Dermatomal Somatosensory Evoked Potentials In The Diagnosis of Patients With Lumbosacral Radiculopathies

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ÖZET

Lumbosakral radikulopatili hastaların tanısında dermatomal duyusal uyarılmış potansiyeller

Amaç: Lumbosakral radikülopatilerde elektrofizyolojik incelemelerin, radyolojik incelemeler ve klinik muayene bulguları ile ilişkisi ve tanıya katkılarının karşılaştırılması planlanmıştır.

Yöntem: Çalışmaya, bel ve bacak ağrısı yakınması ile başvuran, lumbosakral manyetik rezonans görüntüleme (MRG) incelemelerinde kök basısı saptanarak ameliyat edilmek üzere yatırılan 30 hasta (9 Kadın, 21 Erkek) ve nörolojik muayenesi normal olan 21 (11 Kadın, 10 Erkek) gönüllü denek alındı. Çalışmaya alınanlara iki yanlı tibial ve peroneal sinirlerin motor, yüzeyel peroneal ve sural sinirlerin duyusal ileti incelemeleri, tibial sinir F yanıtı, soleus H refleksi, tibial sinir duyusal uyarılmış potansiyel (DUP) ve L3, L4, L5 ve SI dermatomal DUP (DDUP) yanıtları ve hasta grubuna, bunlara ek olarak iğne EMG incelemesi yapıldı.

Bulgular: Çalışmaya alınan 30 hastanın MRG incelemelerinde disk herniasyonu olup, 17'sinin (%58.8) iğne EMG incelemesinde MRG ile uyumlu radikülopati bulguları saptandı. L5/SI disk herniasyonu olan 12 hastanın 7'sinde (%58.3) soleus H refleksi yanıtları patolojikti. DDUP incelemelerinde 27 hastada (%90) patoloji saptanırken, bu inceleme sadece 7 hastada (%23.3) MRI ile uyumlu bulundu. 10 hastada tibial DUP anormalliği saptanırken, 6 hastada (%20) anormallik MRI ile uyumluydu.

Sonuç: Araştırma sonuçları, lumbosakral radikülopatisi olan hastalarda lezyonu lokalize etmede en sensitif elektrofizyolojik inceleme yönteminin iğne EMG incelemesi olduğunu, SI radikülopatili hastalarda soleus H refleks incelemesinin iğne EMG incelemesine benzer bir sensitivitesi olduğunu, DDUP incelemelerinin sensitivitesi yüksek olmakla birlikte subklinik tutulumu da saptadığından spesifitesinin düşük olduğunu göstermiştir.

Anahtar kelimeler: Lumbosakral disk herniasyonu, radikülopati, iğne EMG, soleus H refleksi, dermatomal duyusal uyarılmış potansiyeller

ABSTRACT

Dermatomal somatosensory evoked potentials in the diagnosis of patients with lumbosacral radiculopathies

Objective: To assess the association between electrophysiological studies and magnetic resonance imaging (MRI), clinical findings and its contribution to the diagnosis of lumbosacral radiculopathies.

Method: 30 patients (9 F, 21 M) with back and leg pain and with root compression detected only at one level on MRI were admitted to the study. All patients were under the care of neurosurgery clinic in our hospital. 21 (11 F, 10 M) healthy volunters were admitted to the study as the control group. Bilaterally tibial and peroneal nerve motor, superficial peroneal and sural nerve sensory conduction studies, tibial F response, soleus H reflex, tibial nerve somatosensory evoked potentials (SEP) and L3, L4, L5 and SI dermatomal SEP (DSEP) responses were evaluated in all participants. Additionally, needle electromyography (EMG) examinations were performed in the patient group.

Results: All of the 30 patients had lumbosacral disc herniation on MRI, 17 (58,8%) of them had radiculopathy by needle EMG consistent with MRI findings. 7 (58,3%) of 12 patients who had L5/SI disc herniation, had abnormal soleus H reflex responses. Although DSEP responses of 27 (90%) patients showed an abnormality, only 7 (23,3%) patients' findings were consistent with MRI. Ten patients had tibial SEP abnormalities, however 6 (20%) of these patients' findings were in concordance with MRI.

Conclusions: We suggest that needle EMG is the most sensitive electrophysiological examination to localize the radiculopathy in patients with lumbosacral disc herniation. The sensitivity of soleus H reflex is similar to the needle EMG findings, especially in patients with SI radiculopathy. Although the sensitivity of DSEP examinations was found to be high, spesifity was found to be low due to the detected subclinical involvement.

