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Vestibular findings in patients with white matter disease

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Abstract

Background: Older people develop gait and balance dysfunction that is associated with the gradual onset of cerebral white matter disease. White matter disease is easily detected by neuroimaging, whereas small vessels are not; hence, the term small vessel disease is frequently used to describe the parenchyma lesions rather than the underlying small vessel alterations. This study was done to investigate the relationship between the presence and/or absence of white matter disease identified on magnetic resonance imaging with the vestibular findings in elderly patients with dizziness. The current study was conducted on a total number of 30 elderly patients complaining of dizziness and/or instability. The inclusion criteria are patients above 55 years old and a history of vertigo and/or instability. All the study groups were subjected to full neuro-otological history, hearing assessment, video-nystagmography test (VNG), assessment of the risk of fall by functional gait assessment test (FGA), and radiological assessment: magnetic resonance stroke protocol.

Results: FGA total scores were significantly lower in patients with white matter disease (0.047) specifically PVWM score 3 (0.04) and DWM score 3 (0.19). Abnormal VNG test results were significantly higher in patients with atherosclerotic changes (0.04). The most common VNG finding abnormality was positional nystagmus.

Conclusions: Normal VNG findings in elderly dizzy patients should be complemented with FGA test to assess the risk of falls. The presence of risk factors for white matter disease (WMD) as hypertension, diabetes mellitus, ischemic heart disease, hyperlipidemia, and migraine is an indication for requesting a further radiological assessment. The most frequent VNG abnormality in elderly patients with white matter disease is positional and positioning nystagmus, and a significant number of patients had positional nystagmus of the non-localizing criteria. FGA test scores are significantly related to the severity of white matter disease. The presence of atherosclerotic changes is significantly related to the presence of VNG test abnormality. It is important to ask the patient about the past history of migraine as it has an effect on VNG, FGA, and radiological findings.

Keywords: Elderly, White matter disease, Small vessel disease, Dizziness, FGA

Background

Age-related ischemic disease may manifest clinically with varying degrees and difficulties with mobility [1]. Dizziness and imbalance are some of the most common complaints in the elderly [2]. It is commonly associated with the gradual onset of age-related ischemic cerebral white

matter disease [3]. However, the mechanism through which it affects the gait is unknown [4, 5].

Several theories were proposed to explain the mechanism of gait disturbances in the elderly [6]. VNG as the gold standard tool for assessment of dizziness and vertigo in the elderly has a great role in the diagnosis of those patients; many VNG abnormalities particularly positioning and/or positional nystagmus were encountered in the VNG test in elderly patients [7].

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Mankekar et al. [8] reported that central vestibular findings had a 50% positive predictive value for magnetic resonance imaging abnormalities.

To the best of the authors' knowledge, there are limited researches that examined the relation between age-related ischemic changes as a radiological finding in MRI and MRA and the vestibular findings detected by VNG in elderly patients complaining of dizziness and/or imbalance. Therefore, the present study is designed to evaluate the vestibular findings using VNG in elderly patients and its relation to white matter changes detected by magnetic resonance imaging.

Methods

The current study was conducted on thirty elderly patients complaining of dizziness and/or instability who were selected from the audio-vestibular clinic of El-Demerdash Hospital, during the period from February 2018 to October 2018. The inclusion criteria are age group above 55 years old and positive history of vertigo and/or instability.

The exclusion criteria are patients diagnosed with known causes for dizziness as Meniere's disease, bilateral vestibulopathy, recent vestibular neuritis or labyrinthitis, history of head trauma or surgery, neurological diseases (intracranial space-occupying lesions, multiple sclerosis, parkinsonism and paresis), and patients with an otologic history of otorrhea or ear surgery.

Equipment

The following are the equipment:

- Sound treated room I.A.C model 1602.
- Two-channel audiometer interacustics, model AC40.
- Immitancemetry model otopront.
- Computerized video-nystagmography 2 channels (Micromedical Technologies, mobile eyes, spectrum 8.10).
- Magnetic resonance imaging stroke protocol (MRI and MRA).
- Functional gait assessment (FGA) tools, including stopwatch and two boxes; the height of each is 11 cm.

