

ANATOMIC VARIATIONS OF THE BONE IN SINONASAL C.T.

Y. K. Maru¹, V. Gupta²

ABSTRACT : *Coronal plane Computed Tomographic (C.T.) Scanning of paranasal sinuses is important as a preoperative evaluation tool and providing a road map for Functional Endoscopic Sinus Surgery. The present study was carried out on 61 patients of chronic sinusitis who underwent C.T. Scan of paranasal sinus, (coronal section) prior to Functional Endoscopic Sinus Surgery. The incidence of anatomical variations of the bone such as Agger nasi cells, Middle turbinate pneumatization, Heller's Cells, Paradoxically curved middle turbinate, Deviated septum and Uncinate process variations, etc. were investigated in each C.T. Scan. Mucosal abnormalities in each paranasal sinus were also reported.*

The purpose of this investigation was to determine the background prevalence of bony anatomical variations and mucosal abnormalities of paranasal sinuses and assess the possible pathogenicity of these findings in patients undergoing evaluation for Functional Endoscopic Sinus Surgery.

INTRODUCTION

Chronic recurrent sinusitis is a relatively common disease in ENT practice. The development of Functional Endoscopic Sinus Surgery as a means of managing such patients has heralded the extensive use of Coronal plane Computed tomography of paranasal sinuses. The advent of computerized tomography in the delineation of sinonasal pathology and anatomical variations has proven invaluable to the otolaryngologist in preoperative planning for Functional Endoscopic Sinus Surgery (F.E.S.S). Kennedy et al (1985) described the concept of ostiomeatal obstruction as fundamental to F.E.S.S. and indicated that the obstruction may be due to osteomeatal inflammation or anatomical variations.

Coronal C.T. Scan of Paranasal Sinuses mainly focusses attention to the osteomeatal unit and now has emerged as the standard in presurgical evaluation of patients under consideration for possible F.E.S.S. (Zinreich, 1990). C.T. Scan Coronal Section can provide specific diagnosis and display underlying causes of sinusitis. It can clarify the anatomical relations and variations that may play a role in sinusitis and also provide road map for F.E.S.S.

In this study, the incidence of anatomical variations in the osteomeatal complex and distribution of mucosal abnormalities in each paranasal sinus was investigated by Coronal plane C.T. Scanning.

MATERIALS AND METHODS

Sixty one patients from the Out Patient Department of Otorhinolaryngology, M.G.M. Medical College and M.Y. Group of Hospitals, Indore, between May 1996 - Dec. 1997, with clinical evidence of chronic sinusitis were included in this study. These patient after detailed clinical evaluation and routine investigations were submitted for C.T. Scan paranasal sinus, coronal section prior to Functional Endoscopic Sinus Surgery.

As per the protocol, patients in the 12 to 60 year age group were included irrespective of sex. Patients who were clinically and/or radiologically diagnosed as having chronic sinusitis were included in this study. The chronic sinusitis were defined in this population as nasal congestion, nasal obstruction, nasal discharge, headache, post-nasal drip, proptosis, hyposmia and midfacial pains. These patients were refractory to medical therapy of more than 6 months duration.

All C.T. scans were obtained with C.T. Max 640 (VIPRO-G) Scanner using contiguous 5mm sections, obtained every 5mm from the frontal sinus to the sphenoid sinus, in the head extended supine position. Examinations were evaluated using both bone and soft tissue windows.

Patient's preparation before C.T. scan examination was aimed at maximum removal of "reversible" disease. Each patient was routinely imaged at the end of his or her broad

¹Professor of ENT & Head, Neck Surgery, ²Resident Surgical Officer, Deptt. of ENT & Head Neck Surgery, M.G.M. Medical College & Associated, M. Y. Group of Hospitals, Indore - 452 001, M. P., India.



Fig. I : Concha Bullosa -Vertical Lamellar Cell Pneumatization (Left) seen in C. T. Scan of P. N. S. Coronal section.



Fig. IV : C.T. Scan P. N. S. Coronal section showing Bilateral Paradoxically curved middle turbinates with Pansinusitis.

