# ANATOMICAL VARIATIONS OF THE OSTEOMEATAL COMPLEX TOMOGRAPHIC FINDINGS IN 100 PATIENTS

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**ABSTRACT: OBJECTIVES:** To study the various anatomical variations of the osteomeatal complex and their incidence in patients with chronic rhinosinusitis. **DESIGN:** A prospective study was done on 100 computed tomography scans of patients with chronic rhinosinusitis. **RESULTS:** Various types of anatomical variations were observed in the study viz. concha bullosa, septal deviation, paradoxical middle turbinate, retroverted uncinate process, enlarged ethmoid bulla, haller cells, agger nasi cells, onodi cells and pneumatization of vomer. The most frequent anatomical variation found was septal deviation (30%), followed by presence of concha bullosa (26%).
**CONCLUSION:** Variations are common in the osteomeatal complex. These variations may predispose to sinusal diseases and hence require correction. Also, preoperative detection of such variations by computed tomography avoids complications during functional endoscopic sinus surgery.
**KEY WORDS:** paranasal sinuses; anatomic variation; tomography; nasal septum; turbinates.

**INTRODUCTION:** Paranasal sinus disease is a common clinical problem. It sometimes does not get completely cured by medical line of management, requiring surgical intervention. The introduction of functional endoscopic sinus surgery (FESS) for the management of sinonasal pathology has provided an important role for coronal computed tomography (CT) of the paranasal sinuses, both as a diagnostic tool and as an important part of preoperative planning[1]. The Messerklinger approach of FESS aimed at restoring normal mucociliary drainage has been described by several authors[2,3,4,5].

The osteomeatal complex is differently defined by several authors. In the present study, the concept developed by Stammberger & Kennedy[6] was adopted, defining osteomeatal complex as a functional unit of the anterior ethmoid complex representing the final common pathway for drainage and ventilation of the frontal, maxillary and anterior ethmoid cells. Any of these cells,

clefts, ostia, recesses or cavities may be affected by the variation thus leading to development of pathology in the paranasal sinuses. Dua et al. reported that removal of disease in osteomeatal complex region is the basic principle of FESS which is best appreciated on CT scan[7]. In addition, Stammberger and Hawke have shown that CT examination of the paranasal sinuses will provide an anatomic road map of the paranasal sinuses to identify the presence of significant anatomic abnormalities, the location and severity of the disease and exact location of the obstruction[8].

In the present study, the anatomical variations of the osteomeatal complex were assessed by means of CT scans in patients of chronic rhinosinusitis.

**OBJECTIVES:** To study the various anatomical variations of the osteomeatal complex and their incidence in patients with chronic rhinosinusitis.

**MATERIALS AND METHODS:** This study was carried out at the Department of ENT and Head Neck Surgery, Navodaya Medical College, Raichur. The sources of data for our study were randomly selected patients with a clinical diagnosis of chronic rhinosinusitis. This study is a prospective study, conducted for a period of 6 months from 1st January 2012 to 31st June 2012. The study was carried out on 100 cases. The patients were selected depending on the following Inclusion/Exclusion criteria:

Inclusion Criteria:

1. Adult patients
2. Irrespective of socio-economic status.
3. Clinical diagnosis of Chronic RhinoSinusitis.

Exclusion Criteria:

1. History of previous sinus surgery.
2. History of benign tumors of sinonasal mucosa.
3. History of facial trauma.

All the patients underwent CT scan of the paranasal sinus region with GE Pro-Speed Plus 4 Slice Multidetector CT machine. Coronal sections were performed with the patients in prone position, with extended neck and the plane perpendicular to the infra-orbitomeatal line. The sections were taken with slice thickness of 5 mm. They were analysed for anatomical variations. The data collected was subjected for statistical analysis.

**ETHICAL CONSIDERATIONS:** The study got clearance by the Institutional Ethical Committee before its commencement. Also, a written informed consent was taken from all the patients before participating in the study.

**RESULTS:** The patients were between 18 to 54 years of age (average age was 30.9 years). There were 53 males (53 %) and 47 females (47%).

