IDENTIFICATION OF CERVICAL RADICULO-MYELOPATHY USING DISTRIBUTION OF F-LATENCY (DFL), A NEW NERVE CONDUCTION PARAMETER

K Siddique-e Rabbani[1*], Norazeida Yassin[2] and Yew Long Lo[2]

1:   Department of Biomedical Physics & Technology, University of Dhaka, Bangladesh.
2:   Department of Neurology, National Neuroscience Institute, Singapore General Hospital, Outram Road, Singapore 169608.
Corresponding author email: rabbani@univdhaka.edu

ABSTRACT

Distribution of F-latency (DFL) is a new nerve conduction parameter conceived and developed at Dhaka University which appears to have the ability to detect cervical radiculo-myelopathy early. The present work was taken up to evaluate its performance against diagnosis made using MRI on 24 median nerves of 12 patients reporting cervical radiculo-myelopathy at the Singapore General Hospital. Predictive analyses were carried out using contingency tables to evaluate the classification ability of DFL as against MRI as the standard. For the first analysis only double peaks or distinct broad peaks of DFL were assumed to indicate pathology. However, the sensitivity and accuracy could be improved significantly through redefining a broad peak as the pattern where the frequency of occurrence of a bin adjacent to the peak was greater than one third of the peak value, which was shown by a second analysis. A third analysis was also performed where a case of sensori-motor neuropathy, not identified as radiculo-myelopathy by MRI, was also included as an abnormality. This gave 88% accuracy (correct prediction) and 90% sensitivity. The rather low specificity value, at 67%, was due to the fact that the number of negative cases in the study group was small (5 out of 24). DFL has the potential of identifying cervical radiculo-myelopathy besides certain other peripheral neuropathy and may be used as a first line diagnostic or screening technique.

Keywords: Radiculopathy, Myelopathy, Cervical Spondylosis, Spondylotic neuropathy, Nerve conduction, F-Latency, Distribution of F-Latency, DFL

INTRODUCTION

A peripheral nerve contains thousands of nerve fibres with different conduction velocities of action potential. The number of fibres having different conduction velocities is described by a statistical Distribution of Conduction Velocity (DCV) which essentially plots number of fibres against conduction velocity. There have been many attempts in determining DCV earlier (Harayama H *et al.*, 1991; Barker AT *et al.*, 1979 Feb; Cummins KL *et al.*, 1979 Jun-a; Cummins KL *et al.*, 1979 Jun-b), but none of these produced a reliable technique suitable for a clinic. Recently, using arguments based on physiology, physics and statistics, a group at Dhaka University led by one of the authors developed a new method for obtaining DCV that is simple and suitable for a clinic (Rabbani KS *et al.*, 2007). In this method a peripheral nerve is stimulated supramaximally many times electrically with a time interval of at least one second between two successive ones. The resulting electrical response from a supplied muscle has an initial large response called the M-wave and a late small response, called the F-wave. F-wave occurs due to antidromic conduction in motor nerve fibres and subsequent backfiring of a few percent of the anterior horn cells located in the spinal cord. The recruitment of these few percent of motoneurons is random involving fibres of different conduction velocities at different times for which the F-waves on repetitive stimulation vary in latency, shape and size. Particularly the variation in F-latency indicates that the fastest fibre recruited in any F-wave (or stimulation event) also varies randomly. Arguments were put forward based on this randomness saying that the more number of nerve fibres present in the trunk with a certain conduction velocity, the more probability

this group will have in contributing to the F-latency. Based on this argument the frequency Distribution of F-Latency (DFL) as a new nerve conduction parameter that directly depends on DCV was proposed in that work. DFL is obtained through multiple nerve stimulation, typically 30 to 40 times. Repeat tests for DFL on the same nerve of any subject reproduced the DFL pattern well, within normal statistical uncertainty, which was verified in all subjects tested. This established that DFL is a physiological parameter, and the argument to relate it to DCV as mentioned above holds. Corresponding to each F-latency, a conduction velocity (CV) value may be estimated and using 30 or 40 such values of CV, a DCV may be obtained. Alternatively, for a quick approximation, a mirror image of the DFL may be taken to represent DCV since latency is inversely proportional to velocity. Thus a new method to obtain a relative DCV of peripheral motor nerves, at least for fibres contributing to F-responses, was established with potential in diagnostic applications.

