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Research Article

# Clinical and Ophthalmic Characteristics, Treatment, and Outcomes of COVID-19–Associated Mucormycosis: A Two Center Retrospective Cohort Study


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Abstract: The severe opportunistic fungal infection known as COVID-19-associated mucormycosis can cause extensive sinonasal, orbital, and intracranial illness, leading to significant morbidity and mortality. This study assessed the clinical results, ocular outcomes, clinical symptoms, and demographics of patients with COVID-19-associated mucormycosis. The objective is to assess the clinical features, ocular symptoms, treatment approaches, and clinical results of patients with COVID-19-associated mucormycosis treated in Erbil, Iraq, between January 2021 and August 2025, with a focus on visual outcomes and blindness. ***Methods***: From January 2021 to August 2025, 27 patients treated in Erbil, Iraq, with verified COVID-19 and histopathologically confirmed mucormycosis were included in this retrospective cohort analysis. Medical records were examined for demographic information, comorbidities, corticosteroid exposure, anatomical involvement, presenting symptoms, visual acuity, treatment, and clinical outcomes. ***Results***: Twenty patients (74.1%) were male, and the average age was 54.0 ± 12.43 years (range, 25–75 years). 16 patients (59.3%) had diabetes mellitus, and 23 patients (85.2%) had previously been exposed to corticosteroids. 26 patients (96.3%) had sinonasal involvement, 22 (81.5%) had orbital involvement, 16 (59.3%) had ophthalmoplegia, and six (22.2%) had central nervous system involvement. Twenty-five patients (92.6%) experienced both facial pain and facial numbness. 16 patients (59.3%) did not see light at the time of presentation. Nineteen patients (70.4%) had documented blindness at the time of the final evaluation: eleven had left-eye blindness, seven had right-eye blindness, and one had bilateral blindness. Five patients (18.5%) had orbital exenteration. In total, five patients (18.5%) died, one patient (3.7%) was lost to follow-up, and 21 patients (77.8%) showed clinical improvement. Five (83.3%) of the six patients with central nervous system involvement recovered, while one (16.7%) passed away. ***Conclusion***: Frequent sinonasal and orbital involvement, significant visual impairment, and significant mortality were the hallmarks of COVID-19-associated mucormycosis in this population. Final blindness persisted despite the fact that the majority of individuals had clinical improvement. These results emphasize the serious ocular effects of the condition and the significance of multimodal treatment and early detection.



**Keywords:** Blindness; central nervous system; COVID-19; mortality; mucormycosis; rhino-orbital mucormycosis; visual acuity.


## INTRODUCTION

Mucormycosis is a rare but potentially life-threatening infection that is caused by fungi of the Mucorales order. Thrombosis, ischemia, and tissue necrosis can be caused by the invasion of blood vessels by these organisms. Predisposing conditions include malignancy, organ transplantation, and immunosuppressive treatment, particularly when glycemic control is poor or ketoacidosis is present, as well as diabetes mellitus. [1–3]

The COVID-19 pandemic resulted in a greater awareness of mucormycosis-associated conditions due to the rise in reported cases. Potential contributing factors include metabolic disturbance, hyperglycemia, immune dysregulation associated with COVID-19, and systemic corticosteroid exposure. Diabetes and corticosteroid treatment have been frequently documented in published CAM cohorts. [4–6]

The sinonasal tract is a frequent site of disease, and it has the potential to spread to the central nervous system and orbit. Mucorales' angioinvasive behavior can facilitate rapid extension into adjacent orbital structures and neurovascular tissues, resulting in rhino-orbital or rhino-

orbital-cerebral disease. [5–8] Orbital disease is of particular concern due to the potential for reduced vision, proptosis, ophthalmoplegia, pupillary abnormalities, optic nerve dysfunction, orbital apex involvement, and complete visual loss. The ophthalmic series of CAM that have been published have described significant ocular morbidity and have emphasized the importance of early ophthalmic evaluation and a meticulous assessment of the disease's extent[10]

It is imperative to provide prompt diagnosis and treatment, as delay can result in tissue necrosis, intracranial extension, permanent visual impairment, or death. Liposomal amphotericin B is generally preferred when available, and international guidance supports urgent assessment, surgical debridement when practicable, and systemic antifungal therapy. Squared

Despite the fact that the 2021 outbreaks documented the highest burden of COVID-19–associated mucormycosis, cases continued to be documented in subsequent years. Consequently, our investigation, which spans the years 2021–2025, provides supplementary information regarding the clinical manifestations and consequences of this severe opportunistic infection that extends beyond the peak outbreak period.

