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Role of multidetector CT in evaluation of paranasal sinus pathologies

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Abstract

Background: Paranasal sinuses fill in as a host to a wide range of illnesses and conditions from provocative to neoplasms, both benign and malignant. The use of CT with proper knowledge and cognizance of sinus anatomy and radiological landmarks, along with clinical correlation aids in diagnosing paranasal sinus pathologies accurately.
Aim and Objectives:
1) Evaluation of paranasal sinus pathologies and their anatomical extension and bony involvement using multidetector computed tomography.
2) Correlation of the findings of multidetector computed tomography with clinical diagnosis.

Material and Methods: The hospital based prospective observational study was conducted in the Department of Radiodiagnosis & Imaging, Muzaffarnagar Medical College, U.P, for eighteen months with twelve months for data collection and 6 months for data analysis. Total 40 patients of varied age groups presenting with symptoms and signs of paranasal sinus diseases underwent CT using Siemens Somatom Scope 16 slice CT machine as per standard protocol. Images were acquired in the axial and coronal plane with reformation in sagittal plane.
Results: Maximum numbers of patients were in age group of 21 to 30 (35%) with male to female ratio of 1.2:1. Most common sinus involved was right maxillary sinus (70%). Most common chief complaint was nasal obstruction (97.5%) and nasal discharge (90%) with maximum number cases of sinusitis (22%).
Conclusion: To conclude, Multidetector Computed Tomography of the paranasal sinuses has improved the visualization of paranasal sinus anatomy along with its variants and has allowed efficient diagnosis of paranasal sinus lesions. Precise description of the disease and related microanatomy detected by CT scan provides a reliable pre-operative road map.

Keywords: Computed tomography, multidetector computed tomography, paranasal sinuses, paranasal sinus pathologies

Introduction
1. Background

The Paranasal sinuses are hollow, air-filled spaces that lie within the facial bones, in a

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complex arrangement, and group around the nasal cavity. There are four pairs of sinuses (frontal, maxillary, ethmoid and sphenoid), each connected to the nasal cavity by small openings [1].

The nasal region and paranasal sinuses fill in as a host to a wide range of illnesses and conditions which can be on the whole named as sinonasal pathologies. The sinonasal pathologies incorporate expansive range of conditions going from provocative to neoplasms, both benign and malignant [2].

Their clinical evaluation is hampered by the encompassing bony structures, thus for affirmation of their finding, the job of radiology is of central significance [3].

For a long time, the determination of paranasal sinus pathology has been dependent upon radiological evaluation. Initially, x-rays were the modality of choice for assessing paranasal sinuses due to its advantage of quick and non-invasive assessment. However, it was not very good in visualization of some significant landmarks like anterior ethmoid cells, osteomeatal complex, middle turbinate, upper half of nasal region and frontal recess which are important locations for pathogenesis of various sinonasal lesions. X rays have now been replaced by computed tomography for the assessment of paranasal pathologies [4]. The CT and MRI have the advantage of being able to show fine anatomic detail in serial tomographic sections, thus, eliminating the gross volume averaging inherent in plain films [6].

CT is the investigation of choice for pre-operative evaluation of the nasal cavity and paranasal sinuses and is the gold standard for description of inflammatory sinus disease resulting from obstruction [8]. Coronal CT images closely correlates with the surgical approach [9]. Therefore, CT is the preferred study for Functional Endoscopic Sinus Surgery (FESS) because coronal images mimic the appearance of the sinonasal cavity from the perspective of the endoscope [10].

Multidetector CT (MDCT) allows assessment of the patency of sinonasal passages and shows the effect of anatomic variants, inflammatory disease or both on patency. MDCT can show anatomic structures that are not visualised by physical examination or diagnostic nasal endoscopy and is, hence, the study of choice for the surgeon who is considering functional endoscopic sinus surgery [7].

Therefore, CT has enormous value and is considered as gold standard imaging technique for paranasal sinus diseases. Hence for evaluating lesions of paranasal sinus by multidetector CT, the present study was undertaken.

2. Aim and Objectives

1) Evaluation of paranasal sinus pathologies and their anatomical extension and bony involvement using multidetector computed tomography.
2) Correlation of the findings of multidetector computed tomography with clinical diagnosis.

3. Material and Methods

The hospital based prospective observational study was conducted in the Department of Radiodiagnosis & Imaging, Muzaffarnagar Medical College, U.P, for eighteen months with twelve months for data collection and 6 months for data analysis.

