

## The Usefulness of H-reflex Parameters in Patients with Mild S1 Radiculopathy

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### Abstract

**Background:** Needle EMG may be negative in mild or predominantly sensory lumbosacral radiculopathies. In such cases, an increase in the latency of the soleus H-reflex is a useful diagnostic criterion for establishing sensory fiber compromise at the S1 root level. However, if clinical signs of radicular involvement are lacking, we therefore studied the H-reflex latency and amplitude in patients with radiculopathy in order to determine if there is any evidence to support the assumption that the H-reflex parameters changes are the earlier sign and more sensitive criterion for detecting mild S1 root dysfunction than traditional NCS and EMG, **Patients and Methods:** Clinical and electrophysiological findings from 38 patients with back pain and radiculopathy were compared with data obtained from 40 healthy subjects. All participant underwent bilateral EMG and late response (F-wave and H-reflex) testing Descriptive statistics, including means and standard deviations for age, H-reflex amplitudes, H-reflex latencies, side-to-side H/H and side-to-side latency differences of all participants were calculated using SPSS.

**Results:** patients showed significant H-reflex amplitude asymmetry compared to healthy controls ( $p \leq 0.5$ ). The H/H ratios were 0.5 in patients group and 0.8 in the healthy controls which were significantly different. Soleus H-reflex latencies, soleus side-to-side latency differences of all participants was significantly longer in patients ( $p \leq 0.5$ ). in this study only 52.6% of the patients had EMG changes. 42.1% had prolonged F-wave latencies while 83.2% had abnormal H reflex parameters.

**Conclusion:** The study of soleus H-reflex parameters may be usefully associated to the F-wave and needle EMG study to detect possible S1 root dysfunction in mild lumbosacral radiculopathies. The H-reflex parameters changes may be the earliest abnormality in absence of focal neurological signs.

**Keywords:** NCS, EMG, S1

### الخلاصة

**الخلفية :** غالباً ما يكون تخطيط العضلة الكهربائي سالباً في الحالات البسيطة لانضغاطات جذور الاعصاب الحسية للفقرات القطنية و العجزية . زيادة فترة الكمون لمنعكس الوتر المأبضي للعضلة الاخمصية للحالات المستتبطة في هذه الدراسة لها فائدة في تشخيص مثل هكذا حالات خاصة لانضغاط الجذر الحسي للفقرة العجزية الاولى.

في حالات عدم توفر العلامات السريرية لدى المرضى المصابين بانضغاطات جذور الاعصاب نخري فحص فترة الكمون و سعة الموجة لمنعكس الوتر المأبضي للعضلة الاخمصية لتحديد العلامات المبكرة لهذه الانضغاطات و لكونه الفحص الاكثر دقة لتشخيص النوع البسيط منها في الوقت الذي تعجز فيه الفحوصات التقليدية لتخطيط الاعصاب و العضلات الكهربائي.

**طرق العمل:** شملت هذه الدراسة مجموعتين المجموعة الاولى 38 مريضاً يشكون من اوجاع الظهر و تمت مقارنة نتائج فحوصاتهم مع 40 شخص كمجموعة سيطرة حيث اجري للمجموعتين فحص تخطيط الاعصاب و العضلات الكهربائي بالاضافة الى منعكسات الاستجابة المتأخرة كمنعكس ف و منعكس الوتر المأبضي للعضلة الاخمصية لدراسة بعض الاختبارات الاحصائية و الانحرافات المعيارية

للعمر . سعة الموجة و فترة الكمون لنعكس الوتر المأبضي للعضلة الاخمصية بالاضافة الى نسبة جانب الى جانب لهذه الموجة باستخدام النظام الاحصائي SPSS.

**النتائج:** اظهرت النتائج عدم تناظر ملحوظ في سعة الموجة لنعكس الوتر المأبضي للعضلة الاخمصية مقارنة بمجموعة السيطرة كما و ان النسبة لهذا النعكس كانت 0,5 لدى مجموعة المرضى و 0,8 لدى مجموعة السيطرة حيث كانت مختلفة بشكل واضح. فترة الكمون لنعكس الوتر المأبضي للعضلة الاخمصية و الاختلاف لفترة الكمون بين الجهتين سجلت اطالة ملحوظة لكل المرضى المشمولين بالدراسة.

