Original Article

Evaluation of the Correlation of Magnetic Resonance Imaging and Electrodiagnostic Findings in Chronic Low Backache Patients

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Abstract

Background: Low back pain (LBP) is one of the most common medical complaints and leading cause of workforce loss in many countries. Magnetic resonance imaging (MRI) is a highly sensitive method for the detection of lesions in the spine because of its excellent imaging of anatomical detail. However, MRI does not provide information about physiological nerve function and has relatively low specificity. Electrodiagnostic (EDX) study, including needle electromyography (EMG), is a specific test to assess the physiological functions of nerve roots or peripheral nerves. The aim of the present study was to correlate the electrophysiological and MRI findings in chronic low backache patients. **Materials and Methods:** Fifty patients (26 males and 24 females) with mean age 33.54 ± 8.33 years with a history of LBP of minimum 3 consecutive months were evaluated with MRI and EDX (bilateral nerve conduction study of three nerves [tibial, peroneal, and sural nerve] and bilateral EMG of three muscles [paraspinal, tibialis anterior, vastus medialis]) studies. **Results:** Twenty-seven patients showed disc involvement on MRI and 23 MRI were normal. Mean conduction velocity was mildly decreased in tibial and sural nerves in all the patients either with normal MRI or disc involvement on MRI. In disc involvement conduction velocity, decrease was more as compared to normal MRI. About 39% patients with normal MRI and 78% patients with disc involvement showed abnormal EMG. This data represented statistically significant association of EDX study with MRI ($P < 0.05$). **Conclusions:** In patients with LBP, EDX studies are significantly more correlated with clinical data than MRI. Therefore, EMG may be a useful diagnostic tool to establish management protocols and prevent unnecessary interventions. EDX gives a better representation of physiological status of nerve and muscle, a supra added benefit which MRI lacks. However, MRI gives better visualization of anatomic parameters and structural details which may or may not be associated with chronic LBP.

Keywords: *Chronic low backache, electromyography, magnetic resonance imaging, nerve conduction*

Introduction

Low back pain (LBP) is one of the most common medical complaints and leading cause of workforce loss in many countries. It is estimated that about two-thirds of the adult population will have an episode of LBP at some point in their lifetime.[1] Despite the progress in diagnostic imaging techniques, the exact cause of LBP remains unknown in approximately 85% of the cases. Moreover, the recurrence of LBP is extremely high; 60% to 84% of patients with an acute episode of LBP will have recurrent symptoms in the following year.[2,3]

Magnetic resonance imaging (MRI) has been used to detect spine lesions because of its high sensitivity and excellent anatomical detailing, but it has low specificity. Moreover, it cannot be used to collect information about physiological nerve functions. Asymptomatic individuals may also have MRI findings of herniated intervertebral disc (HIVD) or spinal stenosis (SS); and sometimes, these findings may not corroborate with symptomatology even in symptomatic patients.[4,5]

Therefore, a diagnostic method that is more closely related to patients' symptoms and has a high specificity is required to evaluate subjects with a view to determining the appropriate therapeutic options.[6,7] EDX study, including needle electromyography (EMG), is a specific test to assess the physiological functions of nerve roots or peripheral nerves. The results of EDX study correspond better with the clinical manifestation than do the results of MRI.[8] Although electrodiagnostic (EDX)

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study cannot be used to identify underlying causes, such as tumor, HIVD, or SS, which radiological studies can, abnormal findings in EDX study help in choosing the best therapeutic option, irrespective of the presence of MRI abnormalities.[9]

Nerve conduction study (NCS) is a test for studying the conduction of signals through a nerve. There are essentially no risks involved. An NCS test shows the condition of the best surviving nerve fibers and may remain normal in some cases. A normal NCS test result can occur in some persons with significant nerve disease.[10]

Electrical activity produced by skeletal muscles can be recorded by EMG technique. Muscle cells on activation by electrical or neurological stimulus generate electrical potential, which is recorded as electromyograph. It can be used to detect disease pathology and to analyze biomechanics of movements. It can be recorded by needle electrodes or surface electrodes. Back pain is thought to be associated with increased and/or asymmetrical activity measured by EMG. Electrical activity can be assessed by analysis of frequency, spectrum, amplitude, or root mean square of electrical action potentials.[11]

The aim of the present study was to correlate the electrophysiological and MRI findings in chronic low backache patients.