Total 40 patients of varied age group presenting with symptoms and signs of paranasal sinus diseases referred from department of ENT were studied.

Inclusion criteria

- All patients with clinically suspected paranasal sinuses pathologies.

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Exclusion criteria

- All cases of maxillofacial trauma.
- Previous history of sinonasal surgery.
- Pregnant females with suspected sinonasal pathologies.

Procedure

Computed tomography of paranasal sinuses using Siemens Somatom Scope 16 slice CT machine was performed in Department of Radiodiagnosis at Muzaffarnagar Medical College. Before evaluating a patient, written and informed consent and detailed clinical history was taken. Digital radiograph of involved paranasal sinus (es) was taken. Patients were then subjected to computed tomography (CT) of the paranasal sinuses in axial and coronal planes. All CT scans were reviewed by single radiologist to avoid inter observer variability. The healthy side was used as control.

All patients were advised 4-8 hrs fasting prior to CT examination (if CECT done). Contrast agent, Omnipaque (Iohexol-350mgI/ml) was used if indicated, a calculated dose of 300 mg/kg weight as a single intravenous bolus injection after serum creatinine level was estimated.

CT scan of PNS requires imaging of the anatomy into planes: coronal and axial. A lateral 256 mm scout scan was first obtained at 120 kVp and 300 mA with scan time of 1-5 seconds. Routinely axial scanning was done in supine position. Reformatting in coronal and sagittal planes was done using software provided. Direct coronal imaging was done whenever deemed necessary either by referring physician or by the radiologist. For direct coronal imaging the patient was kept in prone position or in supine position with head of the patient free leading edge of the table of the scanner. The gantry angle used in case of coronal imaging was perpendicular to infra-orbito meatal line and in case of axial sections, parallel to infra-orbito meatal line. 5 mm sections from anterior margin of nose to the posterior margin of sphenoid sinus were taken in coronal sections and from hard palate through frontal sinus in axial sections. Diagnostic images were stored on computer in jpeg version after converting the DICOM file to jpeg file using an e-film software. Final diagnosis was made with histopathological confirmation and/or treatment response. Data was analysed with appropriate statistical tests.

The study was approved by the scientific and ethical committies of our institution & university. All patients had signed an informed consent form and given a written consent to participate in the study.

3. Results

Total 40 patients of varied age groups presenting with symptoms and signs of paranasal sinus diseases were scanned by multidetector spiral CT. In our study it was observed that maximum numbers of patients were in age group of 21 to 30 years (35%) followed by 31 to 40 years (32.5%) and minimum subjects were from the age group of 41-50 years (5%) followed by 51-60 years (7.5%) as shown in table 1. In present study, majority of the patients were male (22 cases). The gender ratio was found to be 1.2: 1 (Male: Female). (Table 2)

Table 1: Age distribution among the study subjects

Age group (in years)	Number (N)	Percentage (%)
18-20	4	10
21-30	14	35
31-40	13	32.5

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41-50	2	5
51-60	3	7.5
>60	4	10
Total	40	100

Table 2: Gender distribution among the study subjects

Gender	Number (N)	Percentage (%)
Male	22	55
Female	18	45
Total	40	100

Table 3, shows the chief complaints among the study subjects. Nasal obstruction, nasal discharge, headache and epistaxis was revealed in 97.5%, 90%, 85% and 10% of the subjects respectively. Clinical diagnosis revealed sinusitis in 42.5%of the subjects while polyp was found in 22.5% cases. Sinonasal mass was reported in 10% of the subjects and nasomaxillary mass was reported in 5% of cases. Fungal polyposis, fungal sinusitis and inverted papilloma was revealed in 1 case each (2.5%). (Table 4).

Table 3: Chief complaints among the study subjects

Chief complaints	Number (N)	Percentage (%)
Nasal obstruction	39	97.5
Nasal discharge	36	90
Headache	34	85
Epistaxis	4	10
Others	36	90

Table 4: Clinical diagnosis among the study subjects

Clinical diagnosis	Number (N)	Percentage (%)
Fungal polyposis	1	2.5
Fungal sinusitis	1	2.5
Inverted papilloma	1	2.5
Nasomaxillary mass	2	5.0
Polyp	9	22.5
ROCM	3	7.5
Sinusitis	17	42.5
Sinonasal mass	4	10.0
Sinonasal polyp	2	5.0
Total	40	100.0