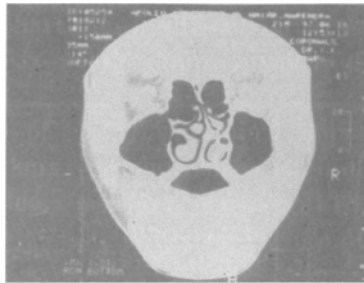


Fig. II : C. T. Scan P. N. S. Coronal section showing Right sided D. N. S. and sharp spur.

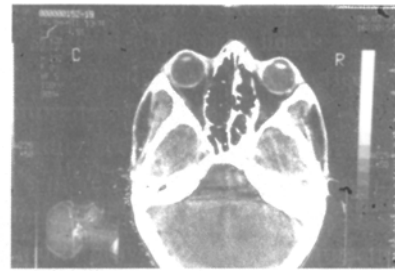


Fig. V : Onodi Cell (Left) seen in Axial section, C. T. Scan of P. N. S.



Fig. III : The Coronal C. T. Scan P. N. S. showing large Heller's Cell with minimal mucosal thickening of left m Maxillary Sinus.



Fig. VI : True Concha Bullosa (Right) seen in C.T. Scan of P. N. S. Coronal section.

spectrum antibiotic courses and antihistamine-decongestant therapy. C.T. Scans were carefully analysed for mucosal abnormalities of each paranasal sinus and anatomical variations, which included Concha Bullosa, Heller's cells, nasal septum deviation, uncinat process variations, paradoxically curved middle turbinate, onodi cells and few unusual variations like septate maxillary sinus, naked optic nerves, carotid artery bulging and low-lying fovea ethmoidalis etc. The reporting proforma was subcategorized into sections spanning the vast majority of structural and pathologic abnormalities within the sinonsal region.

OBSERVATIONS

All the patients had Coronal C.T. scan of the paranasal

sinuses, 5mm coronal sections done. C. T. scans were carefully analysed for anatomical variations and mucosal abnormalities and findings were noted as per the anatomical areas.

Anatomical Variations

Out of the 61 patients with chronic sinusitis like symptoms, the most common anatomical variation associated were Agger Nasi Cells (88.5%), Concha Bullosa (Fig. I) (42.6%) and Deviation of the Septum (Fig. II) (55.7%). The incidence of Right sided deviation(55.9%) were more. Haller's cells (Fig. III) were noted in 36.1% and Paradoxical curvature of middle turbinate (Fig. IV) in 11.5% cases. Onodi Cells (Fig. V) were seen in 9.8% patients and Uncinate process variations also in 9.8% patients. None of the C.T. scans showed uncinat bulla.



Fig. VII : Septate Maxillary Sinus (Left) seen in C. T. Scan P. N. S. Coronal Section.

5 patients had medially bent and 1 patient had laterally bent uncinate process. Pneumatization of the middle turbinate were detected in 26(42.6%) patients. The vertical lamella of the middle turbinate (Fig.I) were pneumatized in 42.3% of these cases thereby forming a "lamellar cell". In 27% of these patients, pneumatization were noted in the inferior bulbous portion of the middle turbinate. Extensive pneumatization of the entire middle turbinate, or a true concha bullosa (Fig.VI) were noted in 8 patients (30.7%). The Agger nasi cells were present in 54(88.5%) of patients. Other anomalies and variations were encountered in 11 (18%) patients, which includes Septate maxillary sinus (Fig.VII) (6.6%) cases, Clinoid process pneumaticisation detected in 2 (3.3%) of patients, Dehiscent



Fig. VIII : C.T. Scan P. N. S. Coronal section showing completely opacified Right Maxillary sinus (Patient Underwent F.E.S.S. and retention cyst was excised endoscopically)

lamina papyracea in 4(6.6%) cases and Crista galli pneumaticisation in 1 (1.6%) case. (Table - I).

