Imaging Recommendations for Diagnosis, Staging, and Management of Sinonasal Tumors

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Abstract

Sinonasal tumors are a relatively rare and heterogeneous group of tumors. Owing to their nonspecific presentation and rarity, they can be potentially overlooked resulting in delayed diagnosis and management, and increased patient morbidity. Imaging is crucial for the detection, staging, surgical planning, follow-up as well as surveillance of sinonasal masses, wherein computed tomography (CT) and magnetic resonance imaging (MRI) play complementary roles. CT is better at depicting bony changes, while MRI is useful for delineating the extent of soft tissue lesion, detect perineural, intracranial, or intraorbital spread as well as differentiate trapped sinus secretions from tumor tissue. Other modalities like fluorodeoxyglucose-positron emission tomography/computed tomography (FDG-PET/CT) and arteriography can be selectively employed. FDG-PET is useful for metastatic workup and detection of residual/recurrent disease. Arteriography and endovascular image-guided interventions are useful to delineate supply of vascular tumors and perform preoperative embolization. A systematic evidence-based approach to a possible case of sinonasal tumor can go a long way in streamlining the detection and management of these tumors, while optimizing the use of available healthcare resources.

Keywords
- guidelines
- malignancy
- tumors
- neoplasms
- paranasal sinus
- radiology
- sinonasal imaging

Introduction

Sinonasal tumors are rare with sinonasal malignancies accounting for about 3% of the head and neck cancers.[1] Many are diagnosed in advanced stages owing to innocuous symptoms until late into disease. The clinical manifestation often is similar to inflammatory sinus conditions including nasal discharge, nasal blockade, headache or epistaxis, thereby making a clinical diagnosis difficult. At times, a mass may be visualized on clinical examination or nasal endoscopy. Even when a mass is visualized, cross sectional imaging is essential to elucidate the origin and extent of the mass.

Computed tomography (CT) and magnetic resonance imaging (MRI) play a complementary role with bony and cartilaginous lesions better depicted by CT, whereas soft tissue extension of tumor, differentiation between tumor and trapped secretions, perineural spread, intraorbital, dural, cavernous sinus, and intracranial involvement are better seen on MRI.

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Although pointing out a histological diagnosis is often impractical on imaging, it does help characterize the lesion into benign versus malignant and guide further management.

Risk Factors and Etiopathogenesis

Predilections and risk factors of the sinonasal tumors vary by the histological subtype.

Notable associations are that of the juvenile nasal angiofibroma (JNA) occurring exclusively in males, bimodal distribution of olfactory neuroblastoma with a peak at age 45-55 years and smaller peak at 10 to 25 years, human papillomavirus (HPV) association of inverted papilloma, Epstein-Barr virus association of sinonasal lymphoepithelial carcinoma.[2]

Important risk factors for malignant sinonasal tumors are inhaled wood dust (particularly hardwood), leather dust, nickel and chrome pigments. The aforementioned reportedly cause 600-fold increased risk for adenocarcinoma and 20-fold increased risk for squamous cell carcinoma (SCC).[3] HPV infection and smoking are the other lesser risk factors.[4] Carcinogens like formaldehyde, diisopropyl sulfate, dichloroethyl sulfide, and thorotrast have also been implicated.

Sinonasal malignancies are not notable for lymphadenopathy or distant metastases. They, however, tend to demonstrate contiguous multicompartmental local invasion with destroyed intervening bones.[5]

Epidemiology, Clinical Presentation in India and Globally

Sinonasal tumors are rare with incidence of less than 1 in 100,000 per year.[6] The sinonasal malignancies comprise 3% of the head and neck cancers and 1% of all malignancies. Peak incidence is in the fifth to seventh decade with a male preponderance.[1] SCC is the most common malignancy accounting for 50 to 80% of epithelial sinonasal malignancies.[2] The nasal cavity, maxillary and ethmoid sinuses are common sites, whereas frontal and sphenoid sinuses are rarely involved. Benign tumors are commoner in the second to third decade, with papilloma being the most common benign epithelial neoplasm.

