

# CT Scan Variations in Chronic Sinusitis

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## ABSTRACT

CT Scan Paranasal sinuses has become mandatory for all patients undergoing functional endoscopic sinus surgery. It depicts the anatomical complexities of osteomeatal complex in much simpler way and acts as a roadmap for endoscopic sinus surgery. Fifty patients of chronic sinusitis were evaluated by CT Scan PNS - coronal and axial views. The anatomical variations and changes in osteomeatal complex on CT Scan were studied. In majority of patients, osteomeatal complex and anterior ethmoids were involved (88%). Agger nasi cells (40%) were the most common anatomical variations followed by concha bullosa and haller cells (16%). Apart from this deviated nasal septum was found in 44% of patients. The variations found on CT Scan were later confirmed on nasal endoscopy. All the patients then underwent endoscopic sinus surgery. This study revealed various anatomical variations which were responsible for the primary pathology of the patient.

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**Keywords:** CT Scan Paranasal sinuses (CT PNS), Functional endoscopic sinus surgery (FESS), Osteomeatal complex (OMC), anterior ethmoids.

## INTRODUCTION

Functional endoscopic sinus surgery (FESS) technique is based on the hypothesis that the osteomeatal complex (OMC) is the key area in the pathogenesis of chronic sinus disease [1-3]. The removal of mechanical obstruction in the OMC area leads to proper ventilation, drainage and resolution of secondary mucosal changes in the frontal, maxillary and ethmoid sinuses [1] without touching the mucosa in these sinuses. This helps in restoration of normal functional and anatomical situation with minimum destruction of nasal and paranasal anatomy [4].

Osteomeatal complex has been defined by various authors in different ways. Zinreich [3,5] includes maxillary sinus ostium and ethmoidal infundibulum and the normal aerated channels which provide air flow and mucociliary clearance of the maxillary, ethmoidal, frontal and sphenoidal sinuses as part of the complex. However, OMC is often referred to the area encompassed by : (a) The ostium of maxillary sinus, the ostia of anterior and middle ethmoidal air cells, the frontonasal duct (frontal recess), the ethmoidal infundibulum, and the middle meatus and (b) The sphenoethmoidal recess and the superior meatus [6]. The (a) and (b) have also been referred to as the anterior and posterior osteomeatal units respectively [7].

Along with the progress in surgical techniques for chronic

sinusitis, sinonasal imaging has also progressed methodically to encroach on the domain of the former generation. While plain radiography was once the most common investigation to evaluate the sinonasal cavity, computed tomography (CT scan) has now supplanted the former because the endoscopic sinus surgery requires greater anatomic precision [8]. The detailed anatomy of the osteomeatal complex as displayed by CT scan acts as a roadmap for surgeons prior to endoscopic sinus surgery [9].

In this study, we have evaluated the CT scan PNS of fifty patients of chronic sinusitis undergoing FESS and studied the changes in the osteomeatal complex.

## MATERIALS AND METHODS

Fifty patients from the outpatient department of Otorhinolaryngology, Dayanand Medical College & Hospital, Ludhiana between May 2000-Jan.2002, with clinical evidence of chronic sinusitis were included in this study. These patients after detailed evaluation and routine investigations were submitted for CT scan paranasal sinuses prior to functional endoscopic sinus surgery.

As per the protocol, chronic sinusitis was defined as nasal blockade, anterior nasal discharge, post nasal drip, headache or facial pain, abnormalities of smell. These

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patients were refractory to medical treatment for more than 3 months duration.

All CT Scans were obtained with Siemens Somatom AR star, spiral scanner ( Forchheim, Germany) . After obtaining the scout projection, the area of scanning was defined to include the region from roof of frontal sinus upto the hard palate. Axial sections were performed with the patient in supine position and the plane of data acquisition parallel to hard palate. The sections were taken with slice thickness of 5 mm and table feed of 7 mm i.e. pitch of 1.4 . Images were reconstructed at 4 mm intervals i.e. image overlap of 1 mm.

