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Evaluation of vestibular evoked myogenic potential values in elder patients with hip fractures: A prospective controlled study

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Ethics Committee Approval
The study was approved by the Kastamonu University clinical research ethical committee, Turkey, (Decision no. 2020-KAEK-143-123 dated 20.10.2021).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

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Abstract

Background/Aim: Hip fractures among the elderly are a major public health problem that cause high rates of morbidity and mortality. There are many studies regarding prevention and defining the underlying causes of hip fractures. The purpose of this study was to evaluate the cervical vestibular evoked myogenic potential (cVEMP) test responses of elderly patients without vestibular symptoms hospitalized due to fall-related hip fractures in order to evaluate the subclinical vestibular dysfunction rates in patients with hip fractures.

Methods: Twenty-two patients aged 67-79 hospitalized due to fall-related hip fractures and 24 control patients presenting to the orthopedic clinic due to knee pain were included in the study. The participants underwent detailed otological examination and cVEMP tests. The two groups' cVEMP records were then compared.

Results: The demographic characteristics of the participants in the patient and control groups including age, gender, and race were similar. There was no statistically significant difference between the groups' absent VEMP response rates. No significant difference in terms of P1 and N1 latencies was determined between the right and left ears in either group. The hip fracture group (study group) had significantly increased P1 and N1 latencies in cVEMP which is associated with central vestibular dysfunction. (P=0.008 and P=0.007, respectively).

Conclusion: The rate of subclinical peripheral vestibular dysfunction, which can be identified by cVEMP evaluation, is increased in elderly patients with hip fractures caused by low energy trauma. Precautions like vestibular rehabilitation can be a preventive measure for hip fractures in the elderly.

Keywords: cVEMP, hip fracture, balance disorder, vestibular dysfunction

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Introduction

Hip fractures are a public health problem causing social and economic problems, particularly among the elderly [1,2]. The global number of hip fractures, 1.26 million in 1990, is expected to rise to 4.5 million by 2050 as the elderly population continues to grow. Although regional data vary between countries, 18% of women and 6% of men are generally expected to be affected [3]. Hip fractures generally result from low-energy traumas in the home and exhibit a high rate of mortality and morbidity within one year following hospitalization [4].

Decreased bone mineral density (BMD) is still the primary risk factor. Factors affecting BMD include genetic predisposition, advanced age, and sex. Other predisposing factors to hip fractures are impaired vision, drug use, and balance problems [5]. Severe increases in mortality and morbidity occur over time in these patients following surgery [1,4].

An increase in daily activities and a decrease in fear of falling and numbers of falls has been observed in these patients as a result of balance studies [4]. Studies of balance problems have reported hip fracture-preventing and postoperative quality of life-enhancing results [4,6]. The incidence of balance problems among the elderly population has been reported as 34% [7]. Measures routinely taken to reduce hip fractures in the elderly population include balance examinations, use of crutches, and balance exercises [7-10].

Some accidents can, therefore, be avoided by means of simple, low-cost measures aimed at serving as guides for the elderly in risky situations. These provide significant benefits in terms of quality of life and significant reductions in mortality, morbidity, and socioeconomic costs of this growing problem [7,10].

Vertigo and balance problems are seen in approximately 15-20% of the adult population. Vestibular disorders can be caused by central or peripheral pathologies. The most widespread causes of peripheral vestibular vertigo in ear, nose, and throat clinical practice are benign paroxysmal positional vertigo, vestibular neuronitis, and Meniere's disease (MD). Vertigo can also result from non-peripheral vestibular causes, such as neurological and autoimmune diseases [11].

Vestibular evoked myogenic potentials (VEMP) testing is a non-invasive and objective method permitting the electrophysiological evaluation of vestibular functions and is used in the diagnosis of vestibular diseases [11,12]. Two types of VEMP test are employed in clinical practice, cervical VEMP (cVEMP) and ocular VEMP (oVEMP) [7]. oVEMP yields information about utriculo-ocular functions, while cVEMP provides data concerning vestibulo-colic reflex functions [12]. The neural pathway tested using cVEMP begins from the saccule and provides stimulation of the sternocleidomastoid (SCM) muscle via the motor neurons of the inferior vestibular nerve, lateral vestibular nucleus, medial vestibulospinal tract, and spinal cord [11,12]. A biphasic response is elicited with the administration of acoustic stimuli. Electromyographic activity is recorded using electrodes placed over the SCM. The presence or absence and the structure and symmetry of the recording provide information about the location of peripheral pathologies of the vestibular nerve [11].