Method

Each participant was subjected to the following:

- Full neuro-otological history
- Hearing assessment in the form of otological examination and pure tone audiometry: air conduction thresholds at 0.25, 0.5, 1, 2, 4, and 8 KHz; bone conduction thresholds at 0.5, 1, 2, and 4 KHz; speech audiometry; and acoustic immittance testing

- Vestibular assessment

Video-nystagmography test (VNG), VNG test battery included the following tests:

- Spontaneous nystagmus
- Oculomotor tests: random saccade, smooth pursuit, optokinetic testing, and gaze test
- Positioning test (Dix-Hallpike, roll test)
- Positional nystagmus
- Caloric testing

The caloric test was done using the "alternate binaural bithermal" caloric method (automated open-loop water irrigation).

Output is using the average of peak slow-phase velocity response of the four irrigations, the software utilized Jongkees' formula to calculate the asymmetry between the ears [9].

The percentage of caloric weakness was considered to be significant at the level of 20% and more, while signs of uncompensation included the presence of spontaneous nystagmus, positional nystagmus, or significant directional preponderance of more than 25% [10].

Video-nystagmography required an average of 30–45 min.

Assessment of risk of fall by functional gait assessment test

The functional gait assessment (FGA) is a standardized test for assessing postural stability during various walking tasks. The test is a modified version of the Dynamic Gait Index test which was developed [11]. Wrisley et al. [12] revised the DGI test to create the FGA test.

The FGA is a 10-item clinical gait test during which participants are asked to perform the following gait activities: walk at normal speeds, at fast speeds, and at slow speeds, with vertical and horizontal head turns, with eyes closed, over obstacles, in tandem, backward, and while ascending and descending stairs. The FGA is scored on a 4-level (0–3) ordinal scale; scores range from 0 to 30, with lower scores indicating greater impairment [13–15].

The FGA test was performed in all patients except 1 due to poor general condition. The instructions of the items were understood by the subjects of the study. The time needed to complete the testing was about 10 to 15 min.

Radiological assessment

Magnetic resonance stroke protocol is a group of magnetic resonance sequences put together to best approach brain ischemia: consists of T1, T2, T2/FLAIR, diffusion (DWI) images, and MR angiography (MRA) [16–20].

Fazekas classification [21] divides the white matter in periventricular (PVWM) and deep white matter (DWM) and is given a grade depending on the size and confluence of lesions on a scale range from 0 to 3 with the highest grade indicating more severe lesions.

Statistical methods

Data were coded and entered using the statistical package for the Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY, USA). Data was summarized using mean and standard deviation for quantitative variables and frequencies (number of cases) and relative frequencies (percentages) for categorical variables. Comparisons between the groups were done using unpaired *t* test when comparing 2 groups and analysis of variance (ANOVA) with multiple comparisons post hoc test when comparing more than 2 groups [22]. For comparing categorical data, the chi-square (χ^2) test was performed. Exact test was used instead when the expected frequency is less than 5 [23]. Correlations between quantitative variables were done using the Pearson correlation coefficient [24]. *P* values less than 0.05 were considered statistically significant.

Results

Please see the results in Tables 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11.

Discussion

In the present work, the authors are demonstrating the vestibular results of 30 dizzy patients in addition to their radiological findings. In 25 of them, no clear diagnosis could be reached after full history taking and VNG testing; 5 patients had BPPV either the only VNG finding (2 patients) or accompanied by other VNG findings (3patients) (Table 2).

All subjects who underwent radiological investigations had one or more abnormal findings, 78.6% had white matter disease (WMD), 71.4% had atherosclerotic changes, and 78.5% had mixed lesions (Table 3). VNG showed abnormal test results in 60% (Table 2) and all had reduced FGA test scores (Table 5).