During the above investigation, initially performed on median nerves, it was observed that DFL obtained from normal subjects has a reasonably sharp single peak, while double, and sometimes triple peaks were observed for cases with diagnosed cervical radiculo-myelopathy (CRM) (Alam MJ and Rabbani KS, 2010). These pattern descriptions for DFL should also hold for DCV based on the above relationship between DFL and DCV. The single peak of DCV for normal healthy persons was also expected based on earlier work using collision techniques (Ingram DA *et al.*, 1987; Harayama H *et al.*, 1991) and diameter distribution of the A-alpha fibres that get stimulated through external electrical stimulation, as obtained from nerve biopsies (Kimura J, 1989) (p. 64). Therefore, the expectation of having a single peak of DCV or DFL for normal healthy subjects is a valid one, and the appearance of double or triple peaks would indicate pathology.

From the above observation on the correspondence between double or triple peak of DFL and CRM, Alam and Rabbani (Alam MJ and Rabbani KS, 2010) had also suggested that broad peaks observed in some subjects were possibly indicative of early stage of CRM. However, it is now understood that a broad peak may occur even at late stages if the contributing nerve branches are all compressed to slightly different degrees. In the course of subsequent routine clinical work at Dhaka double, triple or broad peaks of DFL for the median nerve were observed for many patients who had symptoms of CRM or had proven CRM. Similarly, double or broad peaks of DFL were also observed for Tibial or Common Peroneal nerves for cases with Lumbo-sacral radiculopathy (Rabbani KS, 2011a). Later, a systematic study was taken up where DFL was obtained from the median nerves of 15 subjects with age varying between 25 and 65. Nine of them showing double or broad peaks were subject to X-ray or MRI investigation at regular clinics, where the radiologist gave reports without knowing the purpose of this study, or without any knowledge of the DFL findings. It was found that almost all of these cases had some pathology in the cervical region, whether radiculopathy or myelopathy (Hossain MI *et al.*, 2011). X-ray assessment of one subject who had a single peak of DFL came out normal which agreed to the contention held by the above analysis of DFL.

The observations were explained based on some reasoned arguments, and a generalized hypothesis was put forward that if a segment of a peripheral nerve trunk has a reduced velocity profile while the rest is normal, this will lead to double peak or broad peak of DFL (Rabbani KS, 2011b). Since most of the experiments were performed on median nerves by stimulating at the wrist and recording at the thenar muscle, specifically, Abductor Policis Brevis (APB), the first explanations were put forward related to this configuration. Two nerve branches, C8 and T1, and possibly a third, C7, coming out of the spinal cord contribute to the response from the thenar muscle through the combined median nerve (Gray, 1995; Urschel Jr HC and Razzuk MMA, 2000). Here it was assumed that motor fibres in all the three nerve branches will have the same relative DCV. This is reasonable to assume since the Neuromuscular system branches out and mixes up peripheral neurons randomly in order to provide