## MATERIALS AND METHODS

This retrospective cohort study through January 2021 and August 2025, includes patients with COVID-19–associated mucormycosis (CAM) who were treated at Rizgary Teaching Hospital and selected private hospitals in Erbil, Iraq. The objective of the study was to provide a comprehensive description of the demographic characteristics, predisposing factors, anatomical distribution, ophthalmic manifestations, management, and clinical outcomes of patients who were impacted.

Patients who had histopathologically confirmed mucormycosis and documented COVID-19 infection were included in the study. The COVID-19 status was determined by analyzing available medical records, which included SARS-CoV-2 reverse transcription polymerase chain reaction (RT-PCR) results when available. The diagnosis of mucormycosis was verified through histopathological examination of biopsy specimens. Patients with suspected but unconfirmed. Mucormycosis or inadequate documentation of the principal study variables were excluded.The study's final cohort consisted of 27 patients.

Data were collected using a structured data-collection form to extract data retrospectively from hospital records. Age, sex, diabetes mellitus, malignancy, corticosteroid exposure, anatomical sites of involvement, ophthalmic manifestations, surgical procedures, antifungal treatment, and clinical outcomes were all variables.

The documented clinical, radiological, operative, and histopathological findings were used to classify anatomical involvement. The sinonasal region, orbit, central nervous system (CNS), lungs, hard palate, facial nerve, tonsils, and other documented sites were all evaluated. Blindness and ophthalmoplegia were among the ophthalmic manifestations. These categories were not regarded as mutually exclusive due to the potential for individual patients to have involvement of multiple anatomical sites.

Ophthalmic findings were derived from clinical notes, imaging reports, operative records, and ophthalmology assessments that were accessible. Visual status was evaluated separately during the presentation and at the final documented follow-up.
Blindness was defined in this study as blindness that was explicitly documented in the medical record. Laterality was categorized as bilateral blindness, right-eye blindness, or left-eye blindness. The patients were categorized based on their documented status at presentation and their final recorded visual outcome. Orbital exenteration was recorded as a surgical outcome and was not used as a sole criterion for blindness.

Surgical debridement, other documented surgical procedures, and systemic antifungal therapy were among the treatment details that were extracted from the medical records. Surgical management and liposomal amphotericin B comprised the documented treatment regimen. Amphotericin B liposomes were administered to the majority of patients at a dosage of 3–5 mg/kg/day for a period of approximately one month. The liposomal amphotericin B was administered to all six patients with central nervous system (CNS) involvement at a dosage of 10 mg/kg/day for a period of approximately two months. Posaconazole was subsequently administered for a period of one to three months, with the duration determined by clinical assessment and C-reactive protein (CRP) trends as documented in the medical records.
The final available medical record was used to classify the principal clinical outcomes as clinical improvement, death, or loss to follow-up. Blindness and orbital exenteration were assessed as distinct ophthalmic outcomes. No comparative treatment-effectiveness analysis was conducted, as all patients received surgical treatment and the same reported initial antifungal regimen.

The statistical analysis was performed using SPSS version 25. Means and standard deviations or ranges were employed to summarize continuous variables, as appropriate. The denominator was the total cohort of 27

patients, and categorical variables were presented as frequencies and percentages.

Given the small sample size and potentially low expected cell counts, Fisher's exact test was employed to evaluate any comparisons between categorical variables when it was appropriate. The significance threshold was set at P <.05. All statistical tests were two-sided. The limited sample size necessitated a cautious interpretation of analyzes that involved mortality, blindness, and other clinical outcomes. Unless the actual statistical output was supported, no association was deemed statistically significant.

data collection was started after obtaining The Ethics Committee of the Kurdistan Higher Council of Medical Specialties approval for the study (number issued in). Verbal informed consent was obtained from patients or their legal guardians, as indicated by the study records. The study dataset and manuscript were devoid of any identifying information, and patient confidentiality was preserved during data collection and analysis.

