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RESEARCH ARTICLE

Black fungus due to covid-19: audiological assessment of middle ear functioning

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Abstract

Background and Aim: A rare fungal infection, mucormycosis, has become more common in patients recovering from COVID in its second wave in India. The proximity and easy access to the middle ear through the Eustachian tube from paranasal sinuses alarms the need for early detection of middle ear involvement. Hence, the study was carried out to determine the influence of mucormycosis on Immittance and otoacoustic emissions.

Methods: eleven rhino orbital mucormycosis patients aged 40-60 years participated in the study. Middle ear evaluation was carried out with the help of Immittance and otoacoustic emissions.

Results: It was found that 4/11 (36.36%) participants had abnormal Immittance and absent otoacoustic emissions, indicating middle ear dysfunction. 3/4 participants had middle ear dysfunction in the ear ipsilateral to the side of the infection.

Conclusion: The study results reveal a rare chance of middle ear involvement in mucormycosis patients, which calls for the crucial role of the audiologist in the early detection of middle ear dysfunction.

Keywords: Mucormycosis; immittance; otoacoustic emissions

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Introduction

The human auditory system can get damaged by a number of viral or fungal infections, which cause hearing loss. Certain infections can directly damage inner ear structures, and others can induce inflammatory responses to middle and outer ear structures [1]. Fungal infections are common in the external ear because of their warm, humid environment, which is ideal for the proliferation of fungus [2]. Fungal infections need to be treated vigorously to avoid complications such as hearing loss, tympanic membrane perforations, and invasive temporal bone infection [3]. Long-standing middle ear infections can also lead to permanent sensorineural hearing loss.

One such infrequent fungal infection is mucormycosis which is trending in the name of the black fungus is caused by the fungi of the order mucorales [4]. Individuals with a weak immune system and uncontrolled diabetics are highly susceptible to this infection which initially affects paranasal sinuses majorly and later invades the surrounding tissues, including blood vessels, and damage cranial nerves. Mucormycosis is commonly being found as secondary to COVID infection at their post COVID stage [5]. Intake of corticosteroids for COVID treatment leads to

reduced immunity and increases serum glucose level, making the patient more susceptible tomucormycosis [5].

Since the middle ear and nasal tract are interconnected by the Eustachian tube, there is a high probability of spores invading middle ear structures, leading to conductive hearing loss. Literature provides mucormycosis in the external ear canal and temporal bone, leading to necrotizing otitis externa [6]. There is also evidence of its invasion in the middle ear in diabetic patients and mastoid involvement in the non-diabetic patient [7]. The tympanic cavity has been reported as a new site of involvement for mucormycosis in a case study where facial paralysis has occurred secondary to tympanic mucormycosis [8]. A detailed literature review suggests that, despite its rare involvement of ear-related structures, it can cause a dangerous impact on hearing and ear-related structures. Even though this has some significant complications other than hearing, ignorance of ear involvement can indirectly act as an add-on burden to other severe complications of mucormycosis. Ear-related issues, especially middle ear disorder, need to be ruled out after the primary line of treatment before the patient gets discharged. The role of audiologists in audiological assessments to rule out ear involvement in mucormycosis is well reported in the recent literature, which also states its need very briefly [9]. The type of tympanogram obtained by Immittance audiometry would reveal middle ear status [10], and the presence or absence of stapedial reflex will give an idea about facial nerve status [11]. Otoacoustic emissions (OAEs), especially transient evoked otoacoustic emissions (TEOAEs), would indirectly identify even minimal middle ear dysfunction [12]. Hence, combining OAEs and Immittance audiometry would give a clear picture of middle ear status [13]. The portable instruments for the tests mentioned above would also provide provision for bedside administration. However, many studies have witnessed the rare involvement of the middle outer ear in mucormycosis and have reported the need for a middle ear examination. No studies have demonstrated the Immittance and OAEs findings in mucormycosis patients, which will help determine the middle ear involvement. This study attempts to evaluate patients with mucormycosis with the help of tympanometry and OAEs. Thus, the objectives of the present study were to determine the influence of mucormycosis on tympanometry, reflexometry, otoacoustic emissions and compare these audiological findings between ears in unilateral mucormycosis.

