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Diagnostic imaging of fungal sinusitis: Eleven new cases and literature review*

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SUMMARY

Fungal sinusitis should always be considered in the differential diagnosis of chronic or recurring sinusitis resistant to adequate medical treatment. A high index of suspicion is necessary for the diagnosis, and the clinical examination is rarely conclusive. The definitive diagnosis depends on the pathologist in most cases. We reviewed retrospectively the imaging findings, specifically computed tomography (CT) and magnetic resonance (MR), in a series of fungal sinusitis patients. Non-enhanced CT scan is more sensitive than conventional X-ray in detecting the classical focal areas of hyper-attenuation and calcification seen in soft-tissue masses of fungal sinusitis. MR findings of hypo-intense signals on T_1-weighted sequences which progress to signal-void area on T_2-weighted sequences, are characteristic features of fungal sinusitis; however, it is reserved for cases where intracranial invasion is suspected or CT findings are inconclusive.

Key words: fungal sinusitis, diagnostic imaging, chronic sinusitis

INTRODUCTION

Fungal sinusitis can be classified into four distinct entities: (1) allergic fungal sinusitis (Ence et al., 1990; Allphin et al., 1991), formerly called allergic *Aspergillus* sinusitis by Katzenstein et al. (1983); (2) indolent, slowly-progressive invasive disease; (3) non-invasive local disease or aspergilloma (Bassiouny, 1982); (4) fulminant soft-tissue invasion in immunocompromized host (McGill et al., 1980). Variable factors - including the immune status of the host, the mass of fungi present, and the local sinonasal environment - predispose toward the development of a particular entity (Corey et al., 1990). Endoscopic investigations have shown that anatomical variants narrow the ethmoidal pre-chambers and predispose to recurring or chronic sinus infections and that most of the mycoses grew on stagnant mucus as a result of poor ventilation, decreased mucociliary activity, and bacterial or viral superinfection (Stammberger, 1985).

Fungal sinusitis should always be considered in the differential diagnosis of chronic or recurring sinusitis resistant to adequate medical treatment (Chapnik et al., 1976). A high index of suspicion is necessary for the diagnosis and clinical examination alone is rarely conclusive. Imaging diagnosis, especially computed tomography (CT) and magnetic resonance imaging (MR), can help in defining fungal infections of the paranasal sinuses (Zinreich et al., 1988). Culture and histological examination of suspected tissues are necessary for the definitive diagnosis (Morgan et al., 1984; Hartwick et al., 1991).

The conventional treatment of the non-invasive local disease is surgical removal of the mycotic masses, with restoration of mucociliary drainage and sinus ventilation (Stammberger, 1985). Allergic fungal sinusitis also requires the use of systemic steroids (Ence et al., 1990). Fulminant fungal sinusitis requires surgical debridement and anti-fungal therapy (McGill et al., 1980), but unfortunately in many patients is refractory to any form of therapy. In this paper we review 11 new cases of fungal sinusitis with emphasis on the imaging findings, including CT and MR. The usual CT scan and MR findings for the non-invasive diagnosis of fungal sinusitis are discussed in detail.

PATIENTS AND METHODS

We reviewed retrospectively the files and films of 11 patients with fungal sinusitis diagnosed at St. Joseph's Health Center and Mount Sinai Hospital in the past four years. All patients underwent surgery and the diagnosis of fungal sinusitis was confirmed with culture and histology.

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All patients had CT scans done on either a Siemens Somatron DR3 scanner or Elscint Exel 2400. The coronal plane was selected in order to display the images in the same anatomical plane as that encountered during endoscopic surgery, and to afford optimal demonstration of the anterior ethmoid and ostiomeatal structures. The patients were examined in the prone or supine position with the head extended. The CT scans were done without intravenous contrast. The gantry was angulated perpendicular to the infra-orbital line. Two 4-mm slices were performed from the posterior margin of the sphenoidal sinus to the anterior margin of the frontal sinus. In general, the CT scans were viewed with a wide window-setting of 2,000, centered around -250 or -200 for assessing bony details. For soft-tissue details, a narrow window of 300 to 350 centred at +30 was used. Four patients had MR done on a Phillips 1.5-Tesla MR unit. MR scans were taken in the axial, sagittal, and coronal planes. T_1-weighted and T_2-weighted sequences were done. Gadolinium-enhanced T_1-weighted sequences were done in two patients.

