Proximal Conduction Time Along The Lumbar Plexus

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Summary

Scientific Background: One of the matters in clinical neurophysiology is evaluation of the proximal conduction time along the lumbar plexus. Objectives: Instead of investigating only distal segment of the nerve from the groin as is generally done we aimed to investigate both proximal and distal parts of the nerves originating from the lumbar plexus.

Material and Methods: In this paper different proximal conduction methods were studied in 109 healthy adult human subjects by measuring proximal motor conduction time of femoral, obturator and genitofemoral nerve along the lumbar plexus using both by using lumbar magnetic and peripheral electrical stimulation and by using the H-reflex methods in adductor and quadriceps muscle group. The anatomical parts of the study were applied on 20 human adult cadavers, dissecting femoral, obturator genitofemoral nerve and roots proximally.

Results: The total distance from ligamentum inguinale to spinal level was 392.4±13.3mm in femoral nerve. The total distance was approximately 382.8±11.1mm in obturator nerve and the total distance was approximately 353.1±12.5 mm in genitofemoral nerve. With the H reflex method, using the distance obtained from the cadaver, femoral and obturator nerve proximal conduction velocity were determined to be 62.5±6.1 m/sec and 53.6±7.4 m/sec, respectively. Using lumbar magnetic stimulation and the peripheral electrical stimulation, proximal conduction velocities in femoral, obturator and genitofemoral nerves were determined to be 59.1±13.3m/sec, 52.7±14.9 and 58.7±0.8 m/sec, respectively.

Conclusions: No statistical differences were found between the proximal conduction velocities elicited by both methods. Either approach is preferable to evaluate proximal conduction time.

Key words: Lumbar plexus, proximal conduction time, H reflex, electrical stimulation, magnetic stimulation, femoral nerve, genitofemoral nerve, obturator nerve

Özet

ILETI METOTLARI ÇALIŞTI. Çalışmanın anatomi kısımı 20 yetişkin kadavrada femoral, obturator, genitofemoral sinir ve proksimal kökler diseke edilerek uygulandı. Ligamentum inguinale'den spinal seviyeye ortalaması toplam mesafe femoral sinirinde 392.4±13.3 mm, obturator sinirinde yaklaşık olarak 382.8±11.1, genitofemoral sinirde ise 353.1±12.5 mm olarak ölçüldü. H-refleksi metodu ile, kadavrde elde edilen mesafe kullanılarak femoral ve obturator sinirin proksimal iletim zamanı 62.5±6.1 ve 53.6±7.4 m/sn olarak saptandı. Periferik elektrik uyarım ve lomber manyetik uyarm ile femoral, obturator ve genitofemoral sinirin proksimal ileti hızları sırası ile 59.1±13.3, 52.7±14.9, 58.7±0.8 m/sn olarak ölçülü. Her iki metot da proksimal ileti hızları arasında istatistiksel olarak farklılık gözlemendi. Her iki yaklaşım da olgulara göre proksimal ileti hızını değerlendirilecek için tercih edilebilir.

Anahtar Kelimeler: Lumbar plexus, proksimal iletim zamanı, H refleksi, elektriksel uyarm, manyetik uyarm, femoral sinir, genitofemoral sinir, obturator sinir

INTRODUCTION

The Lumbar Plexus (LP) is formed by the ventral division of L1-L4 spinal nerves. Investigation of lumbar plexus and its nerves has idiosyncratic difficulties especially compared with investigation of sacral plexus and its nerves by clinically and electrophysiologically. Femoral nerve (FN), Obturator nerve (ON) and Genitofemoral nerve (GFN) are proximal motor nerves originated from the lumbar plexus. It is difficult to differentiate them from the lumbosacral radiculopathies especially widespread lesions in both. One of the examples is the asymmetrical proximal motor neuropathy in diabetes mellitus which have time problem to locate the lesion mainly to motor roots, LP or both (8,10,28).