Studies investigating the epidemiology of sinonasal tumors in India are limited. Few retrospective studies done have found a similar distribution of these tumors as seen globally. A study by Satarkar and Srikanth in North India retrospectively analyzed 206 cases of sinonasal tumors and tumor-like conditions during a period of 5 years, and found similar results. In their study, JNA was the most common benign tumor and SCC the most common malignant tumour.[7]

Clinical manifestations of sinonasal tumors are often ambiguous and mimic rhinosinusitis, thereby delaying presentation and diagnosis. Advanced disease with orbital or skull base involvement may present with visual impairment, proptosis, diplopia, epiphora, anosmia, or cranial neuropathies.

Imaging Referral Guidelines

Guidelines proposed by various societies around the world for referral and imaging in sinonasal tumors primarily advocate CT and MRI of the head and neck in complementary roles.

Imaging in the form of combination of CT and MRI is recommended by the Royal College of Radiologists (RCR) in all biopsy proven cases of sinonasal cancer to stage disease (►**Fig. 1**).[8] CT with contrast or MRI with contrast of head and neck is indicated in suspected cases of paranasal sinus (PNS) tumors by the National Comprehensive Cancer Network (NCCN).[9] Maxillofacial CT with or without intravenous (IV) contrast and MRI of orbits face neck with and without IV contrast are usually appropriate as initial imaging for suspected sinonasal mass, as per the American College of Radiology (ACR) appropriateness criteria.[10] If an MRI is planned, then a complementary noncontrast maxillofacial CT is usually sufficient as only bony changes need be assessed on CT. Imaging is to be done ideally before biopsy, if possible, as a biopsy procedure may lead to edema of the tumor and surrounding mucosa and so spuriously overstage disease extent. If advanced disease is detected on CT making a poor surgical candidate, further sinonasal imaging is not recommended by the RCR. It is frequent for tumors to cause obstruction of sinus drainage thus leading to inspissated secretions clogging the sinuses with blocked drainage pathways. Noncontrast CT may not clearly differentiate clogged secretions from tumor, and it is therefore necessary to image with either contrast enhanced CT or with MR for this differentiation.

Noncontrast MRI orbits face neck may be appropriate conditionally, if contrast is contraindicated. Noncontrast CT head or combined pre- and postcontrast maxillofacial CT imaging is not appropriate. Radiography of PNS, fluorodeoxyglucose-positron emission tomography (FDG-PET) whole body, single-photon emission computed tomography of PNS, CT cone-beam PNS and computed tomography angiography/magnetic resonance angiography (CTA/MRA) of head are considered usually not appropriate for initial imaging. CT and MRA may be useful for preoperative planning of a vascular mass. Similarly, craniofacial arteriography is not appropriate as initial imaging, and may be employed in cases of vascular tumors for preoperative embolization, preoperative planning and to control severe epistaxis.

While the RCR recommends CT chest in all clinical stages to rule out lung metastases, the NCCN recommends chest CT with or without contrast in cases of advanced nodal disease to screen for lung metastases.

FDG-PET is not generally indicated for staging. It serves to screen for lymph nodal and distant metastases in advanced disease (stage III or IV)[9] and as a problem-solving modality in cases of suspected recurrence and for suspected cancerous lymph nodes not accessible for fine-needle aspiration (FNA) or with equivocal FNA cytology results.[8]

Contrast CT or FDG-PET/CT of the abdomen and chest as well as contrast MR of the brain is indicated to rule out distant metastases if biopsy reveals a sinonasal mucosal melanoma.[9]

Clinical/Diagnostic Workup (Excluding Imaging)

As per NCCN guidelines, the workup comprises history including documentation and quantification of tobacco use