Materials and Methods

The present study was conducted in the Department of Orthopaedics, Paraplegia, Physical Medicine and Rehabilitation, in collaboration with Departments of Radiodiagnosis and Physiology, of a tertiary care center from May 2012 to November 2014. The study was cleared by the institutional review board, and ethical clearance was given. Consent of the patients was taken for the enrollment to study and use the data of the study for subsequent publication.

Fifty patients (26 males and 24 females) with mean age 33.54 ± 8.33 years with a history of LBP of minimum three consecutive months were evaluated with MRI and EDX (bilateral NCS of three nerves [tibial, peroneal and sural nerve] and bilateral EMG of three muscles [paraspinal, tibialis anterior, vastus medialis]) studies.

Patients with gross deformity of spine such as scoliosis or spondylolisthesis, fracture of spine, tumors and infections of spine, history of hip or pelvic disorder, contraindication for radiographic exposure (e.g., pregnancy), predominant leg pain, presence of motor deficit, and any other associated spine abnormality and bedridden patients (to exclude disuse atrophy) were excluded from the study. Informed written consent was obtained from all the individuals participating in the study.

Each patient of study population was thoroughly examined clinically and subjected to MRI of lumbosacral spine and electrophysiological investigations.

Procedure

Magnetic resonance imaging of lumbosacral spine

All MRI examinations were performed using a 1.5-T superconducting magnet (Phillips Intera). The patients were placed supine with a pillow positioned underneath the knees, ensuring that the patient was lying symmetrically with weight evenly distributed across both sides. Multislice sagittal and axial sections were obtained with following MRI sequences:

- **T1W Images**

Sagittal Section	Axial Section
TE– 11	TE– 8
TR– 400	TR-500

- **T_2W Images**

Sagittal Section	Axial Section
TE– 120	TE– 120
TR– 3500	TR-2500

Electrophysiological study

Electrophysiological study was done in the Department of Physiology using an Aleron 401 model EMG machine for determination of nerve conduction velocity and electromyogram. Concentric needle electrode of a 24–26G, beveled tip exposed to give an oval recording area of 125 × 580 μm^2 used. Two small button type silver electrodes were used as reference and recording electrode for NCS. Ground electrode was used for earthing. The following electrophysiological tests were performed after explaining the procedure to patient in his/her own language, to allay apprehension.

- Motor nerve conduction
  - Tibial nerve (right and left)
  - Peroneal nerve (right and left).
- Sensory nerve conduction (SNC)
  - Sural nerve (right and left).
- EMG
  - Paraspinal muscles (right and left)
  - Vastus medialis (right and left)
  - Tibialis anterior (right and left).

Statistical analysis

Collected data were entered in the MS Excel spreadsheet and analyzed using IBM SPSS (Statistical Package for Social Studies) for Windows version 20.0. (Armonk, NY: IBM Corp) Categorical data were presented as percentage (%). Pearson's Chi-square test was used to evaluate differences between groups for categorized variables. In case expected cell count was <5 in >20% cells, Fisher's exact test was used. Normally distributed data were presented as means and standard deviation, or 95% confidence intervals (CI). For comparing two groups containing quantitative variables, independent sample *t*-test was used. In case of violation of normality, Mann–Whitney

test was used. Pearson's correlation was used for measuring correlation coefficient between two quantitative variables. In case of qualitative variables, spearman's correlation coefficient was applied. All tests were performed at a 5% level significance, thus a difference was significant if the value was <0.05 (P value < 0.05).

