

Radiologic Imaging in Chronic Sinusitis

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Sinusitis is one of the most common diseases which primary care physicians encounter in their daily practice [1]. Nowadays, it's widely approved that radiologic imaging is not indicated to evaluate uncomplicated sinusitis cases. Further diagnostic evaluation and radiologic imaging should be reserved for sinusitis cases whose symptoms persist or recur despite appropriate treatment. Sinusitis can be classified into acute, subacute and chronic sinusitis according to the duration of symptoms. Acute sinusitis is characterized with symptoms lasting shorter than one month. Subacute disease lasts 1-3 months, and chronic sinusitis lasts longer than 3 months and is generally related to suboptimally treat acute or subacute disease [2].

Acute and subacute sinusitis are usually treated medically because clinical judgment is sufficient to diagnose sinusitis in a majority of cases, and empiric treatment is inexpensive and safe, only a small percentage of patients who develop recurrent or complicated sinusitis are candidates for imaging studies. The American Academy of Otolaryngology, in its 2007 clinical practice guideline, recommended against diagnostic imaging for patients with acute or sub-acute sinusitis unless a complication or alternate diagnosis is suspected [3]. Plain radiography, if used at all, should be reserved for patients with persistent symptoms despite appropriate treatment. A single Waters' view (occipitontental) appears to provide as much information as the standard four-view series. However, imaging or nasal endoscopy is recommended for symptoms of chronic sinusitis because this condition may be associated with predisposing factors that contribute to persistence or recurrence of the illness. Imaging or nasal endoscopy are needed to confirm the diagnosis, because the symptoms of chronic sinusitis overlap with other common conditions, including allergic and nonallergic rhinitis, nasal septal deformity, and nonrhinogenic causes of facial pain. Furthermore, imaging is useful in helping to guide treatment and in identifying extrasinus abnormalities associated with chronic sinusitis. Although there is a strong association between allergy and sinusitis, identification of allergies does not imply they are the only cause of sinusitis, and other factors should be considered.

Chronic sinusitis is diagnosed by the presence of two or more symptoms characteristic for sinusitis longer than 3 months. Chronic sinusitis is a common health problem. Like acute sinusitis chronic sinusitis is also usually a clinical diagnosis and imaging is usually reserved for evaluation of suspected complications or for presurgical planning. Chronic sinusitis is believed to be associated with the blockage of the normal drainage pathways of paranasal sinuses. Functional Endoscopic Sinus Surgery (**FESS**) was developed to correct the underlying obstruction in the drainage canals of paranasal sinuses. Also imaging for presurgical planning purpose is very important because it's very important for the surgeon to have an idea about anatomic variations like detached lamina papyracea or displaced cribriform plate. This prevents the surgeon accidentally entering either the orbita or the frontal lobe during the operation [4].

Using CT imaging as the criterion standard, estimates of the prevalence of chronic sinusitis in those referred for evaluation of this condition ranges from 65% to 80% [3]. Therefore, most ENT specialists believe that a definitive diagnosis of chronic sinusitis requires imaging or nasal endoscopy. However European guidelines addressed at primary care givers suggest that empirical treatment without imaging is appropriate in many cases, although anterior rhinoscopy or more detailed endoscopy should be performed to identify polyps. They recommend a trial of topical nasal corticosteroids, nasal douching, and use of antihistamines in allergic patients without further diagnostic tests in patients without, or with less symptomatic polyps. Those patients who do not respond to this treatment should be referred for CT imaging or endoscopy [5].

Recurrent acute sinusitis should be distinguished from acute bacterial sinusitis because of the greater burden of disease and different approach to isolated management. Patients with recurrent

acute sinusitis may benefit from diagnostic tests, such as CT imaging, nasal endoscopy, and allergy and immune testing. For recurrent acute sinusitis, imaging is most useful between episodes in order to identify anatomic variants that may predispose the patient to recurrent disease. CT is also indicated if intraorbital complications are suspected [6].