Table 2 shows that 60% of the study group had abnormal VNG findings in the form of peripheral, non-localizing, and mixed (central and peripheral) vestibular lesions. The number of abnormal patients 60% is lesser than the total number of VNG test findings due to the presence of multiple test findings in the same patient.

*Peripheral vestibular lesion based on the positioning (Dix-Hallpike), peripheral criteria of positional nystagmus as the only finding, and unilateral caloric weakness.

**Non-localizing vestibular lesion based on the presence of positional nystagmus as the only VNG finding with the criteria of positional nystagmus not clearly

Table 1 Distribution of patients according to VNG test findings

VNG findings	No abnormality		Abnormal	
	No of patients	%	No of patients	%
Spontaneous nystagmus	26	86.7	4	13.3
Gaze test	30	100	0	0
Optokinetic	30	100	0	0
Pursuit	30	100	0	0
Saccade	30	100	0	0
^a Positioning	25	83.3	5	16.7
^b Positional	17	56.7	13	43.3
^c Unilateral caloric weakness	26	86.7	4	13.3

N.B.: No isolated central vestibular deficit was detected in the study group. Some patients had multiple VNG abnormalities

^a There was an abnormality in positioning test in 5 patients; 3 of them had in addition to the positioning nystagmus either spontaneous or positional nystagmus (of mixed peripheral and central criteria of vestibular lesion) as follows: vertical nystagmus, one of them diminished while others abolished or diminished with fixation, with a minimal subjective sense of dizziness

^b The other patients with positional nystagmus were either peripheral with the following criteria: horizontal nystagmus, directional fixed, abolished with fixation and with a subjective sense of dizziness, or mixed peripheral and central criteria of vestibular lesion as follows: vertical nystagmus, abolished or diminished with fixation with a minimal subjective sense of dizziness

^c 13.3% of the study group had unilateral caloric weakness; 2 of them were uncompensated as accompanied with spontaneous or positional nystagmus and the other 2 were compensated with unilateral caloric weakness as the only VNG finding

matching a peripheral or central site of lesion (vertical nystagmus, abolished or diminished with fixation with a minimal subjective sense of dizziness).

***Mixed criteria of vestibular lesion based on the presence of multiple VNG finding including BPPV together with spontaneous nystagmus (2patients) and/or positional nystagmus of mixed criteria (peripheral and central) as mentioned above. One of the patients had unilateral caloric weakness in addition to the positioning, positional and spontaneous nystagmus.

The most common risk factors for WMD in the present study were hypertension (53.3%) and diabetes mellitus (43.3%). Other risk factors included hyperlipidemia (30%), ischemic heart disease (23.3%), and migraine (16.7%), and 46.7% of the study group had more than one risk factor (Table 4). Arterial hypertension was found to be the most common risk factor of the dizziness associated with white matter disease in elderly patients with a percentage of 81%. Cardiovascular factors also could have a pathogenic role in WMD as well as in vestibular disorders and in aggravating symptoms of both diseases [25].

Regarding FGA test scores, there were tasks that were expected to be more difficult for people with vestibular disorders and they were ambulating backwards, gait with

Table 2 Distribution of the study group according to the site of the lesion based on the VNG test

VNG test results			No.	%
Normal VNG study			12	40
Abnormal VNG	^a Peripheral vestibular lesion	BPPV	2	6.7
		Positional (peripheral)	6	20
		Unilateral caloric weakness	3	10
	^b Non-localizing positional criteria	4	13.3	
	^c Mixed vestibular lesion	3	10	
Total patient in the study group			30	100

^a Peripheral vestibular lesion based on the positioning (Dix-Hallpike), peripheral criteria of positional nystagmus as the only finding, and unilateral caloric weakness

^b Non-localizing vestibular lesion based on the presence of positional nystagmus as the only VNG finding with the criteria of positional nystagmus not clearly matching a peripheral or central site of lesion (vertical nystagmus, abolished or diminished with fixation with a minimal subjective sense of dizziness)