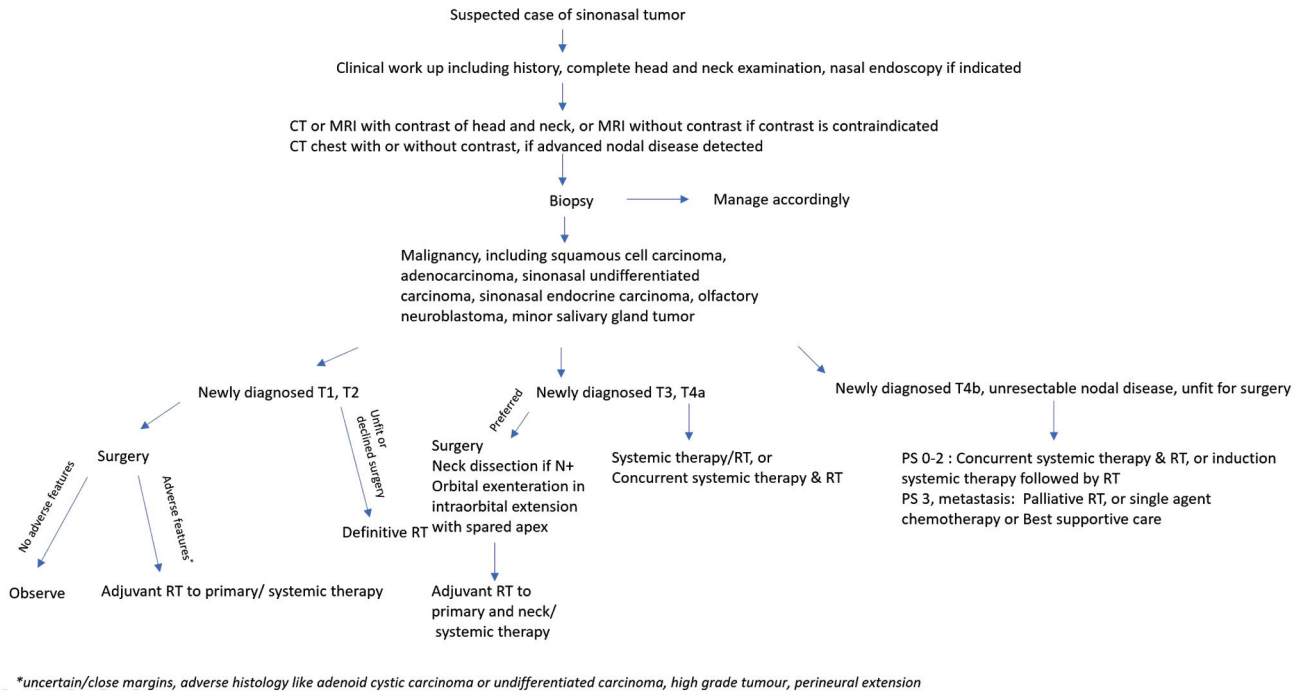

Fig. 1 Simplified flowchart for the management of suspected sinonasal mass (adapted from the NCCN v1.2022 guidelines[9]). CT, computed tomography; MRI, magnetic resonance imaging; RT, radiotherapy.

(pack years smoked) and physical examination including complete head and neck examination with nasal endoscopy as clinically indicated. Dental consultation, nutritional, speech and swallowing evaluation, screening for depression, smoking cessation counselling, and fertility/reproductive counselling are also to be considered as clinically indicated.

Although most tumors require biopsy to establish a histopathological diagnosis, exceptions do exist, like JNA wherein the diagnosis is clinicoradiological and biopsy is usually avoided. Transnasal route for endoscopic/punch biopsy is preferred, when performed. Needle biopsy is acceptable. In sampling of maxillary tumors, canine fossa puncture and Caldwell-Luc approach are to be avoided for biopsy.

Imaging Guidelines

Screening

Sinonasal cancers are rare, and general population screening is ineffective, with a potential for false positive diagnoses. Currently, there is no evidence to support screening of head and neck cancers in general as well as high-risk populations.[11–14]

Diagnosis

Imaging is done with contrast unless contraindicated.[9] The diagnostic CT protocol entails spiral CT following intravenous contrast administration from skull base to thoracic inlet with hands by the sides of the patient. The slice thickness should be no greater than 3 mm. It is viewed in the axial and coronal reformatted planes in soft-tissue as well as bone windows for local extent of tumor and lymph nodal disease.

