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Audiovestibular Evaluation in Post COVID-19 Patients Discharged From Mansoura University Isolation Hospital: A Prospective Study

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ABSTRACT

Background: While COVID-19 is primarily a respiratory illness, emerging evidence suggests it may have neurotropic properties, including potential impacts on the auditory and vestibular systems. Early symptoms such as fever, cough, and fatigue were well-documented, but reports of anosmia and balance disturbances raised concerns regarding broader neurological involvement.

Objective: This study aimed to assess the audiovestibular function in post-COVID-19 patients and to characterize the potential subclinical and clinical effects of SARS-CoV-2 on the auditory and balance pathways.

Methods: A total of 130 post-COVID-19 patients (mean age: 38.64 ± 10.03 years; 70.8% female) were evaluated 1–3 months after confirmed recovery. Audiological assessments included pure tone audiometry (PTA), distortion product and transient evoked otoacoustic emissions (DPOAE and TEOAE), and auditory brainstem response (ABR). Vestibular evaluation included spontaneous and positional nystagmus testing and caloric tests.

Results: Audiovestibular symptoms were reported as dizziness (72.3%), tinnitus (12.3%), and hearing loss (8.5%). PTA revealed elevated thresholds particularly at high frequencies, while DPOAE and TEOAE amplitudes were reduced in a substantial portion of cases, especially among older individuals and males. ABR testing showed no significant alterations, though a subset exhibited absent waveforms. Vestibular testing identified benign paroxysmal positional vertigo (BPPV) and peripheral vestibular lesions in a notable proportion of patients. Age was significantly associated with both hearing loss and OAEs outcomes ($P < 0.001$), while gender differences were also observed in DPOAE and TEOAE results.

Conclusion: These findings support the hypothesis that SARS-CoV-2 may affect cochlear outer hair cells and vestibular function, even in the absence of overt auditory symptoms. The observed dysfunction appears to be more prominent with increasing age but shows no correlation with the time elapsed since infection. Early audiovestibular assessment may be warranted following COVID-19 infection, and longitudinal studies are needed to better understand the persistence and pathophysiology of these effect.

Keywords: *COVID19. Audiovestibular evaluation, hearing loss, Tinnitus.*

1. INTRODUCTION

Coronavirus disease 2019 (COVID-19), was at first discovered in Wuhan, China, in December 2019, is caused by a type of SARS viruses (severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)) [1][2]. Meta-analyses of recent studies have shown that the predominant clinical manifestations of COVID-19 are fever, a non-productive cough, and characteristic abnormalities observable on chest computed tomography (CT) scans. Additional symptoms reported in some patients include myalgia, fatigue, and anosmia or ageusia [3].

Severe cases of COVID-19 can advance to severe form of respiratory distress (ARDS), multi-organ failure, and may present with neurological complications including loss of consciousness, headache, and dizziness. Additionally, otologic manifestations such as facial paralysis, sudden sensorineural hearing loss, and episodes of vertigo have also been documented in association with the disease [4].

Hearing loss has been observed in COVID-19 patients, potentially resulting from the SARS-CoV-2 detrimental effects on cochlear hair cell function, even in individuals who exhibit no other clinical symptoms [5] . Self reported vertigo has been recently diagnosed COVID-19 patients is more likely than those who have not Self-reported vertigo attacks following COVID-19 diagnosis are more severe than the pre-existing vestibular symptoms [6]. Audiovestibular system is known to be affected by viral infection , coronaviruses were found to have neuro-tropic and neuro-invasive effects [7].

Many hypotheses have been put forth to suggest the mechanism of the involvement of the audiovestibular system but the actual mechanism is yet to be known. One explanation suggests that viral damage, which is typically intracochlear, may affect the auditory brainstem: as direct affection to the organ of Corti or stria vascularis, or spiral ganglion, or as secondary damage induced by host-mediated immunity against virally expressed proteins. Although the neurotrophic and neuroinvasive capabilities of the virus are still being investigated, there is supporting evidence suggesting that as some patients present with direct signs of hypercoagulability, there may be vasculitis or vasculopathy involved in the pathogenesis, which can ultimately cause hearing and balance alterations [8]. Our aim of this study is to evaluate the hearing and vestibular impacts in post COVID-19 patients.

2. SUBJECTS AND METHODOLOGY:

Subjects:

* **Subjects**: This study was conducted on 130 post COVID-19 adult patients as the minimum accepted sample size is 117 individuals.

***Inclusion criteria**: Post COVID-19 patients with negative swabs after 1:3 months who were coming to post COVID unit in Mansoura University Isolation Hospital.

***Exclusion criteria:**

a) Patients aged <18 years and > 55years.

b) Patients with +ve SARS-CoV-2 swabs

c) Patients with previous history of any audiovestibular manifestation.

* **Eligibility (ethical considerations):**

The study protocol was approved by the institutional research board (IRB), Faculty of Medicine - Mansoura University (code: MD.22.02.611). Patients had the right to withdraw from the study at any point of time during the study without penalty.

Methodology

All participants in this study will undergo the following audiovestibular protocol:

A) History Taking:

- Demographic information (name, age, gender).
- Present history, including:
    - Presence or absence of hearing loss post-COVID-19 and its duration.
    - Presence or absence of vestibular symptoms post-COVID-19 and their duration.
    - Current medications.

B) Otoscopic Examination.

C) Tympanometry: to assess middle ear function.

D) Puretone audiometry (AC & BC): at frequencies 250 ,500,1000,2000,4000 and 8000 HZ for AC and 500,1000,2000,4000 HZ for BC.

E) Otoacoustic Emissions (OAEs):

1. Distortion Product (DP-OAEs): Measured in the form of a DP-Gram over f2 (750, 984, 1500, 2016, 3984, 6000 and 7969 HZ) using (L1 =65 SPL, f2/f1 ratio =1.22). DPOAE responses were recorded in f2, but are equal to 2f1-f2. DPOAE were considered persent if SNR is 6 dB at least in four frequencies.
2. Transient (TE-OAEs): Induced by clicks (80 dB pe SPL) at 1, 1.5, 2, 3, and 4 kHz in a 20-ms window. TEOAEs were considered present if the response SNR is 3 dB at three frequencies with >70% reproducibility.