RESULTS

The age, sex, medical history, nasal endoscopy, and plain X-ray findings are listed in Table 1. All patients in this series had the chronic form of fungal sinusitis, mainly the indolent slowly-progressive form. None of our patients had any systemic predisposing factors. The only significant contributing factor were ostiomeatal complex dysfunction with recurrent or chronic sinusitis.

Table 2 describes the CT findings and the micro-organisms. *Aspergillus* was the agent in the majority of the patients. The non-enhanced CT scan almost always demonstrated areas of focal hyper-attenuation (Figure 1). Reactive osteitis and ostiomeatal complex disease was present in almost all patients. Bone erosion was seen predominantly on the lateral nasal wall. Remodelling of the bony walls with expansion of the maxillary sinus cavity was also noted.

Table 3 describes the MR findings. On three of the four patients who also had MR done, the T_1-weighted images demonstrated heterogeneous or hypo-intense (dark) intensity masses. The proton-density-weighted MR scan demonstrated the hypo-intense areas to remain of low signal intensity. The T_2-weighted images showed even further loss of signal with signal-void areas (Figures 2A–D). The gadolinium-enhanced images helped to exclude recurrent fungal infection in one patient.

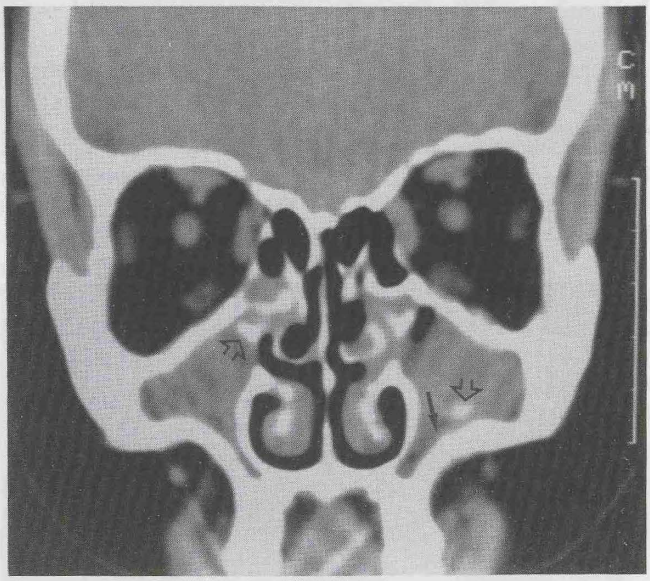

Figure 1. Non-enhanced CT scan: Focal areas of calcification (open arrows) in both maxillary sinus which show sinusitis and reactive osteitis (arrow). Note that the ostiomeatal complex is compromized bilaterally.

Table 1. Findings in 11 patients with fungal sinusitis.

sex, age	history	nasal endoscopy	conventional X-ray
F, 52	postnasal drip, allergic rhinitis	polypoid degeneration anterior end MT	mucosal thickening MS
M, 34 *Figure 3A	headaches, chronic sinusitis, nasal polyposis, allergic rhinitis	septal spur into (R) MM, (L) MM polyps	opacification of the (L) MS antrum
F,23	watery rhinorrhoea, nasal obstruction, recurring sinus infections	allergic mucosa swollen (L) MT, deviated NS	opacification (L) MS
F, 24	nasal obstruction	dark brown mass in the nasopharynx and floor of the (L) nasal cavity	opacification (L) MS and (L) ES, soft tissue mass in the cavum
F, 25	(L) FS chronic sinusitis	wide MT, polyps (L) MM	-
F, 57	nasal obstruction, postnasal drip	(R) MM polyp	(R) MS and (R) ES opacification
M, 51	chronic sinusitis, nasal polyps	polyps (L) MM	opacification both MS, ES
M, 40	nasal obstruction, foul-tasting and smelling discharge	deviated NS, nasal polyp (L) MM	(L) MS opacification
M, 74	chronic sinusitis, nasal polyps	polyps (MM) both sides	mucosal thickening both MS, no air-fluid levels
M, 59	headaches, postnasal drip	wide (L) MT with MM dark mass	(R) and (L) MS, ES opacification
M, 30	nasal obstruction, postnasal drip, allergy, frontal headaches	bilateral polyps arising from the MM	opacification both MS, ES