Generally the proximal FN lesions are observed very often expected. Retroperitoneal hematomas or hemorrhages, retroperitoneal tumors, abscesses, iatrogenically lesions, penetrating injuries, aneurysm of the femoral artery, neurologic amyotrophy and diabetic amyotrophy cause a FN lesion. (7,8,25,28,34) Also various similar conditions such as total hip arthroplasty, pelvic surgery, laparoscopic tubal surgery, metastatic disease to the obturator nerve, diabetes mellitus, myositis may cause Obturator nerve (ON) lesion. (27) Thus, instead of investigating only the distal segment of the nerve from the groin, it might be better to investigate both proximal and distal parts of the main nerves originating from the lumbar plexus, electrophysiologically. While accessing the ON, FN and GFN for routine electrophysiological studies the main limitation is that this nerve has been deeply placed in the pelvis. The proximal part of the major nerves of the lumbar plexus and lombar roots could not be precisely differentiated by the electrophysiologically methods, especially the stimulation of the lomber spinal roots has produced debatable questions from the electrodiagnostic point of view. Lumbar spinal roots can be directly stimulated by two ways: magnetic (MS) and electric (ES). (2,24,29)

Another electrophysiological approach is to evaluate the proximal motor conduction time along the lomber plexus by using the H-reflex methods subtracting H-reflex latency from the distal M-responses of the muscle investigated such as the subtracting distal M-responses from the H-reflex in quadriceps muscle group. (1,15,20,33)

In this paper, the two methods above have been studied in different normal subjects and the electrophysiological results have been compared by the anatomical cadaver studies. Considering of the anatomical and physiological facts and fallacies, the proximal motor conduction time of the FN, ON and GFN were also studied by these methods.
MATERIAL AND METHODS

Subjects

Electrophysiological aspects of the study have been performed on 110 healthy adult human subjects using different methods (see below). The anatomical aspects of the study have been applied on the 20 human adult cadavers dissecting femoral and obturator nerve and roots proximally. In electrophysiological study, we studied different methods on the different group of subjects. Study was approved by the local ethical committees and informed consent was obtained in all cases.

1. Anatomical study

Twenty adult cadavers (13 male, 7 female) were studied. Twenty femoral, twenty obturatory nerves were evaluated using both sites separately and ten genitofemoral nerves were evaluated. All nerves from the cadavers fixed in 10% formalin were examined. In order to obtain the exact length of the proximal femoral obturatory and genitofemoral nerves, the anatomical dissection, including the fibers of nerve crossing the lumbar plexus, were done isolating the nerves from their take off at the L2, L3 and L4 nerve roots level and conversing beneath the inguinal ligament (IL). The over length of L3 spinal nerve from take off level at the foramen intervertebrale (neural foramen) to IL was measured with electronic digital caliper. Then the distance between the level of L3 spinal nerve to medullary L2 level were measured. Finally these two distances were added to find out the length of the proximal femoral, obturatory and genitofemoral nerves. The whole of these dissections were photographed.

2. Femoral nerve and Obturator nerve proximal motor conduction time along the lumbar plexus using H reflex method.

- Motor conduction studies of femoral nerve were made of a total of 40 femoral nerves from the 20 normal subjects (13 female, 7 male). The FN was percutaneously stimulated at the level of the inguinal ligament with the subject lying down in supine position and, hip and knee extended. The pulsation of the femoral artery was used as landmark and bipolar surface electrode was placed just lateral to the point of pulsation over the inguinal ligament (IL) while the recording surface electrodes were placed on the skin over the belly point of vastus medialis (VM) muscle. The reference electrode was placed over the quadriceps tendon just proximal to the patella. The ground electrode was placed between the stimulation electrode and recording electrode. Motor conduction studies of obturator nerve were made from the 19 normal subjects (5 female, 14 male) with the age range of 17-62 years. The recordings were conducted with the subjects supine. Both legs were passively semiflexed at the knee to about 120 degree. The legs were also slightly abducted. The target muscle was the adductor magnus (AM). Subjects were asked to adduct and internally rotate their hip while the AM and other adductors of the inner and proximal site of the thigh were palpated by the examiner. The bulk of the contracted adductor muscles were easily localized and a concentric needle electrode was inserted into the muscle. Other details of recording was described previously. The obturator nerve was stimulated percutaneously by surface bipolar electrodes at the level of the pubic tubercle in order to obtain M-response and H-reflex with high amplitude from the adductor muscle. The needle electrode position adjusted in the adductor muscle to obtain a maximal M-response. The needle electrode was then fixed in position by tapping its cables to the skin. Obturator nerve was stimulated by percutaneous electrical shocks at the level of IL-pubic tubercle.

