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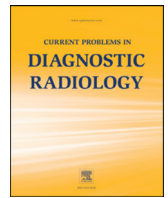
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Imaging Findings in Non-Neoplastic Sinonasal Disease: Review of Imaging Features With Endoscopic Correlates

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ABSTRACT

Non-neoplastic sinonasal disease is common and imaging often plays an important role in establishing the proper diagnosis, guiding clinical management, and evaluating for complications. Both computed tomography and magnetic resonance imaging are commonly employed in the imaging evaluation and it is important to understand the imaging characteristics of the unique types of pathology affecting the sinonasal cavities. This article reviews a variety of infectious, inflammatory, and other non-neoplastic sinonasal pathologies, highlighting imaging features that aid in their differentiation.

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Introduction

Non-neoplastic sinonasal disease is common and imaging often plays an important role in establishing the proper diagnosis, guiding clinical management, and evaluating for complications.^{1,2} Both computed tomography (CT) and magnetic resonance imaging (MRI) are commonly employed in the imaging evaluation and it is important to understand the imaging characteristics of the unique types of pathology affecting the sinonasal cavities. Using representative cases from a single institution, this article reviews the imaging findings of a broad spectrum of non-neoplastic sinonasal disease.

Infectious Pathologies

Acute and Chronic Rhinosinusitis

Acute and chronic rhinosinusitis are defined by the presence of sinonasal symptoms with objective inflammation or infection on nasal endoscopy or imaging. Both acute and chronic rhinosinusitis can present with any combination of the following symptoms: Nasal discharge, facial pain/pressure, nasal obstruction, and loss of smell. Acute rhinosinusitis is classified by symptoms lasting <4 weeks, while chronic rhinosinusitis is defined as symptoms lasting >3 months.³

Although plain radiographs have been used for initial screening for sinonasal disease, CT is the imaging modality of choice.⁴ Imaging features of acute rhinosinusitis include air-fluid levels, mucosal

thickening, sinus opacification, and frothy secretions (Fig 1).⁴ Sclerotic and thickened sinus walls are seen in chronic rhinosinusitis and represent prolonged mucoperiosteal reaction.² MRI features of sinusitis are variable and depend on the protein concentration and hydration of the sinus contents. Sinus disease with low protein content demonstrates hyperintense T2 signal, while high protein concentrations demonstrate hypointense T2 and hyperintense T1 signal.⁵ MRI is helpful in evaluating orbital and intracranial complications of sinusitis.^{4,5}

Odontogenic Sinusitis

Odontogenic sinusitis (ODS) refers to bacterial or fungal maxillary sinusitis, with or without extension to other paranasal sinuses, secondary to either adjacent maxillary odontogenic infection or iatrogenic injury from dental or other oral procedures.⁶ A variety of dental pathologies can lead to ODS, including endodontic disease, periodontitis, oroantral fistula, or dental treatment-related foreign bodies in the sinus.⁷ ODS presents unilaterally most commonly and represents 45%–75% of unilateral sinus opacification on CT.^{7–9}

Imaging typically demonstrates unilateral maxillary sinus opacification, although bilateral involvement has been described.^{9,10} There may be expansile or nonexpansile periapical lucencies around maxillary molars or premolars, with or without bony absence between the diseased tooth and sinus mucosa (Fig 2). Other findings can include absent teeth with oroantral fistulas and sinus foreign bodies from dental procedures. It is important to note that ODS can arise from endodontic disease without any demonstrable dental pathology visible on CT.¹⁰

Differentiating odontogenic from nonodontogenic disease is important because diagnostic and therapeutic approaches differ. Failure to recognize an odontogenic source of disease can lead to failure of both medical and surgical treatment.^{9,11}

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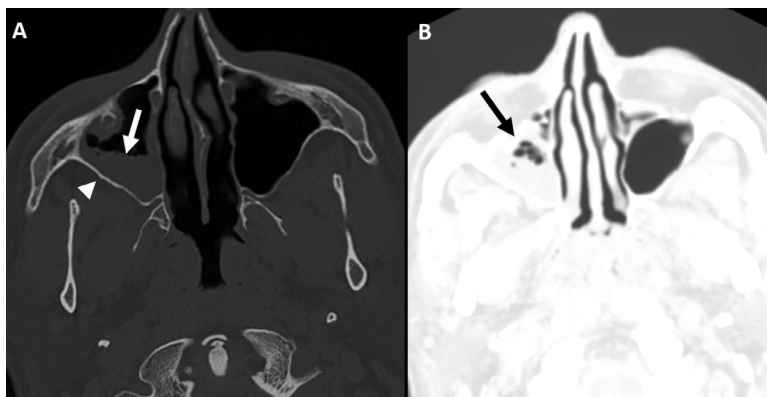


FIG 1. Acute on chronic sinusitis in a 49-year-old male presenting with facial pressure and nasal discharge. Axial CT, (A) bone and (B) lung windows, demonstrates an air fluid level (white arrow) in the right maxillary sinus with frothy secretions (black arrow) and mild reactive neo-osteogenesis (arrowhead).

Invasive Fungal Sinusitis

Acute invasive fungal sinusitis is an aggressive, rapidly progressive infection, typically only seen in immunocompromised states, such as poorly controlled diabetes as well as other causes of absolute or functional neutropenia such as hematologic malignancies, bone marrow transplants, or chronic steroid use.^{12,13} Mortality rates average 50%, though some series have reported rates of up to 80%-100% mortality in select cases.¹⁴ *Aspergillus* is the most commonly implicated organism in neutropenic patients, while *Mucorales* species are more common in uncontrolled diabetics. While patients most commonly present with nonspecific sinonasal complaints, more concerning symptoms include facial numbness, severe headache, or visual loss.¹⁵

On imaging, invasive fungal sinusitis most commonly presents with unilateral sinus mucosal thickening. While osseous destruction of the sinus walls (Fig 3) with rapid intracranial and/or intraorbital extension is both classically described and highly suggestive, it is not always seen, especially in early cases.¹³⁻¹⁵ Absent sinonasal mucosal

enhancement on MRI represents ischemic or necrotic tissue and is one of the earliest imaging signs of disease (Fig 4). MRI has a greater sensitivity than CT for detection of early intraorbital and intracranial spread.^{14,15} Treatment of acute invasive fungal sinusitis requires prompt surgical debridement, systemic antifungals, and reversal of immunosuppression.¹²⁻¹⁴

Allergic Fungal Rhinosinusitis

Allergic fungal rhinosinusitis (AFRS) is a form of eosinophilic chronic rhinosinusitis with nasal polyposis. AFRS is an IgE-mediated hypersensitivity reaction to inhaled fungi resulting in chronic eosinophilic inflammation. It is important to recognize that AFRS typically occurs in immunocompetent patients and is not an invasive fungal infection. Commonly implicated organisms include dematiaceous fungi, *aspergillus*, and *fusarium*.^{4,13} AFRS is more common in warm humid climates such as the southern United States.