^c Mixed criteria of the vestibular lesion based on the presence of multiple VNG findings including BPPV together with spontaneous nystagmus (2 patients) and/or positional nystagmus of mixed criteria (peripheral and central) as mentioned above. One of the patients had unilateral caloric weakness in addition to the positioning, positional, and spontaneous nystagmus

Table 3 Distribution of patients according to different radiological findings. N.B: Two patients were excluded from 30 patients due to contraindication of MRI due to metallic heart prosthesis and metallic clips, so the total radiological investigated patients were 28

	Present		Absent		Total	
	No.	%	No.	%	No.	%
Involution brain changes	15	53.6	13	46.4	28	100
White matter disease	22	78.6	6	21.4	28	100
Old multi-lacunar infarction	12	42.9	16	57.1	28	100
Atherosclerotic changes	20	71.4	8	28.6	28	100
Mixed lesion ^a	22	78.57	6	21.42	28	100

^a Mixed lesion based on the presence of more than one radiological finding in the same patient. No single patient was normal in the radiological assessment

Table 4 Distribution of patients according to known medical history

Risk factors ^a	Present		Absent	
	No.	%	No.	%
Diabetes	13	43.3	17	56.7
Hypertension	16	53.3	14	46.7
Ischemic heart disease	7	23.3	23	76.7
Hyperlipidaemia	9	30.0	21	70.0
Migraine	5	16.7	25	83.3
^b Multiple risk factor	14	46.7	16	53.3

The most common risk factors were hypertension (53.3%) and diabetes (43.3%), and 46.7% of the study group had more than one risk factor

^a All patients had at least one risk factor for WMD

^b In some patients, there were multiple risk factors in the same patient

eyes closed, gait with a narrow base of support, and tasks involving head turns [26, 27]. Our results showed a high percentage of patients having difficulty in performing those tasks (Table 5) that could be due to the large percentage of patients having a vestibular lesion in the study group.

In subjects with WMD and SVD, gait speed was found to be significantly slower, and it was assessed by the 6-m walk test [28]. The same findings were evident in our study group although using simple office tests as all the patients performed the FGA tasks have abnormal gait level surface task (task no. 1) regarding the speed of the task rather than deviation (Table 5).

The value of the present work can be looked for from two perspectives; the first is the normal VNG test results in 40% of patients. In cases of elderly “or adults above the age of 55 years,” testing should not stop at this stage. The present study showed that a simple office test as FGA is mandatory to be conducted and is very beneficial. All subjects in this group (including the 40% normal VNG) (Table 2) had decreased FGA scores (Table 5) and one or more radiological abnormalities as detected by MRI and/or MRA (Table 3).

Furthermore, 50% of normal VNG subjects had atherosclerotic changes as detected by MRA compared to 87.5% of the abnormal VNG group (Table 6). The chi-square test results showed a statistically significant difference (*P* value = 0.044). Elderly dizzy patients with normal VNG findings who have more risk factors for WMD as diabetes

Table 5 Number and percentage of patients of the study group according to FGA different grades

Tasks	Normal		Mild		Moderate		Severe		Total patients	
	N	%	N	%	N	%	N	%	29	100
1. Gait level surface	0	0	4	13.8	21	72.4	4	13.8	29	100
2. Change in gait speed	19	65.5	7	24.1	3	10.3	0	0	29	100
3. Gait with horizontal head turns	4	13.8	21	72.4	4	13.8	0	0	29	100
4. Gait with vertical head turns	13	44.8	16	55.2	0	0	0	0	29	100
5. Gait and pivot turns	23	79.3	5	17.2	1	3.4	0	0	29	100
6. Step over an obstacle	25	86.2	2	6.9	2	6.9	0	0	29	100
7. Gait with a narrow base of support	9	31	4	13.8	10	34.5	6	20.7	29	100
8. Gait with eyes closed	1	3.4	3	10.3	18	62.1	7	24.1	29	100
9. Ambulating backwards	10	34.5	16	55.2	2	6.9	1	3.4	29	100
10. Steps	15	51.7	4	13.8	10	34.5	0	0	29	100
Total score	0	0	17	58.6	12	41.4	0	0	29	100

