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Case Studies

# Electroacupuncture (EA) Treatment for a Chronic Severe Femoral Nerve Injury: A Case Report

**Hossein Haghir[1,2], Hamid Reza Bahrami-Taghanak[1]***

*[1]Department of Acupuncture, School of Persian and Complementary Medicine, Mashhad University of Medical Sciences, Mashhad, Iran*
*[2]Department of Anatomy and Cell Biology, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran*

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## Abstract

Although there have been a few reports of improvement in peripheral nerve injury (PNI) with electroacupuncture (EA), this seems to be the first report of treating a patient with chronic femoral nerve injury using EA. A 35-year-old Iranian woman visited the university acupuncture clinic because of severe difficulties in hip flexion, extension of knee, and sensory loss on the medial side of leg on the right side. The diagnosis of femoral nerve injury was confirmed by physical examination and nerve conduction study (NCS). EA treatment was done three times a week for 12 sessions. A post-treatment physical examination and NCS showed improvement in the patient's motor and sensory symptoms. The patient continued to improve at the follow-up physical examination 7 months after treatment. This case report provides clinical and NCS evidence that EA may effectively treat a chronic severe femoral nerve injury.

**Keywords:** Electroacupuncture; Femoral nerve; Peripheral nerve injuries; Case report

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*Corresponding Author:Hamid Reza Bahrami-Taghanak
Department of Acupuncture, School of Persian and Complementary Medicine, Mashhad University of Medical Sciences, Mashhad, Iran
Email: bahramihr@mums.ac.ir

## Introduction

The femoral nerve, which carries fibers from the L2–L4 segments, is the largest nerve in the lumbar plexus and plays a crucial role in hip flexion, knee extension, and sensation of the medial side of the leg [1]. While iatrogenic femoral nerve damage is a relatively rare complication following surgery [2], studies suggest that up to 60 % of cases may have an iatrogenic origin [3].

Treatments of peripheral nerve injury (PNI) range from conservative approaches to surgical interventions [4]. All surgical approaches, including direct nerve repair, nerve grafting, nerve transfer, fibrin glue, and nerve conduits, not only must be applied within a short time interval after the nerve injury, but also have other limitations such as being time-consuming, expensive, donor unavailability, risk of immunosuppression, and uncertainty of 100% recovery. Conservative approaches include pharmacological, cell-based, and physical therapies. Pharmacological therapies, called neurotrophic drugs, including B vitamins, methylcobalamin, and exogenous neurotrophic factors, may have a role in the repair process of PNI. However, due to low concentrations of local drug in the peripheral blood, these pharmacological therapies often fail to achieve sustained clinical benefits. In recent years, there have been significant advances in cell-based therapies, such as those using Schwann cells (SCs), mesenchymal stem cells (MSCs), bone marrow stromal stem cells, and skin progenitor cells. However, the difficulties associated with obtaining and maintaining such materials severely limit the clinical applications of cell therapy. Physiotherapy modalities are mainly used for rehabilitation rather than peripheral nerve repair [5]. Meanwhile, electroacupuncture (EA), with its unique benefits, including anti-inflammation, analgesia, and speeding up nerve repair, could be a safe, effective, and less painful alternative for repairing PNI [6].

Despite the few reports of improvement in some peripheral nerve injuries such as sciatic, peroneal, median, ulnar and axillary nerves with the use of electroacupuncture (EA) in pre-clinical and clinical studies [6-8], there has been no report on the treatment of femoral nerve injury using EA.

The femoral nerve injury is diagnosed clinically by weakness of ipsilateral hip flexion, knee extension, and numbness over the medial side of the leg [9] and confirmed by electrophysiological criteria of femoral nerve injury on a nerve conduction study (NCS) and needle electromyography (EMG), such as a reduction of the compound muscle action potential (CMAP) area of the vastus medialis muscle evoked after supramaximal stimulation of the femoral nerve at the groin, associated with an absent H-reflex of the femoral nerve and signs of vastus medialis muscle denervation. The CMAP is a surrogate of the maximum muscle strength developed. The H-reflex, or Hoffmann reflex, is a reaction of muscles after incremental electrical stimulation of sensory fibers over the vastus medialis muscle. Signs of denervation are present when fibrillation potentials of the muscle are observed at rest [10]. Accordingly, treatment of femoral nerve injury is defined as return of motor and sensory function of the nerve on clinical examination and normalization of electrophysiological criteria on NCS described above.