PLAIN RADIOGRAPHY

With the wide spread use of CT, the role of conventional radiography has taken second place and presently has a limited role in the management of sinusitis. Today CT imaging is accepted as the primary imaging modality. Low miliampere CT scans can provide much more detailed information about the anatomy and abnormalities of the paranasal sinuses than plain films.

A CT scan provides greater definition of the sinuses and is more sensitive than plain radiography sinuses while delivering almost similar radiation doses when compared with standard 4 projection direct radiographs.

Plain radiography is generally obsolete, but exceptions include its use in confirming air-fluid levels in acute sinusitis and in evaluating size and integrity of the paranasal sinuses. Radiographs may still provide a useful adjunct to diagnosis in parts of the world, where sophisticated imaging is not yet available.

Examination in the erect position is desirable to reveal fluid levels. The following projections allow a good assessment of the paranasal sinuses:

- Waters (occipitomenal) view
- Caldwell (occipitofrontal) view
- Lateral view
- Modified basilar view (a submental vertex view)

The Waters view shows the maxillary antra clearly. The frontal sinus is projected obliquely, and the ethmoid air cells are obscured, although a few may be seen along the medial walls of the orbit and within the nose. The sphenoid sinus is seen through the open mouth.

In the Caldwell view, the frontal sinuses are well seen. The floors of the maxillary sinuses are visible. The floor of the sella turcica, the crista galli, the nasal septum, and the middle and inferior nasal turbinates can be seen. The anterior ethmoid air cells are also seen. However, the sphenoid sinus is obscured.

In the lateral view, the sphenoid and frontal sinuses are visualized. The rest of the sinuses are superimposed. The nasopharyngeal soft tissue and the adenoids are also well visualized.

A modified basilar view (a submental vertex view) may be a useful adjunct when dealing with sphenoid sinus disease.

Whether the Waters view is sufficient for evaluating suspected acute bacterial sinusitis is debated. In general, Waters, Caldwell, and lateral views are obtained.

An orthopantomographic view is not a standard view and requires different equipment. This provides a panoramic view of the floors of the maxillary sinuses and the upper and lower alveoli.

Possible findings in acute sinusitis include mucosal thickening, air-fluid levels, and complete opacification of the involved sinus. Fluid levels are the most common finding in acute bacterial sinusitis and are not generally seen in other forms of sinusitis. Mucosal thickening represented by parallel soft-tissue opacity along the bony walls of the sinuses may be seen. Mucous retention cysts are represented by soft-tissue opacity with a surface convex towards the cavity of the sinus, along any of the walls. The role of imaging in acute sinusitis is controversial, and many regard acute sinusitis a clinical diagnosis. Mucosal thickening is seen in more than 90% of patients with sinusitis, but this finding is highly nonspecific. Air-fluid levels and complete opacification are more specific for sinusitis, but they are seen in only 60% of sinusitis cases [6].

Hypertrophy of the turbinates may be seen. The nasal cavities may be filled in with soft tissues; this finding is suggestive of polyps. Total opacification of a sinus may also be seen. If the sinus is more radio-opaque than its pair or the ipsilateral orbit, it is thought to be totally filled in with soft tissues or fluid.

The most common limitations of plain radiography include other bony structures overlap paranasal sinuses and the high frequency of false positive results. Also posterior ethmoidal cells and the osteomeatal complex cannot be adequately visualised.

Today the role of plain radiography became second place the main reason for this is the fact that there are wide intraobserver differences in the interpretation of plain radiographs, and the rate of false-negative results is high.

In infants aged 3 years or younger, conventional sinus radiographs usually contribute little, because of sinus opacification that occurs secondary to normal nonpneumatized sinuses. Conventional radiographs allow poor visualization of ethmoid air cells. If used at all, conventional radiographs should be reserved for patients with persistent symptoms despite appropriate therapy. A single occipitomeatal (Waters view) suffices in this situation.

Other important limitations of plain radiographs include poor visualization of ethmoid air spaces and difficulty differentiating between infection, tumor, and polyp in an opacified sinus.

