SHORT REPORT

Effect of neck flexion on F wave, somatosensory evoked potentials, and magnetic resonance imaging in Hirayama disease

U K Misra, J Kalita, V N Mishra, R V Phadke, A Hadique

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Background: Flexion myelopathy is one of the suggested mechanism for Hirayama disease (HD) but simultaneous radiological and neurophysiological evaluation is lacking. This study therefore evaluates the effect of neck flexion in HD using somatosensory evoked potentials (SEPs), F waves, and magnetic resonance imaging (MRI).

Method: Eight HD patients and seven matched controls were subjected to median and ulnar F wave (minimal latency, FM ratio, persistence, and chronodispersion), and SEPs evaluating N9, N13, and N20 potentials in neutral and neck flexion. Spinal MRI was carried out in neutral and neck flexion and evaluated for cord atrophy, signal changes, cord compression, posterior epidural tissue, and loss of dural attachment.

Results: The patients were aged 19 to 30 years. Minimal F latency, FM ratio, persistence, and chronodispersion in neutral and neck flexion did not show any change nor was there any change in N13 latency and amplitude on median and ulnar SEPs. The difference in these parameters in neutral and neck flexion were also not significant in HD compared with controls. The change in N13 was also not related to loss of dural attachment and posterior epidural tissue.

Conclusion: Neck flexion does not produce significant changes in N13 and F wave parameters and is not related to dynamic MRI changes. The other mechanisms for HD should therefore be explored.

Hirayama disease (HD) is a non-compressive juvenile spinal muscle atrophy characterised by insidious onset of unilateral or asymmetric oblique amyotrophy affecting C7-T1 myotomes. It is mainly reported from Japan, India, Sri Lanka, Malaysia, and Singapore and also from Denmark, Holland, France, USA, and Italy.^{1–4} The aetiology of HD is not well understood but various possibilities have been suggested such as ischaemia of spinal cord as a result of neck flexion,⁵ autoimmune, atopy,⁶ and genetic factors.^{7–8} SMN gene deletions however were not found.^{7–9} Significant amplitude reduction of N13 cervical somatosensory evoked potential (SEP) on neck flexion has been attributed to cord compression or microvascular changes during neck flexion.¹⁰ Spinal MRI in cervical flexion showed forward displacement of dural sac and compressive flattening of lower cervical cord. Cinematographic magnetic resonance imaging (MRI) showed signal void in posterior epidural space pulsating synchronously with cardiac beat suggesting passive dilatation of epidural venous plexus.⁵ These authors, however, did not evaluate corresponding neurophysiological changes and Restuccia *et al* did not evaluate MRI changes.

F waves are sensitive to postural change. Increased F wave chronodispersion has been reported in patients with lumbar

canal stenosis on standing compared with resting state.¹¹ Comprehensive evaluation of F wave and SEPs with corresponding MRI findings in neutral and neck flexion may provide valuable information regarding the possible mechanism of HD. In this paper we report upper limb SEP and F wave changes in HD during neutral and neck flexion and correlate these with MRI findings.

METHODS

The diagnosis of HD was based on predefined criteria.¹ All the patients had detailed clinical and neurological evaluation. The distributions of muscle wasting were noted. Muscle power was assessed on a 0–V MRC scale and biceps, triceps, knee, and ankle reflexes were tested. Pinprick and joint position sensations were noted. Evidence of Horner's syndrome, hyperhydrosis, and postural hypotension were recorded.

Cervical spinal MRI was carried out in neutral and fully flexed neck position as described earlier⁵ on a 1.5T Signa GE medical system. T1, T2, and PD sequences were obtained in sagittal and axial sections. The MRI was evaluated for lordosis, cord atrophy, abnormal cord intensity, posterior epidural tissue during flexion, cord compression, and loss of posterior dural attachment.

Somatosensory evoked potential

Right median and ulnar SEPs were obtained by stimulating the nerves at the wrist giving a 0.1 ms square wave pulse at 1 Hz to elicit a painless twitch. Recording surface electrodes were applied at Erb's point, C7 spinous process, and contralateral parietal cortex referred to Fz. Ground electrode was placed between stimulating and recording electrodes. A total of 200 epochs were twice averaged at 1 μ V/div, sweep time 100 ms, filter setting 20–2000 Hz. The latency and amplitude of N9, N13, and N20 were recorded.