the maximum protection to limbs and organs of the body against localized injuries. This means that when DFL is determined from the median nerve, contribution to DFL from fibres within each of these three branches will have almost the same pattern at the same range of latency values if everything is normal. Therefore, the combined DFL will have a single peak too as schematically shown in Fig.1a. If due to any disease or disorder the conduction through all the nerve fibres in any of the nerve branches slow down in a proportional way, contribution of these fibres to DFL will shift to a greater delay, while contribution to DFL by the other two unaffected branches will remain unchanged. Thus the combined DFL will have a double peak as shown schematically in Fig.1b. If two of the three nerve branches have different degrees of slowing down, three peaks of DFL may be observed. Again, if the differences in delays through the different nerve branches are not large, a broad peak, rather than clearly defined multiple peaks may be observed. All such patterns of DFL have been observed in practice from patients. Of course if all the three nerve branches undergo the same level of compression leading to the same delay in each, multiple peaks or broad peaks will not be observed, the whole DFL will simply be delay shifted with a sharp peak. However, such pathology is not likely to occur in real life. It was also explained that any compression of the whole of the nerve trunk after the branches join together (for example, distal to Brachial Plexus for Median nerve) will only give rise to a delay shift of the whole DFL, it will not lead to multiple peaks or broad peaks. This was verified in patients with unilateral Carpal Tunnel Syndrome (CTS); the DFL in the affected hand shifted in delay compared to that of the opposite side without significant changes in the shape (Rabbani KS *et*
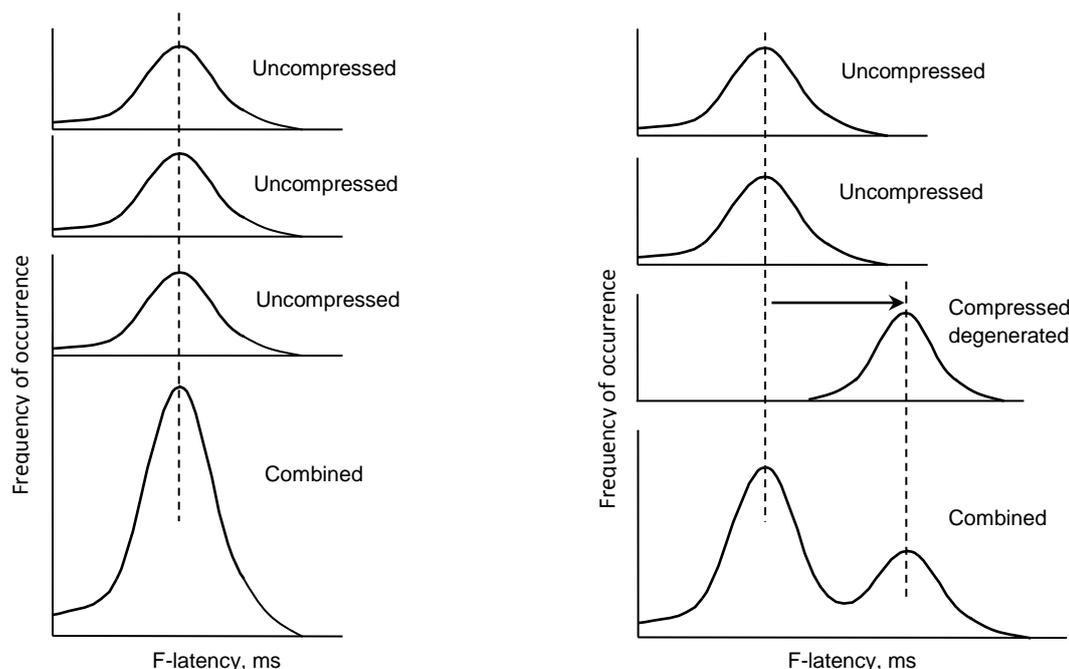

Fig.1: Schematic representation of hypothesis to explain the occurrence of a single peak of DFL from three uncompressed nerve roots (a) and the occurrence of double peaks due to compression at one nerve root (b)

al., 2007).

Based on the above explanations the first hypothesis given was in terms of compression at the nerve root (radiculopathy) of one or two of the nerve branches coming out through C7, C8 and T1, due to bony lesions or disc herniation. However, while trying to establish the above hypothesis it was observed that double peaks of DFL were present in some cases where radiculopathy seemed to be absent, as determined from X-ray images. Further MRI scans of these cases revealed that there was

myelopathy through disc bulging and compression of the spinal cord at one or more of the higher intervertebral levels (C4/5 and C5/6) (Hossain MI *et al.*, 2011).

The above observation led to a second hypothesis, as an extension of the former (Rabbani KS, 2011b). It was assumed that since the spinal cord has a large diameter and is immersed in a fluidic environment in a large spinal canal, disc compression from one side will not affect the whole of the spinal cord, rather it will only compress the nerve fibres locally at the points of compression. The descending nerve fibres at the periphery of the cord are expected to terminate onto the anterior horn cells that give out axons through the next lower levels. With signals not propagating properly through these descending nerve fibres, the body will find less use of the peripheral nerves that these descending nerve fibres terminate to, so there may be degeneration in these peripheral nerves as well as the body tend to throw away organs that are not being used. It was argued that this mechanism may lead to a situation where a segment of nerve fibres within the median nerve will have conduction velocities less than normal, and because of random statistical processes, these will effectively contribute to a delayed distribution of DFL. Due to combination of the distributions from both normal and the degenerated segments of nerve fibres, double peaks of DFL may again be expected (Rabbani KS, 2011b).

