The diagnostic sensitivity of different F wave parameters

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Abstract

***Objective*—To examine the relative diagnostic sensitivity of various F wave parameters.**

***Methods*—Normal values for minimum, mean, and maximum F wave latency, chronodispersion, and persistence in the four major motor nerves were established and systematically applied to at least four separate categories of patients (radiculopathies, polyneuropathies, mononeuropathies, and others). F Waves were studied both isolated and in comparison with other motor nerve conduction parameters.**

***Results*—F Chronodispersion was the most often abnormal parameter, particularly in lumbosacral radiculopathies. Minimum F wave latency was more useful in polyneuropathies. Compared with minimum F wave latency, F chronodispersion was able to identify most additional cases.**

***Conclusions*—F Wave studies should include minimum F wave latency and chronodispersion.**

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Keywords: F wave; chronodispersion; radiculopathy; polyneuropathy

F Waves are the result of discharges of motor neurons that are excited by an antidromically travelling impulse. Their analysis is very useful in clinical neurophysiology. Various F wave parameters, especially F wave minimum latency, are well established in the diagnostic evaluation of peripheral nerve disorders.[1 2] They are particularly useful in the assessment of polyneuropathies.[3] Some investigators have proposed that the use of other parameters, such as persistence or chronodispersion, further increases the diagnostic yield of F wave studies.[4] The present study was undertaken to examine the diagnostic sensitivity of F wave minimum latency (Fmin), F wave maximum latency (Fmax), F wave mean latency (Fmean), F wave chronodispersion (Fc), and persistence (Fp) for various clinical purposes. The special aim of the study was to determine the value of F wave studies compared to other nerve conduction tests.

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Methods

SUBJECTS

Median, ulnar, peroneal, and posterior tibial nerve conduction and F wave studies were performed on 31 normal volunteers aged 19 to 65 (median 30) years, without symptoms or signs of peripheral neuropathies or other neurological illness. The normal values obtained in that control group were retrospectively applied to a group of patients who were recorded in the following way: the records of the last 1520 consecutive patients referred to our laboratory for evaluation of peripheral nerve dysfunction were reviewed. Age ranged from 12 to 97 (median 42) years. They were classified as polyneuropathies (295 nerves), radiculopathies (383 nerves), focal mononeuropathies (282 nerves), others (144 nerves) and normal subjects (740 nerves). All patients with axonal or demyelinating polyneuropathy met the standard diagnostic criteria based on clinical deficits in sensory, motor, or reflex function that included sensory nerve conduction data. For motor conduction, the following criteria were applied[5]: in axonal degeneration (aPNP), reduction of the amplitude of the compound muscle action potential (CMAP), normal shape and duration of the CMAP, prolongation of the distal motor latency by not more than 50% of the normal mean, normal or near normal nerve conduction velocity (NCV)—that is, not more than 40% below the normal mean. In demyelination (dPNP): abnormal shape of the CMAP with multiple phases and prolonged duration (amplitude could be normal or reduced), prolongation of the distal latency (more than 50% of the normal mean), marked decrease of the NCV (more than 40% below the normal mean), and conduction block (optional). At least one motor nerve had to fulfil these criteria for classification as polyneuropathy. Diagnosis of radiculopathy was made on clinical grounds in addition to the results of needle electrode examination and neuroimaging (CT or MRI). Denervation in at least one segmental muscle and an appropriate radiological correlate affecting the corresponding root were essential diagnostic criteria. In cervical radiculopathies, median and ulnar nerve conduction studies on the affected side were usually done and studies of the peroneal and posterior tibial nerve were carried out in lumbosacral radiculopathies. Diagnosis of focal mononeuropathies was based on clinical and electrodiagnostic findings. The remaining group was diagnosed according to the rules of general neurology. Patients with long tract dysfunction and with Guillain-Barré syndrome were not included in the study.