Most common sinus involved was right maxillary sinus (70%) followed by left maxillary sinus (57.5%), right ethmoid sinus and left ethmoid sinus (50% each). Involvement of right and left sphenoid sinus is 45% and 40% respectively. Least common sinus involvement was of left frontal sinus (30%). (Table 5)

Table 5: Involvement of paranasal sinuses among the study subjects

CT Features	Number (N)	Percentage (%)
Right frontal sinus	13	32.5
Left frontal sinus	12	30
Right Maxillary sinus	28	70
Left Maxillary sinus	23	57.5
Right Ethmoid sinus	20	50

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Left Ethmoid sinus	20	50
Right Sphenoid sinus	18	45
Left Sphenoid sinus	16	40

In our study, most common CT finding among all the study subjects was mucosal thickening (95%), followed by presence of mass in 50% of cases. Out of 40 cases, 11 patients had nasal septum in midline (27.5%), whereas 14 patients had right side deviation (35%) and 13 patients had left side deviation of nasal septum (32.5%) with 1 patient having S-shaped nasal septum (2.5%). Out of 40 cases, 29 cases had bone involvement. Bone destruction was seen in 7.5% of cases and bone remodelling was seen in 47.5% of cases, whereas in 2.5% cases there was bone destruction along with bone remodelling. (Table 6)

Table 6: CT features among the study subjects

CT features	Number (N)	Percentage (%)
Proptosis	5	12.5
Mucosal thickening	38	95
Mass	20	50
Nasal septum		
Deviated to left	13	32.5
Destruction of nasal septum	1	2.5
Deviated to right	14	35
Midline	11	27.5
S-shaped	1	2.5
Bone involvement		
Bone destruction	3	7.5
Bone remodelling	19	47.5
Bone destruction+ Bone remodelling	1	2.5

Table 7, shows the CT diagnosis among the study subjects. Sinusitis, fungal sinusitis and antrochoanal polyp (Fig. 1) was reported in 22.5%, 15% and 10% of the subjects respectively.

Table 7: CT diagnosis among the study subjects

CT diagnosis	Number (N)	Percentage (%)
Antrochoanal polyp	4	10.0
Chronic sinusitis	1	2.5
Ethmoidal polyp	2	5.0
Fungal polyp	3	7.5
Fungal polyposis with sinusitis	1	2.5
Fungal sinusitis	6	15.0
Inverted papilloma	1	2.5
Osteoma	1	2.5
Osteosarcoma	1	2.5
Pansinusitis	1	2.5
Rhino-orbito-cerebral Mucormycosis	3	7.5
Sinusitis	9	22.5
Sinusitis with frontal hypoplasia	1	2.5
Sinonasal carcinoma	1	2.5
Sinonasal mass	2	5.0
Sinonasal polyp	2	5.0
Sinonasal polyp with pansinusitis	1	2.5
Total	40	100.0

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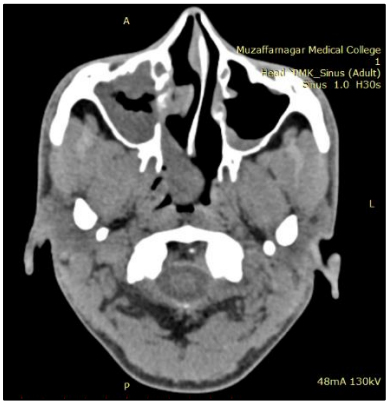

Fig 1: Young female with complain of nasal obstruction and difficulty in breathing through nose. Axial CT showing polypoidal mucosal thickening across right choana & extending posteriorly to nasopharynx without bony erosions, suggestive of antrochoanal polyp.

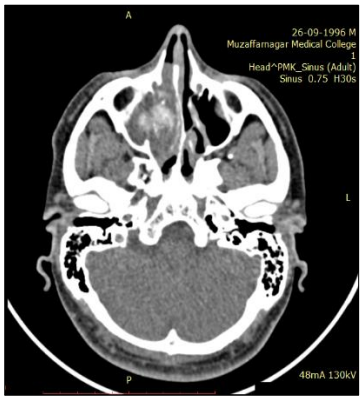

Fig 2: 37-year-old male patient with complain of nasal obstruction with facial pain. Axial CT showing severe mucosal thickening in right maxillary sinus with soft tissue thickening extending into right nasal cavity showing hyperdense contents within it and associated bone remodeling, expansion of ostia and blocked right osteomeatal complex, suggestive of fungal polyposis with sinusitis.