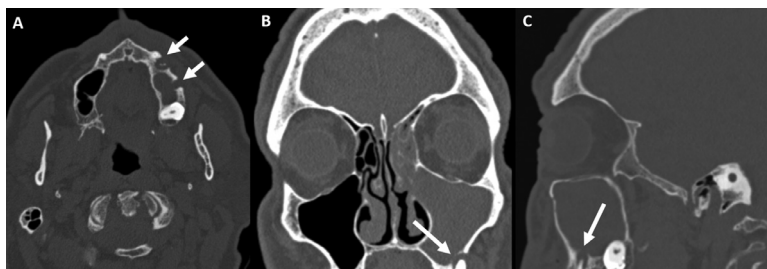


FIG 2. Odontogenic sinusitis in a 73-year-old male with chronic left sided maxillary sinusitis. (A) Axial, (B) coronal, and (C) sagittal CT images demonstrate complete opacification of the left maxillary sinus and anterior ethmoid air cells. Periapical lucency is visible around a left maxillary premolar with bony erosion along the sinus floor (long arrows) and buccal cortex (short arrows).

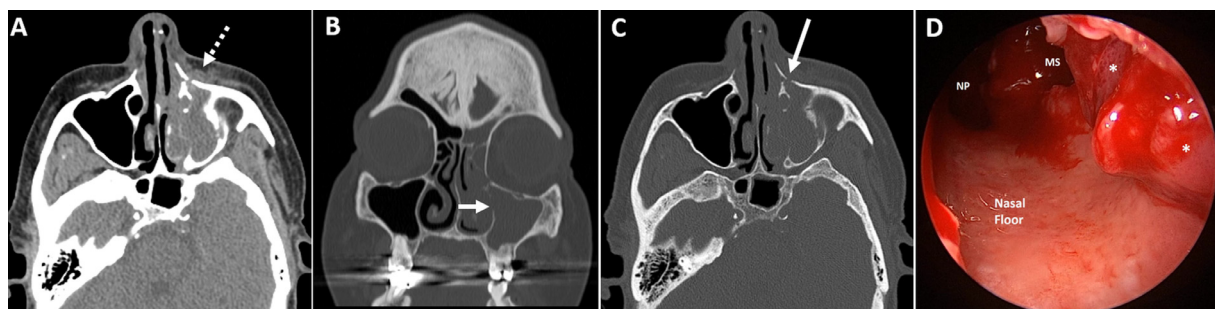


FIG 3. Acute invasive fungal sinusitis (mucormycosis) in a 69-year-old poorly controlled diabetic female. (A) Axial soft tissue window CT demonstrates complete opacification of the left maxillary sinus with stranding in the preantral fat (dashed arrow). (B) Coronal and (C) axial bone window CT demonstrates bony erosion of the medial wall of the maxillary sinus (short arrow) and near the pyriform aperture (long arrow). (D) Endoscopic view of the left nasal cavity and maxillary sinus after the inferior turbinate was resected showing dusky edematous mucosa of the lateral wall of the inferior meatus (*), which is also the medial wall of the left maxillary sinus. MS, maxillary sinus; NP, nasopharynx.

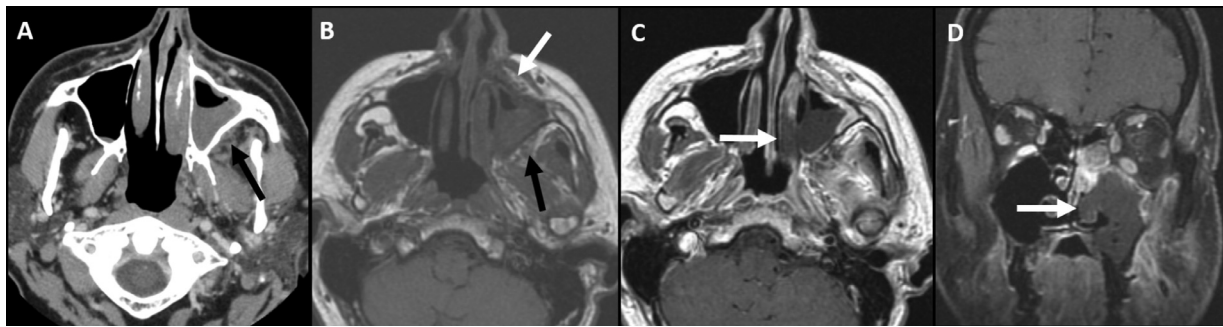


FIG 4. Acute invasive fungal sinusitis (mucormycosis) in a 53-year-old diabetic male with left facial swelling and numbness. (A) Axial CT demonstrates an air-fluid level in the left maxillary sinus with stranding in the retroantral fat (black arrow). (B) Axial pre-contrast T1-weighted image demonstrates stranding in the preantral (white arrow) and retroantral fat (black arrow). (C) Axial and (D) coronal postcontrast T1-weighted images demonstrate a region of nonenhancement (white arrow) of the left inferior turbinate.

Characteristic imaging features include near-complete opacification of the affected sinus or sinuses with expansion and thinning or erosion of the sinus walls (Fig 5). Classically, CT imaging demonstrates heterogeneous opacification of the sinuses with areas of central hyperattenuation.^{13,15} On MRI, sinus contents can have variable T1 signal intensity and typically low T2 signal due to fungal debris and ferromagnetic iron, and manganese microparticulate material.^{13,15}

Fungal Ball (Mycetoma)

Fungal ball formation, formerly known as a mycetoma, is a less common form of fungal sinusitis. It is typically caused by *Aspergillus fumigatus* and denotes a tangled collection of fungal hyphae. The exact pathogenesis remains contested. Patients are generally immunocompetent and a female predilection has been described.^{13,15}

CT features include heterogeneous sinus opacification, typically isolated to a single sinus, most commonly the maxillary and sphenoid sinuses (Fig 6). Focal hyperdensities may be seen within the sinus opacification. While the osseous sinus walls are commonly sclerotic and thickened, they can also appear expanded with focal areas of erosion. On MRI, fungal balls are hypointense on T1- and T2-weighted images due to lack of free water. The presence of paramagnetic elements such as iron and manganese also contribute to the low T2 signal. Treatment typically necessitates endoscopic surgical evacuation of the involved sinus.^{13,15}

Nasal Septal Abscess

Nasal septal abscess is a discrete collection of purulent material in the nasal septum. In adults, nasal septal abscesses occur most commonly after minor nasal trauma, but can also result from iatrogenic causes, as well as sinonasal and dental infections. *Staphylococcus aureus* is the most commonly implicated organism.¹⁶

CT demonstrates a fluid collection with rim enhancement and adjacent inflammatory changes, typical of abscesses seen elsewhere in the body (Fig 7). Prompt incision and drainage is critical to limit regional and systemic spread, as well as to prevent cartilage necrosis and collapse with secondary development of a saddle nose deformity.¹⁶

Mucocele/Mucopyocele

Mucoceles form in the setting of chronic sinus ostial obstruction, usually due to preceding iatrogenic or traumatic injury, with resultant secondary mucus retention and gradual sinus remodeling and expansion.^{17,18} More rarely, mucoceles may occur spontaneously. When secondary infection occurs, the resultant collection is termed a mucopyocele and may constitute a surgical emergency if the orbit or intracranial spaces become involved.