Septal deviation was the most common variation. It was observed in 30 patients (30%) (FIG 1 ). Next common was the presence of concha bullosa (FIG 2). It was observed in 26 patients (26%). Concha bulla was unilateral in 14 cases (14%) and bilateral in 12 cases (12%). Haller cells were observed in 8 patients (8%) (FIG 3). They were unilateral in 5 cases (5%) and bilateral in 3 cases (3%). Pneumatization of vomer was observed in 5 patients (5%) (FIG 4). Onodi cells were observed

in 5 patients (5%). They were unilateral in 3 cases (3%) and bilateral in 2 cases (2%) (FIG 5). Paradoxical middle turbinate was observed in 4 patients (4%). It was unilateral in 3 cases (3%) and bilateral in 1 case (1%) (FIG 6). Agger nasi cells were observed in 4 patients (4%) (FIG 7). They were unilateral in 2 cases (2%) and bilateral in 2 cases (2%). Enlarged ethmoid bulla was observed in 3 patients (3%) (FIG 8). It was unilateral in 2 cases (2%) and bilateral in 1 case (1%). Retroverted uncinate process was found in a single case (1%) and it was bilateral (FIG 9).

**DISCUSSION:** The osteomeatal complex is differently defined by several authors. Scribano et al.[9] have defined the osteomeatal complex as a complex including the maxillary sinus ostium, ethmoid infundibulum and middle meatus; in other words, as the final site of drainage from the frontal and maxillary sinuses and anterior ethmoidal cells. Casiano[10] has defined the osteomeatal complex as the ethmoid bulla, uncinate process and adjacent spaces and ostia draining the anterior sinuses (anterior ethmoid sinus, frontal and maxillary sinuses). Zinreich et al.[11] have defined the osteomeatal complex as the group of bony structures and aerated channels into which the paranasal cavities drain, and have subdivided the complex into three parts. The first most anterior portion of the complex includes structures surrounding the frontal recess; the second one corresponds to the structures including the maxillary sinus and middle meatus; and the third and most posterior portion includes the structures surrounding the sphenoethmoidal recess. The osteomeatal complex would be formed by the two first portions[11]. Mafee et al.[12] and Mafee[13] have described the osteomeatal complex similarly to the definition by Zinreich et al.[11]. Laine & Smoker[14] have defined the osteomeatal complex as an aerated channel of the middle meatus representing the final common pathway for drainage of the maxillary and frontal sinuses and anterior ethmoid cells, delimited by the uncinate process, ethmoidal bulla and middle turbinate. Shankar et al.[15] have defined osteomeatal complex as a complex including the maxillary ostium, ethmoid infundibulum, hiatus semilunaris, middle meatus, frontal recess, ethmoid bulla and uncinate process. In the present study, the concept developed by Stammberger & Kennedy[6] was adopted, defining osteomeatal complex as a functional unit of the anterior ethmoid complex representing the final common pathway for drainage and ventilation of the frontal, maxillary and anterior ethmoid cells. Any of these cells, clefts, ostia, recesses or cavities may be affected by a pathological process, thereby contributing to the symptoms and pathophysiology of sinusitis.

**NASAL SEPTAL DEVIATION:** Deviation of the nasal septum can be defined as any midline deviation[16,17].Septal deviations may be cartilaginous, cartilaginous-bony type, or a combination of both. Since septal deviation causes lateral compression of the middle turbinate and uncinate process pushing them into the infundibulum and thus causes obstruction of osteomeatal complex, it is included in this study. Severe deviated nasal septum results in compression of the middle turbinate and causing an obstruction in the normal mucus flow, thus resulting in sinusitis. Deviation of the nasal septum was found in 30% of cases in the present study. In other studies, this finding ranged from 14.1% to 80%: Dutra & Marchiori[18], 14.1%; Kinsui et al.[19], 23.3%; Arslan et al.[20], 36%; Earwaker[16], 44%; and Pérez-Piñas et al.[21], 80%.

**CONCHA BULLOSA:** The middle concha bullosa is a result of pneumatization of the osseous plate due to ethmoidal extension. The concha pneumatization may occur at several degrees, from that

affecting only the bulbous portion (distal) or lamellar portion (proximal), or the called true variant where there is pneumatization of both portions[22]. Zinreich et al. report that conchae bullosae are best diagnosed radiographically and easily identified with CT[23]. The appearance is that of an air space of the middle concha surrounded by an oval bony rim. Bolger et al., reported this pneumatisation in 53% of the sinus patients, as an extension of the anterior air cells (55%) or posterior (45%) ethmoidal air cells[22]. The highest incidence of 80% was found in the study of Goldman in patients with chronic sinusitis on resected middle concha materials[24]. In our study, the incidence was 26%. These discrepancies in the incidence may depend on the criteria of pneumatisation of different researchers and on the method of analysis. Some researchers accept very small and physiologically insignificant conchae as conchae bullosae. Also, the incidence depends on the patients group, as some studies including ours are performed on patients with sinusitis.