MRI is better for assessing skull base invasion, soft tissue intracranial, or intraorbital extension, differentiating retained secretions from tumor and perineural spread (►**Figs. 2** and **3**). CT is complementary to MRI to assess bony destruction/remodeling (►**Figs. 4** and **5**). The basic MR sequences acquired are pre- and post-gadolinium T1-weighted (T1W), post-gadolinium T1-fat suppressed, T2W, and short tau inversion recovery images in orthogonal planes (axial and coronal) with slice thickness no greater than 4 mm. Additionally, T2W sagittal images and T2W coronal images with increased matrix (512×512) may also be acquired. MRA may be done to delineate arterial involvement, and volumetric post-gadolinium images acquired for radiotherapy (RT) planning.[8]

Ultrasonography (US) may be used for the assessment of clinically occult neck nodes and post-treatment surveillance

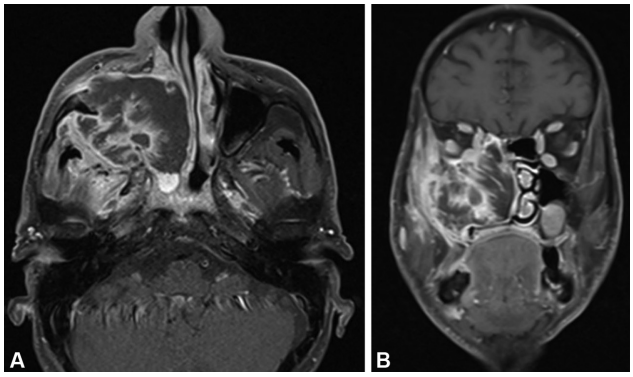

Fig. 2 Well-differentiated squamous cell carcinoma of maxillary sinus. **(A)** Axial post-gadolinium T1-weighted image with fat suppression shows heterogeneously enhancing irregular mass in the right maxillary sinus with destruction of its anterior and posterior walls and invasion of the subcutaneous tissue and pterygoid fossa, respectively. **(B)** Coronal post-gadolinium T1-weighted image with fat suppression shows the mass invading into the orbital fat and ethmoid sinus.

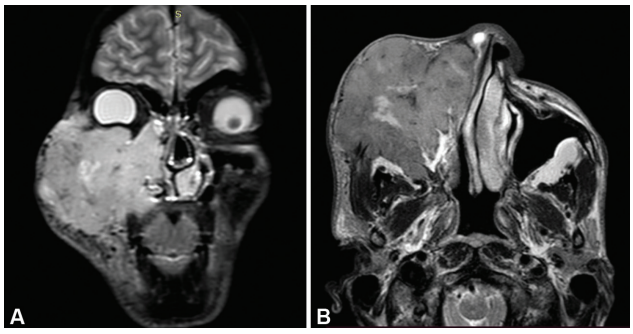

Fig. 3 Nonkeratinizing squamous cell carcinoma of right maxillary sinus. **(A)** Coronal short tau inversion recovery image shows hyperintense irregular mass lesion of the right maxillary sinus invading the subcutaneous tissue and skin of cheek, hard palate, nasal cavity, right ethmoid sinus, and right orbit. **(B)** Axial T2-weighted image shows extension of mass into the right infratemporal fossa as well.

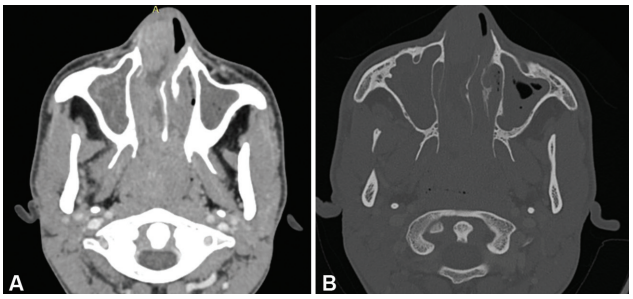

Fig. 4 Sinonasal adenocarcinoma. **(A)** Axial contrast computed tomographic image in soft tissue window shows irregular lobulated mass in the right nasal cavity protruding as far as the anterior choana, and the nasopharynx. Retained secretions in the maxillary sinus noted. (**B)** Axial bone window image shows destruction of the right turbinate.

of neck nodes. In nodal assessment by US, it is noteworthy that size criterion (short axis diameter > 1.0 cm) has poor sensitivity and additional features in form of shape, contour, echogenicity, grouping, internal architecture, necrosis and pattern of Doppler vascularity must be taken into account to achieve greater accuracy (reportedly more than 90%).[15] US-guided FNA cytology is useful to detect metastatic nodes with high specificity.