Scanning parameters included 105 mA, 130 kV and tube rotation time of 1.5 seconds. Coronal sections were performed with the patients in prone position with extended neck and the plane perpendicular to axial plane. The scan parameters were same as in axial plane. Extended cephalic / caudal sections were done in a few patients to see extension of the disease process.

The photographs thus generated were photographed at appropriate window widths and window level to depict the bony abnormalities as well as soft tissue pathologies.

The CT Scans were then classified according to the Lund & Mackay(1993) radiological system of scoring [10].

The patients had CT Scan PNS , 5 mm coronal and axial sections done. They were analysed for anatomical variations and mucosal abnormalities which were as follows :

The men outnumbered the women in the ratio of 2 : 1 (33 men, 17 women ). The sinonasal polyposis was seen in 31 patients (62%). (Table 1).

CT Scan detection of anatomic variations : Deviated nasal septum was the most common variation in 22 (44%) followed by agger nasi in 20 (40%) patients. Other variations found were concha bullosa, paradoxical middle turbinate, overpneumatized ethmoidal bulla or giant bulla, haller cells, onodi cells, lamina papyracea pushed laterally, maxillary sinus septae and pneumatization of vomerine bone in 1 (2%) patient (Table 2).

CT Scan detection of mucosal abnormalities : The CT Scan was evaluated to find out the incidence of involvement of different sinuses. The mucosal abnormalities were graded as per the Lund Mackay system of scoring.

**Table 1**  
**Clinical Diagnosis**

Diagnosis	U/L		B/L		Total	%age
	Pts.	%age	Pts.	%age		
Chronic sinusitis	11	22%	8	16%	19	38%
Ethmoidal polyp	10	20%	18	36%	28	56%
Antrochoanal polyp	3	6%			6	6%

**Table 2**  
**CT Scan detection of anatomic variations**

Anatomic variation	U/L		B/L		Total	%age
	Pts.	%age	Pts.	%age		
Concha bullosa	5	10%	3	6%	8	16%
Paradoxical middle turbinate	3	6%	2	4%	5	10%
Curved uncinat process	2	4%	1	2%	3	6%
Overpneumatized ethmoidal bulla	4	8%	3	6%	7	14%
Haller cells	4	8%	4	8%	8	16%
Agger nasi cells	-	-	20	40%	20	40%
Onodi cells	2	4%	1	2%	3	6%
Lamina papyracea pushed laterally	-	-	2	4%	2	4%
Maxillary sinus Sepatae	1	2%	2	4%	3	6%
Pneumatization of Vomer					1	2%
Septal Deviation/spur					22	44%

**Table 3**  
CT Scan detection of mucosal abnormalities

Mucosal abnormalities	U/L		B/L		Total	% age
	Pts.	%age	Pts.	%age		
Maxillary antra	12	24%	13	26%	25	50%
Osteomeatal complex	23	46%	21	42%	44	88%
Anterior ethmoids	23	46%	21	42%	44	88%
Posterior ethmoids	15	30%	18	36%	33	66%
Frontal sinuses	9	18%	7	14%	16	32%
Sphenoid sinuses	6	12%	3	6%	9	18%

**Table 4**  
Lund Mackay scoring of CT Scans (Acc. to no.of sides)

	Score	Total (Max.)	%age
Maxillary antra	50	200	25%
Osteomeatal complex	150	200	75%
Anterior ethmoids	150	200	75%
Posterior ethmoids	100	200	50%
Frontal sinuses	28	200	14.5%
Sphenoid sinuses	16	200	8%

The anterior ethmoids and osteomeatal unit were the most commonly involved (44 patients - 88%). This was followed by posterior ethmoids, maxillary antra, frontal sinuses and the sphenoids which were minimally involved.

If the number of sinus (1,2) sides were counted and multiplied by the score of individual unit (0-2), then the anterior osteomeatal unit was found to be maximally involved in 150/200 (75%) and sphenoids least involved in 16/200 (8%) (Table 4).