CT IMAGING

The high contrast of CT images clearly shows air spaces, opacified sinuses, and the fine structural architecture of bony anatomy. It is, therefore, the gold standard for delineating inflammatory sinus disease and evaluating variants. Mucosal abnormalities, sinus ostial obstruction, anatomic and sinonasal polyps. CT provides an excellent anatomic display of soft-tissue attenuation. This

depiction includes fluid levels and polypoid masses within the normally air-filled cavities of the sinuses, nasal cavity, and postnasal space. Most important, disease extending beyond the bony perimeters of the sinuses into the adjacent soft tissue of the orbit, brain, and infratemporal fossa can be imaged.

The standard imaging modality in the diagnosis of sinusitis is CT, which provides more detailed information about the anatomy and abnormalities of the sinuses than does plain radiography. Computed Tomography (**CT**) scanning is the examination of choice in sinusitis, particularly in cases of chronic sinus disease, providing excellent detail of sinus anatomy. The ostiomeatal units are brilliantly shown on CT scans, which provide greater definition of the pathology than do other images, especially within the sphenoid and ethmoid sinuses. CT also shows the relationship of the sinuses to the orbit and the brain. This is very important in any patient with rhinosinusitis that is severe enough to produce complications [7].

The primary role of CT is to aid in the diagnosis and management of recurrent and chronic sinusitis and to define the anatomy of the sinuses prior to surgery. However, CT is usually not useful in acute sinusitis, as diagnosis in acute cases is primarily based on clinical findings. ACR recommends a noncontrast CT scan as the examination of choice in recurrent or chronic sinus disease. All imaging findings are interpreted in conjunction with clinical and endoscopic findings. Good anatomic definition is desirable before surgical intervention [8,9]. Obstruction of the draining pathways of the sinuses is now thought to be the main cause of sinusitis. Examples of these pathways include the ostia of the maxillary sinuses and the hiatus semilunaris, where the anterior group of paranasal sinuses drains. Clearance of this obstruction is the aim of endoscopic surgery. Functional Endoscopic Sinus Surgery (**FESS**) has revolutionized the treatment of sinusitis. The therapeutic benefits of FESS have helped a large number of patients with chronic sinus disease. Imaging has also progressed with FESS, and Computed Tomography (**CT**) scanning can now demonstrate the sinus anatomy and patterns of sinusitis in exquisite detail before surgery.

Coronal CT imaging is the preferred initial procedure. Bone-window views provide excellent resolution and good definition of the complete ostiomeatal complex and other anatomic details that play a role in sinusitis. In addition, the coronal view is best correlated with findings from sinus surgery, with anatomy and pathology visualized in a plane almost identical to that seen by the endoscopist.

The characteristic features in CT images of both chronic and acute sinusitis include air-fluid levels, mucosal thickening, Sclerotic, thickened bone in the sinus walls is characteristic of chronic sinusitis, although this feature is not seen in every case. In chronic sinusitis, the ethmoid sinus is commonly involved. Findings include mucosal thickening, complete opacification, bone remodeling and thickening due to osteitis, and polyposis. The appearance of the mucosa is non-specific and the extent of inflammatory disease does not always correlate with the severity of symptoms or their effects on the quality of life. Therefore, mucosal thickening should be interpreted in the context of clinical examination or nasal endoscopy or both [10].

In general, non enhanced CT scans suffice in cases of uncomplicated sinusitis. Multidetector CT (**MDCT**) seems to have the potential to replace primary coronal CT of the paranasal sinuses without any loss of image quality, and it may even improve the overall diagnostic value. It allows objective assessment of the patency of intercommunicating passages and shows how anatomic variants, inflammatory disease, or both may affect patency.

Anatomic variants that may predispose to chronic disease include septal deviation, concha bullosa, Haller cells, hypoplasia of the maxillary sinus, and narrowing or obstruction of the osteomeatal complex. MDCT can show anatomic structures that are not visible by physical examination or nasal endoscopy and is, therefore, the study of choice for the surgeon who is considering or planning functional endoscopic sinus surgery. MDCT allows the reconstruction of data set. When a low radiation- dose protocol is used coronal and sagittal images from a single imaging, the radiation dose from CT is comparable to the standard four-view plain radiographic series. Coronal reconstructions provide views similar to those seen by endoscopy. Axial and sagittal reconstructions are especially useful in delineating certain anatomic abnormalities, such as an Onodi cell, or extrasinus abnormalities. These findings are important to recognize prior to sinus surgery [11,12].

