infundibulum (pointed by the arrow). Haller air cell (arrowhead) is observed on the left side above the maxillary sinus (M).

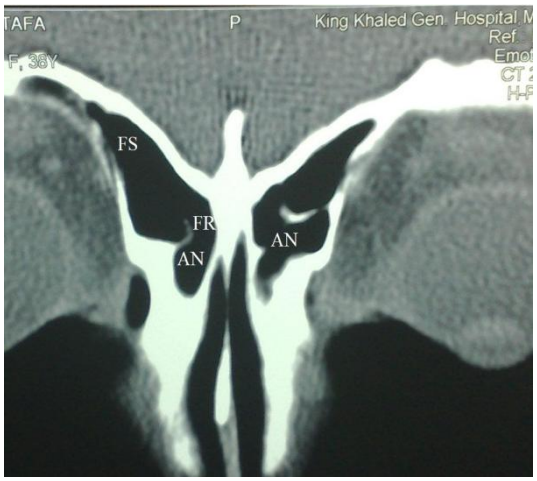


Fig. 12

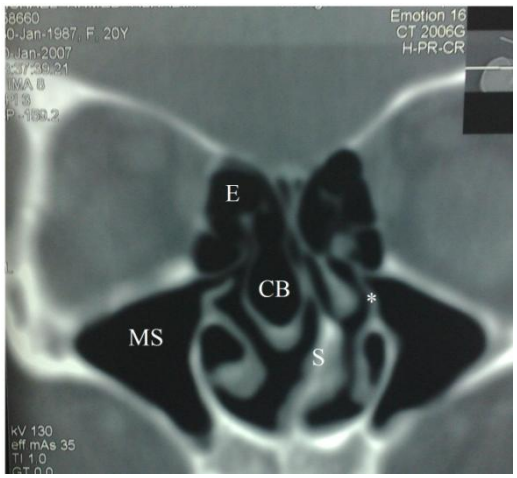


Fig. 13

Fig. 12: Oblique CT scan shows the most anterior ethmoidal air cells, called agar nasi cells (AN), lying below the frontal sinus (FS). The frontal recess (FR) is marked.

Fig. 13: Oblique CT scan shows a large concha bullosa (CB), communicated with ethmoidal sinus (E). The uncinate process (asterisk) on the other side is laterally deviated and fused to the floor of the ethmoidal sinus.

DISCUSSION

Many authors agree that frontal (coronal) CT scan is more informative than the transverse one in cases of anatomical studies of paranasal sinuses[6, 7]. They add that the frontal CT shows the anatomical structures progressively, much as a surgeon would see them, and offers optimal visualization of the relationships between the sinuses and the adjacent structures. However, the frontal study should be accompanied by an axial study

which provides a better visualization of the anterior and posterior walls of the frontal sinuses and of the anatomical relations between the posterior ethmoidal cells and the sphenoid sinus[7]. In the present study, the osteomeatal complex was better visualized through single oblique coronal planes. Only attention must be paid in their orientation i.e. the upper part of the image indicates the upper and posterior structures while the lower part indicates lower and anterior.

The osteomeatal complex has been defined in different ways. Many authors define it as the region of middle meatus that comprises the maxillary sinus ostium, ethmoidal infundibulum, hiatus semilunaris and frontal recess[1,2,5,8]. However, others refer to this region as the anterior osteomeatal complex, while they define another region as the posterior osteomeatal complex[9,10]. They add that the posterior osteomeatal complex is located in the spheno-ethmoidal recess and drains the posterior ethmoid and sphenoid sinuses. This complex is less involved in chronic sinusitis than the anterior one because its anatomic variations are fewer. In the current study, the first definition was adopted because the defined region of middle meatus represents the most complex region of the lateral nasal wall[11], and its obstruction plays the pivotal role in the development and persistence of sinusitis[1].

Nasal Septum

Nasal septal deviation was the most common type of variation in the current study. It was found in 78% of cases. This finding is in general agreement with previous results[1,12] and nearly similar to the incidence of 80% reported by Perez-Pinas et al[7]. However, it is higher than that reported by Sazgar et al[13] (63%), Dua et al[14] (44%), Daghighi and Daryani[15] (34.24%) and Riello and Boasquevisque[5] (28.5%). The presence of septal bony spurs was noticed in 7% of the examined cases. It is lower than that shown by Perez-Pinas et al[7] (13.6%). Marked deviated nasal septum or bony spur was noticed to be associated with reduction of the osteomeatal unit. It predisposes to nasal obstruction and related complications[14].