في هذه الدراسة 52,6% من المرضى كان لديهم تغيرات في تخطيط العضلات . 42.1 % كان لديهم اطالة لنعكس ف بينما 83,2% كان لديهم قراءات غير طبيعية لنعكس الوتر المأبضي للعضلة الاخمصية.

**الاستنتاجات:** دراسة منعكس الوتر المأبضي للعضلة الاخمصية بالاضافة الى بقية منعكسات الاستجابة المتأخرة كنعكس ف و تخطيط العضلات له فائدة في تحديد الانضغاطات البسيطة لجذور الاعصاب للفقرة العجزية الاولى . التغيرات لقراءات منعكس الوتر المأبضي للعضلة الاخمصية قد يكون الفحص الاكبر لتشخيص هذه الحالات في غياب العلامات العصبية السريرية.

**الكلمات المفتاحية:** تخطيط الاعصاب والعضلات، جذور الاعصاب العجزية.

## Introduction

The H-reflex is a useful electrophysiological procedure for diagnosing radiculopathy at the lumbosacral spinal level (Braddom *et al.*, 1974; Deschuytere *et al.*, 1976; Troni 1983; Wilbourn 1988; Sabbahi MA *et al.*, 1991; Dhand UK *et al.*, 1991; White 1991) In patients with chronic low back pain, it is important to establish whether or not radiculopathy is present. This is not difficult when clinical, radiological and electromyographic abnormalities consistent with focal nerve root involvement are found (Nardin *et al.*, 1999). However, a high percentage of the patients referred to back pain clinics presents with leg pain only. The neurological examination may be normal or confusing showing nonradicular sensory changes or minimal reflex decrement (Frymoyer, 1988) Imaging studies may lack diagnostic specificity (Nardin *et al.*, 1999). Needle EMG, which tests only ventral root function, may be normal in the absence of motor symptoms (Robinson, 1999). The recommended H-reflex diagnostic criteria are side-to-side latency differences (Braddom *et al.*, 1974; Deschuytere *et al.*, 1976; Troni 1983; Wilbourn, 1988; Sabbahi *et al.*, 1991; Dhand *et al.*, 1991; White 1991). Prolonged latency, absence of the H-reflex on the affected side (Troni, 1983; Han *et al.*, 1997 and Aiello, 1981), or H-reflex amplitude reduction the affected side (Deschuytere *et al.*, 1976; Wilbourn, 1988; White, 1991 and Nardin, 1999). Others criteria include the threshold level of evoked potential and changes in the shape and number of phases of the H-reflex action potential. However, these criteria can be deceptive.

We have recently reported prolongation of the latency of the soleus H-reflex as the only abnormality revealed by standard electrodiagnostic procedures in patients with lumbar spondylolisthesis (Mazzocchio *et al.*, 2000) This finding implies that the H-reflex test is an essential diagnostic criterion for radiculopathy, especially when clinical and electrophysiological signs of motor root involvement are lacking. However, one important diagnostic limitation of the H-reflex test was that its latency was not sensitive enough to detect subclinical nerve root dysfunction; i.e., a prolonged H-latency was noted only when clinical signs of root injury were manifest. We therefore investigated whether the amplitude, H/H ratio and latency differences of the soleus H-reflex might be a further diagnostic criterion for assessing S1 root function in patients with chronic back pain and mild radiculopathy.

H-reflex latency prolongation or side-to-side differences in patients with radiculopathy probably indicates neural demyelination with significant damage of large diameter nerve axons (Ali AA *et al.* 2000). Conversely, absent or reduced amplitude on the affected side is probably indicative of nerve conduction block in absence of extensive demyelination (Jankus *et al.*, 1994). The conduction block decreases the

recruitment of the spinal motoneurons (Dumitru D 1995) Especially those fast conducting neurons.

Demyelination and conduction block may occur simultaneously and with varying degrees in radiculopathy (Sabbahi *et al.*, 1990 and Mazzocchio *et al.*, 2001). However in the acute stage, the H-reflex latency compromises the axonal function before enough demyelination has occurred. The effect of the changes in the H-reflex amplitude might be minimal, structurally and functionally, in the acute stage but may progress to full-fledged pathology with continuous neural impingement/compression. Thus, H-reflex amplitude changes (e.g., asymmetry, absence, reduction) may be more evident than latency changes (e.g., prolongation, side-to-side differences) in patients with early radiculopathy.

