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Imaging in Sinonasal Disorders

Heidi Beate Eggesbø

Abstract

Computed tomography (CT) is the “working horse” in sinonasal imaging and should always be the first choice. Magnetic resonance imaging (MRI) is complementary to CT when complications to rhinosinusitis or neoplasm are suspected. Imaging of the paranasal sinuses is common due to stuffy nose. In order to correct interpretation, proper imaging technique as well as knowledge of bony anatomy and variants and mucosal incidental findings are of outmost importance. Acute rhinosinusitis is very common and does not need imaging unless complications are suspected. In chronic rhinosinusitis, a CT examination is needed to find the cause and site of the mucociliary obstruction and to rule out other causes as odontogenic and fungal sinusitis and neoplasms.

Keywords: paranasal sinuses, computed tomography, magnetic resonance imaging, retention cysts, polyps, mucocele, pyocele, rhinosinusitis, odontogenic sinusitis, fungal sinusitis, neoplasms, systemic diseases

1. Introduction

Computed tomography (CT) is the “working horse” in sinonasal imaging and should always be the first choice. Magnetic resonance imaging (MRI) is complementary to CT when complications to rhinosinusitis or neoplasm are suspected.

Imaging of the paranasal sinuses is common due to stuffy nose. In order to correct interpretation, proper imaging technique as well as knowledge of bony anatomy and variants and mucosal incidental findings are of outmost importance.

Imaging should be performed when the stuffy nose and rhinosinusitis do not heal despite medical therapy. Acute rhinosinusitis (ARS) is usually self-limiting, and imaging is only indicated when complications are suspected.

In chronic rhinosinusitis, a CT examination is needed to find the cause and site of the mucociliary obstruction and to rule out other causes as odontogenic and fungal sinusitis and neoplasms.

2. Imaging techniques

Imaging of the paranasal sinuses should always start with CT. CT delineates both bony anatomy and possible sinonasal opacifications.

Odontogenic pathology in the upper jaw often involves the maxillary sinuses. Hence, it is of outmost importance that the upper jaw teeth are included in the image volume and that this area is included in the radiological report [1].

Post-processing of the CT images usually include only reconstruction with bone algorithm in three planes. However, in case of opacification, soft tissue algorithm offers important details of the sinus content [2].

Reconstruction with bone algorithm should be done with slices no thicker than 1 mm. Thin slices are important for evaluation of periapical tooth lucencies as seen in odontogenic sinusitis and for erosion and destruction of bone in case of malignant disorders.

Additional reconstruction with soft tissue algorithm, with 2.5-mm-thick slices, may be extremely valuable and mandatory in case of soft tissue pathology inside or outside the sinus walls. In the case of pyocele or allergic fungal sinusitis, the attenuation usually is higher than mucus [3], and a fungus ball (mycetoma) has typical scattered microcalcifications that are better presented on soft tissue algorithm. In the case of invasive fungal sinusitis, this can be diagnosed by obliteration of the fat planes outside the sinus walls that is best seen on soft tissue algorithm.

Magnetic resonance imaging (MRI) is complementary to CT when complications to infection and neoplasms must be assessed.

Low-dose CT (<20 mAs), without intravenous contrast medium, usually will be sufficient for “screening.” However, if complications or malignant disease are suspected, CT should be performed with at least 50 mAs and with intravenous contrast medium administration.

3. Retention cysts and polyps

Retention cysts, mucinous or serous, are common findings and appear as smooth, convex soft tissue masses from the mucosal lining (**Figure 1a** and **b**) and should not be mistaken as fluid (**Figure 2**). The floor of the maxillary sinus is the most common site for retention cysts.

Mucinous retention cysts are due to obstruction of a mucinous gland, while serous retention cysts are caused by accumulation of fluid in the submucosal layer. Hence, they are not “true” cysts and therefore are also referred to as pseudocysts [4]. Retention cysts have no clinical significance and usually show no significant change in size by time [5].

Odontogenic cysts may mimic retention cysts. However, CT with bone algorithm and thin slices may reveal a tiny, peripheral calcification that will differentiate these from retention cysts (**Figure 3a** and **b**).



Figure 1.
(a) Axial CT shows maxillary sinus retention cyst bilaterally from the posterior wall with dome-shaped appearance with upward convexity. (b) Coronal CT clearly reveals the cystic appearance.



Figure 2.
Axial CT demonstrates bilateral maxillary sinus fluid. In contrast to retention cysts, fluid has upward concavity due to the fluid that settles along the sinus walls.

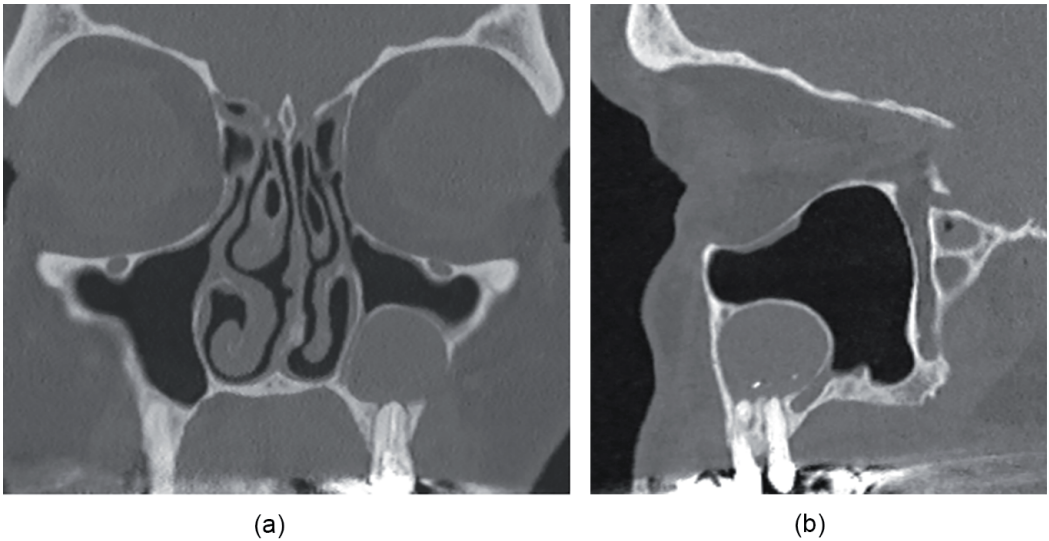


Figure 3.
(a) Coronal CT and (b) sagittal CT show an odontogenic cyst with characteristic peripheral calcification. Odontogenic cysts may persist, despite dental treatment.