Methods

Participants

The study includes nine patients diagnosed with unilateral rhino orbital mucormycosis and two patients with bilateral involvement. Mucormycosis was diagnosed based on the combined reports of tissue biopsy and CT scan of lungs and sinuses. All the participants were been infected with the COVID-19 and were diagnosed based on positive RT-PCR report and developed high blood sugar levels post COVID infection. The individuals with diabetes mellitus pre COVID infection were excluded from the study. The study also excluded those with a history of otological signs and symptoms before COVID infection. All the participants reported having no hearing loss before the infection. The demographic details of the participants are mentioned in the Table 1.

Procedure

A detailed case history was taken to select the participants with the help of the above-mentioned inclusion and exclusion criteria. Written consent was obtained from all the participants before carrying out the tests. Bedside evaluation was carried out using a portable handheld Immittance meter (Maico-Easytymp Pro) and easy screen otoacoustic emissions (Maico) in a quiet environment. A handheld Immittance meter was used to administer tympanometry, and stapedial reflex for 500 Hz, 1, 2, 4 kHz were recorded for 226 Hz probe tone. Distortion product otoacoustic emissions (DPOAEs) and TEOAEs were recorded in a screening mode using an easyScreen (Maico Diagnostic Gmbh, Germany) otoacoustic emissions instrument. Good probe fit was ensured, and DPOAEs were recorded for

Table 1. Demographic details of the participants considered for the study

Participant	Age	Gender	COVID history	Medical details	Diagnosis
BF_1	50	Male	Present	Post COVID diabetes	Right rhino-orbital mucormycosis
BF_2	53	Female	Present	Post COVID diabetes	Right rhino-orbital mucormycosis
BF_3	51	Male	Present	Post COVID diabetes	Right rhino-orbital mucormycosis
BF_4	48	Male	Present	Post COVID diabetes	Right rhino-orbital mucormycosis
BF_5	40	Female	Present	Post COVID diabetes	Left rhino-orbital mucormycosis
BF_6	50	Male	Present	Post COVID diabetes	Right rhino-orbital mucormycosis
BF_7	60	Female	Present	Post COVID diabetes	Right rhino-orbital mucormycosis
BF_8	45	Female	Present	Post COVID diabetes	Bilateral rhino-orbital mucormycosis (left major involvement)
BF_9	40	Male	Present	Post COVID diabetes	Right rhino-orbital mucormycosis
BF_10	52	Male	Present	Post COVID diabetes	Bilateral rhino-orbital mucormycosis
BF_11	56	Male	Present	Post COVID diabetes	Right rhino-orbital mucormycosis

BF; black fungus

pure tones F1 and F2 at an F2/F1 ratio of 1.22. The F1 and F2 primaries are presented at 65 dB and 50 dB, respectively. The measurement covered the 1.4 kHz to 6 kHz frequency range in four frequency bands. Minimum 6 dB signal to noise ratio or −5 dB SPL otoacoustic emission level in three out of four frequency bands was considered as the presence of DPOAEs. Similarly, TEOAEs were recorded for non-linear click stimulus presented at 83 dB pe SPL transient evoked otoacoustic emissions recording covers a range of frequencies from 1.4 kHz to 4 kHz in four frequency bands. Minimum 4 dB SNR or −5 dB SPL otoacoustic emission level in three out of four frequency bands was considered as the presence of TEOAEs. The test was carried out individually for all the participants' ears, and responses were noted down separately.

In the present study, all the testing procedures were carried out on humans using non-invasive techniques, adhering to the guidelines of the Ethics Approval Committee of the institute. All the procedures were explained to the participants, and informed consent was taken from all the participants of the study.

Results

The type of tympanogram was classified based on the admittance and peak pressure value measured with the Immittance meter [14]. The results revealed that the abnormal tympanogram type and absent reflexes were found in three participants on the ipsilateral side of mucormycosis infection and one on the contralateral side. Both DPOAEs and TEOAEs were absent on three participants in the ipsilateral side of mucormycosis infection and one participant on the contralateral side. It is also observed that otoacoustic emissions were absent only in those individuals/ears who had abnormal tympanogram and absent reflexes. The findings of Immittance and otoacoustic emissions for all the participants in both ears are given in Table 2. Although acoustic reflex thresholds were found to be higher in all the participants, the interaural comparison shows that acoustic reflex thresholds were higher in the ear ipsilateral to the side of infection. The interaural comparison also indicates that three among eleven participants had absent OAEs and abnormal type of tympanogram in the ear, which is ipsilateral to the side of infection. However, the ear,

Table 2. Immittance and otoacoustic emissions findings for both the ears in the participants considered for the study