We present a case study involving a 35-year-old woman in which a post-surgical chronic severe femoral nerve injury improved with electroacupuncture (EA) treatment. The CARE Guideline was applied for this reporting.

## Case Presentation

### *Patient Information*

The patient, a single 35-year-old Iranian woman, referred to the acupuncture clinic of Mashhad University of Medical Sciences (MUMS) due to significant difficulties in flexing her right hip and extending her right knee. These issues persisted for 11 months following knee surgery. Her condition began after an accidental fall in February 2021, resulting in pain and swelling in her right knee. Despite a year of physiotherapy, with a preliminary diagnosis of patellar dislocation, she underwent medial patellofemoral ligament (MPFL) reconstruction surgery in February 2022. Post-surgery, she received outpatient physiotherapy for three months, followed by hydrotherapy (water exercises) as recommended by her surgeon. A week into hydrotherapy, her therapist observed difficulties in hip flexion and knee extension in the right lower limb, prompting a referral back to the surgeon. An initial NCS conducted on June 13, 2022, indicated moderate neuropraxia of the right femoral nerve with a good prognosis. Following the surgeon's advice, she underwent nine months of physiotherapy to address the femoral nerve injury, which proved unsuccessful. On March 18, 2023, a neurologist examined her and conducted the second NCS, noting severe weakness in flexing the right hip and extending the right knee, a diminished right knee jerk reflex, and sensory loss on the medial side of the right leg. The NCS revealed a chronic axonal injury in the right femoral nerve proximal to the inguinal ligament. She visited our acupuncture clinic one month after the second NCS on April 29, 2023. A summarized schedule of the patient timeline is presented in figure 1.

### *Clinical findings*

Neurological examination revealed an inability to flex the right hip joint or extend the right knee joint, even in the horizontal plane (Figure 2A). Although quadriceps femoris contraction was visible and palpable when attempting to extend the right knee, it did not result in knee joint movement (Figure 2B). Muscle Strength Testing (MST) for the right iliopsoas and quadriceps femoris was rated 1/5, indicating severe weakness. The right knee jerk reflex was absent. The muscle force and reflexes were nor-