## RESULTS

The mean age of the 27 patients was 54 years (range 25 to 75 years) and the majority were men (74.1%). Diabetes was present in 59.3% and 85.2% had received corticosteroids. Sinonasal involvement was common (96.3%) and orbital involvement was seen in 81.5%. Six (22.2%) patients had CNS involvement, and five (18.5%) underwent orbital exenteration. (Table 1)

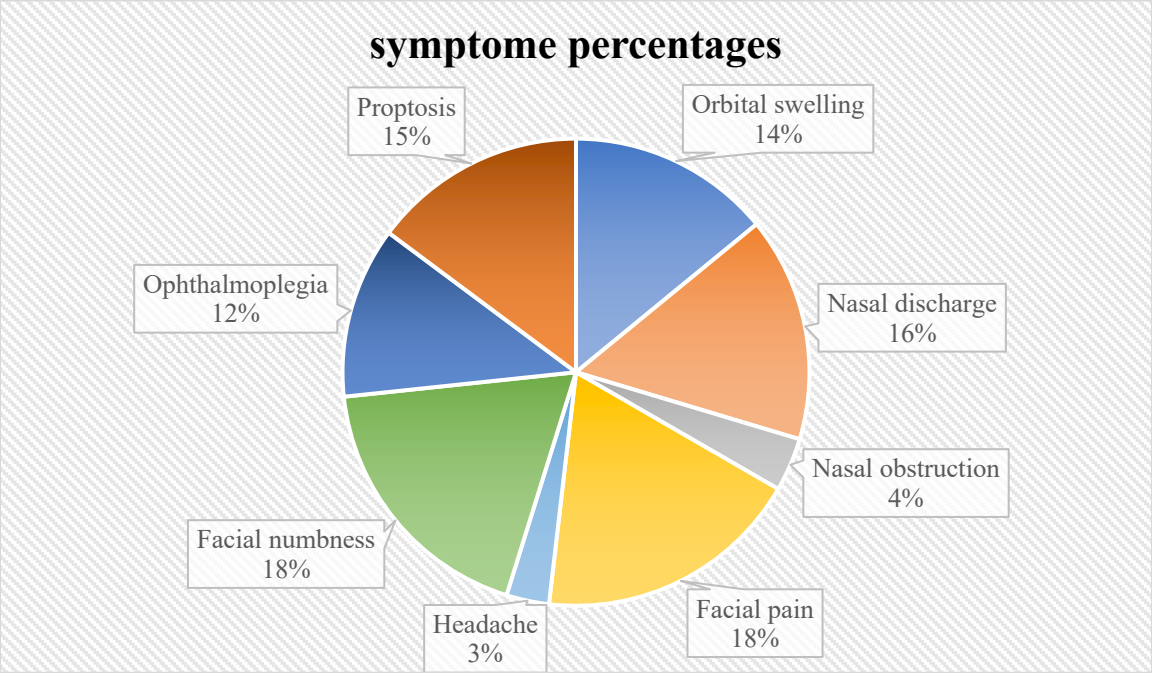
**Table 1. Demographic characteristics and clinical manifestations of patients with COVID-19–associated mucormycosis (n = 27)**

| Characteristic | Category | n (%) |
|---|---|---|
| Age (years) | Mean ± SD** | 54.0 ± 12.43 |
| | Range | 25–75 |
| Sex | Male | 20 (74.1) |
| | Female | 7 (25.9) |
| Diabetes mellitus | Yes | 16 (59.3) |
| | No | 11 (40.7) |
| Cancer | Yes | 2 (7.4) |
| | No | 25 (92.6) |
| Corticosteroid exposure | Yes | 23 (85.2) |
| | No | 4 (14.8) |
| Sinonasal involvement | Yes | 26 (96.3) |
| | No | 1 (3.7) |
| Orbital involvement | Yes | 22 (81.5) |
| | No | 5 (18.5) |
| Ophthalmoplegia | Yes | 16 (59.3) |
| | No | 11 (40.7) |
| CNS* involvement | Yes | 6 (22.2) |
| | No | 21 (77.8) |
| Pulmonary involvement | Yes | 1 (3.7) |
| | No | 26 (96.3) |
| Hard palate involvement | Yes | 10 (37.0) |
| | No | 17 (63.0) |
| Facial nerve involvement | Yes | 2 (7.4) |
| | No | 25(92.6) |
| Tonsillar involvement | Yes | 1 (3.7) |
| | No | 26(96.3) |
| Orbital exenteration | Yes | 5 (18.5) |
| | No | 22 (81.5) |