In resource-poor settings, a holistic workup might not always be practical. The bare minimum investigations as recommended by the National Cancer Grid in such scenarios include diagnostic nasal endoscopy with biopsy and IHC, CT PNS, and chest X-ray.[16] It recommends MRI of face and neck, CT Thorax, ophthalmic and endocrine evaluation for optimal assessment. PET CT is deemed optional in initial assessment.

The synoptic reporting formats for CT PNS have been provided in ►**Supplementary Material**.

Staging

More than 70 histopathological entities of sinonasal neoplasms have been classified by the World Health Organization, based on tissue of origin and differentiation, and grouped under benign and malignant tumours.[2]

The American Joint Committee on Cancer—Tumour Node Metastasis (AJCC TNM) staging system for malignancies of the nasal cavity and PNS is referred to for staging of epithelial (non-melanoma) sinonasal tumours.[17] TNM staging of head and neck mucosal melanomas is separately described to stage them. The current edition (8th at the time of publication) distinguishes and separately describes the staging of maxillary sinus and ethmoid sinus tumors (►**Table 1**). No system for staging of malignancies of the frontal and sphenoid sinus is defined. Staging systems other than the TNM exist too for certain tumor histologies, like the Kadish staging for olfactory neuroblastoma.

Follow-Up

For follow-up, the NCCN recommends complete head and neck physical examination including mirror and fiberoptic examination as per the following schedule—every 1 to 3 months in year 1, 2 to 6 months in year 2, 4 to 8 months in years 3 to 5, and annually thereafter.

In the early postoperative period ($\leq$ 6 months), the preoperative baseline imaging modality can be conveniently repeated to establish a baseline postoperative scan. However, MRI has been found more helpful than CT for follow-up. FDG-PET/CT is to be done within 3 to 6 months of definitive RT or systemic therapy/RT for response assessment and to identify residual tumor. Early FDG-PET before 12 weeks is prone to false positives, and therefore the optimal timing is 3 to 6 months.

Surveillance (6 Months to 5 Years)

Most of the post-treatment recurrences occur in the first 2 years. Various modalities are employed across various centers for surveillance. FDG-PET/CT is reportedly the most sensitive modality for surveillance.

Surveillance using imaging is not supported by evidence for asymptomatic cases with negative initial PET (at 3–6 months post-treatment) and no worrisome features on clinical examination.[9] Clinical nasal endoscopy is now routinely available and enables a full evaluation of the surgical cavity, thus limiting somewhat the additional value of imaging. Another recent trend has, however, been for the use of free flaps for reconstruction of the surgical defect and the palate. Free flap reconstruction may potentially hide early recurrences emerging under the flap, and imaging for surveillance has therefore to be used more frequently in this setting. Hence, further imaging is tailored based on the presence of worrisome features, equivocal signs/symptoms on physical examination, smoking history and to assess areas inaccessible to clinical examination. Annual imaging (CT or MRI) may be done to assess for areas difficult to assess on clinical examination. US examination of the neck is useful for nodal surveillance. Annual chest CT is recommended in those with a smoking history or at high risk for lung metastases.

Principles of Management

No randomized trial exists investigating the optimal treatment for PNS tumors owing to rarity and heterogeneity of this group of neoplasms. Therefore, the general guidelines for

Table 1 TNM staging for epithelial PNS cancers other than mucosal melanomas (adapted from AJCC Cancer staging manual, 8th edition, 2017[17])