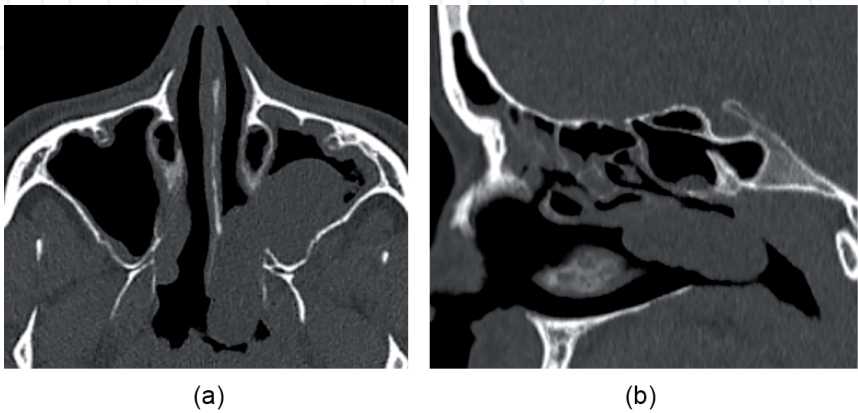


Figure 4.
(a) Coronal CT and (b) sagittal CT reveal a large pseudocyst growing out of the left maxillary sinus into the nasal cavity and choana forming an antrochoanal polyp.

When more fluid is accumulated in the retention cysts, they may grow out of the maxillary sinus through the ethmoid infundibulum or the accessory maxillary ostium into the nasal cavity and choana and then be referred to as an antrochoanal polyp [4] (**Figure 4a and b**).

Pseudocysts are often referred to as a polyp in the radiological report. However, polyps contain more fibrous connective tissue than pseudocyst and tend to be more fibrotic. Hence polyps can surgically be removed intact, but not pseudocysts [4]. Pseudocysts may also rupture spontaneously or traumatically, causing unilateral rhinorrhea [6].

4. Acute rhinosinusitis and complications

Acute rhinosinusitis (ARS), defined as symptoms less than 4 weeks, is the most common disease of the paranasal sinuses. Fluid is often an incidental finding at CT (**Figure 2**) and should not be misinterpreted as ARS. Mucosal thickening and air bubbles in the opacification can be interpreted as ARS, if clinical symptoms harmonize [7] (**Figure 5a and b**).

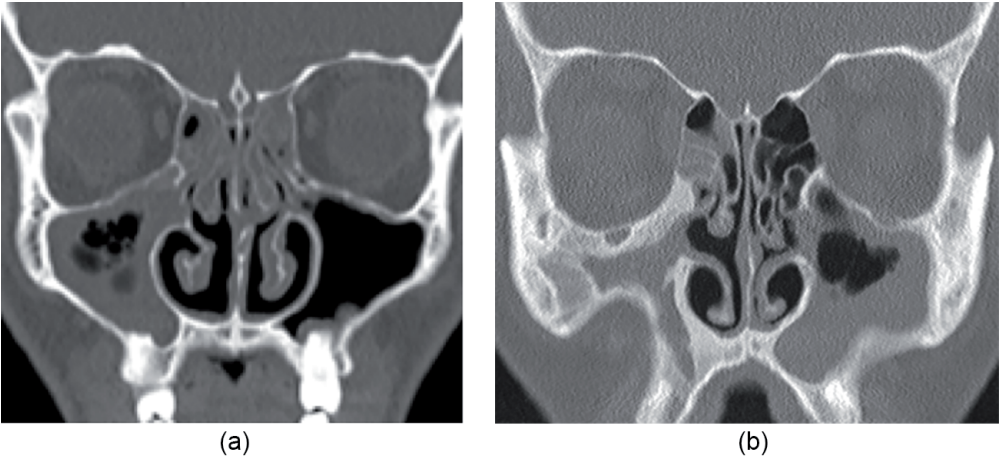


Figure 5.
(a) Coronal CT shows right-sided maxillary opacification with air bubbles consistent with acute rhinosinusitis.
(b) Coronal CT shows thick, sclerotic right maxillary sinus walls that indicate a long-standing infection. In addition, the sinus walls are retracted due to a vacuum effect, referred to as sinus silent syndrome. In the left maxillary sinus, the opacification contains air bubbles consistent with an active bacterial infection.

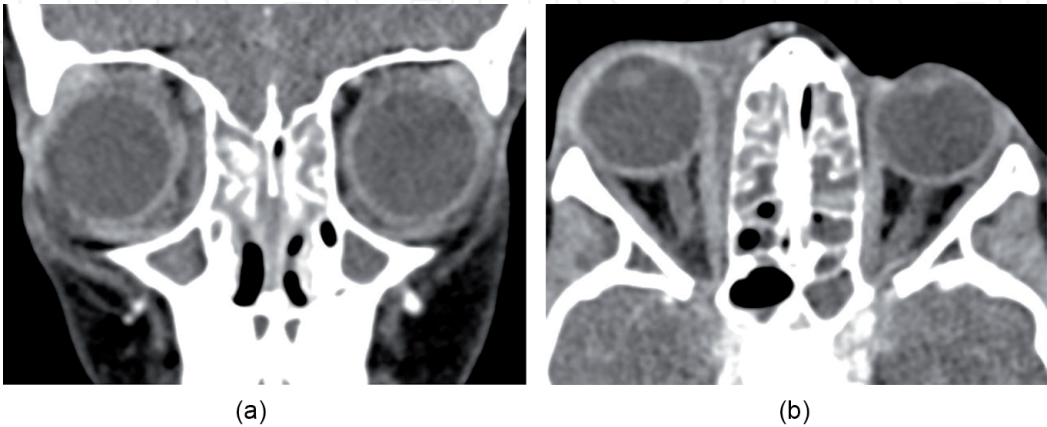


Figure 6.
(a) Coronal and (b) axial CT of a 6-year-old boy with complication to acute rhinosinusitis. The infection has spread through the thin lamina papyracea on the right side, and there is stranding of the fat preseptal and postseptal (intraorbital), consistent with phlegmon. Notice also the marked proptosis of the affected side and slightly lateral displacement of the medial rectus muscle.