Results

Motor nerve conduction study of tibial and peroneal nerve

The mean latency difference and amplitude of tibial nerve were within normal limit in all the patients whereas mean conduction velocity was mildly reduced. Mean latency of the right side was 8.61 ± 1.31 ms and left side 8.83 ± 1.39 ms. In amplitude, on the right side, it was 10.77 ± 7.23 mV and left side 10.92 ± 6.77 mV. With reference to conduction velocity, it was 40.53 ± 4.82 m/s on the right side and 40.04 ± 4.84 m/s on left side. The mean latency difference and conduction velocity of peroneal nerve were within normal limit in all the patients but mean amplitude was reduced. Mean latency of the right side was 6.89 ± 1.02 ms and left side 6.91 ± 0.91 ms. In amplitude; on the right side, it was 4.17 ± 4.43 mV and the left side 4.35 ± 5.27 mV. With reference to conduction velocity, it was 43.34 ± 5.09 m/s on the right side and 43.35 ± 4.68 m/s on the left side [Table 1].

Sensory nerve conduction study of sural nerve

The mean latency difference was slightly increased, and amplitude was within normal limit in all the patients but mean conduction velocity was reduced. Mean latency of the right side was 4.20 ± 0.94 ms and left side 4.17 ± 0.82 ms. In amplitude, on the right side, it was 141.94 ± 171.52 µV and left side 174.56 ± 203.17 µV. With reference to conduction velocity, it was 41.84 ± 5.77 m/s on the right side and 42.36 ± 5.12 m/s on the left side [Table 2].

Relation between conduction velocities of three different nerves with disc involvement on magnetic resonance imaging (n = 27)

Normal values of conduction velocity of tibial, peroneal, and sural nerves are 48 ± 4.5 m/s, 42 ± 5 m/s and 50 ± 5 m/s, respectively. Twenty-seven patients had lumbar disc involvement on MRI. When their conduction velocities for three different nerves were computed, both tibial and sural nerve had decreased conduction velocity. Peroneal nerve conduction velocity was within normal limit [Table 3].

Relation between conduction velocities of three different nerves with normal magnetic resonance imaging (n = 23)

In the present study, 23 patients had normal MRI findings. When their conduction velocities for three different nerves were computed, both tibial and sural nerve had mildly decreased conduction velocity whereas peroneal nerve conduction velocity was within normal limit [Table 4].

Electromyography study of paraspinal muscle

We found mean recruitment of motor unit potential (MUP) on the right side 58.20 ± 16.86% and on the left side, it was

Table 1: Motor nerve conduction study of tibial and peroneal nerve (n=50)

	Mean±SD (range)	
	Tibial nerve	**Peroneal nerve**
Latency (ms)		
Right	8.61±1.31 (6.1-11.7)	6.89±1.02 (5.3-9.6)
Left	8.83±1.39 (6.2-14.3)	6.91±0.91 (5.4-10.1)
Amplitude (mV)		
Right	10.77±7.23 (1.4-22.6)	4.17±4.43 (0.3-22.0)
Left	10.92±6.77 (3.0-28.5)	4.35±5.27 (0.6-30.3)
Conduction velocity (m/s)		
Right	40.53±4.82 (30.8-49.6)	43.34±5.09 (33.4-52.4)
Left	40.04±4.82 (32.8-49.6)	43.35±4.68 (29.7-52.4)

SD – Standard deviation

Table 2: Sensory nerve conduction study of sural nerve (n=50)

	Mean±SD (range)
Latency (ms)	
Right	4.20±0.94 (3.0-6.9)
Left	4.17±0.82 (3.0-6.3)
Amplitude (µV)	
Right	141.94±171.52 (8.9-800)
Left	174.56±203.17 (17.9-800)
Conduction velocity (m/s)	
Right	41.84±5.77 (27.4-57.0)
Left	42.36±5.12 (28-55.9)

