(International Print/Online Journal)

SJIF IMPACT FACTOR: 6.829
PUBMED-National Library of Medicine ID-101739732

ISSN (Print): 2209-2870
ISSN (Online): 2209-2862

International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume 9, Issue 1 , Page No: 556-571
January-February 2026

IJMSCR

Role Of Imaging In Paranasal Sinus Pathology Imaging

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Type of Publication: Original Research Paper
Conflicts of Interest: Nil

Abstract

Background: Paranasal sinus (PNS) pathologies encompass a wide spectrum of inflammatory and neoplastic conditions. Imaging plays a pivotal role in diagnosis, characterization, and assessment of disease extent and complications.

Objectives: To evaluate the role of various imaging modalities in the assessment of sinonasal pathologies and to analyze their patterns of presentation, extent, and complications.

Materials and Methods: This prospective study included 50 patients with clinically suspected sinonasal disease. Imaging evaluation was performed using plain radiography, computed tomography (CT), and magnetic resonance imaging (MRI) where indicated. Imaging findings were correlated with clinical features and histopathological diagnosis.

Results: Sinonasal pathologies showed a male predominance, with maximum incidence in the second and fifth decades. The maxillary sinus was the most commonly involved sinus in both neoplastic and non- neoplastic conditions. Nasal obstruction was the most frequent presenting symptom. Non-neoplastic lesions accounted for the majority of secondary bony changes and intracranial extensions, while benign neoplastic lesions commonly caused intraorbital involvement. Ethmoid and sphenoid sinus neoplasms frequently showed cavernous sinus involvement. Plain radiographs were inadequate for evaluating the osteomeatal complex and differentiating between infection, tumor, and polyp. Non-contrast CT proved to be the modality of choice for evaluating sinusitis, bony anatomy, and preoperative planning. MRI was superior for soft-tissue characterization and for detecting orbital, intracranial, perineural, and vascular complications.

Conclusion: CT remains the primary imaging modality for evaluation of paranasal sinus diseases, particularly for bony assessment and surgical planning, while MRI serves as a complementary tool in selected cases. Histopathological examination remains essential for definitive diagnosis

Keywords: Paranasal sinus diseases; Computed tomography; Magnetic resonance imaging; Sinonasal tumors; Fungal sinusitis; Orbital complications

Introduction

Sinonasal inflammatory disease is common, with most individuals experiencing symptoms at some point due to infection, allergy, or other causes. Imaging is indicated in patients who are unresponsive to medical therapy, have chronic sinusitis, abnormal physical examination findings, are immunocompromised, or present with suspected complications such as orbital cellulitis or intracranial abscess. Preoperative imaging is routinely performed in patients planned for surgical intervention.

The sinonasal tract harbours a wide spectrum of neoplasms, both epithelial and non-epithelial, with epithelial tumors being predominant. In India, cancers of the upper aerodigestive tract constitute approximately 30–35% of all malignancies. Malignancies of the nasal cavity and paranasal sinuses account for a small proportion (3-5%) of these tumors, with the maxillary sinus being the most commonly involved site, followed by the ethmoid sinus. Frontal and sphenoid sinus involvement is rare.Due to the complex anatomy of the sinonasal region and frequent coexistence of infection, neoplasms often remain clinically occult until an advanced stage, resulting in delayed diagnosis and poor prognosis.

Conventional radiography, once the primary imaging modality for sinonasal evaluation, lacked adequate spatial resolution for precise lesion characterization. The advent of cross-sectional imaging, particularly computed tomography (CT) and magnetic resonance imaging (MRI), has significantly improved early detection, staging, treatment planning, and follow-up. CT is the modality of choice for eva1 luating bony anatomy, erosion, and destruction, while MRI offers superior soft-tissue contrast and is particularly useful in assessing perineural spread, orbital involvement, and intracranial extension. With the development of multidetector CT, multiplanar reconstructions can now be obtained with reduced scan time and motion artifacts, making CT a cost-effective and widely available modality for both initial evaluation and post-treatment follow-up.

Aims And Objectives-

Aim:

To evaluate the role of radiography, multidetector computed tomography (MDCT), and magnetic resonance imaging (MRI) in the assessment of paranasal sinus lesions.

Objectives:

1. To evaluate and compare the diagnostic utility of radiography, MDCT and MRI in paranasal sinus lesions.
2. To assess the pattern and extent of paranasal sinus involvement, including spread to adjacent anatomical structures.
3. To characterize the imaging features of paranasal sinus lesions across different imaging modalities.
4. To differentiate fungal sinusitis from malignant paranasal sinus lesions based on imaging findings.

Materials And Methods-

This observational (cross-sectional) study was conducted on patients suspected of having various paranasal sinus pathologies, who were evaluated over a period of one year, from November 2024 to November 2025, using plain radiography, computed tomography (CT), and magnetic resonance imaging (MRI) in Department of Radiology in PDU Government Medical college and Civil hospital, Rajkot, Gujarat: after taking proper consent from them. The indication and details of the radiological procedure are explained to the patient. A written consent is obtained either from the patient or his/her relatives.

Sample size: 50, Study design: observational study, Type of study: prospective, Duration of study: 1 year (November 2024 to November 2025), Place of study: PDU Medical College and Civil Hospital.

Method Of Collection Of Data

The main source of data for the study were patients referred to the Radiodiagnosis department who presented with clinical symptoms and signs pertaining to paranasal pathologies.