Key words: Lumbosacral disc herniation, radiculopathy, needle EMG, soleus H reflex, dermatomal sensory evoked potentials

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INTRODUCTION

Radiculopathies most frequently occur due to secondary root compression in the ligament hypertrophy with disk herniation, protrusion, and/or disk degeneration in the cervical and lumbosacral regions – although metabolic conditions such as diabetic radiculopathy may also cause thoracic radiculopathies in particular (1-4). With the development of magnetic resonance imaging (MRI), electrophysiological examinations have lost their significance in radiculopathy diagnosis. They may, however, help in the definitive diagnosis particularly when the patient's clinical and MRI findings are incompatible, there are root compressions at more than one level, the patient's history and clinical findings suggest radiculopathy but the MRI examination is normal, or the patient's history and clinical findings do not allow a distinction among plexopathy, mononeuritis, and radiculopathy (2-5). Although different electrophysiological examinations such as needle electromyography (EMG), late responses, and evoked potentials are complementary methods in the evaluation of radiculopathies, the results obtained are inconsistent since only one of these methods is usually evaluated in the studies carried out (5). In the diagnosis of radiculopathies, the use of somatosensory evoked potential (SEP) responses obtained by the evocation of mixed nerves may not be useful in the evaluation of the physiologic status of a single root, since mixed nerves enter the spinal cord from more than one level (5,6). It has been suggested that dermatomal somatosensory evoked potential (DSEP) responses recorded from the somatosensory cortex with the evocation of a dermatome are more sensitive in the localization of radiculopathy in a single root (6).

This paper assessed the association between electrophysiological examinations, magnetic resonance imaging (MRI), and clinical findings, as well as the contribution of electrophysiological examinations to the diagnosis of lumbosacral radiculopathies.

METHOD

Thirty patients (9 female, 21 male) with back and leg pain and with root compression detected only at one level on the MRI were enrolled in the study. All patients were receiving care at the neurosurgery clinic in our hospital. Twenty-one (11 female, 10 male) healthy volunteers were admitted into the study as the control group.

Individuals who were older than the age of 65, had metabolic disease such as diabetics, uremia, etc., and who had had previous disk-related operation were excluded from the study. All participants underwent a neurologic examination and patients in whom unilateral discopathy in a single distance was localized in clinical and MRI examinations were admitted into the patient group, while patients with clinical findings and complaints of root compression were not admitted into the control group.

Electrophysiological examinations: All electrophysiological examinations were performed with patients lying in supine position in a quiet environment, using the Medelec Sapphire 4ME device. Bilaterally tibial and peroneal nerve motor in the lower extremities, superficial peroneal and sural nerve sensory conduction examinations, tibial F response, soleus H reflex, tibial nerve somatosensory evoked potentials (SEP) and L3, L4, L5, and S1 dermatomal SEP (DSEP) responses were evaluated in both groups. Additionally, needle electromyography (EMG) examinations were performed in the patient group.

Motor conduction examinations: Motor conduction examinations were performed at 5 millivolt (mV) sensitivity, 50 millisecond (ms) seep rate, and 3 hertz (Hz) - 5 kilohertz (kHz) filtration range. The tibial nerve was evoked from the wrist and the popliteal region and recordings were made from the abductor hallucis (AH) muscle, while the peroneal nerve was evoked from the wrist, the head of fibula (caput fibulae), and the popliteal region, and recordings were made from the extensor digitorum brevis muscle, assessing the motor conduction examinations via standard methods (7-9). The initial latencies, compound muscle action potential (CMAP) amplitudes, and motor conduction speeds of the results were evaluated.

Sensory conduction examinations were performed at 20 microvolt (μV) sensitivity, 10ms sweep speed, and 20Hz-2kHz filtration range. Sural and superficial peroneal nerves were evoked from the leg and the recordings were made from the external malleolus and 1/3 outer side of the wrist, respectively, to be evaluated

antidromically via standard methods (7-9). The initial and peak latencies, somatosensory action potential (SEP) amplitudes, and sensory conduction speeds of the results were evaluated.

Soleus H reflex examinations were performed at 500μV sensitivity, 50ms sweep speed, and 20Hz-5kHz filtration range. The recording electrode was placed in the middle of the popliteal-calcaneal distance and popliteal evocation intensity was gradually increased. The latency of the result was compared to the normal value calculated according to the patient's age and length of leg, then compared to the other side and to the control group. Failure to obtain an H reflex response or the existence of a difference of more than 2ms between two sides was evaluated to be pathological (10-12).

Tibial nerve F response examinations were performed at 200μV sensitivity, 50ms sweep speed, and 500Hz-5kHz filtration range. The tibial nerve was evoked 10 times from the wrist with supramaximal intensity and the recordings were made from the AH muscle to evaluate the minimum latency of the results. Failure to obtain a response, the existence of a difference of more than 2ms from the minimum F latency calculated according to the patient's age and length of leg, or a decreased persistence were evaluated to be pathological (11,13,14).

Needle EMG examinations were performed in 3Hz-10kHz filtration range and at 100ms sweep speed. Evaluations were made on the existence of denervation potentials at 50μV sensitivity at rest, the characteristics of motor unit potentials at 100-200μV sensitivity at slight contraction, and interference characteristics at 200-500μV sensitivity at full contraction. The iliopsoas, vastus medialis, and vastus lateralis muscles were examined for L3 radiculopathy; tibialis anterior, vastus lateralis, and rectus femoris muscles for L4 radiculopathy; tibialis anterior, peroneus longus and extensor hallucis longus, and gluteus medius muscles for L5 radiculopathy; and gluteus maximus and gastrocnemius muscles for S1 radiculopathy. Additionally, needle EMG was performed on the paraspinal muscles of all the patients (3,15).

