A comparison of magnetic resonance imaging with electrodiagnostic findings in the evaluation of clinical radiculopathy: a cross-sectional study

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Abstract

Purpose The aim of this study was to evaluate the agreement of magnetic resonance imaging and electrodiagnostic studies by comparing their findings in patients with clinically suspected radiculopathy. The agreements between these two procedures and clinical findings were also examined.

Methods In a 2-year cross-sectional study, a total of 114 patients with clinically suspected cervical or lumbosacral radiculopathy were included.

Results The total agreements between clinical with MRI and EDX findings were 72 and 52 %, respectively while their agreements were similar in group definite (89 vs. 82 %). The agreement between EDX and MRI was 59.6 in total and 49 % with respect to clinical findings.

Conclusion This study further supports that these two methods are complementary in general. It is reasonable to add EDX when there is discrepancy between MRI and clinical findings or when MRI neurologic findings are not visible.

Keywords Cervical · Lumbosacral · Radiculopathy · Magnetic resonance imaging · Electrodiagnostic studies

Introduction

Radiculopathies are characterized by inflammation [1] or compression of nerve roots producing pain and tingling, numbness or neurological deficit along the distribution of the affected nerve roots [2, 3].

Electrophysiologic studies are commonly used in the diagnosis of radiculopathies. They are useful in determining the level of a radiculopathy, determining its chronicity, and degree of severity, particularly when the patient's history and physical examination are inadequate for the diagnosis [4] or in differentiating disease processes that are clinically indistinguishable [5]. This procedure has few if any serious complications [6].

Imaging techniques are also frequently used in evaluation of radiculopathies. Of the several different imaging methods that are helpful in evaluation of the patients with radiculopathy, magnetic resonance imaging (MRI) is the preferred technique [7]. In patients with disc herniation, the resolution of symptoms with nonsurgical management has been reported to correlate with attenuation of the herniation on imaging studies [8, 9].

Electrodiagnostic studies (EDX) are operator dependent and different methods and normal values are used by laboratories. If the symptoms are intermittent and have duration of more than a year and pain without weakness is the primary complaint, the yield of the tests is frequently low. These studies do not evaluate sensory fibres and they are insensitive to demyelinating lesions. In fact, they are sensitive to motor radiculopathies; however, root injury from any structural lesion (e.g., disc herniation, tumour encroachment, and scarring) can produce similar electrical findings. Furthermore, timing is of significance in the usefulness of the electrodiagnostic examinations. Moreover, needle electrode examination requires patient

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cooperation [10]. On the other hand, structural abnormalities in MRI do not necessarily imply the underlying cause of the presenting clinical symptoms [11]. Thus, relying solely on one diagnostic procedure may be misleading and counterproductive. In addition, the possibility for the presence of dual pathology should be taken into consideration. Accordingly, more viable diagnostic strategies are needed in the diagnosis of radiculopathies.

The aim of this study was to evaluate the diagnostic efficacy of MRI and electrodiagnostic studies by comparing their findings in patients with clinically suspected radiculopathy. The agreements between these two procedures and clinical findings were also examined.

Materials and methods

Design and setting

For 2 years, a cross-sectional analysis of the results of MRI and EDX in patients with radiculopathy was conducted in an outpatient clinic at Imam Reza University Hospital, a physical medicine and rehabilitation practice and research center in Tehran. Consecutive patients who had been referred with the complaint of radicular neck or back pain during April 2007 to April 2009 were enrolled in the study.

Participants

Overall, 126 patients with clinical findings consistent with lumbar or cervical radiculopathies were recruited. All participants were referred by specialists other than those who performed the study. The patients underwent both EDX and MRI if they had not undertaken MRI within a month prior to the study. Information on the characteristics of the patients, containing demographic data and medical history was obtained from the patients at the first hospital visit and entered into a computer database.

Inclusion and exclusion criteria

Patients who aged over 18 years with complaints of pain, paresthesia, or decreased sensation in a dermatomal pattern and referred pain limbs, or any sign of muscle atrophy or weakness as well as decreased muscle stretch reflexes were included in the study.

In short, patients were considered eligible for the study if they had the manifestations of radiculopathy. In addition, the analysis was limited to patients with a spine MRI taken within 1 month prior to the study. MRIs were performed in Imam Reza Hospital and other institutions. Patients with clinical or electrophysiological evidence of poly or mononeuropathy, plexopathy, myopathy, and any concurrent

pathology which might confound were not included in the study. Also, participants with previous spine surgery were excluded. Additionally, for exclusion of non-structural causes of roots lesion, patients with the involvement of more than two nerve roots in clinical exam or electrodiagnostic study were excluded from the study.

