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Original Article

Radiology Section

MRI Evaluation of Invasive Sinonasal Mucormycosis in Post COVID-19 Patients: A Retrospective Study

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ABSTRACT

Introduction: Mucormycosis is also known as phycomycosis or zygomycosis, is caused by a saprophytic fungal infection. During the second wave of coronavirus disease-2019 (COVID-19), secondary complication among clinically severe COVID-19 with or without diabetes was the involvement of the paranasal sinuses, rhino-orbitalocerebral, cutaneous, gastric and lungs by mucormycosis. The disease progresses rapidly within a few hours to days, causing cranial nerve palsies and intracranial spread of the disease. Early imaging is helpful in assessing the extent of the spread of the disease and complications and planning the treatment.

Aim: To assess the distinct MRI findings in invasive sinonasal mucormycosis in post COVID-19 patients and also to describe the various patterns of extension.

Materials and Methods: This retrospective study was carried out on post COVID patients with imaging features of invasive sinonasal mucormycosis in the rural population of Hoskote, Bangalore, who underwent Magnetic Resonance Imaging (MRI) at MVJ Medical College and Research Hospital, Hoskote, Bangalore, India in a tertiary care center, between May 2021 to July 2021. A total of 20 patients met the inclusion criteria. The various imaging features of invasive sinonasal mucormycosis were evaluated and tabulated, along with a description of its extensions. All the data obtained from the study was compiled with Microsoft Excel (2019 version).

Results: The study showed a male predominance with a mean age of 47.5 years. The most commonly involved sinus was the ethmoid sinus, seen in all 20 patients (100%), followed by a combination of the ethmoid and maxillary sinus 10 (50%). The MRI showed T2W hyperintense mucosal thickening with hypointense contents within the involved sinuses in all cases, hypointensity along the turbinates and nasal septum and heterogeneous post contrast enhancement. The intraorbital extension was seen in 15 patients (75%), intracranial involvement in 4 patients (20%), bone involvement in 2 cases (10%) and pterygopalatine fossa involvement in 5 patients (25%), face involvement seen in 2 patients (10%).

Conclusion: Magnetic Resonance Imaging (MRI) aids in a thorough evaluation of intracranial and soft tissue involvement, orbital, skull base invasion, perineural spread and vascular invasion. The MRI demonstrates variable signal intensity depending on the sinus contents and variable enhancement patterns with a lack of enhancement due to tissue necrosis, an early finding of mucormycosis. Therefore, radiologists should be aware of the imaging findings and evaluation of the extensions, which can lead to early diagnosis and timely management, reducing the morbidity and mortality rates.

Keywords: Black turbinate sign, Coronavirus disease-2019, Guitar pick sign, Magnetic resonance imaging, Rhino-orbito cerebral mucormycosis

INTRODUCTION

Mucormycosis, also known as phycomycosis or zygomycosis of the brain, has been described in the French literature since 1885 [1] and in English literature since 1943 [2]. It is caused by a saprophytic fungal infection by non septate hyphae of the class Phycomycetes, order Mucorales and the genus *Rhizopus, Rhizomucor, Mucor* or *Absidia* [2]. Inoculation of fungi occurs by inhalation and when spores reach the nasal cavity or nasopharynx. The fungus may spread to the Paranasal Sinuses (PNS) and to the orbit, meninges and brain by direct extension [3].

A study by Petrikkos G et al., [4] on the epidemiology and clinical manifestations of mucormycosis reviewed the various risk factors for mucormycosis and stated that in developed countries, the disease remains uncommon and is mostly seen in patients with diabetes mellitus and hematological malignancies undergoing chemotherapy and those who have received allogeneic stem cell transplants. Whereas in developing countries, especially in India, mucormycosis cases, occur mainly in patients with uncontrolled diabetes or trauma. The early clinical symptoms of sinonasal mucormycosis include fever, headache, facial pain, facial swelling, nasal discharge, nasal obstruction and crusting. The disease progresses rapidly within a few hours to days, causing cranial nerve palsies and intracranial spread of the disease [4].

During the second wave of COVID-19, a secondary complication among clinically severe COVID-19 and uncontrolled diabetic patients is the involvement of PNS, rhino-orbitalo cerebral, cutaneous, gastric and lungs by mucormycosis.

Joshi AR et al., [5] conducted a study on the imaging findings of invasive mucormycosis on post COVID-19 patients and reported findings such as the maxillary sinus to be the most commonly involved, bony erosions of the walls of the paranasal sinuses and hyperattenuating sinus content on CT. The MRI showed T2 hyperintense sinus content with enhancing mucosal thickening. In contrast enhanced images, enhancing soft tissue obliterating the retroantral fat and focal areas of lack of mucosal enhancement (i.e., the black turbinate sign) was described. Orbital and optic nerve involvement and intracranial extensions in the form of vasculitic infarcts, cavernous sinus thrombosis, pachymeningeal enhancement and trigeminal nerve involvement were also recorded.