F) Auditory Brainstem Response (ABR): using navigator pro (bio-logic) with TDH49 headphones. Responses to click stimulus at a repetition rate of 21.1/sec. Two channels electrode montage were used.

G) Vestibular Assessment: Conducted with videonystagmography (VNG) to assess spontaneous nystagmus, Positioning tests, including the Dix-Hallpike test and supine roll test, positional tests to evaluate the effects of different head positions (such as sitting, supine, supine with head turned right, supine with head turned left, right decubitus, and left decubitus) and caloric tests .

Statistical analysis:

The collected data obtained were coded, processed and analyzed using the SPSS program for windows. The appropriate statistical tests were used when needed. The level of statistically significant difference were considered at 5% (P ≤0, 05).

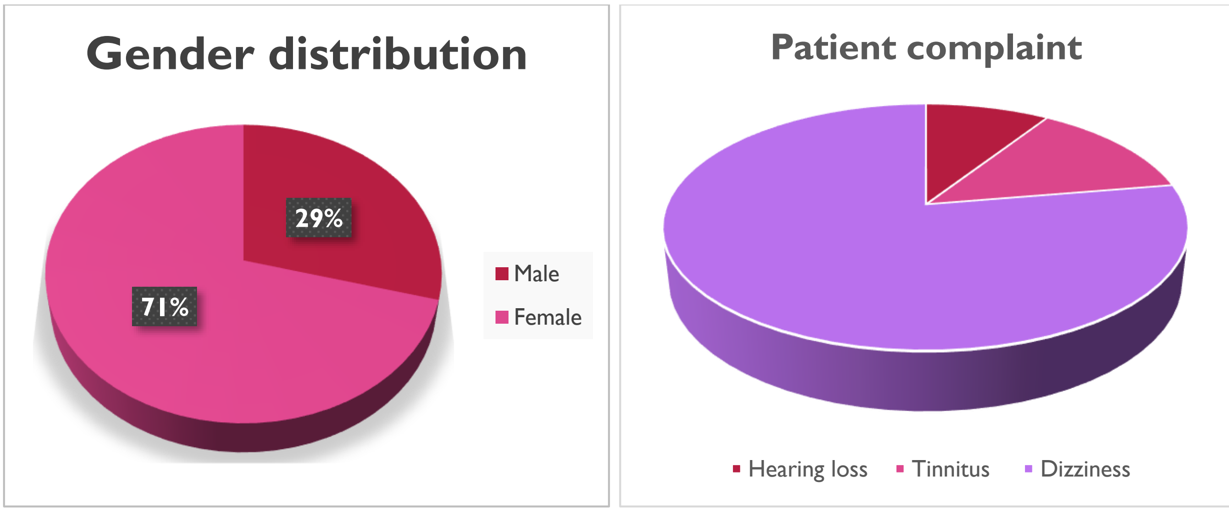
3. RESULTS

Demographic data of the subjects

Table (1): demographic data and patient complaints among studied cases

Demographic data		
Age (years)		
Mean ±SD	38.64±10.03	
Gender		
Male Female	38 92	29.2% 70.8%
Patient complaints		
Hearing loss	11	8.5%
Tinnitus	16	12.3%
Dizziness	94	72.3%
No complaints	31	23.8

Table 1 shows mean age of studied cases is 38.64±10.03 (years). Majority of the cases are females (70.8%), while males are (29%). Patient complaints are Hearing loss, Tinnitus and Dizziness in (8.5%, 12.3% and 72.3%, respectively) in many patients there were more than one complaint and 23.8% of cases had no complaints.



Graph (1): shows gender distribution and patient complaints among studied cases

1) **Basic audiological evaluation:**

a) **Pure tone audiometry**

Table (2): Pure tone audiometry (Air conduction threshold) among studied cases (N=130)

	Right ear Mean ±SD	Left ear Mean ±SD
250 Hz	18.23±3.98	19.31±2.97
500Hz	18.42±5.35	19.0±5.26
1000 Hz	15.46±4.64	16.54±4.97
2000 Hz	17.27±6.56	16.96±6.18
4000 Hz	18.69±4.76	18.73±6.82
8000 Hz	23.08±11.29	23.19±9.80

Table (3): Pure tone audiometry (Bone conduction threshold) among studied cases (N=130)

	Right ear Mean ± SD	Left ear Mean ± SD
500Hz	18.42±5.35	19±5.26
1000 Hz	15.46±4.64	16.42±4.83
2000 Hz	17.27±6.56	16.92±6.11
4000 Hz	18.69±4.76	18.54±6.48

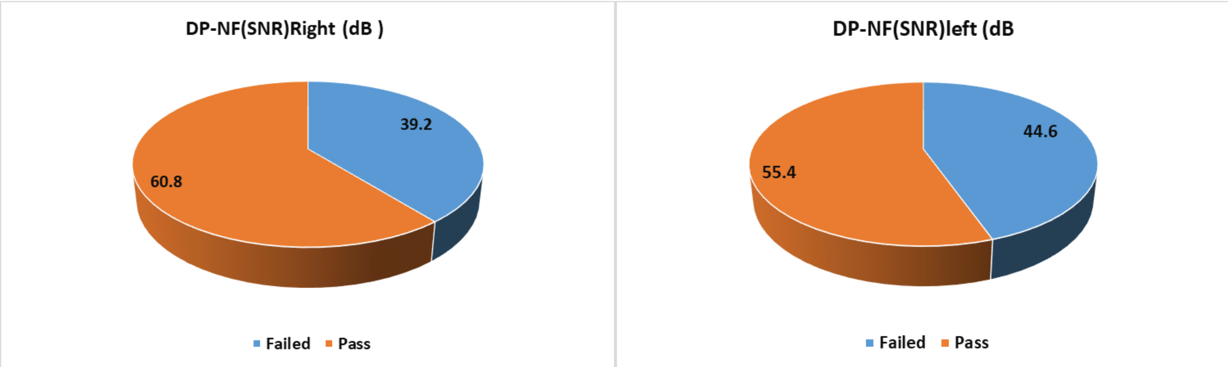
Tables 2&3 show the PTA among the studied cases.