**HALLER CELLS:** Haller's cell is the pneumatization of the anterior ethmoid cells into the roof of the maxillary sinus extending into the floor of the orbit. In our study, Haller cells were observed in 8 patients (8%). They were unilateral in 5 cases (5%) and bilateral in 3 cases (3%). Zinreich[1] reported it in 10% of cases. However, using the same criteria, Bolger reported it in 45.1% of cases[22]. Lloyd reported it in 2% of cases[25]. Earnwaker reported it in 20% of cases[16]. Bolger described the possible reasons for this discrepancy as a consequence of difference in interpretation of Haller cell, sample study or in the technique of CT scanning. Bolger also suggested that a narrow window setting often fails to delineate Haller cell[22].

**PNEUMATIZATION OF VOMER:** Pneumatization of vomer was observed in 5 patients(5%) in the present study. Similar variant has also been described by Lang Jin his work[26].

**ONODI CELLS:** Also known as sphenoethmoidal cells, Onodi cells were first described by the Hungarian laryngologist Adolf Onodi, in 1904[29]. Onodi cells (FIG 10) are ethmoid cells that have migrated to the anterior region of the sphenoid sinus, with anterosuperior location, and intimately related to the optic nerve, causing optic neuropathy in case of certain conditions that affect such cells[27]. Onodi cell is the most posterior ethmoid air cell that extends laterally. This extension is near the carotid canal and close to the optic nerve, which emphasizes the clinical importance of considering this anatomic variation prior to any attempt for invasive intervention. The surgeon must pay close attention to the occasional Onodi cell in preoperative evaluation to avoid potential complications of endoscopic sinus surgery. Therefore it would seem logical to assume that rhinogenic optic neuritis and Onodi cell are related findings[28]. In our study, Onodi cells were observed in 5 patients (5%). They were unilateral in 3 cases (3%) and bilateral in 2 cases (2%). In other studies, this finding ranged from 7% to 12%: Jones[30], 7-9%; Basic[31], 10%; Perez et al.[21], 11%; and Arslan et al.[20], 12%.

**PARADOXICAL MIDDLE TURBINATE:** Paradoxical middle turbinate occurs if the convexity of the middle turbinate is directed towards the medial wall of the maxillary sinus. Stammberger and Wolf accept paradoxical curvature of the middle concha as an etiologic factor because it may cause obliteration or alteration in nasal air flow dynamics[4]. In our study, paradoxical middle turbinate

was observed in 4 patients (4%). It was unilateral in 3 cases (3%) and bilateral in 1 case (1%). In other studies, this finding ranged from 12% to 26.1%: Calhoun[32], 12%; Lloyd[25], 17%; and Bolger[22], 26.1%.

**AGGER NASI CELLS:** Agger nasi cells are the most anterior ethmoid cells and extend anteriorly into the lacrimal bone. They are located in the anterior floor of the frontal sinus, on the drainage pathway of the frontal sinus, and therefore are possibly involved in recurrent or chronic frontal sinusitis. In our study, agger nasi cells were observed in 4 patients (4%) . They were unilateral in 2 cases (2%) and bilateral in 2 cases (2%). Schaefer et al.[2], reported an incidence of 10% while van Alyea[33] had observed an incidence of 89% in their series of anatomic dissections.

**ENLARGED ETHMOID BULLA:** An enlarged ethmoidal bulla may obstruct the infundibulum or the middle meatus. The exact prevalence of enlarged ethmoidal bulla is not known[14]. Its size is an important factor when associated with opacification of anterior ethmoidal cells at CT in patients diagnosed with sinusopathy[34]. However, one has not found in the literature an objective description of what could be considered an enlarged ethmoidal bulla[14]. Late in its development, the ethmoidal sinus measures on average 36 x 18 x 14 mm (length, height and width) in measurements as performed in MRI studies[35]. These measures were similar in cadaver skulls[36]. The ethmoidal bulla, however, has not been separately evaluated in these studies. In measurements at CT in adults, the average area of each ethmoidal cell is 0.73 ± 0.42 $cm^2$, the larger ones, situated in the posterior portion of ethmoid, measure 1.46 ± 0.64 $cm^2$ [37]. Again, the size of the ethmoidal bulla has not been described separately. Since the ethmoidal bulla is the largest anterior cell[35], it is implicit that its average area should not exceed 2.1 $cm^2$. In our study, enlarged ethmoid bulla was observed in 3 patients (3%). It was unilateral in 2 cases (2%) and bilateral in 1 case (1%).