CT demonstrates complete opacification of the affected sinus with smooth expansion and thinning of the sinus walls (Fig 8). The mucocele may extend into the adjacent orbit, intracranial cavity, or even into the face subcutaneously with or without sinocutaneous fistula

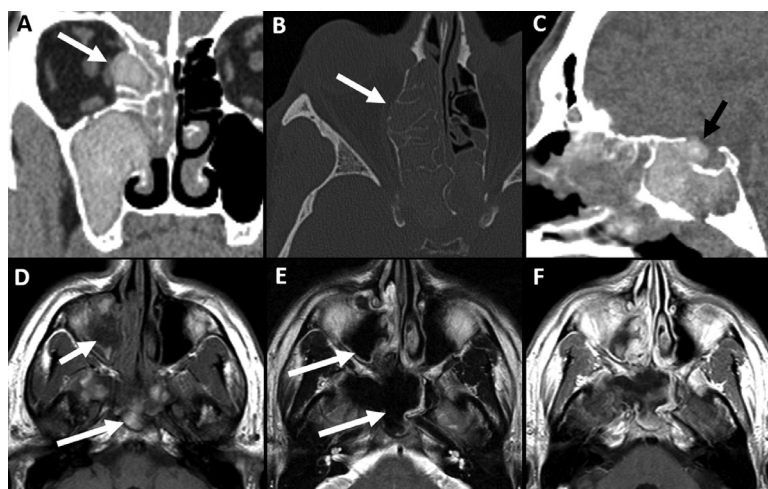


FIG 5. Allergic fungal rhinosinusitis in a 50-year-old male with chronic nasal obstruction, drainage, anosmia, and headache. (A, B, C) Noncontrast CT demonstrates complete heterogeneous opacification of nearly all right-sided paranasal sinuses, with relative sparing of the left sinuses, except for the left sphenoid and posterior ethmoid sinuses. There is hyperdense mucus in the sinuses and expansion and erosion of the lamina papyracea (white arrows) with extension of hyperdense mucin into the medial orbit (white arrows) and sella turcica (black arrow). (D) Axial T1, (E) axial T2 and (F) axial T1 postcontrast MR images demonstrate extensive sinus disease with contents demonstrating variably T1 hyperintense (long arrow, D) and hypointense (short arrow, D) signal, T2 hypointense signal (arrows, E), and no internal enhancement.

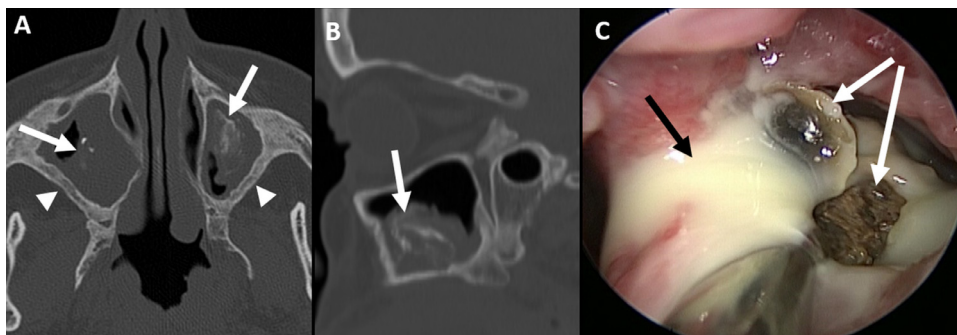


FIG 6. Bilateral maxillary sinus fungal balls (mycetomas) in a 68-year-old female with a 3 months history of nasal drainage. (A) Axial and (B) sagittal bone window CT images demonstrate mucosal thickening of the bilateral maxillary sinuses with internal hyperdensities (arrows). There is sclerosis and thickening of the sinus walls consistent with reactive neo-osteogenesis (arrowheads). (C) Endoscopic image demonstrates fungal debris/hyphae (white arrows) with surrounding purulent material (black arrow) in the left maxillary sinus.



FIG 7. Nasal septal abscess in a 22-year-old female with nasal pain and swelling. (A) Axial, (B) sagittal, and (C) coronal contrast-enhanced CT images demonstrate a rim enhancing fluid collection (arrows) involving the cartilaginous portion of the nasal septum. There is obliteration of the nasal passage bilaterally.

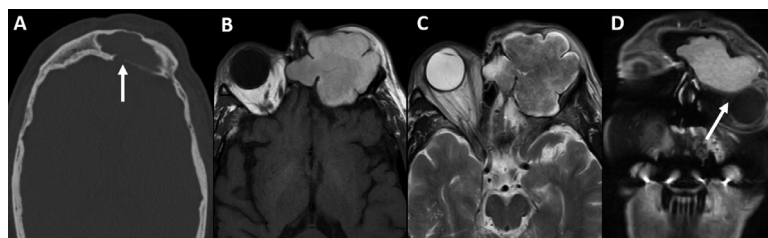


FIG 8. Left frontal sinus mucocele in a 65-year-old male with history of esthesioneuroblastoma resection. (A) Axial CT bone window demonstrates complete opacification of the left frontal sinus with thinning of the walls and osseous dehiscence of the posterior wall (arrow). On axial MR imaging the contents of the left frontal mucocele are predominantly (B) T1 hyperintense and (C) T2 hypointense. (D) Coronal postcontrast fat-saturated T1-weighted image demonstrates expansion into the superior orbit with mass effect on the globe (arrow).

formation.^{17,18} The appearance on MRI is variable and depends both on the protein content as well as the hydration status. Most commonly, mucoceles have a high internal water content and demonstrate T2 hyperintense and T1 hypointense signal. In contrast, proteinaceous mucoceles are T1 hyperintense and T2 hypointense due to diminished free water content. Thickened peripheral rim enhancement suggests a mucopyocele. Treatment requires endoscopic sinus surgery and is typically curative in the absence of recurrent postoperative ostial stenosis.^{17,18}

Inflammatory Pathologies

Antrochoanal Polyp

Antrochoanal polyps are benign lesions that by definition arise from the maxillary sinus mucosa and extend into the nasal cavity, typically through an accessory maxillary sinus ostium.¹⁹ Patients most commonly present with nasal obstruction, with or without secondary sinusitis. Antrochoanal polyps are a rare cause of sinonasal

disease and are typically found in isolation with no secondary sinonasal or systemic comorbidities.