In course of routine clinical work, it was also observed that patients with external injuries contributing to partial degeneration of peripheral nerves also led to double peaks of DFL in some cases. There again it was explained in a similar way, that a segment of nerve fibres within the nerve trunk had a reduced conduction velocity profile leading to a delayed DFL (Rabbani KS, 2011b).

One should not confuse double peaks of DFL with double peaks in the M-response obtained from a muscle through an evoked response. The M-response is a record of the muscle action potential with time while DFL is statistical frequency distribution of F-latencies obtained through multiple stimulations. Of course, the shape of the M-response may show kinks or distortion for cases with CRM (Mahbub ZB *et al.*, 2012), which may have a link to the double or triple peaks of DFL or DCV.

In order to establish the above findings and hypotheses on a firmer ground the present work was taken up in Singapore General Hospital on patients with suspected cervical spondylotic neuropathy. The results gave a strong support to the hypothesis. Besides, it also provided a better definition for the broad peak which had some ambiguity earlier.

METHODS

The study recruited 12 patients with suspected cervical radiculopathy for MRI and electrophysiological evaluation (including DFL) over a 9 month period in 2011 at the Singapore General Hospital. The authors in Singapore had earlier obtained ethics approval from the Singapore General Hospital Ethics Committee for studying MRI and electrophysiological data on patients with cervical myelopathy and radiculopathy. All patients had informed consent. As this investigation is based on standard clinical investigation, only oral consents were taken from the subjects mentioning that their data would be used for research without disclosing their identity. No written consent notes were obtained.

All patients presented with classical symptoms of neck pain and radicular symptoms but were otherwise healthy. None had any history of external nerve injury. Most of the patients did not have other causes of nerve or muscle disorder. Complete neurological examination of patients performed by the attending physician did not reveal significant motor weakness or dermatomal sensory loss. All patients had electrophysiological tests and MRI performed within 3 months of each investigation. Specific diagnoses were made based on the MRI findings which were taken as the respective

references for this study. The MRI diagnosis did not clearly identify right or left sided lesions. Therefore, the MRI findings were applied bilaterally. On the other hand, the DFL findings were identified for each side individually. Although most of the subjects had radiculopathy, some had myelopathy as well. One subject had sensori-motor neuropathy as indicated by clinical tests while MRI findings for radiculo-myelopathy were negative.

In order to obtain DFL, for which facilities were not readily available in the equipment used, F-latencies for each nerve were recorded manually for about 20 to 30 stimulations applied to the median nerve at the wrist. The intervals between stimulations were maintained at more than one second. This large time interval was chosen to ensure relaxation of the neurons to normal physiological conditions so that each of the stimulation produces random backfiring of the cell bodies, located inside the spinal cord. Necessary software was developed using Microsoft EXCEL to obtain DFL from these F-latency values. The software grouped the F-latencies into 2 ms bins between 20ms and 40 ms and kept a record of the frequency of occurrence in each bin. A frequency polygon was then plotted which gave the desired DFL.

Identification of the patterns of DFL that are used to detect Cervical Spondylotic neuropathy need some clarification. Single, double or triple peaks of DFL can be identified visually with relative ease. However, distinguishing broad peaks from single peaks poses some difficulty. In our earlier studies we followed some rules which are explained below, with reference to some real patterns obtained from patients in this study. These DFL patterns are shown in Figs. 3*a* to 3*i*, and all are based on a 2ms bin size for DFL. The patterns in Figure 3 may be categorized in the following way.

- Single peak (representing normalcy, or healthy condition): The maximum frequency of occurrence of DFL happens at one of the bins and the adjacent ones have lower values as in Figs.3a-d.

- Broad peak (representing pathology): These were defined to have reasonably high values at a separation of at least 4ms (two bins apart) without a dip in the middle as indicated in Figs.3e and 3f.

- Double and triple peaks (representing pathology): With a 2 ms bin size, clearly resolved double peaks need to have at least a difference of 4 ms, with a dip in the middle, as represented by Figs.3g and 3h. Triple peaks were observed in some cases as shown in Fig.3i.