The mortality reaches greater than 80% with intracranial involvement of invasive sinonasal mucormycosis. Because of the aggressive nature of the disease, it must be recognised early and treated promptly. Imaging allows early diagnosis of the disease and is helpful in assessing the extent of the spread of the disease, the complications and planning the treatment. The purpose of this study is to assess the distinct MRI findings in invasive sinonasal

mucormycosis in post COVID-19 patients and also to describe the various patterns of extension.

MATERIALS AND METHODS

This retrospective study was conducted in the Department of Radiodiagnosis, MVJ Medical College and Research Hospital, Hoskote, between the months of May and July 2021. The records of all patients with a radiological diagnosis of invasive sinonasal mucormycosis were extracted from the Radiology Department database.

Inclusion criteria: Cases with imaging features of invasive sinonasal mucormycosis on MRI and with a history of COVID-19.

Exclusion criteria: Disoriented and sick patients who are uncooperative for imaging.

Study Procedure

Twenty five patients with suspected post COVID-19 invasive sinonasal mucormycosis had undergone MRI (plain and contrast) at the institute during the mentioned time frame. All the MRI scans were done using Siemens MAGNETOM essenza 1.5 T machine using head coils. MRI head with orbit and PNS imaging including T1 weighted image, T2 weighted image, FLAIR and fat suppressed post contrast T1 weighted images were acquired. Diffusion weighted images were also acquired.

Out of the 25 patients with suspected invasive mucormycosis, a total of 20 patients were included in the study after the inclusion and exclusion criteria were met. Five patients were excluded from the study, of which the imaging findings in two patients were normal. The MRI findings of the other three patients demonstrated only marginal mucosal thickening with no imaging features of invasive mucormycosis and hence were excluded from the study. Whereas out of the 20 patients, the diagnosis was confirmed by histopathology in 11 patients. The rest of nine patients were referred to other centres and lost for follow-up. Since this is a descriptive observational study of patients, where the data of the cases were extracted from the radiology database, where the participants are deidentified or cannot be contacted, research was carried out on anonymised biological samples/data and no interventional procedures were conducted, ethical clearance was waived off.

Image analysis: The MRI's were interpreted by two experienced radiologists, both with experience of at least five years in interpreting MRI. On MRI, T1 weighted, T2 weighted, and DWI images with post contrast fat suppressed T1 weighted images were evaluated for signal changes and enhancement patterns. In all cases, the paranasal sinuses, nasal cavities, orbits and brain were evaluated for any extension of the disease.

In air cells, the presence of marginal mucosal thickening with partial or complete opacification or air fluid levels was evaluated. Soft tissue extension into the nasal cavity, along the nasal septum, nasolacrimal duct, lacrimal sac, orbits, pterygopalatine fissure, infratemporal fossa, face, cavernous sinus and brain involvement were examined and looked for any soft tissue thickening. For orbital cellulitis, fat stranding in the intraconal fat space with thickening of extraocular muscles or superior ophthalmic vein was examined and the presence of any abscess formation was looked for.

For intracranial involvement, images were examined for features of dural enhancement, cerebritis and infarcts. Other intracranial complications like cerebral oedema, cerebritis, cerebral abscess formation, cavernous sinus involvement and arterial thrombosis were also evaluated. In post contrast study, the type of enhancement in the air cells was studied. The patients in this study were divided into three groups based on paranasal sinuses involvement and extensions according to the classification suggested by Rupa V et al., [6] [Table/Fig-1].

Stage	Areas involved
Stage 1	Nose and paranasal sinuses alone
Stage 2	Paranasal sinuses with immediate adjacent areas which are surgically resectable with minimal morbidity eg. Orbit (extraconal), palate and oral cavity.
Stage 3	Intracranial extension (extradural/intracerebral) or partially resectable with extension to pterygopalatine fossa, cavernous sinus, cheek and periorbital region.

[Table/Fig-1]: Paranasal sinus involvement and soft tissue extension [6].

STATISTICAL ANALYSIS

All the data obtained from the study was compiled with Microsoft Excel (2019 version) the results were expressed in percentages and the data was depicted in tables.

RESULTS

Population characteristics: The characteristics of the study population are summarised in [Table/Fig-2]. A total of 25 patients with suspected mucormycosis post COVID-19 underwent MRI imaging and 20 patients were included in the study after the inclusion criteria were met. Among the 20 patients post contrast study with gadolinium was done in 15 patients. The contrast study was contraindicated in five patients due to deranged renal function tests and therefore had undergone only a non contrast MRI scan.