Inclusion Criteria

1. Nasal blockage
2. Headache and facial pain
3. Recurrent rhinorrhea
4. Recurrent upper respiratory tract infection
5. Nasal swelling
6. Nasal bleeding

Exclusion Criteria

1. Cardiac pacemaker
2. Metallic implants
3. Claustrophobia
4. Non-cooperative patients
5. Elevated serum creatinine levels
6. Known allergy to contrast material

Equipment Used

1. Plain Radiography: Samsung GU 60A U-arm X-ray unit
2. Computed Tomography: 128-slice GE CT scanner

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3. Magnetic Resonance Imaging: 1.5 Tesla Siemens Magnetom, 16-channel system

Imaging Technique Used Plain Radiography

Plain radiography was performed using the occipitomental (Waters) view. Among the three traditional projections for paranasal sinus imaging—occipitomental, occipitofrontal, and lateral—the occipitomental view alone was considered sufficient for diagnostic purposes.

Computed Tomography

Non-contrast and contrast-enhanced CT scans of the paranasal sinuses were performed as indicated using a CT scanner. Spiral volumetric acquisition was performed with contiguous axial reconstructions of 5 mm slice thickness. When required, 40 mL of non-ionic contrast material was administered intravenously following a negative test dose.

Magnetic Resonance Imaging

All patients underwent MRI on a 1.5 Tesla scanner (Imaging was performed using T1-weighted, T2-weighted, STIR, diffusion-weighted imaging (DWI), and gradient-echo (GRE) sequences in axial, coronal, and sagittal planes. Slice thickness ranged from 3–4 mm. Contrast-enhanced sequences were obtained when indicated. A matrix size of 358 × 448 was used with a field of view (FOV) of 24–30 cm for coronal and sagittal images and 14–16 cm for axial images, adjusted as required.

Classification Of Paranasal Sinus Pathologies:

A) Anatomic variants,

B) Inflammation,

1. Acute sinusitis
2. Chronic sinusitis
3. Aspergillosis with fungus ball
4. Invasive aspergillosis
5. Fungal sinusitis
6. Non-invasive
7. Invasive
8. Aspergilloma
9. Mucocele
10. Organizing hematoma
11. Polyps
12. Wegener's granulomatosis
13. Postoperative maxillary cyst: POMC

C) Tumor.

A) Benign

1. Osteomas.
2. Inverted papilloma.
3. Cemento-ossifying fibroma.
4. Nasopharyngeal angiofibroma.

B) Malignant

1. Squamous cell carcinoma: SCCA (Maxillary, ethmoid and frontal sinus)
2. Adenoid cystic carcinoma: ACC
3. Malignant melanoma
4. Malignant lymphoma.
5. NK-/T-cell lymphoma

D) Trauma:

1. Le Fort fracture, (type 1-3)
2. Orbital fracture, (superior, medial and inferior)
3. ZMC (zygomatic-maxillary complex) fracture.
4. NOE (nasoorbitoethmoid) fracture.

Imaging Modalities In Paranasal Sinus Pathologies

Imaging Techniques -

Radiographs - While occasionally ordered by referring physicians, radiographs are limited in their depiction of sinonasal disease processes. Plain radiographs do not allow adequate evaluation of the osteomeatal complex (OMC). They cannot reliably differentiate between infection, polyp, and tumor in an opacified sinus.

Computed Tomography (Ct)

Computed tomography is the workhorse modality in paranasal sinus imaging. In the past, single-detector CT required patients to be imaged twice—once axially in the supine position and then coronally in the prone position with the neck extended. While this technique could determine the mobility of intrasinus material, it was uncomfortable for patients and was susceptible to significant streak artifacts from dental hardware.

Modern-day multidetector CT (MDCT) allows patients to be scanned rapidly in the supine position, with images reconstructed in the sagittal and coronal planes, thereby minimizing dental artifacts. However, this reconstruction technique makes assessment of air-fluid levels and mobility of secretions more difficult.

High-resolution, thin-section CT scans depict bony erosions more accurately. Critical areas such as the bony orbital walls, cribriform plate, fovea ethmoidalis,

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posterior wall of the maxillary sinus, pterygoid plates, pterygopalatine fossa, and sphenoid sinus can be visualized with a high degree of accuracy.

MDCT has established a definite role in management, especially in head and neck neoplasms. Advantages of MDCT over single-slice CT include reduced scanning time, lower contrast requirement, multiplanar imaging capability, and virtual endoscopy.

PET/CT (Positron Emission Tomography–CT) is a secondary complementary modality in sinonasal disease, typically used in cases of malignancy to assess residual or recurrent tumor and metastatic spread. Important roles of CT

1. Detection of soft tissue masses
2. Evaluation of sinusitis, including the affected sinus and osteomeatal unit
3. Assessment of bony abnormalities: thickening, erosion, destruction, and remodeling
4. Preoperative evaluation for endoscopic sinus surgery (ESS)
5. Identification of anatomical variants

Magnetic Resonance Imaging (Mri)

MRI is a secondary complementary modality and is particularly useful when a mass or intracranial extension is suspected. MRI is also valuable in assessing the extent of soft tissue involvement, especially when CT findings are inconclusive.

Important Roles Of MRI

1. Detailed evaluation of soft tissues
2. Assessment of tumor spread in soft tissues
3. Differentiation of tumor from secretions
4. Characterization of lesions based on protein content, which results in variable signal intensities on T1- and T2-weighted images
5. Evaluation of vascularity
6. Use of dynamic contrast enhancement when indicated
7. Detection of perineural tumor spread (PNS)
8. Detection of intracranial invasion

(Skull base involvement is seen as replacement of the normal high T1-weighted signal of fatty marrow by hypointense tumor signal)

Limitations Of MRI

The main limitations of MRI in paranasal sinus evaluation include limited delineation of bony details and higher costs compared with CT. Additionally, patients with severe claustrophobia may not tolerate MRI in closed-gantry systems.

The American College of Radiology (ACR) Appropriateness Criteria are useful in determining which patients require sinonasal imaging and the preferred imaging modality.

Although CT has many advantages, MRI provides superior soft-tissue resolution. In cases of early perineural invasion, intracranial extension, and intraorbital complications, MRI is superior to CT. However, CT remains the modality of choice for evaluating bony destruction and erosion. CT is superior to MRI in terms of availability, cost-effectiveness, and shorter imaging time.