For the tibial SEP examination, right and left tibial nerves were respectively evoked from lateral malleolus, with an intensity to create a slight twitch in the fingers, and recordings were made with silver/silver chloride (Ag/AgCl) disk electrodes from the popliteal and lumbar regions as well as from Cz (referred to Fz) according to the international 10-20 system (cortical region). Examinations were performed at 50μV sensitivity, 10 Hz-2kHz filtration range, and 50ms sweep speed for the popliteal and lumbar regions, 100ms for the cortical region. The average of 512 responses was taken twice. The N7 latency of the response recorded from the popliteal region, N30 latencies of the response recorded from lumbar region, and P37, N45, P60, P95 latencies and P37/N45 and N45/P60 amplitudes of the response recorded from cortical region were statistically evaluated (16,17).

For dermatomal SEP examinations, evoking electrodes were placed on the inner side of the femur, four cm above the knee for the L3 dermatome; in the medial leg, in the region where the saphenal nerve ranges superficially for the L4 dermatome; in the foot, between the first and second toes for the L5 dermatome; and lateral malleolus for the S1 dermatome. Evocation intensity was set at a level where the individual would easily perceive the evocation, but would not sense pain or would not twitch. Cortical responses obtained from Cz, referred to Fz according to the international 10-20 system, were recorded at 5μV sensitivity, 100ms sweep speed, and 10Hz-2 kHz filtration range. The average of 256 cortical responses was taken twice for each dermatome. N1, P1, N2, and P2 latencies and N1/P1, P1/N2, and N2/P2 amplitudes of the results were statistically evaluated. In tibial and dermatomal SEP examinations, a latency difference above 5ms between two sides and/or an amplitude decrease above 50% was evaluated as pathological (5,16).

Statistical Analysis

The statistical data were analyzed using the SPSS program. The patients' parametric data were evaluated through the Student t-test, while the symptomatic and asymptomatic sides of patients and right and left sides of the control group was compared using the "paired samples" t-test.

RESULTS

There was no significant difference (p=0.48)

Table 1: Clinical, radiological, and electrophysiological characteristics of patients with lumbosacral disk hernia

	Yaş	Cins	MRG	M.Kayıp	D.Kayıp	EMG	F yanıtı	DDUP	H ref.	Ref. Değ.
1	25	M	PL,L5/S1, R	No	No	Nl	Nl	Nl	Nl	No
2	42	M	PL,L4/L5,L	Yes	Yes	L5,T	Nl	Lat↑,S1	Nl	No
3	56	M	P,L4/L5,R	Yes	Yes	L5,T	Nl	Lat↑,L5(R), Amp↓L4,L5(L)	Nl	No
4	32	M	PL,L5/S1,R	No	Yes	Nl	Nl	Lat↑,L5(L), Amp↓L4,L5(R)	Nl	Yes
5	65	F	PL,L4/L5,R	Yes	Yes	Nl	Nl	Lat↑ Amp↓L5	Nl	No
6	43	F	PL,L5/S1,L	No	No	Nl	Nl	Lat↑,S1(L), Amp↓L5,S1(R)	Lat↑	Yes
7	34	F	PL,L5/S1,R	No	No	S1,D,T	Nl	Lat↑,L5,S1(R) Amp↓S1(L)	Lat↑	Yes
8	50	M	PL,L4/L5,R	Yes	Yes	L5,T	Nl	Amp↓S1(L)	Nl	No
9	62	M	PL,L5/S1,R	No	No	S1,T	Nl	Lat↑,S1(R), Amp↓L5,S1(R)	(-)	Yes
10	38	F	PL,L5/S1,L	Yes	Yes	S1,T,D	Lat↑	Nl	Lat↑	Yes
11	38	M	PL,L4/L5,L	No	No	Nl	Nl	Lat↑,L5	Nl	No
12	56	M	PL,L2/L3,L	No	No	Nl	Nl	Lat↑,L4,L5,S1(L), Amp↓L5(L)	Nl	No
13	46	M	PL,L4/L5,L	Yes	No	L5,T	Nl	Lat↑,L5(L), Amp↓L4(L)	Nl	No
14	33	M	PL,L4/L5,R	Yes	No	Nl	Nl	Amp↓L4,L5(L)	Nl	No
15	40	M	PL,L4/L5,R	No	No	Nl	Nl	Amp↓L4,L5(L)	Nl	No
16	32	M	PL, L5/S1,R	No	No	Nl	Nl	Lat↑,S1, Amp↓L5 (L)	Nl	Yes
17	35	F	PL,L5/S1,L	Yes	No	Nl	Nl	Amp↓S1(L)	Nl	No
18	38	F	PL, L5/S1,R	No	Yes	S1,T,D	Nl	Amp↓S1(L)	Lat↑	Yes
19	62	M	PL,L3/L4,R	No	Yes	L4,T	Lat↑	Lat↑Amp↓L5(L)	Nl	No
20	35	M	PL,L5/S1,L	Yes	Yes	S1,T	Nl	Amp↓L4,L5(L)	Lat↑	No
21	50	F	PL,L4/L5,R	Yes	Yes	L5,T,D	Nl	Amp↓L5,S1(L)	Nl	No
22	30	M	PL,L4/L5,L	No	Yes	L5,T,D	Nl	Amp↓L3,L4(L)L5(R)	Nl	No
23	52	M	PL,L4/L5,R	Yes	Yes	L5,T,D	Nl	Lat↑Amp↓L5(R) Amp↓L4,L5(L)	Nl	No
24	21	F	Medial,S1	No	Yes	Nl	Nl	Nl	Nl	Yes
25	36	F	PL,L5/S1,L	No	No	Nl	Nl	Amp↓L4,S1(L)	Nl	No
26	41	M	PL,L5/S1,R	Yes	No	L5,T,D	Nl	Lat↑Amp↓L4,S1(L)	Nl	No
27	32	M	PL,L4/L5,R	Yes	Yes	L5,T,D	Nl	Amp↓L5,S1(R) Amp↓L3,S1(L)	Nl	No
28	28	M	PL,L3/L4,R	No	Yes	Nl	Nl	Amp↓L3, S1(L)	Nl	No
29	32	M	PL,L4/L5,R	No	No	L5,T	Nl	Lat↑Amp↓L5(R)	(-)	No
30	61	M	PL,L5/S1,R	Yes	Yes	S1,T,D	Nl	Amp↓S1(R)	Nl	No