Mucosal abnormalities

Mucosal abnormalities detected on Coronal C.T. Scan of Paranasal sinuses ranged from minimal mucosal thickening to total sinus opacification (Fig.VIII). C. T. Scans were evaluated on a 0-4 scale according to severity of disease. C. T. score 0=No mucosal thickening; C.T. score 1=Diseased but <50% opacified; C.T. score 2 = Diseased>50%, but not completely opacified; C.T.score 3=completely opacified and C.T. score 4=Bone destruction.

Table I : C.T. Detection of Anatomic Variations

Anatomical Variation	No. of Pts.	Percentage	Remarks
1. Concha Bullosa	26	42.6%	5 Bilateral, 21 Unilateral
A. Pneumatisation of vertical Lamella (Lamellar Cells)	11 (42.3%)		
B. Pneumatisation of inferior bulbous portion of middle turbinate.	07 (27%)		
C. True Concha Bullosa	08 (30.7%)		
2. D. N.S.	34	55.7%	Rt - 19 (55.9%) Lt - 15 (44.01%)
3. Agger Nasi Cells	54	88.5%	All Bilateral
4. Haller's Cells	22	36.1%	3 Bilateral, 19 Unilateral
5. Onodi Cells	6	9.8%	1 Bilateral, 5 Unilateral
6. Paradoxical Middle Turbinate	7	11.5%	2 Bilateral, 5 Unilateral
7. Uncinate Process Variation	6	9.8%	5 Medially bent, 1-Laterally bent
8. Others	11	18%	
A. Septate Maxillary Sinus.	4	6.6%	
B. Dehiscent Lamina Papyracea	4	6.6%	
C. Clinoid Process Pneumaticisation	2	3.3%	
D. Crista Galli Pneumaticisation	1	1.6%	

Total No. of Patients = 61

Table II : C.T. Scan Detection of Mucosal Abnormalities.

Site of Involvement	No. of Sinuses diseased	Per-centage	Remarks
1. Anterior ethmoids	90	73.7%	1 Bone destruction
2. Maxillary Antra	86	70.4%	1 (25.4%) Complete Sinus Opacification
3. Infundibulum		85	70%
4. Posterior ethmoids	64	52.4%	
5. Frontal		59	48.3%
6. Sphenoids		51	41.8%

Total no. of patients = 61, 122 sides

According to mucosal abnormalities detected, the most frequently involved sinus area were the anterior ethmoid region 73.7% and in 70% patients infundibulum was diseased, more on right side. Maxillary sinus was involved in 70.4% of patients. In this group, complete opacification of maxillary sinus was observed in 31 sites (25.4%). In 64 sites (52.4%), Posterior ethmoids were diseased. Mucosal abnormality detected in 59 sites (48.3%) of Frontal and 51 sites (41.8%) of Sphenoid sinuses. Bone destruction in ethmoid sinuses was observed only in one patient on right side (Table- II).

The presence of mucosal abnormality within the Anterior ethmoid region or Ethmoid infundibulum was associated with a corresponding abnormality in the ipsilateral maxillary or frontal sinus in 80% of patients on the right and 82% of patients on the left.

DISCUSSION

Anatomical Variations - Messerklinger in year 1967, discussed in his published work that the infundibulum and the middle meatus are the channels most frequently affected by anatomical variations which narrow them and juxtapose their mucosal surfaces and facilitate the infection. Certain normal variants increase operative risk and the surgeon should be fore-warned about these. In this study the incidence of Agger Nasi cells, Haller's Cells, Middle turbinate pneumatization, Paradoxically bent middle turbinate and septum variations etc were investigated.

Stammberger (1988) suggested that these anatomical variations may impede the drainage and ventilation of the large sinuses or cause complete blockage of the sinus.