Obsevations And Analysis –

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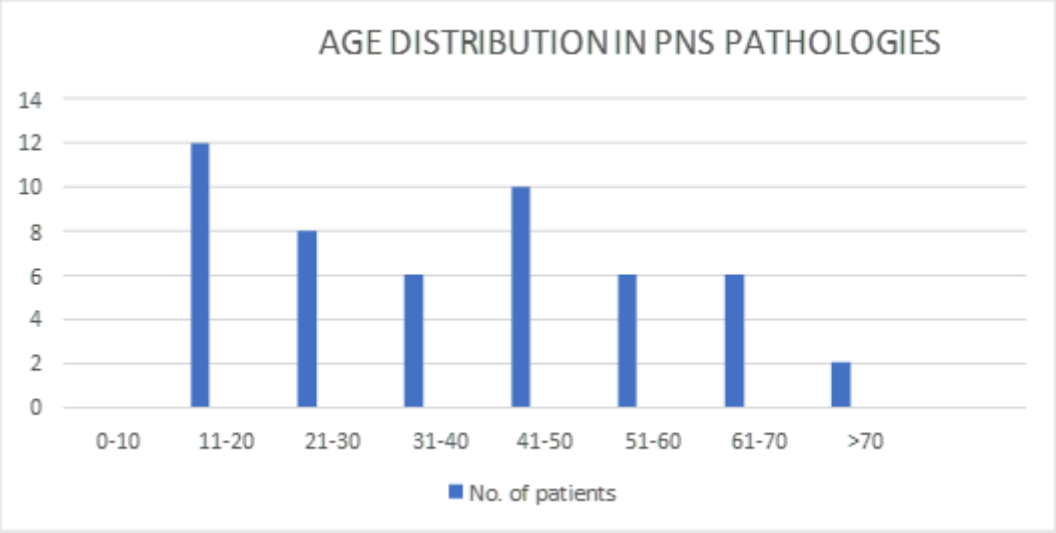
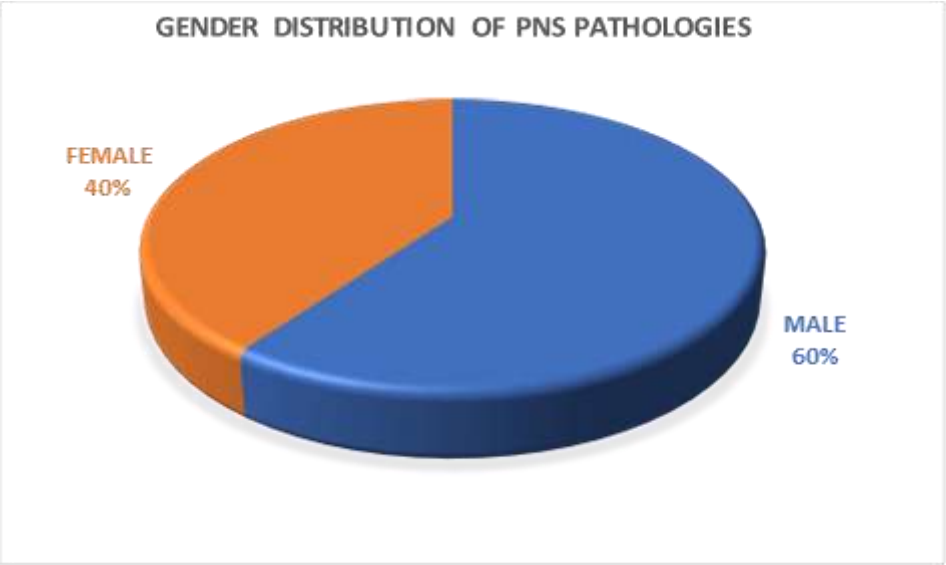
Table 1: Age Distribution For Pns Pathologies



It is observed that the largest group was 11-20 and 41-50 years (2ntl and 5th decade) consisting of 12 and 10 patients respectively, followed by 21-30 (3rd decade) consisting 8 cases, 31-40 years, 51-60 years & 61-70 years (4th decade, 6th decade & 7th decade) each consisting of 6 , 6 and 2 cases respectively.

Table 2: Gender Distribution For Pns Pathologies



Sinonasal pathologies have predilection for males, demonstrating a male to female ratio of 3:2.

Table 3: Clinical Symptoms In Pns Pathologies:

SYMPTOMS	No. of patients
Epistaxis	6
Sneezing	4

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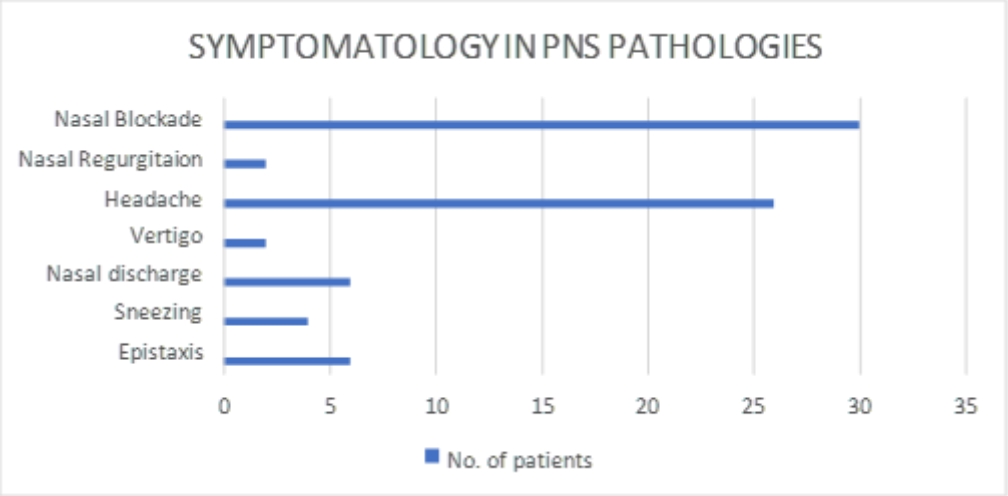
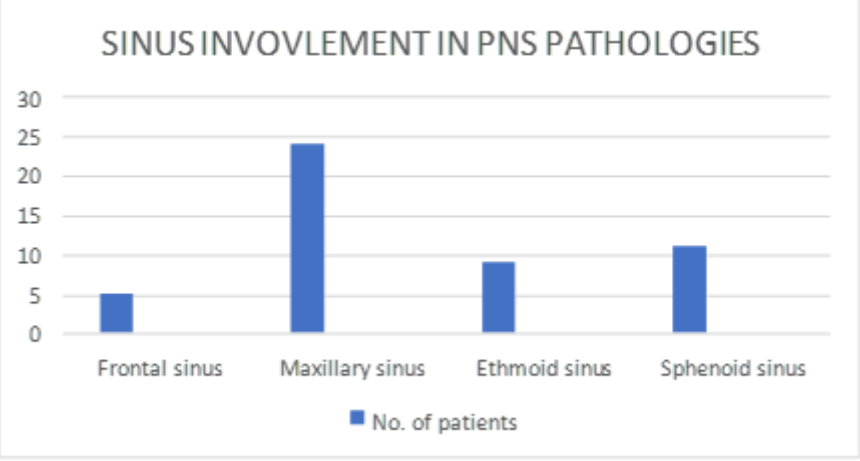
Nasal discharge	6
Vertigo	2
Headache	26
Nasal Regurgitation	2
Nasal blockade	30

Figure 3–SYMPTOMS IN PNS PATHOLOGIES



From the above table, it is seen that nasal blockage predominates and is seen in 30 patients, followed by headache which is seen in 26 patients, followed by epistaxis and nasal discharge.

Table 4: Sinus Involvement In Pns Pathologies:



It is observed that the involvement of maxillary sinus is the most common in various sinus pathologies, followed by ethmoidal and sphenoidal sinuses.

Table 5: Frequency Of Various Sinonasal Pathologies:

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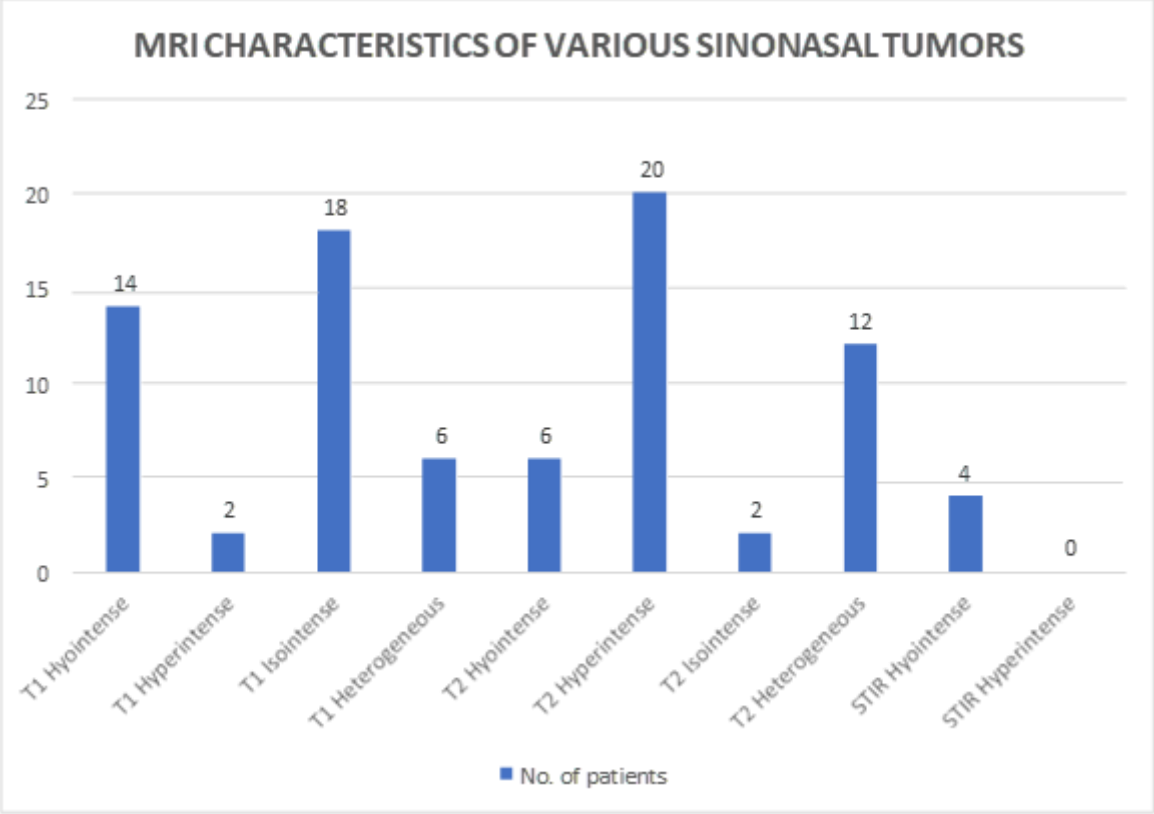
INCIDENCE	No. of cases	Percentage
Non neoplastic lesions	26	52
Benign neoplastic lesions	14	28
Malignant Neoplastic lesions	10	20
Total	50	100

Amongst the various sinonasal pathologies seen, number of cases with nonneoplastic lesions is maximum followed by benign neoplastic mass and malignant neoplastic mass.