DSEP: Dermatomal somatosensory evoked potential, S. Loss: Sensory loss, M. Loss: Motor loss, R: Right, L: Left, PL: Posterolateral, D: Denervation, T: Twitch, Amp: Amplitude, Lat: Latency, H ref: H reflex, Ref ch.: Reflex change, Nl: Normal, M: Male, F: Female.

between the average ages of the patient (41.5±11.9) and control groups (36.7±10.2).

Table 1 shows the clinical, MRI, and electrophysiological characteristics of the LRP patients. There were LRS complaints on the right side of 19 patients (63%) and on the left side of 11 patients (36.6%). Muscle weakness was detected in 14 patients (47%) and sensation disorder in 19 patients (63%). In MRI examinations, one patient (3%) was revealed to have L2-L3, two patients (6%) L3-L4, 15 patients (50%) L4-L5, and 12 patients (40%) L5-S1 disk herniation.

In the control group, in the right- and left-side motor and somatosensory conduction examinations, there was no significant difference between F response H reflex latencies, and between latencies and amplitudes of tibial and dermatomal SEP responses (Table 2,3,4). Figure 1 shows the L5 DSEP responses of a patient from the control group.

In the motor conduction examinations of patients with lumbosacral disk radiculopathy, the amplitudes of the tibial nerve's compound muscle action potential on the symptomatic side were significantly lower than on the asymptomatic side (p=0.02). In examinations of motor distal latencies, motor conduct speeds and

Table 2: Results of motor and sensory conduction examinations, F response and soleus H reflex in patients with lumbosacral radiculopathy (LSR) and control group

	LSR Patients			Control Group		
	Affected side	Healthy side	p	Right	Left	p
Tibial						
Dis. latency	4.62±0.63	4.66±0.62	0.63	4.20±0.52	4.40±0.44	0.18
CMAP	8.55±2.47	9.30±2.03	0.02	8.70±2.45	8.95±3.25	0.51
MCS	46.5±2.59	45.3±2.93	0.71	46.3±3.65	46.9±3.85	0.28
Peroneal						
Dis. latency	4.39±0.92	4.20±0.63	0.11	3.93±0.69	4.08±0.46	0.13
CMAP	4.44±2.35	4.80±2.35	0.23	5.19±1.84	4.85±0.87	0.36
MCS	46.2±4.04	46.1±3.15	0.52	48.4±5.38	48.4±4.22	1.00
Sural						
SEP amp.	17.4±6.76	18.1±5.84	0.44	17.2±2.97	18.1±3.49	0.07
Peak lat.	3.68±0.50	3.67±0.37	0.79	3.65±0.32	3.75±0.41	0.30
SCS	47.4±5.05	48.5±5.05	0.21	48.0±5.75	48.9±4.35	0.43
Sup. peron.						
SEP amp.	15.8±4.77	15.7±3.53	0.73	15.9±4.62	17.1±3.39	0.65
Peak lat.	3.37±0.44	3.35±0.46	0.89	3.38±0.33	3.22±0.35	0.07
SCS	47.7±6.98	48.2±6.71	0.50	47.6±4.15	48.1±4.15	0.72
Tibial						
F latency	48.9±3.75	48.8±3.64	0.16	46.9±2.62	46.6±2.19	0.27
Soleus						
H reflex	28.1±0.79	29.4±2.30	0.36	28.2±2.69	28.2±2.65	0.92

Dis. latency: Distal latency; CMAP: Compound muscle action potential amplitude; MCS: Motor conduction speed; SEP amp: Somatosensory action potential amplitude; Peak lat: Peak latency; SCS: Sensory conduction speed

Table 3: Latencies and amplitudes of bilaterally tibial SEP responses in patients with lumbosacral radiculopathy (LSR) and control group