F wave

F waves were recorded from abductor digiti minimi (ADM) and abductor pollicis brevis (APB) by stimulating ulnar and median nerves respectively. Surface recording electrodes were used in a belly tendon montage keeping the resistance below 5 k Ω . Twenty supramaximal stimuli were delivered at 0.5 Hz. The gain was 0.1–0.2 mV, filter setting 10–10 000 Hz, and sweep time 50 ms. F waves were analysed for minimal latency, FM ratio (amplitude as percentage of M wave), persistence, and chronodispersion. These were repeated during sustained neck flexion. During the studies, laboratory temperature was 22–25°C. All the patients consented for the study. SEP and F wave parameters were compared with

Abbreviations: MRI, magnetic resonance imaging; HD, Hirayama disease; SEP, somatosensory potential

Table 1 F wave and spinal (N13) somatosensory evoked potential parameters in Hirayama disease and controls in neutral and neck flexion

	Hirayama disease			Control		
	Neutral	Flexion	p Value	Neutral	Flexion	p Value
Median F						
Latency (ms)	30.60 (0.81)	29.81 (1.90)	0.24	27.74 (2.22)	28.11 (2.03)	0.13
FM ratio	10.32 (7.95)	9.09 (7.81)	0.51	4.57 (1.72)	5.00 (2.00)	0.45
Persistence	7.20 (6.30)	9.00 (6.52)	0.14	13.71 (2.21)	13.14 (3.34)	0.65
Chronodispersion (ms)	2.01 (3.14)	2.08 (1.55)	0.95	2.31 (0.81)	2.24 (1.57)	0.91
Ulnar F						
Latency (ms)	30.62 (1.10)	29.80 (1.10)	0.16	27.81 (1.95)	28.21 (2.02)	0.29
FM ratio	13.25 (12.34)	8.63 (9.19)	0.55	3.84 (2.08)	2.41 (0.90)	0.14
Persistence	9.67 (6.50)	11.33 (4.32)	0.29	14.86 (3.67)	15.57 (2.88)	0.55
Chronodispersion (ms)	2.42 (1.85)	4.38 (3.74)	0.08	2.24 (1.14)	1.86 (0.80)	0.18
Somatosensory evoked potential						
Median N13						
Latency (ms)	13.56 (0.79)	13.47 (0.86)	0.73	13.41 (1.06)	13.74 (1.04)	0.13
Amplitude (μ V)	1.86 (0.88)	1.99 (1.01)	0.77	2.66 (0.55)	2.61 (0.86)	0.93
Ulnar N13						
Latency (ms)	14.26 (0.71)	13.81 (0.83)	0.27	14.41 (1.02)	14.61 (1.29)	0.58
Amplitude (μ V)	1.62 (0.54)	1.69 (1.08)	0.86	1.91 (0.63)	1.62 (0.48)	0.36

Data shown as mean (SD).

normal controls, who were obtained from age (17–30 years) and sex matched healthy volunteers using same protocol.

RESULTS

There were eight patients with HD, aged 19 to 30 years, all men, four students, four sedentary workers. The duration of illness ranged between one and five years and the symptoms were stationary for 6 to 24 months. The age of disease onset was 16–25 years. Muscle wasting was bilateral in six and unilateral in two patients. Cold paresis and polyminimyclo-nus were present in all. None had Horner's syndrome or sensory loss. Biceps, knee, and ankle reflexes were normal but triceps was diminished.

Neurophysiological studies

Median motor nerve conduction were unrecordable in three and ulnar in two patients. The ulnar CMAP (compound muscle action potential) was reduced in two but nerve conduction velocity was normal. Median and ulnar sensory conduction were normal in all. Electromyography showed fibrillations and fasciculations and neurogenic motor unit potentials in C7-T1 myotomes.

F wave

Median F was unrecordable in three and ulnar in two patients. In neutral position the minimal median F latency in HD patients was 30.60 (SD 0.81) ms, FM ratio 10.32 (SD 7.95), persistence 7.20 (SD 6.30), and chronodispersion 2.01 (SD 3.14) ms. These parameters in ulnar F study were minimal F latency 30.62 (SD 1.10) ms, FM ratio 13.25 (SD 12.34), persistence 9.67 (SD 6.50), and chronodispersion 2.42 (SD 1.85) ms. On neck flexion these parameters did not significantly change compared with that in neutral position in both the patients and controls (table 1).

Somatosensory evoked potential

Median and ulnar SEPs were recordable in all the patients. The mean (SD) of median N9, N13, and N20 latency and amplitudes were normal. There was no difference in the latency and amplitude of N13 in neutral and neck flexion both in HD and controls (table 1, fig 1). In HD patients the mean difference between neutral and neck flexion of median N13 latency was 0.97 (0.70) (control -0.33 (0.49)) ms ($p = 0.19$), amplitude -0.05 (1.32) (0.01 (1.15)) μ V ($p = 0.93$), and that of ulnar N13 latency 0.46 (1.03)

(-0.19 (0.90)) ms ($p = 0.22$) and amplitude -0.01 (0.94) (0.31 (0.75)) μ V ($p = 0.47$).