The bony portion of the nasal septum is often pneumatized[10]. This condition was observed in 20% of cases in the current study. However, it was only detected in 2% of cases in a previous study[14]. In cases of overexpansion, it may impair airflow into the bilateral sphenoid ostia[10].

Middle Concha (Turbinate)

Concha bullosa, an air cell within the middle concha, is usually an extension of the anterior ethmoidal air cell[16]. Its presence is one of the most frequent anatomical

variations[5,16]. It ranges between 4% and 80% in several studies[7]. Such a wide range of incidence is due to the criteria of pneumatization adopted. Some authors considered any degree of pneumatization as concha bullosa[5] , while others limited this definition to the large pneumatization of middle concha involving its vertical lamina and inferior bulb[7,17]. The present study adopted the second opinion. Using this criterion, concha bullosa was only defined in 18% of the examined cases. Meanwhile, the percentage of total cases of pneumatization was 38%. Small pneumatization was not associated with other variations in the current findings, but it may lead to mucocele formation[16]. However, large pneumatization, termed concha bullosa was noticed to be associated with nasal septal deviation and reduction of the nasal cavity. There is a strong association between the existence of concha bullosa and septal deviation in the opposite directions[15]. Sazgar et al[13] suggested that the nasal septal deviation is an indirect result of the presence of concha bullosa. Moreover, the presence of concha bullosa has been implicated as a possible cause for chronic or recurrent sinusitis[14].

Another anatomical variant of the nasal cavity with the potential for airway compromise and chronic sinusitis is the paradoxical middle concha[10]. Normally, the convexity of the middle concha is directed medially, toward the nasal septum. When paradoxically curved, the convexity is directed laterally[11]. In the present study, paradoxically curved middle concha was found in 16% of the examined cases. This incidence is nearly similar to that of 15% reported by Llyod et al[18] and 13.97% by Liu et al[19]. It is lower than the incidence of 29%, found by Riello and Boasquevisque [5].

Hypoplastic middle concha was detected in 8% of the examined cases. This result is consistent with the finding of Riello and Boasquevisque[5]. However, it was not detected in other reviewed studies[7].

Ethmoidal Sinus

This sinus comprises a group of air cells, which form one of the most complex structures in the body. Hence the sinus is rightly named the ethmoid 'labyrinth'[20]. Although traditionally divided into anterior, middle and posterior ethmoidal air cells, the ethmoidal sinuses are now commonly considered by clinicians as consisting of anterior and posterior groups on each side, the middle ethmoidal air cells being incorporated into the anterior group. The groups are separated from each other by the basal lamella of the middle meatus[1,8]. Using oblique coronal CT scan in this study, these groups were clearly shown.

The air cells extending within the ethmoid complex are the intramural cells, while the other extensions are the extramural[7]. The agger nasi cells, the most anterior extramural ethmoid cells, are located in the most antero-superior aspect of the middle meatus, below the frontal sinus[21]. This group of cells were observed in 22% of cases in this study. Previous studies varied widely regarding the presence of these cells. For example, it was detected in 92.1% of population by Nitinavakarn et al[21], 36.22% by Daghighi, and Daryani[15], 13.5% by Riello and Boasquevisque[5] and 0.7% by Zhonghua et al[19]. The surgical importance of the cell is in its anatomical relation with the adjacent structures. The frontal recess lies behind the posteromedial wall of this cell. If the agger nasi cell is excessively pneumatized it can cause obstruction of the frontal sinus ostium and can produce frontal sinusitis[22].

Haller cells are ethmoidal air cells that project inferiorly, below the ethmoidal bulla, in relation with the floor of the orbit and in the region of the maxillary sinus ostium[23]. They are encountered in 8% of the examined group of patients. This finding is consistent with that of Riello and Boasquevisque[5], but other authors have reported a wide variation in the prevalence rates such as 23.8% by Nitinavakarn et al[21], 16% by Dua et al[14], 1.41% by Daghighi and Daryani[15] and 1% by Liu et al[19]. Stammberger and Wolf[24] considered the existence of these cells as a predisposing cause for recurrent maxillary sinusitis.

The ethmoidal bulla is the largest ethmoidal air cell of the ethmoidal complex. When it reaches sufficient size it can tighten or even obstruct the middle nasal meatus and the infundibulum. In this case it is considered as a great ethmoidal bulla[7]. According to Laine and Smoker[11], the exact incidence of this anatomical variant is unknown. Also, Perez-Pinas el al[7] did not observe this variant in their study. However, it was noticed in 7% of patients in the present study. Other studies detected higher incidence such as 30.30% by Liu et al[19] and 10% by Mazza et al[25].

