DOI: 10.7860/JCDR/2021/50087.15646

Case Series

Dentistry Section

Post COVID-19 Mucormycosis in Immunocompromised Individuals with Uncontrolled Diabetes Mellitus: A Series of Seven Cases

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ABSTRACT

An upsurge in the cases of severe opportunistic infections such as mucormycosis has been observed due to Coronavirus Disease 2019 (COVID-19), that is a viral infection caused by Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2). Even though it was a rare opportunistic infection, the incidence of this disease seems to be increasing with the emergence of COVID-19 infection worldwide. Individuals are vulnerable to this secondary infection due to uncontrolled diabetes, coronavirus disease infection therapy, immunosuppression, and pre-existing co-morbidities. This case series aimed to report how aggressive and fatal mucormycosis can be in diabetic and immunocompromised cases as well as the outcome of its treatment protocol. Authors hereby have reported seven individuals treated at our institute, who were affected by COVID-19 a few months back, were long-term diabetics and then, developed mucormycosis. Removal of all devitalised tissue was the treatment protocol author followed, along with antifungal therapy. All the cases were monitored using clinical evaluation and Computed Tomography (CT). Amongst the seven individuals, five survived uneventfully with no recurrence of the infection.

Keywords: Amphotericin-B, Black fungus, Coronavirus disease-2019, Immunosuppression, Posaconazole, Zygomycosis

INTRODUCTION

Multiple cases of mucormycosis in people with COVID-19 are increasingly being reported around the world [1]. Out of those, rhino-orbital-cerebral mucormycosis is also reported in a greater frequency as a result of post COVID-19 infections which was earlier a rare entity [2,3]. The incorrect use of steroids to treat COVID-19 patients has been held responsible for the rise in mucormycosis cases, according to numerous experts [1]. However, another school of thought suggests that India has an epidemic of type 2 DM [1] which are mostly diagnosed late, affecting the immune status of the individuals, thereby leading to the occurrence of this opportunistic infection.

Hence, in this case series, authors have incorporated seven mucormycosis cases encountered in COVID-19 infected individuals and their management.

CASE SERIES

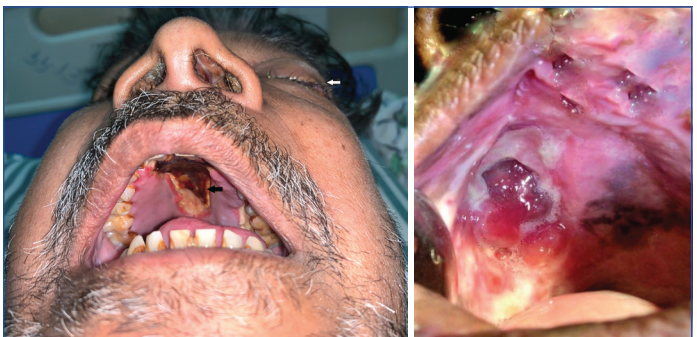
Case 1

A 52-year-old male patient with long-standing Diabetes Mellitus (DM) reported to our institute with complaints of pain, difficulty in eating for one month, and discharge from the left eye. The pain was persistent and dispersed to the temporal area. It worsened with head movements and went away on its own.

The patient was diagnosed with type 2 DM seven years ago and was on irregular treatment with oral hypoglycaemic drugs. He gave a positive family history of DM. His medical history also revealed that he tested positive for SARS-CoV-2 two months ago via RT-PCR. He was under antiviral therapy. On day one, he received 200 mg of remdesivir intravenously, followed by 100 mg once daily for 10 days, as well as a tapering dose of steroid (6 mg dexamethasone i.v. and multivitamins.

On general examination, he was conscious, co-operative, well-oriented to place, person, time, and event. He was afebrile and no other abnormalities were detected. Temporomandibular Joint (TMJ) and salivary glands appeared normal. His intraoral examination revealed a tenderness of the alveolar mucosa accompanied by black barebone with loss of mucoperiosteum over the midline of the palate and an ulcerative lesion on the alveolar process of the left side of the maxilla [Table/Fig-1]. Additionally, gingival necrosis was observed. Gram stain, acid-fast bacilli stain, and fungal smear were all negative, but after 6 days of incubation, a cottony greyish-white colony grew on Sabouraud Dextrose Agar (SDA). Further examination with Lactophenol Cotton Blue (LCB) revealed short sporangiophores and aseptate hyphae with nodal rhizoids suggestive of Rhizopus microsporus.