Based on the above descriptions of normalcy and pathology, DFL from 24 median nerves of the 12 patients were analysed (Analysis-1 in the results section). However, when compared with the MRI findings there was a significant percentage of false negatives; diagnosed as free of lesion by DFL, while MRI suggested otherwise. It was observed though that many of the false negatives had DFL patterns similar to those in Figs. 3b-d which were considered as single peaks. Since these cases had pathology, we felt a need to redefine broad peaks of DFL to include such cases. It was observed that for all such cases the frequency value adjacent to the peak (at a separation of 2 ms) is more than one third that of the highest peak value. Based on this observation, a new definition of a broad peak was made as follows, based on which another analysis was performed (Analysis-2 in the results section): Broad peak, new definition (representing pathology): a distribution will be termed to be a broad peak if the frequency value adjacent to the peak (at a separation of 2 ms) is more than one third that of the highest peak.

This was, in fact, a learning process based on MRI which is an important contribution of the present work. Broad peak, new definition (representing pathology): a distribution will be termed to be a broad peak if the frequency value adjacent to the peak (at a separation of 2 ms) is more than one third that of the highest peak.
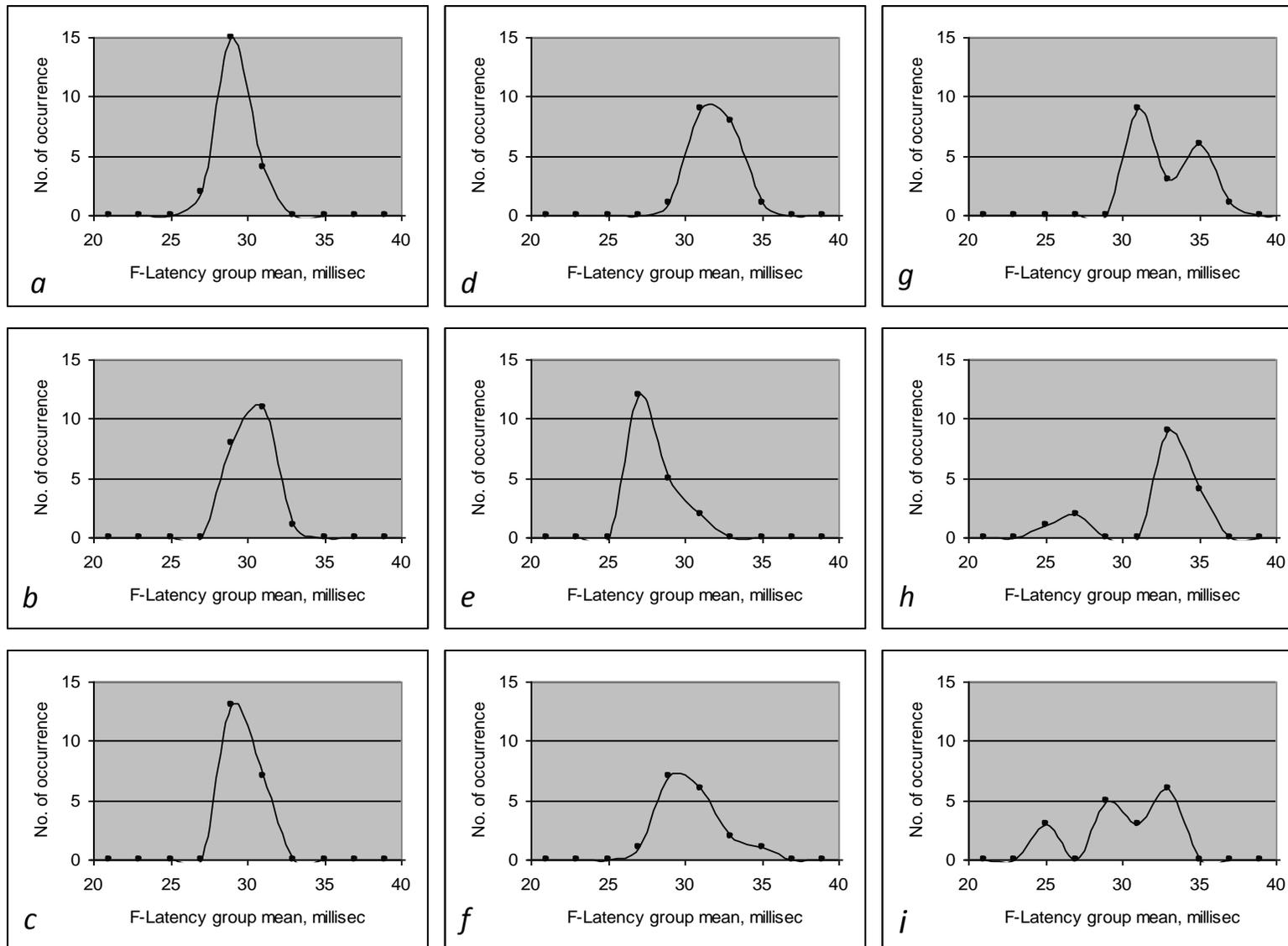
Fig.3: Representative real life DFL to show occurrence of single peak (a-d), broad peak (e,f), double (g,h) and triple peaks (i). Later findings of this paper re-categorised b-d as broad peaks as well.

