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Diagnostic utility of F waves in cervical radiculopathy: Electrophysiological and magnetic resonance imaging correlation

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Abstract

Objective: F wave study is a simple, non-invasive method commonly utilized for evaluation of cervical root lesions. Its diagnostic sensitivity is low. There are no large series comparing F wave studies with MRI as a reference standard.
Patients and methods: We performed F wave studies in 30 controls (15 men; mean age: 50 years; standard deviation: 17.9 years; range: 21–80 years) and, prospectively, 31 patients (19 men; mean age: 48 years; standard deviation: 16.2 years; range: 26–79 years) referred for evaluation of cervical spondylotic radiculopathy (CSR). All patients' MRIs were compared with F wave parameters.
Results: Combined utilization of minimal F latency, F chronodispersion, F persistence and side to side differences resulted in 55% sensitivity and 100% side concordance for detecting CSR, with MRI as a comparison standard. F wave parameters also provided complementary information to needle electromyography in the diagnostic evaluation of CSR. Although F waves were not indicative of radiculopathy levels, 4/31 (13%) of cases had at least one abnormal F wave parameter, despite normal electromyography findings.
Conclusions: Combined utilization of multiple F wave parameters is a useful, diagnostic adjunct in the electrophysiological evaluation of CSR.

Keywords: Cervical spondylosis; Cervical spondylotic myelopathy; F waves; Nerve conduction study; MRI

1. Introduction

The etiology of cervical spondylosis (CS) is often degenerative. It is associated with lesions ranging from radiculopathy (CSR) to myelopathy (CSM) as the most severe complication. In clinical settings, both conditions frequently coexist, leading to a combination of upper and lower motor neuron signs. This can result in diagnostic difficulties for the attending clinician. In this respect, electrophysiology [1] can be a valuable adjunct in its management.

F waves are the most commonly utilized parameters for evaluating proximal conduction abnormalities. Magnetic resonance imaging (MRI) is widely regarded as the investigation of choice for CSR [2,3]. To our knowledge, correlation of MRI findings with F waves in CS has not been systematically addressed previously. In this study, we evaluate the diagnostic utility of F waves in CSR, with MRI as the reference standard.

2. Methods

With local ethical committee approval, we studied 30 controls (15 men; mean age: 50 years; standard deviation: 17.9 years; range: 21–80 years) with no past medical history, including diabetes mellitus, renal impairment, neck trauma and peripheral nerve disorders. They were equally divided into three age groups: 20–39, 40–59 and above 60. We also

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noted heights of these subjects, who were hospital staff or their acquaintances. All had given written consent. An experienced neurologist performed a screening examination.

Over a 1-year period, 31 patients with CSR and 6 with CSM (19 men; mean age: 48 years; standard deviation: 16.2 years; range: 26–79 years) were referred for electrophysiological evaluation of CS (at least 3 months after symptomatic onset) were entered into the study prospectively. However, it is recognized that the APB muscle is mainly innervated by C8 and T1 root levels, although possible contributions from C6 and C7 cannot be totally excluded. As such, other nine cases with C5 radiculopathy on MRI have been eliminated from calculation of F wave result. Each patient's symptoms, physical findings and MRI findings were noted. We excluded patients with carpal tunnel syndrome, diabetes mellitus, peripheral neuropathy, cervical spine surgery and all other neurological diseases. CSR symptoms strictly consisted of neck discomfort and numbness or weakness in a root distribution.