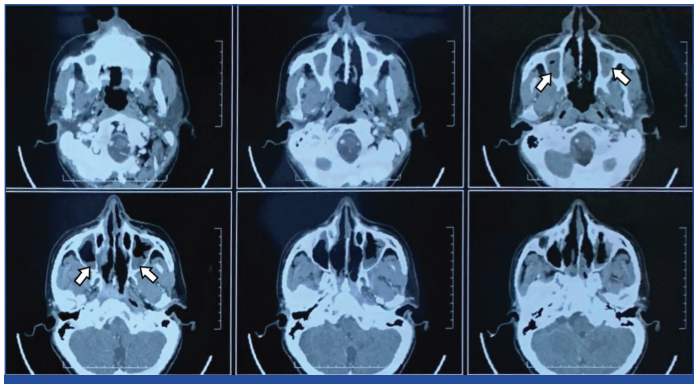
On radiological examination, Computed Tomography (CT) showed gross destruction of the roof, anterior and lateral walls, and floor of right and left maxillary sinus along with mucosal thickening [Table/Fig-2]. Brain MRI revealed an abscess in the left orbit and sinusitis in ethmoid and maxillary sinuses [Table/Fig-3]. Biopsy revealed the presence of granulation tissue with fungal elements.



[Table/Fig-1]: Clinical photograph showing black barebone with loss of mucoperiosteum in the mid-palate (black arrow) and left orbital swelling (white arrow); **[Table/Fig-2]:** Postoperative picture showing wound healing. (Images from left to right)

Upon confirmation of the diagnosis, treatment with 2 mg/kg/day amphotericin-B i.v. was administered to the patient for 8 days and a total maxillectomy along with surgical debridement was planned. Due to the elevation of serum creatinine and hypokalemia that occurred

because of amphotericin-B, the antifungal therapy was changed to a loading dose of two tab. posaconazole 200 mg twice a day followed by one tablet twice daily thereafter, for 28 days. Functional Endoscopic Sinus Surgery (FESS) was done. Total maxillectomy and left eye enucleation were carried out and hard tissue samples were sent for Histopathological Examination (HPE). Subsequently, an obturator was given and the patient continued antifungal treatment with Posaconazole. The wound healing was satisfactory [Table/Fig-3] with no recurrence and the patient was discharged after 2 weeks. He was advised to control DM with hypoglycaemic drugs and diet alteration under his physician's supervision. The patient has been disease free for the past 7 months.

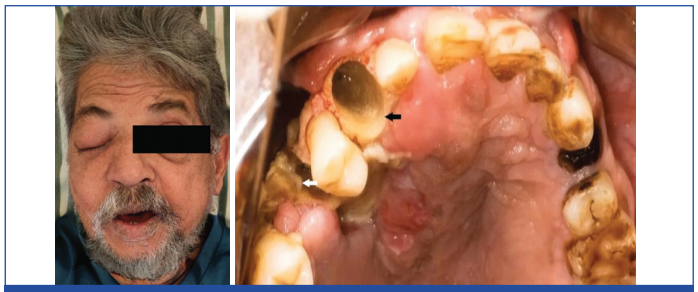


[Table/Fig-3]: A CT scan showing mucosal thickening of right and left maxillary sinus.

Case 2

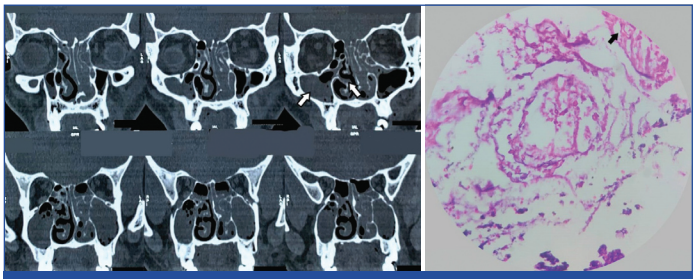
A 58-year-old male with long-term diabetes, hypertension, and ischaemic cardiomyopathy complained of pain and swelling in the right back tooth region for the previous month, as well as a palate ulcer for the previous 15 days. He described that he had a undergone extraction of his upper right canine and oedema around his right eye a month ago. He was diagnosed with type 2 DM 12 years before and on presentation, his diabetes was uncontrolled with a Fasting Blood Sugar (FBS) level of 420 mg/dL. He was also suffering from end stage renal disease and had been on haemodialysis for the past year. He was diagnosed with COVID-19 a month ago and was given a tapering dosage of 40 mg prednisone and a loading dose of remdesivir 200 mg i.v. followed by 100 mg i.v. for seven days.

On inspection, a widespread sensitive swelling was found in the right side's middle third of the face [Table/Fig-4]. Intraorally, an ulcerative lesion was seen in the right half of the hard palate, covered with yellowish slough and everted borders [Table/Fig-5]. Diagnostic nasal endoscopy was done, pus was seen in the middle and inferior meatus. Granular mass was seen in the right nasal cavity and pushing the septum towards the opposite side, partly eroding and destroying it. Keeping in mind the patient's medical history and a rapidly increasing ulcer involving the palate and medial wall of the maxilla, a provisional diagnosis of either osteomyelitis or mucormycosis was made.