Table 6: Mri Characteristics Of Various Sinonasal Tumors



Most of the tumours are isointense on T1 weighted images and hyperintense on T2 weighted images. On STIR sequences most of the tumours were hyperintense.

Table 7: Secondary Bony Changes In Various Sinonasal Pathologies:

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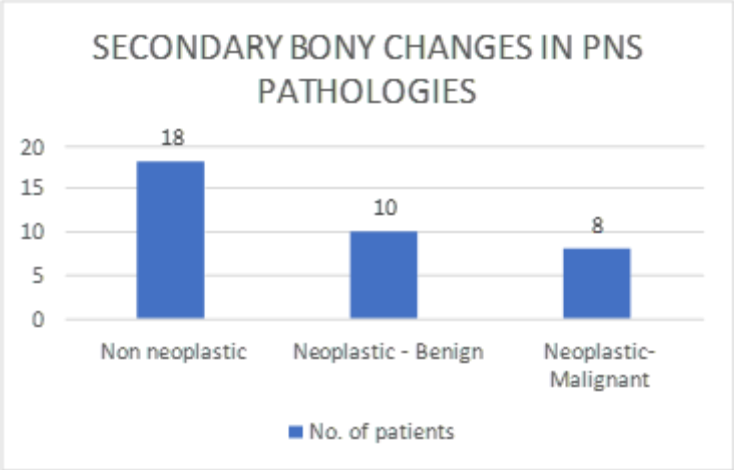
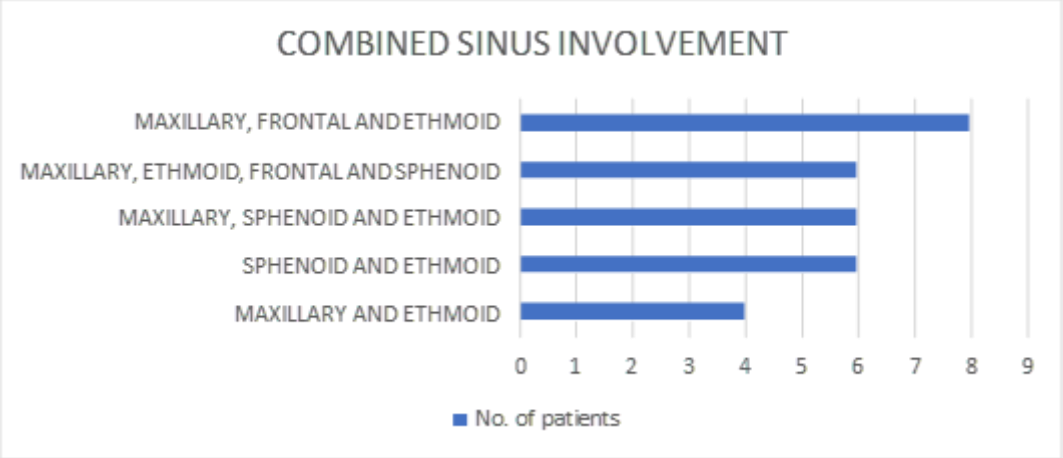


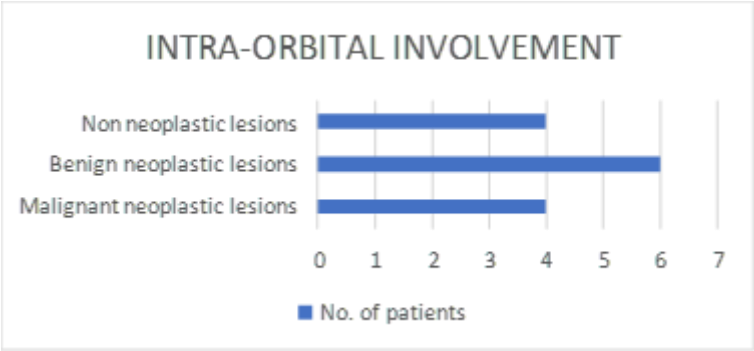
Bony changes were noted in 18 cases of non-neoplastic conditions like inflammatory/ infective aetiologies, 10 cases of benign neoplastic lesions and 8 case of malignant neoplastic lesion

Table 8: Combined Sinus Involvement:



It is observed that, in multi sinus involvement, anterior group of sinuses are more commonly involved that the posterior group of sinuses.

Table 9: Intra Orbital Involvement



It is observed that the intra-orbital involvement by benign neoplastic lesion is most common, followed by malignant neoplastic lesion and non-neoplastic lesions