T staging	Maxillary sinus	Nasal cavity and ethmoid sinus	
Tx	Primary tumor cannot be assessed		
Tis	Carcinoma in situ		
T1	Limited to mucosa with no bony erosion/destruction	Limited to one subsite with or without bony invasion	
T2	Bony destruction including extension to hard palate and/or middle meatus, but not including posterior wall of maxillary sinus and pterygoid plates	Tumor involves two subsites within the same region or extends to an adjacent region within the nasoethmoidal complex ± bony invasion	
T3	Involvement of one of the following —bone of posterior wall of maxillary sinus, subcutaneous tissues, floor or medial wall of orbit, pterygoid fossa, ethmoid sinuses	Invasion of medial wall or floor of orbit, maxillary sinus, palate or cribriform plate	
T4	T4a—termed moderately advanced local disease. Invasion of anterior orbital contents, skin of cheek, pterygoid plates, infra-temporal fossa, cribriform plate, sphenoid or frontal sinuses T4b—termed very advanced local disease. Invasion of orbital apex, dura, brain, middle cranial fossa, cranial nerves other than V2, nasopharynx or clivus	T4a—termed moderately advanced local disease. Invasion of anterior orbital contents, skin of cheek, minimal extension to anterior cranial fossa, pterygoid plates, sphenoid or frontal sinuses. T4b—termed very advanced local disease. Invasion of orbital apex, dura, brain, middle cranial fossa, cranial nerves other than V2, nasopharynx or clivus	
N staging (clinical)			
Nx	Regional lymph nodes cannot be assessed		
N0	No regional lymph node metastasis		
N1	Single ipsilateral lymph node metastasis < 3cm in greatest dimension and no extranodal extension (ENE)		
N2	N2a—Single ipsilateral lymph node metastasis (3-6 cm) with ENE (−) N2b—Multiple ipsilateral lymph node metastasis, all < 6 cm and ENE (−) N2c—Bilateral or contralateral lymph node metastasis < 6 cm and ENE (−)		
N3	N3a—Metastasis in a lymph node with greatest dimension > 6 cm and ENE (−) N3b—metastasis in any node(s) with clinically overt ENE		
M staging			
M0	No distant metastasis		
M1	Distant metastasis		
Prognostic stage groups			
Stage 0	Tis	N0	M0
Stage I	T1	N0	M0
Stage II	T2	N0	M0
Stage III	T1, 2	N1	M0
	T3	N0, 1	M0
Stage IVA	T1, 2, 3	N2	M0
	T4a	N0, 1, 2	M0
Stage IVB	Any T	N3	M0
	T4b	Any N	M0
Stage IVC	Any T	Any N	M1

head and neck cancers are often referred to and treatment is tailored to the individual patient.

In general, surgical resection is recommended in all operable cases regardless of nodal status or histology (►**Fig. 1**). An exception is lymphoma that is treated with chemotherapy alone. Transnasal endoscopic surgery is recently gaining preference over open surgical approaches due to reduced post-surgical morbidity and complications while achieving comparable prognosis in carefully selected situations.[18,19] This, however, mandates careful imaging to ensure that the endoscopic minimally invasive surgery would be effective in fully encompassing the tumor with appropriate margins. Post-surgery RT is administered in T1 and T2 cases with positive/uncertain margins, or with adverse prognostic factors (adverse histology like adenoid cystic carcinoma or undifferentiated carcinoma, high grade tumor, perineural extension). Adjuvant RT is recommended in all advanced cases (T3, T4) due to high risk of recurrence.[20] Orbital exenteration is indicated in cases with tumor transgressing the periorbita into the intraorbital fat. Breach of the lamina papyracea and invasion of the orbital periosteum alone do not mandate exenteration.[21]

Lymph nodal involvement is uncommon, unless tissues with rich lymphatic supply like the anterior skin, nasopharynx, oropharynx, and hard palate are invaded. The retropharyngeal lymph nodes, followed by periparotid, level 1b and 2 nodes are the most common to be involved. Cases with clinical lymph nodal disease are treated with lymph node dissection and adjuvant RT. Prophylactic nodal dissection in clinically node negative cases is not recommended. However, prophylactic RT to ipsilateral neck or ipsilateral node dissection may be advocated in advanced (T3, T4) disease.[22]

Radical RT or chemoradiotherapy without surgery is not usually recommended but may be instituted in the subsets of unresectable cases, or patients unwilling or unfit for surgery. Neoadjuvant chemotherapy might shrink the tumor size and save surgical morbidity from an otherwise more extensive resection; however, supporting evidence is scarce. Recurrent disease is treated with a combination of surgery and chemoradiation.