[Table/Fig-4]: Clinical image showing right orbital involvement.
[Table/Fig-5]: Intraoral necrotic bone seen with extraction socket (black arrow) and ulcerative lesion covered with yellowish slough (white arrow) and everted borders. (Images from left to right)

The CT showed diffuse radiopacity of the right maxillary sinus and right nasal cavity with bony erosion, extending to the right orbit [Table/Fig-6]. Invasion to brain vessels was seen. Subtotal maxillectomy of the right side was done including removal of part of the alveolar margin and medial wall of the maxilla, creating wide middle meatal antrostomy and the right eye was enucleated. Multiple yellowish black soft tissue bits aggregating to approximately 2×1×0.5 cm was sent for HPE. Microscopic evaluation revealed predominantly multiple viable and necrotic bony, mucosal and soft tissue focally covered with acute inflammatory exudates. Extensive fungal outgrowth and foci of angioinvasion were seen. The fungal element consisted of multiple broad aseptate hyphae and few brownish spores and their slender hyphae. Multiple dilated vascular channels with haemorrhage were also seen. Confirmatory diagnosis was made as mucormycosis [Table/Fig-7].



[Table/Fig-6]: A CT scan showing radio-opacity of the right maxillary sinus and right nasal cavity, extending to the orbit; **[Table/Fig-7]:** Histopathological examination (Haematoxylin and Eosin stained slide in 40X magnification) revealed multiple head aseptate hyphae. (Images from left to right)

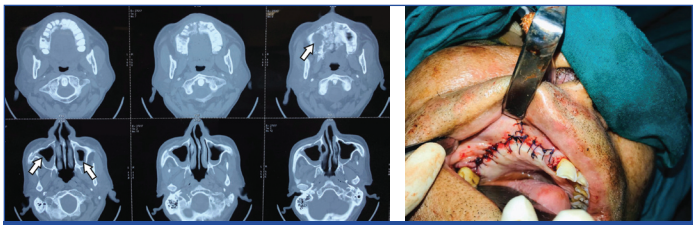
Subsequently, the patient was started on intravenous liposomal amphotericin-B 2 mg/kg/day and broad-spectrum antibiotics i.v. ciprofloxacin 400 mg. Hypokalemia was observed in this patient along with moderate acute renal failure. Four days after surgery, he developed an inter-hemispheric cerebral haematoma, which was complicated by coma and respiratory distress and resulted in his death.

Case 3

A 60-year-old male complained of pain and mild swelling over the right back teeth region for the previous week. He gave a history of extraction in the same region. He was diagnosed with DM six years back and was positive for COVID-19 five months back for which he was treated with steroids, along with remdesivir and tocilizumab.

On general examination, he appeared to be a middle aged man who was conscious and co-operative, febrile, and showed no signs of anaemia or jaundice. During the oral examination, mucus discharge from the extracted tooth socket was collected for examination. Investigations revealed that his blood sugar level was 250 mg/dL. CT showed erosion of the anterior wall of the right maxillary antrum, as well as sinus lining thickening extending to the maxillary alveolar ridge [Table/Fig-8].

Histopathological findings and the results of culture confirmed it as mucormycosis. Antifungal therapy with amphotericin B (1 mg/kg/day) was started and FESS was done followed by limited maxillectomy on the right side [Table/Fig-9]. Amphotericin B (1.5 mg/kg/day and then to 3 mg/kg/day for 3 weeks) was given and after two weeks, the patient got discharged. No evidence of recurrence was seen after two months.



[Table/Fig-8]: A CT scan showing sinus opacification and sinus wall destruction.
[Table/Fig-9]: Postoperative photograph immediately after suturing. (Images from left to right)

Case 4

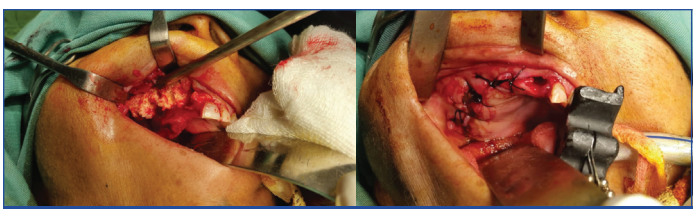
A 56-year-old male complained of pain in his upper right tooth region for three weeks. He had difficulty opening the mouth due to the pain. He added a history of being diabetic for 8 years and also had history of coronary artery disease for 3 years. He was also positive for COVID-19 infection six months back for which Inj. remdesivir i.v. (loading dose 200 mg followed by 100 mg afterward for 8 days) and steroid therapy was given (details of which are unknown). A general examination revealed that he had facial cellulitis in his right buccal, maxillary, and infraorbital areas [Table/Fig-10]. He was febrile, weak, and pale with sclera icterus.

[Table/Fig-10]: Clinical picture showing right midface swelling.