The latency values of the M and H responses were measured from stimulus artifact to the onset of the action potentials.
Peak to peak amplitude of both responses were also measured. For each stimulation and recording trial, at least three responses were collected. For latency of the proximal conduction time, the latency of M response was subtracted from H-reflex latency and then divided by 2 (H-M/2). The distance from the cathode of the stimulating electrode on the IL to the recording site at the muscle was measured.

The GFN was stimulated around the anterior superior iliac spine in order to obtain M-response and H-reflex with high amplitude from the cremaster muscle by bipolar surface electrodes. The needle electrode was used to record from the cremaster muscle to obtain a maximal M response and H reflex.

The temperature of the room during examination was about 21-23 °C.

3. Proximal motor conduction time of femoral, obturator and genitofemoral nerve along the lumbar plexus using lumbar MS and peripheral ES (Figure 1).

Figure 1: The diagram shows stimulation and recording points of the femoral, obturator and genitofemoral nerves of the proximal motor conduction studies. Black point twins denote stimulation points of each nerve for electrical stimulation (ES). Circular coil is over the lumbar spines for Magnetic stimulation (MS). Small ecliptics denote the insertion areas of the needle electrodes for recording.

Fifty-four healthy adult subjects (17 female, 37 male). During the initial assessment procedure, the EMG activity of the AM and VM was recorded by means of disposable concentric needle electrodes (diameter, 0.46mm, recording area 0.07 mm²). Before insertion of the needle electrode, volunteers were asked to contract their adductor muscles\(^{14}\) (see Ertekin et al 2006). Once insertion was identified the needle recording electrode was introduced into the AM muscle.
Another concentric needle electrode was inserted into the belly of VM muscle and connected to a separate channel of the EMG equipment (Viking IV, Nicolet Biomedical, Madison, Wisconsin). As it was previously described, with the subject lying down, the obturator nerve was stimulated percutaneously at the level of the pubic tubercle. Bipolar stimulation electrodes (Medelec 16893) were placed 1-2 cm inferior and 1-2 cm lateral to tubercle. The position of the electrodes was close to the lateral hold of skin of pubic region and slightly medioinferior to the IL. To accomplish maximum stimulation of the obturatory nerve, it was necessary to press firmly the stimulation electrode over the lateral hold of the skin of the pubic region. During stimulation against to the moving back of the needle electrode and near cables was fixed by scotch-tapes.

Femoral nerve was stimulated as was described above. The concentric needle electrode was already inserted into the VM muscle. Both nerves were stimulated by the rectangular pulses (0.2-0.5 ms duration) and the stimulus intensity was increased in a step wise manner until a supramaximal M-Responses were obtained from the adductor or VM muscle. For both nerves, the distances between the cathode of the stimulation electrodes and the needle insertion points were measured. The lumbar roots were stimulated at the L1-L2 spine levels by a circular coil (Novometrix magstim 200, 2 tesla version, whitland, Dyfed, Wales, UK) Magnetic stimulation (MS) over the lumbar spines was generally confounded by a large stimulus artifact that varied greatly with only slight changes in position of the stimulation coil. If the magnetic circular coil was moved slightly lateral toward to the site of recording leg, the artifact was smaller. (The AM and VM were maximally stimulated at the L1-L3 spine levels slightly ipsilateral to the muscle recording place) However stimulation was still capable of producing responses down to the L4 spine level in some subjects. Threshold for the lumbar innervated muscles under investigation was highly variable probably due to variable thickness of the tissue. However, it was often sufficient 70 to 80 percent of the maximal output of the stimulator. Sometimes the maximal output of the stimulator spread out the excitation points of lumbar roots and their latency become very close to the latencies obtained by those of peripheral nerves. Therefore, we have excluded to those subjects from the study. However we mostly encounter with submaximal response of the peripheral muscles by the lomber root stimulation. Fortunately the decision of submaximal response could be understood with the double responses first one was M-response and second one was H-reflex. In these cases, if the responses were obtained by the maximal output of the magnetic stimulator (%100), then we accepted the M-responses with an unchanged, fixed latency values. Unfortunately, we could not measure the exact distance from lumbar roots to the proximal nerve stimulation sites, because of anatomically impossible to measure our normal subjects. But we used pelvimeter to measure the output points of magnetic coil at the back to the proximal stimulation sites of obturatory and femoral nerves. These were only an approximate distances.