Table (4): SNR-Distortion product among studied cases (N=130)

	Right Mean DP-NF	Left Mean DP-NF
7206 Hz	6.0(-16.3, 22.0)	8.1(-10.8,16.1)
5434 Hz	8.7(-11, 19.8)	8.2(-17.4,19.2)
3616 Hz	3.60(-8.4,20.1)	8.1(-6.8,17)

2730 Hz	8.25(-12.2,24.1)	9.1(-2.5,17)
1818 Hz	8.8(-8.2,22.9)	9.1(-11.9,19.1)
1352 Hz	8.35(-10.6,23.9)	7.3(-2.8,25.6)
886 Hz	7.8(-17.7,20.5)	2.1(-18.2,20)
Qualitative DP-OAEs:		
Failed	51(39.2%)	58(44.6%)
Pass	79(60.8%)	72(55.4%)

Table 4 shows that right ear DP-NF (SNR) (dB) among studied cases had a qualitative pass in 60.8% of the cases but failed in 39.2%, while in Left ear it showed a qualitative pass in 55.4%of the cases but failed in 44.6%.

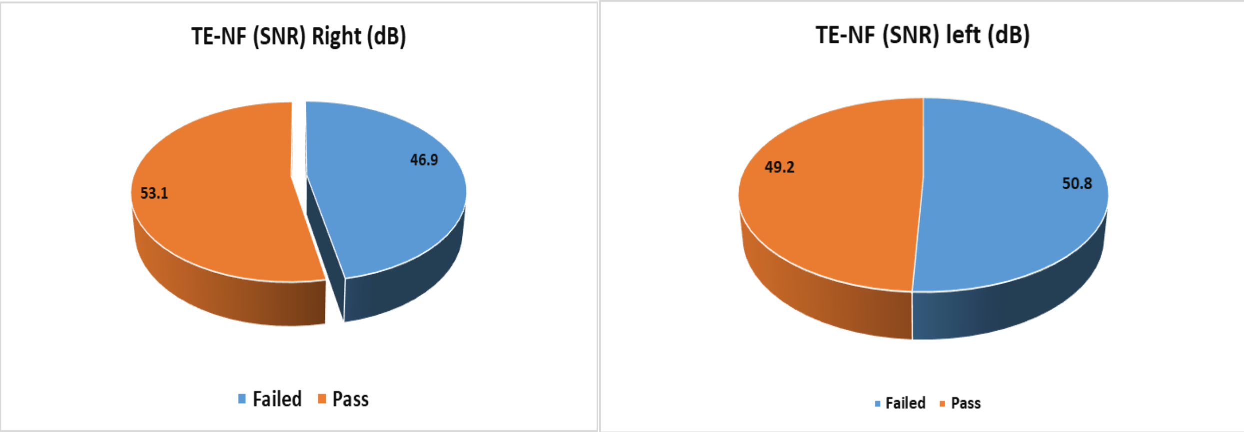


Graph (2): shows DP-NF (SNR) among studied cases

Table (5): TE-NF (SNR) among studied cases (N=130)

	Right Mean TE-NF	Left Mean TE-NF
1000 Hz	3(-3.4,8.9)	1.9(-3.6,7.2)
1500 Hz	4(-2.6,13.0)	3.9(-6.3,14.8)
2000 Hz	3(-2.5,12.2)	1.9(-2.4,15.0)
3000 Hz	2.9(-3.0,10.5)	1.8(-1.9,6.9)
4000 Hz	5.05(0.7,11)	4.6(-1.2,10.2)
Qualitative TE-OAEs:		
Failed	61(46.9%)	66(50.8%)
Pass	69(53.1%)	64(49.2%)

Table 5 shows that TE-NF (SNR) of right ears studied cases had a qualitative pass in 53.1% of the cases but failed in 46.9%, while in Left ears it showed a qualitative pass in 49.2% of the cases but failed in 50.8%.



Graph (3): shows TE-NF (SNR) among studied cases

Table (6): ABR (Wave V Latency) Right (msec.) among studied cases

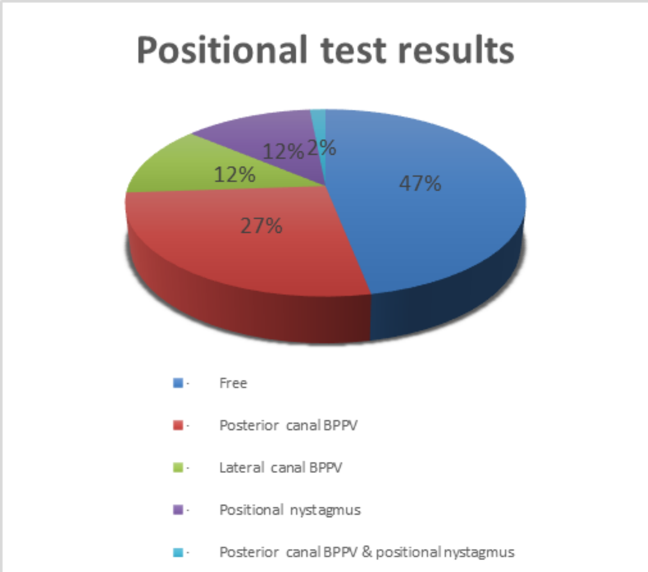
(Wave V Latency)	Right (msec.)	left (msec.)
90 dB	5.38(5.0,5.94)	5.45(5,5.95)
70 dB	5.75(5.25,6.3)	5.64(5.25,6.29)
50 dB	6.16(5.84,7.08)	6.10(5.95,7)
30 dB	6.86(6.33,7.62)	6.91(6.32,8.64)

Table 6 shows that ABR (Wave V Latency) among the studied cases at (90 dB, 70 dB, 50 dB and 30 dB). At the right side were (5.38, 5.75, 6.16 and 6.86, respectively), while on the left side were (5.45, 5.64, 6.10 and 6.91, respectively). Cases with no ABR waves were 10.8% for each dB in the right ear and 11.5% for each dB in the left ear.