In the control group and in the patient group the following nerve conduction data were recorded for analysis and for comparison with F wave results: distal motor latency (DML), CMAP amplitude (baseline to peak of the negative phase), CMAP duration (duration of

Table 1 Results of regression analysis of F wave parameters

Parameter	*Nerve*	*Variable*	r^2	*p (ANOVA)*	*Regression equation*	*Standard error of estimate*
Fmin	Peroneal	Height	0.201	0.0001	y=11.715+0.198x	4.082
	Posterior tibial	Height	0.260	0.0001	y=8.870+0.224x	3.951
	Median	Height	0.174	0.011	y=10.228+0.095x	1.91
	Ulnar	Height	0.419	0.0001	y=−2.621+0.172x	1.896
Fmax	Peroneal	Height	0.095	0.0001	y=20.696+0.198x	6.202
	Posterior tibial	Height	0.286	0.0001	y=8.168+0.265x	4.393
	Median	Height, age	None	—	—	—
	Ulnar	Height	0.241	0.003	y=4.362+0.157x	2.534
Fmean	Peroneal	Height	0.225	0.0001	y=14.447+0.207x	3.967
	Posterior tibial	Height	0.399	0.0001	y=6.465+0.258x	3.38
	Median	Height	0.180	0.01	y=2.854+0.153x	3.018
	Ulnar	Height	0.472	0.0001	y=−5.149+0.197x	1.952

r =Adjusted squared multiple *r*. ANOVA=analysis of variance. The 95th percentile was used as the upper limit of normality for Fmax in the median nerve (35,22 ms).

the negative phase, onset to its zero crossing point), CMAP area (area of the negative phase), NCV, dispersion, amplitude, and area decay. Dispersion was defined as the percentage increase in duration of the proximal CMAP (CMAPp) compared with the distal CMAP (CMAPd); amplitude and area decay were defined as the difference in amplitude and area, respectively, between CMAPd and CMAPp and given as a percentage of CMAPd.[6–8] In addition, antidromic sensory conduction velocity, distal latency, sensory nerve action potential amplitude (SNAP), and duration were available for the median, ulnar (wrist to digit), superficial radial and sural nerve, and, in ulnar nerves, motor and sensory conduction velocity were available across the elbow.

ELECTRODIAGNOSTIC TECHNIQUE

Nerve conduction and F wave studies were performed according to standard techniques using surface electrodes.[9] A gain of 200 μV/division was used for all M response latency measurements.[10] For the F wave, amplifier gain was 100 μV/division; the filters were set between 30 Hz and 10 kHz. Temperature was maintained at or above 32°C. Ten supramaximal percutaneous stimuli were delivered to the wrist or ankle, 8 cm proximal to the active recording electrode, at a frequency ⩽0.2 Hz with the cathode proximal to the anode. Latency to onset of the first negative or positive deflection from baseline of all F responses ⩾20 μV in peak to peak amplitude was recorded.[6] Among all onset latencies recorded, Fmin was the shortest and Fmax the longest. Fp was defined as the number of such F responses obtained with 10 stimuli; Fmean was defined as the mean onset latency of such F responses, Fc was defined as the difference between Fmax and Fmin. Measurements were made using a commercial computer assisted semiautomatic method (Excel®, Cadwell, USA). To identify repeater F waves, late components of the M response, A waves, and axon reflexes, visual inspection and correction were necessary. If necessary, A waves or spinal reflex components were identified by double stimulation with a short interstimulus interval.[11] The baseline was clearly discernible during the recording; no special attempts were made to produce facilitation.

Table 2 Percentile ranking of F chronodispersion and persistence

Parameter	*Nerve*	*Median (ms)*	*95th percentile (5th for persistence)*
Fc	Peroneal	6.49	10.59
	Posterior tibial	5.31	9.45
	Median	4.48	8.92
	Ulnar	3.61	8.7
Fp	Peroneal	9	3
	Posterior tibial	10	9
	Median	9	6
	Ulnar	10	8

Note the large normal values for Fc, especially in the peroneal nerve (extensor digitorum brevis muscle).[28]

STATISTICAL METHODS

In the control group linear regression analysis was used to study the effects of age and height on the F wave parameters and on the other indices of nerve conduction. When the original data did not assume a gaussian distribution, logarithmic transformation was performed. When logarithmic transformation did not establish a normal distribution, percentile ranking of the values was used to establish the limits of normality. In regression analysis, the upper limit of normal was set at 2 SD above the estimate.[3 12] The relative diagnostic sensitivities of different F wave parameters were assessed by calculating z scores to test for differences in the frequency with which abnormalities were identified by each parameter. The analysis of the patient group was divided in two parts. Part A took only F wave results into account; part B also considered parameters of distal motor nerve conduction.