Characteristic	Values
Age (Years): Mean±SD	47±13 years
Sex: n (%)	
Male	16 (80)
Female	4 (20)
Sign and symptoms: n (%)	
Proptosis	2 (10)
Headache and fever	20 (100)
Facial swelling	10 (50)
History of COVID: n (%)	
Mild	0
Moderate	15 (75)
Severe	5 (25)
Co-morbidities: n (%) Diabetes mellites:	
Uncontrolled	15 (75)
Hypertension	5 (25)
Medical renal disease	5 (25)
Blood tests: (mg/dL)	409
FBS (mean):	(Range: 253-565)

[Table/Fig-2]: Characteristics of the patient population.

In the present study, males were affected more than females, with 16 out of 20 study subjects being males. The mean age of all the patients in the study was 47±13 years. All patients had a history of COVID-19, the severity of the disease in 15 out of 20 was moderate and five out of 20 was severe. Treatment of all patients for COVID was as per guidelines set by AIIMS/ICMR COVID-19 National task force [7] and included injection methylprednisolone 0.5 to 1 mg/kg in two divided doses for a duration of 5 to 10 days for moderate cases and injection methylprednisolone 1 to 2 mg/kg two divided doses for a duration of 5 to 10 days for severe cases. Few of the patients had continued with oral methylprednisolone after discharge from the hospital for an unknown duration.

The 15 out of 20 patients had associated diabetes mellitus who were on insulin. The most common clinical presentation was headache and fever which was seen in all 20 patients, 10 patients had facial swelling, and two patients had proptosis.

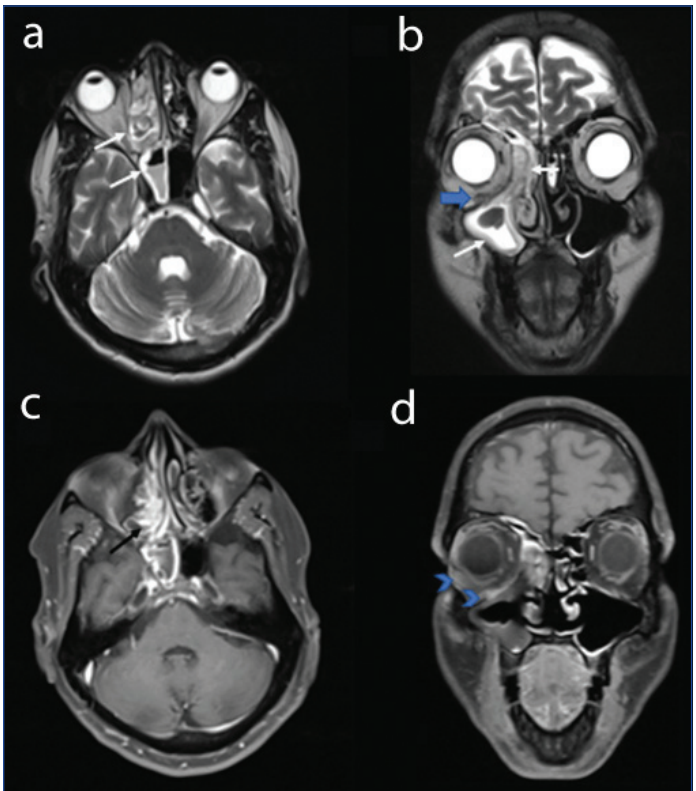
Imaging Findings

Sinonasal involvement: [Table/Fig-3] summarises the sinuses involved. In most of the patients, multiple sinuses were involved, the combination of ethmoid, maxillary and sphenoid sinuses was more common. Ethmoid sinuses were the most commonly involved sinus seen in all 20 patients; its involvement is either isolated (n=2) or in combination with other sinuses. A combination of the ethmoid and maxillary sinus was the most common pattern and seen in 10 patients.

Sinuses involved	Number (%)
Ethmoid alone	2 (10)
Ethmoid+Maxillary	10 (50)
Ethmoid+Sphenoid	5 (25)
Ethmoid+Maxillary+Sphenoid	2 (10)
Ethmoid+sphenoid+Frontal	1 (5)
Pansinusitis	0