On clinical examination, multiple pus draining sinuses over the maxillary arch along with soft tissue necrosis of the same region was seen along with mobile teeth. The patient was admitted with a provisional diagnosis of osteomyelitis and was started on Inj. Piptaz 4.5 g/8 hourly, Inj. Metronidazole 500 mg/8 hourly and Inj. Fluconazole 200 mg/12 hourly. A biopsy was sent for histopathology diagnosis.

Microscopic examination revealed that the tissue was lined by stratified squamous epithelium and underlying subepithelial tissue, with vast stretches of ulceration, necrosis, and inflammation, primarily of neutrophils with scattered lymphocytes, plasma cells, macrophages, and a few giant cells. There were areas of inflamed granulation tissue, haemorrhage, and congestion. Mucormycosis was diagnosed based on histopathological findings and culture results.

The medical regimen was then altered to include injections of amphotericin B 300 mg/day, eyedrops tobramycin BD and Nepalact TDS, and further debridement of the site. FESS was done followed by segmental maxillectomy of the right side [Table/Fig-11]. Amphotericin B (1.5 mg/kg/day and then to 3 mg/kg/day for 3 weeks) was given and after 18 days, the patient got discharged with an improved condition. Resolution of complaints was observed at the end of 28 days. The wound healing was satisfactory with healthy granulation tissue [Table/Fig-12]. The patient was followed-up for three months and remained asymptomatic.



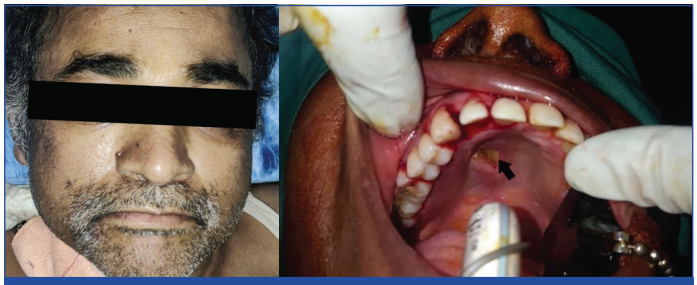
[Table/Fig-11]: Intraoperative picture showing segmental maxillectomy of the right-side; **[Table/Fig-12]:** Postoperative picture showing closure. (Images from left to right)

Case 5

A 48-year-old male patient who had recovered from COVID-19 presented to us with the primary complaint of pain and swelling in the midface region [Table/Fig-13]. He was in excruciating pain and numbness in the right and left midface regions. He was diagnosed with diabetes mellitus three years ago and was on medication for it.

The patient was infected with COVID-19 eight months back. He stated that he had been in the Intensive Care Unit for 5 days after testing positive for COVID-19 infection, and he was started on Inj. remdesivir i.v. with a loading dose of 200 mg, followed by 100 mg daily for 15 days. Methylprednisolone was administered intravenously at a rate of 80 mg per day for 18 days. In addition, Inj. dexamethasone 4 mg twice daily was given for 12 days to treat COVID-19 infection.

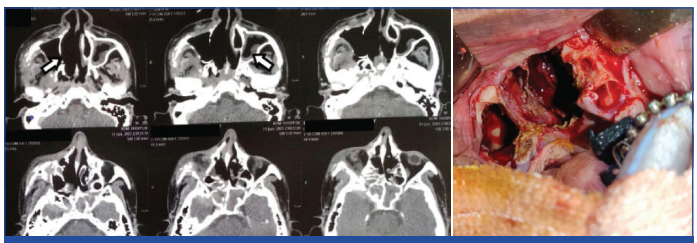
On presentation, the patient was febrile. Intraorally, yellowish discoloration of the mucosa of the right palate with necrotic bone [Table/Fig-14] was observed along with bad breath. It was provisionally diagnosed as post COVID fungal infection and was advised for a CT scan.



[Table/Fig-13]: Clinical picture showing midface swelling; **[Table/Fig-14]:** Intraoral picture revealing necrotic bone on the right side of the hard palate. (Images from left to right)

Mucosal thickening was found in the bilateral maxillary, sphenoid, and ethmoidal sinuses, as well as partial obliteration of the fronto-ethmoidal recess on the right side, and thinning of the right maxillary sinus wall with ill-defined soft tissue thickening in the premaxillary region, according to patient's CT scan [Table/Fig-15].

The patient underwent subtotal maxillectomy of both sides and debridement of bilateral maxillary sinus along with the extraction of the loosened tooth [Table/Fig-16]. FESS was done. The specimen was sent for histopathological diagnosis. Necrotic areas showed colonies of broad, non septate hyphae suggestive of mucormycosis.



[Table/Fig-15]: A CT scan showing thinning of the wall of the right maxillary sinus; **[Table/Fig-16]:** Intraoperative picture showing subtotal maxillectomy of both sides. (Images from left to right)

The diffuse opacification of the bilateral sphenoid, ethmoid, and maxillary sinuses was reduced after one week of treatment with intravenous amphotericin-B antifungal therapy (2-3 mg/kg/day). Other parameters were taken care of while the clinical signs decreased. He was discharged after 14 days with satisfactory wound healing. The patient was followed-up for three months and has healed uneventfully.