Features on CT classically include a unilateral, smooth, hypodense polypoid mass arising from the maxillary antrum and extending into the nasopharynx (Fig 9). There may be remodeling of the sinus ostia, however frank osseous destruction is lacking.^{19,20} On MRI, antrochoanal polyps are typically T1 hypointense and T2 hyperintense with a thin rim of mucosal enhancement. Increased protein content however may result in T1 shortening with increased T1 and intermediate to decreased T2 signal. Though recurrence has been described, endoscopic resection is typically a safe and effective treatment for removing antrochoanal polyps.^{19,20}

Chronic Rhinosinusitis With Nasal Polyposis

Chronic rhinosinusitis with nasal polyposis is a form of CRS, denoted by the presence of multiple benign mucosal polyps both within the sinuses as well as the nasal vault. The majority of cases are due to chronic eosinophilic inflammation, although 10%-20% are

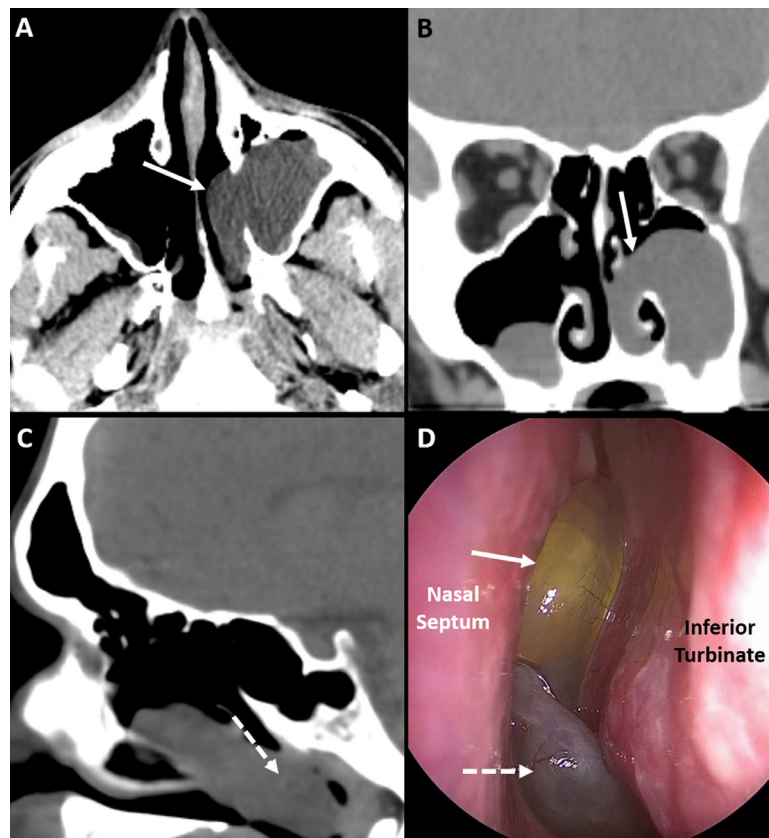


FIG 9. Antrochoanal polyp in a 39-year-old male with chronic left-sided nasal obstruction. (A) Axial noncontrast CT image demonstrates near complete opacification of the left maxillary sinus with lobular low attenuation soft tissue arising from the left maxillary antrum (arrow). Coronal (B) and sagittal (C) reformats demonstrate extension into the nasal cavity (arrow) and into the nasopharynx (dashed arrow). (D) Endoscopic image demonstrating the antrochoanal polyp with a large cystic component (solid arrow) emanating from the maxillary sinus and a more solid portion (dashed arrow) filling the nasal cavity and extending into the nasopharynx.

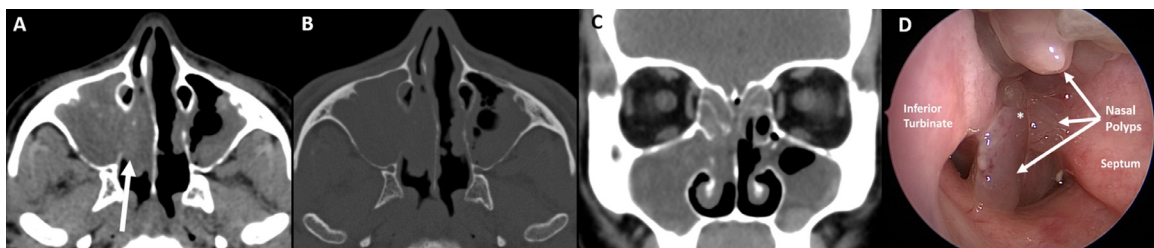


FIG 10. Chronic rhinosinusitis with nasal polyposis in a 52-year-old male with chronic nasal obstruction and anosmia. (A–C) Noncontrast CT demonstrates bilateral sinus partial to complete opacification with soft tissue opacification of the right nasal passage (arrow). There is no bony expansion or erosion. Endoscopic image in a different patient demonstrates nasal polyps.

noneosinophilic and may be seen with recurrent infections or cystic fibrosis.^{21,22} Patients present with nonspecific sinusitis symptoms, most commonly nasal obstruction and anosmia.

CT features include hypodense to isodense polypoid soft tissue in the sinuses causing partial or complete sinonasal opacification (Fig 10).²³ There can be associated bone remodeling with sclerosis and thickening of the sinus walls, but bone thinning and erosion can also be seen. Increased attenuation suggests inspissated mucous or superimposed fungal sinusitis.²³ Treatment options include both medical management with systemic and topical steroids as well as endoscopic sinus surgery with long-term topical postoperative intranasal steroid therapy.^{21,22} More recently, biologic immunomodulatory agents have also emerged as a treatment option for recurrent polyposis after sinus surgery.²⁴

Granulomatosis With Polyangiitis

Granulomatosis with polyangiitis (GPA), formerly known as Wegener's granulomatosis, is a systemic antibody-mediated disease that

primarily affects both the respiratory tract and kidneys. Histopathologic analysis of affected organs reveals vasculitis and necrotizing granulomatous inflammation.^{25–27} Rhinosinusitis is a common manifestation of GPA.

Imaging features include mucosal thickening, neo-osteogenesis, osseous erosion, and destruction. Osseous destruction occurs in a typical pattern with initial involvement of the septum and turbinates followed by symmetric spread to the adjacent sinuses, ultimately leading to auto-exenteration and a secondary large sinonasal monocavity (Fig 11). The hard palate is classically spared.^{25–27} Alternatively, the sinuses may undergo complete osseous obliteration due to chronic repetitive reparative attempts. Mucosal inflammation and granulomatous tissue are difficult to distinguish on imaging during the initial inflammatory stages of GPA.²⁷ However, over time, granulomas may be more readily detected on MRI, typically appear as enhancing areas of low signal intensity on both T1- and T2-weighted images.²⁷ As imaging features of GPA can overlap with other entities such as sinonasal sarcoidosis and lymphoma, clinical or imaging correlation for evidence of systemic involvement elsewhere can be helpful.