Allergic fungal sinusitis can involve complete opacification of multiple paranasal sinuses, unilateral or bilateral; sinus expansion and erosion of a wall of the involved sinus; and high-attenuating areas scattered amid mucosal thickening on nonenhanced scans. With fungal sinusitis, the maxillary and ethmoid sinuses are most commonly involved. These areas are due to inspissated secretions or heavy metals, such as iron, manganese, and calcium

Dense opacification or opacification with inhomogeneous “hyperdensities” is suggestive of thick, inspissated mucus and is a feature of “allergic fungal sinusitis” a condition associated with type I IgE-mediated hypersensitivity to one or more fungi. This condition accounts for less than 10% of chronic sinusitis cases but is associated with severe persistent disease. Invasive fungal disease is rare unless the patient is immune compromised or has poorly controlled diabetes [13,14].

CT can also play an important role in excluding the presence of aggressive infections or neoplastic disease. Characteristics that are suggestive of malignancy include osseous destruction, extra-sinus extension, and local invasion. If these findings are noted, MR imaging should be performed to differentiate between benign obstructed secretions and tumor and to assess for intracranial spread [12].

CT findings should not be interpreted in isolation, and scans should always be read in conjunction with clinical and endoscopic findings because of high rates of false-positive results. Up to 40% of asymptomatic adults have abnormalities on sinus CT scans, as do more than 80% of those with minor upper respiratory tract infections.

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 the basis of imaging alone. Thus, the clinician cannot rely solely on CT imaging and must maintain a high index of suspicion when evaluating immunocompromised patients to establish a prompt diagnosis. Early nasal endoscopy, along with biopsy and the initiation of appropriate therapy, is necessary to improve the patient's prognosis.

The disadvantages of CT include use of ionising radiation, higher cost compared to direct radiography and limited availability in small facilities or rural areas. Also the soft tissue resolution of CT is not as high as that of MRI. Although CT scanning provides an excellent anatomic display, it generally does not help in predicting the histologic nature of the pathologic process. On CT scans, it is difficult or impossible to differentiate tumor tissue from retained fluid in sinuses, where the drainage of a sinus is blocked by obstruction from the tumor.

MR IMAGING

CT scanning remains the standard modality in diagnosing sinusitis and Magnetic Resonance Imaging (**MRI**) is generally reserved for the evaluation of any complications of local sinus infections, particularly suspected intracranial extension, especially in patients with intracranial complications and an extension of infection or in those with suspected superior sagittal venous thrombosis. The lack of ionizing radiation and ability to image in any plane is a considerable advantage of MRI over CT. If complications of sinusitis are suspected, superior soft tissue contrast of MR imaging is recommended to evaluate skull base or intracranial invasion and to determine the relationship between invasive masses and vital structures, such as the optic nerve and the carotid artery.

Both CT and MRI have improved the care and outcomes of patients who have sinusitis with complications. T1-weighted and fat-saturated, T2-weighted coronal sequences are routinely performed. Axial T1- and T2-weighted and fat-saturated, T2-weighted sagittal sequences may also be performed. Fluid is hypointense on T1-weighted images and hyperintense on T2-weighted images. Mucosal swelling may be confused with fluid on T2-weighted MRIs; however, on T1-weighted MRIs, it stands out as soft-tissue thickening against the fluid. Tumor tissue appears hypointense in comparison with mucosal swelling on T2-weighted images. Mucocele is hyperintense in T1- and T2-weighted sequences because of its protein content. The signal intensity on MR depends on the age and degree of inspissation of the secretions. Older mucoceles will lose their T2 signal and then their T1 signal.