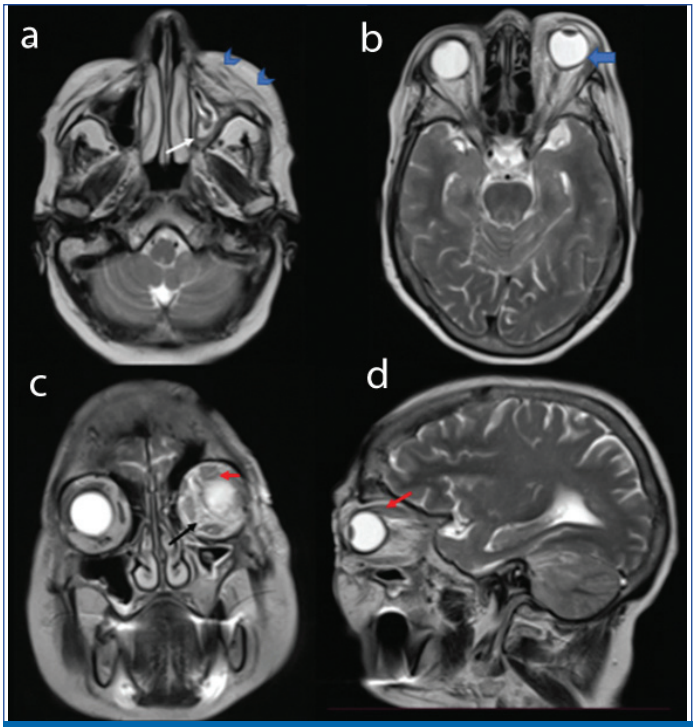
[Table/Fig-3]: Sinuses involved in mucormycosis.

Signal characteristics and imaging appearances on MRI: On MRI, the mucosal thickening was seen as isointense to hypointense on T1 weighted images compared to the adjacent muscles. On T2 weighted images, hyperintense mucosal thickening with hypointense contents within the sinuses was seen. These altered signal intensities were seen in all studied patients [Table/Fig-4 (a-d), 5 (a-c) and 6 (a-f)].

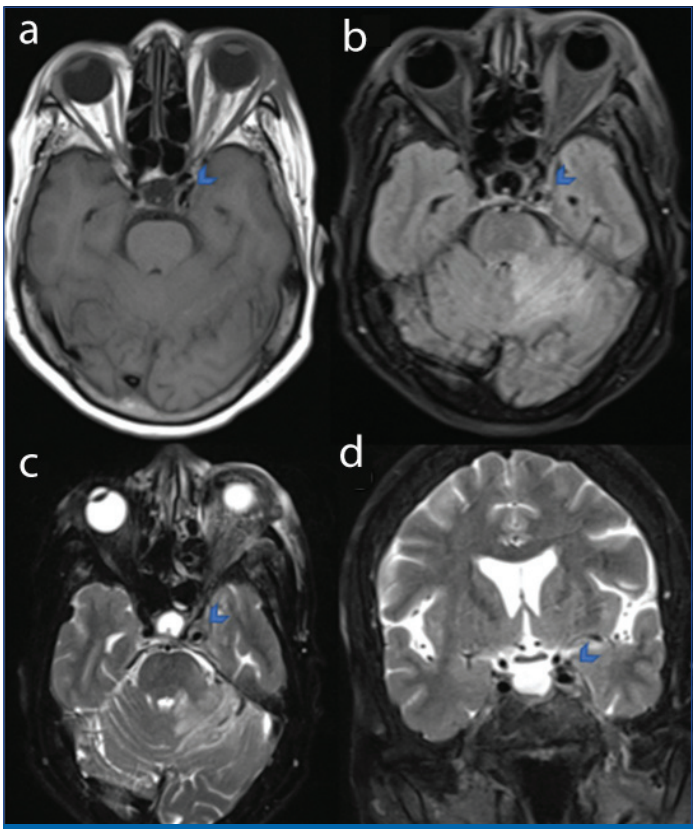


[Table/Fig-4]: The MRI images of a 53-year-old male post COVID-19 patient with complains of headache. (a and b): Axial and coronal T2W MRI images shows mucosal thickening of right ethmoid, maxillary, sphenoidal air cells (white arrow) and air fluid in right ethmoid and sphenoid air cells appearing T2W hypointense. Subtle irregular extension into right extraconal fat space seen as T2W hypointensity along inferomedial wall and floor of right orbital wall (blue arrow). (c and d): T1 fat suppressed contrast enhanced axial and coronal MRI images shows heterogeneous peripheral mucosal enhancement in right ethmoid sinus (black arrow). Thin rim of enhancement is seen along the infero medial wall and floor of the right orbit in anterior aspect (blue arrow heads).

T2W hypointensity along the turbinates (n=2) [Table/Fig-6b] and nasal septum (n=1) were also demonstrated. T2 weighted hyperintense intrasinus fluid level was seen in seven patients. The findings on diffusion weighted images were non specific, one of the cases in this study showed diffusion restriction in the involved sinus. Decreased signal intensity on both DWI and ADC maps in the involved sinuses was seen in 12 cases.