It was important to obtained MEPs from lumbar innervated muscles with very fixed latencies even if the presence of a later response suggesting the H-reflex. The latency value in a given condition of MS at the back has never been changed, but the amplitude could be changeable. When the amplitude values of the MEP was less than one-fifth of M response obtained by peripheral ES, this subject is also excluded from the study. Although the amplitude values are also measured; our most important aim was to measure the “lumbar plexus conduction time”. For this purpose, latency values were very important. Therefore we used needle electrodes in order to obtain more sharp and stable
latency values. Secondly, the amplitude values were more variable than the latency values as mentioned before. Thirdly, the volume conducted potentials of the muscles in between femoral and obturator muscles could be reduced in needle recordings\(^{(32)}\) interfering also in the onset latencies. We preferred needle recording electrodes and of course, latency values were calculated rather than the amplitudes. Some information was missed by needle recording but submaximal stimulation of the lumbar roots by MS was in reality and the amplitude measurements might produce some misinterpretation.

The technique of stimulation of genitofemoral nerve (GFN) at the root and periphery has been previously described.\(^{(13)}\) Seventeen healthy adult male subjects were investigated (age range: 18-68) by this method. Indicator muscle of the GFN was cremasteric muscle (CM) The needle electrode was inserted into the inguinal canal after palpabling the intracanaliculer structures The precise location of the needle electrode was determined by the detection of motor unit potentials with sharp configuration in activating them by the elicitation of the CM-reflex. The lumbar roots were magnetically stimulated at the lumbar spines from L1-L3 using by a circular coil (Novometrix Magstim 200, 2 tesla version, Whitlant, Dyfed Wales UK). The maximal response of CM was elicited about 70-100% of the output of the magnetic stimulator position of the coil at the lumbar spine was oriented to neuroforaminal axis and the current is most likely focally concentrated there as was previously suggested.\(^{(26)}\)

The GFN was stimulated around the anterior superior iliac spine. Bipolar surface electrodes were used for stimulation (Medelec Large LBS, Ref: 16893T, Oxford Instrumants medical old Woking, UK). The rectangular electrical shocks have duration of 0.1-0.3 ms and variable intensity; they were delivered toward the inside of palpable surface of the anterior superior iliac crest. In each stimulation and recording condition, the shortest onset latency and the largest amplitude were selected from the consecutive recordings in a set of 8 to 16 sweeps. The proximal motor conduction time of GFN was calculated by the subtraction of minimal latency of the root response from the shortest latency of the CM muscle by the GFN stimulation for each subject.

5. Statistical methods

A p-value of <0.05 was considered statistically significant. Mean ± SD of all measured quantities was calculated and student t-test was applied for comparison between groups.

RESULTS

1. Anatomic Studies

With anatomic dissection, for femoral nerve the distance from IL to the L3 root foramen was determined as 195.1 ± 11.5mm (min. and max. values 176-217mm) (Figure 2) The distance from L3 vertebrae to Thoracal 10 spine that is the level of medullary L2 spinal segment was measured as 197.26 ± 5.7mm (min. –max. 186.9 - 206.2 mm) (Figure 3) The mean total distance was 392.4 ± 13.3mm (min. – max. 377.0 – 484.0 mm). Obturator nerve length from L3 root foramen to the obturator canal entrance was determined as 185.6 ± 11.1 mm, and to the canalis obturatorius exit was 215.4 ± 11.7 mm (Figure 4). The distance from L3 vertebrae to T10 spine was the same for both the obturatorius and femoral nerves, so the total distance was approximately 382.8±11.1 mm. Genitofemoral nerve length from L2 root foramen to the IL was determined as 161.0 ± 11.5 mm (Figure 5). The mean total distance was 353.1 ± 12.5 mm (min. –max. 337.0 – 373.0 mm).
Figure 2: Anterior view of the posterior abdominal wall after the removal of the internal organs for measurement of the femoral nerve (A: Abdominal aorta, F: Femoral nerve, L2-L3-L4: The anterior ramus of the second, third and forth lumbar spinal nerves respectively, LCF: Lateral femoral cutaneous nerve, O: Obturator nerve, VC: Inferior vena cava, asterisk: Inguinal ligament)