**RETROVERTED UNCINATE PROCESS:** The presence of a retroverted uncinate process, wherein the uncinate process ( rather than the middle turbinate) is the first bone to encountered, can be misleading to the rhinologic surgeon and lead to inadequate surgery. Familiarity with anatomic variations such as the retroverted uncinate process should increase the safety and effectiveness of FESS [38]. In our study, retroverted uncinate process was found in a single case (1%) and it was bilateral. Earwaker, in a study of 800 cases, have described variants of the uncinate process in detail[16].

**CONCLUSION:** Anatomical variations are common in the osteomeatal complex. The most frequent anatomical variation found in our study was septal deviation (30%), followed by presence of concha bullosa (26%). Awareness of the possibility of such variations helps in making therapeutic decisions. This will also help the otorhinolaryngologist and/or radiologist to evaluate the CT of paranasal sinuses better. This will, in turn, help in endoscopic examination as well as in FESS.

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FIG 1: CORONAL CT SCAN SHOWING SEPTAL DEVIATION TOWARDS RIGHT (arrow). (MS:MAXILLARY SINUS)

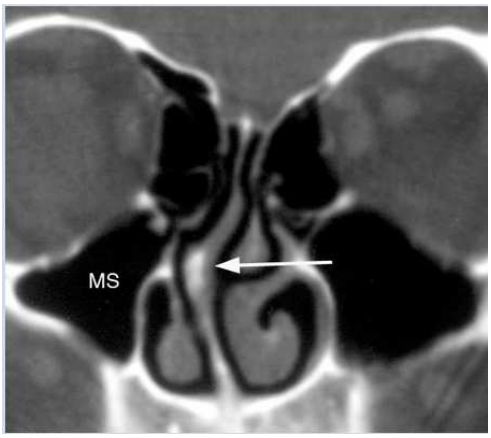
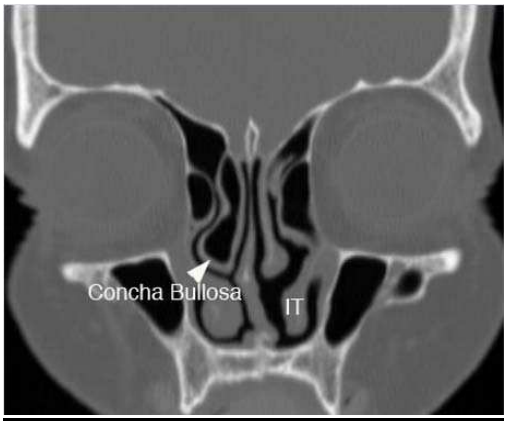



FIG 2: CORONAL AND AXIAL CT IMAGES SHOWING RIGHT CONCHA BULLOSA. (IT: INFERIOR TURBINATE, MT: MIDDLE TURBINATE)



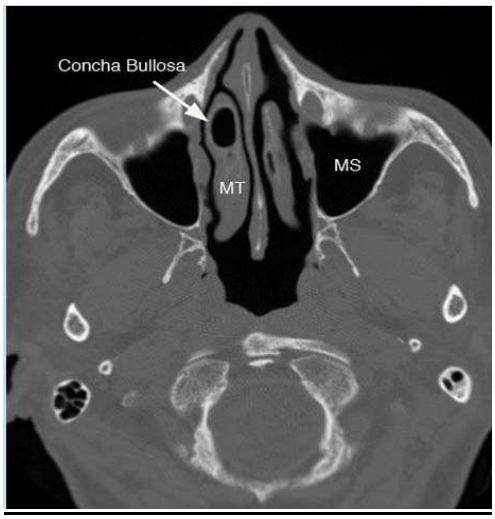
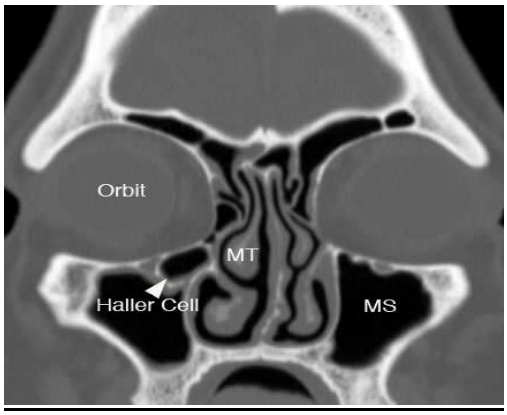