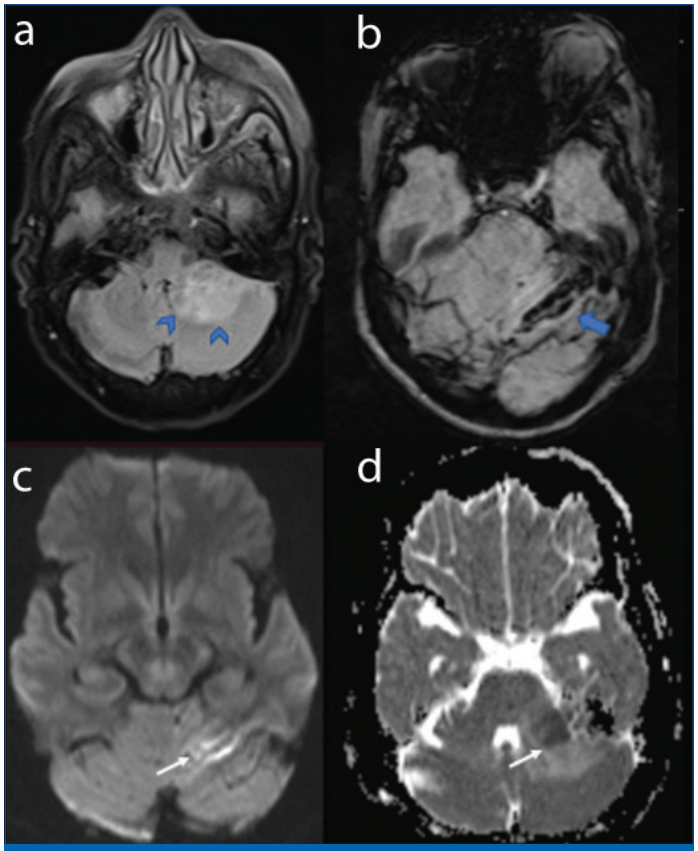


[Table/Fig-5A]: A 80-years-old female patient with headache, facial pain, proptosis and disorientation. (a and b): Axial T2W images show hyperintense mucosal thickening in left maxillary sinus associated with hypointense within (white arrow), evidence of subtle periantral fat standing anterior to left maxillary sinus (blue arrow heads). Proptosis of left globe (blue arrow) associated with stretching of left optic nerve and "guitar pick sign". (c and d): Coronal and sagittal T2W images show extensive retroorbital and periorbital fat stranding (black arrow) and mild oedematous thickening seen in the extraocular muscles (red arrow). The left superior ophthalmic vein was congested showing loss of flow void.

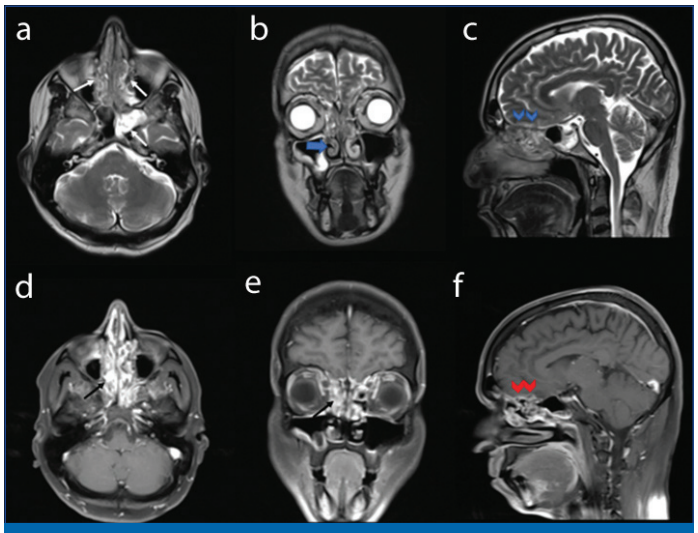


[Table/Fig-5B]: The MRI of the same patient as 5A. Axial T1W (a), Axial FLAIR (b), Axial T2 fat suppressed image (c), Coronal T2 FS (d) images shows left cavernous sinus bulky and heterogeneous in signal intensity (blue arrow heads).

In post contrast study, there was peripheral mucosal enhancement with heterogeneous or complete non enhancing central lesions seen in all 15 cases which underwent post contrast study [Table/Fig-4,6]. The 'black turbinate' sign, which is the non enhancement of the nasal turbinate, was seen in one case. Extension and enhancement of lesions were best seen on fat suppressed postgadolinium images.



[Table/Fig-5C]: The MRI of the same patient as 5A. (a: FLAIR axial images show hyperintense area seen in left cerebellar hemisphere (blue arrow heads). (b): SWI images (with motion artefacts) showing foci of "blooming" (blue arrow). (c and d): DWI and ADC images showing patchy areas of diffusion restriction in the same area (white arrows). These features of infarct with haemorrhagic transformation suggest angioinvasive disease.