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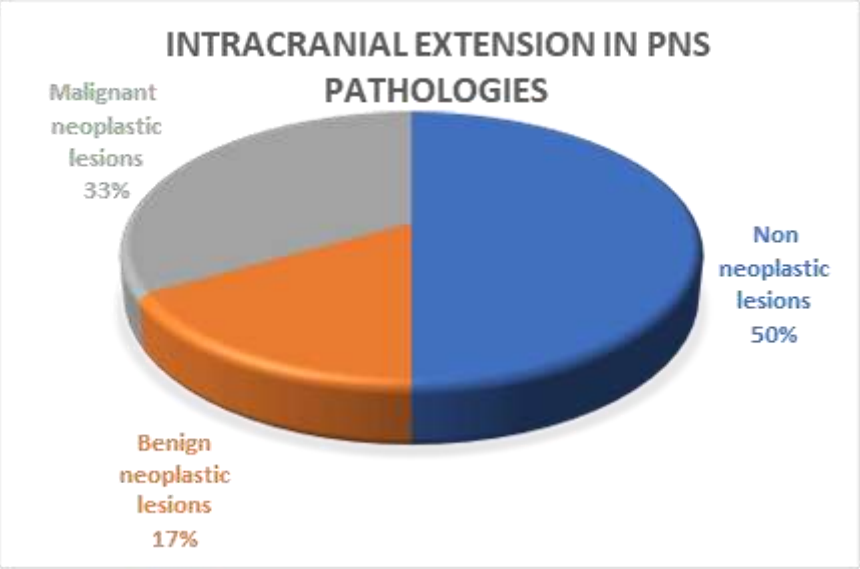
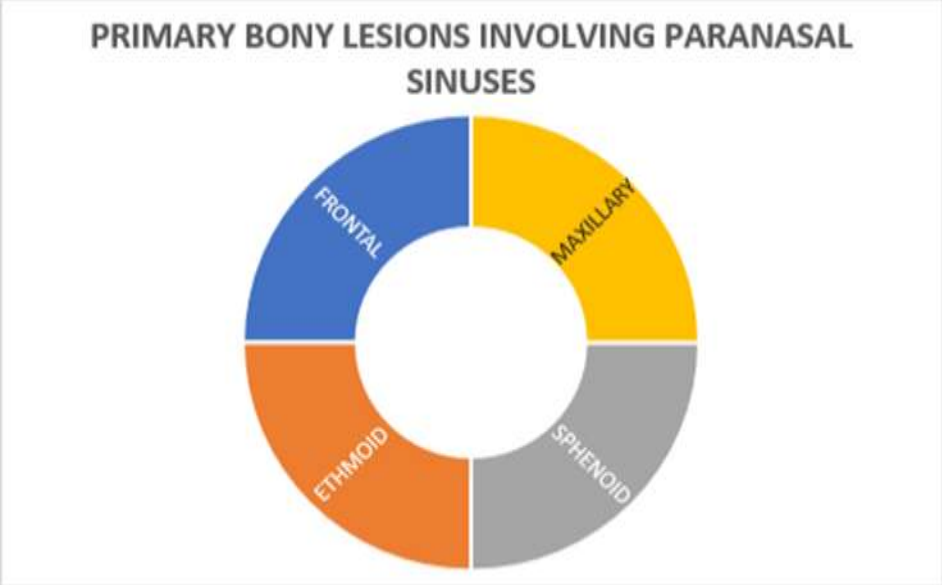
Table 10: Intracranial Extension In Pns Pathologies:



It is observed that intracranial extension is most common in infective non neoplastic pathologies, followed by malignant neoplastic lesions.

Table 11: Primary Bony Lesions Involving Paranasal Sinuses:



In our study , Primary bony lesions involving maxillary, ethmoid, frontal and sphenoid sinus are 2 each. Frontal sinus is involved in osteoma, maxillary sinus is involved in cemento-ossifying fibroma and sphenoid and ethmoid sinus are involved in fibrous dysplasia.

Table 12: Cavernous Involvement In Neoplastic Pns Pathologies:

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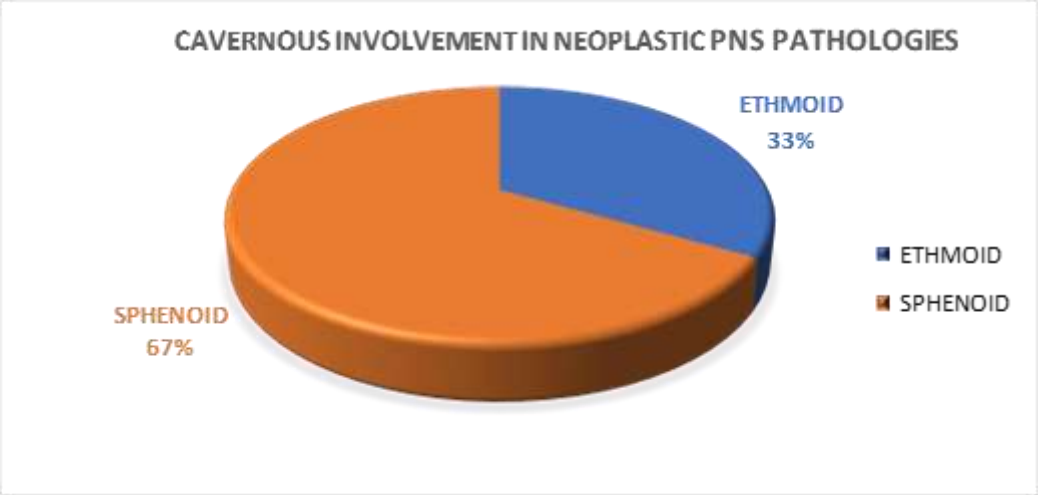

It is observed that number of cases of cavernous sinus involvement with neoplastic paranasal sinus pathologies of sphenoid sinus is 4 and ethmoid sinus is 2.

Discussion –

This study evaluated 50 cases of paranasal sinus pathologies over a one-year period (November 2024 to November 2025) using multiple imaging modalities.

The highest incidence was observed in the 11–20 years and 41–50 years age groups, with sinusitis predominantly affecting patients aged 11–30 years, while malignancies were more common after the fifth decade. These findings are consistent with previous studies by Bakari et al. and Zafar et al., which reported peak incidence in younger age groups for inflammatory disease and later presentation for malignancies.

A male predominance was observed in our study (male:female = 3:2), similar to findings reported by Zafar et al., suggesting greater susceptibility among males.

Nasal obstruction was the most common presenting symptom, followed by headache, correlating with observations by Kishve et al. The maxillary sinus was the most frequently involved sinus (48%), consistent with prior reports by Nadia Shiradi et al.

Non-neoplastic lesions were more common (80%) than neoplastic lesions (20%), in agreement with Lathi et al. Allergic and inflammatory polyps constituted the majority of non-neoplastic lesions, while hemangioma and inverted papilloma were the most common benign tumors. Squamous cell carcinoma accounted for the majority of malignant lesions.

Most neoplastic lesions demonstrated isointense T1 and hyperintense T2 signal characteristics on MRI, consistent with previously described imaging patterns. Bony changes were more frequently observed in inflammatory and infective conditions and were better evaluated on CT, reaffirming its role as the imaging modality of choice for osseous assessment.