Table (7): Vestibular evaluation of studied cases (N=130)

Vestibular evaluation		
Spontaneous nystagmus	16	12.3%
Positional tests (dix-hallpike & supine roll)		
• Free	61	46.9%
• Posterior canal BPPV	35	26.9%
• Lateral canal BPPV	16	12.3%
• Positional nystagmus	16	12.3%
• Posterior canal BPPV & positional nystagmus	2	1.5%
Caloric test		
No weakness	113	86.9%
Peripheral weakness	17	13.1%

Table 12 shows that 12.3% of the cases have Spontaneous nystagmus. Positional tests (dix-hallpike & spine roll) are Free in 46.9% of the cases, but show (posterior canal BPPV, lateral canal BPPV, positional nystagmus, posterior canal BPPV with positional nystagmus) in 26.9%, 12.3%, 12.3% and 1.5%, respectively). Caloric test showed no weakness in 86.9% of the cases and Peripheral weakness in 13.1%.

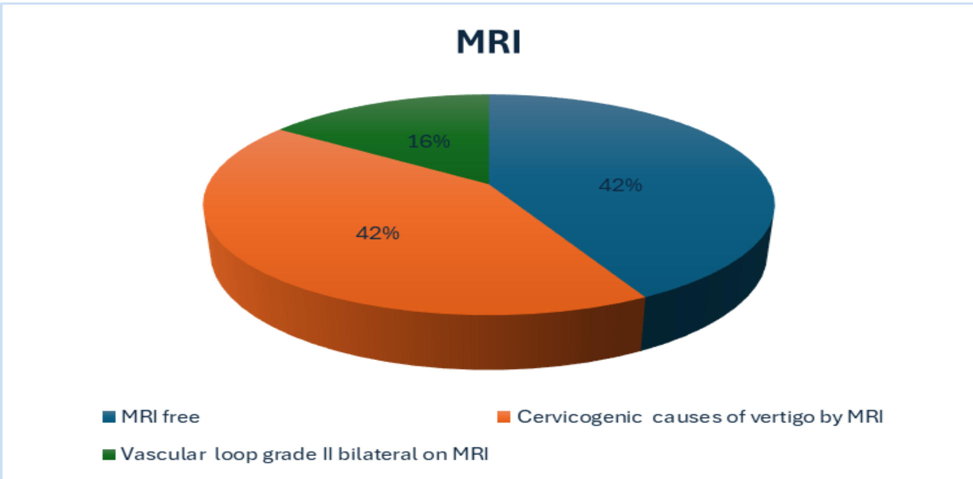


Graph (4): shows results of the results of vestibular evaluation.

Table (8): MRI scanning (N=26)

MRI	N =26	%
MRI free	11	42.3
Cervical problem by MRI	11	42.3
Vascular loop grade II bilateral on MRI	4	15.4

Table 8 shows MRI scanning results that were done for some selected cases to find any suspected causes for vestibular manifestation (26 cases of 130) and were as follows free MRI image is in 42.3% and Cervicogenic causes of vertigo in 42.3% and Vascular loop grade II bilateral in 15.4% of cases

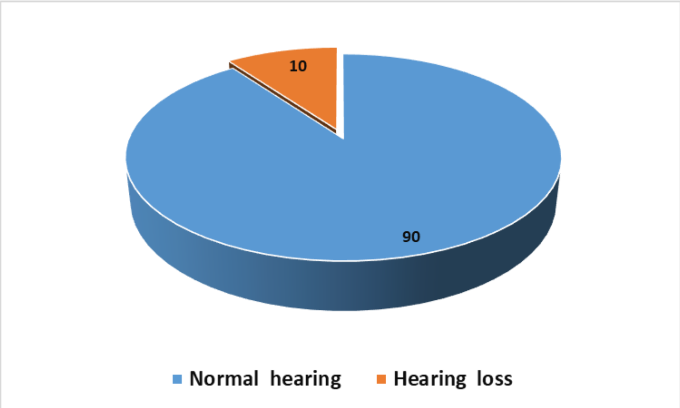


Graph (5): shows the results of MRI scanning for some selected cases.

Table (9): Prevalence of hearing loss among studied cases

	N=130	%
Normal hearing	117	90.0
Hearing loss (bilateral high-frequency SNHL)	13	10.0

Table 9 shows that only 10% of the cases have bilateral high-frequency SNHL hearing loss, while 90% of the cases had normal hearing.



Graph (6): shows the prevalence of hearing loss among studied cases

Table (10): relation between demographic characters and hearing loss among studied cases

Demographic data	Normal hearing N=117	Hearing loss N=13	Test of significance
Age (years): Mean ±SD	37.21±9.44	51.54±4.50	t=5.39 P<0.001*
Gender			
Male	34(29.1)	4(30.8)	χ^2=0.017
Female	83(70.9)	7(69.2)	P=0.898

t:Student t test , χ^2=Chi-Square test *statistically significant

Table 10 shows a statistically significant relation between age and hearing loss among studied cases (P<0.001), where hearing loss is associated with older age. However, there is a statistically non-significant relation between gender and hearing loss among studied cases (P=0.898).

Table (11): Relation between demographic characters and Right ear SNR-Distortion product

Demographic data	Right ear DP-NF (SNR)		Test of significance
	Failed (N=51)	Pass (N=79)	
Age (years): Mean ±SD	44.14±8.94	35.09±9.09	t=5.58 p<0.001*
Gender			
Male	14(27.5)	24(30.4)	χ^2=0.129
Female	37(72.5)	55(69.6)	P=0.720

t:Student t test , χ^2=Chi-Square test *statistically significant

Table 11 shows a statistically significant relation between age and right ear DP-NF (SNR) (P<0.001), where right ear DP-NF (SNR) was pass in younger age. However, there was a statistically non-significant relation between gender and right ear DP-NF (SNR) among studied cases (P=0.720).