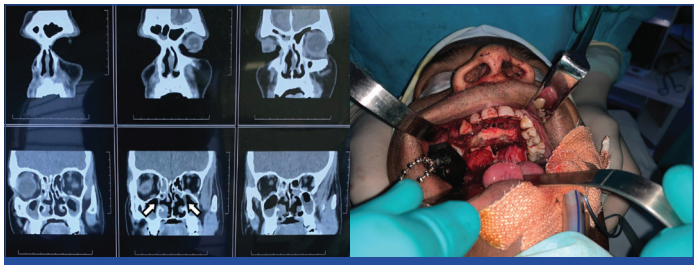
Case 6

The main complaint of a 65-year-old man, who reported to institution was swelling and extreme discomfort in the right side of his face that extended to his eye, as well as acute toothache in the upper right premolar region. The patient had a history of uncontrolled non insulin dependent DM for 15 years and was also hypertensive since 13 years for which he was under medication. He revealed a history of developing fever and partial blockage of his right nostril two weeks back.

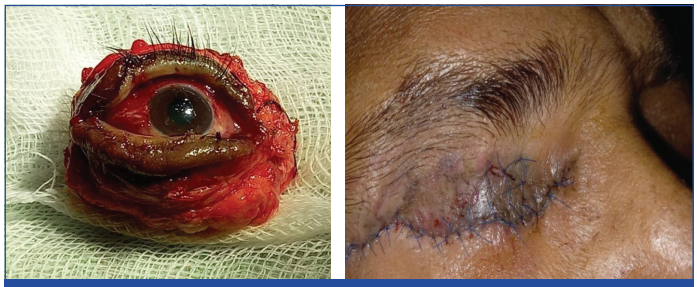
He tested positive COVID-19 for four months back and was admitted to the intensive care unit and cured with a tapering dose of Inj. prednisone 40 mg i.v. for 11 days. He was discharged after testing negative for the same. On presentation, his FBS was 220 mg/dL.

Clinical examination showed a febrile, fully conscious patient with mild right orbital swelling and paraesthesia of the right infraorbital nerve. Severe ptosis was observed over the right eye along with orbital oedema. Intraoral examination revealed a tender swelling of the upper right buccal mucosa with black necrotic gingival tissue and areas of necrotic bone extending from the extraction site to the adjacent teeth. Additionally, the gingival necrosis had started to involve the adjacent palatal mucosal. Biopsy samples were taken for histopathological diagnosis. A CT scan exhibited a clear obliteration of the right and left maxillary sinus [Table/Fig-17].

Samples were sent and the histopathology diagnosis was positive for mucormycosis. Upon confirmation of the diagnosis of mucormycosis, the patient was in progress on intravenous liposomal amphotericin-B 2 mg/kg/day. Patient gave consent for surgical debridement under general anaesthesia. FESS was done. The surgical debridement involved curettage of all necrotic tissues, and partial maxillectomy [Table/Fig-18]. Along with right eye exenteration [Table/Fig-19] and sutured with nylon sutures [Table/Fig-20].



[Table/Fig-17]: A CT scan showing clear obliteration of the right and left maxillary sinus; **[Table/Fig-18]:** Picture showing necrosed palatal bone. (Images from left to right)



[Table/Fig-19]: Picture showing exenterated right eye; **[Table/Fig-20]:** Postoperative picture showing closure. (Images from left to right)

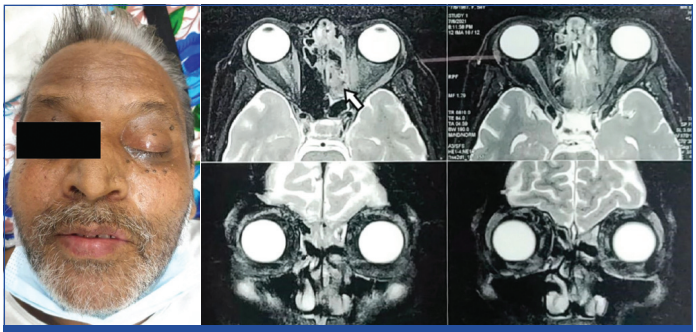
For the next few days, the patient was stable and the sinus was continuously irrigated with 0.2% chlorhexidine antiseptic mouth wash, 3% hydrogen peroxide solutions, and the pack was habitually changed every 10 days for 3 weeks. Monocef 1 g/12 hourly was added to the pre-existing regime. He was discharged from the hospital after uneventful healing of the wound but developed extensive pneumonia with respiratory distress and expired due to the same after one month of treatment.

Case 7

A 69-year-old male presented to the Department of Oral and Maxillofacial Surgery complaining of a foul odour from his mouth for two weeks, as well as swelling and pain on the left side of his face. He was diabetic for 12 years and hypertensive for 10 years and under medication for the same. He tested positive for COVID-19 infection four months back. He gave history of developing severe hypoxia due to the same and was kept on a ventilator. He received tocilizumab and prednisone (details of dosage unknown).