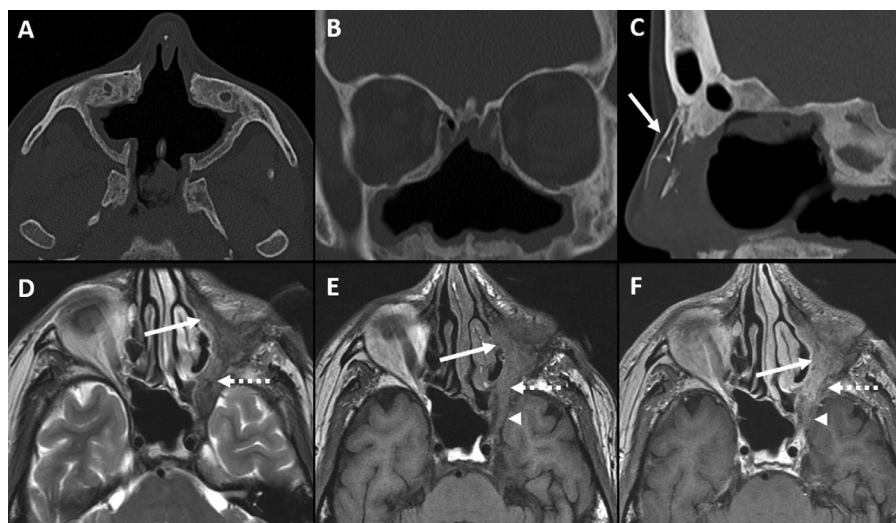


FIG 11. Granulomatosis with polyangiitis in a (A–C) 45-year-old female with prior reconstructed saddle nose deformity and a (D–F) 61-year-old male with chronic sinusitis and prior left orbital and maxillary sinus surgery. (A) Axial, (B) coronal, and (C) sagittal CT images demonstrate destruction of the nasal septum, turbinates, and medial maxillary sinus walls with a large single sinus cavity, as well as neo-osteogenesis of the maxillary sinus walls. There is evidence of prior saddle nose surgical correction (arrow). Axial T2, T1, and postcontrast T1-weighted images demonstrate (A) T2 hypointense (arrows), (B) T1 iso- to hypointense (arrows), and (C) enhancing soft tissue (arrows) within the left maxillary sinus with extension into the left pterygopalatine fossa (dashed arrows) and the left foramen rotundum (arrowhead, E, F).

Sinonasal Sarcoidosis

Sarcoidosis is a multiorgan non-necrotizing granulomatous disease that most commonly affects the lungs. In the United States, it is more common among African Americans and has a slight female predominance. Sinonasal involvement is rare with an incidence between 0.7% and 6% in the literature.^{28,29} Patients present with refractory nonspecific symptoms of nasal obstruction, rhinosinusitis, and, most commonly, nasal mucosal crusting. Concomitant systemic symptoms including cough, shortness of breath, fatigue, and weight loss usually prompt consideration of sarcoidosis. Diagnosis of sinonasal sarcoidosis requires tissue biopsy demonstrating histologic evidence of non-caseating granulomas.^{28,29}

Sinonasal imaging is typically nonspecific, but may demonstrate nodular thickening of the nasal septum and turbinates (Fig 12). Imaging features are also similar to chronic sinusitis with mucosal thickening and periosteal thickening with a predilection for the maxillary and ethmoid sinuses. The frontal sinuses are almost always spared.^{29,30} Nasal septal perforation from granulomatous inflammation may occur.^{29,30} Aggressive granulomatous disease may also cause osseous destruction of the nasal turbinates and paranasal sinus walls. Given the nonspecific imaging features, clinical or imaging manifestations of sarcoidosis involving other organ systems, such as pulmonary involvement can help in suggesting the diagnosis. Treatment of sinonasal sarcoidosis is typically nonoperative, employing topical nasal or oral steroid therapy as needed.^{28–30}

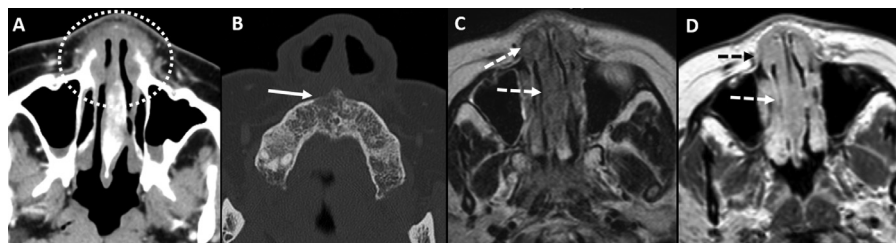


FIG 12. Sinonasal sarcoidosis in a 54-year-old female presenting with epistaxis. Axial noncontrast CT images in (A) soft tissue and (B) bone window demonstrate irregular soft tissue thickening overlying the nasal bones (dotted circle) with involvement of the nasal septum and subtle erosive changes involving the anterior maxilla (arrow). Axial T2 (C) and post-contrast axial T1-weighted (D) MR images demonstrate T2 hypointense and enhancing soft tissue overlying the nasal bones and extending into the nasal septum (dashed arrows).

Other Pathologies

Rosai-Dorfman Disease

Rosai-Dorfman disease, also termed sinus histiocytosis with massive lymphadenopathy, is a rare disease most commonly presenting with nontender exuberant cervical lymphadenopathy secondary to intranodal deposition of histiocytes.³¹ Extranodal involvement is common with typical sites including the nasal cavity, sinuses, parotid glands, pachymeninges, orbits, and skin. Patients with sinonasal Rosai-Dorfman disease most often present with progressive nasal obstruction, facial pain, epistaxis and anosmia³¹ with the maxillary and ethmoid sinuses being most commonly affected.

CT and MRI findings include generalized mucosal thickening and sinonasal opacification or a nonspecific focal soft tissue density mass (Fig 13). Osseous erosion may be present.^{32,33} Focal mucosal lesions typically enhance and are markedly hypointense on T2-weighted images.^{32,33} Management depends on the extent of systemic involvement and individual patient symptoms, with options including observation, systemic steroids, chemotherapy, immunomodulatory therapy, radiation, and surgical debulking.³¹

Fibrous Dysplasia

Fibrous dysplasia (FD) is a benign developmental anomaly in which connective tissue and immature bone replace the normal bone