Table (12): Relation between demographic characters and Left ear SNR-Distortion product

Demographic data	Left ear DP-NF (SNR)		Test of significance
	Failed (N= 58)	Pass (N= 72)	
Age (years): Mean ±SD	43.28±8.12	34.90±9.91	t=5.18 p<0.001*
Gender Male Female	 7(12.1) 51(87.9)	 31(43.1) 41(56.9)	 χ^2=14.91 P=0.001*

t:Student t test , χ^2=Chi-Square test *statistically significant

Table 12 shows a statistically significant relation between age and left ear DP-NF (SNR) (P<0.001), where left ear DP-NF (SNR)was pass in younger age. Also, there was a statistically significant relation between gender and left ear DP-NF (SNR) among studied cases (P<0.001), where left ear DP-NF (SNR) was pass mainly in females.

Table (13): Relation between demographic characters and Right ear SNR-Transient evoked OAEs

Demographic data	Right ear TE-NF (SNR)		Test of significance
	Failed (N =61)	Pass (N= 69)	
Age (years) Mean ±SD	43.08±8.89	34.71±9.36	t=5.21 p<0.001*
Gender Male Female	 17(27.9) 44(72.1)	 21(30.4) 48(69.6)	 χ^2=14.91 P=0.001*

t:Student t test , χ^2=Chi-Square test *statistically significant

Table 13 shows a statistically significant relation between age and right ear TE-NF (SNR) (P<0.001), where right ear TE-NF (SNR) was pass in younger age. Also, there was a statistically significant relation between gender and right ear TE-NF (SNR) among studied cases (P<0.001), where right ear TE-NF (SNR) was pass mainly in females.

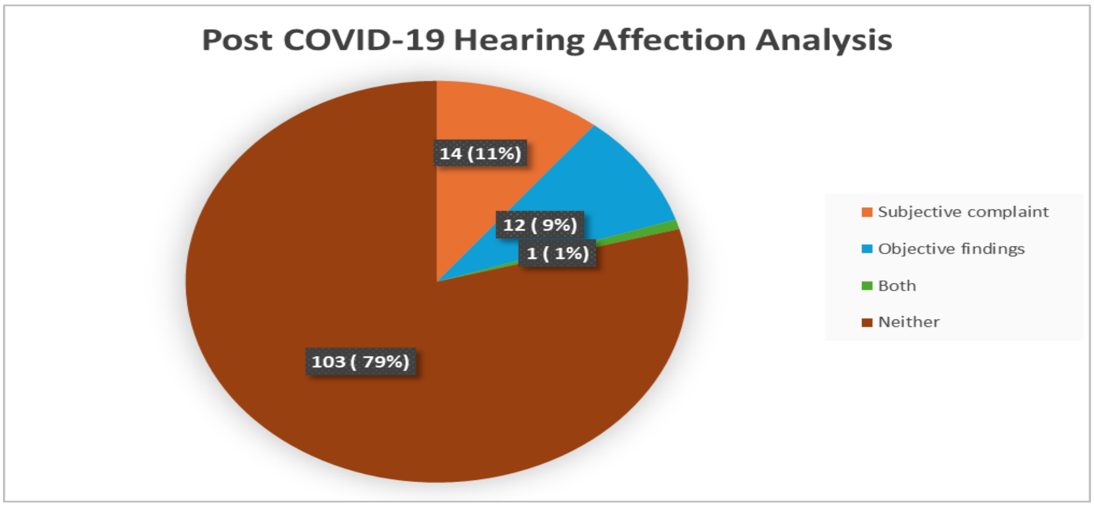
Table (14): Relation between demographic characters and left ear SNR-Transient evoked OAEs

Demographic data	Left ear TE-NF (SNR)		Test of significance
	Failed (N =66)	Pass (N= 64)	
Age (years) Mean ±SD	43.85±8.04	33.27±9.03	t=7.06 p<0.001*
Gender Male Female	 7(10.6) 59(89.4)	 31(48.4) 33(51.6)	 χ^2=22.48 P=0.001*

t:Student t test , χ^2=Chi-Square test *statistically significant

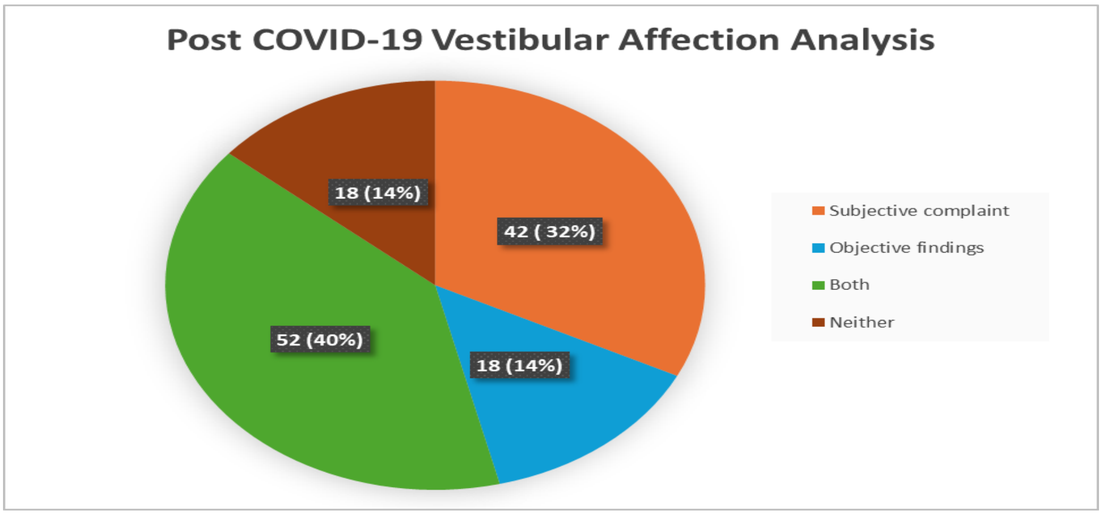
Table 19 shows a statistically significant relation between age and left ear TE-NF (SNR) (P<0.001), where left ear TE-NF (SNR) was pass in younger age.