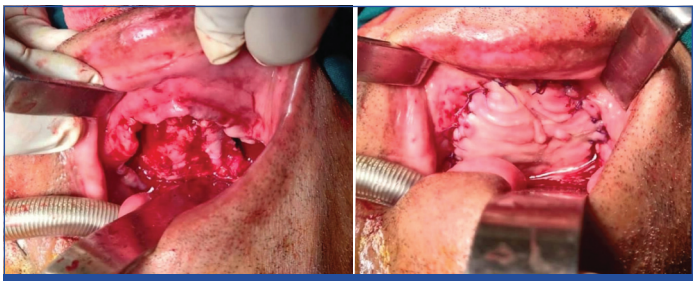
On general examination, the patient was febrile with orbital oedema and ptosis of the left eye [Table/Fig-21]. On intraoral examination, pus discharge with soft tissue necrosis over the left and right maxillary alveolus. The presence of non vital bone, necrotic fibrous connective tissue, foreign material, and flattened, broad, wide angle hyphae was revealed in incisional biopsy of both maxillary alveolar ridges, suggestive of mucormycosis.

A facial and brain MRI revealed mucolytic and destructive foci involving the left and right maxilla, as well as the posterior aspect of the left nasal bone [Table/Fig 22]. The left maxillary sinus was obliterated, and the midface was swollen, according to a facial CT scan.

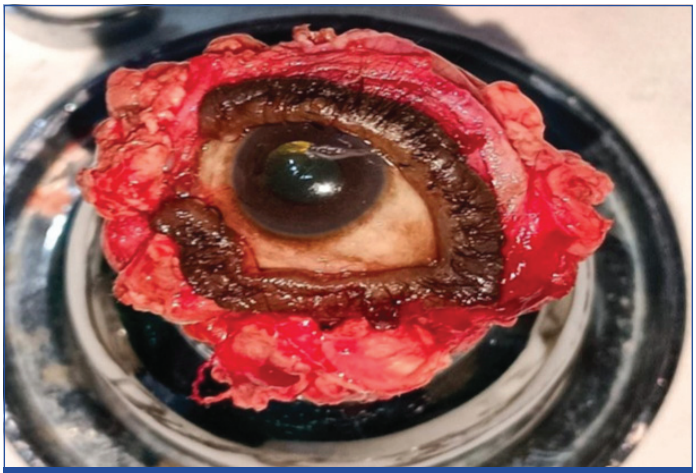


[Table/Fig-21]: Clinical picture showing ptosis of the left eye; **[Table/Fig-22]:** A MRI revealing destructive foci involving the left nasal bone. (Images from left to right)

The clinical and radiographic findings suggested rhino-orbito-cerebral mucormycosis. The patient was admitted to the hospital after the diagnosis was confirmed, and his blood sugar was monitored by the doctor. Under general anaesthesia, functional endoscopic sinus surgery (FESS) and a total maxillectomy were performed [Table/Fig-23] and closure obtained with 3-0 polyglactin 910 sutures [Table/Fig-24]. Left eye exenteration was also performed [Table/Fig-25] and sutured with 5-0 nylon sutures.



[Table/Fig-23]: Complete total maxillectomy; **[Table/Fig-24]:** Postoperative picture showing closure. (Images from left to right)



[Table/Fig-25]: Exenterated left eye.

For 22 days, the patient received i.v. amphotericin B as an infusion of 1 mg/kg/day in 100 mL of 5% dextrose over one to two hours, with daily monitoring of kidney function and electrolyte levels. After satisfactory wound healing, the patient was discharged one month postoperatively. He was being followed-up for six months and was asymptomatic. The clinical profile, management, and outcome of all the seven cases treated at our institute with mucormycosis following COVID-19 infection have been summarised in the [Table/Fig-26].

Variables	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Age (years)	52	58	60	56	48	65	69
Gender	M	M	M	M	M	M	M
Co-morbidities	DM	DM, HTN, ICM, ESRD	DM	DM, CAD	DM	DM, HTN	DM, HTN
Duration of diabetes mellitus (years)	7	12	6	8	3	15	12
FBS at presentation (mg/dL)	350	420	250	200	180	220	280
HbA1c	9.5	11	NA	NA	NA	NA	7.6
COVID-19 treatment with corticosteroids (Tapering doses of Dexamethasone (DMS) 6 mg/ Prednisone (PS) 40 mg)	Yes DMS	Yes PS	Yes NA	Yes NA	Yes DMS	Yes PS	Yes PS
Remdesivir/ Tocilizumab	Yes Both	Yes R	Yes Both	Yes R	Yes R	No	Yes T
Duration between COVID-19 and mucormycosis infection (months)	2	1	5	6	8	4	4
FESS	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Duration of follow-up (months)	7	4 days	2	3	3	1	6
Life salvage	Yes	No	Yes	Yes	Yes	No	Yes
Eye salvage	No	No	Yes	Yes	Yes	No	No
Mucormycosis	Proven	Proven	Proven	Proven	Proven	Proven	Proven