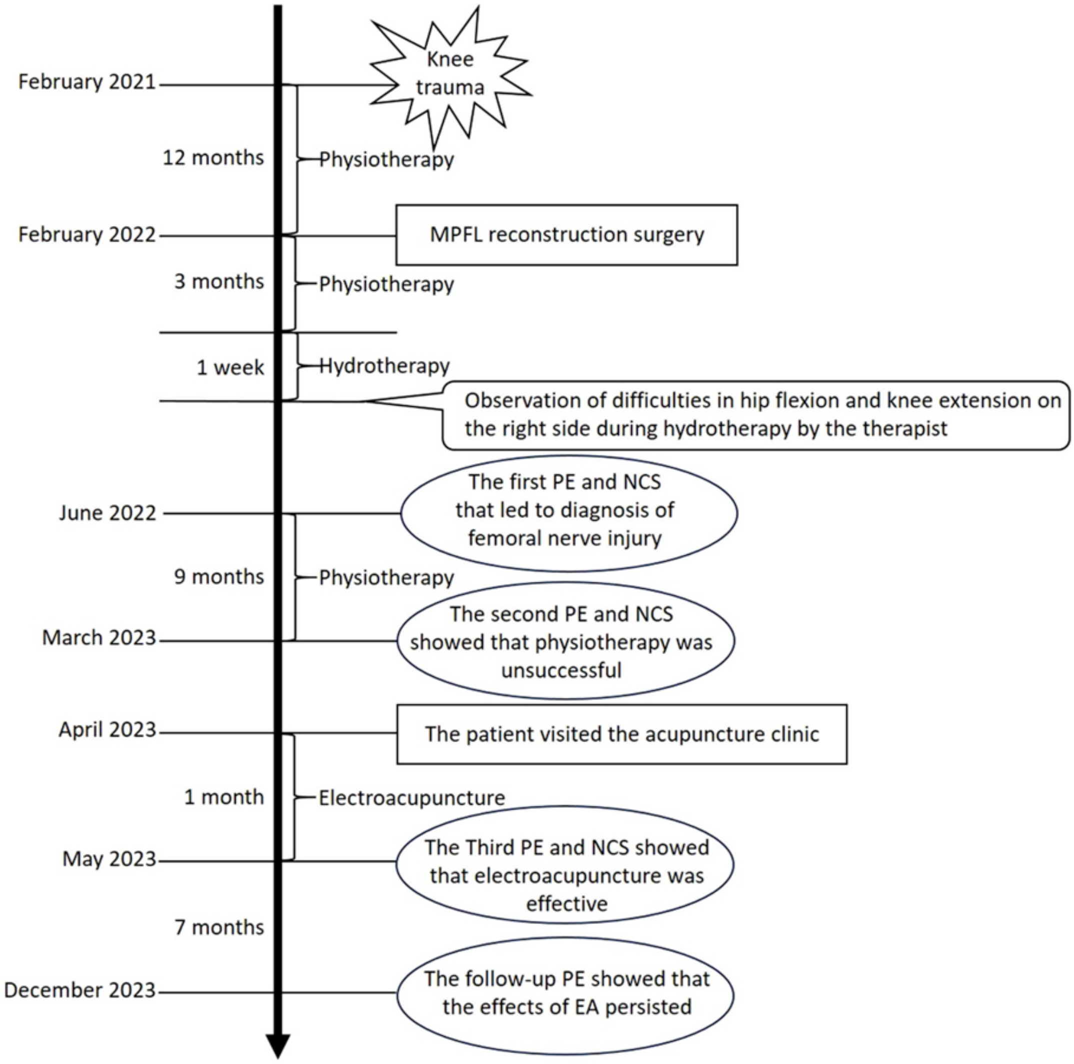


**Figure1.** Timeline of the patient's diagnosis, interventions, and outcomes. MPFL: medial patellofemoral ligament, PE: physical examination, NCS: nerve conduction study, EA: electroacupuncture.

mal on the left lower limb. Sensory examination showed severe hypoesthesia on the medial surface of the right leg. From a Traditional Chinese Medicine (TCM) viewpoint, the patient's pulse was full and rapid, and her tongue was red (slightly dark) without coating at the initial visit.

## *Diagnostic assessment and diagnosis*

The first NCS, conducted on June 13, 2022, identified impaired latency of the right saphenous nerve and electromyographic (EMG) findings suggestive of neuropathic changes in the right quadriceps femoris muscle, leading to a diagnosis of moderate neuropraxia of the right femoral nerve with a good prognosis. The second NCS, on March 18, 2023, showed significant reductions in amplitude and nerve conduction velocity between the right and left saphenous nerves, along with a neurogenic pattern on needle EMG in the iliopsoas and quadriceps femoris muscles. Combination of physical examination and electrodiagnostic findings led to a diagnosis of chronic right femoral nerve axonotmesis with rather poor prognosis.

## *Interventions*

On the first day of admission (April 29, 2023), the patient received plum blossom needle acupuncture treatment targeting the Bladder (BL13-28, BL36-40, and BL55-60) and Stomach (ST30-40) meridians bilaterally. Following disinfection with 75% alcohol, each acupoint was delicately tapped for about 5 seconds using a sterile, detachable, blunt-ended plum blossom needle (PBN), with the objective of eliciting skin flushing while minimizing bleeding. Throughout the procedure, it was crucial to maintain the needle tips in a consistent plane, perpendicular to the skin, and to achieve a swift upward bounce upon contact. The tapping force was applied gently, especially in superficial areas such as BL60, ensuring that the patient experienced little to no discomfort; while still facilitating effective penetration of the targeted area.

Two days after the initial treatment, EA therapy commenced, administered three times weekly. For this procedure, acupuncture needles (0.25 × 40 mm, Huan-Qiu disposable needle, China) were vertically inserted into designated acupuncture points including BL18/23/24/36/37/40/58/60 (in a prone position for 15 min.) and ST30/31/32/33/34/35/36/37, GB 30/31/32/33/34/39/40, SP6, and CV6 (in a supine position for 15 min.). The EA was facilitated by an electroacupuncture device (Great Wall, KWD808I, China), which served as the electrical generator, with the inserted needles acting as electrodes. On either side a proximal on each meridian (BL18, ST30, and GB30) functioned as the anode, and a distal needle on the same meridian (BL60, ST37, and GB40) served as the cathode. Low frequency (2 Hz) burst symmetrical monophasic square waves was used with the maximum intensity the patient could tolerate.