SD – Standard deviation

Table 3: Relation between conduction velocities of three different nerves with disc involvement on magnetic resonance imaging (n=27)

	Conduction velocities in m/s (mean±SD)			P
	Tibial nerve	**Peroneal nerve**	**Sural nerve**	
Right	37.7±3.48	41.1±5.17	39.8±5.75	0.04
Left	37.3±3.20	42.1±4.25	41.2±4.44	<0.001

SD – Standard deviation

Table 4: Relation between conduction velocities of three different nerves with normal magnetic resonance imaging findings (n=23)

	Conduction velocities in m/s (mean±SD)			P
	Tibial nerve	**Peroneal nerve**	**Sural nerve**	
Right	43.7±4.10	45.9±3.61	44.2±4.91	0.190
Left	43.2±4.53	44.8±4.81	43.7±5.62	0.544

SD – Standard deviation

58.40 ± 21.51% with a range of 20%–90%. With reference to peak to peak amplitude, it was 1625.04 ± 713.38 μV on the right side and 1637.98 ± 666.28 μV on the left side [Table 5].

Electromyography study of tibialis anterior muscle

Mean recruitment of MUP on the right side was 66.60 ± 15.06% and on the left side it was 70.80 ± 15.75% with a range of 30%–90%. With reference to peak-to-peak amplitude, it was 1728 ± 710.69 μV on the right side and 1919.18 ± 750.19 μV on the left side [Table 5].

Electromyography study of vastus medialis muscle

We found mean recruitment of MUP on the right side 65.40 ± 17.28% and on the left side it was 66.02 ± 16.02% with a range of 30%–90% and 20%–90%, respectively. With regard to peak-to-peak amplitude, it was 1972.72 ± 713.73 μV on the right side and 1995.10 ± 728.20 μV on the left side [Table 5].

Relation between recruitment of motor unit potential of three different muscles with disc involvement on magnetic resonance imaging in Group A (*n* = 27)

Table 3 shows needle EMG study done for paraspinal and 2 lower limb muscles (vastus medialis and tibialis anterior). In the present study, 27 patients had lumbar disc involvement on MRI. All the disc involved patients had decreased recruitment in all the 3 muscles. In increasing order, the recruitment of motor unit potentials was as follows: Paraspinal < vastus medialis < tibialis anterior muscle [Table 6].

Relation between recruitment of motor unit potential of three different muscles with normal magnetic resonance imaging findings (*n* = 23)

Table 4 shows needle EMG study done for paraspinal and 2 lower limb muscles (vastus medialis and tibialis anterior). In spite of normal MRI, these patients had decreased recruitment in all the three muscles. In increasing order, the recruitment of motor unit potentials is as follows: paraspinal < vastus medialis < tibialis anterior muscle [Table 7].

Showing relation between disc involvement as seen on magnetic resonance imaging and normal magnetic resonance imaging finding and deficit found on electrodiagnostic study

Table 5 shows that out of the 27 patients showing disc involvement on MRI, EDX study (EMG) showed deficit in 21 patients (78%). In 23 patients showing normal MRI, EDX deficit was present in nine patients (39%). This data represents that there is statistically significant association of EDX study with MRI in chronic LBP patients [Table 8].

Table 5: Electromyography study of paraspinal muscle (*n*=50)

	Mean±SD		
	Paraspinal	Tibialis anterior	Vastus medialis
Recruitment of MUP (%)			
Right	58.20±16.86	66.60±15.06	65.40±17.28
Left	58.40±21.51	70.80±15.75	66.02±16.02
Peak-to-peak amplitude (μV)			
Right	1625.04±713.38	1728.56±710.69	1972.72±713.73
Left	1637.98±666.28	1919.18±750.19	1995.10±728.20

MUP – Motor unit potentials; SD – Standard deviation

Table 6: Relation between recruitment of motor unit potentials of three different muscles with disc involvement on magnetic resonance imaging (*n*=27)