[Table/Fig-26]: The clinical profile, management, and outcome of patients with mucormycosis following COVID-19 infection.
ESRD: End-Stage Renal Disease; CAD: Coronary Artery Disease; DMS: Dexamethasone; PS: Prednisone; R: Remdesivir; T: Tocilizumab

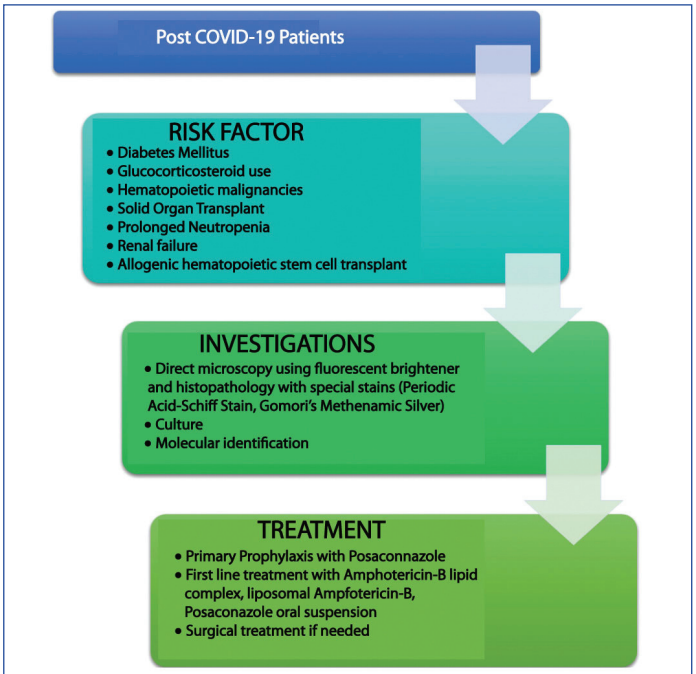
DISCUSSION

Mucormycosis is a fulminant opportunistic infection caused by fungi from the order Mucorales and the family Mucoraceae [4]. This is particularly observed in neonates, those with wounds caused by surgery, trauma, and burns [5]. It has always been known to affect immunocompromised individuals mostly those with uncontrolled diabetes and with the current scenario, the incidence of concurrent mucormycosis in post COVID-19 infected individuals has significantly amplified [1].

The COVID-19 is a pandemic and substantial problem worldwide. It showed an improved survival rate with antiviral drugs and systemic glucocorticoids [6]. But, the frequent use of systemic glucocorticoids might exacerbate glucose homeostasis that makes the patient immunocompromised and can lead to secondary bacterial or fungal infections, such as mucormycosis [7]. Corticosteroid use is a significant risk factor for opportunistic mycoses such as mucormycosis [7].

Mucormycosis usually occurs in immunocompromised individuals but can also infect healthy individuals [8]. Some of the predisposing factors are uncontrolled diabetes, malignancies, end-stage renal disease, cirrhosis, organ transplantation, corticosteroid and immunosuppressive therapy, burns, malnutrition, and acquired immune deficiency syndrome [8-12]. According to evidence, SARS-CoV-1 causes pancreatic islet damage, resulting in acute diabetes and diabetic ketoacidosis. [13] As there is a high expression of angiotensin-converting enzyme-2 receptors in pancreatic islets, as well as increased insulin resistance due to cytokine storm, this is a likely elucidation for the "diabetogenic state" in SARS-CoV-2 infection [14]. Recently, euglycaemic DKA is additionally reported in COVID-19 patients [15]. COVID-19 infection caused sequestration of CD4+ T-lymphocytes in the reticuloendothelial system and inhibited the transcription of cytokines leading to immunosuppression [16].

Song G et al. noted in a review that fungal infections are more likely to develop during the middle and later stages of COVID-19 infection, and hence, they developed guidelines for the diagnosis and treatment of mucormycosis in COVID-19 patients [Table/Fig-27] [17].



[Table/Fig-27]: Guidelines for diagnosis and treatment of mucormycosis in patients with COVID-19 (Modified from Song G et al., [17]).