## Materials and methods

### We selected for this study two groups:

Patients group which include 38 patients (20 male and 18 female between the age 25 and 62 years (mean  $44 \pm 10$ ); mean height  $166 \text{ cm} \pm 12$ , height range 150-187).

Control group included 40 healthy subjects (30 males and 20 females between the ages of 18 and 60 years (mean  $39.69 \pm 12.4$ ); mean height  $167 \pm 12$ , height range 145-182), with no previous or current history of disease, in particular back pain and radiculopathy. They were selected on an age and height basis so as to be matched with the patient group. Physical and neurological examination were normal. The electrophysiological tests were done at the neurophysiological unit of Mirijan Teaching hospital in Babylon City, during the period Dec/2011-July/2012.

All patients had a history of lower back pain, and lumbosacral radiculopathy at S1 spinal level. These patients had no history or clinical signs suggesting vascular or systemic diseases, and no clinical or electrophysiological signs suggesting pathological conditions such as myelopathy, polyneuropathy, myopathy or neuromuscular transmission disorders. The patients were examined with plain radiographs, computed tomography scans and magnetic resonance imaging of the lumbosacral spine. Radiographic data were gathered from the reports made by experienced radiologists who had no clinical information available. For purposes of this study, computed tomography and magnetic resonance finding were defined as abnormal if there was evidence of nerve root impingement.

The clinical criteria present with S1 radiculopathies were varying degrees of unilateral pain and paresthesia in the lumbosacral or lower limb (Weingarden *et al.*, 1980) The EMG criteria were a unilateral denervation pattern in at least two muscles innervated by the affected nerve root as well as segmental paraspinal muscles, with no measurable changes in the sensory or motor conduction velocities.

All patients underwent bilateral EMG and late response (F-wave and H-reflex) testing, Nicolet NCS – EMG machine was used. The stimulus intensity can be manually changed. This system include four channels preamplifiers and adjusted (0-99) mA. Positive EMG signs included: a) abnormal spontaneous activity in at least two areas of the examined muscle; b) long duration motor unit action potentials, and c) decreased recruitment pattern. Ten F-wave responses were recorded from the extensor digitorum brevis muscle and flexor hallucis brevis muscle ("marker muscles for L5 and S1 roots) after supramaximal stimulation of the peroneal nerve and tibial nerve at the ankle, respectively. With the participant lying prone, the soleus H-reflex was stimulated and recorded bilaterally, according to the method of Sabbahi and Khalil (Sabbahi, 1990) The soleus H-reflex by electrically stimulating the tibial nerve (duration = 1.0 ms, frequency

= 0.2 PPS) at the popliteal fossa. The muscle response was then recorded using surface bar electrodes. A fixed distance was used between the stimulation and recording electrodes throughout the testing experiment (from popliteal fossa for stimulation to the recording electrically at 3 cm. distal to the bifurcation of the gastrocnemii). The stimulation intensity for H-maximum was maintained by verifying the constant amplitude of the minimal M-wave. To control for the excitability of the motoneurons, participants were instructed to relax completely during data collection while keeping the head in the neutral position. This procedure reduced the reflex amplitude variability to the minimum. Seven to ten traces were elicited and recorded for each participant and the largest five traces were included in the analysis.

The peak-to-peak amplitude and latency to deflection of the five representative traces of the soleus H-reflex from the healthy controls and the patients were averaged. The side-to-side amplitude (H/H) ratios for the healthy controls were calculated according to the method of Jankus and colleagues (Jankus WR et al 1995) (i. e. smaller amplitude/larger amplitude). The patients H/H ratios were calculated according to the method of Han and colleagues (Han TR et al 1997) (i.e. affected limb/non-affected limb). The affected limb was identified by positive EMG results. Based on Han et al study (Han *et al.*, 1997), side-to-side latency differences were calculated (i.e., the abnormal result were identified larger than 1.0 ms).

Descriptive statistics, including means and standard deviations for age, H-reflex amplitudes, H-reflex latencies, side-to-side H/H ratios, and side-to-side latency differences of all participants were calculated using SPSS.