MR imaging is also useful for determining the extent or source of an infection, such as an orbital abscess, and it plays a vital role in the diagnostic evaluation of aggressive fulminant fungal sinus infections. It should be noted that the MR appearance of sinus occlusion depends on the protein concentration of the mucus, which is related to the degree of its desiccation. If the protein concentration is high, T2 images are hypointense and can be mistaken for normal, air-filled

sinuses. Hyperdensities seen in an opacified sinus by CT imaging, which is a classic feature of allergic fungal sinusitis, often appear hypointense by T2-weighted MR imaging. Similar ranges in intensity may be observed in mucoceles, which also have varying concentrations of protein [15].

Gadolinium-based contrast agents (gadopentetate dimeglumine [Magnevist], gadobenate dimeglumine [MultiHance], gadodiamide [Omniscan], gadoversetamide [OptiMARK], gadoteridol [ProHance]) have been linked to the development of Nephrogenic Systemic Fibrosis (**NSF**) or nephrogenic fibrosing dermopathy (NFD. The disease has occurred in patients with moderate to end-stage renal disease after being given a gadolinium-based contrast agent to enhance MRI or MRA scans.

NSF/NFD is a debilitating and sometimes fatal disease. Characteristics include red or dark patches on the skin; burning, itching, swelling, hardening, and tightening of the skin; yellow spots on the whites of the eyes; joint stiffness with trouble moving or straightening the arms, hands, legs, or feet; pain deep in the hip bones or ribs; and muscle weakness.

The false-positive rate with MRI is high. Abnormal sinus MRI findings are common among otherwise healthy adults, among children attending school, and among totally asymptomatic children. Incidental MRI findings should be interpreted as normal; they do not indicate that children imaged for purposes other than an evaluation of sinus disease require sinus treatment [16].

MRI improves the differentiation of soft tissue, but it does not help in evaluating bones. MRI clearly depicts tumor from surrounding inflammatory tissue and secretions in the sinuses. CT scanning relies on the high contrast between air, soft tissue, and bone in evaluating the paranasal sinuses. Membrane, polyps, and mucus have similar attenuation, but the polypoid appearance helps in distinguishing the inflammatory polyps. On T2-weighted MRIs, the edematous membrane and mucus are distinctly hyper intense, whereas nasal polyps have more intermediate signal intensity. MRI cannot define bony anatomy as well as CT does.

Other disadvantages of MRI include a high rate of false-positive findings and its higher cost. MRIs take considerably longer to acquire than CT scans, and they may be difficult to obtain in patients who are claustrophobic Figure 1-7.



Figure 1: Coronal paranasal sinus CT showing septal deviation and bony spur as well as diffuse soft tissue attenuation occupying ethmoid air cells indicating sinonasal polyposis. Also note loss of aeration and secretions filling bilateral maxillary sinus.



Figure 2: Coronal paranasal sinus CT showing aeration of the left middle concha (Concha Bullosa) as well as minimal hypertrophy of the left inferior concha and mild septal deviation.

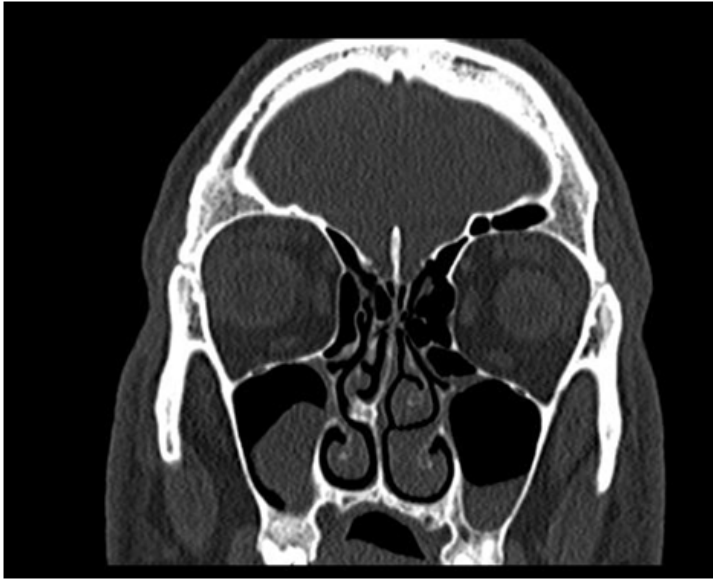


Figure 3: Coronal paranasal sinus CT showing retention cyst in the right maxillary sinus, fluid level indicating acute sinusitis in the left maxillary sinus as well as hypertrophy of the left inferior and middle concha ,bony spur and mild septal deviation.