Table 8, shows the final diagnosis among the study subjects. Sinusitis, fungal sinusitis, fungal polyp and antrochoanal polyp was reported in 22.5%, 15%, 12.5% and 10% of the subjects respectively.

Table 8: Final diagnosis among the study subjects

Final Diagnosis	Number (N)	Percentage (%)
Antrochoanal polyp	4	10.0
Chronic sinusitis	1	2.5
Ethmoidal polyp	1	2.5
Fungal polyposis	5	12.5
Fungal sinusitis	6	15.0
Inverted papilloma	1	2.5
Osteoma	1	2.5
Osteosarcoma	1	2.5
Pansinusitis	1	2.5
ROCM	3	7.5
Sinusitis	9	22.5
Sinusitis with frontal hypoplasia	1	2.5
Squamous cell carcinoma	1	2.5
Sinonasal mass	2	5.0
Sinonasal polyp	2	5.0

Sinonasal polyp with pansinusitis	1	2.5
Total	40	100.0

Table 9 depicts association between CT diagnosis and final diagnosis in study subjects. Out of 40 cases, 38 cases had similar CT diagnosis and final diagnosis.

Table 9: Correlation between CT Diagnosis and final diagnosis

CTD	Final Diagnosis																Total
	AP	CS	EP	FP	FS	IP	O	OS	PS	ROCM	S	S,FH	SCC	SNM	SNP	SNP,PS	
AP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
CS	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
EP	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
FP	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3
FP,S	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
FS	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	6
IP	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
O	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
OS	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
PS	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
ROCM	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3
S	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	9
S,FH	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
SNC	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
SNM	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
SNP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
SNP,PS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	4	1	1	5	6	1	1	1	1	1	9	1	1	2	2	1	40
False Positive	1																
False Negative	1																

AP: Antrochoanal polyp, CS: Chronic sinusitis, EP: Ethmoidal polyp, FP: Fungal polyposis, FS: Fungal sinusitis, IP: Inverted papilloma, O: Osteoma, OS: Osteosarcoma, PS: Pansinusitis, ROCM: Rhino-orbito-cerebral mucormycosis, S: Sinusitis, FH: Frontal hypoplasia, SNC: Sinonasal carcinoma, SNM: Sinonasal mass, SNP: Sinonasal polyposis.

5. Discussion

Sinonasal imaging has progressed in an orderly fashion as each generation of imaging modality has advanced gradually on the domain of the former generation. New generation of imaging modalities have completely changed the picture of sinonasal imaging. Previously, plain radiography was most commonly done. Now it has been replaced by computed tomography (CT) as per endoscopic sinus surgeon requirement for greater anatomic precision [5].

CT is accepted as the gold standard for pathological & anatomical evaluation of paranasal sinus disease. CT is especially considered an obligatory part of planning surgical procedures. High resolution CT scanning provides excellent bone detail and accurate soft tissue mapping. High resolution CT is used routinely before endoscopic surgery to evaluate extent of the inflammatory disease and to assess important anatomic landmarks and their variations [4].

In the present study, an attempt has been made to study the importance of the CT scan in evaluation of paranasal sinuses pathologies. This includes studying the usefulness of CT scan for identifying the lesion and delineating its extensions. The computed tomographic scans of 40 patients who were found to have lesions of paranasal sinuses were obtained and results were analysed with available similar studies.

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In study done by Zenreich (1990) [11] and Bolger *et al.* (1991) [12], maxillary sinus was most commonly involved sinus (65% and 77% respectively) which is comparable with the present study. In present study, maxillary sinus (92.3%) was the most common type of paranasal sinus affected. The other types of paranasal sinus affected in our study included ethmoid sinus in 46.1%, frontal sinus in 46.1 and sphenoid sinus in 61.5%. The difference in incidence between the present study and other studies may be due to the variation in the number of cases taken up for study or due to disease demographics in north India.
In our study, presenting age range was 19-65 years with maximum cases in 20-30 years of age with slight female predominance. Most common presenting symptoms were nasal obstruction and nasal discharge (100%) followed by headache in 84.6% cases and most common CT finding was mucosal thickening which was present in 95% patients.

Distribution of patients with sinonasal polyps

We came across multiple cases of sinonasal polyps in our study. There were 13 patients with sinonasal polyps, which included, Fungal polyposis (38.4%), Antrochoanal polyp (30.7%), Ethmoidal polyp (7.6%) and Sinonasal polyp (23.3%). The presenting age range was 18-72 years with most number of cases (38.4%) in 21-30 years of age group out of which there were 4 males and 1 female, followed by 2 patients in age groups 11-20, 31-40 and 41-50 each. Male to female ratio was 2.3:1 corresponding to 9 males and 4 females.
Most common clinical presentation in our study was nasal obstruction (100%) and followed by nasal discharge (92.3%), which is comparable with the study by J. Drutman *et al.* [15] (35 cases) having 100% cases with nasal obstruction and 69% cases with nasal discharge.