	LSR Patients			Control Group		
	Affected Side	Health Side	p	Right	Left	p
N7 latency	7.96±0.82	7.92±0.76	0.80	8.04±0.52	8.20±0.72	0.19
N20 latency	21.20±1.71	21.16±1.47	0.92	21.94±2.28	21.81±1.28	0.77
P37 latency	40.18±3.14	39.94±3.64	0.49	38.55±1.57	38.88±1.86	0.28
N45 latency	48.70±3.51	48.17±3.58	0.40	47.36±2.02	47.69±2.33	0.34
P60 latency	60.53±4.61	60.59±4.91	0.88	58.86±3.98	58.30±2.70	0.42
P95 latency	91.75±4.50	92.51±4.01	0.09	91.16±3.25	90.64±3.71	0.48
P37/N45 amp.	2.18±1.80	2.56±2.44	0.09	2.00±1.68	2.00±1.28	0.99
N45/P60 amp.	2.10±1.86	2.43±2.44	0.08	1.61±1.31	1.79±1.06	0.20

Amp.: Amplitude

somatosensory conduct speeds, however, there was no significant difference between the amplitudes, latencies, and conduction speeds of symptomatic and asymptomatic sides (Table 2).

In the needle EMG examination, no pathologic findings were detected in 13 patients (43%). One patient (3%) was detected to have L4, 11 patients (37%) L5, and five patients (17%) S1 root compression; the MRI results of these patients showed L3-L4; L4-L5, and L5-S1 disk herniation, respectively (Table 1).

There was no significant difference (p=0.16) between the latencies of the tibial nerve F responses in the patients' symptomatic and asymptomatic sides. The tibial nerve F response was longer than normal in two patients, while the needle EMG and MRI showed L4 radiculopathy and L3-L4 disk herniation in one patient, S1 radiculopathy and L5-S1 disk herniation in another (Table 1,2).

Similarly, there was not a significant difference (p=0.36) between the soleus H reflex latencies in the patients' symptomatic and asymptomatic sides (Table 2). Among 12 patients with S1 root compression, seven (58%) had a pathological condition such as lack of soleus H reflex or latency extension on the symptomatic side, while patients with root compression at other levels had no pathological conditions in their H reflex responses (Table 1).

The tibial SEP examination of patients with

Table 4: Latencies and amplitudes of bilaterally dermatomal SEP responses in patients with lumbosacral radiculopathy (LSR) and control group

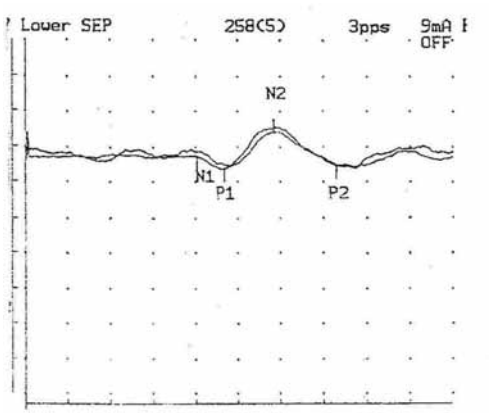
	LSR Patients			Control Group		
	Affected Side	Healthy Side	p	Right	Left	p
L3						
N1 latency	29.06±2.29	29.24±2.93	0.62	28.32±3.22	29.08±3.21	0.14
P1 latency	36.43±2.61	36.77±2.28	0.40	35.45±3.61	35.65±3.28	0.68
N2 latency	45.09±2.38	44.22±3.20	0.33	44.00±3.63	44.22±3.20	0.59
P2 latency	56.17±3.03	56.14±2.86	0.96	54.24±4.50	54.36±4.40	0.78
N1/P1 amp.	0.59±0.33	0.48±0.33	0.16	0.45±0.37	0.48±0.27	0.68
P1/N2 amp.	0.99±0.52	0.88±0.58	0.22	0.62±0.33	0.65±0.35	0.78
N2/P2 amp.	1.29±0.71	1.09±0.64	0.03	0.86±0.76	0.73±0.40	0.38
L4						
N1 latency	32.43±2.87	32.47±3.83	0.77	31.52±4.78	32.40±4.22	0.09
P1 latency	41.14±3.24	41.11±3.61	0.95	39.95±4.64	40.67±3.52	0.07
N2 latency	50.51±3.30	50.15±3.12	0.22	49.03±3.71	49.37±3.19	0.41
P2 latency	62.84±3.44	62.02±3.73	0.04	60.55±3.90	59.97±3.97	0.22
N1/P1 amp.	0.73±0.56	0.83±0.72	0.44	0.45±0.35	0.44±0.25	0.95
P1/N2 amp.	1.36±1.08	1.42±1.12	0.54	0.78±0.63	0.73±0.34	0.75
N2/P2 amp.	1.54±1.06	1.73±1.30	0.25	0.89±0.73	0.78±0.37	0.55
L5						
N1 latency	39.88±4.34	38.39±3.79	0.01	36.69±4.98	36.55±5.21	0.79
P1 latency	49.94±5.93	48.66±3.99	015	46.70±4.54	45.88±3.75	0.08
N2 latency	60.97±5.39	59.78±3.83	0.26	57.67±5.00	56.47±3.76	0.06
P2 latency	74.20±5.58	72.67±5.19	0.08	69.10±4.95	68.73±1.09	0.41
N1/P1 amp.	0.91±0.43	0.97±0.65	0.56	0.91±0.52	0.96±0.76	0.70
P1/N2 amp.	1.89±1.09	1.94±1.24	0.85	1.56±0.75	1.75±1.34	0.42
N2/P2 amp.	1.83±1.24	1.96±1.24	0.63	1.22±0.46	1.31±0.74	0.59
S1						
N1 latency	37.90±3.13	37.45±2.53	0.33	37.28±3.29	37.10±4.04	0.72
P1 latency	46.44±3.20	45.48±3.03	0.07	44.80±3.37	45.22±4.22	0.51
N2 latency	56.44±3.03	55.80±2.93	0.29	54.90±4.53	55.65±5.28	0.17
P2 latency	69.49±3.18	69.15±3.89	0.68	66.80±5.38	67.37±6.04	0.32
N1/P1 amp.	1.04±0.71	1.27±0.97	0.11	0.70±0.53	0.75±0.57	0.73
P1/N2 amp.	2.06±1.41	1.98±1.77	0.79	1.15±0.82	1.11±0.85	0.78
N2/P2 amp.	2.12±1.45	2.00±1.81	0.55	0.98±0.64	1.01±0.62	0.62