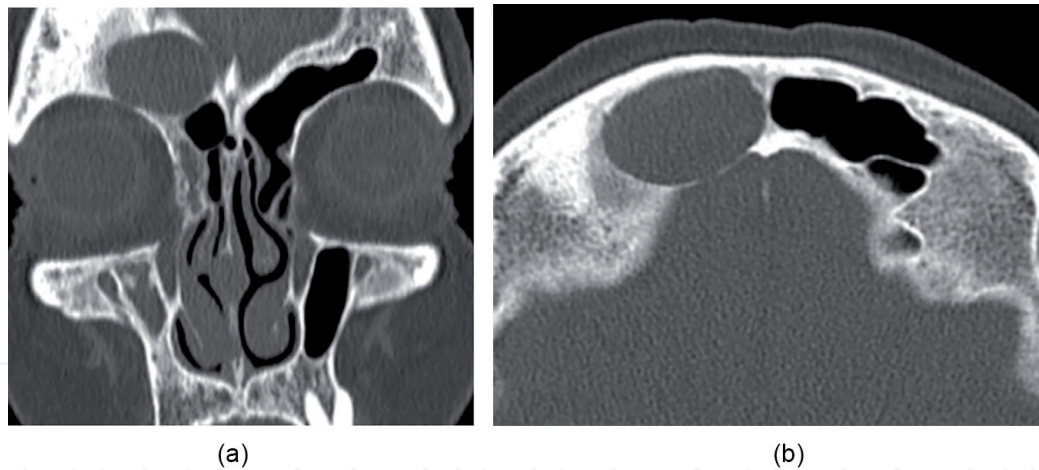


Figure 7.
(a) Coronal CT in a patient with granulomatosis with polyangiitis shows a frontal sinus mucocoele/pyocoele due to obstruction of the frontal recess. By time remodelling of bone may cause erosion into the orbit. (b) Axial CT demonstrates erosion of the posterior sinus wall and risk of intracranial involvement.

In acute rhinosinusitis, imaging is only indicated when complications are suspected. Extra-sinonasal spread of infection is rare but needs urgent treatment. Children are at most risk. Intraorbital spread from ethmoid and frontal ARS is the most common complication and may present as cellulitis, subperiosteal or intraorbital phlegmon and abscess, and lateral displacement of the medial rectus muscle (**Figure 6a** and **b**). The clinical presentation may be forward protrusion of the eyeball, proptosis [8–10].

Intracranial spread is most commonly seen in frontal and ethmoid ARS and presents as complications that include epidural and brain abscesses, subdural empyema, meningitis, and cavernous sinus thrombosis [11].

Mucocoele and pyocoele if not treated may also erode into the orbit and cranial cavity by time (**Figure 7a** and **b**) or erode the anterior frontal bone resulting in a subcutaneous abscess, referred to as Pott's puffy tumor.

A recent study has focused on the intake of ibuprofen in children as a risk factor for developing orbital and intracranial complications of ARS [12].

5. Chronic rhinosinusitis and complications

An underlying odontogenic infection is reported to be the cause in up to 40% of chronic rhinosinusitis (CRS). In addition, several other conditions may mimic rhinosinusitis and challenge the radiological interpretation.

Five distinct radiological inflammatory patterns have been described, each with a different therapeutic course and surgical options [13], where the first three are caused by obstruction of the mucociliary flow. Obstruction of the maxillary sinus drainage is the most common. The level of obstruction is at the ostium and the thin ethmoid infundibulum and referred to as infundibular pattern. Obstruction of the middle meatus, the common drainage way for the frontal, anterior ethmoid, and maxillary sinuses, will cause obstruction of ipsilateral sinuses and is referred to as ostiomeatal (from ostium and meatus) complex (OMC) pattern. Less common is obstruction of the sphenoethmoidal recess that drains the posterior ethmoid and sphenoid sinuses. The two last patterns are sinonasal polyposis and incidental findings.

Surgical intervention of mucociliary obstruction is referred to as functional endoscopic sinus surgery (FESS). Functional refers to the widening of the natural ostia. For the infundibular and OMC inflammatory pattern, FESS includes uncinectomy (removing the uncinate process), opening the ethmoid infundibulum, and making a larger opening to the antrum (maxillary sinus) referred to as media-antrostomy.

