Oculomotor Test Changes in Patients with Peripheral Vestibular Dysfunction

Periferik Vestibüler Fonksiyon Bozukluğu Olan Hastalarda Okülomotor Test Değişiklikleri

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ABSTRACT

Objective: Peripheral vestibular hypofunction can be seen unilaterally or bilaterally. The aim of this study is to investigate the oculomotor test results in patients with unilateral and bilateral peripheral vestibular weakness.

Material and Methods: The study consisted of 35 patients with a normal peripheral vestibular system, 35 patients with idiopathic unilateral peripheral vestibular weakness and 30 patients with idiopathic bilateral peripheral vestibular weakness according to the caloric test. Oculomotor tests including saccade, smooth pursuit and optokinetic tests were performed and evaluated in all patients.

Results: A pathology was observed in 5 of 35 (14.2%) patients with unilateral vestibular weakness and 9 of 30 (30.0%) patients with bilateral vestibular weakness while no pathology was observed in the control group in terms of smooth pursuit.

Conclusion: Smooth pursuit pathology can be seen both in patients with unilateral vestibular weakness and bilateral vestibular weakness. The optokinetic test and saccade test are not affected by unilateral vestibular weakness or bilateral vestibular weakness.

Key Words: Caloric tests, Oculomotor test, Peripheral vestibular dysfunction

ÖZ

Amaç: Periferik vestibüler hipofonksiyon tek taraflı veya bilateral olarak görülebilir. Çalışmanın amacı tek taraflı ve bilateral periferik vestibüler zayıflığı olan hastalarda okülomotor test sonuçlarını araştırmaktır.

Gereç ve Yöntemler: Çalışmaya, kalorik test sonucuna göre normal periferik vestibüler sistemi olan 35 hasta, idiopatik tek taraflı periferik vestibüler zayıflığı olan 35 hasta ve idiopatik bilateral periferik vestibüler zayıflığı olan 30 hasta dahil edildi. Tüm hastalara sakkad test, smooth pursuit test ve optokinetik testlerden oluşan okülomotor testler yapıldı ve değerlendirildi.

Bulgular: Smooth pursuit testi açısından tek taraflı periferik vestibüler zayıflığı olan 35 hastanın (%14,2) 5'inde, bilateral periferik vestibüler zayıflığı olan 30 hastanın (%30,0) 9'unda patoloji gözlenirken, kontrol grubunda patoloji gözlenmedi.

Sonuç: Smooth pursuit patolojisi hem tek taraflı periferik vestibüler zayıflığı olan hem de bilateral periferik vestibüler zayıflığı olan hastalarda görülebilir. Optokinetik test ve sakkad test tek taraflı veya bilateral periferik vestibüler zayıflıktan etkilenmez.

Anahtar Sözcükler: Kalorik test, Okülomotor test, Periferik vestibüler disfonksiyon

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INTRODUCTION

Vertigo and dizziness are among the most common reasons for referral to neurologists and otolaryngologists in emergency departments and outpatient clinics. The incidence of vertigo is 1.8% in young adults and over 30% in the elderly. The incidence increases with age, and 13–38% of patients over 65 years old in United States have complained of vertigo (1,2).

The vestibular system consists of the central and peripheral components. The peripheral vestibular system consists of three semicircular canals, otoliths, vestibular ganglia and vestibular nerves while the central vestibular system consists of the vestibular nucleus, cerebellum, autonomic nervous system, thalamus and cerebral cortex (3,4). Peripheral vestibular hypofunction can be seen unilaterally or bilaterally. Vestibular neuritis, vestibular labyrinthitis, perilymphatic fistula, acoustic neuroma, benign paroxysmal positional vertigo (BPPV) or Meniere's disease may be the cause of unilateral peripheral vestibular hypofunction (5). The majority of vestibular dysfunction is caused by unilateral peripheral vestibular dysfunction (UPVD) and symptoms of dizziness, visual disturbance, imbalance, and functional deficits can be seen in patients with UPVD (6). Postural instability, physical deconditioning, and visual or gaze disturbance (oscillopsia) are usually observed in patients with bilateral vestibular system dysfunction. Bilateral vestibulopathy is rare and constitutes approximately 1-2% of patients who undergo electronystagmography (7). Videonystagmography (VNG), audiological assessment, magnetic resonance imaging (MRI) and Doppler studies are often used for the diagnosis of vertigo (8). VNG provides a general evaluation of peripheral vestibular and central vestibular function. VNG tests include oculomotor, spontaneous nystagmus, positional and caloric tests. Gaze, saccade, smooth pursuit, and optokinetic (OPK) tests can be evaluated with an oculomotor test (9).