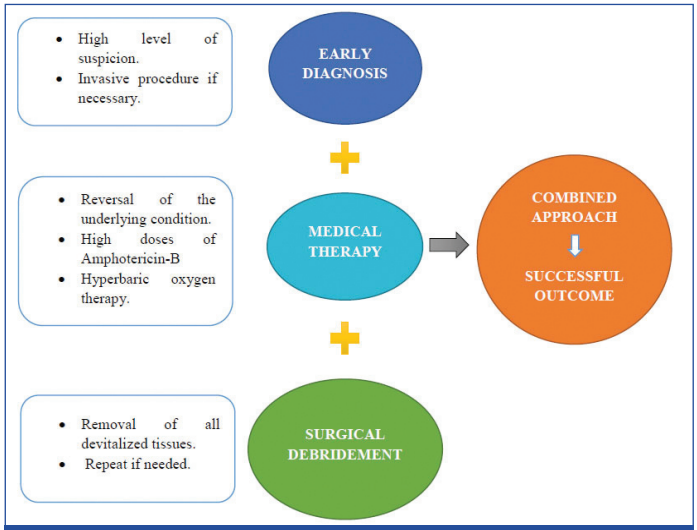
The rate of secondary infection during hospitalisation in COVID-19 patients (bacterial and fungal) has been reported to be 8% [18,19]. The mortality rate is also greater amongst the patients of COVID-19 with secondary fungal infection i.e., mortality rate of 53% observed in patients with invasive fungal infection and 31% in patients without the presence of any fungal disease [18]. It's mortality rate is very high despite antifungal therapy [17-19].

The individuals treated at our institute were COVID-19 positive a couple of months back and treated with corticosteroids. Mucormycosis appears to be the node of COVID-19 and poorly controlled DM. The primary reason for the Mucorales spores' ability to germinate in COVID-19 infected individuals is an ideal environment of low oxygen (hypoxia), acidic medium (diabetic ketoacidosis), high glucose (diabetes, new-onset hyperglycaemia, steroid-induced hyperglycaemia), elevated iron levels (increased ferritins), and diminished phagocytic activity of white blood cells (WBC) owing to immunosuppression (SARS-CoV-2 mediated, steroid-mediated or background co-morbidities) and the reduced amounts of T-lymphocytes, CD4+T, and CD8+T cells (altered innate immunity) [20], on top of several other risk factors including prolonged hospitalisation with or without ventilators [1]. Not only long-term use of corticosteroids has been associated with opportunistic fungal infections such as aspergillosis and mucormycosis, but lately, even a short course of corticosteroids has been reported to link with mucormycosis, especially in people with DM [1]. Corticosteroids causes damage to neutrophil migration, ingestion, and phagolysosome fusion. The probable effects of steroid induced hyperglycaemia make the diabetic COVID-19 individuals vulnerable to the development of mucormycosis [16,21]. A cumulative dose of prednisone of greater than 600 mg or a total dose of 2-7 g of methylprednisone predisposes immunocompromised people to mucormycosis [22]. There are also a few case reports of mucormycosis resulting from a short course of steroid therapy (5-14 days), particularly in people with DM.

Mucormycosis management is a huge challenge that is based on various approaches that includes rapid diagnosis, removal or reduction of risk factors, rapid and aggressive antifungal therapy with or without surgical debridement, and finally, adjuvant therapies [23]. There are ample findings in relation to mucormycosis but it needs a

relook when associated with COVID-19 pandemic and its treatment with corticosteroids for the reason that there has been a significant increase in case reports/series of mucormycosis in people with COVID-19, particularly in India and other parts of the world. [1] Because of the high fatality rate of mucormycosis, these findings are exceptional and of enormous public health significance, [1], and the intracranial involvement of mucormycosis has increased the fatality rate to 90% [24].

Hence, the early definitive diagnosis should be made by clinical manifestation of the disease, HPE of infected tissues, culture tests, and radiographic features. Prompt medical therapy and extensive surgical debridement of all the devitalised tissue can only leads to a successful outcome [Table/Fig-28] [23]. Amongst the patients we encountered, 5 out of 7 of them survived uneventfully.



[Table/Fig-28]: Combined Approach in the treatment of Mucormycosis (Modified from Spellberg B et al., [23]).

CONCLUSION(S)

This report described a series of seven cases with the hope of outlining the early diagnosis of post-coronavirus disease associated mucormycosis in individuals with uncontrolled diabetes and immunosuppression, the necessary investigations, and the treatment protocol for the successful management of post-coronavirus disease associated mucormycosis in individuals with uncontrolled diabetes and immunosuppression. It also brings into light the predisposing factors for COVID-19 infected patients that make them susceptible to mucormycosis. The sudden surge in the cases of this opportunistic infection prompted us to collaborate the cases encountered by us and help the clinicians to get aware of the possibility of mucormycosis, especially in individuals with underlying co-morbidities. Because of the invasive nature of the common underlying malignancy, morbidity and mortality from this infection are high; therefore, early diagnosis and treatment of secondary fungal infections are critical for early and appropriate management.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Apr 27, 2021
- Manual Googling: Jul 19, 2021
- iThenticate Software: Oct 09, 2021 (10%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Apr 25, 2021**
Date of Peer Review: **Jun 19, 2021**
Date of Acceptance: **Jul 26, 2021**
Date of Publishing: **Nov 01, 2021**