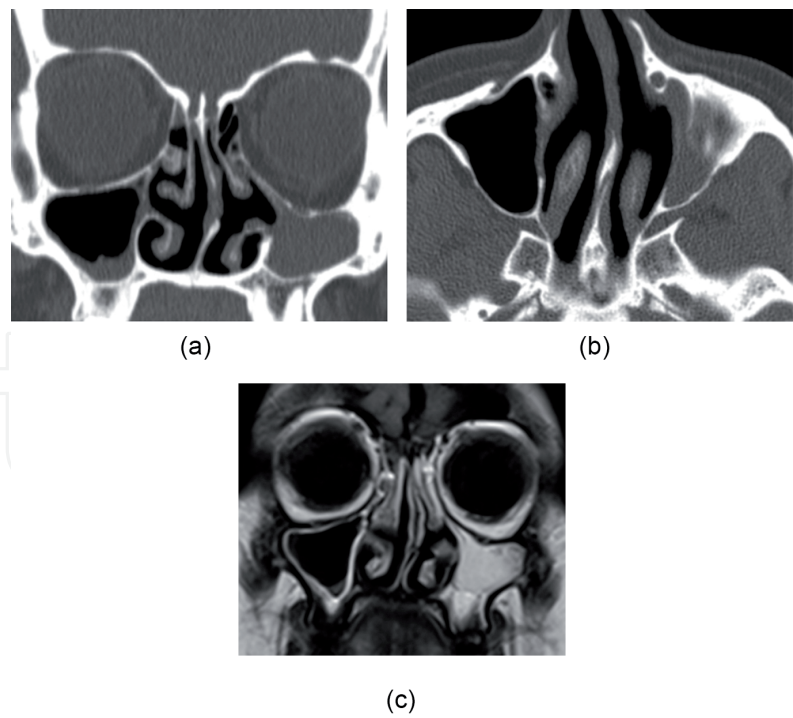


Figure 8.
(a) Coronal CT and (b) axial CT demonstrate a left-sided hypoplastic maxillary sinus with a retracted posterior fontanelle (lateral nasal wall) that mimic chronic rhinosinusitis. (c) On coronal MRI with T2 sequence, the sinus content is equal to mucus. There is no bowing of the sinus walls as typical for mucocoele.

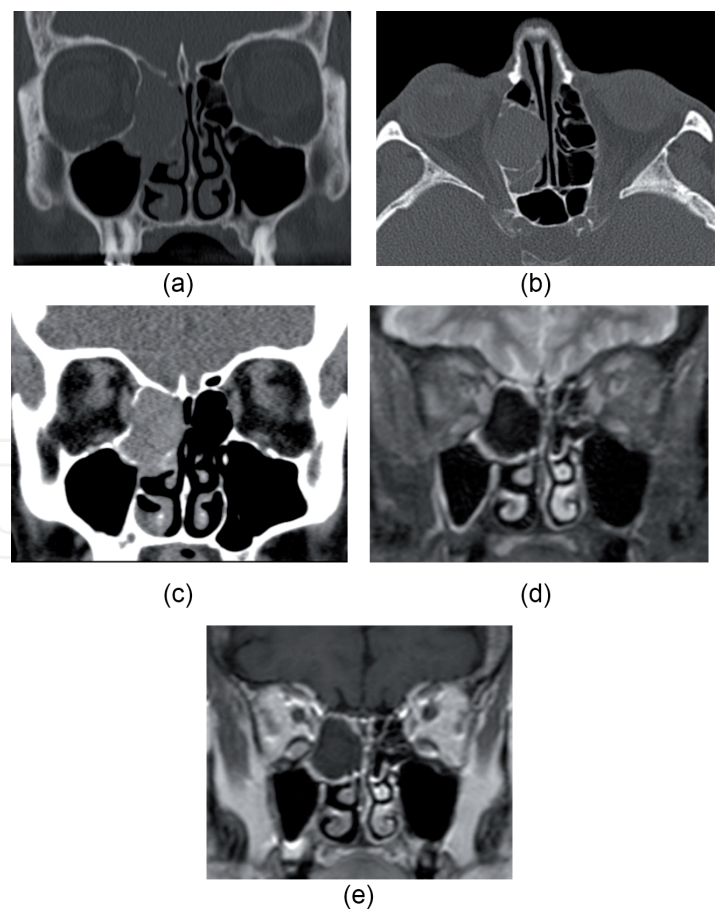


Figure 9.
(a) Coronal CT and (b) axial CT with bone algorithm and (b) with soft tissue algorithm demonstrate a pyocoele (superinfected mucocoele). (c) Coronal CT with soft tissue algorithm shows high attenuation more characteristic for a pyocoele than a mucocoele. (d) Coronal MRI T2 with fat suppression shows characteristic signal void of the pyocoele. (e) Coronal MRI T1 with gadolinium shows contrast medium enhancement only in the peripheral mucosal lining.

Sometimes ethmoidectomy also is performed during FESS. Therefore, the course of the anterior ethmoid artery should be included in the radiological report.

Complications to CRS are bone thickening (sclerosis, osteitis, neo-osteogenesis), demineralization and erosion of bone, and a negative sinus pressure that can cause infoldings of the sinus walls, referred to as silent sinus syndrome (**Figure 5b**), which may result in larger orbit and cause enophthalmos and diplopia.

Hypoplastic maxillary sinus with retracted posterior fontanelle (**Figure 8a–c**) may mimic silent sinus syndrome but usually has no clinical impact despite the mucus-filled sinus (**Figure 8c**).

In addition, retracted posterior fontanelle should not be confused with a mucocoele that remodels and expands the sinus. A bacterial superinfection of a mucocoele will result in a pyocoele. A pyocoele has characteristic CT and MR findings compared to a mucocoele (**Figure 9a–e**).

6. Odontogenic sinusitis

Odontogenic sinusitis should be suspected when maxillary sinusitis does not heal [14, 15]. This is especially in the case of unilateral CRS (**Figure 10a and b**), but odontogenic infection may also be the source of bilateral CRS. Before referring to FESS, due to maxillary sinus opacification, odontogenic maxillary sinusitis must be ruled out. FESS in odontogenic cases may induce more inflammation and osteitis [1]. Odontogenic sinusitis and sinonasal complications of dental disease or treatment represent a heterogeneous group of conditions that often require multidisciplinary care [17].