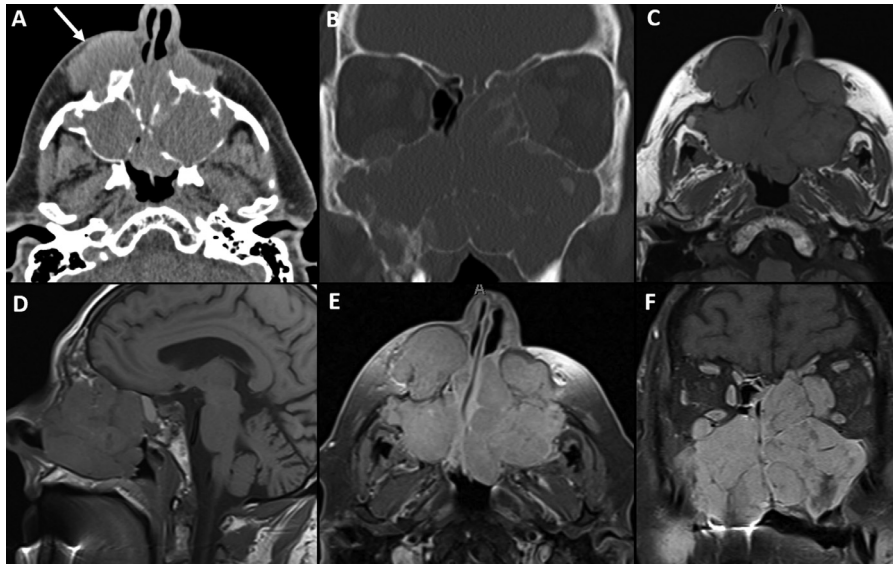


FIG 13. Sinonasal Rosai-Dorfman disease in a 67-year-old female with a 2-year history of bilateral nasal obstruction. Axial (A) and coronal (B) noncontrast CT demonstrates near complete soft tissue opacification of the bilateral nasal cavities, maxillary and ethmoid sinuses with erosion of the maxillary and ethmoid sinus walls and soft tissue extension into the premaxillary soft tissues (arrow). Precontrast axial (C) and sagittal (D) T1-weighted images demonstrate low-to-intermediate T1 signal of the mass with diffuse enhancement on the postcontrast axial (E) and coronal (F) fat-saturated T1-weighted images.

architecture. FD most commonly develops within long bones, ribs, and the craniofacial bones, although other areas throughout the skeleton have been described.³⁴⁻³⁶ Involvement may be monostotic or polyostotic as seen in McCune-Albright syndrome.

Three characteristic CT imaging patterns are recognized including a ground-glass, homogeneously sclerotic, or cystic appearance with an expansile ground-glass lesion being the most commonly encountered (Fig 14).^{34,35} The MRI appearance varies depending on the internal composition with lesions typically being low-to-intermediate signal on T1-weighted imaging.³⁶ On T2-weighted images, lesions having a highly mineralized matrix demonstrate low signal while those with a greater fibrous tissue content or cystic spaces have higher T2 signal. Contrast enhancement is highly variable with avid enhancement being associated with lesion activity.^{35,36}

Rhinolith

Rhinoliths are rare calcified sinonasal masses that arise due to precipitation of mineral salts around endogenous or exogenous material.^{37,38} Endogenous niduses are more common and include ectopic teeth, bone fragments, dried blood products as well as other substances. Patients may present with unilateral nasal obstruction, foul nasal odor, or headaches though rhinoliths may also be an incidental imaging finding.^{37,38}

CT demonstrates a mass with irregular calcified margins and a hypodense central area (Fig 15). Rhinoliths are most commonly located at the floor of the nasal cavity,^{37,38} but can form in the sinuses as well, and may grow over time if left untreated (Fig 16). Treatment typically includes endoscopic removal.³⁸

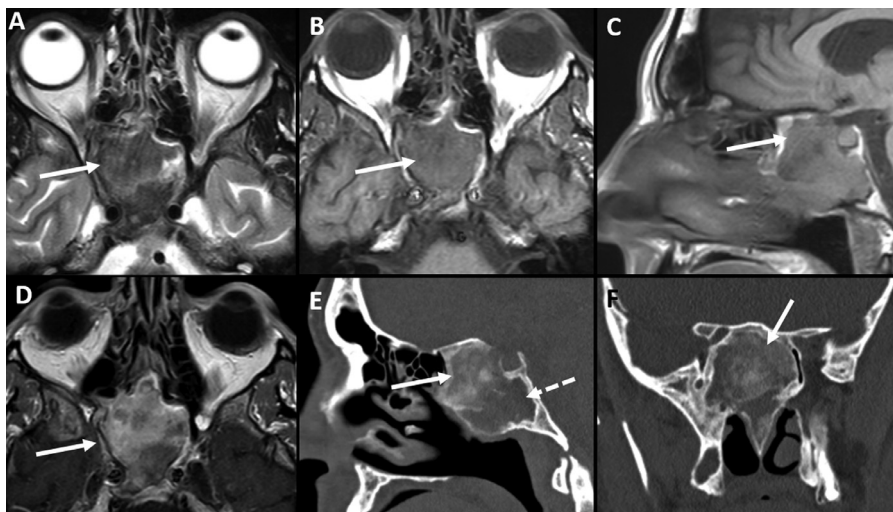


FIG 14. Fibrous dysplasia in a 52-year-old male found to have an incidental sphenoid lesion. Axial (A) T2, (B) axial T1, and (C) sagittal T1-weighted MR images demonstrate a predominantly T2 hypointense and T1 isointense expansile lesion involving the basisphenoid and filling the right sphenoid sinus (arrow). (D) On the postcontrast T1-weighted image this lesion enhances heterogeneously. (E, F) Sagittal and coronal noncontrast CT images demonstrate predominantly ground glass density (arrow) with obstructive opacification of the sphenoid sinus (dashed arrow).



FIG 15. Rhinolith in a 67-year-old female with a 2-year history of nasal obstruction. Axial (A) and coronal (B) noncontrast sinus CT images demonstrate an irregularly shaped calcified mass (white arrow) within the right nasal cavity between the inferior turbinate and nasal septum, with mass effect causing lateral bowing of the medial wall of the right maxillary sinus (black arrow), but no osseous erosion.

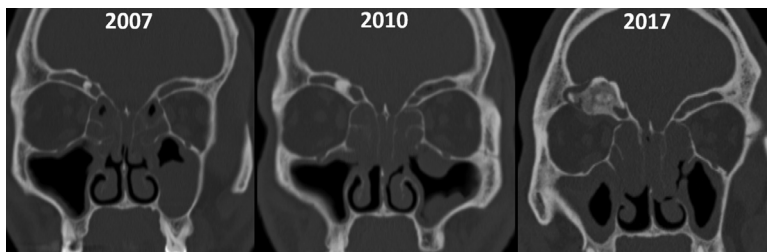


FIG 16. Enlarging sinolith in a patient with eosinophilic chronic rhinosinusitis with nasal polyposis. Consecutive coronal CT images demonstrate a rare example of a sinolith in a right supraorbital ethmoid cell. The sinolith grew gradually, eventually resulting in bony remodeling and dehiscence along the orbital roof and skull base.