All of the patients had mild and moderate degrees in FGA

*The mean and SD of the patients in the study group is 20.4 ± 4.1 for the total patients who performed FGA test in the study group, while it ranges from 23.2 ± 1.9 in the patients with mild FGA impairment to 16.4 ± 2.7 in the patients with moderate FGA impairment

Table 6 The chi-square test between VNG test results and different radiological findings

		VNG results				P value
		Normal		Abnormal		
		No.	%	No.	%	
Atherosclerotic changes	Yes	6	50.0	14	87.5	0.044
	No	6	50.0	2	12.5	
Old lacunar inf.	Yes	4	33.3	8	50.0	0.378
	No	8	66.7	8	50.0	
WMD	Yes	9	75.0	13	81.3	1
	No	3	25.0	3	18.8	
Involution brain changes	Yes	7	58.3	8	50.0	0.662
	No	5	41.7	8	50.0	

The presence of atherosclerotic changes as a finding detected by MRA was statistically significantly higher in patients having abnormal VNG test findings (P value = 0.04)

Table 7 Distribution of the patients according to Fazekas scoring

PVWM 0		PVWM 1		PVWM 2		PVWM 3		Total		PVWM+ DWM	
N	%	N	%	N	%	N	%	N	%		
8	28.6	4	14.3	4	14.3	12	42.9	28	100	No	%
DWM 0		DWM 1		DWM 2		DWM 3		Total		19	67.9
N	%	N	%	N	%	N	%	N	%		
7	25	5	17.9	6	21.4	10	35.7	28	100		

The most common Fazekas scorings in the study group are grade 3 WMD (PVWM and DWM) and combined lesion of both PVWM and DWM

or hypertension should be subjected to FGA and radiological studies to receive appropriate medical treatment if needed.

Another interesting finding in the present work is the normal oculomotor test results in all subjects (Table 1). Contrary to the present study, another study found that there was a positive predictive value of

Table 8 Unpaired *t* test between FGA total score and radiological findings as detected by magnetic resonance imaging (MRI and MRA)

		FGA total score		P value
		Mean	Standard deviation	
Atherosclerotic changes	Yes	20.58	4.65	0.923
	No	20.75	2.38	
Old lacunar inf.	Yes	20.75	3.86	0.894
	No	20.53	4.34	
WMD	Yes	19.81	3.98	0.047
	No	23.50	3.08	
Involution brain changes	Yes	21.00	4.57	0.632
	No	20.23	3.56	

Patients with WMD as a radiological finding detected by MRI had lower FGA total scores (*P* value = 0.047)

Table 9 Unpaired *t* test between PVWM 0 and PVWM 3 with the FGA total scores

	PVWML 0		PVWML 3		P value
	Mean	SD	Mean	SD	
FGA total score	22.88	3.04	18.73	4.56	0.040

Patients with PVWM 3 had lower FGA total scores (*P* value = 0.04)

Table 10 ANOVA test between FGA total score and Fazekas scores (DWM)

	DWM								P value
	DWM 0		DWM 1		DWM 2		DWM 3		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
FGA total score	23.29	2.87	22.60	1.95	20.33	3.67	17.67	4.30	0.019

Table 11 Post hoc pair-wise comparisons between the FGA total scores and different grades of DWM

	DWM 0	DWM 1	DWM 2	DWM 3
DWM 0		0.987	0.442	0.020
DWM 1	0.987		0.709	0.081
DWM 2	0.442	0.709		0.482
DWM 3	0.020	0.081	0.482	

FGA total scores were statistically significantly higher in patients with DWM 0 than in patients with DWM 3 (23.29 ± 2.87 vs 17.67 ± 4.3, *P* value = 0.02)

abnormal oculomotor test findings in relation to magnetic resonance imaging abnormalities. Compared to the present work, their group included cortical and cerebellar atrophy subjects' accordingly central vestibular

lesion, and abnormal oculomotor abnormalities can be expected [8].