There are few studies investigating the relationship between peripheral vestibular weakness and oculomotor tests (10, 11). In a study, smooth pursuit pathology was detected in 41% and saccade pathology was detected in 9% of patients with bilateral vestibular weakness (11). The aim of this study was to investigate whether peripheral vestibular weakness has an impact on oculomotor testing and also to compare the oculomotor test results in patients with unilateral and bilateral peripheral vestibular weakness

MATERIAL and METHODS

Between 2016 and 2018, subjects who complained of vertigo or dizziness and had a VNG performed at the Department of Otorhinolaryngology, were retrospectively analyzed. The protocol of this study was reviewed and approved by the Karabuk University Review Board (77192459-050.99-E.1522). On physical examination of the patients, dysdiadokinesis and finger-to-nose tests were performed to evaluate the cerebellum. Patients with otologic disorders such as tympanic membrane perforation, visual defects such as cataracts, spontaneous nystagmus or central nervous system disease, and those using sedative drugs were excluded from the study.

A complete battery of VNG tests were carried out with a videonystagmography system (Spectrum software; Micromedical Technologies Inc., Chatham, Illinois, USA).

The caloric test was performed by stimulating each ear separately with 47°C warm air and 27°C cold air for 60 seconds. Unilateral peripheral vestibular weakness was considered when the slow phase velocity showed > 20% asymmetry between the two ears (12). Bilateral vestibular weakness was considered when the slow phase velocity was lower than 12°/s in total warm and cold stimuli for both ears (13).

Saccade velocity values were considered pathological under 275°/s, saccade accuracy values were considered normal between 80–134%, and saccade latency values were considered pathological over 260 ms (14). In the smooth pursuit test, the patient was asked to follow the light moving to the right and to the left at a speed of 1, 2 and 4 kHz, respectively. The results were calculated by taking the averages of the best smooth trace at 1, 2 and 4 kHz. Smooth pursuit gains were considered pathological under 0.75 at 1 kHz, under 0.80 at 2 kHz, and under 0.75 at 4 kHz (14). Asymmetry was also evaluated during the smooth pursuit test. Optokinetic gain values were considered pathological under 0.6°/s (14).

According to the caloric test results, 35 patients with normal peripheral vestibular system as a control group, 35 patients with idiopathic unilateral vestibular weakness (UVW) and 30 patients with idiopathic bilateral vestibular weakness (BVW) were included in the study.

In this study we aimed to discover whether there are differences in oculomotor tests between the control group, UVH and BVH groups.

The statistical analysis was performed using SPSS 21.0 (SPSS software, SPSS Inc., Chicago, IL, USA). Descriptive statistics were shown as the median, mean, standard deviation (SD), minimal and maximal values, and frequency (%). Fisher's exact test was used to compare the velocity value of the saccade test statistically. Statistical significance was analyzed by one-way ANOVA in case of a comparison between more than 2 groups and in case of homogeneity. Kruskal-Wallis tests were used if the distribution of the variables was not normal. Tukey's test was used for post-hoc analysis. The Student t-test and the nonparametric

Mann–Whitney U test were used to compare two groups. A p-value of <0.05 was considered statistically significant for all analyses.

RESULTS

Clinical characteristics of subjects

Of the 100 patients, 61 (61%) were females and 39 (39%) were males, and there was no significant difference between the groups in terms of gender (p:0.756). The mean age was 42.49±12.12 (22–71 years) in the control group, 47.51±11.62 (27–67 years) in the unilateral vestibular weakness (UVW) group 44.97±13.30 (21–67 years) in the bilateral vestibular weakness (BVW) group. There were no significant differences between the groups in terms of age (p:0.873) (Table I).