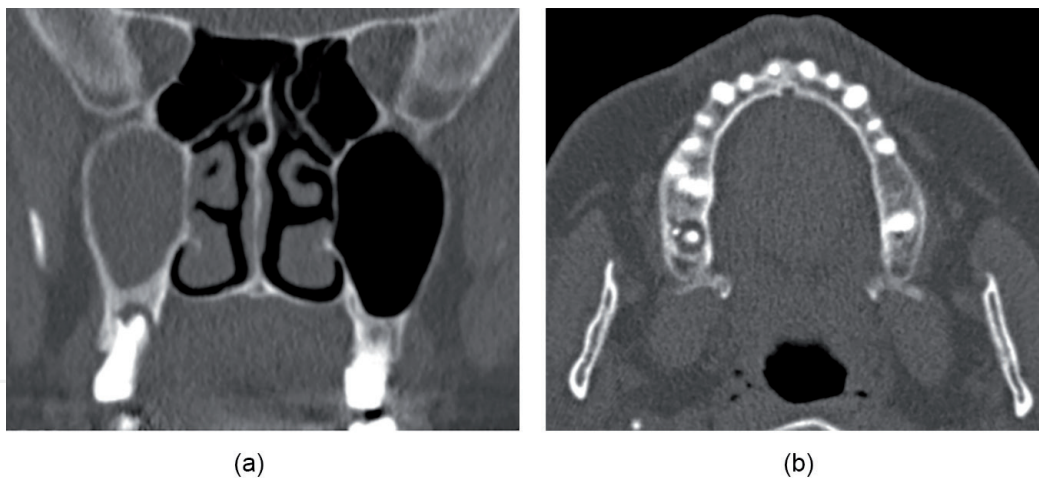


Figure 10.
(a) Coronal CT and (b) axial CT reveal periapical lucency around a molar tooth [16] consistent with odontogenic infection as the cause of sinusitis. The sclerotic maxillary sinus walls indicate a long-standing infection.

7. Fungal sinusitis

Fungal sinusitis can be noninvasive, which includes fungus ball (mycetoma) (**Figure 11a–c**) and allergic fungal sinusitis (**Figure 12a–d**), or invasive with an acute, chronic, or granulomatous course [16].

Invasive fungal sinusitis is revealed by fungal deposits outside the sinus walls that obliterate the fat plane. The sinus wall usually is sclerotic and intact, and the spread of fungus is by the vessels through the bone (**Figure 13a–d**). Demineralization and erosion of the lateral nasal wall is usually seen when the maxillary sinus is involved. Invasive fungal sinusitis is most common in immunocompromised patients.

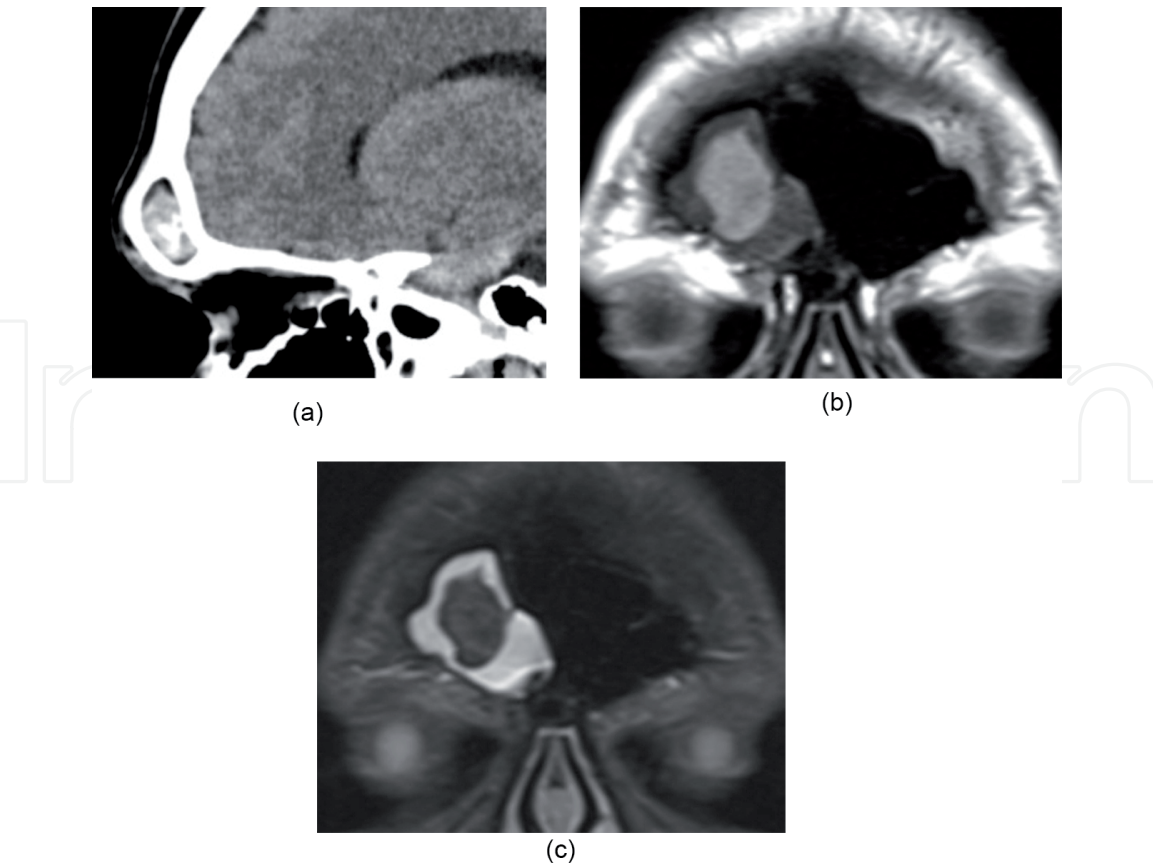


Figure 11.
(a) Sagittal CT shows scattered calcifications in the frontal sinus opacification consistent with a fungus ball (mycetoma). (b) Coronal MRI T1 shows the central fungus ball as high signal surrounded by low signal from edematous thickened mucosal lining, while (c) coronal MRI T2 shows fungus ball with low signal, surrounded by high signal mucosal lining. The low signal is explained by the iron and manganese contents in the fungi.