Moreover, oculomotor abnormalities are often accompanied by CNS diseases with symptoms such as blurred vision, oscillopsias, double vision, or staggering [29]. Such conditions were among the exclusion criteria in the present study.

Concerning subjects with abnormal VNG findings (60% of the study group), they demonstrate either peripheral site of lesion (36.7%), combined site of lesion (10%), or the site could not be otherwise specified (26.3%) as shown in Table 2. This agreed with other studies who found that there was a higher prevalence of pathological vestibular signs of a peripheral type in patients with WMD [30, 31]. Also, other researchers found that BPPV was found to be the main cause of dizziness in 26% of patients with WMD (Fazekas score 2–3) [31].

In the present study, the most frequent VNG abnormality was the presence of positional nystagmus in 43.3% of patients (Table 1), some of peripheral and other with non-localizing criteria. In the present authors' experience, the presence of positional nystagmus of non-localizing character as "the only abnormality in VNG" is almost always related to the presence of age-related ischemic changes [7]. In fact, peripheral vestibular involvement or CNS involvement may provide similar findings during testing. The delineation between the peripheral and central sites of the lesion within the vestibular system based on the

criteria of positional nystagmus alone should be avoided. It was reported that positional tests could evaluate the state of cerebral perfusion contralateral to the direction of head movement [32]. In agreement with the present results, it was reported that lack of fixation suppression of positional nystagmus supports CNS involvement, but it is also not uncommon for some suppression to occur. Both age-related CNS changes and migraine may be the cause of positional nystagmus. They also reported an imperative need for correlation with patient history and symptoms, in addition to the results of VNG and other diagnostic evaluations [33].

In the present study, 5 patients had BPPV, 2 of them had the disease diagnosed by positioning Dix-Hallpike test alone while the rest of this group (3 subjects) had in addition positional nystagmus of non-localizing

character (Tables 1 and 2). The causes of BPPV are primarily believed to be mechanical [34, 35]. But the BPPV recurrence rate is approximately 12–20% [36, 37]. Approximately 2.4% of the population will at some point in their life be affected by BPPV, among individuals who live into their 80s, the rate is as high as 10% with the onset typically being between 50 and 70 years [38]. Accordingly, conditions that are comorbid with BPPV have been rigorously investigated in the literature.

It is reported that BPPV patients with hypertension and hyperlipidemia are more likely to experience recurrence [39]. Moreover, age, migraine, hypertension, hyperlipidemia, and stroke were found to be independently associated with BPPV [40]. In addition, it was found that the prevalence of hypertension, diabetes mellitus, atrial fibrillation, coronary artery disease, and hyperlipidemia is higher among patients with BPPV than among those without BPPV [41].

The clinical implication of these findings in patients with BPPV is remarkable. The full VNG test battery is recommended in persistent dizziness after a successful repositioning maneuver. The underlying cause of such dizziness may be due to the presence of combined condition as WMD. In the latter case, neurological consultation, radiological assessment, and medical treatment are warranted.

In the present study, there were 5 patients with a past history of migraine (Table 4). Among those patients, there were 3 patients with abnormal VNG test findings in the form of positional nystagmus of peripheral criteria, and 2 patients showed normal VNG test results. Furthermore, all the patients had an abnormality in the radiological assessment. In a systemic review and meta-analysis, it was found that migraine may be a risk factor for structural changes in the brain including WMLs, lacunar infarction, and brain involucional changes [42].