*Central nervous system, **standard deviation

Facial pain and numbness were the most common symptoms among 27 patients (25; 92.6% each), followed by nasal discharge (21; 77.8%), proptosis (20; 74.1%), orbital swelling (19; 70.4%), and ophthalmoplegia (16; 59.3%). Least common were headache (4; 14.8%) and nasal obstruction (5; 18.5%). Fig. 1.

***Figure 1. Distribution of reported symptoms among patients (%).***



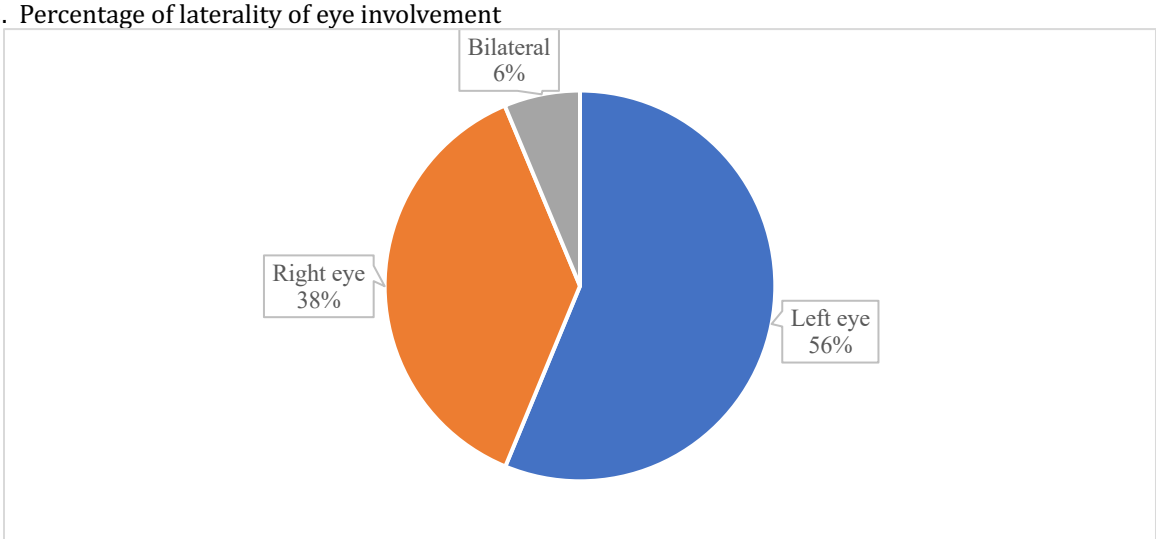

Among 27 patients, 16 (59.3%) had no light perception (NLP). Four patients (14.8%) had vision worse than 20/40 to 20/200, and 3 (11.1%) had fair vision on bedside assessment. Light perception and visual acuity of 20/40 or better were each recorded in 2 patients (7.4%). Table 2

**Table 2: Visual acuity among patients (n = 27)**

| **Visual acuity category** | **n (%)** |
|---|---|
| 20/40 or better | 2 (7.4%) |
| Worse than 20/40 to 20/200 | 4 (14.8%) |
| Fair vision on bedside assessment | 3 (11.1%) |
| Light perception (LP) | 2 (7.4%) |
| No light perception (NLP) | 16 (59.3%) |
| **Total** | **27 (100.0%)** |

Sixteen patients were blind at presentation; nine (56.3%) were blind in the left eye, six (37.5%) were blind in the right eye, and one (6.3%) was blind in both eyes. Figure 2.