The purpose of this study was to determine the effect of balance problems, which exacerbate falls, one of the etiological causes of hip fractures, with the evaluation of cVEMP.

Materials and methods

Approval for this prospective study was granted by the Clinical Research Ethical Committee of Kastamonu University Clinical Ethical Board (Decision no. 2020-KAEK-143-123 dated October 20, 2021). Written informed consent was obtained from all the participants after the study protocol had been explained to them in detail. Twenty-two consecutive patients who were hospitalized at the orthopedic clinic due to hip fracture between November 1, 2021 and May 1, 2022 were included in the study. The control group consisted of 24 random patients with a similar age range and similar demographic characteristics admitted to the orthopedic clinic due to knee pain. All participants underwent detailed otological examinations, and their demographic characteristics, additional diseases, and clinical features were recorded. The two groups' cVEMP records were compared. Individuals with histories and complaints of vertigo, with middle and outer ear diseases, with neuropsychiatric diseases or with histories of otological surgery were not included in the study. Those using muscle relaxant drugs or hearing devices were also excluded from the study.

The VEMP test was performed in the patient's room using a Socrates device (Hedera Biomedics, Taranto, Italy). Recordings were taken with the patients in a supine position and facing the contralateral side in order to ensure sufficient and continuous tension in the SCM. Electromyographic activity was measured using an active electrode placed on the upper third of the SCM muscle, a reference electrode on the suprasternal notch, and a ground electrode on the forehead. The skin was cleaned where the electrodes were attached. The response of the ipsilateral SCM to monoaural stimuli was recorded. Acoustic stimuli (tone-burst, 500 Hz, 4.3/s stimulus rate, rise=2 ms, plateau=1 ms, and fall=2 ms) were applied by means of Etymotic ER3C insert earphones (USA). A 90 dB stimulus was applied to determine the VEMP threshold, and ipsilateral myogenic potentials were recorded. The first positive wave was recorded as P1 and the first negative wave as N1. The latencies and amplitudes of these waves were calculated and recorded. When biphasic wave forms were not recognizable and repeatable, the VEMP response was regarded as absent. The VEMP asymmetry rate (VAR) was calculated using the formula VEMP asymmetry (%)=100(Ar-Al)/(Ar+Al) and subsequently recorded.

Statistical analysis

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 20.0 software (IBM Corporation, New York, NY, USA). Normality of data distribution was evaluated using the Shapiro-Wilk test. Student's t test was applied in the case of normal distribution, and the non-parametric Mann-Whitney U test in the case of non-normal distribution. Data were expressed as mean (SD). The chi-square test was applied in the analysis of categorical data. *P*-values <0.05 were regarded as significant for all tests.

Results

Twenty-two patents aged 64-79 and a control group consisting of 24 individuals aged 67-83 were included in the study. The patient group was made up of 13 women and 9 men, and the control group consisted of 14 women and 10 men. No significant age or gender difference was observed between the two groups.

Eleven members of the patient group had been hospitalized due to a left hip fracture and 11 with a right hip fracture. Both groups underwent detailed otological examinations. Audiograms were not performed since the patients were immobile. However, as previously mentioned, patients with hearing loss or using hearing aids were excluded from the study.

Unilateral absent VEMP response was observed in five and bilateral absent VEMP response in three members of the patient group, while in the control group unilateral absent VEMP response was determined in two individuals and bilateral absent VEMP response in one. No significant difference in asymmetry rates was determined between the patient and control groups (P=0.505).