MS: maxillary sinus; ES: ethmoidal sinus; FS: frontal sinus; MM: middle meatus; NS: nasal septum; MT: middle turbinate; (R): right; (L): left.

Table 2. Micro-organisms and CT scan findings.

sex, age	CT scan findings	micro-organisms
F, 52	pan-sinusitis; large chunky Ca^{++} (L) MS lumen; air fluid level (L) concha bullosa; obstructed OMC; reactive osteitis	*Aspergillus* ssp.
M, 34 *Figure 3B	curvilinear Ca^{++} (calcific type densities) in the (L) MS which shows reactive osteitis: Ca^{++} in OMC; large CB with inflammatory changes	mucormycosis
F, 23	increased attenuation mass in (L) MS surrounded by fluid; dystrophic Ca^{++} in MM and ethmoid; pan-sinusitis with reactive osteitis; large EB, PMT; bilateral IT hypertrophy	*Aspergillus* ssp.
F, 24	large soft tissue mass in the (L) nasal cavity and nasopharynx with focal area of increased attenuation; smooth remodelling of the MS lumen with expansion is noted	*Aspergillus* ssp.
F, 25	dystrophic calcifications (L) MS and MM	actinomycosis
F, 57	large antrochoanal mass with areas of speckled Ca^{++} ; destruction of the lateral nasal wall; remodelling of MS wall with reactive osteitis	mucormycosis
M, 51	amorphous Ca^{++} in the (L) MS; antrochoanal polyp; reactive osteitis	mucormycosis
M, 40 *Figure 1	reactive osteitis; bilateral pan-sinusitis; dystrophic Ca^{++} MS and OMC	*Aspergillus* ssp.
M, 74	Ca^{++} seen in the (L) MS; thickened MS mucosa; medially-bent uncinate process; large polypoidal mass (R) ES	*Aspergillus* ssp.
M, 59	linear amorphous Ca^{++} in the (R) MS; thickened bony wall; chunk of Ca^{++} (L) nasal cavity medial to the inferior turbinate; large fungal concretion in (L) MM	*Aspergillus* ssp.
M, 30	pan-sinusitis; MS medial wall destroyed	*Aspergillus* ssp.

MS: maxillary sinus; ES: ethmoidal sinus; FS: frontal sinus; MM: middle meatus; NS: nasal septum; MT: middle turbinate; (R): right; (L): left; CB: concha bullosa; OMC: ostiomeatal complex; EB: ethmoid bulla; PMT: paradoxically bent middle turbinate; FR: frontal recess; UP: uncinate process; IT: inferior turbinate.

Table 3. MR findings.

sex, age	T_1-weighted images	PD-weighted images	T_2-weighted images	gadolinium
F, 52 *Figures 2A-D	heterogeneous signal intensities with area of signal void in the (L) MS; the contents of MS cavity hypo-intenses bilaterally	poorly delineated fungus balls bilaterally with signal void areas in both MS surrounded by inflamed mucosa	large fungus balls in both MS with signal void areas surrounded by inflammatory mucosa	enhancement of the inflamed sinus mucosa outlining the hypo-intense fungus ball in the sinus bilateral
M, 34 *Figures 4A-C	large fungus ball iso-intense with brain and focal areas of signal void	significant loss of signal intensity in the fungus ball	inflamed mucosa surrounding a large fungus ball which shows several scattered areas of signal loss	-
F, 23	hyperintense fungus mass with some heterogeneity surrounded by fluid	the well defined focus in the fungus ball to be hypo-intense; the remaining mass is iso-intense with the brain	inflamed hyperintense mucosa around the fungus ball	-
M, 30	masses iso-intense with brain	iso-intense masses	hyperintense masses	polypoidal mass with minimal enhancement of mucosa. No classical fungal infection seen