Multisinus involvement predominantly affected the anterior group of sinuses, with combined maxillary, frontal, and ethmoid sinus involvement being common. Orbital involvement was more frequently associated with neoplastic lesions, whereas intracranial extension was more commonly seen in infective pathologies, particularly involving the frontal, ethmoid, and sphenoid sinuses.

Fibro-osseous lesions showed site-specific involvement, with osteoma commonly affecting the frontal sinus, cemento-ossifying fibroma the maxillary sinus, and fibrous dysplasia the sphenoid and ethmoid sinuses.

Cavernous sinus involvement was primarily associated with sphenoid and ethmoid sinus pathologies. Overall, our findings reinforce the complementary roles of CT and MRI in the evaluation of paranasal sinus diseases, with CT excelling in bony assessment and MRI providing superior soft-tissue characterization and detection of complications.

Summary And Conclusion –

1. In the present study of 50 cases, male preponderance for sinonasal pathologies was

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higher compared to females, with the largest group of patients in the 2nd and 5th decades.

2. The maxillary sinus was the most commonly involved sinus in sinonasal pathologies, both neoplastic and non-neoplastic, which is similar to findings in other studies.
3. The common presentations of sinonasal masses were nasal obstruction (97.3%), rhinorrhoea (49.1%), hyposmia (31.3%), and headache (16.9%). These findings compare favourably with other studies.
4. Non-neoplastic aetiologies of paranasal sinus disease caused the maximum secondary bony changes and intracranial extensions, while benign neoplastic lesions were the most common cause of intraorbital involvement.
5. Ethmoid and sphenoid sinus neoplastic pathologies were responsible for cavernous sinus involvement.
6. Plain radiographs do not allow adequate evaluation of the osteomeatal complex and recesses. It was observed that they cannot differentiate between infection, tumor, or polyp in an opacified sinus and have a high rate of false-positive results.
7. In immunocompromised patients with invasive sinusitis, CT findings may be negative in the early stages. In advanced cases, differentiating this condition from malignancy may be difficult on imaging alone and requires biopsy.
8. Non-contrast CT of the sinuses is the imaging modality of choice in patients with recurrent acute sinusitis or chronic sinusitis and for defining sinus anatomy prior to surgery. Bone-window views provide excellent resolution and detailed evaluation of the complete osteomeatal complex. CT also provides excellent anatomic display of soft-tissue attenuation. In diagnosing sinus fungus balls, a high index of suspicion is necessary, and pathological confirmation is mandatory.
9. Although CT remains the criterion-standard modality for diagnosing sinusitis, MRI is indicated in cases of clinically suspected complications, especially in patients with intracranial complications, perineural invasion, extension of infection, or suspected superior sagittal venous thrombosis.
10. Tumor characterization is better performed on MRI compared with CECT, particularly in cases of inverted papilloma, nasopharyngeal angiofibroma, sphenoid masses with intracranial extension, and masses extending into the orbit with orbital involvement.
11. Histopathological examination is conclusive in diagnosing polypoid lesions, determining both aetiology and cellular details. It is the only definitive method for establishing whether the disease is inflammatory or neoplastic. Radiological investigations aid in understanding the type of pathology, extent of lesion, and associated sinus involvement.

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Case Images

Antrochoanal polyp in case of chronic sinusitis:

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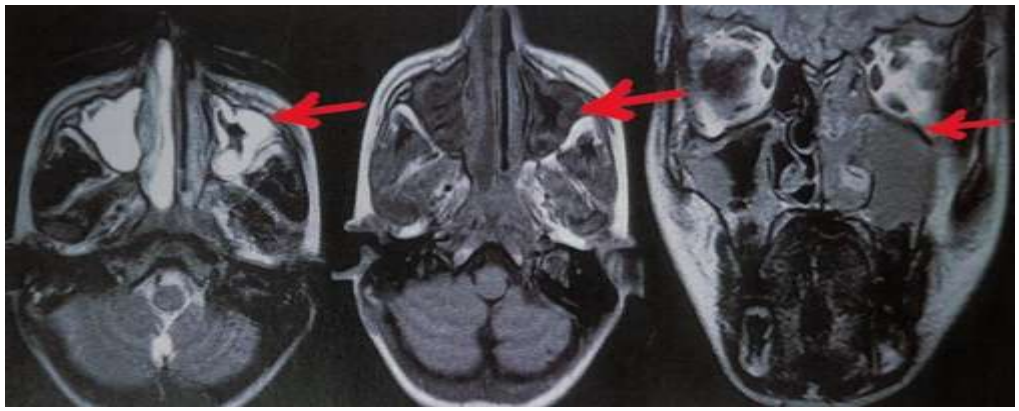
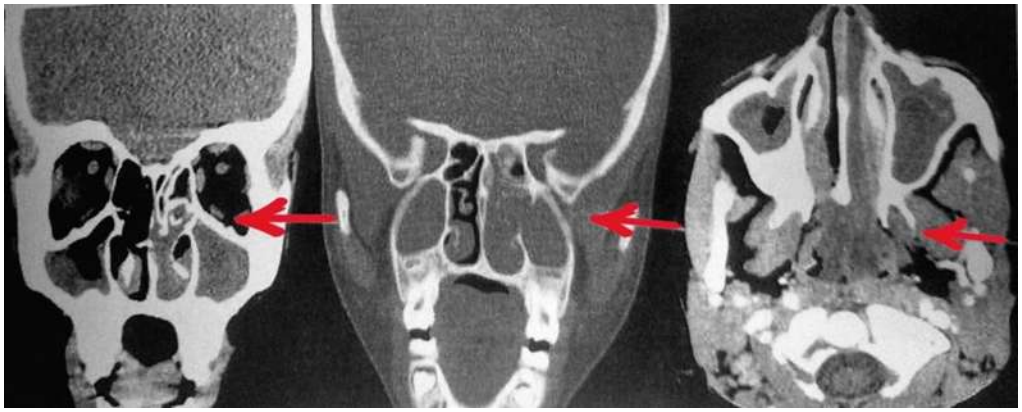
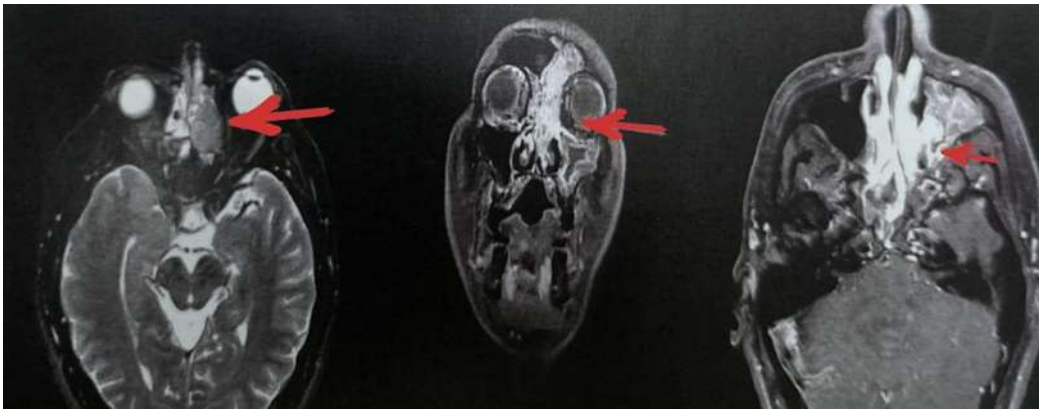