Again, in Analyses 1 and 2 the abnormality was defined as only due to radiculopathy or myelopathy as suggested by MRI. However, there was one case (subject mentioned in the last row of Table 1) where MRI did not suggest the above but this case had clear double peaks of DFL on both hands indicating neuropathy. On later enquiry, the clinicians confirmed the patient to have sensori-motor neuropathy without specifying any focused lesion. This was then also included as a case with abnormality on both sides and accordingly the performance of DFL was evaluated (Analysis-3 in the results section).

Therefore, the first two analyses considered MRI findings only as the gold standard, while Analysis-3 considered other clinical findings in addition to that from MRI as the reference.

Prediction capabilities of DFL with reference to MRI (with the addition of other clinical findings for Analysis-3) were evaluated for all the 24 median nerves of the 12 subjects based on the above three analyses. The predictive parameters evaluated are given in Table-1 with corresponding abbreviations in brackets.

Table-1: Predictive parameters (abbreviations in brackets).

True positive (tp)	Positive predictive value [tp/(tp+fp)]
True negative (tn)	Negative predictive value [tn/(tn+fn)]
False positive (fp)	Sensitivity [tp/(tp+fn)]
False negative (fn)	Specificity [tn/(tn+fp)]
	Accuracy (correct prediction value) [(tp+tn)/total]

RESULTS

A collated summary of the comparison between the MRI findings and that from Analysis-1 of DFL regarding definition of single and broad peak as presented above are presented in Table 1. The individual lesions as suggested by MRI and other clinical tests are summarised through numbered notes following the table. As mentioned earlier, the MRI findings were applied bilaterally, so that the diagnosis based on MRI are the same on both sides.

For Analysis-2 of DFL regarding definition of single and broad peak as presented above, the changes that need to be made with respect to Table-2 are as follows.

   i.   For right side, 'N' changes to 'Y' for 5 subjects: 6,7,8,9 and10.

   ii. For left side, 'N' changes to 'Y' for 4 subjects: 2,5,8 and 11.

   iii. As a result, True Positive increases by 8, False positive increases by 1, True negative decreases by 1 and False negative decreases by 8

These were used to reevaluate the predictive parameters.

For Analysis-3, the changes that need to be made with respect to Table-2 in addition to the changes made above for Analysis-2 are as follows.

   i.   For right side, 'N' changes to 'Y' for 1 subject 3.

   ii. For left side, 'N' changes to 'Y' for 1 subject 3.

iii. As a result, True positive increases by 2 and False positive decreases by 2

The prediction capabilities of DFL based on all the first two analyses with reference to MRI findings are summarized in columns 2 and 3 of Table 3. It is clear from the values in the table that the predictive quality of DFL increases significantly with the new definition of broad peak used for Analysis-2. Besides, further improvement in predicting peripheral neuropathology beyond cervical radiculo-myelopathy is indicated by Analysis-3 (column 4 of Table 3).

Table-2: Analysis – 1, Comparison of diagnosis using DFL and MRI considering only double peaks of DFL as abnormal (single peak and broad peak as normal).