FIG 3: AXIAL AND CORONAL CT IMAGES SHOWING HALLER CELL (INFRAORBITAL AIR CELLS) [MT-MIDDLE TURBINATE, NLD-NASOLACRIMAL DUCT, MS-MAXILLARY SINUS]



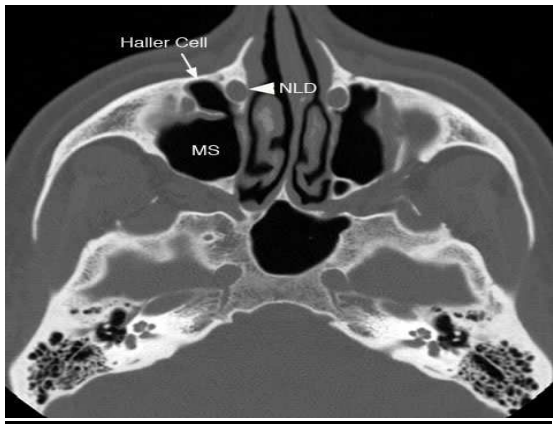




FIG 4: CORONAL CT IMAGE OF PARANASAL SINUS AREA SHOWING PNEUMATIZATION OF VOMER (V)

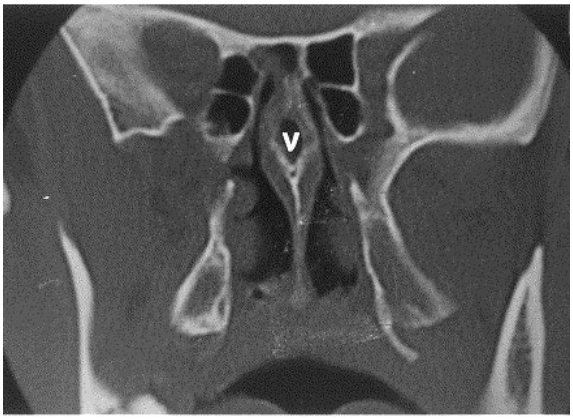
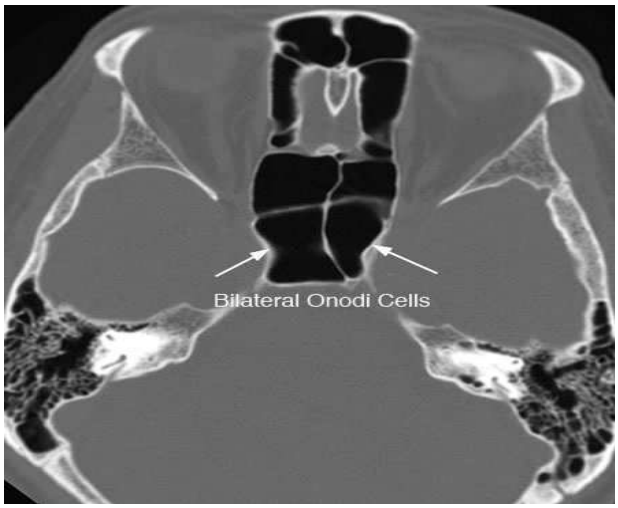


FIG 5: AXIAL AND CORONAL CT IMAGES SHOWING ONODI CELLS [SPHENOETHMOIDAL AIR CELLS]



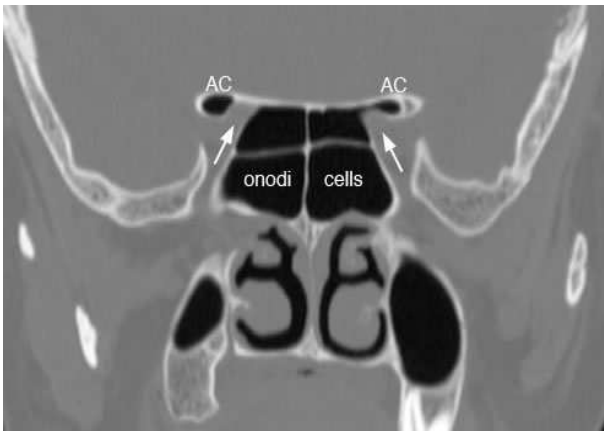



FIG 6: CORONAL CT IMAGE SHOWING PARADOXICAL TURN OF RT MIDDLE TURBINATES. (IT: INFERIOR TURBINATE)