Results

CONTROL GROUP

Results of regression analysis of F wave parameters are shown in table 1. In every parameter the correlation with height or age was investigated. The influence of height exceeded the influence of age 9 to 26 times, depending on which nerve or parameter was chosen. Including the age dependency in regression analysis did not increase the diagnostic yield, so only height was accepted as an independent parameter. Fc and Fp did not correlate with age or height and had a non-gaussian distribution. Therefore percentile ranking was used (table 2).

PATIENTS

In part A of the analysis, the normative data of tables 1 and 2 were applied to the patient

Table 3 Descriptive patient data for the median nerve and the frequency of F wave abnormalities

	Diagnosis	*n*	*Fmin*	*Fmax*	*Fmean*	*Fp*	*Fc*	*Total*
A:								
	PNP	28	9	8 (0)	7 (0)	3 (2)	2 (0)	11
	C5/6	12	2	—	—	1 (0)	—	2
	C7	24	3	3 (2)	—	1 (1)	1 (1)	7
	C8	4	—	—	—	—	—	—
	CTS	93	6	4 (2)	1 (0)	0 (0)	1 (1)	9
	MonoN/plexopathy	20	2	2 (1)	1 (0)	3 (2)	1 (1)	6
	Normal subject	31	—	1 (1)	1 (0)	1 (1)	1 (0)	2
	Total	222	22	18 (6)	10 (0)	9 (6)	6 (3)	37
B:								
	PNP	10	1	1 (0)	0 (0)	3 (3)	0 (0)	4
	C5/6	9	—	—	—	1 (1)	—	1
	C7	14	—	2 (2)	0 (0)	1 (1)	1 (0)	3
	C8	2	—	—	—	—	—	—
	CTS	32	1	1 (1)	—	—	1 (0)	2
	MonoN/plexopathy†	11	—	1 (1)	0 (0)	2 (2)	1 (0)	3
	Normal subject	31	—	1 (1)	1 (0)	1 (1)	1 (0)	2
	Total	109	2	6 (5)	1 (0)	8 (8)	4 (0)	15

The figures in parentheses are the number of patients in each column that could be classified as abnormal by analysis of the parameter in question, but not by Fmin (the number of patients that could be detected additionally). PNP=polyneuropathy; C5, C6, C7, C8=radiculopathy C5, C6, C7, C8.; CTS=carpal tunnel syndrome; MonoN=mononeuropathies of the median nerve besides CTS; plexopathy†=plexopathies with upper trunk involvement and normal conduction in the median nerve.

group; patients with more than one diagnosis were excluded. Patients with radiculopathy with a diminished sural SNAP on the site of the lesion were also excluded to avoid mixture with axonal polyneuropathy, although such constellations are described in pure radiculopathy.[13] The results are presented for the median, ulnar, peroneal, posterior tibial nerve in tables 3–6. These tables are composed identically as explained in the legends.

In a second step (part B of each table) all patients with abnormal peripheral motor nerve conduction studies were excluded. Mean values for peripheral motor conduction were outside the normal range for at least one of the following parameters: DML, NCV, CMAP amplitude, area and duration, amplitude decay, area decay, and dispersion. Then the same F wave criteria of tables 1 and 2 were applied to the rest of the patient group. By this exclusion of patients with abnormal NCV the usefulness of F wave parameters in the presence of strictly normal peripheral motor nerve conduction can be studied.