Hyperintense: bright on comparison to muscles or brain; hypo-intense: dark; isointense: with CSF; heterogeneous: variation of several signals intensities; signal void: black areas (bone, air, Ca^{++} or heavy metals); (L): left; MS: maxillary sinus; PD: proton density.

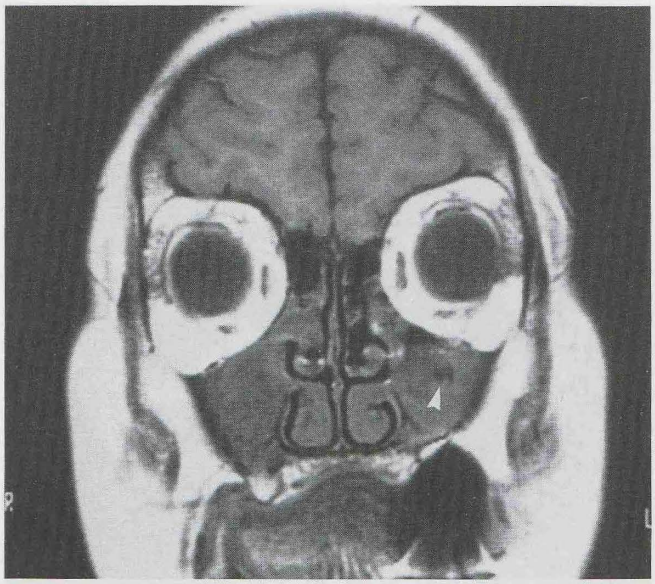

Figure 2A. T_1-weighted image: Heterogeneous signal intensities intermediate with areas of signal void in both maxillary sinuses. These areas are more easily seen in the left maxillary sinus (arrowhead).

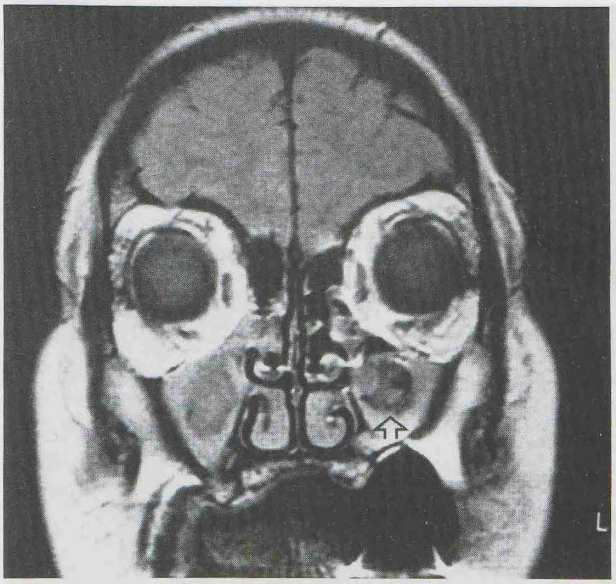

Figure 2B. Proton-density image: The mass of fungus ball appears larger with a large signal-void area representing the fungus (open arrow).