Figure 2. Percentage of laterality of eye involvement



Documented blindness was reported in 19 patients (70.4%); 8 (29.6%) had no documented blindness. Table 3

**Table 3. Documented visual outcome (n = 27)**

| **Visual outcome** | n(%) |
|---|---|
| No documented blindness | 8 (29.6) |
| Documented blindness | 19 (70.4) |
| Total | 27 (100.0) |

Blindness was seen in 11 patients (57.9%) in the left eye, 7 (36.8%) in the right eye, and 1 (5.3%) in both eyes. Table 4

**Table 4: Laterality among patients with documented final blindness (n = 19)**

| **Laterality** | n(%) |
|---|---|
| Left eye | 11(57.9) |
| Right eye | 7 (36.8) |
| Bilateral | 1(5.3) |
| Total | 19 (100.0) |

Clinical improvement was observed in 21 patients (77.8%), 5 patients (18.5%) died and 1 patient (3.7%) was lost to follow up. Table 5.

**Table 5: Overall clinical outcomes (n = 27)**

| **Clinical outcome** | n(%) |
|---|---|
| Clinical improvement | 21 (77.8) |
| Death | 5 (18.5) |
| Lost to follow-up | 1 (3.7) |
| Total | 27 (100.0) |

Clinical improvement was seen in 5/6 patients with CNS involvement (83.3%) and 16/21 patients without CNS involvement (76.2%). Death was observed in 1 patient (16.7%) with CNS involvement and 4 (19.0%) without CNS involvement. One patient without CNS involvement was lost to follow-up. Table 6

**Table 6: Clinical outcomes by CNS involvement**

| **CNS involvement** | **Improved, n (%)** | **Death, n (%)** | **Lost to follow-up, n (%)** | **Total** |
|---|---|---|---|---|
| No | 16 (76.2) | 4 (19.0) | 1 (4.8) | 21 |
| Yes | 5 (83.3) | 1 (16.7) | 0 (0.0) | 6 |
| Total | 21 (77.8) | 5 (18.5) | 1 (3.7) | 27 |

The most commonly performed procedure was orbital decompression (10 patients, 37.0%), followed by total maxillectomy (9, 33.3%) and orbital exenteration (5, 18.5%). Medial maxillectomy data not collected

**Table 7. proportion of surgical procedures performed**

| **Surgical procedure** | **n (%)** |
|---|---|
| Medial maxillectomy without hard palate involvement | Not recorded |
| Total maxillectomy with hard palate involvement | 9 (33.3%) |
| Infra-alveolar maxillectomy with hard palate involvement | 1 (3.7%) |
| Orbital decompression | 10 (37.0%) |
| Bilateral middle turbinate resection in patients with leukemia | 1 (3.7%) |
| Unilateral middle turbinate resection in patients with leukemia | 1 (3.7%) |
| Orbital exenteration | 5 (18.5%) |

## DISCUSSION

In this retrospective study, we aimed to evaluate the clinical features, ophthalmic manifestations, treatment, and outcomes of 27 histopathologically confirmed cases of COVID-19-associated mucormycosis (CAM) in Erbil, Iraq. Sinonasal disease was present in 26 patients (96.3%), orbital involvement in 22 (81.5%) and ophthalmoplegia in 16 (59.3%). Also common were

diabetes mellitus and exposure to corticosteroids. Visual impairment was significant; at presentation 16 patients (59.3%) had no light perception and at final assessment documented blindness was seen in 19 (70.4%). Clinical improvement was noted in 21 patients (77.8%) and death was noted in 5 patients (18.5%). The results show that systemic improvement and visual outcome are different end points, and recovery from infection does not ensure vision preservation.

Sixteen patients (59.3%) were diabetic mellitus and 23 patients (85.2%) had a history of corticosteroid exposure. Diabetes, especially with poor glycemic control or ketoacidosis, is a well-known risk factor for mucormycosis. Metabolic disturbances can compromise host immune responses and allow fungal growth. In addition, immune dysregulation related to COVID-19 and immunosuppression from corticosteroids may predispose to invasive fungal infections. Similar risk factors have been reported in published series of CAM. [4]–[8] However, the presence of diabetes and corticosteroid exposure in this cohort do not prove that either factor alone was responsible for infection or contributed to blindness. The study did not have a control group and detailed information on corticosteroid dose, duration, timing and glycemic control was not available, so individual effects could not be determined.