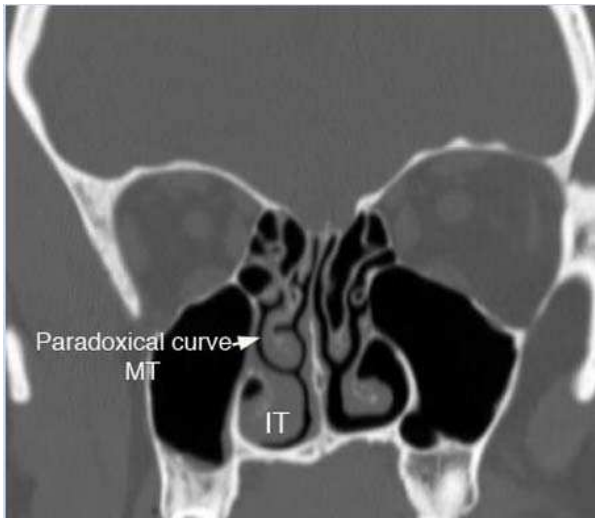
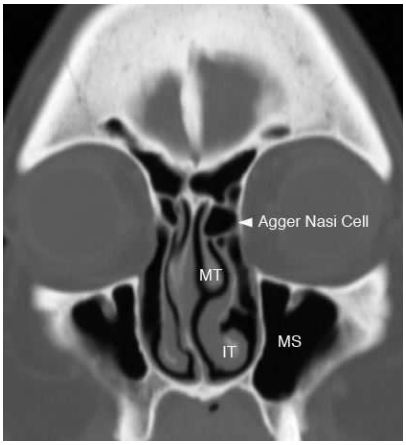



FIG 7: AXIAL AND CORONAL CT IMAGES SHOWING AGGER NASI CELL [AE-ANTERIOR ETHMOID, PE-POSTERIOR ETHMOID, SPS-SPHENOID SINUS, MTMIDDLE TURBINATE, IT-INFERIOR TURBINATE, MS-MAXILLARY SINUS]



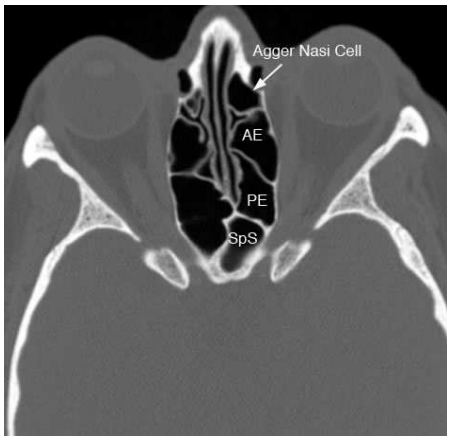



FIG 8: CORONAL CT IMAGE SHOWING BILATERAL LARGE ETHMOIDAL BULLAE (EB) COMPROMISING THE OUTFLOW OF BOTH THE MAXILLARY ANTRUM AND THE FORNTAL SINUS BY DISTRORTING THE ETHMOID INFUNDIBULUM AND THE FRONTAL RECESS, RESPECTIVELY. [U: UNCINATE PROCESS, MT: MIDDLE TURBINATE]

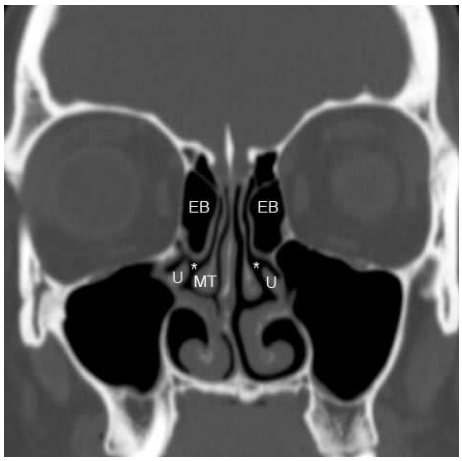



FIG 9: CORONAL CT SHOWING RETROVERTED BILATERAL UNCINATE PROCESS (ARROWS)