1. Agger Nasi Cells - Agger Nasi cells were the most frequent anatomical variation in our study and were observed in 88.5% of patients suffering from chronic recurrent sinusitis. Lloyd (1990) suggested that agger nasi cells narrow the frontal recess and obstruct the lower end of frontonasal duct. In our series there were 25 cases in which the agger nasi cells were clearly obstructing the frontal sinus drainage. With regard to the incidence of agger nasi cells in patients with chronic sinusitis on Coronal C. T. scan findings, Bolger et al (1991) reported it to be 98.5% and Zinreich (1988) noted the presence of Agger Nasi cells in nearly all the patients evaluated. In anatomic dissections, Messerklinger (1978) encountered the Agger Nasi cells in 10-15% of the specimens, Davis in year 1914 in 65% of specimens and Mosher (1929) in 40% of specimens (As quoted by Bolger et al. in 1991). The definition used by Zinreich et al (1988) that the Agger Nasi cell is the air chamber below the frontal sinus which extends to the frontal recess superiorly, reaches the lacrimal fossa inferolaterally and is anterolaterally arched by the nasal bones. All our C.T. scans of paranasal sinuses fitting this definition were included in our statistical analysis.

2. Haller's Cells - Haller's cells are ethmoid air cells that project beyond the limits of the ethmoid capsule into the maxillary sinus. Lloyd (1990) considered them as ethmoid cells that grow into the floor of the orbit and may narrow the adjacent ostium of the maxillary sinus and this is especially likely to occur if the cells become infected. In our study, the incidence of Haller's cells were 36%. The incidence of Haller's cells on coronal C.T. Scanning in patients with chronic sinusitis in series of Bolger et al (1991) were 45.9%, Lloyd et al (1990) 15% & Zinreich (1988) was 10%. In our study, Haller's cells were found in 36% cases (22 cases, 3 bilateral, 19 unilateral). Table I.

3. Pneumatized Middle Turbinate (Concha Bullosa) - Extensive pneumatization of the middle turbinate, also referred to as Concha Bullosa, has been implicated as a possible etiologic factor in recurrent sinusitis, due to its postulated negative influence on paranasal sinus ventilation and mucociliary clearance in the middle meatus region. Zuckerkandel (Quothed by Tonai A. et al, 1996) noted middle turbinate pneumatization and described it as Concha

Bullosa. Coronal C. T. Scan, enables further detailed observation and a very small pneumatization of middle turbinate can also be visualised. The incidence of Concha Bullosa in patients with chronic sinusitis as detected by Calhoun et al (1991) 29%, Lloyd et al (1990) 24%, Zinreich (1988) 34% and Bolger et al (1991) to be 53.6%. Discrepancy in the reported prevalence of middle turbinate pneumatization may be due to factors such as inherent differences in study population, differences in criteria of pneumatization and sensitivity of the method of analysis. In many anatomic dissection by different workers, the incidence of concha bullosa were reported to be between 9-20%.

Zinreich et al (1988) encountered Concha Bullosa in 34% of patients suffering from symptomatic sinus disease and he employed a definition of concha bullosa as any degree of middle turbinate pneumatization noted on C.T. Scan.

In our study, the incidence of Concha Bullosa were 42.6% (Table - I). As per the interpretation proposed by Bolger et al (1991) we divided the middle turbinate pneumatization into three patterns. First pattern-air cells were localised in the vertical lamella of the turbinate (42%). Second pattern-air cells were localised in the bulbous segment of the turbinate (31%) and the third pattern-true Concha Bullosa were present in (27%) cases.

4. Paradoxically Curved Middle Turbinate - The middle turbinate may be bent in the reverse direction and this may lead to impingement of the middle meatus and thus to sinusitis. The incidence in our study was 11.5% (2 cases bilateral). The incidences on coronal C.T. findings as detected by Bolger et al (1991) 27.1%, Lloyd et al (1990) 15%, Calhoun et al (1991) 12% and Elahi et al (1996) was 8%. The incidence of accompanying sinusitis was high in patients with a large paradoxically curved middle turbinate as such patients are likely to develop osteomeatal obstruction. However a small paradoxically curved middle turbinate may not become a clinical problem.