Figure 3: The posterior view of the spinal cord after the removal of the vertebral arches for measurement of the caudal part of the femoral nerve (F: Femoral nerve, L2-L3: The anterior ramus of the second and third lumbar spinal nerves respectively, asterisk: Medullary cone, arrowhead: the entrance point of the second lumbar nerve into the spinal cord)
**Figure 4:** Anterior view of the posterior abdominal wall after the removal of the internal organs for measurement of the obturator nerve (A: Abdominal aorta, F: Femoral nerve, L2-L3-L4: The anterior ramus of the second, third and forth lumbar spinal nerves respectively, LCF: Lateral femoral cutaneous nerve, O: Obturator nerve, VC: Inferior vena cava, asterisks: obturator canal entrance and exit)

**Figure 5:** Anterior view of the posterior abdominal wall after the removal of the internal organs for measurement of the genitofemoral nerve (GF: Genitofemoral nerve, L1-L2: The anterior ramus of the first and second lumbar spinal nerves respectively)
2. Calculation of the femoral and obturatory nerve proximal segment velocities by H reflex;

Vastus medialis and adductor muscles were evoked submaximally but H reflex disappeared as the stimulator output increased to the level at which a maximum M-response was obtained (Figure 6). M and H responses were shorter in the obturatory nerve than the femoral nerve. This was probably due to the short distance between the stimulation and recording sites. However, the H-M latency were not significantly different for both nerves.

The mean of the difference between right and left side H-M latency was 1.17±0.5 msec and upper level of the side difference is 2.17 msec. for femoral nerve. The mean latency of H-M in the VM muscle was 12.70±1.4 msec (Table 1). No differences in latencies were demonstrable between male and female or right and left lower extremities. Proximal segment of the femoral and obturatory nerves measured on the cadaver was 392.4±13.3 mm and 382.8±11.1 mm respectively. The mean H-M latency supplied from healthy subjects was found 12.7±1.4 msec and 14.5±2.0 msec respectively. Thus, the total distance should be calculated by considering the afferent and efferent of the nerve segment for the H-M latency; which were 2x392=784 mm. and 2x383=766 mm. respectively. This formula is;

\[
\text{The mean distance x 2 (from cadaver)} / \text{Mean H-M latency (from normal subjects)}
\]

GFN was evoked submaximally to obtain H reflex from the ipsilateral cremaster muscle but H reflex could not be recorded even if the stimulator output increased to the level at which a maximum M-response was obtained. So, proximal conduction velocity was not calculated for GFN by H reflex method.

3. Proximal motor conduction time of femoral, obturator and genitofemoral nerve along the lumbar plexus using lumbar MS and peripheral ES.

The values of motor conduction time from lumbar MS to the VM and the adductor muscles were almost the same and that was 8.6±1.3 ms and 8.4±1.4 ms respectively in 54 normal healthy subjects (Figure 7). The maximal ES on the femoral and obturatory nerve at the IL were evoked M responses from both muscles with similar latencies, however the mean value of distal motor latency was slightly longer for VM than adductor muscle, probably due to distance from groin to muscles was shorter for the adductor muscle. But this difference is not statistically significant. The proximal motor conduction time could be calculated in each normal control by the latency values from those of lumbar MS to those of maximal ES at the IL. Proximal motor conduction that also included the conduction time along the lumbar plexus was averaged as 4.3±0.9 ms for VM and 4.7±1.0 ms for adductor muscles. They were not significantly different from each other.