Amp.: Amplitude

lumbosacral disk hernia did not show a significant difference between the response latencies and amplitudes on the symptomatic and asymptomatic sides (Table 3). When the symptomatic and asymptomatic sides are compared for each patient, SEP examinations showed that eight out of 30 patients had an amplitude difference over 50% between two sides, and two patients had a latency difference over 5 ms. Five out of 12 patients with S1 radiculopathy, four out of 15 patients with L5 radiculopathy, and one out of two patients with L4 radiculopathy had tibial SEP abnormality. Among 10 patients with tibial SEP abnormality, this abnormality was on the symptomatic side in six patients and on the asymptomatic side in four patients.

In the DSEP examinations of 30 patients with lumbosacral disk hernia, the P2 latency of L4 DSEP response (p=0.04) and N1 latency of L5 DSEP response (p=0.03) were seen to be longer on the symptomatic than the asymptomatic side, while N2/P2 amplitude of L3 DSEP response (p=0.03) was significantly lower than on the asymptomatic side. There was no significant difference between the latencies and/or amplitudes of S1 DSEP responses (Table 4).

When the symptomatic and asymptomatic sides of all 30 patients were compared one by one, 27 patients (90%) were seen to have a significant difference in the latencies and/or amplitudes of their DSEP responses, while the abnormality was on the symptomatic side in 13 patients and on both the symptomatic and asymptomatic sides in seven patients. In just seven patients, the DSEP abnormality was compatible with MRI and clinical findings. With needle EMG, 17 patients (57%) was detected to have radiculopathy.



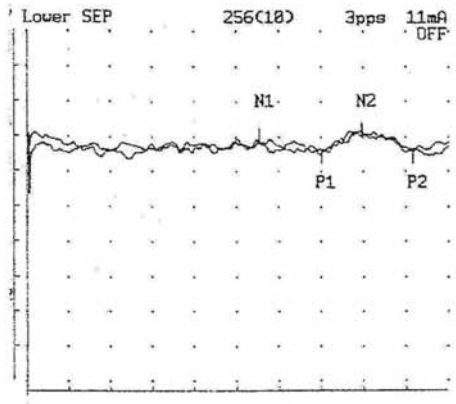
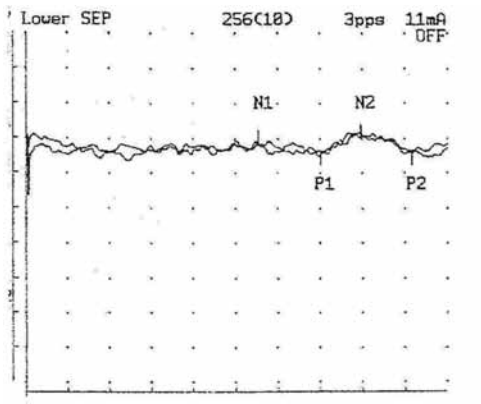


Figure 1a-b: Right (a) and Left (b) L5 DSEP responses of a person from the control group



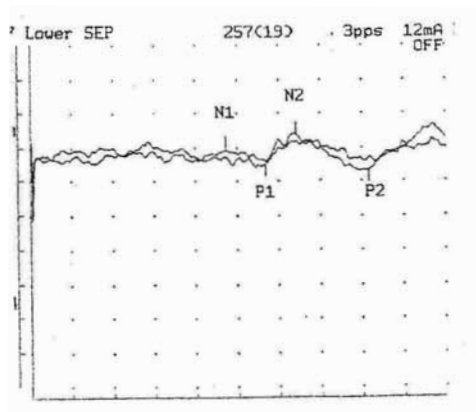


Figure 2a-b: Right (a) and left (b) DSEP responses of a patient with right L5 radiculopathy (latency extension in the right)

Fifteen patients were revealed to have pathology in both EMG and DSEP examinations. Fifteen of the DSEP latency and/or amplitude abnormalities were in L5, 9 in S1, 2 in L4, 1 in L3 dermatomes (Table 1).