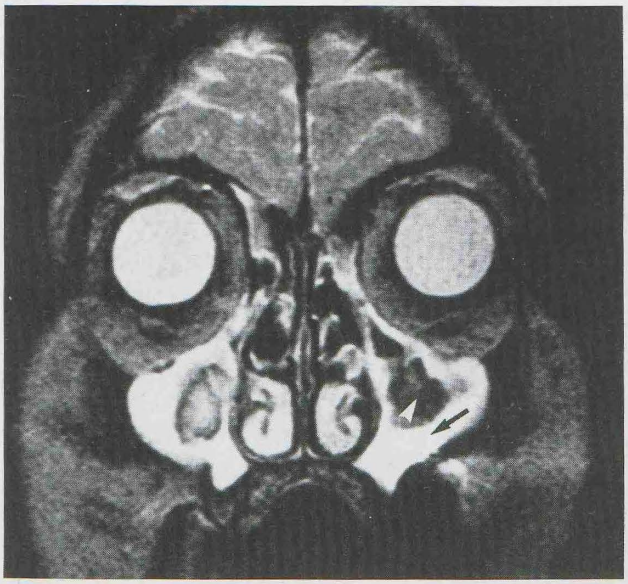

Figure 2C. T_2-weighted image: Large fungus balls on both maxillary sinuses with signal-void areas (arrowhead) surrounded by inflammatory mucosa (arrow).

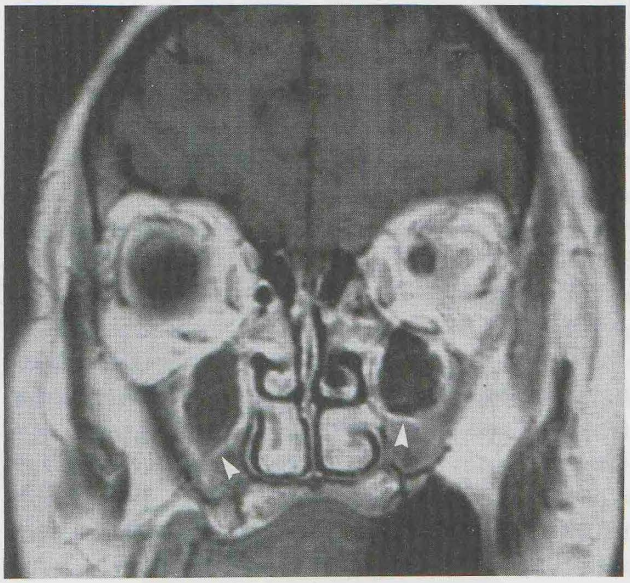

Figure 2D. The gadolinium-enhanced T_1-weighted MR scan shows clearly a rim of enhancement surrounding the fungus ball bilaterally (arrowheads).

DISCUSSION

The diagnosis of fungal sinusitis is not always possible until the surgical or pathological specimen is examined. The clinical picture of fungal sinusitis is quite non-specific. A high index of suspicion is required for the diagnosis, especially in immunocompetent patients with recurring or chronic sinus infections refractory to conventional medical treatment (Morgan et al., 1984).

The patients in our study had clinical symptoms/signs similar to non-specific, non-fungal sinusitis. Most of these patients had chronic recurring sinusitis and there were no classic endoscopic findings to suggest fungal disease. None of our patients were immunocompromized and the diagnosis was not suspected by the clinical picture and conventional X-rays. The suspicion of fungal infection was raised on CT scan findings. The MR findings in three patients were also highly suggestive of fungal sinus disease.

The fact that healthy subjects can develop fungal sinus infections indicates the influence of local predisposing factors in the origin of the disease (Stammberger, 1985). During nasal endoscopy and at functional endoscopic nasal surgery significant ostiomeatal complex disease was demonstrated in our patients. *Aspergillus* species were isolated in the majority. Two patients had the non-invasive form attributed to mucormycosis. This suggests that the aggressiveness of the disease depends on more than only the virulence of the organism (McGill et al., 1980; Zieske et al., 1991).