Patient ID	Gender	Age	Diagnosis (Y/N)			
			Right		Left	
			DFL	MRI	DFL	MRI
1	M	70	Y	Y[1]	Y	Y[1]
2	F	45	N	N	N	N
3	M	38	Y	N[2]	Y	N[2]
4	M	64	Y	Y[3]	Y	Y[3]
5	M	61	N	Y[3a]	N	Y[3a]
6	F	72	N	Y[4]	Y	Y[4]
7	M	73	N	Y[5]	N	Y[5]
8	M	53	N	Y[3a]	N	Y[3a]
9	M	51	N	Y[6]	N	N
10	F	68	N	Y[7]	Y	Y[7]
11	M	46	Y	Y[8]	N	Y[8]
12	M	71	Y	Y[9]	Y	Y[9]

[1]Severe spondylosis with spinal cord impingement and foramina stenosis
[2]Sensorimotor neuropathy but no exit or foramina stenosis
[3] Spondylosis with canal and foramina stenosis
[3a] Canal and foramina stenosis

[4]C2/3, C5/6 foramina stenosis
[5] C7 Infective but foramina stenosis
[6] C3/4/5 mild canal and foramina stenosis
[7] Mild foramina exit stenosis
[8] C6-8 Foramina stenosis
[9]Spinal cord compression and foramina stenosis

DISCUSSION

Conventional electrophysiological techniques have not produced any method so far to give a positive diagnosis of cervical radiculo-myelopathy (CRM) except for excluding other peripheral nerve disorders. Using a train of 200 stimuli, Peioglou-Harmaoussi et al (Peioglou-Harmoussi S *et al.*, 1987) studied the frequency of occurrence of F-responses from Ulnar nerves, frequency of identical responses, and F-wave shapes in order to relate these to CRM. None of these led to any clear method as the distinctions were not well marked. However, there appears to be a correspondence between one of their observations and the inference based on DFL.

Table-3: Prediction capability of the three analyses (total number of cases = 24). Analysis-1 uses old definition of a clear broad peak. Analysis-2 uses the new definition of broad peak arising out of the present work. Analysis-3 includes a case without Radiculopathy but having sensorimotor neuropathy as abnormal.

Parameter	Analysis-1 (Notes: 1,3)	Analysis-2 (Notes: 2,3)	Analysis-3 (Notes: 2,4)
True positives (tp)	9	17	19
True negatives (tn)	3	2	2
False positives (fp)	2	3	1
False negative (fn)	10	2	2
Positive predictive value [tp/(tp+fp)]	82%	85%	95%
Negative predictive value [tn/(tn+fn)]	23%	50%	50%
Sensitivity [tp/(tp+fn)]	47%	89%	90%
Specificity [tn/(tn+fp)]	60%	40%	67%
Accuracy (correct prediction) [(tp+tn)/total]	50%	79%	88%
Notes: 1. Based on earlier broad peak definition 2. Based on redefined broad peak 3. Only for CSN from MRI 4. Including other neuropathy			

Peioglou-Harmaoussi et al found that F-wave for cases with CRM appeared complex visually compared to those from controls. In our findings and that of the Dhaka University group earlier, DFL is a simple distribution with a single peak for normal subjects. Therefore, the backfiring nerve cells have less dispersion in latency among them, contributing to simple F-waves on combination of the

individual motor unit action potentials. On the other hand, in case of CRM, DFL has more dispersion with double, triple or broad peaks, meaning that latencies from backfiring nerves have wider separation among them, leading to more complex patterns on combination. Interestingly there have been many attempts at relating F-responses and their properties like frequency of occurrence, range of values, etc., to different neurological disorders including CRM (Lo Y L *et al.*, 2008). However, all these studies are based on blind statistical correlation methods only, without giving any understanding of the underlying physiological mechanism. On the other hand, DFL introduced by Rabbani et al (Rabbani KS *et al.*, 2007) and their arguments that related it to DCV of motor nerves in a peripheral nerve based on physics, physiology and probability statistics (Rabbani KS, 2011b) gives an insight and understanding which enhances the capability of judgement and analysis significantly. DFL also gives a clear indication of the side of the pathology, whether it is on the right side or the left side.

The present work allowed us to find out the following:

i.   Whether DFL can be considered as a method to detect cervical radiculo-myelopathy, as an alternative to MRI.

ii.   Whether the definition of broad peak as used in analysis-2 is worth considering (should be so if it gives a better performance in the predictive parameters).

iii.   Whether abnormalities (pathologies) not detected by MRI but detected through other clinical means should be considered for an assessment of the performance of DFL.