Occasionally, a posterior ethmoid air cell may invade the anterior-superior aspect of the sphenoid sinus and come to lie in close relation with the optic nerve. It is then called the cell of Onodi[20]. The investigation of this type of cell by CT study is less sensitive than anatomical studies [26]. No cases of Onodi cell were encountered in the present findings. In a study by Nitinavakarn et al[21], it was found in 25% of cases. This finding is much higher than those found by other CT studies such as those of Daghighi and Daryani[15] and Weinberger et al[27] where the

prevalence was 0.40% and 8% respectively.

Uncinate Process

The uncinate process is a key bony structure of the lateral wall of the nasal cavity. Together with the ethmoidal bulla, it limits the semilunar hiatus and the ethmoidal infundibulum[7]. The superior aspect of the uncinate tip may deviate laterally, medially or anteriorly out of the meatus, appearing as a second middle concha[24]. When deviated medially, it comes into contact with and compromises the middle meatus. When deviated laterally, it may encroach on the hiatus semilunaris and infundibulum, impeding drainage and ventilation of the anterior ethmoidal, frontal and maxillary sinuses. The exact prevalence of these variations and their relation to sinus disease have not been determined[11]. In the present study, the deviation of uncinate process was noticed in 5% of cases. The incidence is similar to that of Dua et al[14].

Pneumatization of the uncinate process was not observed in the present study nor in that of Perez-Pinas et al[7]. Other studies reported a prevalence rates of 2.5% by Bolger et al[4] and 13% by Riello et al[5]. The exact mechanism by which uncinate pneumatization occurs is not known[11]. Bolger et al[17] assumed that it might be due to extension of the agger nasi cells into the anterosuperior portion of the process.

The differences in the incidence of the anatomical variations in the different studies might be due to discrepancies in data analysis and interpretation as well as specious variations of the studied groups.

CONCLUSION

Oblique coronal CT scan is a good method to evaluate the osteomeatal complex. It could be used instead of the more common method where both coronal and axial CT scans need to be done, especially for screening diseased cases. Using this method, the osteomeatal complex showed a wide prevalence of anatomical variations. Determination of these variations is essential for surgeons before any management or surgical interference. Furthermore, special attention must be paid for the existence of nasal septal deviation and pneumatized middle concha because of their high prevalence and frequent accompaniment with osteomeatal reduction.

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الاختلافات التشريحية في التعقيد (المركب) الصماخي العظمي للأنف في الإنسان "دراسة بالتصوير الإشعاعي المقطعي"

إن المعرفة الدقيقة لتركيب هذه المنطقة غاية في الأهمية، حيث أن ذلك يساعد في معرفة كيفية حدوث المرض بها، وبالتالي الطرق المثلى لعلاجه ، بالإضافة إلى ذلك فإن إدخال جراحة المناظير في هذا المجال يحتاج لمعلومات دقيقة وكافية عن الاختلافات التشريحية لتلك المنطقة.
يهدف البحث الحالي إلى تحديد معدل وشكل تلك الاختلافات، في عينة من المرضى بالمملكة العربية السعودية.
طريقة البحث: تم فحص صور إشعاعية مقطعية "تاجية مائلة" لمنطقة الأنف، لعدد مائة مريض بالتهابات محتملة للجيوب الأنفية، بقسم الأشعة التشخيصية بمستشفى الملك خالد بالمجمعة بالمملكة العربية السعودية.
النتائج: تم تحديد عدد كبير من الاختلافات التشريحية في هذه المنطقة، كان أكثرها شيوعاً هو انحراف الحاجز الأنفي (78%)، تلاه القرين الأوسط الهوائي (38%). هذه الاختلافات كثيراً ما كانت مصاحبة بضيق في التعقيد الصماخي العظمي.
الخلاصة: المستوى التاجي المائل للتصوير الإشعاعي المقطعي هو طريقة جيدة لتقييم التعقيد الصماخي العظمي للأنف، حيث وُجد اختلافات تشريحية عديدة، كذلك فإن تحديد هذه الاختلافات يساعد في الرؤية الجراحية الجيدة لتلك المنطقة، وبالتالي تجنب أو تقليل المضاعفات المحتملة للجراحة في هذه المنطقة المعقدة.