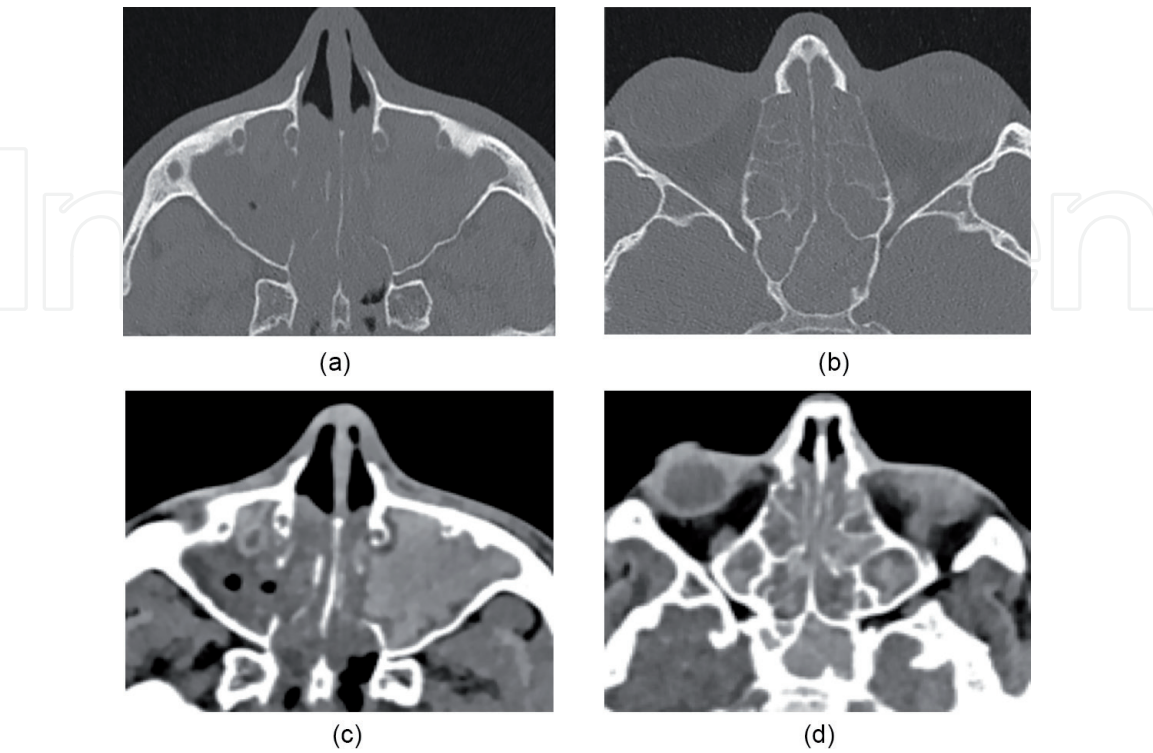


Figure 12.
Axial CT at the level of the (a) maxillary and (b) ethmoid sinuses shows panopacification. Reconstruction, with soft tissue algorithm (c) and (d), shows high attenuation in all sinuses, which is typical for allergic fungal sinusitis. Slightly thickened, sclerotic sinus walls indicate a long-standing condition.

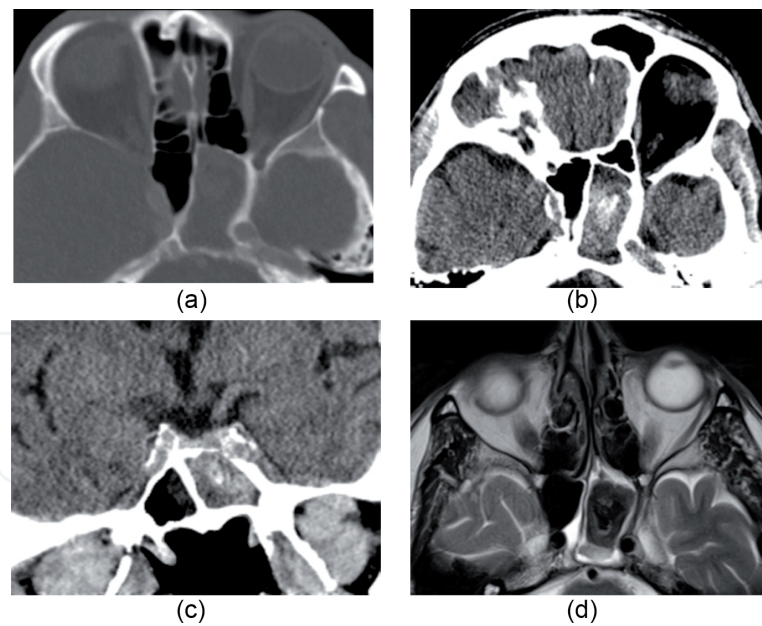


Figure 13.
A 53-year-old man, who presented with diplopia. (a) Axial CT with bone algorithm was reported as chronic sphenoid sinusitis. The patient did not improve on antibiotic treatment. (b) A new examination with cerebral CT and reconstruction with soft tissue algorithm revealed scattered calcifications in the opacification and (c) erosion of the thickened, sclerotic bone, consistent with invasive fungal infection to the cavernous sinus and hence possible affection of the cranial nerves 3, 4, 5, and 6 that pass through the cavernous sinus. (d) Axial MRI with T2 sequence shows fungi with low signal surrounded by mucosal lining with high signal.

8. Systemic diseases

Several systemic diseases have sinonasal manifestations [18]. One of these is granulomatosis with polyangiitis (GPA) (formerly Wegener’s granulomatosis), with a prevalence of 10–25/100,000. Age group mostly affected is 50–70 years. Oral and sinonasal manifestations are seen in 85%.

Both extensive bone osteoneogenesis (osteitis) and destructions seen in GPA imaging are used to assess disease activity even though little is known about CT or