Table 4 Descriptive patient data for the ulnar nerve and the frequency of F wave abnormalities

	Diagnosis	*n*	*Fmin*	*Fmax*	*Fmean*	*Fp*	*Fc*	*Total*
A:								
	PNP	18	8	5 (0)	8 (0)	4 (1)	0 (0)	9
	C5/6	4	—	—	—	—	—	—
	C7	10	1	1 (0)	1 (1)	—	—	2
	C8	4	—	1 (1)	1 (0)	1 (1)	2 (1)	3
	Elbow	78	7	7 (5)	12 (5)	5 (4)	3 (3)	24
	MonoN/plexopathy	29	1	2 (1)	2 (1)	6 (4)	2 (1)	8
	Normal subjects	31	—	—	—	1 (1)	1 (1)	2
	Total	174	17	16 (7)	24 (7)	17 (11)	8 (6)	48
B:								
	PNP	7	4	1 (0)	4 (0)	2 (1)	—	5
	C5/6	4	—	—	—	—	—	—
	C7	9	1	—	1 (0)	—	—	1
	C8	1	—	—	—	—	—	—
	Elbow*	53	1	2 (2)	4 (3)	4 (4)	1 (1)	11
	MonoN/plexopathy†	13	1	1 (1)	1 (0)	3 (2)	1 (0)	4
	Normal subjects	30	—	—	—	1 (1)	—	1
	Total	117	7	4 (3)	10 (3)	10 (8)	2 (1)	22

Elbow=Ulnar mononeuropathies at the elbow; elbow*=patients with normal motor conduction in the forearm segment of the ulnar nerve; plexopathy†=plexopathies with upper trunk involvement and normal conduction in the ulnar nerve. Other abbrevations as in table 3.

F WAVE PARAMETERS

A total of 1086 motor nerve conduction studies were analysed. In general (all nerves, every pathological condition), the sensitivity of any F wave parameter was greater in part A than in part B of the analysis (z=3.98; p<0.0001). This was significant for Fmin, Fmax, and Fmean, not for Fp and Fc (Fmin z=4.14; p<0.0001; Fmean z=3.66; p<0.001; Fmax z=3.60, p<0.001). The most often abnormal parameter was Fc in both parts (part A z=2.42; p<0.05; part B z=4.52; p<0.0001).

In the median nerve, Fmin was the most sensitive parameter in part A and Fp in part B (not significant). In the ulnar nerve, Fmean was the most sensitive parameter both in part A and in part B (not significant). In the lower extremity, Fc was the most sensitive parameter, but significant only in the peroneal nerve (part A z=3.44; p<0.001; part B z=4.23; p<0.0001).

NOSOLOGICAL ENTITIES

Polyneuropathy

None of the F wave parameters was significantly more sensitive than Fmin. The combined F wave sensitivity was higher in part A than in part B for both axonal and demyelinating polyneuropathies (z=2.09; p<0.05). Forty five per cent of the neuropathic nerves with normal distal motor conduction studies could be identified by F wave analysis. F Waves were significantly more abnormal in polyneuropathies than in focal mononeuropathies or in radiculopathies (part A z=6.8; p<0.0001; part B z=2.95; p<0.01). Fmin, Fmax, and Fmean were significantly more often prolonged in demyelinating than in axonal polyneuropathies (Fmin z=2.1; p<0.05; Fmax z=3.69; p<0.001; Fmean z=2.06; p<0.05). Fp was more often abnormal in axonal polyneuropathies (z=1.99; p<0.05). For Fc there was no significant difference.

Radiculopathy

If all four nerves were taken together, the sensitivity of Fc was significantly greater than that of Fmin, both in part A (z=3.94, p<0.0001) and in part B (z=3.69, p<0.0001). This was due to the high proportion of lumbar and sacral radiculopathies with abnormalities in the peroneal nerve. For example, analysis of the F wave in the peroneal nerve identified 58 of 110 isolated radiculopathies of L5 (53%) and 14 of 19 radiculopathies L5/S1 (74%). In these subgroups, Fc was the single most sensitive parameter (z=5,24; p<0.0001). In radiculopathies of S1 and in cervical radiculopathies the share of the cases detected by F waves was clearly smaller. In radiculopathies of S1 more cases were identified by peroneal than by tibial nerve F wave analysis (not significant). However, there was a trend of C7 radiculopathies to abnormalities in the median (p=0.03, Fisher's exact test) and of C8 radiculopathies to abnormalities in the ulnar nerve (p=0.006; Fisher's exact test).