	Recruitment of MUP (mean±SD)			*P*
	Paraspinal muscle	Tibialis anterior muscle	Vastus medialis muscle	
Right	57.4±14.30	67.8±15.3	63.3±19	0.07
Left	60.0±19.01	71.5±17.9	66.3±18.8	0.08

MUP – Motor unit potentials; SD – Standard deviation

Table 7: Relation between recruitment of motor unit potentials of three different muscles with normal magnetic resonance imaging findings (*n*=23)

	Recruitment of MUP (mean±SD)			*P*
	Paraspinal muscle	Tibialis anterior muscle	Vastus medialis muscle	
Right	59.1±19.75	65.2±15	67.8±15.1	0.203
Left	56.5±24.42	70.0±13.1	66.1±12.3	0.03

MUP – Motor unit potentials; SD – Standard deviation

Table 8: relation between disc involvement as seen on magnetic resonance imaging and normal magnetic resonance imaging finding and deficit found on electrodiagnostic study (*n*=50)

	Electrodiagnostic deficit		Total	Pearson χ^2
	Absent	Present		
Disc involvement	6	21	27	χ^2=7.72
Normal MRI	14	9	23	*P*=0.005
Total	20	30	50	(significant)

MRI – Magnetic resonance imaging

Discussion

Nerve conduction study

Conduction velocity was mildly reduced in the tibial nerve whereas found normal in peroneal nerve. The amplitude was mildly reduced in the peroneal nerve. Latency was mildly increased in sural nerve, and conduction velocity was mildly reduced. Robinson and Lee[12] also found

abnormal sural NCS in 97% patients (86% bilaterally and 11% unilaterally) abnormal peroneal NCS in 89% patients (76% bilaterally and 13% unilaterally) and F-wave abnormality in 70% patients (66% bilaterally and 4% unilaterally). Khatri *et al*.[13] reported normal motor and SNC studies in all patients except two, who demonstrated generalized peripheral neuropathy.

Relation of low back pain with recruitment of motor unit potentials in paraspinal and two lower limb muscles

Paraspinal muscle showed minimum recruitment followed by vastus medialis muscle followed by tibialis anterior muscle. Dillingham *et al*.[14] also studied tibialis anterior, vastus medialis, and vastus lateralis muscles, like in our study. Johnson and Fletcher[15] reported positive waves/fibrillations in tibialis anterior, vastus medialis, and paraspinal muscles in patients with L4 affection, in paraspinal muscles in L4 and S1 root affection giving similar results as in present study. Lee and Lee[16] reported similar findings. Johnson and Melvin[17] reported that in one third of their patients EMG abnormalities were solely present in the paraspinal muscles and observed that extensor hallucis longus and anterior tibial muscles were most frequently involved with an L5 radiculopathy. For S1 root, EMG abnormalities were present usually in gastrocnemius (medial head) and gluteus maximus. They also reported reduced number of motor unit action potentials as compared to strength of contraction. Robinson and Lee[12] reported 84% bilateral EMG abnormalities and 16% unilateral EMG abnormalities. Khatri *et al*.[13] examined tibialis anterior, medial gastrocnemius, soleus, peroneal, rectus femoris, and paraspinal muscles and reported EMG abnormalities in 51 of the 80 patients which correlated well with CT diagnosis.

Correlation of disc involvement on magnetic resonance imaging with conduction velocity

In the present study, mean conduction velocity was mildly decreased in tibial and sural nerves in all the patients either with normal MRI or disc involvement on MRI. In disc involvement, conduction velocity decrease was more as compared to normal MRI. An extensive search did not reveal any literature correlating disc involvement on MRI with conduction velocity.