[Table/Fig-6]: A 47-years-old male post COVID patient with history of headache, left periorbital swelling and watering of both eyes. (a, b and c) Axial, coronal and sagittal T2W MRI images show T2W hypointensities in bilateral ethmoid and left sphenoid sinus with air fluid level (white arrow). The right inferior turbinate shows T2 hypointensity (blue arrow). Sagittal image shows breech in the basi ethmoidalis with intracranial extension of T2W hypointense soft tissue into basal aspect of anterior cranial fossa (blue arrow heads). (d, e and f) Axial, coronal and sagittal contrast enhanced T1 fat suppressed MRI images show heterogeneous enhancement seen in PNS and turbinates (black arrows). Sagittal MRI image shows thick smooth continuous dural enhancement in the basal aspect of anterior cranial fossa (red arrow heads).

The extensions were also noted involving orbits, nasolacrimal ducts, lacrimal sac and intracranial extension seen in the form of dural enhancement in post contrast study.

Extrasinus extension: The sites of extrasinus involvement are summarised in [Table/Fig-7], and involve the orbit, face, orbital apex, pterygopalatine fossa, bone, cavernous sinus, brain and internal carotid artery. In the current study, orbital involvement was seen in 15 of 20 patients, five of 20 patients had orbital apex and pterygopalatine fossa involvement, two of 20 had face and bone involvement, two cases showed the brain infarcts, one of 20 patients had cavernous sinus and one patient had internal carotid artery involvement. The PNS involvement and extensions were also classified according to the system suggested by Rupa V et al., [6] and are summarised in [Table/Fig-8].

Site of extension	Number (%)
Orbit	15 (75)
Face	2 (10)
Orbital apex	5 (25)
Pterygopalatine fossa	5 (25)
Bone	2 (10)
Cavernous sinus	1 (5)
Brain infarcts	2 (10)
Internal carotid artery	1 (5)

[Table/Fig-7]: Site of extension of mucormycosis.

Stage	Areas involved	Number (%)
Stage 1	Nose and paranasal sinuses alone	3 (15)
Stage 2	Paranasal sinuses with immediate adjacent areas which are surgically resectable with minimal morbidity eg. Orbit (extraconal), palate and oral cavity.	13 (65)
Stage 3	Intracranial extension (extradural/intracerebral) or partially resectable with extension to pterygopalatine fossa, cavernous sinus, cheek and periorbital region.	4 (20)

[Table/Fig-8]: Classification system of PNS involvement and extensions as suggested by Rupa V et al., [6].

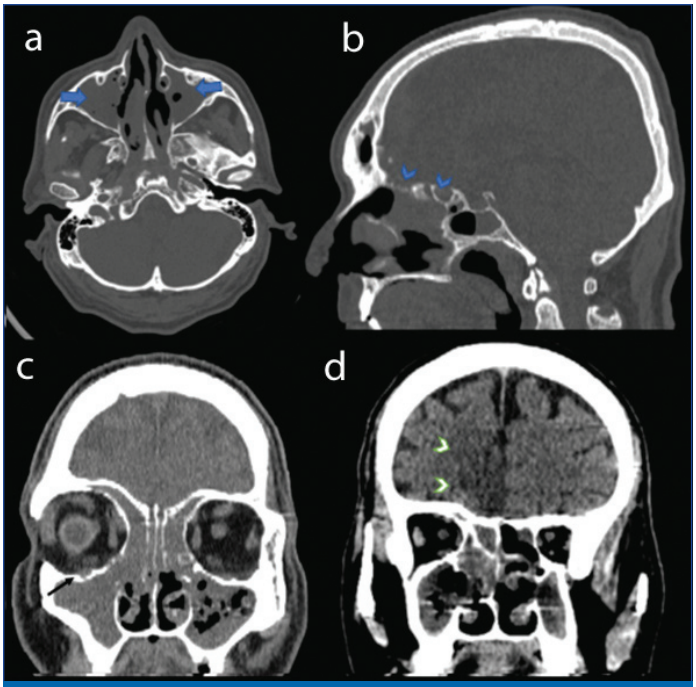
Periantral involvement: Periantral involvement is highly suggestive of invasive mucormycosis. In this study, five patients showed fat stranding in the pterygopalatine fossa and two patients show fat stranding in the face [Table/Fig-5A, B].

Orbital involvement: The 15 patients showed features of intraorbital involvement which was seen as extraconal fat stranding in all these patients. Whereas four patients showed increased bulk and oedema of the rectus muscles of which the medial and inferior rectus muscles were the most commonly involved [Table/Fig-5A]. The inferior rectus being involved in three out of four cases and the medial rectus being involved in two out of four cases. And five patients had extensions to involve the orbital apex. In one of the cases severe proptosis was seen, severe stretching of the left optic nerve, which tethers the globe which was deformed, giving a characteristic 'guitar pick' appearance [Table/Fig-5a]. In post contrast study the orbital extension was seen as a rim of enhancement along the walls of the orbit [Table/Fig-4d].

