The Value of the Examination of Visuooculomotor Reflexes in Diagnosis of Posterior Cranial Fossa Lesions

Henryk Kaźmierczak and Katarzyna Pawlak-Osińska

Ludwik Rydygier Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University, Torún, Poland

Abstract: The aim of this study was to compare the frequency of pathological types of smooth-pursuit and saccadic movements in different localizations of vestibular lesions. We tested 112 patients using videonystagmography. The smooth pursuit was appreciated qualitatively on the basis of Malecki's patterns. We analyzed the saccadic movements taking three parameters into consideration: latency, velocity, and accuracy. The patients suffered from posterior cranial fossa lesions, supratentorial damage, and peripheral vestibular disorders. We discovered that testing of smooth pursuit and saccades was very helpful in pointing to the localization of the damage in the posterior fossa. The frequency of the pathological saccadic and eye-tracking movements was similar for the different sites of deficit inside the posterior fossa, so recognizing the precise localization of lesion in this anatomical region was difficult.

Key Words: posterior cranial fossa lesions; saccadic movements; smooth pursuit

Saccadic movement and smooth-pursuit (eye-tracking) movement examination are the standard otoneurological tests [1–4]. Latency, velocity, and accuracy of eye movements are appreciated during the saccadic test. Eye-tracking or caloric eye-tracking tests are classified on the basis of a suggestion from Maspetiol et al. [4] with four types of curves or, according to Malecki [3], using three different patterns: the first, normal, the other two, pathological.

The saccadic pathology is encountered in degenerative central nervous system lesions and in disorders of brainstem, cerebellum, and frontoparietal and parieto-occipital cerebral cortex [5]. Abnormal smooth pursuit may be observed in disabilities of the cerebellum, the dorsolateral part of the brainstem, and vestibular nuclei, but nystagmus of typical peripheral origin can also affect the eye-tracking test [5,6].

Not clearly defined is which localization of posterior cranial fossa damage is responsible for disturbed saccadic or eye-tracking movements. Belton and McCrea [7], Mano et al. [8], Sato and Noda [9], Zee [10], and Zee et al. [11] are of the opinion that the saccadic pathology originates from vermis lesions. Helmchen et al. [2] observed abnormal smooth pursuit in such localization of lesion. Krauzlis and Miles [12] and Suzuki and Keller [13] suggested that damaged vermis disturbs both saccadic and eye-tracking movements. These two pathological visuooculomotor reactions can be present not only in cerebellar but in brainstem deficits [14].

PATIENTS AND METHODS

We tested 112 patients (41 women, 71 men) aged 27–59 years (mean, 31.7 years). Of these, 21 suffered from cerebellar hemisphere tumors (group I); in 13, we discovered vermis tumors (group II); 32 had cerebellopontine-angle tumors in brainstem stage (group III); 19 manifested supratentorial tumors (group IV) localized in the frontal (4), temporal (11), and temporoparietal regions (4). Group V consisted of 27 persons with vestibular neuronitis.

All cerebral tumors were revealed during computed tomography or magnetic resonance imaging and then (after this study) were verified during neurosurgical treatment. We tested saccadic and eye-tracking movements using videonystagmography. To induce saccadic

Reprint requests: Dr. Katarzyna Pawlak-Osińska, Bratkowa Street 11, 85-361 Bydgoszcz, Poland. Phone and Fax: +48 52 3796590; E-mail: osinskakl@wp.pl

movements, we moved the target with the amplitude of ±20 degrees and a frequency of 0.3 Hz. Latency (milliseconds), velocity (degrees per second), and accuracy (percentage) were appreciated. We obtained the normal ranges for these parameters from healthy subjects in our previous study; they were as follows: 335 ± 86 milliseconds for latency; 416 ± 89 degrees per second for velocity; and 20.4% of difference of ideal target pattern for accuracy. During the eye-tracking test, the target moved with the amplitude of 20 degrees and a frequency of 0.7 Hz. We performed the classification of smooth pursuit according to Malecki [3]. We performed statistical analysis using the Student's *t* test.