Focal mononeuropathy

F Waves in the ulnar nerve were more sensitive for ulnar neuropathies at the elbow than F

Table 5 Descriptive patient data for the peroneal nerve and the frequency of F wave abnormalities

	Diagnosis	n	Fmin	Fmax	Fmean	Fp	Fc	Total
A:								
	aPNP	139	25	18 (13)	30 (8)	12 (6)	33 (28)	80
	dPNP	40	11	13 (6)	13 (3)	2 (1)	11 (8)	29
	L5	132	11	18 (13)	17 (8)	9 (7)	38 (35)	74
	S1	64	4	5 (5)	4 (2)	4 (3)	17 (17)	31
	MonoN	43	3	4 (3)	3 (1)	2 (2)	7 (7)	16
	Normal subjects	31	1	1 (1)	1 (0)	2 (2)	3 (1)	5
	Total	449	55	59 (41)	68 (22)	31 (21)	109 (96)	235
B:								
	aPNP	51	6	4 (3)	9 (5)	1 (0)	10 (9)	23
	dPNP	7	1	—	—	—	1 (1)	2
	L5	82	3	12 (10)	7 (5)	6 (5)	29 (27)	50
	S1	42	3	4 (4)	3 (1)	2 (1)	10 (10)	19
	Peroneal	16	—	1 (1)	—	1 (1)	3 (3)	5
	Normal subjects	30	—	1 (1)	—	2 (2)	3 (1)	4
	Total	228	13	22 (19)	19 (11)	12 (9)	56 (51)	103

L5, S1=radiculopathy L5, S1; MonoN=mononeuropathies of the peroneal nerve, usually at the fibular head Some patients with radiculopathies of L4/5 are summarised under L5 and some patients with L5/S1 are summarised under S1. Other abbrevations as in table 3.

waves in the median nerve for carpal tunnel syndromes (z=3,48; p<0.001). In lesions of the common peroneal nerve at the fibular head, the rate of abnormal F wave findings was not significantly smaller than in ulnar neuropathies at the elbow (z=0.46; p>0.3) and higher than in carpal tunnel syndromes (z=3.59; p<0.001). The most often abnormal F wave parameter in ulnar neuropathies at the elbow was Fmean, in peroneal lesions Fc, and in carpal tunnel syndromes Fmin (non-significant). In most of the patients with carpal tunnel syndrome and prolonged median DML, Fmin from the wrist was proportionately prolonged. Only in a few patients was DML prolonged out of proportion to Fmin. In most of the these cases, however, the amount of the prolongation was too small to permit a classification as abnormal.

Diagnostic utility

To answer the question, which F wave parameter is the most useful one, the sensitivity of Fmax, Fmean, Fp, and Fc was compared with the sensitivity of Fmin. Fmin was chosen as the point of reference as it is the most often used parameter. Besides the median and the ulnar Fp in part B of the analysis (median nerve: z=2.89, p<0.01; ulnar nerve z=2.38, p<0.05), in the lower extremity significant results were obtained only for Fc. Here Fc was able to identify most of the additional abnormal cases (peroneal nerve, part A: z=5.17; p<0.0001; part B: z=4.18; p<0.0001; in the posterior tibial nerve this was significant only in part B: z = 2.75; p < 0.01).