Also, there was a statistically significant relation between gender and left ear TE-NF (SNR) among studied cases (P<0.001), where left ear TE-NF (SNR) was pass mainly in females.



Graph (7) Relationship between subjective and objective hearing loss among study cases

Graph shows that 14 cases representing 11% of total cases complained of hearing loss (subjective), 12 cases representing 9% of total cases diagnosed with hearing loss (objective), one case representing 1% of total cases complained of hearing loss and diagnosed with hearing loss and 103 cases representing 79% were free.



Graph (8) Relationship between subjective and objective vestibular affection among study cases

Graph shows that 42 cases representing 32% of total cases complained of dizziness (subjective), 18 cases representing 14% of total cases diagnosed with vestibular problem (objective), 52 cases representing 40% of total cases complained of dizziness and diagnosed with vestibular problem and 18 cases representing 14% were free.

4. DISCUSSION

The rapid onset of the COVID-19 pandemic prompted extensive global efforts to understand the characteristics of a previously unknown disease. Early in the pandemic, it became evident that certain symptoms, such as fever, dry cough, respiratory distress, and fatigue, were strongly associated with acute infection **[9].**

As COVID-19 spread rapidly across the globe, additional symptoms, including anosmia (loss of the sense of smell), began to emerge in the literature. Other symptoms were initially viewed as incidental, with no clear causation or pathophysiological explanation **[10].**

Viral infections are well-documented triggers for auditory and vestibular dysfunction, making it important to consider them when evaluating patients with sudden hearing loss or acute vestibular issues. The hearing loss associated with viral infections varies widely, from mild to profound impairment, and can be unilateral or bilateral, appearing at any point from birth to adulthood. In some cases, viral-related hearing loss progresses over time, with gradual deterioration occurring years after the initial infection, as seen in congenital CMV infections **[11].**

A recent cross-sectional study reported a potential link between SARS-CoV-2 infection and hearing loss as shown by abnormal hearing thresholds at 4 to 8 kHz, and lower transient evoked oto-acoustic emissions (TE-OAEs) amplitude **[12].**

Therefore, the current study aimed to evaluate the audiovestibular function in post-COVID-19 patients. The current study included 130 post-COVID-19 patients after -ve swab by 1:3 months presented to post-COVID-19 unit in Mansoura University Isolation Hospital.

The current study showed mean age of studied cases was 38.64±10.03 (years). Majority of the cases were females (70.8%), while males were (29%). The patient complaints were Dizziness (72.3%), Tinnitus (12.3%), and Hearing loss (8.5%)

The findings among COVID-19 patients with audio-vestibular symptoms revealed that 20.3% experienced hearing loss, 13.3% had tinnitus, 36.7% reported vertigo (true spinning), and 6.25% of cases experienced dizziness. **[13].**

The current study showed that 13 patients had hearing loss out of 130 post COVID-19 patient came in alignment with the study showedpure tone audiometry in only 2 patients (6.7%) had mild high-frequency sensorineural hearing loss at 8000 Hz. **[14]**. This low percentage aligns with the estimated prevalence of hearing loss associated with COVID-19 infection reported in the literature, which is approximately 7.6%. **[15].**

The current study showed that DP-NF (SNR) was passed in 60.8% of the cases but failed in 39.2% for the right ear and passed in 55.4% of the cases but failed in 44.6% for the left ear.

Also, the current study showed that TE-NF (SNR) was passed in 53.1% of the cases but failed in 46.9% for the right ear and passed in 49.2% of the cases but failed in 50.8%for the left ear.

In a similar manner, it was observed that there is a significant difference in TEOAE signal-to-noise ratio (SNR) at high frequencies (2.8 and 4 kHz), with the COVID-19 group showing poorer SNR. This suggests a potential subclinical auditory dysfunction, indicated by reduced otoacoustic emission (OAE) amplitudes, despite the absence of elevated audiometric thresholds. **[14]**.

These results align with findings from other studies that reported significantly lower OAE amplitudes at high frequencies in COVID-19 patients, which may be linked to the sensitivity of hair cells in the cochlear basal region **[16]**.

The study also showed that pure tone audiometry and extended high-frequency mean threshold values were higher in the COVID-19 group. Additionally, transient evoked otoacoustic emissions (TEOAE) SNRs were bilaterally lower at 4 kHz in individuals with a history of COVID-19. In auditory brainstem response (ABR) testing, only the interpeak latencies of waves III-V were significantly different between groups **[17].**

These findings suggest that COVID-19 may cause mild damage to cochlear outer hair cells, particularly in the basal turn of the cochlea, possibly due to ischemia from endothelial damage, thrombotic processes, and respiratory distress, similar to the effects seen in SARS-CoV-2 infection **[18].**

The current study showed that Auditory Brainstem Response (ABR) (Wave V Latency) was within normal average. Absent cases were10.8% and 11.5% for right and left ears respectively.

These findings are consistent with pervious findings which stated that there was no long-lasting significant difference between the study and control groups as regards ABR parameters at high and low repetition rates **[19]**.

Similarly, it was previously reported that there were no significant differences in ABR waves between recovered COVID-19 patients and control **[11,20].** In contrast, some authors demonstrated longer latencies of waves III, V, and time intervals I–III, I–V in post-COVID-19 patients complaining of hearing loss or tinnitus with the majority of his study group had SNHL **[21].**

Interestingly, the current study showed that, as regards the vestibular evaluation, 12.3% of the cases had spontaneous nystagmus. Positional tests (dix-hallpike & supine roll) were Free in 46.9% of the cases, but showed Posterior canal BPPV, Lateral canal BPPV, Positional nystagmus, Posterior canal BPPV & positional nystagmus) in (26.9%, 12.3%, 12.3% and 1.5%, respectively). Caloric test showed No weakness in 86.9% of the cases and Peripheral weakness in 13.1%. MRI image was free in 42.3%, and cervical problems in 42.3% and Vascular loop grade II bilateral in 15.4%.