Nasopalatine Duct Cyst

Nasopalatine duct cysts (NPDC), also known as incisive canal cysts, are cystic structures within the incisive canal region that form when an embryonic epithelial remnant of the nasopalatine duct undergoes proliferation and cystic degeneration.³⁹ NPDCs occur most commonly in males in their forties and are typically asymptomatic unless they obstruct the nasal cavities, compress adjacent structures, or become infected.³⁹

On CT, NPDCs appear as anterior midline palatine cystic structures with well-defined round, ovoid, or heart shapes (Fig 17).^{39,40} NPDCs may displace central incisor tooth roots, resulting in root resorption. On MRI, NPDCs have high T2 signal and intermediate to high T1 signal.⁴⁰ Treatment of NPDCs involves surgical resection.³⁹

Lobular Capillary Hemangioma

Mucosal lobular capillary hemangioma (LCH), formerly known as pyogenic granuloma, is a benign proliferation of capillaries that commonly originates from the anterior nasal septum. Risk factors for developing LCH include pregnancy, oral contraceptives, chronic nasal digital irritation, nasal packing, and trauma. Common presenting symptoms include unilateral epistaxis and nasal obstruction.^{41,42}

CT demonstrates a soft tissue lesion with intense enhancement (Fig 18). There is typically no osseous erosion or invasion into the sinuses, although erosion has been reported at the site of origin.⁴¹ On MRI, lesions demonstrate isointense to intermediate T1 signal and heterogeneously hyperintense T2 signal. LCH secondary to pregnancy may regress following childbirth. Treatment of persistent lesions and LCH due to other etiologies includes surgical resection, with or without preoperative embolization depending on lesion size.^{41,42}

Intraosseous Vascular Malformation

Intraosseous vascular malformations (IVM) affecting the craniofacial skeleton are rare and account for only 1% of osseous tumors. IVMs are thought to be due to embryologic tissue remnants with progressive ectasia of abnormal vessels. Patients with IVMs typically present with an enlarging hard lump that may cause discomfort.^{43,44}

CT demonstrates an expansile soft tissue mass with internal coarse trabeculae with preserved outer cortex. MRI demonstrates hyperintense T1 signal typically due to fat within the bone marrow and hyperintense heterogeneous T2 signal (Fig 19). IVMs have intense contrast enhancement. Surgical resection is the mainstay of treatment.⁴⁴

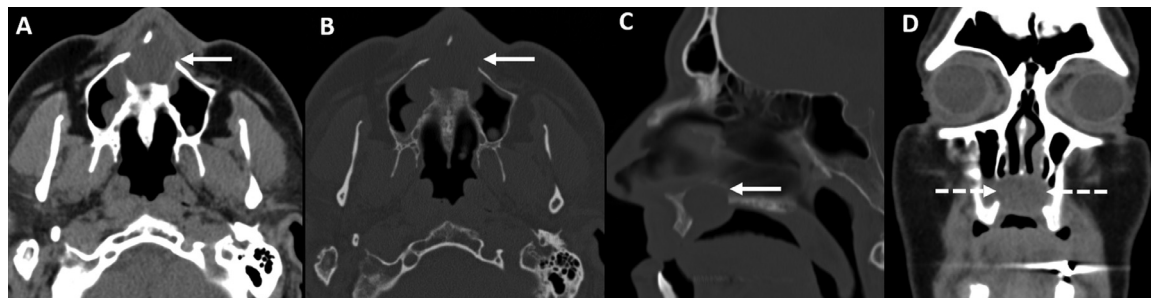


FIG 17. Nasopalatine duct cyst in a 58-year-old male with pain and swelling of the anterior maxilla and hard palate. Axial (A) soft tissue and (B) bone window CT images demonstrate a midline cystic mass (arrows) centered at the junction of the nasal septum and the anterior hard palate. (C) Sagittal bone and (D) coronal soft tissue window images demonstrate osseous remodeling and dehiscence of the floor of the hard palate (arrow), nasal septum, and medial walls of the maxillary sinuses (dashed arrows).

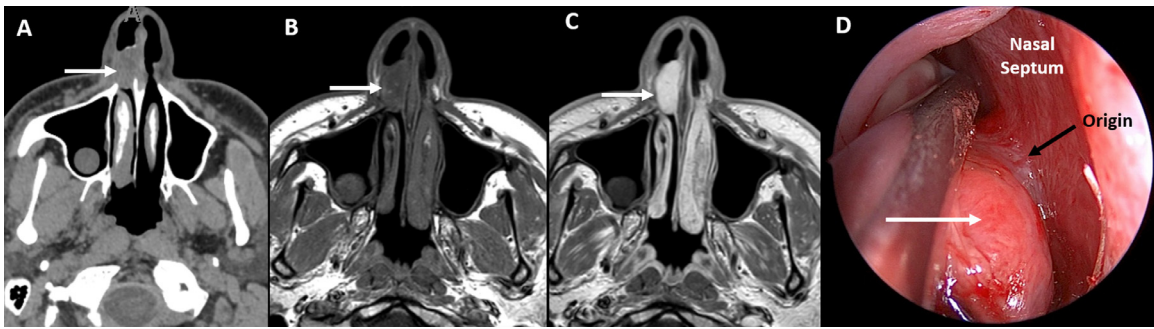


FIG 18. Lobular capillary hemangioma (pyogenic granuloma) in a 21-year-old male with gradually worsening rhinorrhea and sinus pain. (A) Axial noncontrast CT shows a lobular soft tissue mass (arrow) in the right nasal passage. (B) Axial precontrast T1-weighted image shows the same mass with hypointense T1 signal (arrow). (C) The mass demonstrates avid enhancement on postcontrast imaging (arrow). (D) Endoscopic image demonstrates a hypervascular mass filling the anterior nasal cavity (white arrow) with its vascular origin from the nasal septum (black arrow).

Meningocele/Encephalocele

Meningoencephaloceles are rare and refer to herniation of the meninges and brain parenchyma through a defect in the calvarium or skull base. Meningoencephaloceles can be congenital or acquired. Acquired meningoencephaloceles can occur after trauma, but are more frequently due to elevated intracranial pressure, as in cases of idiopathic intracranial hypertension. While these may be diagnosed incidentally on imaging, patients may present with clear rhinorrhea or meningitis suggesting a cerebrospinal leak.^{45,46} Identification of meningoencephaloceles is critical prior to sinonasal surgery as surgical manipulation can result in cerebrospinal leak and increased risk of intracranial infection.

CT is key both for identifying the site of the osseous defect as well as evaluating and mapping the extent for surgical planning (Fig 20). While a simple meningocele will be hypodense or nearly cystic in appearance, the presence of cerebral tissue in a meningoencephalocele will result in increasing internal complexity. Both CT and MRI

can help define the intracranial origin and delineate the connection of cerebral tissue through the defect.⁴⁵⁻⁴⁷

Foreign Body

Nasal foreign bodies most commonly occur in the pediatric population, though can also be seen in mentally handicapped adults or in the setting of trauma. Foreign bodies can both serve as a nidus for bacterial infection as well as a site for rhinolith development.^{48,49} Depending on the nature of the object, foreign bodies may incite inflammation or erosion of adjacent structures. Patients with chronic nasal foreign bodies commonly present with unilateral mucopurulent discharge with foul odor.^{48,49} Treatment may require endoscopic removal if not readily accessible through the anterior nasal cavity.