## DISCUSSION

Stamberger [11] and Stamberger et al [12] proposed that stenosis of the osteomeatal complex, from either the anatomical configuration or hypertrophied mucosa, can cause obstruction and stagnation of secretions that may become infected or perpetuate infection.



Fig. 1: Agger nasi cells both sides

Agger nasi cells lie just anterior to the anterosuperior attachment of the middle turbinate and frontal recess. These can invade the lacrimal bone or the ascending process of maxilla (Fig.1). These cells were present in 20 patients (40%). The incidence is less as compared to 98.5% by Bolger [13] and 88.5% by Maru [14]. But Asruddin [15] reported an almost similar incidence of 48%. In anatomic dissections, Messerklinger encountered the Agger nasi cells in 10-15% of the specimens, Davis in 65% of specimens and Mosher in 40% of specimens as quoted by Bolger [13].



Fig. 2: Concha bullosa with posterior ethmoidal involvement both sides

Haller's cells are ethmoid air cells that project beyond the limits of the ethmoid labyrinth into the maxillary sinus. They are considered as ethmoid cells that grow into the floor of orbit and may narrow the adjacent ostium of the maxillary sinus especially if they become infected [16]. The incidence of Haller's cells in our study was 8/50 (16%). Llyod reported 15% [16] and it was less than that reported by Bolger 45.9% [13], Maru 36% [14] and Asruddin 28% [15].

Concha bullosa (pneumatized middle turbinate) has been implicated as a possible aetiological factor in the causation of recurrent chronic sinusitis. It is due to its negative influence on paranasal sinus ventilation and mucociliary clearance in the middle meatus region as quoted by Tonai [17] (Fig 2). The incidence of concha bullosa was 16% which is less as compared to the reported incidence of 53.6% by Bolger et al [13], 42.6% by Maru et al [14], 28% by Asruddin et al [15], 24% by Llyod [16].

The middle turbinate may be paradoxically curved i.e. bent in the reverse direction. This may lead to impingement of the middle meatus and thus to sinusitis (Fig.3). It was found in 5 patients (10%) - 3 unilateral, 2 bilateral. The incidence is similar to that of 12% by Asruddin et al [15] and 15% by Llyod [16]. It is less than that reported by Bolger et al (27%) [13].

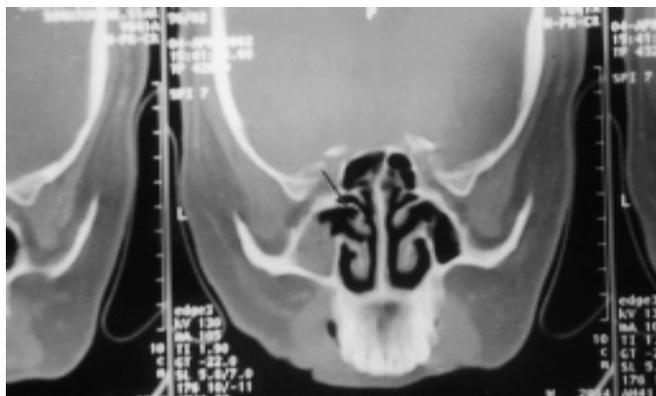


Fig. 3: Paradoxical middle turbinate both sides

Zinreich first observed that the uncinata process may be curved or bent. It can impair sinus ventilation especially in the anterior ethmoid, frontal recess and infundibulum regions. The curved uncinata was found in 2 patients unilaterally (4%) and 1 patient bilaterally (2%), a total of 6%. It is slightly higher than that of 2.5% reported by Bolger [13] and 2% by Asruddin [15] and less than that of 9.8% by Maru et al [14].