The predominance of sinonasal involvement, together with orbital disease in 22 patients (81.5%), reflects the recognized pattern of rhino-orbital mucormycosis. Mucorales can invade blood vessels, leading to thrombosis, reduced blood flow, ischemia, and tissue necrosis. The infection may extend from the sinonasal region into the orbit, orbital apex, optic nerve, extraocular muscles, and neighboring neurovascular structures. [5]–[10]

Ophthalmoplegia occurred in 16 patients (59.3%) and may reflect involvement of the extraocular muscles, cranial nerves, or orbital apex. CNS involvement was identified in six patients (22.2%), indicating that the disease extended beyond the sinonasal region in a subset of this cohort. Such anatomical spread is clinically important because involvement of the optic nerve, orbital apex, or intracranial structures can threaten vision and may complicate treatment. Previous ophthalmic studies of CAM have likewise emphasized the substantial ocular morbidity associated with this infection. [9], [10]

At presentation 16 (59.3%) patients had recorded blindness, increasing to 19 (70.4%) at last recorded assessment. The difference reflects that a greater proportion of patients were assessed as blind at the last assessment. The overall numbers do not show how many went newly blind during the follow-up period. We would need to use patient-level records to track changes in visual status over time for each eye. There are several mechanisms for severe or progressive loss of vision in mucormycosis. The fungus is angioinvasive and may cause vascular thrombosis and interruption of blood supply to the retina, optic nerve and orbital tissues. Even after antifungal therapy and surgical debridement are begun, ischemic injury and necrosis may continue. Second, infection can spread to the orbital apex or optic nerve, causing optic neuropathy, abnormal eye movement, and severe visual impairment. Thirdly, between the first and the next examination the infection may spread rapidly, causing further tissue destruction.

The timing of presentation and treatment may also be relevant. Delayed recognition of an aggressive invasive fungal infection can allow disease to extend into critical structures before definitive management is established. However, because treatment delays were not specifically analyzed in this study, they cannot be identified as the cause of blindness in these patients.

The reversibility of the visual impairment may also differ. In some patients, inflammation, edema, or congestion may be responsible for impaired vision, whereas vascular occlusion, optic nerve infarction, and extensive tissue necrosis are less likely to recover. Other factors that may affect host responses or disease severity include diabetes, hyperglycemia, corticosteroid exposure, and malignancy, but their independent relationships with blindness could not be assessed in this limited cohort. These explanations are consistent with the known pathophysiology of mucormycosis, but the mechanisms responsible for visual loss in individual patients were not established by the current data. [1], [9]–[11], [16]

Five patients (18.5%) underwent orbital exenteration, reflecting the need for extensive surgical management in some cases. However, exenteration should still be interpreted separately from the visual outcome; it is a surgical procedure and should not be counted as an additional case of blindness without confirmation from the patient-level records.

At presentation, 16 patients (59.3%) had no light perception and the other patients had light perception, bedside described fair vision or some measurable visual acuity. At the final visit, documented blindness was observed in 19 patients (70.4%), 11 patients were blind in the left eye, seven patients were blind in the right eye, and one patient was blind in both eyes.

These results show a significant ophthalmic burden. However, the absence of documented blindness should not be automatically interpreted as normal vision or complete visual recovery, especially because standardized final visual-acuity measurements were not

available for every patient. Similarly, without paired patient-level evaluations, the baseline and final blindness counts cannot ascertain individual improvement or worsening.

Future studies should record visual acuity in each eye separately at presentation and at pre-determined follow-up times. Pupillary responses, ocular motility, fundoscopic findings, optic nerve function, and orbital imaging should be systematically documented. Such data would provide a more reliable assessment of the progression, reversibility and long-term effects of visual impairment.