Radiographs are typically the initial study of choice; however, CT has greater sensitivity for detecting small or soft tissue isodense foci (Fig 21). Common nonradiopaque foreign bodies include plastic, wood, thin aluminum objects, and fish bones while potential

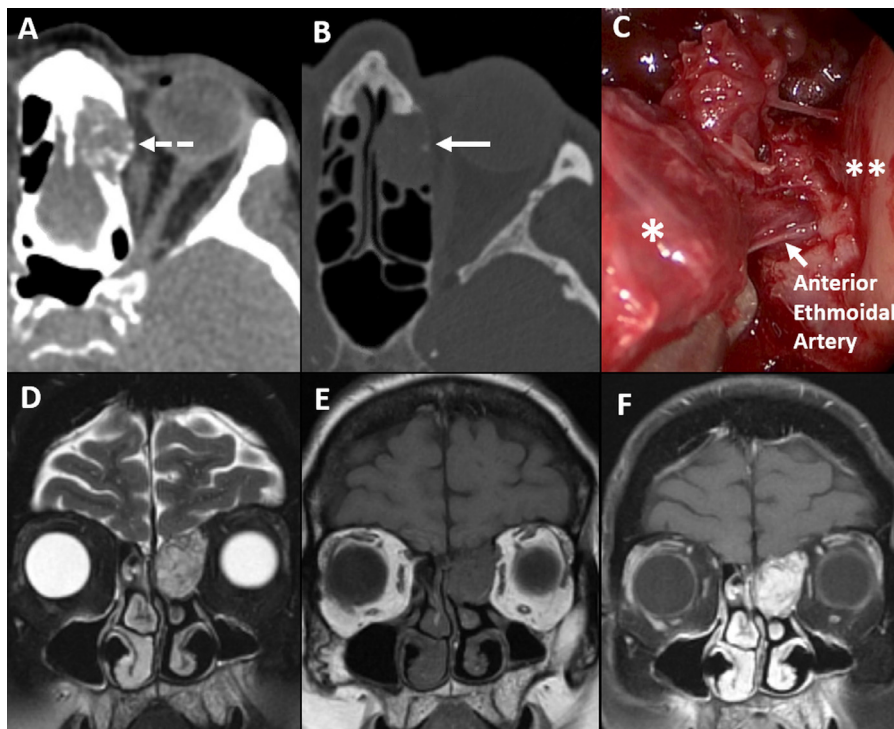


FIG 19. Intraosseous vascular malformation in an 85-year-old male with facial and orbital pressure. Axial noncontrast CT images in (A) soft tissue and (B) bone window demonstrate an expansile mass with internal calcifications in the anterior ethmoid air cells with thinning of the lamina papyracea (solid arrow) and bowing into the left orbit (dashed arrow). (D) Coronal fat-saturated T2, (E) coronal T1, and (F) coronal postcontrast fat-saturated T1-weighted MR images demonstrate a heterogeneous T2 hyperintense, T1 iso- to hypointense, and avidly enhancing mass. (C) Endoscopic image demonstrates the vascular malformation (*) abutting the periorbita (**).



FIG 20. Meningoencephalocele in a 56-year-old male with history of craniopharyngioma resection. (A, B) Axial and coronal noncontrast CT images demonstrate a low density collection occupying the superior nasal cavity and ethmoid air cells (arrow). This collection communicates with the intracranial cavity through a defect in the cribriform plate (dashed arrow). (C) Sagittal T1-weighted MR image shows communication of the CSF through the large skull base defect (arrow) with convergence of gyri toward the defect (dashed arrow). (D) Endoscopic images in another patient demonstrate a frontoethmoidal meningoencephalocele (arrow) herniating through a skull base defect to occupy the nasal cavity.

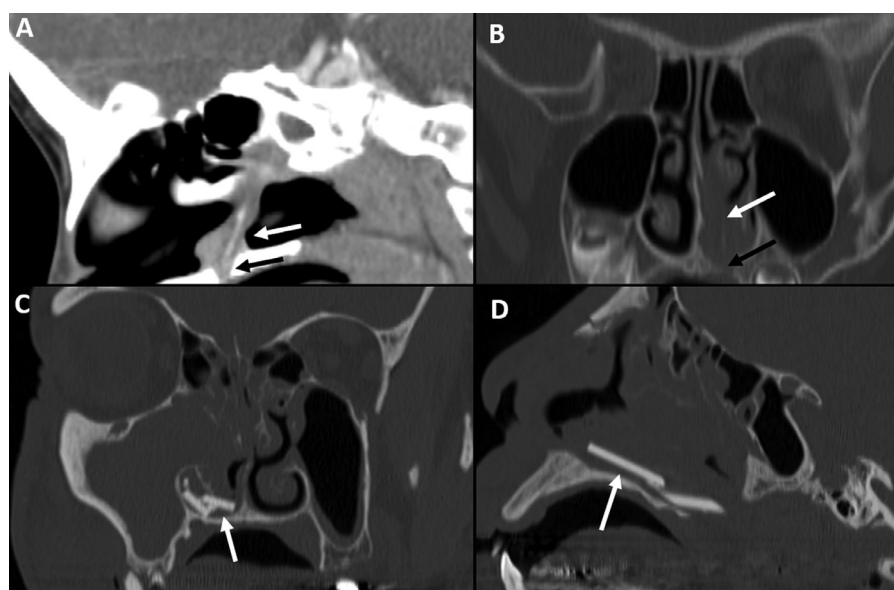


FIG 21. Nasal foreign bodies in a 5-year-old with snoring (A, B) and a 52-year-old male after assault (C, D). (A) Sagittal soft tissue and (B) coronal bone window CT images demonstrate a linear hyperdense foreign body (white arrow) within the left nasal passage with surrounding soft tissue with erosion of the hard palate (black arrow). (C) Coronal and (D) sagittal bone window images demonstrate a hyperdense foreign body (arrows) inferior to the right inferior turbinate and extending into the nasopharynx.

radiopaque foreign bodies include glass, metals, bones, and certain medications. CT also allows for precise localization and can aid in surgical planning prior to removal. MRI is contraindicated in patients with suspected ferromagnetic foreign bodies.^{48,49}

Conclusion

CT and MRI are commonly employed when evaluating sinonasal disease and it is important to understand the imaging characteristics of the unique types of pathology affecting the sinonasal cavities. Sinonasal endoscopy critically complements imaging findings. Close collaboration of otolaryngologists and radiologists is imperative for both an expeditious diagnosis as well as treatment planning in patients with complex sinonasal disease.

Declaration of Competing Interest

None.

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