The tibial SEP examinations of 15 patients with L5 radiculopathy showed no significant difference. The N1 and P2 latencies of L5 DSEP responses were significantly longer on the symptomatic than on the asymptomatic side (p=0.01 and p=0.05, respectively). When the symptomatic and asymptomatic sides of these patients were compared one by one, all (100%) were revealed to have pathology in their DSEP latencies and/or amplitudes, while only in four patients DSEP abnormality was found to be compatible with MRI lesion. Figure 2 shows the responses of a patient with right L5 radiculopathy who was found to have right DSEP latency extension compatible with MRI lesion.

In the tibial SEP examination of 12 patients with S1 radiculopathy, cortical N45 latency was longer on the symptomatic than the asymptomatic side (p=0.01). No significant difference was found between the DSEP latencies and amplitudes in symptomatic and asymptomatic sides. When the symptomatic and asymptomatic sides of patients were compared one by one, out of 12 patients, nine (75%) had pathology in their DSEP latencies and/or amplitudes; in three of these nine patients, the DSEP abnormality lesion could be correctly localized.

DISCUSSION

For patients with radiculopathy complaints, in addition to neurologic examination and MRI (a noninvasive examination method), electrophysiological examinations help in the localization of the lesion and these are all therefore complementary examination methods.

Since the lesion is more proximal than the location

where the peripheral nerve is evoked in radiculopathy, the results of the motor and sensory conduction examinations are generally normal (3,4). Such a result can likely be attributed to the fact that the lesion is limited to a small segment of the affected root. Since disk herniation or spondylosis affects the preganglionic sensory root fibers, which are more proximal to the posterior root ganglion but do not affect the postganglionic peripheral sensory fibers, sensory conduction examinations yield normal results. If there is loss of action or degeneration in more than one root, however, CMAP amplitudes may decrease (3,4). This paper showed that patients' tibial nerve CMAP amplitudes were lower on the symptomatic side than on the asymptomatic side (p=0.02).

Before the development of magnetic resonance imaging techniques, it was claimed that EMG was the most sensitive examination method for the localization of root lesion and showed 70-90% correlation with myelography results. The sensitivity of EMG in the exact localization of root compression varied from 45% to 78% in different studies (5). Tullberg et al. (5) found the correlation of EMG with CT (computerized tomography) correlation to be 20% in patients with lumbosacral radiculopathy, while Walk et al. (18) demonstrated the correlation of the myelography, CT or MRI results with EMG to be 47%. Aminoff et al. (19) detected, using EMG examination, denervation findings showing myotomal distribution in 21 (75%) out of 28 patients with L5 or S1 radiculopathy, although electrophysiological and other examinations yielded normal results; consequently, Aminoff et al. claimed that EMG examination was the most useful electrophysiological method. They did not discuss, however, the relation between the EMG and radiological monitoring. Similarly, Eisen (20) reported that EMG examination was the most sensitive electrophysiological method, but did not discuss the correlation of EMG with radiological monitoring methods such as myelography and/or contrast-enhanced computerizes tomography (CT). Our study revealed that with EMG, the radiculopathy findings in the relevant muscles of 17 (56.6%) out of 30 patients were shown to have root compression in the MRI. That our study's results are higher than those of other studies could be due to the higher sensitivity of the MRI method in localizing the root lesion compared to other imaging techniques.

The F response evaluates motor functions and gives information on the conduction characteristics of the more proximal parts such as motor neurons and motor roots (1-5,21). The study by Tullberg and al. (5) showed the peroneal and tibial nerve F response latencies to be longer in seven (35%) out of 20 patients, in three (15%) of which this was compatible with their radiculopathy. Aminoff et al. (19) detected pathology in F responses of five (18%) out of 28 patients. This paper revealed the F response latencies to be long in 6% of the patients with radiculopathy. Our results may be lower than those reported in the literature because we studied only tibial nerve F responses, which were not limited to a single root, and because we included in our study only those patients with a lesion limited to a single root.

The H reflex is a reflexive response that evaluates both motor and sensory roots and can be easily obtained (1-4,21). Although obtainable from a great number of muscles, the H reflex is most easily obtained from the soleus and flexor carpi radialis (FCR) muscles. In practice, the soleus H reflex and FCR H reflex may be used as a supplementary electrophysiological method in the diagnosis of S1 and C6/C7 radiculopathies, respectively (1-4,21). Aminoff et al. (19) detected some pathology such as the lack of H response or long latency in nine (41%) out of 22 patients with S1 radiculopathy, while our study detected pathology in eight (58%) out of 12 patients with S1 radiculopathy.