A total of 126 patients were eligible for inclusion in the study and were approached by study clinicians to participate in the study. Of these, one patient refused to participate due to anxiety in EDX study room, even after the administration of lorazepam 2 mg orally and 11 patients were excluded because of involvement of more than two roots in electrodiagnostic study. Eventually, 114 patients composed the analytical sample population of this study. None of the participants had contraindication to MRI or EDX studies.

Clinical findings

One board-certified physical medicine and rehabilitation specialist, other than the one who performed EDX study, visited the participants, completed a detailed medical history, performed physical examinations, and conducted further investigations if needed.

The physical examination consisted of sensory testing (light touch and pinprick) based on Foerster dermatome map [12], motor examination using the standard American Spinal Injury Association motor examination of key muscles and Medical Research Council Scale [13] and determination of stretch reflexes (patellar, Achilles, and medial hamstring in lower limbs and biceps, triceps and brachioradialis in upper limbs).

EDX studies

A resident of physical medicine and rehabilitation performed nerve conduction study and needle electrode examination for all patients under the direct supervision of the study physiatrist. They were blinded to clinical findings. Motor and sensory nerve conduction studies were carried out at first, in all patients. Late responses, H reflex from the soleus and flexor carpi radialis muscles and F waves, were investigated.

A concentric needle electrode was used for electromyography (EMG). Electrical activity of muscles was recorded by evaluating motor unit action potential recruitment, amplitude, duration, and configuration at differing levels of muscle contraction in needle electromyography. Spontaneous activity or motor unit potentials more than 5 mV in amplitude for maximum contraction or more than 16 ms in duration in at least two muscles of one myotome in any extremity innervated by the same myotome but by separate peripheral nerves were considered as conclusive evidence

for the diagnosis of radiculopathy. C5–T1 root levels in the patients with suspected cervical radiculopathy and L2–S1 in the participants with suspected lumbar radiculopathy were investigated as well. For all patients, two or three muscles were examined in each myotome, including paraspinal muscles [14]. In our research, the diagnosis of radiculopathy was made mainly by needle electromyography and nerve conduction study was used to exclude other diseases and confirm the diagnosis.

MRI study

The study specialist, who interpreted MRIs (sagittal and axial T1- and T2-weighted sequences), was a board-certified radiologist experienced in neuroradiology and was blind to the patients' medical history and physical examination at the time of enrollment. Any sign of bulged, extruded, or protruded cervical disc as well as non-discogenic causes (i.e., facet hypertrophy, facet joint synovial cyst, osteophytosis, spondylolisthesis, hypertrophy of the spinal ligaments, particularly the ligamentum flavum) on MRI (if resulted in any foraminal, central or lateral recess stenosis) was noted and defined as an abnormal finding. Bulging was reported if disc material was displaced more than 50 % of its circumference. Protrusion of the disc was considered when a focal convexity had a width wider than depth. Also, the criteria for extrusion were a focal convexity with a depth greater than the width, extension of the nuclear material cephalad and caudal past the levels of the end plates, or visible extension through the annulus and posterior longitudinal ligament.

Ethical considerations

The study was performed in accordance with the Declaration of Helsinki. Ethics approval was obtained from the institutional review boards, and the rationale of the study was explained to all participants. All patients signed written consent forms prior to entering the study. A trained nurse accompanied the participants throughout the study and gave them an information leaflet before the procedure.

Analysis

Descriptive statistics are presented as mean for continuous variables and count with relative frequencies (%) for categorical outcomes. Practices were stratified according to the clinical syndromes, diagnostic procedures and the site and the level of pathology. Chi-square test was used to assess agreement between diagnostic methods based on patients' clinical syndromes. The sensitivity and specificity of MRI and EDX were also calculated based on the findings of root involvement detected just on physical

examination and not sensory symptoms. Statistical analyses were done using Statistical Package for the Social Sciences, version 14.0 (SPSS Inc, Chicago, IL, USA).

Participants were assigned to three groups of clinical syndromes; “definite”, “probable” and “possible”. The “definite” group included the patients with both signs and symptoms compatible with a specific root lesion. The “probable” group was characterized by clear symptoms such as pain, paresthesia or anaesthesia consistent with a specific root involvement but normal physical examination at the same time. In the “possible” group, the patients had suggestive but uncertain symptoms that were not compatible with injury of any specific root level.