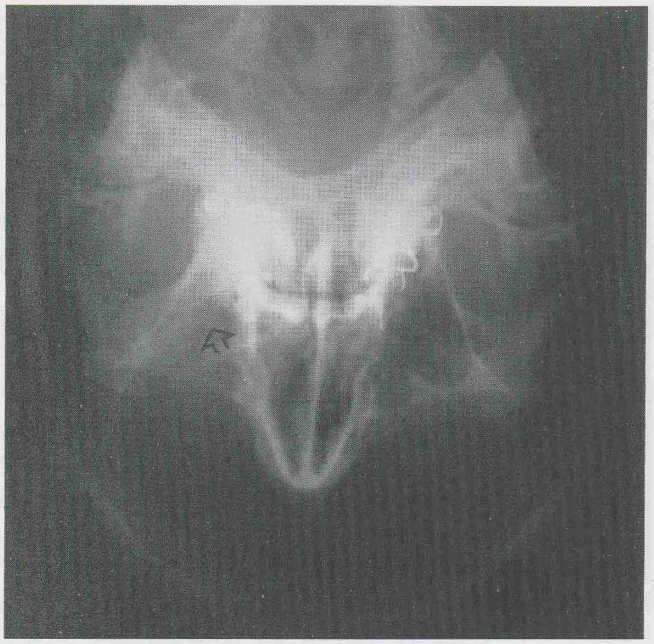

Figure 3A. Conventional X-ray showing thickened mucosa and opacification of the left maxillary sinus (open arrow).

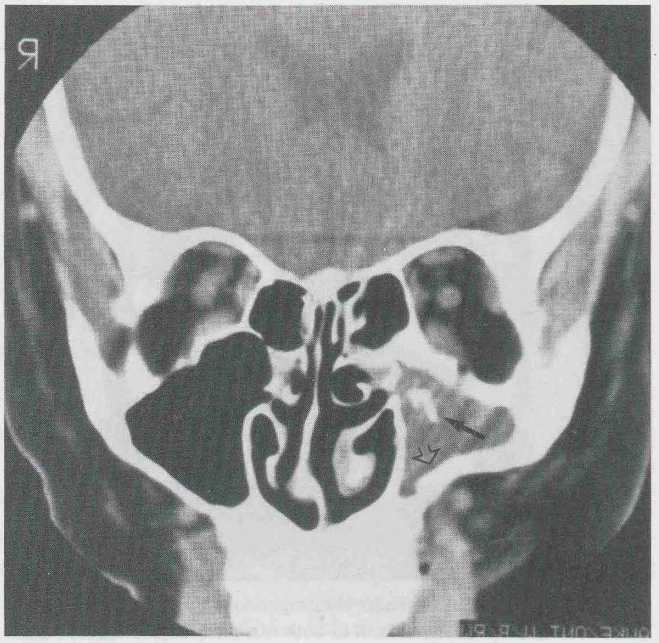

Figure 3B. Non-enhanced CT scan on the same patient of Figure 3A demonstrates focal area of calcification (arrow) in the left maxillary sinus, which shows sinusitis and reactive osteitis (open arrow).

The findings of nodular mucoperiostal thickening with focal areas of calcification on plain radiographs or conventional tomography should raise the suspicion of fungal involvement of the paranasal sinuses (Stammberger et al., 1984; Kopp et al., 1985), but these findings were not observed in our patients (Figures 3A–B). Areas of focal hyper-attenuation noted on paranasal sinuses masses were formerly related to the presence of heavy metals and calcium in the fungal mass. These areas are more readily detected by non-enhanced CT scan (Figures 1 and 3B), but the hyper-attenuation is not pathognomic of fungal infections (Zinreich et al., 1988).

It is also seen in the presence of thick pus, desiccated secretions, thrombus, intrasinus haemorrhage, foreign bodies, bony tumours surrounded by inflammation, and in reaction to sarcomas. Dystrophic calcification as seen in fungal sinusitis is also seen in inverting papilloma. We could not make the diagnosis of fungal sinusitis in all of our patients based on the CT-scan findings alone, although areas of increased attenuation strongly suggested fungal disease.