Saccades

When the velocity values were evaluated in the saccade test, 1 of 35 (2.8%) patients in the control group, 2 of 35 (5.7%) patients in the UVW group and 1 of 30 (3.3%) patients in the BVW group had pathological results. There were no statistically significant differences between the groups in terms of velocity values (p:0.781). The accuracy of the saccade test was observed at normal values (80–134%) in the control group, BVW and UVW groups. The latency of the saccade test was observed at normal values (<260 ms) in the control group, BVW and UVW groups (Table I).

Smooth Pursuit

Pathology was observed in 5 of 35 (14.2%) patients with unilateral vestibular weakness and 9 of 30 (30.0%) patients with bilateral vestibular weakness while no pathology was observed in the control group.

When the gain values were evaluated in the smooth pursuit test, statistically significant differences were observed between the control group and UVH group (p<0.001) and between the control group and BVH group (p<0.001). However, no significant differences were found between the BVH and UVH groups (p:0.402). Likewise, when asymmetry was evaluated in the smooth pursuit test, statistically significant differences were observed between the control group and UVH group (p:0.019) and between the control group and the BVH group (p:0.028). No significant differences were found between the BVH and UVH groups (p:0.916) (Table II, Table III).

Optokinetic

The gain of the optokinetic test was observed at normal values (>0.6°/s.) in the control group, BVW and UVW groups (Table I).

DISCUSSION

Vestibular, visual and somatosensory systems must work together in harmony to maintain the balance system (15). Vestibular system-related reflexes are the vestibulo-ocular reflex (VOR), vestibulo-spinal reflex (VSR) and the vestibulo-collic reflex (VCR). The VOR system helps stabilize eye gaze during head movements and is regulated by the semicircular canals and otolith organs (3). VSR provides postural control during movement by adjusting muscle contractions (16). VCR provides head stabilization by controlling neck muscle contractions (3). Videonystagmography (VNG) is a non-invasive method used frequently to diagnose vestibular disorders, record horizontal and vertical eye movements and measure the VOR system (17, 18). The caloric test evaluates and records the labyrinthine function separately and indicates which side is affected. Caloric stimulation can be performed with water or air to stimulate VOR. The caloric test measures the function of the lateral semicircular canal but does not assess

Table I: The oculomotor test results of the unilateral vestibular weakness (UVW), bilateral vestibular weakness (BVW) and control groups.

	Unilateral VW	Bilateral VW	Control	P value
Age	47.51±11.62	44.97±13.30	42.49±12.12	0.873[1]
Saccade				
Velocity (n)	2/35	1/30	1/35	0.781[2]
Accuracy	91.06±5.19	92.77±4.91	93.26±4.88	0.162[1]
Latency	150.17±24.16	146.30±29.21	139.14±23.53	0.194[1]
Smooth Pursuit				
Gain	0.88±0.07	0.87±0.08	0.96 (0.75-1.02)	<0.001[3]
Asymmetry	13 (1-74)	13 (0-92)	7 (0-54)	0.030[3]
Optokinetic				
Gain	0.80±0.12	0.82±0.10	0.86±0.10	0.084[1]

[1]One-way **ANOVA**, [2]Fisher's exact test, [3]Kruskal-Wallis.

Table II: The number of patients with pathological smooth pursuit gain of the control, unilateral vestibular weakness (UVW) and bilateral vestibular weakness (BVW) groups shown at 1 kHz, 2 kHz, 4 kHz and any frequency of 1, 2 or 4 kHz separately.

Smooth Pursuit	Unilateral VW	Bilateral VW	Control
1 kHz	2	2	0
2 kHz	3	5	0
4 kHz	3	3	0
1, 2 or 4 kHz	5	9	0

Table III: Smooth pursuit gains values of the control, unilateral vestibular weakness (UVW) and bilateral vestibular weakness (BVW) groups shown at 1 kHz, 2 kHz, and 4 kHz separately.

Frequencies	Unilateral VW	Bilateral VW	Control	P value
1 kHz	0.88 (0.63-1.00)	0.88 (0.52-1.00)	0.98 (0.75-1.05)	<0.001[1]
2 kHz	0.93 (0.71-1.03)	0.93 (0.74-1.02)	1.00 (0.75-1.05)	<0.001[1]
4 kHz	0.92 (0.70-1.00)	0.89 (0.55-1.00)	0.99 (0.75-1.03)	<0.001[1]

[1]Kruskal-Wallis Test.

the function of the saccule or the utricle. Absent or reduced caloric response defines peripheral vestibular dysfunction (19). In the present study, the caloric test showed bilateral weakness in 30 patients, unilateral weakness in 35 patients and normal caloric response in 35 patients.