In patients with clinically estimated involvement of two roots, the results of EDX or MRI were considered clinically relevant if at least the involvement of one similar root or level was observed. In the “possible” group, evidence of any root or level involvement in EDX or MRI was regarded relevant.

Results

A total of 114 patients with radiculopathy underwent both MRI and EDX studies. Of these, 31 (27.2 %) had cervical and 83 (72.8 %) had lumbosacral nerve root involvement. The study sample was composed of 47 (41.2 %) women and 67 (58.8 %) men. They ranged in age from 19 to 90 years, with a mean age of 41.25 years. Overall, 34.2 % of the participants had normal EDX and 18.4 % had normal MRI. In addition, EDX and MRI showed that there was clinically asymptomatic nerve root involvement in 9.7 and 28.7 % of the patients, respectively.

The agreements between clinical findings with MRI and EDX findings and also between MRI and EDX in patients with suspected cervical and lumbosacral radiculopathy are shown in Tables 1 and 2.

Regarding the clinical syndromes (“definite”, “probable”, and “possible”), there was a significant agreement only between the clinical findings and relevant MRI but not between the clinical findings and relevant EDX and both MRI and EDX. The highest agreements were present in the

Table 1 Cervical EDX and MRI findings

Clinical level	<i>n</i>	Clinically relevant MRI (%)	Clinically relevant EDX (%)
C5/C5–C6	10	100	20
C6/C6–C7	5	40	0
C7/C7–C8	5	100	100
C8/C8–T1	5	20	40
Indeterminate	6	83.3	33.3
Total	31	74.2	35.5

Table 2 Lumbosacral EDX and MRI findings

Clinical level	<i>n</i>	Clinically relevant MRI (%)	Clinically relevant EDX (%)
L4/L3–L4	6	33	67
L5/L4–L5	30	57	50
S1/L5–S1	35	91	65.7
Indeterminate	12	67	50
Total	83	71	58

“definite” group (Table 3). In 29 patients, only one of MRI or EDX studies was clinically relevant (26 vs. 3).

Table 4 demonstrates clinically relevant MRI and EDX findings in patients with suspected cervical and lumbosacral radiculopathy based on clinical syndrome.

Table 5 demonstrates sensitivity and specificity of MRI and EDX were calculated based on the findings of root involvement detected just on physical examination.

Discussion

A major limitation in diagnostic studies of nerve root involvement is the absence of a gold standard due to the inherent limitation of all diagnostic methods even operating findings [15, 16] which makes studies of relative diagnostic sensitivity difficult [17].

EDX examination and neuroimaging studies focus on different aspects of nerve roots. EDX examination detects functional abnormalities, whereas neuroimaging studies detect structural abnormalities [17] with their own merits and limitations [14, 18].

In the present study, the results of EDX studies, MRI, and clinical findings in a sample of patients with cervical or lumbosacral radiculopathy were compared. Total agreement between EDX and MRI studies was 59.6 % similar to previous studies (60 %) [19], although the agreement between them in relation to the clinical findings was 49 %. MRI and EDX presented similar agreement with clinical findings in the “definite” group while agreement of MRI with clinical findings was higher in other two groups.

In previous studies of patients with clinically suspected radiculopathy, the sensitivity of electromyography (EMG) was reported to range from 49 to 86 % [19–23] based upon history and physical examination which is similar to the figure of 54 % (95 % confidence interval: 0.44–0.64) in the present study. Data on agreement of EDX and MRI with clinical findings in radiculopathy are conflicting. The variability of results regarding these diagnostic methods in addition to the absence of a gold standard for diagnosis may be related in part to the patient population or method of investigation employed.

In the study done by Nardin et al. [19], 55 % of the participants had an electromyography abnormality consistent with clinical radiculopathy similar to the present study but contrary to it in that they found clinically relevant MRI abnormalities in 57 % of the patients which is lower than that of the present study.

On the other hand, Ashkan et al. [24], in their study of patients with cervical radiculopathy who had undergone preoperative neurophysiologic studies and MRI, found a higher sensitivity for MRI compared to neurophysiologic studies in the diagnosis of cervical radiculopathy (93 vs. 42 %) similar to the present study, although positive predictive values for the two procedures were the same (approximately 90 %). However, a study [25] of patients with lumbosacral intervertebral herniated disc or spinal stenosis, diagnosed by clinical assessment and magnetic resonance imaging, indicated that electrodiagnostic study correlated more significantly with clinical data and had a higher specificity than MRI. In this study, unlike the present study, the correlation was investigated just in terms of physical examination data and not sensory symptoms.