Onodi cells are posterior ethmoid cells that extend posteriorly, laterally and sometimes superior to sphenoid sinus, lying medial to the optic nerve. The chances of injury of optic nerve are increased when the bony canal of

the nerve is lying dehiscent. It was found in 3 patients in our study (6%), 2 patients unilaterally, 1 patient bilaterally. A similar incidence was found by Arslan in 12/200 patients and Jones in 8/200 patients [18].

Deviated nasal septum or bony spur causes a decrease in the critical area of the osteomeatal unit predisposing to obstruction and related complications. It was found in 22/50 patients (44%), the maximum anatomical variation in our study. It was less than 55.7% in study by Maru [14] and more than that of 38% reported by Asruddin [15].



Fig. 4: Overpneumatized ethmoidal bulla both sides



Fig. 5: Pneumatization of vomerine bone

overpneumatized ethmoid bulla was found in 4 patients unilaterally (8%) and 3 patients bilaterally (6%) (Fig.4). Maxillary sinus septae in 1 patient unilaterally and 2 patients bilaterally (6%). Pneumatization of vomerine bone in 1 patient (2%) (Fig.5). Lamina papyracea was pushed laterally in 2 patients (4%).

The anterior ethmoids were the most common sinus to be involved (88%) (Fig.6). These are almost similar to that of Yousem (82%) [8] and Bolger 84.3% [13]. It was higher than that of Maru (73.7%) [14], Zinreich (72%) [19] and Smith and Brindley (76.5%) [20].

The posterior ethmoids were involved in 66%, maxillary



Fig. 6: Left sided DNS with concha bullosa right side and anterior ethmoidal involvement and maxillary sinus haziness both sides

antra in 50%, frontal sinuses in 32% and sphenoids in 18%. The extent of involvement reported by other authors was also in the same range. Zinreich [5] published maxillary sinus involvement in 65%, posterior ethmoids in 40%, frontal in 34% and sphenoid sinus involvement in 29%. Bolger [13] reported maxillary sinus involvement in 77.7%, posterior ethmoids in 38.6%, frontal sinus in 36.6% and sphenoid sinus in 25.4%. Smith and Brindley [19] found maxillary sinus involvement in 55.5%, posterior ethmoids in 46.5%, frontal sinus disease in 30% and sphenoid sinus in 20%. Maru [14] reported maxillary sinus involvement in 70.4%, posterior ethmoids in 52.4%, frontal in 48.3% and sphenoids in 40.8%.

According to Mackay and Lund [20] the osteomeatal complex acts a drainage pathway for maxillary, anterior ethmoids and frontal sinuses. Posterior osteomeatal unit was considered as part of the sphenoid sinus. In several areas of the osteomeatal complex, two mucosal layers contact each other, thus increasing the likelihood of local impairment of mucociliary clearance. Secretions may then be retained at the site, creating the potential for infection even without ostial closure. Anatomically, the most likely areas of mucosal contact are in the narrow mucosa lined

channels of the middle meatus and the ethmoidal infundibulum [1] (Fig.7).

The osteomeatal unit was found to be involved in 88% of



Fig. 7: Right sided DNS, concha bullosa left side and blockade of osteomeatal unit both sides

patients in our study. Zinreich et al [3] found middle meatus opacification in 72% of the patients with chronic sinusitis, and, of these 65% had maxillary sinus mucoperiosteal sinus thickening. Yousem et al found that when the middle meatus was opacified, the maxillary and ethmoid sinuses showed inflammatory changes in 84% and 82% respectively. Another study found frontal or maxillary sinus disease in 84% patients who had OMC opacification [8]. Thus these findings support the contention that obstruction of the narrow drainage pathways will lead to subsequent sinus inflammation.

## CONCLUSION

Computed Tomography of the paranasal sinuses has improved the visualisation of paranasal sinus anatomy and has allowed greater accuracy in evaluating paranasal sinus disease. It evaluates the osteomeatal complex anatomy which is not possible with plain radiographs. Anatomical variations studied on CTScan are found to block the OMC and cause chronic sinusitis. The blockade in the OMC leads to impaired drainage of maxillary, frontal and anterior ethmoid thus causing chronic sinusitis. Thus, this study has re-emphasized the concept that Osteomeatal complex is the key factor in the causation of chronic sinusitis. Removal of disease in Osteomeatal complex region is the basic principle of FESS which is best appreciated on CT Scan.