Vestibulopathy may impair the VOR and retinal slip may not be able to compensate properly with high frequency head movements. In a studying using functional MRI, it was shown that when patients with bilateral vestibulopathy were compared with healthy subjects, optokinetic stimulation induced a higher activation of the visual cortex and oculomotor areas in patients with bilateral vestibulopathy (20).

Among the oculomotor tests, saccade maintains the position of an image of a target over the fovea in the case of quick eye movement (10). Saccade functions, especially latency and velocity, improve with age via development of the prefrontal function and brain myelination, visual maturation and development of the cerebral cortex (9). Saccade can be impaired in cases of intoxication such as anticonvulsive or benzodiazepine use and in neurodegenerative disorders such as brainstem lesions, midbrain lesion, progressive supranuclear palsy, cerebellum or cerebellar pathways (17). Ghazizadeh Hashemi et al. demonstrated that saccade abnormalities were detected in 9% of patients with bilateral vestibular weakness (11). Tuma et al. included 60 patients with dizziness of peripheral vestibular disorder and investigated the oculomotor tests of these patients. The study showed that fixed saccadic movement latency was altered in all patients, and fixed saccadic movement velocity was altered in 35.0% of patients. The randomized saccadic movement latency was altered in all patients, and randomized saccadic movement precision was altered in 78.3% of patients (10). In the present study, we found that the accuracy and latency of saccade were normal in the bilateral vestibular weakness and unilateral vestibular weakness group.

Smooth pursuit keeps the image of the moving object stable on the fovea (10). Smooth pursuit function, especially phase and gain, improve with age via brainstem, cerebellum, and parietal, temporal, and frontal cortices development (9). Smooth pursuit can also be affected by alertness and various drugs. Smooth pursuit can be impaired by intoxicants such as anticonvulsives, benzodiazepines or alcohol, and can also be impaired by degenerative disorders such as the cerebellum or extrapyramidal system disorders (17). Oh et al. showed that smooth pursuit gain decreased bilaterally in 11 of 23 (47.8%) vestibular migraine patients (21). Hashemi et al. investigated oculomotor tests in patients with bilateral vestibular weakness with the caloric test. In their study, 6.4% of the patients had gaze abnormality and 41% of the patients had smooth pursuit impairment (11). Tuma et al. showed that smooth pursuit gain alteration was 15%, 21.7%, and 13.3% in the 0.1 kHz, 0.2 kHz, and 0.4 kHz frequencies, respectively in patients with a peripheral vestibular disorder (10). In our study we found that the smooth pursuit test was pathological in 14.2% of patients with unilateral vestibular weakness and in 30.0% of patients with bilateral vestibular weakness. Although the exact mechanism of oculomotor alteration in patients with peripheral vestibular disorders is unknown, gaze stability may deteriorate when VOR deteriorates in patients with vestibular weakness.

Bilateral vestibulopathy has been reported to impair VOR significantly and can therefore cause oscillopsia (20). Guinand et al. showed that moderate to extreme oscillopsia was found in 81% of patients with bilateral vestibulopathy and in 9% of patients with unilateral vestibular loss (20). The smooth pursuit impairment seen in our study can be due to oscillopsia.

Optokinetic produces slow pursuit movements or quick fixation movements in response to image movements. Optokinetic nystagmus occurs rhythmically, involuntarily, unconsciously and automatically (10). Optokinetic function is related to vestibular nuclei, nucleus of the optic track, accessory optic system, cerebral cortex, temporal lobes, and parietal lobes (9). Tuma et al. demonstrated that optokinetic nystagmus gain was altered in 5.0% of patients with peripheral vestibular disorder and claimed that vestibulo oculomotor dysfunction may be a sign of peripheral dysfunction as well as central nervous system impairment (10). In our study, we found that the optokinetic gain values were normal in the bilateral vestibular weakness and unilateral vestibular weakness groups.

CONCLUSIONS

Smooth pursuit pathology can be seen both in patients with UVW and BVW. There were no differences between control and peripheral vestibular weakness groups in terms of the optokinetic test and saccade test.

DISCLOSURE

The authors declare no conflict of interest.

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