In the present study most of the decisions were taken assuming MRI as the gold standard. As can be seen, the assumption made in Analysis-1 resulted in a reasonably good positive predictive value, meaning 82% of the identified positive cases were true, but it was accompanied by a large number of false negatives giving a low negative predictive value of only 23%. Sensitivity and accuracy (correct prediction) were both low, at only 47% and 50% respectively.

However, the prediction capability improved drastically in Analysis-2 with the new definition of broad peak as detailed in the methods section. The improvement was marked in the negative predictive value, sensitivity and accuracy (correct prediction), the values being 50%, 89% and 79% respectively.

However the specificity value became low, from 60% in Analysis-1 to only 40% in Analysis-2, meaning that DFL gave some more false positives. The low value of specificity, however, could be attributed to the very small number of actually negative cases, given by the sum of the true negatives and false positives which, in this case, is only 5 (=2+3) out of a total of 24. Since specificity equals detected true negatives divided by all the actual negative cases, a single change in detection from such a small negative group contributes to a large change in specificity. One needs a larger number of actually negative cases to give a statistically acceptable value of specificity. Therefore, the specificity values obtained in this study may be ignored.

In Analysis-3 the neuropathy was not kept restricted to CRM alone as diagnosed through MRI. As mentioned before, one subject demonstrated clear double peaks of DFL indicating segmental involvement in a nerve trunk but MRI finding was negative for CRM. On further query to the clinicians it was revealed that the patient had sensori-motor neuropathy with unspecified origin. This shows the power of DFL, it may be able to detect some other peripheral neuropathy beyond CRM. Since the MRI finding did not show CRM it was not reported as an abnormality earlier. Inclusion of this abnormality in Analysis-3 increased the positive predictive value, sensitivity and accuracy further

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from 85%, 89% and 79% to 95%, 90% and 88% respectively. Thus in this case where MRI could not identify pathology, DFL could.

The high values of predictive analysis mentioned above suggest that multiple peaks or broad peaks of DFL may be useful in screening for peripheral neuropathy, a greater part of which could be CRM or radiculo-myelopathy. At present no technique exists to distinguish patterns of DFL due to unspecified sensorimotor neuropathy, radiculopathy or myelopathy. Therefore, the latter two are indicated only when there are no clinical findings suggesting the former and thus detecting radiculo-myelopathy constitutes a significant domain for the application of DFL.

One important by-product of the present work is the definition of a broad peak of DFL to represent abnormality, as done for Analysis-2. Although taking the cut-off at $1/3^{rd}$ of the peak frequency value in DFL for the adjacent bin may appear rather arbitrary, but it was decided through a careful observation of the DFLs and MRI findings for all the 24 patients in this work. The improvement in the quantitative values of the predictive parameters also supports this choice. Since the whole technique depends on randomness and probability statistics there will be some individual variation around this value, but this may be fine-tuned through further studies involving a large number of subjects. Meanwhile this cut-off value may be used for identification of peripheral neuropathy.

The present method of obtaining relative DCV is a direct experimental one, and is therefore free from analytical errors. This method may be applied to any of the peripheral nerves of the limbs, upper or lower, that are usually studied for NCV determination and for which an F-response can be obtained. The present method can be readily implemented using standard EMG equipment through manual recording of the F-latencies. However, specialised computer based equipment with automatic evaluation of DFL or DCV, as has been done in the laboratory of Dhaka University, will make the measurement simpler and suitable for routine measurement in clinics or hospitals, particularly for initial screening.

CONCLUSIONS

The present work established DFL as a reliable method for the detection of cervical radiculo-myelopathy, clearly distinguishing the side of the pathology, whether to the right or to the left. However, it cannot specify the exact level and origin of the lesion. Measurement of DFL can be performed using standard EMG equipment with evoked potential measuring ability, which is a potentially low cost device and can be made into a portable unit unlike MRI. Besides this has almost zero consumable cost. Therefore, DFL is attractive as a first line diagnostic or screening technique in cervical radiculo-myelopathy, and offers an alternative to MRI for this purpose. It may also be used as a research tool for prevalence studies of such neuropathy. The present work also allowed us to refine the pattern identification of DFL in the case of a marginal broad peak to indicate neuropathy as in analysis-2, which gave a significant improvement over analysis-1. Lastly, DFL could detect some other peripheral neuropathy that could not be detected by MRI, which shows a great promise for this new technique.

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