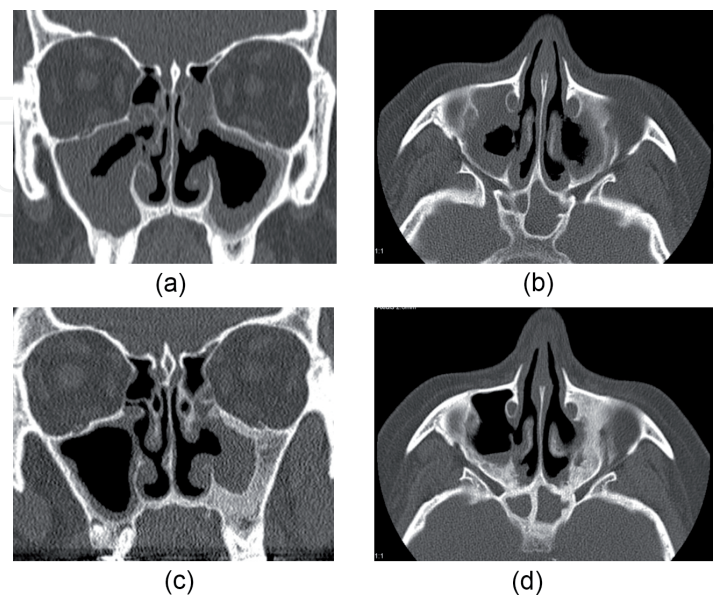


Figure 14.
(a) Coronal CT and (b) axial CT in granulomatosis with polyangiitis show status after bilateral endoscopic sinus surgery (media-antrostomy). The bone is thickened due to chronic osteitis. Notice small peripheral rim of osteoneogenesis along the lining of the left maxillary sinus. (c) Coronal CT and (d) axial CT, follow-up CT 5 years later, demonstrate extensive bilateral osteitis of the maxillary and sphenoid sinuses. Notice also the small periapical lucencies around the roots of the right upper molar, often seen in patients with granulomatosis with polyangiitis.

MRI findings that may indicate poor prognosis [19]. Sinonasal surgery in GPA is debated [20] and may cause increased osteoneogenesis (**Figure 14a–c**).

9. Neoplasms

Osteoma is one of the most common benign neoplasms in the paranasal sinuses (**Figure 15a and b**), followed by fibrous dysplasia (**Figure 16a–c**) and inverted papillomas (IP) (**Figure 17a–c**).

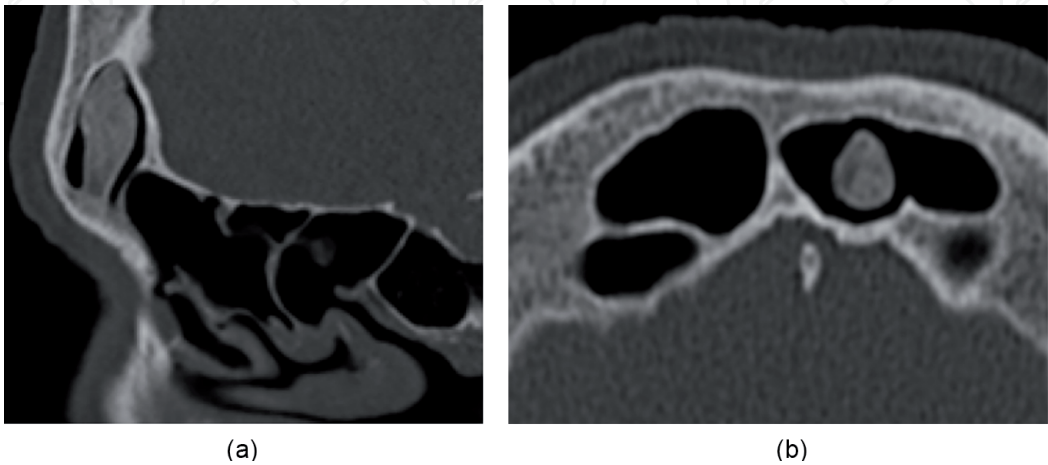


Figure 15.
(a) Sagittal and (b) axial CT of an osteoma in the frontal sinus. Unless obstruction of the mucociliary drainage, osteomas have no clinical impact.

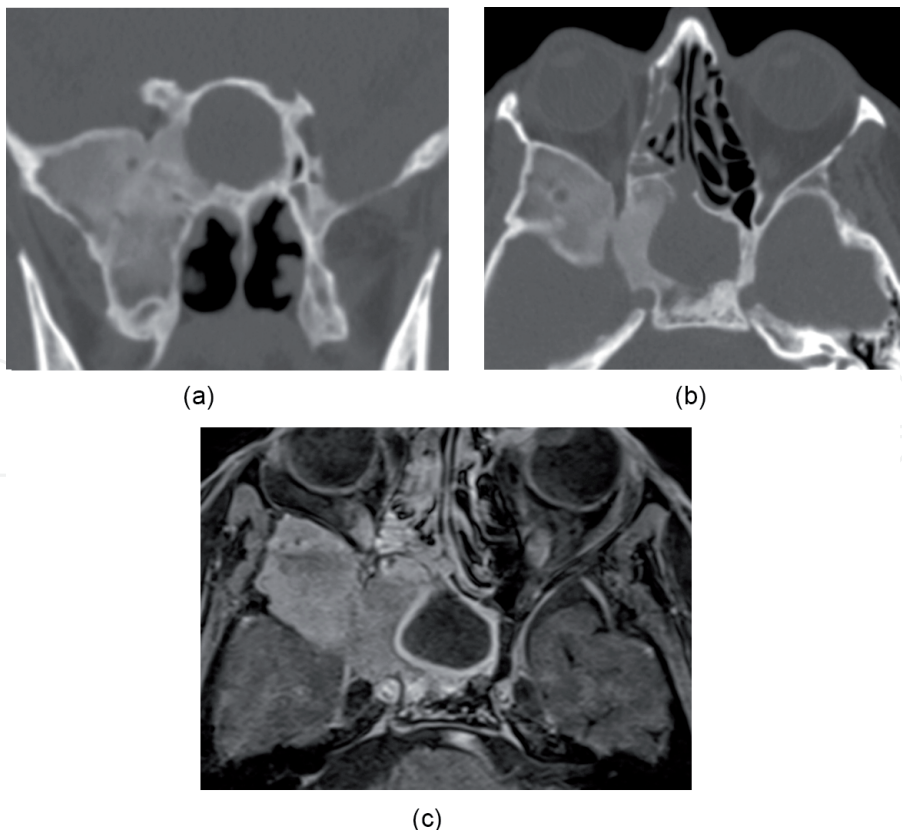


Figure 16.
(a) Coronal CT and (b) axial CT demonstrate fibrous dysplasia, in the right sphenoid bone. The bone has characteristic “ground glass” appearance and encircles the foramen rotundum and the Vidian canal. In addition, the sphenoethmoid recess is obstructed and mucus entrapped in the right sphenoid sinus, with bowing of the sinus walls typical for mucocoele and pyocoele. (c) Axial MRI with T1 with gadolinium shows contrast medium enhancement limited to the mucosal lining. The low signal in the sinus is consistent with a mucocoele.