Cribriform plate defect with associated CSF rhinorrhoea

Inverted Papilloma-



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Non invasive sinusitis

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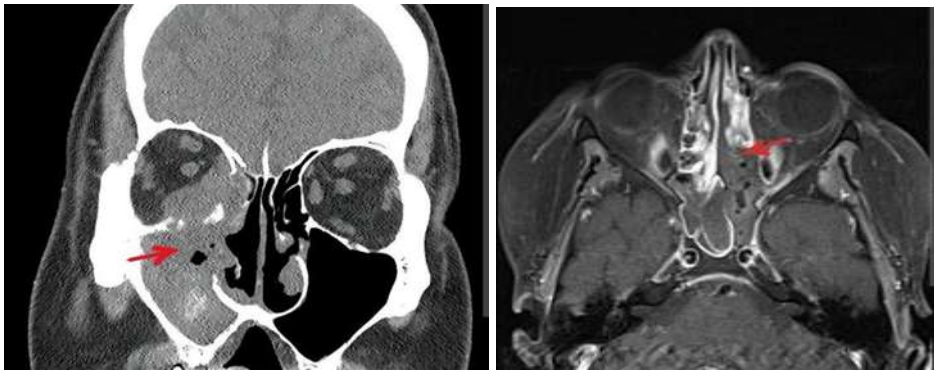
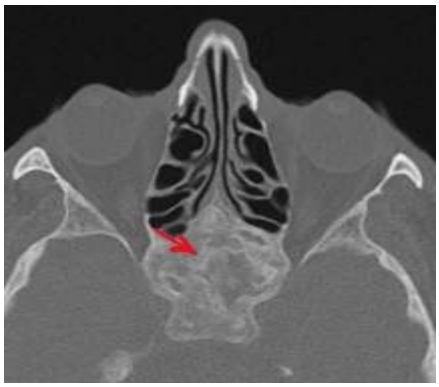
Squamous cell carcinoma of hard palate with maxillary sinus involvement

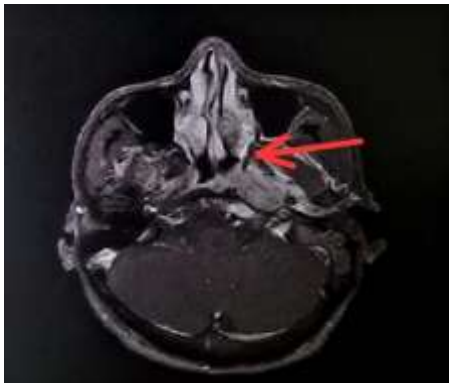
Acute invasive fungal sinusitis



Fibrous dysplasia of sphenoid



Nasopharyngeal carcinoma



Oroantral fistula

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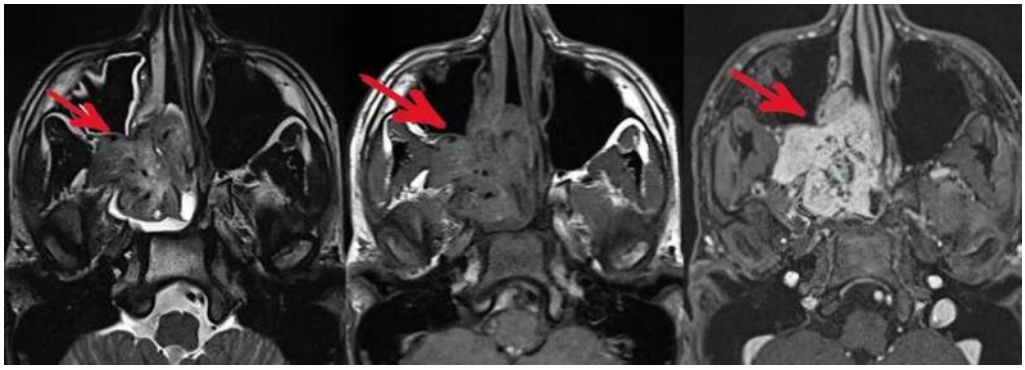
Juvenile nasopharyngeal angiofibroma



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