Table 6 Descriptive patient data for the posterior tibial nerve and the frequency of F wave abnormalities

	Diagnosis	n	Fmin	Fmax	Fmean	Fp	Fc	Total
A:								
	aPNP	46	10	9 (2)	12 (2)	11 (8)	8 (5)	27
	dPNP	20	8	6 (1)	8 (1)	4 (1)	6 (2)	13
	L5	65	1	1 (0)	2 (1)	2 (2)	7 (7)	11
	S1	64	8	10 (5)	10 (2)	2 (1)	12 (9)	25
	MonoN	15	2	3 (1)	3 (1)	4 (3)	3 (2)	9
	Normal subjects	31	—	—	—	1 (1)	2 (2)	3
	Total	241	29	29 (9)	35 (7)	24 (16)	38 (27)	88
B:								
	PNP	21	6	2 (0)	5 (0)	1 (1)	3 (3)	10
	L5	53	—	—	1 (1)	1 (1)	6 (6)	8
	S1	42	4	2 (0)	6 (2)	1 (0)	5 (4)	10
	MonoN	7	—	—	—	—	—	—
	Normal subjects	30	—	—	—	1 (1)	1 (1)	2
	Total	153	10	4 (0)	12 (3)	4 (3)	15 (14)	30

MonoN=mononeuropathies of the sciatic or of the posterior tibial nerve. Other abbrevations as in table 5.

The number of normal subjects falsely classified as abnormal by F wave analysis was small (Fmin part A 1%, part B 0%; Fmax part A 1%, part B 1%, Fmean part A 2%, part B 1%; Fp 4% in both parts, Fc part A 6%, part B 4%). With all parameters together, 9,6% of the normal subjects were false positive in part A and 7,5% in part B.

Discussion

In this study, normal values for five F wave parameters in the four major motor nerves have been established and systematically applied to at least four separate categories of patients. For normal values, Fmin, Fmean, and usually Fmax—but not Fc or Fp—correlate with age and height, as shown by previous investigators.[3 14] For the relative diagnostic sensitivity of these F wave parameters, we found Fc the most often abnormal parameter, certainly more sensitive than Fmin. This did not apply to polyneuropathies, when Fmin was found more useful.[3] The contribution of Fmean and Fmax was small and the usefulness of Fp was limited.

The protocol used in this study—recording F waves from 10 stimuli with the muscle relaxed—seems to be sufficient for routine diagnostic purposes.[3] It is relatively fast, reliable, and minimises patient discomfort. Upper limits of normal on the basis of 10 stimuli can be established with high sensitivity and reasonable specificity.[3]

Besides examining the sensitivity of these F wave parameters relative to each other, their combined sensitivity to that of other parameters of standard peripheral nerve conduction studies, including dispersion, amplitude, and area decay, was compared. The sensitivity of Fmin, Fmean, and Fmax was greater before exclusion of those patients with abnormal distal conduction. Thus F wave sensitivity decreases in the presence of strictly normal peripheral motor conduction studies. This reflects the influence of distal conduction in F wave latency but does not diminish the ability of the F wave to assess proximal conduction.[15]

The results indicate a high diagnostic sensitivity of Fc, at least in radiculopathies and in focal mononeuropathies of the lower limbs. Fc was the only parameter under investigation that could provide additional information in a significant amount when Fmin was chosen as point of reference. The sensitivity of Fc seems to depend on the length of the nerve. This is in line with the concept that Fc is a measure of the variability of conduction in different axons in the whole nerve, although there are other possibilities for enhanced Fc such as different refractory periods in proximal segments of the α motor neuron. When an extensive motor conduction study of the distal segment was done and all other parameters of motor neurography were within the normal range, Fc

was able to provide more than twice as much information as Fmin in the lower limbs. This underscores the usefulness of Fc for detecting mild abnormalities.[4] In this study, this conclusion is based primarily on peroneal data and is not true for median and ulnar data.

Additionally, F waves are more sensitive than motor conduction studies in axonal polyneuropathies.[3] Our findings suggest that F waves are able to identify 45% of the axonal polyneuropathies with normal peripheral motor conduction studies. Of course these data are biased toward sensory nerve conduction studies, because these were—according to the study design—crucial for diagnosis in mild polyneuropathies, but F waves may provide the earliest means of detecting abnormalities in motor fibres.[3] Decreased Fp was a rare finding in polyneuropathies; it was found more often in axonal than in demyelinating polyneuropathies. Therefore, decreased persistence or even absence of responses does not necessarily imply proximal conduction block or immune mediated attack, but may indicate axonal loss, especially if there is additional evidence of axonal polyneuropathy in studies of distal conduction.[3] In polyneuropathies, the absence of F waves in the presence of normal distal conduction and amplitudes was hardly seen, probably due to the lack of patients with Guillain-Barré syndrome in this study.