Distribution of patients with fungal etiology

In our study, we came across 14 patients with PNS diseases of fungal etiology including 5 patients with fungal polyposis (35.7%), 6 patients with fungal sinusitis (42.9%) and 3 patients of rhino-orbito-cerebral mucormycosis (21.4%). The presenting age range was 18-72 years with maximum number of cases in 31-40 years of age group with M: F ratio of 1.3:1. In cases of fungal polyposis, the most common presenting symptoms were nasal discharge, nasal obstruction and headache (100%) followed by facial pain presenting in 4 (80%) out of 5 patients. The persistent CT finding was presence of mass with mucosal thickening in involved sinus along with bony remodelling. In cases of fungal sinusitis, the most common presenting symptoms were nasal obstruction and headache (100%), followed by facial pain in 5 (83%) out of 6 patients and nasal discharge in 4 (66.6%) out of 6 patients. The persistent CT finding was mucosal thickening of involved sinuses, followed by bony remodelling in 4 out of 6 patients. In cases of rhino-orbito-cerebral mucormycosis, all patients presented with facial asymmetry, proptosis, headache along with nasal obstruction and nasal discharge. The persistent CT findings in all 3 cases were mucosal thickening, bone remodelling and proptosis.

Distribution of patients with Sinonasal mass

In our study period, we encountered 6 patients with sinonasal mass which included 1 patient with osteosarcoma, 1 patient with squamous cell carcinoma, 1 patient with osteoma, 1 patient with inverted papilloma and 2 patients with unspecified sinonasal mass due to unavailability of histopathological reports of these patients. The presenting age range for these masses were 24-65 years with M:F ratio of 2:1. The most common presenting symptom was nasal obstruction (100%) in all patients followed by nasal discharge (83.3%) and facial pain and swelling (83%). The patients with proven malignancy (osteosarcoma fig. 3 and squamous cell carcinoma fig.4) also presented with facial asymmetry and proptosis. The CT findings in 5

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(83.3%) out of 6 patients included osseous changes in form of bone remodelling, bone destruction or both followed by mucosal thickening in 4 (66.6%) out of 6 patients.

Fig 3: Axial CT showing bony mass with both intra sinus & extra sinus component, arising from right maxillary sinus, and showing soft tissue component with bony spicules lying radially giving sunburst appearance. Histologically proven as osteosarcoma.

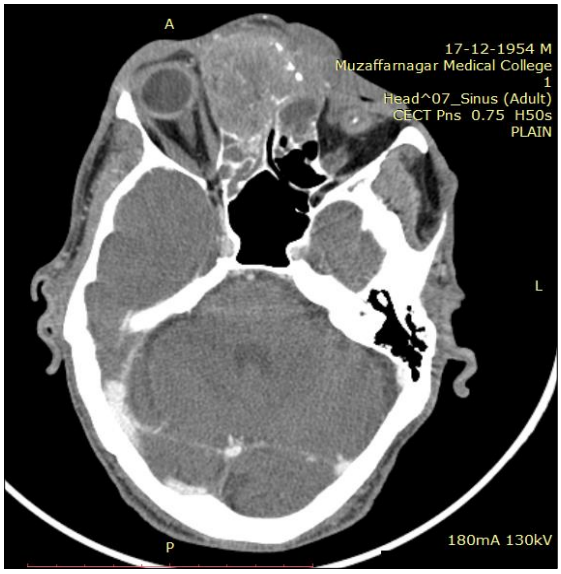

Fig 4: Axial CECT showing soft tissue density lesion in right nasal and right maxillary sinus showing heterogeneous enhancement. Superiorly it is reaching upto right ethmoid sinus and partially into right frontal sinus with thinned out and remodelled walls. Histopathologically proven as squamous cell carcinoma.

Distribution of cases with deviated nasal septum

In our study, DNS were seen in 27 of 40 patients constituting 67.5%. DNS to right side was seen in more patients than the left. Similar findings were observed in study by Dua K (44%) [13] and Asruddin (38%) [14].