No significant difference was determined between the right and left ears in either group in terms of P1 and N1 latencies. However, P1 and N1 values in both the right and left ears differed significantly between the fracture and control groups (P=0.008 and P=0.007, respectively). The hip fracture group had significantly increased P1 and N1 latencies, which is associated with central vestibular dysfunction (Table 1).

Table 1: The mean values of P1 an N1 latencies evaluated cVEMP of fracture and control groups

	Control group	Fracture group	*P*-value
Right P1	15.17 (6.02)	29.20 (6.05)	0.007
Left P1	15.79 (6.07)	28.63 (6.19)	0.007
Right N1	15.33 (8.19)	29.04 (8.23)	0.008
Left N1	17.62 (8.21)	29.96 (8.38)	0.008

Discussion

Decreased bone quality due to osteoporosis is the most important cause of hip fractures in the elderly. However, balance problems that exacerbate falls represent another important risk factor [1,3,4,9,10].

A complex interaction of physiological mechanisms is involved in the safe performance of such daily activities as walking and standing. An important risk factor for falls in the elderly is an age-related decrease in balance control [10], and balance disorders are one of the causes of hip fractures. Shunney et al. [9] reported that 53% of patients had fallen at least once in the six months prior to hospitalization due to hip fracture.

Hip fractures increase with age and cause high rates of mortality and morbidity. It is, therefore, essential to identify these patients beforehand and administer the requisite fall-prevention treatment and rehabilitation. Even the use of crutches alone has been identified as a fall-preventing factor [8]. Postoperative rehabilitation and balance therapies in elderly individuals with hip fractures have resulted in early returns to daily life, faster walking, and an improved quality of life [8-10].

Significant changes in VEMP have been shown in superior semicircular canal dehiscence syndrome, an inner ear disease characterized by audiological findings, such as dizziness, imbalance, hyperacusis, autophony, pulsatile tinnitus, and conductive hearing loss occurring with pressure and loud noise [13]. Ziniga et al. [14] showed that hearing loss associated with exposure to noise can lead to falls, and suggested that it would be useful for patients to be evaluated in terms of saccular dysfunction using VEMP.

VEMP is a clinical reflex test employed in the diagnosis of vestibular diseases and involves the recording and evaluation of muscle potentials resulting from stimulating the vestibular system with different stimuli. cVEMP is an effective method that successfully shows balance functions in both humans and animals [16]. Differences in VEMP recordings appear in diseases deriving from the ear and the vestibular system [12,14,15]. Some studies have shown that VEMP is not useful in the diagnoses of MD and vestibular neuritis. This situation, known as absent response, indicates inferior vestibular nerve involvement [16].

Several studies of oVEMP and cVEMP tests have reported that no response could be obtained in elderly individuals in particular. Although up to 40% of otologically and neurologically healthy individuals over the age of 60 do not produce a cVEMP in response to an air conduction tone burst at 500 Hz, Piker et al. [17] recommended that this should be investigated at 500 or 750 Hz for obtaining cVEMP response. In a study of patients over 60, Rosengren et al. [12] reported an absence of cVEMP rate of 5-15%. In the present study, cVEMP was applied at 500 Hz to all patients. No failure to achieve a bilateral response occurred in any patient. The most consistent age-related finding is a decreased peak-to-peak amplitude and a threshold that increases in line with age (in other words, a threshold occurring at higher stimulus levels).

In a study of patients followed-up due to osteoporosis, Gargeshwari et al. [18] described the absence of oVEMP in particular as significant when they applied oVEMP and cVEMP tests. They also suggested that it should be mandatory for elderly individuals under follow-up due to osteoporosis and osteopenia to be assessed in terms of balance.

Limitations

There are also certain limitations to this study. The most important limitation of this study is the absence audiometric analysis for the patients due to their lack of mobility. The relatively low number of patients prevented us from subgrouping the patients in terms of age and fracture types. This subject might be usefully investigated in future and more extensive studies.

Conclusion

This study revealed that the rate of subclinical peripheral vestibular dysfunction, which can be identified by cVEMP evaluation, is increased in elderly patients with hip fractures caused by low energy trauma. Precautions like vestibular rehabilitation can be a preventive measure for hip fractures in the elderly.

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