Abnormalities of F waves in carpal tunnel syndrome were less frequent than in compression neuropathies of the ulnar nerve at the elbow or of the common peroneal nerve at the fibular head.[16–18] The lower F wave yield in carpal tunnel syndrome might reflect the fact that the F wave passes the side of entrapment in carpal tunnel syndrome only once. Because the proportion of cases with exclusively sensory damage was considerably smaller in carpal tunnel syndromes than in ulnar neuropathies at the elbow, the lower diagnostic yield of the F wave in carpal tunnel syndrome cannot be due to a preferential involvement of sensory axons.

In radiculopathies, enhanced Fc was the most prominent pathological sign.[19] The prolongation of Fc is most likely due to the effect of focal demyelination, which results in root lesions in differential slowing.[13] Focal demyelination can be expected in compressive root injury comparable with the effect of compression in peripheral nerve injury, although it is not known whether the nerve root reacts to compression in the same manner as a peripheral nerve.[13] Although in this study the upper limit of Fc in the peroneal nerve was rather high, prolongation of Fc was of significance only in L5 radiculopathies when recordings were made from the extensor digitorum brevis muscle. This peculiarity can be explained by the fact that, different from muscles that are normally used in motor nerve conduction studies, the extensor digitorum brevis muscle may be innervated in a substantial amount by one single root (L5) and so an unusually high number of its motor units can be injured.[20] This claim, however, was not verified in a recent study.[21] Even in this study, more radiculopathies of S1 were identified by peroneal than by tibial nerve Fc (non-significant). Therefore, in cases of radiculopathy, prolongation of Fc in the peroneal nerve is a non-localised finding. Different from reports in the literature Fp was not reduced in L5 radiculopathies in this study, but the low normal value of Fp confirms the experience that F waves in the peroneal nerve can be infrequent.[22 23] In radiculopathies of S1 and in cervical radiculopathies the proportion of abnormal F waves was considerably lower. In cervical radiculopathies, there was a trend towards abnormalities in the corresponding segment (median nerve for C7 radiculopathies and ulnar nerve for C8 radiculopathies). Interestingly, C7 radiculopathies can impair the median nerve F wave response. This may provide evidence for an at least partial innervation of the thenar muscles by the C7 root in some patients. Although most human myotomal charts relate the thenar muscles to the C8-T1 myotomas, there are occasional clinical data for an involvement of the thenar muscles in C7 radiculopathies.[24] As a whole, changes of more localising value were found on needle electrode examination. F Wave studies provide complementary information and may disclose abnormalities when the EMG data do not provide information.[25 26]

The rate of false positive findings reported above can be expected when the upper limit of normal is set at 2 SD above the mean or at the 95th or 5th percentile. As a positive result is recorded if at least one of the five F wave parameters is outside the normal range, a true negative result in a normal subject can be expected with a probability of 86% (part A) or 87% (part B).[27] This fits well with the reported rate of false positive results and underscores the fact that F wave findings should be interpreted in relation to the particular clinical setting.

In which cases is it rational to record the F wave when all other parameters of motor (and of sensory) nerve conduction are normal?

F Waves are often abnormal and provide complementary information. The concept that the F wave is ideally suited to assess proximal conduction was supported by the study. F Wave analysis added information in the evaluation of polyneuropathies, even if sensory nerve conduction studies were performed. In radiculopathies, F wave studies were particularly useful in milder cases, when the EMG data were inconclusive. F Wave studies should include Fmin, Fc, and Fp. The judicious application of the F wave in assessment of mild peripheral nerve pathology or of potentially more generalised processes can be recommended.

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