5. Uncinate Process Variations - Uncinate process pneumatization, also referred to as uncinata bulla or Bent Uncinate Process can impair sinus ventilation especially in the anterior ethmoid, frontal recess and infundibulum regions. None of the C.T. Scans in our study revealed uncinata bulla. Zinreich first observed it in 1988 on coronal C.T. Scan in one of 230 patients with chronic sinus

complaints. Bolger et al (1991) observed it in 2.5% of patients. In our series we observed bent uncinata process in 9.8% patients (5 cases medially bent, 1 laterally bent).

6. Nasal Septum Variations - Deviation of nasal septum is the other common variant seen in patients with chronic sinusitis. A deviated nasal septum or a bony spur causes a decrease in the critical area of the osteomeatal unit predisposing to obstruction and related complications. In our series, D. N. S. was noted in 55.7% patients with a predominance to right (55.9%).

7. Onodi Cells - Onodi cells are posterior ethmoid cells that extend posteriorly far laterally and sometimes superior to the sphenoid sinus, lying medial to the optic nerve. They are best seen on axial sections (Fig.V) and the surgeon should be fore-warned as the optic nerve may be at risk during posterior ethmoidectomy in these cases. In our series we found Onodi cells in 6 cases (9.8%).

Miscellaneous Bony Anomalies - In our study, miscellaneous bony anomalies such as septate maxillary sinus, pneumatization of anterior clinoid process and crista galli implicated in the etiology of sinusitis were also observed (Table -I). maxillary sinus septae were observed in 7% of cases (Fig. VII). Lamina Papyracea was found dehiscent in 4 cases (6.6%). We also found that the preoperative C.T. Scan evaluation was helpful for structural findings that may predispose the patient to a C.S. F. leak such as low lying fovea ethmoidalis. The cribriform plate, fovea ethmoidalis, roof of the posterior ethmoids and superior and lateral walls of the sphenoid sinus should be inspected carefully for any extreme thinning or dehiscence and this will save both the surgeon and the patient from many complications.

Mucosal Abnormalities - In our study any imaging of the paranasal sinus mucosa was considered abnormal, as recommended by Som (1985). Accordingly, mucosal abnormalities ranged from minimal mucosal thickening to total sinus opacification (Fig. III and VIII) Mucosal abnormalities were most frequently noted in the Anterior ethmoid region 73.7%, followed by Maxillary 70.4%, Posterior ethmoids 52.4%, Frontal 48.3% and Sphenoid sinuses 41.8%. These findings are consistent with the statement by Stammberger (1986) that the "Condition of the frontal and maxillary sinuses is highly dependant on the condition of their prechambers in the anterior ethmoids". According to Zinreich (1990) et al, the

incidence of mucosal abnormalities in the anterior ethmoid, maxillary, posterior ethmoids, frontal and sphenoid sinuses were 72%, 65%, 40%, 34% and 29% respectively and Bolger et al (1991) reported 84.3%, 77.7%, 38.6%, 36.6% and 25.4% respectively. In our study, in 73.7% cases, the anterior ethmoids were considered to be key location for sinusitis to recur and become chronic.

CONCLUSION

From this study we concluded that Chronic sinusitis is a common disease condition affecting all age groups and the combination of X-ray PNS (Water's View) followed by coronal plane C.T. Scan study and Fibreoptic nasal endoscopic examination and sinus surgery has proved to be excellent for the precise evaluation of the nasal cavity, the osteomeatal unit and management of the disease process. The Coronal C.T. Scan PNS acts as a preoperative road map to accurately define the relevant microanatomy of osteomeatal complex and other hidden areas.

We are in total agreement with other workers in this field that the anatomical variations that predispose to sinusitis include Concha Bullosa, Nasal Septal deviation, Haller's cells, Paradoxical curvature of the middle turbinate, Medial or Lateral deviation of Uncinate Process, variations in Agger Nasi cells and Onodi cells etc. We emphasize that C.T. Scans should be critically evaluated for these variations, causing obstruction and hampering mucociliary drainage thus leading to chronic sinusitis. We also conclude that the Osteomeatal complex disease is most common and prevalent pattern of presentation and also re-emphasize the concept "Osteomeatal complex and ethmoid disease is the key factor in the causation of chronic recurrent sinusitis."