## Results

Means and standard deviations for age, height in both control and patients group were shown in table (1):

**Table (1) Means and standard deviations for age, height in both control and patients groups**

| Parameters | Control group | Patient group |
|------------|---------------|---------------|
| age/ years | 39.69 ± 12.4  | 44.76 ± 10.4  |
| Height/cm  | 167 ± 12      | 166 ± 12      |

All participants (healthy controls and patients) in this study showed an H-reflex. However, soleus H-reflex amplitudes in millivolts (mV), soleus side-to-side amplitude H/H ratios, were shown in table (2) patients showed significant H-reflex amplitude asymmetry compared to healthy controls ( $p \leq .05$ ). the H/H ratios were 0.5 in patients group and 0.8 in the healthy controls which were significantly different.

**Table (2) Mean and standard deviation of soleus H-reflex amplitudes and side-to-side amplitude H/H ratios in both control and patients groups.**

| Amplitude (m.v)<br>(mean± SD) | Control group | Patient group |
|-------------------------------|---------------|---------------|
| Symptomatic side              | 4.9 ± 1.7     | 2.5 ± 1.2     |
| Asymptomatic side             | 5.8 ± 2.4     | 4.2 ± 2.1     |
| H/H ratio                     | 0.8 ± 0.1     | ± 0.1*        |

\* Significant = p-value < 0.05

Soleus H-reflex latencies in millisecond (ms), soleus side-to-side latency differences of all participants was significantly longer in patients ( $p \leq 0.5$ ) as shown in table(3).

**Table (3) Mean and standard deviation of soleus H-reflex latencies and side-to-side differences latencies in both control and patients groups.**

| Latency (m.s)<br>(mean $\pm$ SD) | Control group   | Patients group  |
|----------------------------------|-----------------|-----------------|
| Symptomatic side                 | 27.6 $\pm$ 2.7  | 33.9 $\pm$ 2.2* |
| Asymptomatic side                | 5.8 $\pm$ 2.4   | 4.2 $\pm$ 2.1   |
| Side to side latency differences | 0.11 $\pm$ 0.01 | 1.42 $\pm$ 0.4* |

\* Significant = p-value < 0.05

However, H-reflex parameters changes occurs than EMG changes and f-response in mild/acute radiculopathy as shown in table (4)

**Table (4) the correlation between the changes of H-reflex parameters, EMG and f-response in mild/acute radiculopathy.**

| EMG findings | F-response | H-parameter changes |
|--------------|------------|---------------------|
| 20 (52.6%)   | 16(42.1%)  | 23(84.2%)           |

## Discussion

Our results showed H-reflex amplitude asymmetry and H-reflex H/H ratio as well as the latency differences was more evident in patients with S1 radiculopathy. The reported H-reflex amplitude asymmetry in patients with radiculopathy were probably due to conduction blockage in some large-diameter nerve axons (Sabbahi, 1990; Mazzocchio, 2000; Jankus, 1995). Conduction blockage reduce the traveling neural signal in the nerve root (Dumitru D 1995). It also result in desynchronisation of input signal (Fisher, 1992). This decreased motoneuron recruitment and in amplitude reduction of descendant volley and H-reflex (Dumitru, 1995; Mazzocchio *et al.*, 2001; Weingarden *et al.*, 1980; Bosnjak *et al.*, 2010). In this study, the H/H ratio was 0.8 when the latency was normal and it reduced to 0.5 when the latency was abnormal this indicates that as the pathology progresses and more neural axons are involved, changes (reduction) in H-reflex amplitude continues.

Increased or prolonged latency in patients with neural impingement and lower back pain is a constantly reported finding (Troni, 1983; Aiello *et al.*, 1981; Fisher *et al.*, 1992), especially in more chronic conditions. Such latency changes is not transient because it is caused by structural changes in the neural myelination (demyelination) as well as axonal damage, to a large extent. As these occur in chronic or long-standing conditions, a greater number of neural axons will be compromised and the patients symptoms increase. Decompressing the nerve root, either mechanically or surgically, will not restore normal reflex latency. This might require more time for neural structural regeneration.