Intracranial involvement: Four Patients i.e. 20% of the cases, had intracranial involvement. Wherein meningeal enhancement was seen predominantly in the basal aspect of the anterior cranial fossa [Table/Fig-6f]. Cerebellar and cerebral infarcts were in seen in one case each [Table/Fig-5c]. MRI of one of the patients was suggestive of cavernous sinus thrombosis [Table/Fig-5B], and one patient had internal carotid artery thrombosis.

Bone involvement: Bone involvement was seen in two patients in the form of altered marrow signal intensity. One of the patients whose Computed Tomography (CT) was done showed bony erosions of the walls of the maxillary and sphenoid sinuses and the floor of the orbit [Table/Fig-9].

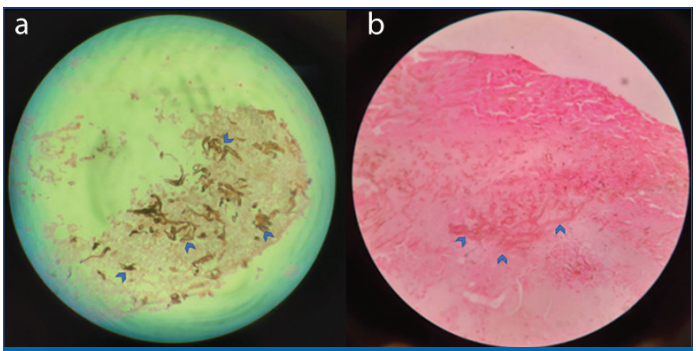
A 80-years-old female patient with headache, facial pain, proptosis and disorientation. (a and b): axial T2W images show hyperintense mucosal thickening in the left maxillary sinus associated with hypointense within (white arrow), evidence of subtle periantral fat standing anterior to the left maxillary sinus (blue arrow heads) [Table/Fig-5A (a and b)]. Proptosis of the left globe (blue arrow) associated with stretching of the left optic nerve and "guitar pick sign". (c and d): Coronal and sagittal T2W images show extensive retroorbital



[Table/Fig-9]: (a and b) Axial and sagittal CT images, bone window showing mucosal thickening with air fluid levels involving bilateral frontal, maxillary, ethmoid and sphenoid sinuses (blue arrows). Subtle bony erosions noted involving the walls of maxillary and sphenoid sinuses, bilateral fovea ethmoidalis (blue arrow heads) and floor of the orbit. (c) CT coronal spine window demonstrates subtle soft tissue extension seen along the floor of the orbit (black arrow). (d) CT coronal brain window demonstrates acute infarct involving parasagittal region of right frontal lobe (arrow heads).

and periorbital fat stranding (black arrow) and mild oedematous thickening seen in the extraocular muscles (red arrow). The left superior ophthalmic vein was congested, showing a loss of flow void [Table/Fig-5a (c and d)].

The diagnosis of 11 out of the 20 patients was confirmed by histopathology [Table/Fig-10] using different staining techniques, of haematoxylin and eosin stain which showed fungal hyphae as broad, ribbon like, irregular and aseptate with branching at a right angle. The rest of nine patients were referred to other centres and lost to follow-up.



[Table/Fig-10]: Histopathology: (a) Grocott-Gomori's Methenamine Silver (GMS) stain (special stain) and (b) H&E stain showing the fungal hyphae (blue arrow heads) seen as broad, ribbon like, irregular and aseptate with branching at a right angle (10X).

DISCUSSION

Invasive fungal sinusitis is a disease characterised by mucosal infiltration of the fungal organisms and angiocentric extension into orbital and intracranial structures.

Acute Invasive Fungal Rhinosinusitis (AIFRS) is rare, aggressive disease and often fatal angioinvasive infection of the paranasal sinuses [8]. Acute fungal FRS is a disease of <4 weeks duration [9]. The AIFRS is most commonly seen in immunocompromised patients. The most common predisposing factors are haematology neoplasm (in particular post bone marrow biopsy), type 1 diabetes mellitus (in the setting of ketoacidosis), AIDS and chronic systemic steroid use [10].

Fungal organisms are a diverse group of pathogens that are widely distributed in the environment. Normally these organisms are saprophytes that are found in the decomposing matter, and these can proliferate in the aerodigestive tract of humans when immunocompromised, these become opportunistic and pathogenic [8].

The most common clinical presentation includes fever, facial pain and swelling, periorbital pain and swelling, nasal discharge and headache. Less common are ophthalmologic complaints, including decreased visual acuity or ophthalmoplegia [10]. The current study found that headache and fever was the most common complaint seen in all patients, 50% of patients had facial swelling and 10% had proptosis.