When only sensory neurons are affected, EMG monitoring results and F responses may be normal. In this case, in order to investigate the existence of radiculopathy, SEP evaluations may be added to electrophysiological examinations to obtain information on sensory paths in a more proximal region (3-5, 21). ESP evaluations performed with peroneal and tibial nerve evocation fall short in the precise localization of the lesion, since these nerves enter the spinal cord with more than one root. Consequently, DSEP responses obtained with the evocation of a single dermatome are claimed to be more specific and sensitive in localizing the lesion (3-6, 21). Katifi and Sedgwick's (21) study reported pathology in tibial SEP responses of seven (33%) of 21 patients found through radiological and

surgical methods to have lumbosacral radiculopathy. On the other hand, Walk et al. (18) detected abnormality in myelography and CT of 38 out of 59 patients with lumbosacral radiculopathy. They also showed that 32 of these patients (84%), as well as 20 (87%) out of 23 patients with focal motor deficit or reflex change, had abnormality in their SEP examinations, and reported that the SEP examination is a useful method in patients with normal needle EMG results in particular. In the study performed by Aminoff et al. (19) on patients with L5 and S1 radiculopathy, no pathology was found in SEP examinations performed via peroneal nerve evocation. Our study detected tibial SEP abnormality in 10 (33%) out of 30 patients. Eight of them had an amplitude decrease over 50% and two had a latency extension over 5 ms compared to the other side. Among 12 patients with S1 radiculopathy, five were detected to have tibial SEP abnormality, which was on the symptomatic side in two patients and on the asymptomatic side in three. In one of two patients with tibial SEP abnormality on the symptomatic side, EMG also detected root compression. In two out of three patients with SEP abnormality on the asymptomatic side, EMG detected S1 radiculopathy findings on the symptomatic side. Four out of 15 patients with L5 radiculopathy were detected to have SEP abnormality, which was on the symptomatic side in three of them. But none of the patients with the tibial SEP abnormality on the symptomatic side had radiculopathy findings in EMG. One out of three patients with L4 radiculopathy had SEP abnormality on the symptomatic side and L4 root compression findings were also detected in EMG. Consequently, in patients with lumbosacral radiculopathy, the specificity of the tibial SEP abnormality to lesion was low and there was tibial SEP abnormality on the asymptomatic side. Similarly, Katifi and Sedgwick (21) detected tibial and peroneal SEP abnormalities on the asymptomatic side, and the researchers considered these results to be associated with spinal roots affected bilaterally by central disk protrusion or subclinical effect by the spinal narrow vein. Our study supports this view.

Many studies acknowledge that the evaluation of somatosensory evoked potential was not specific to a single root, while some argue that the segmental sensitivity of DSEP obtained via the evocation of a cutaneous region in a single dermatome is higher in the localization of root lesions (5,6,19,21,22). Aminoff et al. (19,22) performed two separate studies and found that DSEP abnormality localized correctly the root lesion in seven (25%) out of 28 cases (25%) in the first study and in six (32%) out of 19 cases in the second. Katifi and Sedgwick (21) found that DSEP responses were abnormal in 19 out of 20 patients surgically proven to have lumbosacral root compression and claimed that DSEP evaluation had as high a sensitivity as the myelography in localizing the root compression and was a non-invasive and repeatable method, compared to myelography. These two studies detected abnormality on the asymptomatic side in three patients and bilateral abnormality in six patients in the DSEP evaluation. Researchers considered these results to be associated with subclinical root compression related to spinal stenosis (19,21,22). Later, Tullberg et al. (5) detected DSEP abnormality in eight (40%) out of 20 patients with lumbosacral disk herniation, and showed that this DSEP abnormality was compatible with CT only in three of them (15%). Moreover, they found that DSEP abnormality did not change in three patients who recovered from surgery or whose condition even worsened. Dumitru et Dreyfuss (23) performed segmental SEP or DSEP examinations in patients with unilateral and single-level L5 or S1 radiculopathy and compared the symptomatic and asymptomatic sides to find that the extension of P1 latency was 40% for patients with L5 radiculopathy, while the sensitivity in those with S1 radiculopathy was 10%. Consequently, they considered the usefulness the segmental SEP or DSEP examinations to be limited in patients with L5 or S1 radiculopathy in single level. In our study, DSEP examinations showed abnormality in 27 (90%) out of 30 patients while in seven patients (23.3%), the DSEP abnormality was found to be compatible with MRI. The DSEP abnormality in our study was high – similar to the results of Katifi and Sedgwick (21) – while its sensitivity in localizing the lesion was similar to the results of Aminoff et al. (19,22). Although our findings suggest the DSEP examinations are a sensitive method in localizing a subclinical radiculopathy, the results must be carefully evaluated, given that its specificity to the lesion is low and its contribution to the clinical diagnosis is limited.

CONCLUSION

Our results suggest that needle EMG is the most sensitive electrophysiological examination to localize the lesion in patients with lumbosacral radiculopathy. The sensitivity of the soleus H reflex is similar to the needle EMG findings, especially in patients with S1 radiculopathy. Although the sensitivity of DSEP examinations was high, specificity was low due to the subclinical involvement detected. Since clinical and radiological results are not consistent with each other, it should also be remembered that electrophysiological examinations such as EMG examination, F response, H reflex, tibial SEP, and DSEP examinations are complementary methods and may help in localizing the lesion.

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