In harmony, most of the participants (40 individuals, accounting for 76.9%) experienced vertigo, dizziness, and imbalance, with a history of COVID-19 infection occurring 4 to 6 months prior to the onset of these symptoms. Among these 40 cases, 17 (42.5%) were diagnosed with benign paroxysmal positional vertigo (BPPV), 13 (32.5%) had uncompensated peripheral vestibular dysfunction, and 10 (25%) were diagnosed with both BPPV and vestibular neuritis (VN) **[13].**

Against current findings, Vestibular assessments of eight patients who experienced vertigo following COVID-19 infection revealed that all were diagnosed with BPPV. The researchers proposed that the development of BPPV in these cases may be linked to factors such as medication use, extended periods of bed rest, and direct viral effects on the peripheral vestibular system—particularly damage to the otolithic membrane—resulting from the virus's cytopathic action and the body's inflammatory response. **[22]**.

Also, conversely, In a previous study, among patients who developed vertigo after COVID-19 infection, 57.1% experienced spontaneous vertigo, while the remaining cases reported positional vertigo. The duration of vertigo varied, with 54% experiencing symptoms for only a few seconds, 34% for several minutes, and 9% for extended periods lasting hours. **[23].**

Additionally, the current study showed that only 10% of the cases had hearing loss which was bilateral high-frequency SNHL, while 90% of the cases had normal hearing.

A recent study found a 10% prevalence of newly developed hearing loss, which is higher than the 6.31% reported in a previous study that used a questionnaire to evaluate short- and long-term cochleovestibular symptoms among 301 patients with varying severities of COVID-19 **[24]**.

In contrast, another study indicated that 40% of patients experienced new or worsened hearing loss, and 20% reported the onset or worsening of tinnitus. **[25].** These discrepancies could be attributed to differences in assessment methods and the potential for inaccuracies in self-reported data, which may lead to either overestimation or underestimation of symptoms.

Specifically, the current study showed a statistically significant relation between age and hearing loss among studied cases (P<0.001), where hearing loss was associated with older age. However, there was a statistically non-significant relation between gender and hearing loss among studied cases (P=0.898).

Also, the current study showed a statistically significant relation between age and DP-NF (SNR) Right (dB) (P<0.001), where DP-NF (SNR) Right (dB) was passed at younger age. However, there was a statistically non-significant relation between gender and DP-NF (SNR) Right (dB) among studied cases (P=0.720). There was a statistically significant relation between age and DP-NF (SNR) left (dB) (P<0.001), where DP-NF (SNR) left (dB) was passed at younger age. Also, there was a statistically significant relation between gender and DP-NF (SNR) left (dB) among studied cases (P<0.001), where DP-NF (SNR) left (dB) was passed mainly in females.

The current study showed a statistically significant relation between age and TE-NF (SNR) left (dB) (P<0.001), where TE-NF (SNR) left (dB) was passed at younger age. Also, there was a statistically significant relation between gender and TE-NF (SNR) left (dB) among studied cases (P<0.001), where TE-NF (SNR) Right (dB) was passed mainly in females.

Similarly, the final meta-analysis revealed that hearing loss occurred in 8.2% of individuals who tested positive for COVID-19 (95% CI: 5.0–12.1). Age-based subgroup analysis showed a notably higher prevalence among middle-aged and older adults—20.6% in those aged 50–60 and 14.8% in those over 60—compared to younger age groups, where the rates were 4.9% for individuals aged 30–40 and 6.0% for those aged 40–50. **[26].**

Contrary to the present findings, a case was reported involving a 27-year-old otherwise healthy male who developed sudden unilateral sensorineural hearing loss (SSNHL) one month after being diagnosed with COVID-19 **[27].** Additionally, another study described a 38-year-old man with previously normal hearing who experienced sudden bilateral hearing loss following intensive care treatment for severe COVID-19. While these cases imply a potential link between COVID-19 in younger adults and an elevated risk of hearing loss or SSNHL, they are based on descriptive reports and thus have limited generalizability**[28].**

Alternatively, gender was also investigated as a variable in the relationship between COVID-19 and hearing loss in a previous study **[29]**. The analysis revealed no significant effect of sex on pure tone audiometry (PTA) outcomes in the right ear after COVID-19 infection, nor was there any notable interaction between sex and post-infection PTA changes. Similarly, no significant effects or interactions were observed in the left ear, indicating that sex did not appear to influence hearing threshold shifts following COVID-19.

The precise origin of the vestibular symptoms reported in COVID-19 patients remains unclear; however, milder manifestations such as dizziness and imbalance may stem from the significant fatigue and weakness commonly associated with the illness. Research indicates that inner ear structures are especially vulnerable to ischemic events and vascular injury, which can contribute to both auditory and balance disturbances **[30].**

5. CONCLUSION

The findings of the present study suggest that a single episode of COVID-19 may be enough to cause detectable alterations in the auditory pathway, even in the absence of noticeable hearing complaints. Furthermore, the test results did not demonstrate any significant improvement or deterioration over time following the infection. Nonetheless, further longitudinal research is necessary to validate this observation.

REFERENCES

[1] Singhal, T., A review of coronavirus disease-2019 (COVID-19). The indian journal of pediatrics, 2020. 87(4): p. 281-286.

[2] Cevik, M., et al., Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission dynamics should inform policy. Clinical Infectious Diseases, 2021. 73(Supplement_2): p. S170-S176.

[3] Aiyegbusi, O.L., et al., Symptoms, complications and management of long COVID: a review. Journal of the Royal Society of Medicine, 2021. 114(9): p. 428-442.

[4] Borah, P., et al., Neurological consequences of SARS-CoV-2 infection and concurrence of treatment-induced neuropsychiatric adverse events in COVID-19 patients: navigating the uncharted. Frontiers in molecular biosciences, 2021. 8: p. 27.

[5] Gallus, R., et al., Audiovestibular symptoms and sequelae in COVID-19 patients. Journal of Vestibular Research, 2021(Preprint): p. 1-7.