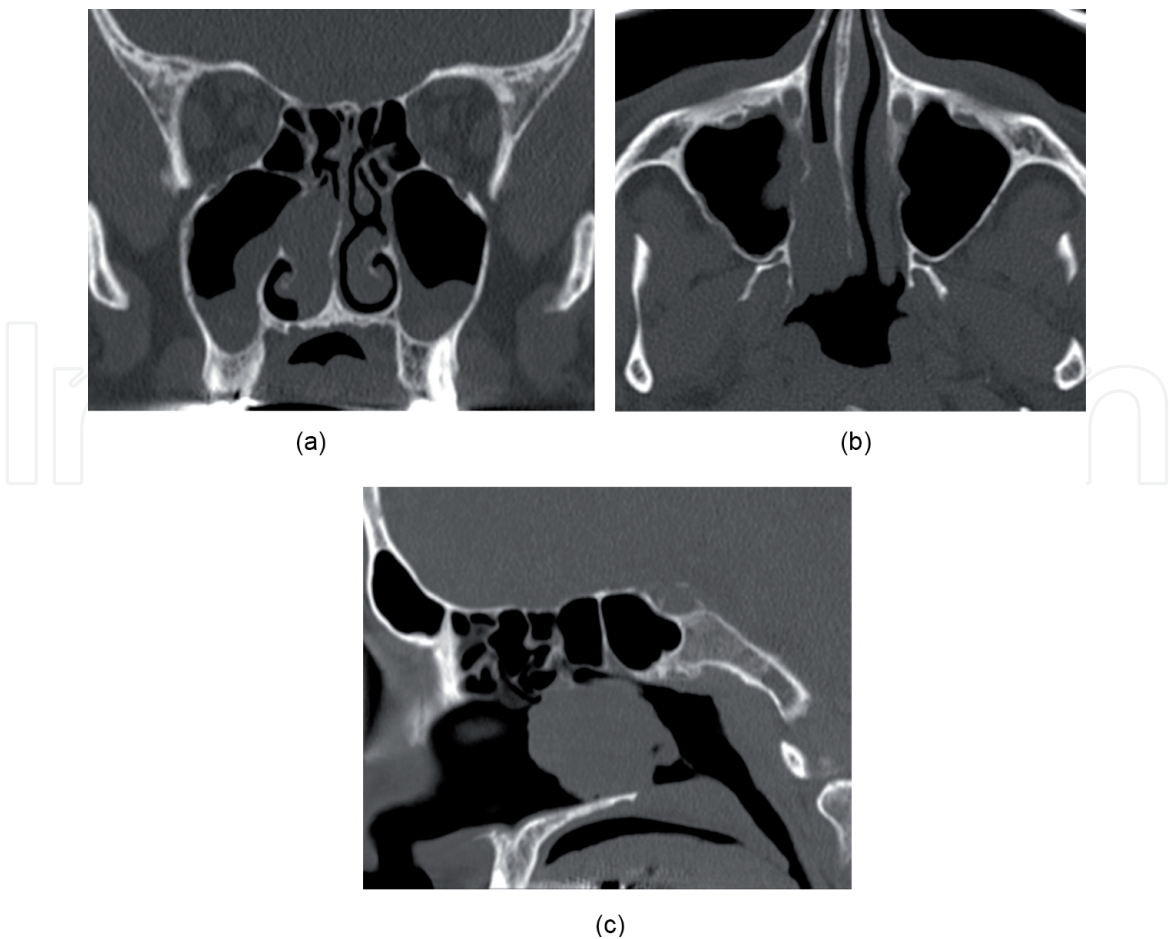


Figure 17.
(a) Coronal, (b) axial, and (c) sagittal CT of an inverted papilloma originating from the ethmoid sinus and filling the middle part of the nasal cavity and choana. The site of origin often shows hyperkeratosis. In this case the origin could be from beneath the ethmoid cells that shows slight keratosis at the sagittal CT.



Figure 18.
(a) Coronal CT shows a tiny polyp in the right nasal cavity. Histopathology revealed olfactory neuroblastoma. (b) Coronal CT shows a polyp in the left nasal cavity, where histology revealed acinic cell carcinoma, which is a malignant salivary gland tumor. Malignancy in solitary polyps in the nasal cavity must always be ruled out.

IP is reported to be up to 5% of sinonasal tumors. Age group affected is 40–70 years, with a male preponderance. IP derives from the respiratory mucosa. The characteristic growth pattern with mucosal infoldings into the stroma is the origin to the name inverted. In most cases IP originates from the ethmoid sinuses and middle meatus [21]. Etiology is not confirmed, but a viral infection has been postulated as a cause [22].

Though initially benign, the recurrence rate is up to 25%, and malignant transformation is common, especially in smokers.

IP may display characteristic hyperkeratosis at CT from where the IP origin in the sinus wall. Radiological reporting of the attachment site is important for complete surgical resection [23] (**Figure 17a–c**).

Malignant sinonasal tumors are rare, and squamous cell carcinomas are the most common (80%). Rarer malignant sinonasal neoplasms are adenocarcinoma, olfactory neuroblastoma (**Figure 18a**), salivary gland tumors (**Figure 18b**), chondrosarcoma, B- and T-cell lymphoma, and mucosal malignant melanoma.

Juvenile nasopharyngeal angiofibroma is a benign tumor in adolescent males that arises from testosterone-sensitive cells in the pterygoid plates [24].

10. Conclusion

Imaging of sinonasal disorders shows a wide specter of diseases. However, the most common cause to unilateral CRS is odontogenic infection.

Odontogenic infection, pyocele, and fungal sinusitis are very often not in the list of the radiologist's differential diagnoses and often due to wrong CT imaging technique.

Sinonasal malignancy is rare but should always be in mind, especially in unilateral disease.

Conflict of interest

The author declares no conflict of interest.

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