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Distribution of cases with proptosis

In our study, proptosis was observed in 5 cases, comparison was done with a comparable study by KK Sabarwal *et al.,* who have demonstrated the causes of proptosis due to paranasal sinus diseases. In both the studies, most common cause of proptosis is infections constituting of 9 cases (18%) in the KK Sabarwal *et al.,* study and 3 cases (7.5%) in the present study. The second cause of proptosis in our study was carcinoma with 2 cases (5.0%).

6. Conclusion

To conclude, computed tomography of the paranasal sinuses has improved the visualization of paranasal sinus anatomy along with its variants and has allowed efficient diagnosis of paranasal sinus lesions. Precise description of the disease and related microanatomy detected by CT scan provides a reliable pre-operative road map.

Multiplanar CT evaluation of paranasal sinuses in orthogonal and non-orthogonal planes is important to outline the anatomy and identify surgically important anatomic variants. Pre-FESS CT examinations of the paranasal sinuses are usually non–contrast-enhanced studies. Contrast examinations are reserved for evaluating specific pathologies (aggressive infections, neoplasm, and vascular lesions) and for assessing extension into orbit, intracranial compartment, and surrounding soft tissues.

CT was able to characterize the PNS diseases along with their extension. It could also delineate the bony involvement of PNS diseases. Preoperative CT enabled the surgeon to visualize the drainage pathways, anatomical and critical variants in paranasal sinuses thus allowing effective management of the patient. Its importance lies in its ability to detect bony erosion. It is now being increasingly used as complement to sinus endoscopy to evaluate areas, which are blind to endoscopy. Recently developed multidetector CT (MDCT) enables us to obtain 1mm collimation scans and subsequent high quality multiplanar reformations.

CT is now considered as an obligatory investigation in the diagnostic evaluation of diseases of PNS and contemplate management strategies, hence it is referred to as the gold standard imaging technique for PNS diseases.

References

1. CT Scan of the Paranasal Sinuses: History, Basic Concepts, Anatomy https://emedicine.medscape.com/article/875244-overview#a2
2. Dhingra P. Diseases of ear, nose and throat. 7th ed. Elsevier, 2017.
3. Kandukuri R, Phatak S. Evaluation of sinonasal diseases by computed tomography. Journal of clinical and diagnostic research: JCDR. 2016 Nov;10(11):TC09.
4. Verma J, Tyagi S, Srivastava M, Agarwal A. Computed tomography of paranasal sinuses for early and proper diagnosis of nasal and sinus pathology. International Journal of Otorhinolaryngology and Head and Neck Surgery. 2016;2(2):70.
5. Yousem DM. Imaging of sinonasal inflammatory disease. Radiology. 1993 Aug;188(2):303-14.
6. Fatterpekar G, Delman B, Som P. imaging the paranasal sinuses: Where we are and where we are going. Anat Rec. 2008;291(11):1564-72.
7. Miller JC. Imaging for Sinusitis. Radiology Rounds A Newsletter for Referring Physicians Massachusetts General Hospital Department of Radiology, 2009, 7(8)
8. Duvoisin B, Landry M, Chapuis L, Krayenbuhl M, Schnyder P. Low-dose CT and inflammatory disease of the paranasal sinuses. Neuroradiology. 1991;33:403-06.
9. Spector SL, Berstein IL, Li JT, *et al.* Joint task force on practice parameters, joint council of allergy, asthma and immunology. Parameters for the diagnosis and

management of sinusitis. J Allergy Clin Immunology. 1998;102(6-2):s107-44.

10. Gotwald TF, Zinreich SJ, Corl F, Fishman EK. Three-dimensional volumetric display of the nasal ostiomeatal channels and paranasal sinuses. AJR. 2001;176(1):241-45.
11. Zinreich SJ. Paranasal Sinus Imaging. Otolaryngology-Head and Neck Surgery. 1990;103(5):863-869. Doi: 10.1177/01945998901030S505
12. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. Laryngoscope. 1991;101(1-1):56-64. doi:10.1288/00005537-199101000-00010
13. Dua K, Chopra H, Khurana AS, Munjal M. CT scan variations in chronic sinusitis. Ind J Radiol Imag. 2005;15:315-20.
14. Asruddin, Yadav SPS, Yadav RK, Singh J. Low dose CT in chronic sinusitis. Indian J Otolaryngol. 1999-2000;52:17-22.
15. Drutman J, Harnsberger HR, Babbel RW, *et al.* Sinonasal polyposis: investigation by direct coronal CT. Neuroradiology. 1995;36(6):469-72.