In the treatment records, all patients underwent surgical management in addition to liposomal amphotericin B. Most were reported to have received liposomal amphotericin B at 3 to 5 mg/kg/day for approximately one month, while the six patients with CNS involvement received 10 mg/kg/day for approximately two months. Posaconazole was then administered for approximately 1-3 months depending on clinical judgment and the trend of C-reactive protein as documented in the charts. These details describe the treatment approach used in this cohort; the study design does not allow for comparison of the effectiveness of different doses, treatment durations or step-down regimens. International guidelines support early systemic antifungal therapy and adequate surgical intervention. Liposomal amphotericin B is a valuable first-line option. [1,11]

Surgical procedures were chosen according to the described extent of anatomical disease. Patients without hard-palate involvement were treated with medial maxillectomy and clearance of involved paranasal sinuses. Of the patients with hard palate involvement, nine underwent total maxillectomy and one underwent infraalveolar maxillectomy. Based on the available operative information, orbital decompression was performed in 10 patients to provide access for surgical debridement. Two patients with leukemia underwent middle turbinate resection (unilateral in 1 patient and bilateral in 1 patient) without documented sinonasal or orbital involvement. Orbital exenteration was performed in 5 patients.
The procedures described are representative of the variety of surgical approaches used for the anatomic presentations seen in this group. Nonetheless, the independent contribution of any particular operation to survival or visual outcome is not calculable, as there was no control group and treatment was individualized.

Clinical improvement was observed in 21 patients (77.8%). Five patients (18.5%) died and one patient (3.7%) was lost to follow-up. Sepsis, septic shock and/or multiorgan failure were registered in the causes of death; however, the available information does not allow reliable patient counts for each cause separately.

The mortality observed in this cohort underscores the potentially lethal nature of CAM. But the small number of deaths limits the ability to find dependable predictors of death. CNS subgroup also should be interpreted cautiously: 5 of 6 patients with CNS involvement improved clinically, 1 died. Of course, this descriptive finding should not be interpreted to mean that CNS involvement was associated with a better prognosis, given the small size of the subgroup and the failure to control for potential confounders.

It is important to point out that the rate of clinical improvement observed should not be interpreted as evidence of complete eradication of the fungus or preserved vision. Mortality. Clinical status and visual outcome should be evaluated as separate endpoints.

The present study describes clinically histopathologically confirmed CAM in Erbil, Iraq and reports the anatomical involvement, ophthalmic findings, surgical management and systemic outcomes in the same cohort. The inclusion of cases of patients with documented COVID-19 and proven mucormycosis adds to the clinical relevance of the observations.

Several limitations should be noted. First, the sample was small and recruited from hospitals in one city which might limit the generalizability of the findings. Second, the retrospective design of the study was limited by the quality and completeness of the available medical records. Third, the standardized examinations of ophthalmic and final measurements of visual acuity were not performed on all patients. So, not having a documented blindness does not imply a confirmed normal vision. Also, the difference between blindness at presentation and final assessment does not reflect changes in individual visual status without verified paired records.

The study also lacked a control group, so it did not establish any causal relationships between diabetes, corticosteroid exposure, timing of treatment, surgical procedures and blindness. Finally, the small number of deaths and patients with CNS involvement limit the reliability of subgroup comparisons and prognostic conclusions.

The high frequency of orbital involvement and the large number of patients with documented blindness at final assessment underscore the importance of assessment of visual function independent of overall clinical recovery. Early recognition, early systemic antifungal treatment, early surgical evaluation and coordinated care by

otorhinolaryngology, ophthalmology, infectious diseases, radiology and other relevant specialties remain important in the management of this aggressive infection.

Consistent documentation is also important. Visual acuity should be recorded for each eye separately and rechecked at follow-up. Blindness, orbital exenteration, clinical improvement and mortality should be reported as distinct outcomes. Larger prospective studies with standardized ophthalmic assessments and patient-level follow-up are needed to clarify the factors associated with visual deterioration and recovery.

## CONCLUSION

Blindness was documented in the majority (70.4%) of this 27-patient cohort with COVID-19–associated mucormycosis; 77.8% improved, 18.5% died, and 18.5% underwent orbital exenteration. No cause for the blindness could be found. These findings support early multidisciplinary care, standardized ophthalmic follow-up, and prospective studies on visual outcomes.

**Recommendation**: early multi displinary treatment and regular ophthalmic assessment is recommended for patients with COVID-19 associated mucormycosis.

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