Zinreich et al. (1988) compared the efficacy of CT scan and MR findings in a series of fungal sinusitis patients and concluded that MR was more sensitive and specific in the diagnosis of fungal infections. MR scans demonstrated iso-intense, hypo-intense or heterogeneous intensity masses on T_1-weighted images. The proton-density-weighted MR scan demonstrated the hypo-intense areas to remain of low signal intensity. On T_2-weighted images the areas showed even further loss of signal with signal-void areas. These features were clearly demonstrated in three patients in this series (Figures 2A-C and 4A-C). These relaxation times are related to the percentage of free water, proteinaceous secretions (Som et al., 1989), calcium, air, and ferromagnetic elements in the fungal masses. The presence of manganese and iron by spectrometric analysis in fungus-infected mucin further decreases the signal activity on T_2-weighted MR images (Zinreich et al., 1988). MR, however, has an increased cost over CT and should be reserved for cases where there is suspicion of intracranial invasion or where the CT scan is inconclusive.

Som et al. (1990) confirmed that the finding of low signal intensity on T_1-weighted sequences, lower signal intensity on T_2-weighted sequences or the presence of signal voids may be similar in mycetomas, chronic secretions (thick paste-like consistency), and acute clotted haemorrhage. They also noted that the signal voids observed in chronic secretions and mycetomas may be confused with air and tooth enamel on MR images. They concluded that MR should be used to help differentiate some of the conditions that have similar CT-scan characteristics.

It is important to make the diagnosis of fungal sinusitis in order to offer the appropriate treatment. The usual treatment is surgical debridement, drainage and re-establishment of normal sinus ventilation. This treatment rationale not only aborts the vicious cycle of chronic sinusitis, but also prevents conversion of indolent, chronic infection into fulminant disease (Oates et al., 1987). The surgical approach used in this series of patients was functional endoscopic sinus surgery as described by Stammberger et al. (1990).

The pathologist should be alerted of the suspicion of fungal infection in order to use special stains if necessary to identify fungi and/or allergic mucin (allergic fungal sinusitis; Corey, 1992). If there is tissue invasion, the treatment may have to be appropriately altered.

The fulminant form of fungal sinusitis has an aggressive evolution with orbital, intracranial and vascular invasion. This is followed by gangrenous necrosis with poor response to all kinds of treatment including systemic amphotericin (McGill et al., 1980; Weingarten et al., 1987).

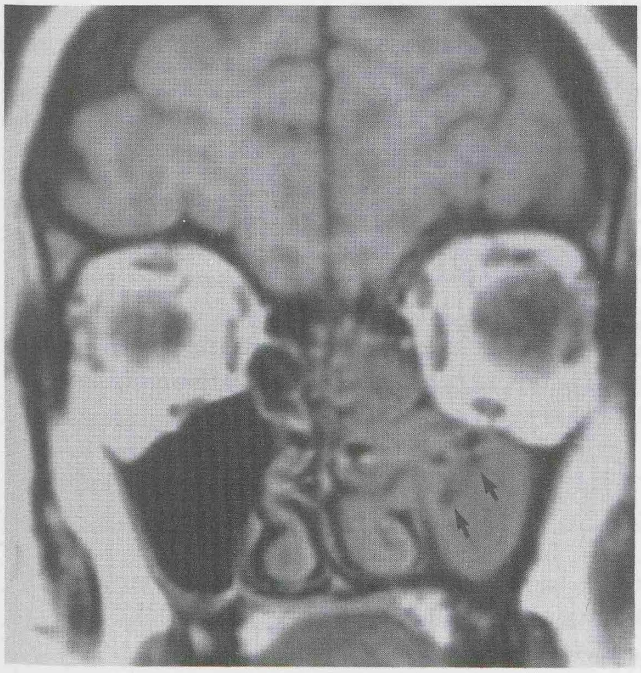

Figure 4A. T_1-weighted MR scan showing four focal hypo-intense areas (arrows) in a sinus filled with a mass iso-intense with brain.