Figure 4: Waters view showing diffuse prominent mucosal thickening in the right maxillary sinus and mild nmucosal thickening in the left maxillary sinus. Please note that normal aeration in the maxillary sinuses is demonstrated as relative decreased density of the maxillary sinuses when compared to the density of the orbita.



Figure 5: Waters view showing retention cysts in both maxillary sinus represented as hyperdense nodular lesions with convex borders projected into the maxillary sinus lumen. The retention cyst in the right maxillary sinus is much more prominent when compared to that in the left.

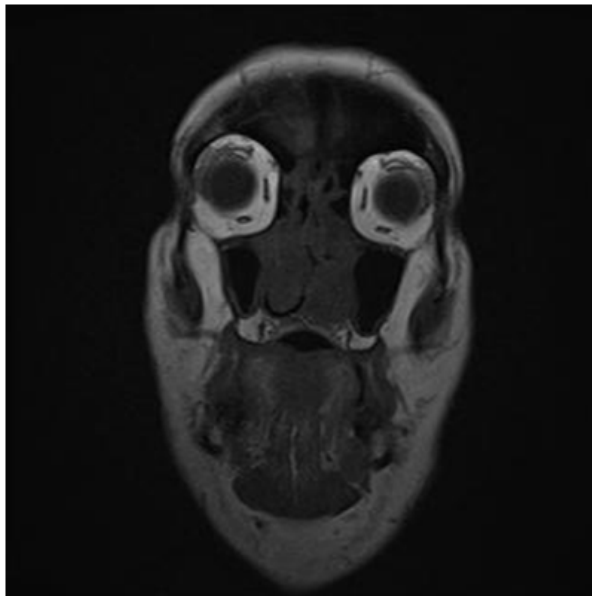


Figure 6: Paranasal sinus MRI Coronal precontrast T1 demonstrating complete loss of aeration in bilateral ethmoid cells and total obliteration of nasal passage on the left and near total obliteration of the nasal passage on the right.

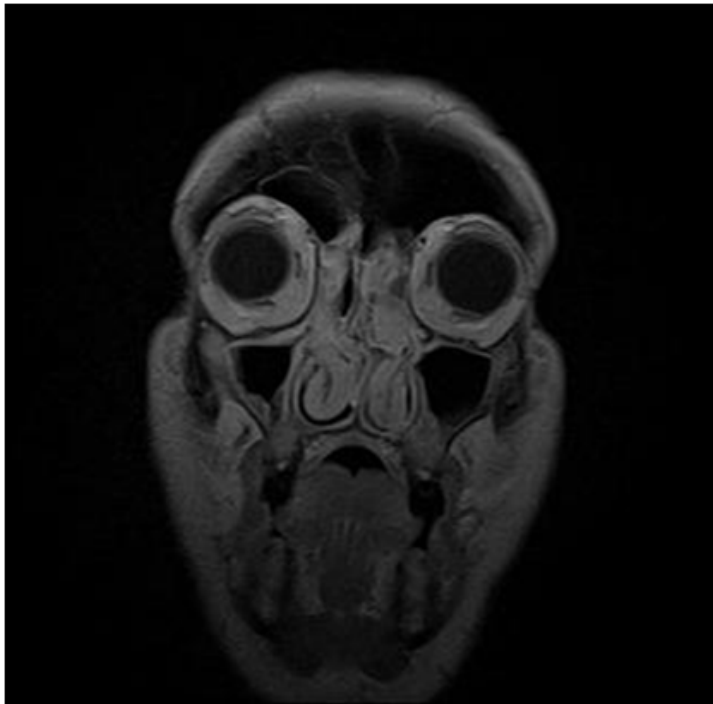


Figure 7: Paranasal sinus MRI Postcontrast Coronal T1 weighted image showing diffuse enhancement of the area causing loss of aeration in ethmoid cells and both nasal passages indicating that polyposis is the problem rather than secretions.

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