[6] Betton, V., Towards a Digital Ecology: NHS Digital Adoption through the COVID-19 Looking Glass. 2022: CRC Press.

[7] Durgut, O., et al., The effects of SARS-CoV-2 on hearing thresholds in COVID-19 patients with non-hospitalized mild disease. American journal of otolaryngology, 2022. 43(2): p. 103320.

[8] Arigapudi, N., T.K. Suvvari, and P.N. Murthy, Auditory manifestations associated post-COVID-19: What we need to know? Journal of Dr. NTR University of Health Sciences, 2021. 10(2): p. 72.

[9] Cascella, M., Rajnik, M., Aleem, A., Dulebohn, S. C., & Di Napoli, R. (2020). Features, evaluation, and treatment of coronavirus (COVID-19).

[10] Soler, Z. M., Patel, Z. M., Turner, J. H., & Holbrook, E. H. (2020, July). A primer on viral-associated olfactory loss in the era of COVID-19. In International Forum of Allergy & Rhinology (Vol. 10, No. 7, pp. 814-820).

[11] Dror, A. A., Kassis-Karayanni, N., Oved, A., Daoud, A., Eisenbach, N., Mizrachi, M., ... & Sela, E. (2021). Auditory performance in recovered SARS-COV-2 patients. Otology & Neurotology, 42(5), 666-670.

[12] Saniasiaya, J. (2021). Hearing loss in SARS-CoV-2: what do we know?. Ear, Nose & Throat Journal, 100(2_suppl), 152S-154S.

[13] Nada, E. H., El-Gharib, A. M., & Mandour, M. (2022). Common and uncommon audio-vestibular findings in COVID-19 patients. The Egyptian Journal of Otolaryngology, 38(1), 119.

[14] Nassar, A. A. M., El-Kabarity, R. H., El-Din Hassan, N. N., & El-Gendy, A. M. (2024). Evaluation of cochlear and auditory brainstem functions in COVID-19 patients; a case control study. The Egyptian Journal of Otolaryngology, 40(1), 29.

[15] Gabr, T., Kotait, M., & Moaty, A. S. (2022). Audiovestibular and vaccination complications of COVID-19. The Egyptian Journal of Otolaryngology, 38(1), 105.

[16] Degen, C. V., Mikuteit, M., Niewolik, J., Joosten, T., Schröder, D., Vahldiek, K., ... & Steffens, S. (2022). Audiological profile of adult Long COVID patients. American Journal of Otolaryngology, 43(5), 103579.

[17] Gedik, Ö., Hüsam, H., Başöz, M., Tas, N., & Aksoy, F. (2021). The effect of coronavirus disease 2019 on the hearing system. The Journal of Laryngology & Otology, 135(9), 810-814.

[18] De Luca, P., Scarpa, A., Ralli, M., Tassone, D., Simone, M., De Campora, L., ... & Di Stadio, A. (2021). Auditory disturbances and SARS-CoV-2 infection: brain inflammation or cochlear affection? Systematic review and discussion of potential pathogenesis. Frontiers in neurology, 12, 707207.

[19] Hassani, S., Lazem, M., & Jafari, Z. (2021). No lasting impact of Covid-19 on the auditory system: a prospective cohort study. The Journal of Laryngology & Otology, 135(12), 1063-1068.

[20] Visram, A. S., Jackson, I. R., Guest, H., Plack, C. J., Brij, S., Chaudhuri, N., & Munro, K. J. (2024). Pre-registered controlled comparison of auditory function reveals no difference between hospitalised adults with and without COVID-19. International journal of audiology, 63(5), 300-312.

[21] Dorobisz, K., Pazdro-Zastawny, K., Misiak, P., Kruk-Krzemień, A., & Zatoński, T. (2023). Sensorineural hearing loss in patients with long-COVID-19: objective and behavioral audiometric findings. Infection and Drug Resistance, 1931-1939.

[22] Picciotti, P. M., Passali, G. C., Sergi, B., & De Corso, E. (2021). Benign paroxysmal positional vertigo (BPPV) in COVID-19. Audiology research, 11(3), 418-422.

[23] E1ldeeb, M., Eldeeb, D., & Elsherif, M. (2023). Prevalence of self-perceived audiovestibular symptoms in Egyptian COVID-19 patients. Journal of the Egyptian Public Health Association, 98(1), 18.

[24] Almishaal, A. A., & Alrushaidan, A. A. (2022). Short-and long-term self-reported audiovestibular symptoms of SARS-CoV-2 infection in hospitalized and nonhospitalized patients. Audiology and Neurotology, 27(4), 297-311.

[25] Freni, F., Meduri, A., Gazia, F., Nicastro, V., Galletti, C., Aragona, P., ... & Galletti, F. (2020). Symptomatology in head and neck district in coronavirus disease (COVID-19): a possible neuroinvasive action of SARS-CoV-2. American journal of otolaryngology, 41(5), 102612.

[26] Tang, M., Wang, J., & Zhang, Q. (2023). Prevalence of hearing loss in COVID-19 patients: A systematic review and meta-analysis. Acta Oto-Laryngologica, 143(5), 416-422.

[27] Pokharel, S., Tamang, S., Pokharel, S., & Mahaseth, R. K. (2021). Sudden sensorineural hearing loss in a post-COVID-19 patient. Clinical Case Reports, 9(10), e04956.

[28] Gerstacker, K., Speck, I., Riemann, S., Aschendorff, A., Knopf, A., & Arndt, S. (2021). Deafness after COVID-19?. Hno, 69(Suppl 2), 92-95.

[29] Mikhail, J., & Paez, A. COVID-19's Effect on Pre-existing Hearing Loss. Hearing Review. 2024;31(4):20-23.

[30] Mao, L., Jin, H., Wang, M., Hu, Y., Chen, S., He, Q., ... & Hu, B. (2020). Neurologic manifestations of hospitalized patients with coronavirus disease 2019 in Wuhan, China. JAMA neurology, 77(6), 683-690.