In other studies, agreements between MRI and surgical findings in cervical and lumbar disc diseases were reported 93 and 82.6 %, respectively [8, 24]. There is also a high prevalence of abnormal neuroimaging findings in asymptomatic individuals [11, 26, 27], whereas in the study done by Bertilson et al. MRI-visible nerve involvement was significantly less common than and showed weak agreement with physical examination of nerve involvement in patients with long-standing nerve root symptoms in the

Table 3 Agreement between EDX, MRI, and clinical findings based on clinical syndrome

Clinical syndrome	<i>n</i>	Clinically relevant MRI % (<i>n</i>)	Clinically relevant EDX % (<i>n</i>)	Similar findings on EDX and MRI		Dissimilar findings on EDX and MRI	
				Both clinically relevant % (<i>n</i>)	Both clinically irrelevant % (<i>n</i>)	One clinically relevant % (<i>n</i>)	Both clinically irrelevant % (<i>n</i>)
Definite	28	89.3 (25)	82.1 (23)	82 (23)	7.2 (2)	7.2 (2)	3.5 (1)
Probable	68	64.7 (44)	41.2 (28)	36.7 (25)	13.2 (9)	32.3 (22)	17.6 (12)
Possible	18	72.2 (13)	44.4 (8)	44.4 (8)	5 (1)	27.7 (5)	22.2 (4)
Total	114	71.9 (82)	51.8 (59)	49.1 (56)	10.5 (12)	25.4 (29)	14.9 (17)
χ^2 <i>P</i> value		0.051	0.001	<0.001			

Table 4 Cervical and lumbosacral EDX and MRI findings based on clinical syndrome

	Cervical				Lumbar			
	Definite <i>n</i> = 5	Probable <i>n</i> = 20	Possible <i>n</i> = 6	Total <i>n</i> = 31	Definite <i>n</i> = 23	Probable <i>n</i> = 48	Possible <i>n</i> = 12	Total <i>n</i> = 83
Clinically relevant MRI (%)	100	65	83.3	74.2	87	64.6	66.7	71
Clinically relevant EDX (%)	80	25	33.3	35.5	82.6	47.9	50	57.8

Table 5 Sensitivity and specificity of MRI and EDX to findings of root involvement detected in physical examination

	Sensitivity (95 % CI)	Specificity (95 % CI)
MRI	0.74 (0.64–0.82)	0.39 (0.18–0.64)
EDX	0.54 (0.44–0.64)	0.61 (0.36–0.82)

CI Confidence interval

lumbar spine [28]. In addition, Shafaie et al. [29] reported that the correlation between MRI and surgical findings was frequently unreliable. Recording the standard MRI in supine position, leakage of chemical mediators or inflammatory cytokines through annular tear, functional instability, fluctuating disc bulges, and restrictions caused by discoligament injuries are some of the explanations proposed for this weak agreement [28–33]. Furthermore, duration of symptoms could be a causative factor as Jensen et al. [34] indicated that improvement of disc herniations and nerve root compromise over time did not coincide with definite recovery.

However, some previous studies have shown the value of electrodiagnosis in localizing the involved root level as well as predicting surgical outcome and selecting patients who benefit from surgery [16, 35, 36].

Although in the present study, MRI, contrary to EDX, presented a significant agreement with clinical findings, this higher agreement should be interpreted in the context of other findings. First, this higher agreement was in the “probable” and “possible” groups, not in the “definite” group. Furthermore, MRI had higher abnormalities on clinically irrelevant levels compared to EDX (28.1 vs. 9.7 %). Higher false positive findings indirectly imply lower specificity for MRI. Besides, the specificity of MRI based on physical examination is lower than EDX (39 vs. 61 %). In addition, considering the higher agreement of these two methods in the “definite” group and lower sensitivity of EDX in other two groups, this study further supports that these two methods are complementary in general.

Lack of a gold standard in the diagnosis of radiculopathy is the main limitation in the present study. Furthermore, for

comparing the two methods, classification of patients into three clinical syndromes (possible, probable and definite) based on severity of clinical suspicion is not purely objective. Study design is another shortcoming as in cross-sectional studies, the relationship between the findings and outcomes as well as impact of tests on subsequent care cannot be compared.

Conclusion

Findings of this study show higher sensitivity for MRI while higher specificity for EDX based on physical examination. This study further supports that these two methods are complementary in general. It is reasonable to add EDX when there is a discrepancy between MRI and clinical findings, MRI neurologic findings are not visible or when symptoms are vague and uncertain.

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Conflict of interest The authors declare no conflict of interest.

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