Cervical spine MRI

Cervical spine MRI in seven patients showed loss of cervical lordosis in one, cord atrophy in six, and posterior epidural tissue during neck flexion in five patients (fig 1C). Loss of dural attachment was 33% in four, 66% in one, and complete in one patient. One patient did not have loss of posterior dural attachment in flexion. N13 latency (median $r = 0.08$, ulnar $r = -0.16$) and amplitude (median $r = -0.69$, ulnar $r = 0.73$) of ulnar and median SEP were not related to extent of loss of posterior dural attachment during neck flexion.

DISCUSSION

Our study shows that there was no significant change in SEP and F wave parameters on neck flexion compared with neutral position. F waves are used to evaluate the proximal nerve conduction and anterior horn cell disorders. Because of chronic denervation there may be prolongation of latency, reduction in amplitude; however depending on reinnervation, the amplitudes may increase. Persistence of F also may decline. In patients with severe wasting, the F wave may become unrecordable. In our study F wave was unrecordable in three patients. On neck flexion, F wave latency, FM ratio, persistence, and chronodispersion did not significantly change. F wave has been reported to be sensitive to change in posture. In a study on lumbar canal stenosis, F waves showed significant changes on standing compared with supine.¹¹

SEP changes in HD have reported reduction of N13 amplitude, which was not found in our study. The SEP amplitudes are quite variable and should decline by 50% to achieve significance.¹² During ischaemia N20 potential has become unrecordable if regional cerebral blood falls below 12–15 ml/100 g/min. A study of ischaemic myelopathy after surgery for coarctation of aorta showed normal tibial SEPs in both the patients.¹³ Moreover, the SEP abnormalities are expected when there is severe spinal cord ischaemia involving the posterior one third of spinal cord, which is generally supplied by two posterior spinal arteries with good collaterals. During ischaemic myelopathy, corticospinal pathways being located in the border zone are vulnerable. This would be associated lower limb pyramidal sign especially in the presence of severe anterior horn cell involvement of C8-T1 region as this falls in watershed zone. Postulation of flexion

Figure 1 Median somatosensory evoked potential of a patient with Hirayama disease showing no change in latency and amplitude of N13 potential recorded in neutral (A) and neck flexion (B) position. (C). Spin echo T1 cervical MRI, sagittal section of the same patient in neck flexion showing cord atrophy and posterior epidural tissue (arrow).

myelopathy if correct, the neck flexion should be associated with symptoms, which should regress in neutral position as was found in lumbar canal stenosis. The earlier SEP study however reported N13 amplitude reduction but did not evaluate the corresponding MRI findings.

In our study the MRI showed cord atrophy without cord compression during neck flexion. Presence of posterior epidural tissue or loss of dural attachment during neck flexion reflects the segmental spinal cord atrophy of C7-T1 region rather than its cause. None of these patients had lower limb hyperreflexia. In our earlier study lower limb hyperreflexia have been reported in two of seven HD patients.³ Detailed investigations of lower limb hyperreflexia using HM ratio, vibratory, and reciprocal inhibition were not significantly changed suggesting lack of significant corticospinal dysfunction in HD.³ The natural history of HD is quite characteristic. In young adults, near pubertal age there is

slowly progressive weakness and wasting with cold paresis in C7-T1 myotomes, which stabilises after a few years. No progression of HD has been reported; therefore spinal flexion mechanism does not explain the natural history. While conducting a SEP study in neutral and neck flexion the minimal shift of recording electrodes, associated change in skin resistance and movement of spinal cord generator may influence the results especially the amplitude. These variables have been excluded by following the same protocol in HD and controls.

Occurrence of HD in young men and reports in two families by us^{3,7} and identical twins by others⁸ suggest a possibility of a hereditary disease and highlight the need for further study.

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Authors' affiliations

U K Misra, J Kalita, V N Mishra, Department of Neurology, Sanjay Gandhi PGIMS, Lucknow, India

R V Phadke, A Hadique, Department of Radiology, Sanjay Gandhi PGIMS

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Correspondence to: Professor U K Misra, Department of Neurology, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Raebareilly Road, Lucknow 226014, India; ukmisra@sgpgi.ac.in, drukmisra@rediffmail.com

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