Correlation of magnetic resonance imaging with electrodiagnostic findings

In the present study, 39% patients with normal MRI and 78% patients with disc involvement showed abnormal EMG. This data represented statistically significant association of EDX study with MRI with $P < 0.05$. Conversely, in 61% patients with normal MRI findings and 22% patients with disc involvement, EMG was normal. This substantiates that EDX studies are more physiological and give better representation of functional status of an individual. Lee and Lee[16] study showed that 22.1% of EDX(+) patients were MRI(−) and 46.8% of MRI(+) patients were EDX(−), thus supporting our study. They also compared between MRI finding of root compression and radiculopathy as observed on EDX study for the specificity and sensitivity and concluded that in symptomatic patients EDX was significantly more correlated with clinical data than was MRI. In the present study, 27 patients were MRI(+) and 21 of them were EDX(+). Conversely, 23 patients were MRI(−) and 9 of them were EDX(+). Coster *et al*.[8] reported that approximately 7% of the EDX(+) patients were MRI(−) and 26% of MRI(+) patients were EDX(−). Johnson and Melvin[17] studied the distribution of EMG abnormalities in one-hundred and eleven patients with lumbar radiculopathy and concluded that the relationship of EMG abnormalities to the motor radiculopathy is direct, accurate, and specific. Khatri *et al*.,[13] had correlated the results of CT and EMG and observed that an abnormal EMG correlated better with radiculopathy than CT.

In the current study, 6 out of 27 MRI (+) patients were EDX(−). This discrepancy can be explained, as asymptomatic herniated disc are common finding on MRI in the normal population (25%), and therefore, it is assumed that within symptomatic patients a substantial number of herniated disc are asymptomatic too.[5,6]

Research studies using MRI as a radiological investigation only reveal structural abnormalities, which may also be present in asymptomatic participants or may be unrelated to the clinical findings. This was confirmed by our present study where MRI showed disc involvement but recruitment of MUPs was normal in 6 out of 27 patients. Although there were patients with decreased recruitment on EMG, which correlated significantly with radiological findings, EMG does not always correspond with MRI.

Similar results were obtained by Lauder *et al*.[18] in which they observed that tibialis anterior muscle was abnormal in 92% of radiculopathies at L4-L5 level, extensor hallucis longus muscle was abnormal in 87% of radiculopathies at L5 level, vastus lateralis muscle was abnormal in 100% of radiculopathies at multiple levels, and vastus medialis was abnormal in 54% patients when L3–L4 level and 17% when L4–L5 level was involved. Dillingham *et al*.[14] observed that when paraspinal muscles with other four muscles were screened on EMG, 94% to 98% of lumbosacral radiculopathies were diagnosed. In the present study, we also studied three muscles including paraspinal muscles. They were of the opinion that if screening study reveals a positive radiculopathy, the EMG examination can then be expanded to evaluate the specific radiculopathy level and exclude other diagnostic possibilities.[18]

The present study demonstrated the useful characteristics of EMG. First, EMG demonstrated a more significant correlation with poorer functionality of lower limb (evident by decreased recruitment in all the three tested muscles) than did MRI in the disc involved patients. This was

explained by the fact that EMG abnormalities were dependent on the loss of motor axons. Second, EMG was more correlated with the signs and symptoms of the patients and tells more about the functional status of the nerves and muscles. It has higher specificity and lower level of false positivity and hence can play an important role in steering patients toward appropriate treatments.[19] Third, EMG could also be used to identify the level of disc involvement in patients of radiculopathy.[19,20]

Conclusions

It is concluded from the present study that EDX studies are more physiological and give better representation of functional status of an individual. In patients with chronic LBP, with or without disc involvement, nerve conduction studies correlated less and nonsignificantly while EMG correlated significantly, both clinically and radiologically. EDX studies are useful diagnostic tool to establish management protocols and prevent unnecessary interventions. EDX gives a better representation of physiological status of nerve and muscle, a supra added benefit which MRI lacks. However, MRI gives better visualization of anatomic parameters and structural details which may or may not be associated with chronic LBP. In nutshell, neuroelectrophysiology not only correlates well with both clinical and radiological data but also gives additional information regarding disease pathophysiology.

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Conflicts of interest

There are no conflicts of interest.

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