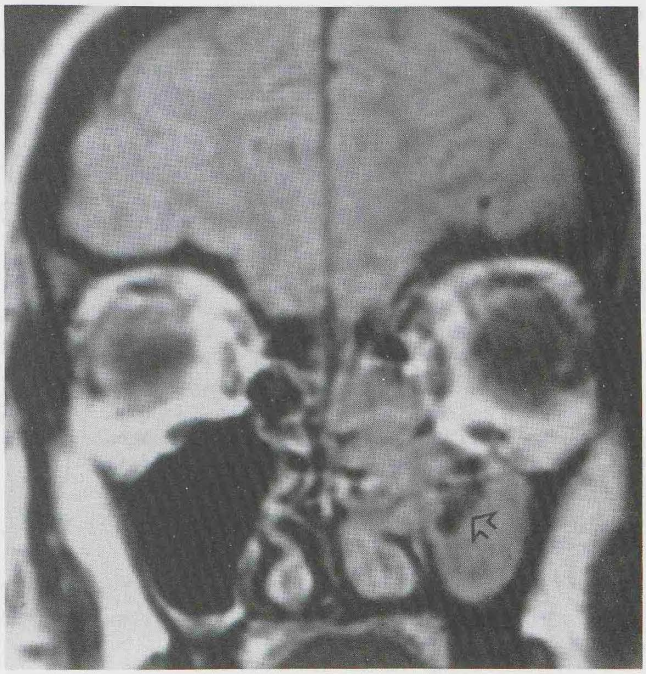

Figure 4B. Proton-density image shows the hypo-intense areas (open arrow) to be a lot larger. The inflammatory process seems to involve the anterior ethmoidal sinus, ostiomeatal complex and left maxillary sinus.

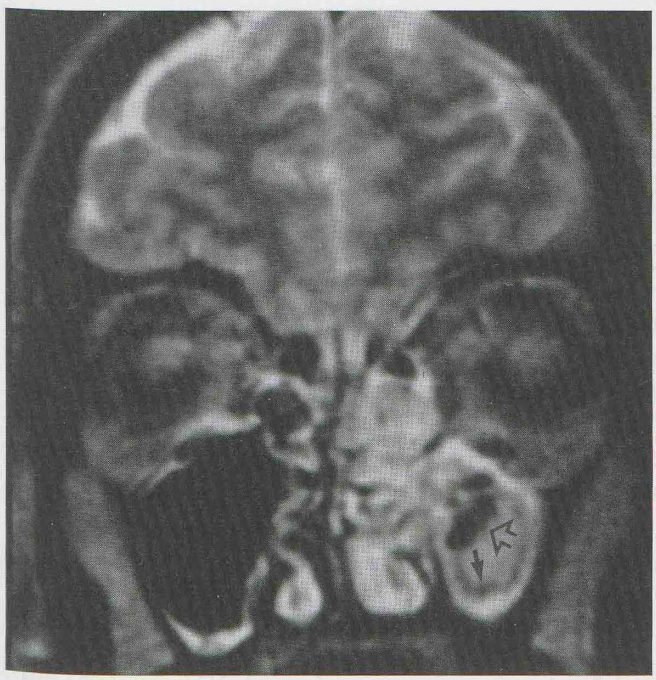

Figure 4C. The hypo-intense areas are now noted to be signal-void areas (open arrow). A rim of signal void in the fungus ball is seen surrounded by hyper-intense inflamed mucosa (arrow).

CONCLUSIONS

1. High index of suspicion is required for the diagnosis: Patients with recurrent or chronic sinusitis are resistant to adequate treatment.
2. Non-enhanced CT scans are more sensitive than conventional X-rays in detecting the classical focal areas of hyperattenuation and calcification in soft-tissue masses of fungal sinusitis.
3. MR findings of hypo-intense signals on T_1-weighted sequences which progress to signal-void areas on T_2-weighted sequences are characteristic features of fungal sinusitis and dense desiccated secretions.
4. The radiographic findings in this study, especially CT scan and MR, certainly offered a definitive diagnosis of fungal sinusitis in most and a high index of suspicion of fungal infection in some.
5. MR should be reserved for cases where intracranial invasion is suspected or the CT scan is not conclusive.

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