In this present study, the patients belong to the aged 47±13 years. The age of involvement in the study is similar to the results of Therakathu J et al., [11] who studied a total of 43 patients with rhinocerebral mucormycosis and found patients ages between 40 to 60 years were most affected. Other studies by Singhal A et al., [12] and Sarkar S et al., [13] also reported that 60% to 50% of patients belonged to a similar age group. The disease predominantly affected males in this study is similar to the results of previous studies [11,12].

In the current study the ethmoid sinuses are most commonly involved seen in all cases, followed by a combination of ethmoid and maxillary seen in 50%. These findings are similar to studies by Therakathu J et al., [11], wherein the ethmoid and maxillary were involved in 86% and 79% respectively. A study by Kondapavuluri S K et al., [14]. On sinonasal mucormycosis in post COVID-19 patients also showed maxillary and ethmoid sinuses to be most commonly affected.

In a study by Mangal R et al., [15] on rhino-orbito cerebral mucormycosis in 67 post COVID-19 patients, on MRI, they found the mucosal thickening was hypointense to isointense on the T1W sequence and hyperintense on the T2W sequence. In some cases, T2 hypointense thickening was also seen. The retained intra sinus secretions were isointense on T1 with T2 variable signal with restricted diffusion was seen in some of the cases in their study. In the present study, similar findings were demonstrated with T2W hyperintense mucosal thickening with hypointense contents within the sinuses, hypointensity along the nasal septum and intrasinus fluid level. However, the findings on DWI sequences were non specific, with restriction diffusion seen only in one case. However, various other studies [11,14,16] show variable signal intensities on both T1W and T2W images.

A study by Herrera DA et al., [16] on five patients with rhinocerebral mucormycosis found variable enhancement patterns from absent to mild to marked. Lack of contrast enhancement in the nasal cavity due to mucosal necrosis occurs in patients with mucormycosis, due to its angioinvasive nature [17]. This is the early finding of mucormycosis on MRI, which is termed as a 'black turbinate sign'. In a retrospective review by Seo J et al., [18] 17 of their 23 patients with AIFS demonstrated this radiologic finding. In this study, in post contrast study, there was peripheral mucosal enhancement with heterogeneous or complete non enhancing central lesion and the 'black turbinate sign' was seen in one case.

In a study by Jindal G et al., [19] on the Imaging findings in invasive rhino orbito cerebral mucormycosis in post COVID-19 patients, they found that orbital and intracranial invasion was seen in 73.3% and 60% of patients, respectively. Singhal A. et al., [12] on the study on imaging findings in COVID-19-related rhino-orbito cerebral mucormycosis found orbital involvement in 60% and intracranial involvement in 20 % of cases. In this study, the orbital extension was seen in 15 out of 20 patients 75%, and intracranial extension seen in 4 patients 20% the cases.

Bone erosion or extrasinus extension, both of which are highly suggestive of AIFRS, are less commonly seen in early phase of the disease [20]. Periantral fat obliteration is a subtle sign of invasion. When this is the only radiologic finding, periantral soft tissue infiltration should suggest the possibility of invasive FRS in the appropriate clinical setting [21]. The spread of disease from ethmoid to interorbital is also a feature of AIFRS. There can be periantral and intraorbital invasion without evidence of bony erosion. In a study by Joshi AR et al., [5] on the CT and MRI findings of invasive mucormycosis on 25 patients with COVID-19 found sinus wall erosions in 20 patients. In this study, bone involvement was seen in two patients on MRI only as altered marrow signal changes. This inconsistency is likely because the bone erosions demonstrated in the study by Joshi AR et al., was based on CT, which is more sensitive to pick up bone involvement in comparison to MRI.

Limitation(s)

The study include firstly the sample size of the study was small. Secondly, all patients did not undergo a contrast studies due to abnormal Renal Function Test (RFT) values. Lastly, the patients were referred to other hospitals for further management and lost to follow-up; histopathological confirmation was not possible in nine patients. Therefore, a more extensive study sample size and long term follow-up is likely to throw more light onto the disease pathogenesis and the imaging implications.

CONCLUSION(S)

Mucormycosis is considered an emerging, rapidly disseminating fungal infection associated with immunocompromises conditions and has a fatal prognosis if there is cavernous involvement. MRI aids in the evaluation of intracranial and soft tissue involvement, orbital, skull base invasion, perineural spread and vascular invasion. MRI demonstrates variable signal intensity depending on the sinus contents and irregular enhancement patterns with a lack of enhancement due to tissue necrosis which is an early finding of mucormycosis. However, MRI in invasive sinonasal mucormycosis should be correlated with CT study for bone erosions. Therefore, radiologists should be aware of the imaging findings and evaluation of the extensions, which can lead to early diagnosis and timely management with antifungal agents and surgical debridement. This can further reduce the rates of morbidity and mortality.

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