Nerve conduction studies on controls and patients were performed to exclude carpal tunnel syndrome based on previously published criteria [4]. Bilateral F wave studies of the median nerves were obtained with amplifier gain of 100 μV/division and filters set between 20 Hz and 10 kHz. Horizontal sweep speed was 5 ms/division. Surface recording was from the abductor pollicis brevis (APB). Temperature was maintained at or above 32 °C. Twenty supramaximal stimuli were delivered to the wrist at 1 Hz frequency with the cathode proximal to the anode. Onset latency of the first negative or positive deflection from baseline of F responses above 20 μV in peak to peak amplitude was recorded. All F responses were obtained with controls or patients reinforcing by clenching and releasing the contralateral hand. Fmin and Fmax were defined as the shortest or longest latencies obtained, respectively. F persistence (Fp) was the number of F responses obtained with 20 stimuli. The difference between Fmax and Fmin was known as F chronodispersion (Fc). Visual inspection was performed in all studies to identify and exclude axon reflexes. Right left difference (RLD) of Fmin, Fp and Fc were also analyzed. Electrophysiological studies were performed on a Dantec Counterpoint or Key point EMG machine (Dantec, Skovlunde, Denmark).

In addition, all patients had electromyography (EMG) to determine root lesions. The first dorsal interosseous, extensor digitorum communis, pronator teres, biceps brachii and deltoid muscles were sampled. Presence of active denervation (fibrillations, positive sharp waves) and chronic regenerative changes (polyphasic motor units, increased duration) were regarded as pathological.

All patients had MR imaging of the cervical spine within 8 weeks after electrophysiological testing on either a Siemens 1.0 T Expert or 1.5 T Vision superconducting unit, using the tailored cervical spine phased-array coil. The patients were separated into four groups according to the degree of cord compression (no significant myelopathy, mild, moderate or severe CSM) by degenerative osteo-cartilaginous elements at the most significant level on MRI [5]. MRI was interpreted by an experienced neuroradiologist blinded to F wave findings. Radiculopathy was suspected based on effacement of the lateral recesses and neural foramina by bony or disc elements. If the nerve root was visualized, radiculopathy was determined by visualizing contact or indentation of the disk/bony element with the nerve root.

3. Results

In controls, only Fmin was found to correlate significantly with height (Pearson's correlation coefficient, $p < 0.05$). There was no significant correlation of all parameters with age ($p > 0.05$ for all). As there were no significant differences between right- and left-sided values of all three parameters, the data from both sides were pooled to compute normal values (Wilcoxon Signed Ranks Test, $p > 0.2$), As data was not normally distributed (Shapiro–Wilk test), the 5th percentile and 95th percentile were used to provide reference ranges, as depicted in Table 1.

A total of 31 patients had MRI evidence of CSR at C6 (12 patients), C7 (12 patients), C8 (5 patients) and T1 (2 patients), and 6 had CSM without significant MRI evidence of CSR. Incidental asymptomatic root lesions were present in 2 of the 31 patients: C6 (1 patient) and C7 (1 patient) based on our MRI criteria. Also, based on MRI, one patient had both C5 and C6 radiculopathy, and two patients had both C6 and C7 radiculopathy.

Of 31 patients without CSM, combined utilization of all six parameters (Fmin, Fc, Fp and respective RLDs) provided a result of 17/31 (55%) for CSR, if abnormality in one or more parameter was regarded as a positive result. For RLD parameters, side concordance with MRI evidence of CSR was 100% for Fmin and Fp. None of the patients had absent F wave responses. Only four of six patients with CSM had F wave abnormalities (three for Fc and one for Fp).

Needle EMG diagnosed radiculopathy in 23/31 (75%) of patients with MRI as reference standard. However, combined use of F wave parameters with EMG needle findings diagnosed radiculopathy in 27/31 patients (87%). Hence, F wave evaluation provided an additional yield of four patients with radiculopathy not evident with EMG alone.

Table 2 summarizes F wave abnormalities, in relation to EMG findings, at various root levels. Fig. 1 provides graphical representation of Fmin against height in a scatter plot.

Table 1
Percentile values in normal controls

Parameter	50th percentile	95th percentile
Fmin	23.7 ms	28.4 ms
Fc	3.5 ms	8.1 ms
Fp	16	11
Fmin RLD	0.55 ms	2.1 ms
Fc RLD	1.2 ms	6.4 ms
Fp RLD	2.0	6

The 5th percentile was utilized for Fp in place of the 95th percentile.