			Stapedial reflex thresholds											
	Tympanogram type		500 Hz		1000 Hz		2000 Hz		4000 Hz		DPOAE		TEOAE	
Participant	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
BF_1	B	A	Absent	100	Absent	100	Absent	105	Absent	Absent	Absent	Present	Absent	Present
BF_2	A	A	100	95	100	95	105	100	Absent	110	Present	Present	Present	Present
BF_3	A	A	105	90	110	95	110	95	Absent	Absent	Present	Present	Present	Present
BF_4	A	A	105	95	110	100	105	100	Absent	Absent	Present	Present	Present	Present
BF_5	A	Cs	100	Absent	100	Absent	100	Absent	110	Absent	Present	Absent	Present	Absent
BF_6	A	As	100	Absent	100	Absent	105	Absent	110	Absent	Present	Absent	Present	Absent
BF_7	A	A	100	95	100	95	110	100	110	105	Present	Present	Present	Present
BF_8	A	A	95	100	100	105	100	110	Absent	Absent	Present	Present	Present	Present
BF_9	A	A	105	95	110	100	105	100	Absent	Absent	Present	Present	Present	Present
BF_10	A	A	100	100	100	100	105	105	Absent	Absent	Present	Present	Present	Present
BF_11	Cs	A	Absent	100	Absent	105	Absent	110	Absent	Absent	Absent	Present	Absent	Present

DPOAE; distortion product otoacoustic emissions, TEOAE; transient evoked otoacoustic emissions, BF; black fungus

which is contralateral to the side of infection in the same patient, showed otoacoustic emissions and a normal tympanogram. One exceptional finding was also found where one patient had normal OAEs and tympanometric findings in the ear ipsilateral to the side of infection whereas, the ear contralateral to the side of the infection had abnormal tympanometric findings and absent OAEs.

Discussion

Middle ear dysfunction is confirmed with the combined results of type of tympanogram, acoustic reflexes, and OAEs. Based on the above criteria, the present study shows that four out of eleven patients showed middle ear dysfunction post mucormycosis infection. The findings also revealed that middle ear dysfunction was majorly (3/4) ipsilateral to the side of infection. The results indicate that there is a rare involvement of the middle ear also in the patients with mucormycosis post-COVID infection. These findings are also in agreement with the previous studies [6,7,15], where the involvement of the middle ear and external ear was demonstrated in case studies. The proximity and easy access to the middle ear through the Eustachian tube from sinuses may contribute to the rare middle ear involvement [15]. Previous case reports have reported moderate conductive hearing loss in individuals with mucormycosis [7,15]. Elevated and absent reflexes found in the present study may indicate a middle ear pathology in patients with mucormycosis [6,16]. Normal middle ear functioning is a must for recording otoacoustic emissions [12]; hence, the absent otoacoustic emissions in the present study serve as supplementary evidence for the middle ear involvement. This study reveals the probability of middle ear involvement in patients with mucormycosis. However, the absence of OAEs may also indicate possible cochlear damage.

Further studies using pure tone audiometry and other tests to assess cochlear functioning can help understand the pathophysiology. Despite its rare occurrence, it can be dangerous if it is left undetected. In the long run, it might also lead to inner ear disorders leading to severe complications. Hence, the audiologist's role in the early detection of ear involvement in mucormycosis patients before they get discharged [9].

However, the study has certain limitations as the sample size of the mucormycosis patients is limited due to the inclusion criteria. Also, an attempt was not made to administer pure tone audiometry due to difficulty getting a behavioral response from bedridden patients, which could have helped determine the hearing sensitivity. It was also difficult to rule out any aural involvement due to COVID-19, which could also affect the test results. In addition, the indication of middle ear dysfunction in the contralateral side of mucormycosis also needs to be explored. Future studies can be carried out with increased sample size and demonstrate its effect on other audiological tests.

Conclusion

The present study was carried out to determine the involvement of the middle ear in mucormycosis patients and its influence on Immittance and otoacoustic emissions. The results showed that four out of eleven patients exhibited middle ear dysfunction where 3/4 had abnormal middle ear functioning in the ear ipsilateral to the side of infection. This indicates that there is a rare involvement of the middle ear in mucormycosis fungal infection. Thus, audiologists and otorhinolaryngologists play a crucial role in the early detection of middle ear dysfunction by alleviating future complications.

Conflict of interest

Authors declare no conflict of interest and are solely responsible for the writing and content of the paper.

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