There is always concern among clinicians about using amplitude instead of the latency parameter for diagnostic purposes. This might be due to the high degree of reflex parameter variability (Nishida *et al.*, 1996 and Sabbahi *et al.*, 2011). Reflex amplitude variability is the result of vestibular excitability, muscle activity, and cognitive state (Aiello *et al.*, 1983 ; Zehr, 2002). However, clinical and research-supported experience with the H-reflex show that standardized testing will result in increased reflex stability (Sabbahi *et al.*, 1982). Subject relaxation, use of taped-on stimulating electrodes and maintaining the head in the neutral position with arms symmetrically rested at the subjects sides improved reflex stability. It is also as important for the subject to empty his/her bladder before testing for increased reflex

stability during the longer testing period. Repetitive stimulation at the beginning of the test and before collection the data also results in stabilization of the tibial nerve threshold level to electrical stimulation, causing more stable H-reflex amplitude throughout the test to (Sabbahi *et al.*, 1982). These contributing effects would be less evident during standing (loading) compared with lying (unloading) (Ali *et al.*, 2000).

Using the H-reflex, Jin *et al.* (Jin *et al.*, 2010) introduced a new sensitive measure to evaluate S1 radiculopathy. Specifically, they compared two methods of recording the H-reflex: conventional H-reflex and S1- foramen H-reflex. In the convention H-reflex recording, the S1- foramen H-reflex, the H-reflex is elicited by stimulation of the S1 nerve root at the S1 foramen. In our study, only the conventional; H-reflex was used to review and report the electrophysiological changes associated with the pathological processes in patients with lumbosacral radiculopathy at the S1 spinal level to support the assumption that H-reflex amplitude, latency changes may be an earlier indicator of nerve root involvement. In the study by Jin *et al.* (Jin *et al.*, 2010), ways to improve the sensitivity of H-reflex recording were examined.

Several representative traces are important for clinical decision making. However, previous studies reported that four traces are the fewest needed to determine amplitude depression or recovery (Williams *et al.*, 1992 and Handcock *et al.*, 2001). In this study fives traces were recorded. Recording these traces is time consuming, especially if lower limbs are tested in lying and standing conditions (Ali *et al.*, 2000).

The H-reflex amplitude and H/M ratio have long been used in the literature interchangeably. A previous study showed that both parameters related the same information and behave similarly to intervention (Ali *et al.*, 2000).

Another study recommended an H/H ratio smaller than 0.4 in the absence of latency differences, as measured in healthy individuals, to diagnose S1 neural involvement (Jankus, 1994). For patients with S1 radiculopathy, an H/H ratio smaller than 0.5, in the absence of latency differences, indicated S1 neural involvement. Our result also emphasize the value of comparing both lower limbs rather than just reporting on the affected lower limb. Reflex asymmetry would, therefore, be the preferred parameter over a single data point.

In this study only 52.6% of the patients hand EMG changes 42.1% had prolonged F-wave latency, while 83.2% had abnormal H-reflex parameters.

The F-wave and needle EMG tests alone were not sensitive in detecting the cases of acute mild S1 radiculopathy than the H-reflex parameter changes, suggesting a lack of motor root compromise. Human sensory and motor axons have been shown to differ in excitability in many ways (Bostock *et al.*, 1994 and Mogyoros *et al.*, 1997). This difference may give rise to a differential susceptibility of sensory and motor axons in nerve root lesions. The large sensory fibers activated in the H-reflex pathway are extremely sensitive to the effects of cuff compression of the sciatic nerve (Zhu *et al.*, 1998). It may thus be hypothesized that the H-reflex changes here reported may be expression of damage produced at S1 root level by mechanical/ischemic factors. The failure of imaging studies to provide evidence of anatomical involvement may due to several reasons. One such reason is that degenerative conditions of the lumbar spine are most likely to be very dynamic and as such cannot be fully appreciated by means of standard radiographic examinations. Another reason is that following mechanical deformation of spinal roots, there may be changes in root microcirculation (Rydevik, 1984) and/or local release of inflammatory substances (Saal, 1995) which can result in symptoms and electrophysiological abnormalities without ZCT/MRI changes.

## Conclusion

The study of soleus H-reflex parameters may be usefully associated to the F-wave and needle EMG study to detect possible S1 root dysfunction in mild lumbosacral radiculopathies. The H-reflex parameters changes may be the earliest abnormality in the absence of focal neurological signs.

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