In the present study, 13.3% of the study group have unilateral caloric weakness 50% of them were compensated, and the other 50% were uncompensated (Tables 1 and 2). Regarding the compensated patients, it was found that the compensation process that follows vestibular loss may be the key to the structural reorganization of white matter tracts involved in balance maintenance [43]. As the process of compensation is accompanied by structural reorganization of white matter disease so patients with uncompensated unilateral caloric weakness may suffer from WMD in this stage as there are more burdens on the central vestibular pathway. Moreover, regarding the uncompensated patients, as the atherosclerotic changes and small vessel disease result in ischemia of the affected structure, this may delay the process of central compensation that will result in more burdens on the central vestibular system.

This agreed with another study that found a significant canal paresis in (38.7%) of SVD and the dizziness was likely due to insufficient central compensation after a previous vestibular loss [30].

The most common radiological findings among the study group were white matter disease (WMD) (78.6%) and atherosclerotic changes (71.4%) (Table 3). Periventricular white matter Fazekas score 3 (PVWM 3) was found in 42.9%, and deep white matter Fazekas score 3 (DWM 3) was found in 35.7% reflecting the degree of severity of WMD in the dizzy patients. Combined lesions (both PVWM and DWM) were also very prevalent (67.9%) regardless of severity (Table 7).

Conducting statistical analysis of the present data showed that the presence of WMD (PVWM 3 and DWM 3) detected by MRI was associated with lower FGA total scores (Tables 8, 9, 10, and 11). Moreover, the presence of atherosclerotic changes detected by MRA was associated with a higher percentage of VNG abnormalities ($p = 0.04$) (Table 6).

Gait deterioration was found to be associated with white matter atrophy and was independent of age, gender, height, and follow-up duration [44]. It is reported also that the presence of WMD seems to be the major driving force for gait impairment in elderly subjects [26]. The cause of this correlation between dizziness-induced gait abnormality and WMD could be the disruption of neuronal networks that mediate higher vestibular cortical function [25]. Also, a systematic review indicated that WMD are common in older people and are significantly associated with impaired balance, gait, mobility, and falls. However, in many studies, these findings were only evident in people who have the most severe degree of WMD [45].

Moreover, SVD is a dynamic and highly variable disease process with progression and in some regression of SVD [46, 47]. In a recent study, reduction in blood pressure was associated with a reduction in WMD volume [47]. This suggests that better blood pressure control could attenuate or even reverse the WMD growth and consequently could lead to better gait function over time.

Age-related ischemic changes as a disease prevalent among older adults present with various degrees of dizziness and gait impairment. Dizzy patients with no clear etiology above the age of 55 years old have signs of white matter disease with variable degrees of severity and different radiological presentations.

The present results suggest that elderly patients with dizziness, without a clear diagnosis and despite clinical and vestibular assessment, should undergo brain imaging to assess the level of WMD and possible comorbid condition as presence of atherosclerotic changes.

Conclusion

- The presence of risk factors of white matter disease (WMD) such as hypertension, diabetes mellitus, ischemic heart disease, hyperlipidemia, and migraine is a medical indication for requesting further radiological assessment in dizzy patients.
- The most frequent VNG abnormality in elderly patients with white matter disease is positional and positioning nystagmus, and a significant number of patients had positional nystagmus of non-localizing criteria.
- FGA test scores are significantly related to the severity of white matter disease.
- The presence of atherosclerotic changes is significantly related to the presence of VNG test abnormality.
- It is important to ask the patient about the past history of migraine as it has a reflection on VNG, FGA, and radiological findings.

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Authors' contributions

NH contributed to the idea, funding, supervision, and analyses of the results. AY contributed to the analysis, revision, and funding of the research. NS contributed to the supervision and funding and participated in working cases and analysis of the results. AA contributes to working cases and writing. All authors have read and approved the final manuscript.

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Availability of data and materials

Data and materials were available. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The protocol was ethically approved by the ENT Department Board, the Research Ethical Committee, Faculty of Medicine, Ain Shams University. Reference number is not available. Informed verbal consent was taken from the participants.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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