Prognosis

The overall 5-year survival rates average to about 50%, but vary across various histologies and stages.[23] The better prognostic factors include lower stage, absence of lymph nodal involvement, maxillary sinus tumor over ethmoid sinus tumor, and adenocarcinoma over SCC/undifferentiated carcinoma.

Summary of Recommendations

- Imaging with CT and/or MRI of the head and neck is indicated in patients of suspected as well as biopsy proven sinonasal tumors for staging. CT and MRI have complementary roles. Imaging is done with contrast, unless contraindicated. FDG-PET/CT, CT/MRA, and arteriography are not appropriate for initial imaging and may be considered selectively.
- Chest CT is recommended to screen for lung metastases in advanced disease. FDG-PET/CT is useful for surveillance to detect recurrence, and for metastatic workup.
- There is no role of screening in the general population or high-risk population owing to the rarity of these tumors.
- Surgical resection is preferred across all histologies except lymphoma, with adjuvant RT in advanced disease (T3, T4) as well as early disease with adverse prognostic factors (adverse histology, high grade, perineural spread). Lymph node dissection and adjuvant RT are warranted in clinically node positive cases. Prophylactic lymph node dissection is rarely advocated, but prophylactic neck RT may be selectively done in advanced disease (T3, T4) with no clinically apparent nodes.
- Post-surgical baseline CT or MRI is acquired within the first 6 months for follow-up. FDG-PET/CT is used for early follow-up within 3 to 6 months of completing adjuvant RT to detect residual tumor. Surveillance is essentially clinical, unless the surgical cavity is not entirely clinically accessible. In such cases, annual CT/MR is advisable. US of the neck is useful for nodal surveillance.

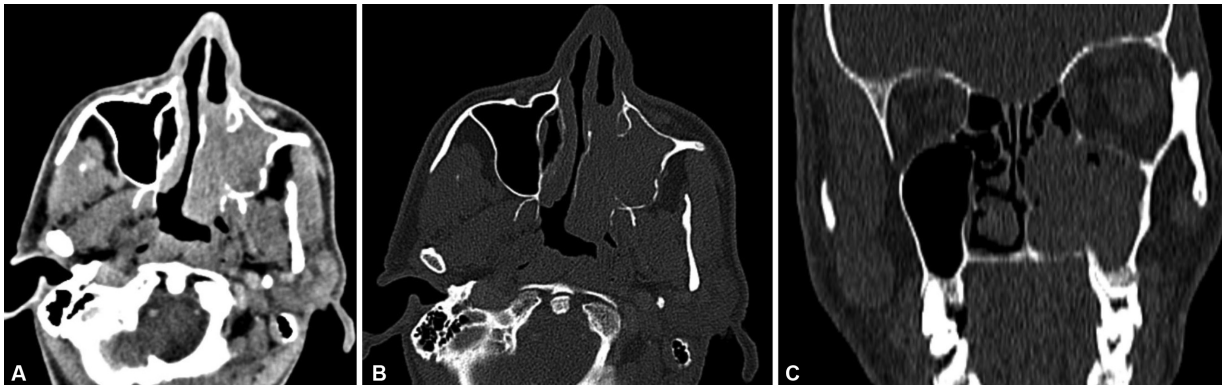

Fig. 5 Sinonasal undifferentiated carcinoma. **(A)** Axial contrast computed tomographic image in soft tissue window shows enhancing mass in the left maxillary sinus invading the left nasal cavity. **(B)** Bone window image better depicts the erosion of the posterior wall of left maxillary sinus, and the left medial pterygoid plate. The turbinates are destroyed. **(C)** Coronal reformatted bone window image shows erosion of the hard palate.

Authors' Contributions

ASB, GMNI, SM contributed in the concept, design, literature search, manuscript preparation, editing, and review. AG, RK, AS, AT, and AI contributed to the manuscript editing and review.

The authors hereby declare to have read and given their approval for this manuscript.

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Conflict of Interest

None declared.

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