Being aware of needle EMG electrodes we can not give clear information about the total muscle fibers excited by any kind of stimulation, such a comparison could carry on the same disadvantages and; comparison might give an approximate opinion about the excited motor fibers around the needle electrode at two different sites. However the latency values of needle recording is more precise and reproducible in this kind of conduction time studies.

Since GFN arises in the L1 and L2 roots and consists of motor fibers to cremasteric muscle; we have investigated almost all proximal nerve as a branch of lumbar plexus from their L1 and L2 roots exit to the entrance of motor fibers into the inguinal canal. Lumbar MS have been performed slightly upward than in those of adductor and VM muscles. The M response of CM muscles by the stimulation
of the GFN at the beginning of inguinal canal was shown in the Figure 8. MS over the upper lumbar spines was encountered by a large stimulus artifact that varied greatly with only slight changes in the position of the stimulating coil. If the magnetic coil was moved slightly lateral to the recording site, the artifact was diminished.

Figure 6: Femoral nerve was stimulated from inguinal ligament and M response recorded from VM. Upper traces show vastus medialis M response during supramaximal femoral nerve stimulation. Bottom traces show H reflex response from VM during femoral nerve stimulation submaximally. There is no M response in the bottom trace. Three different recordings superimposed for each responses.

Figure 7: The maximal electrical stimulation (ES) on the femoral and obturatory nerve at the groin (upper traces). The Magnetic stimulation (MS) over the lumbar spines (Lower traces) . Proximal motor conduction time of femoral (left panel) and obturator nerve (right panel) along the lumbar plexus calculated by using lumbar MS and peripheral ES.
Table 1: The data’s of MS-ES method and H reflex method

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<tbody>
<tr>
<td></td>
<td>Latency msec</td>
<td>Distance (mm)</td>
<td>Conduction velocity m/sec</td>
<td>H-M msec</td>
<td>Distance (mm)</td>
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<td>Femoral nerve</td>
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<td>59.10±13.3</td>
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<tr>
<td>Obturator nerve</td>
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<td>244±24.6</td>
<td>52.70±14.9</td>
<td>14.5±2.0</td>
<td>185.6±11.0</td>
<td>382.8±11.1</td>
</tr>
<tr>
<td>Genitofemoral nerve</td>
<td>4.5±1.1</td>
<td>212±49.0*</td>
<td>58.70±0.8</td>
<td>NR</td>
<td>161.0±11.5*</td>
<td>353.1±12.5*</td>
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MS, Magnetic stimulation; ES, Electrical stimulation

Figure 8: Calculation of the proximal motor conduction time of GFN. The M response of CM muscles by the stimulation of the GFN at the beginning of inguinal canal (Panel A) and the magnetic stimulation (MS) over the upper lumbar spines (Panel B). Three different recordings superimposed at each panel.
DISCUSSION

In our study, with anatomic dissection, the distance of femoral nerve from ligamentum inguinale to L3 root foramen was found 195.1 ± 11.5 mm. The overall distance was 392.4 ± 13.3 mm. Johnson et al. reported that the length of the femoral nerve from root level to vastus medialis muscle is 354 ± 19 (min-max; 290-380 mm). (18) Obturator nerve length from L3 root foramen to the obturator canal entrance and to the canalis obturatorius exit were determined to be 185.6 ± 11.1 mm and 215.4 ± 11.7 mm respectively. The distance from L3 vertebrae to T10 spine was the same for obturatorius nerve and femoral nerve, so the total distance was approximately 382.8 ± 11.1 mm. There is no cadaveric measure for ON in literature. Cremaster nerve length from L2 root foramen to the IL was determined to be 161.0 ± 11.5 mm and the total distance was approximately 353.1 ± 12.5 mm. There is no cadaveric measure for GFN in literature also too.