## BIBLIOGRAPHY

1. Kennedy DW, Zinreich J, Rosenbaum AE, Johns ME. Functional endoscopic sinus surgery: Theory and

- diagnostic evaluation. Arch Otolaryngol Head Neck Surg 1985; 111: 576-582.
2. Rice DH. Basic surgical techniques and variations of endoscopic sinus surgery. Otolaryngol Clin North Am 1989; 22: 713-726.
  3. Zinreich SJ, Kennedy DW, Rosenbaum AE, Gayler BW, Kumar AJ, Stammberger H. Paranasal sinuses: CT imaging requirements for endoscopic surgery. Radiology 1987; 163: 709-775.
  4. Elwany S, Hisham M, Gamee R. The effect of endoscopic sinus surgery on mucociliary clearance in patients with chronic sinusitis. European Arch of Oto-Rhino-Laryngol 1998; 255: 511-514.
  5. Zinreich SJ, Abidin M, Kennedy DW. Cross-sectional imaging of the nasal cavity and paranasal sinuses. Oper Techniq Otolaryngol Head Neck Surg 1990; 2: 94-98.
  6. Mafee MF, Chow JM, Meyers R. Functional endoscopic sinus surgery : Anatomy, CT Screening, indications, and complications. American Journal of Radiology 1993; 160: 735-744.
  7. Nayak S. Radiologic anatomy of the paranasal sinuses. Seminars in Ultrasound, CT and MRI 1999; 20: 354-378.
  8. Yousem DM. Imaging of the sinonasal inflammatory disease. Radiology 1993; 188: 303-314.
  9. Rao VM, El-Noueam K. Sinonasal imaging: Anatomy and pathology. Radiologic Clinics of North America 1998; 36: 721-738.
  10. Lund VJ, Mackay IS. Staging in rhinosinusitis. Rhinology 1993; 31: 183-184.
  11. Stammberger H. Secretion transport. In: Functional endoscopic sinus surgery. Philadelphia: BC Decker, 1991: 17-46.
  12. Kopp W, Stammberger H, Fötter R. Special radiologic image of the paranasal sinuses. Eur J Radiol 1988; 8: 152-156.
  13. Bolger EW, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities - CT analysis for endoscopic sinus surgery. Laryngoscope 1991; 101: 56-64.
  14. Maru YK, Gupta V. Anatomic variations of the bone in sinonasal CT. Indian Journal of Otolaryngol and Head Neck Surgery 2001; 53:123-128.
  15. Asruddin, Yadav SPS, Yadav RK, Singh J. Low dose CT in chronic sinusitis. Indian Journal of Otolaryngology and Head Neck Surgery 2000; 52: 17-21.
  16. Lloyd GAS, Lund VJ, Scadding GK. Computerised tomography in the preoperative evaluation of functional endoscopic sinus surgery. Journal of Laryngology and Otolaryngology 1991; 105: 181-185.
  17. Tonai A, Bala S. Anatomic variations of the bone in sinonasal CT. Acta Otolaryngol. (Stockh) Supplement 1996; 525: 9-13.
  18. Jones NS. CT of the paranasal sinuses: a review of the correlation with clinical, surgical and histopathological findings. Clin. Otolaryngol. 2002; 27: 11-17.
  19. Smith LF, Brindley PC, Galveston H. Indications, evaluation, complications and results of functional endoscopic sinus surgery in 200 patients. Otolaryngol-Head Neck Surg. 1993; 108: 688-696.
  20. Mackay IS, Lund VJ. Surgical management of sinusitis. In: Scott-Brown's Otolaryngology, 6th ed. Oxford: Butterworth-Heinemann, 1997: 4/12/1-4/12/29.