The Coronal C.T. Scan study shows extent of mucosal disease deep in the osteomeatal complex and it often showed anterior ethmoid and infundibular disease consistent with a rhinogenic origin of paranasal sinus infections. It optimally displays regional anatomy and therefore it is mandatory to have this study before the patient is to undergo a surgical procedure for the treatment of chronic sinusitis.

ACKNOWLEDGEMENT

Authors are thankful to the Dean, M.G. M. Medical College, Indore and Superintendent, M.Y. Hospital, Indore for their permission to use the hospital records.

REFERENCES

1. Bolger W. E., Butzin C. A., Parsons D. S. : Paranasal sinus bony anatomic variations and mucosal abnormalities : CT analysis for endoscopic sinus surgery, *Laryngoscope* 1991 ; 101 : 56-64.
2. Calhoun Karen H., A Gerard. : CT evaluation of the paranasal sinuses in symptomatic and asymptomatic population. *Otolaryngol Head Neck Surg* 1991; 104-480.
3. Elahi M., Frenkiel s., Remy H., Hust N. : Development of a standardized proforma for reporting computerised tomographic images of the paranasal sinuses. *J. Laryngol Otol* 25(2) 113-20, 1996 Apr.
4. Kennedy D. W., Josephson J. S. Zinreich S. J., Mattox D. E., Goldsmith M. M. : Endoscopic sinus surgery for mucocoeles : a viable alternative. *Laryngoscope* 1989 ; 99 : 885-895.
5. Kennedy D. W., Zinreich S. J., Rosenbaum A. E., John M.E. : Functional endoscopic sinus surgery : theory and diagnostic evaluation. *Arch Otolaryngol* 1985 ; 111 : 576-582.
6. Kennedy D. W., Zinreich S. J., Kuhn F., Shaalan H, Naclerio R., Loch E. : Endoscopic middle meatal antrostomy : Theory, technique and patency. *Laryngoscope* 1987 ; 97 (suppl. 43) : 1-9.
7. Lloyd G. A. S. : CT of the paranasal sinuses : study of a control series in relation to endoscopic sinus surgery. *J. Laryngol Otol* 1990; 104 : 477-481.
8. Messerklinger W. : On the drainage of the normal frontal sinus of man *Acta Otolaryngologica*, 1967 ; 63 : 176-181.
9. Messerklinger W., : *Endoscopy of the nose*. Urban and Schwarzenberg, Baltimore, Md., 1978.
10. Som P. M. : CT of the paranasal sinuses, *Neuroradiology* (1985); 27 : 189-201.
11. Stammberger H., Wolf G. : Headaches and sinus diseases : the endoscopic approach. *Ann Otol. Rhinol. Laryngol* 1988 ; 97 (suppl 134) : 3-23.
12. Stammberger H. : Endoscopic endonasal surgery - concepts in treatment of recurring rhinosinusitis. *Otolaryngol Head Neck surg.* 94 : 143, 1986.
13. Tonai Akira, Baba Shunkichi. : Anatomic variations of the bone in sinonasal CT. *Acta Otolaryngol* (Stockh) 1996; Suppl 525 : 9-13.
14. Zinreich S. J., Kennedy D.W., Rosenbaum A. E., Galyler B.W., Kumar A. J., Stammberger H. : CT of nasal cavity and paranasal sinuses : imaging requirement for functional endoscopic sinus surgery. *Radiology* 1987 ; 163 : 769-775.
15. Zinreich S. J., Kennedy D.W., Mattox D. E. : Concha bullosa : CT evaluation. *Journal of Compute assisted Tomography*, 1988 ; 12(5); 778-784.
16. Zinreich S. J. : Paranasal sinus imaging. *Otolaryngol Head Neck Surg.* 1990; 103 : 863-869.

Address for Correspondence

Dr. Y. K. Maru
V-7, Sanvad Nagar, Navalakha,
Indore, M. P. -452 001