We could evaluate the proximal motor conduction time along the lomber plexus by using the H-reflex methods. With H reflex method, using distance elicited from cadaver, the femoral nerve conduction velocity and the obturator nerve conduction velocity were established to be 62.5 ± 6.1 msec and 53.6 ± 7.4 m/sec, respectively. Although the femoral nerve H reflex has been studied more than once, there is no systematic comparative study related to the proximal conduction velocity. (1,2,17,19,20,30) Guiheneuc P and Bathien N evaluated the proximal conduction velocity using H-M interval in patients with polyneuropathies. In 42 normal control subjects and 172 patients with chronic renal insufficiency and alcoholism, they measured the proximal conduction velocity of sciatica nerve by using H reflex index. (16)

Another electrophysiological study method we used was the measurement of proximal motor conduction time and conduction velocity of FN, ON and GFN using lumbar MS and peripheral ES. Proximal conduction velocity in FN was 59.1 ± 13.3 m/sec, proximal conduction velocity in ON and GFN was 52.7 ± 14.9 and 58.7 ± 0.8 m/sec respectively. In Uludag et al. study the proximal and distal motor nerve conduction in ON and FN by electrical stimulation of lomber roots at laminar level and ligamentum inguinale. (32) Up to now lomber spinal roots can be directly stimulated by two ways: magnetic (MS) and electric (ES). Lomber spinal roots have been stimulated either by high voltage percutaneous electrodes (2,24,29) or using the needle electrodes at the level of vertebral laminal the electrical shocks were delivered. (11,12) ES methods either at the cutaneous or epidural level have not been used in daily practice due to their unpleasant nature. MS is a non-invasive and painless method for the evaluation of the lumbar roots. (21,22,23,31) However, it was documented that the lumbosacral MS evokes submaximal motor responses from the leg muscles. Further more MS of the lomber roots are excited near their exit from the spinal foramina (or neural foramina). The stimulation site is distal to that of roots compression or spondylotic changes. (4,26,31) Though Maccabee et al. have demonstrated that lumbar root fibers could also be stimulated within the vertebral column before their exit at the neural foramina. (21,22)

Despite submaximal amplitude of the motor evoked potentials (MEP) and their stimulation sites were often near to root exit at the neural foramina, the MEP latencies were constant and reproducible. (5,6) As a results; it can be said that the lumbar magnetic stimulation could not be used for the situations where the proximal conduction block is sought. Because, MEPs are obtained as submaximal in lumbar MS even in normal conditions. The highly constant and reproducible MEP latencies may be beneficial for the calculation of the
proximal motor conduction time of the lumbar plexus and its nerves. So that, the lumbar MS and the ES of the peripheral part of major branches of lumbar plexus could give us a priori motor conduction time from the lumbar root to the inguinal ligament (IL), for the motor fibers of the femoral, obturator and genitofemoral nerves. This kind of an approach to the proximal motor conduction time might be used for the differentiation of localization of the proximal/distal lesions and root lesions.

Usually, the motor conduction velocity studies of FN, ON and GFN based on the measurement of the motor distal latency and comparison of the right/left differences. Since these nerves are located deep within the muscle, femoral and obturator nerve motor conduction velocity studies are not convenient for practical usage. It has some handicaps for both patient and practitioner.

In this paper, the two methods above have been studied in different normal subjects. The results obtained by both methods were compared. There were no any statistically difference between the proximal conduction velocities which are elicited by either methods (P>0.05). Two kind of approach will be a good candidate to show the pathology. Measuring lumbar plexus proximal conduction velocity by H reflex method appears to be easier and less time consuming and non invasive.

In conclusion, it can be better to investigate both proximal and distal parts of the main nerves originated from the lumbar plexus, electrophysiologically. But the proximal part of the major nerves of the lumbar plexus and lumbar roots could not be precisely differentiated by the electrophysiologically method, especially the stimulation of the lumbar spinal roots has produced debatable questions from the electrodiagnostic point of views. Considering of the anatomical and physiological facts and fallacies, the proximal motor conduction time of the femoral, obturator and genitofemoral nerves was also studied by this method. In daily electrophysiological studies, we can measure the conduction velocities of the terminal motor nerves emerging from lumbar plexus either with H-reflex method or ES-MS method. While ES and MS are preferred if H reflex cannot be elicited, in cases where H reflex can be elicited it is possible to calculate velocity and show abnormality with records from a single muscle and stimulation from a single localization.

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