RESULTS

The results of saccadic movements in all tested groups are demonstrated in Table 1. The results of the eye-tracking test in all subjects divided into groups are demonstrated in Table 2.

DISCUSSION

Our results showed that the disturbances of both saccadic and eye-tracking movements are rarely encountered in peripheral vestibular lesions and supratentorial tumors [3–5,15]. These visuooculomotor pathologies are more frequently observed in infratentorial lesions. In none of our tested groups with posterior fossa lesions (groups I–III) are saccadic and smooth-pursuit pathologies present with statistical significance. The similar frequency of the presence of saccadic or eye-tracking disturbances both in vermis and cerebellar cortex and brainstem damages seems to suggest evidence of the same pathways for these reflexes. Sensory and motor visual neurons are engaged in a process of creating these eye movements, but they are strongly influenced by voluntary reflexes dependent on alertness and motivation [1,16]. The pontine part of the reticular formation is responsible for the fast phase of spontaneous and optokinetic nystagmus, and it is also important in saccadic movements [14,17]. In humans, the neocerebellum is the first modulator of voluntary eye movements (in our case, both saccadic and smooth pursuit). The afferent pathways (pontocerebellar, olivary-cerebellar) and efferent pathways (inferior and superior cerebello-reticular and probably existing medial cerebelloreticular) join the nuclei of a "new" cerebellum with the pontine part of the reticular formation [11,18–20]. This is most likely the cause of the similar frequency of pathological saccadic and eye-tracking movements in both the cerebellar hemisphere and brainstem lesions [11,18,19,21].

The role of vermis in balance and motor function can be characterized as special. It collects the phylogenetic old tracts (e.g., the vestibulocerebellar, spinocerebellar, and sphenocerebellar) but also collects a phylogenetic newer pathway (i.e., the olivary-cerebellar). The rich vermis connection with motor neurons may result in pathology of visuooculomotor reflexes during its deficit. However, one must remember that the archicerebellum does not play such an important role in mammals, owing to a joined cerebral cortex and neocerebellum [8,17,22–24]. Our observations confirm those previously obtained regarding the similar frequency of abnormal saccades and smooth pursuit both in cerebellar hemisphere tumors and vermis pathology and brainstem damage in cerebellopontine-angle tumors [20,25–27].

Generally, testing of these visuooculomotor reactions is very helpful in distinguishing between vestibular pathologies localized in posterior cranial fossa and those in other locations. Saccadic and eye-tracking test disturbances were more often encountered in posterior cranial fossa lesions than in peripheral and supratentorial damages [15].

Table 1. Results of Saccadic Movements (mean values)

	Localization of Lesion				
Parameter	Cerebellar Cortex	Vermis	Brainstem	Supra-tentorial	Peripheral
Latency (msec)	464	520	590	310	290
Velocity (degrees/second)	240	304	270	450	456
Accuracy (%)	58	64	65	98	97

Table 2. Results of Saccadic Movements in Tested Groups of Subjects (% of patients)

	Type of Eye-Tracking Test Pattern		
Localization of Lesion	I	II	III
Cerebellar cortex	0	57.1	42.9
Vermis	0	61.5	38.5
Brainstem	9.4	53.1	37.5
Supratentorial region	68.4	21.0	10.6
Peripheral	92.6	7.4	0

CONCLUSIONS

The pathology of saccadic and eye-tracking movements is helpful in diagnosing posterior cranial fossa lesions. A more difficult problem is to indicate the particular structure belonging to the posterior cranial fossa that is suspected to be damaged. In our study, cerebellar cortex, cerebellar vermis, or brainstem lesions did not manifest the definite pattern of saccadic or smooth-pursuit disturbances or differences from one another and, when comparing these three localizations of the pathological process, one was not significantly more or less frequent than another.

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