## *Follow-up and outcomes*

During the sixth acupuncture session, the patient excitedly demonstrated a slight ability to flex her right hip against gravity. Upon physical examination, she could fully flex the right hip joint on the horizontal plane. However, when subjected to gravity, flexion of the right hip was limited to approximately 60 degrees (Figure 2C). Additionally, she could move her right knee horizontally from full flexion to full extension. While seated on the edge of the bed, she managed to move her right knee from 90 degrees of flexion to nearly full extension against gravity (Figure 2D). Starting from the sixth acupuncture session, the patient engaged in corrective exercises three times a week to strengthen the iliopsoas and quadriceps muscles. After completing twelve acupuncture sessions, the patient underwent the third NCS on May 31, 2023. The results indicated normal SNAPs (sensory nerve action potentials) especially in right saphenous nerve, which means no major femoral lesion. However, neurogenic pattern in right quadriceps muscle was still observed during needle EMG, potentially indicative of a mild lesion in the right femoral nerve.

The patient returned to our clinic for a follow-up visit on


**Figure 2.** Active range of motion in the patient's right knee and hip joints before and after treatment. A) Before treatment, the patient was unable to extend her right bent knee or flex her right extended hip joint even in a horizontal plane (without the effect of gravity). B) Before treatment, the patient's attempt to extend her right knee while sitting on the edge of the bed (knee extension against gravity) did not result in any movement. C) After treatment, the patient was able to flex her right hip to 60 degrees in the supine position (against gravity) and at the same time fully extend her right knee. D) After treatment, the patient was able to extend her right knee almost completely against gravity while sitting on the edge of the bed.

December 21, 2023. During the physical examination, the strength of the quadriceps and iliopsoas muscles were within normal limits, and no sensory disturbances were noted on the medial side of her right leg. The patient refused to repeat the NCS examinations.

## Discussion

Clinically, injuries to the femoral nerve are marked by deficits in both motor and sensory functions. Motor impairment manifests as paresis or paralysis of the quadriceps muscle, severely limiting or abolishing knee extension. Severe limitation or abolition of hip flexion can also be observed due to paralysis of the iliopsoas muscle. Additionally, the patellar reflex is significantly diminished or absent. Regarding sensory function, lesions of the femoral nerve lead to hypoesthesia or paresthesia within its distribution territory—specifically, the anterior and medial aspects of the thigh and the medial side of the leg. Due to the sensory innervation overlap between the femoral and obturator nerves in the thigh, the medial side of the calf serves as the specific region for assessing femoral nerve sensory disturbances. Diagnostic evaluations typically include nerve conduction studies (NCS) and needle electromyography (EMG) to ascertain the severity, location, and prognosis of the peripheral nerve injury [2]. Our reported case had all the physical examination criteria of femoral nerve injury at her first visit to the acupuncture clinic, which completely improved after EA treatment. Although the patient's nerve conduction studies, prepared at each stage by a different specialist, allow comparison of results and general interpretations, they do not allow comparison of details due to differences in tools and operators. Patient nerve conduction study reports will be provided upon request.

The femoral nerve injury may be due to laceration, compression, stretching, or ischemia [6]. The classification system for peripheral nerve injuries, aiding in prognosis and treatment strategy determination, was initially described by Seddon in 1943, encompassing neurapraxia, axonotmesis, and neurotmesis. Sunderland expanded this classification in 1951 to five degrees by further subdividing neurotmesis into three levels of severity based on damage to the endo-, peri-, and epineurium [11].

Iatrogenic damage to the femoral nerve can occur as a complication of common orthopedic, abdominal, and pelvic surgeries [2]. The mechanisms of injury can range from direct trauma and ischemia to nerve compression or stretching of the nerve, while anatomical variations seldom being the cause. Although the prognosis is favorable in most instances, some patients may necessitate nerve repair or grafting and some may experience permanent residual neurological deficits [12]. In our case study, prolonged use of a pneumatic tourniquet may have resulted in femoral nerve compression and subsequent injury.

The spectrum of treatments for PNI varies from conservative methods to surgical procedures. Electrical stimulation (ES) techniques, notably EA, as the most common non-surgical treatment used in neuropraxia and axonotmesis, offering a safe and effective option for most patients [13]. Most studies employed low-frequency ES to enhance nerve regeneration [14].

Inoue (2003) investigated the impact of a novel treatment method utilizing EA with intermittent direct current (DCEA) on peripheral nerve regeneration in animal models. The findings revealed that DCEA with a distal cathode and a proximal anode has a positive effect on accelerating peripheral nerve regeneration [7]. According to the preliminary results of this previous animal study, Inoue et al, (2011) used DCEA (with the cathode distal and the anode proximal to the lesion site) to treat seven patients with motor paralysis resulting from PNI [8]. Throughout the treatment process, complete restoration of motor function was observed in four cases (comprising two instances of possible neurapraxia and two cases of axonotmesis). One case of axonotmesis was not included in the analysis due to premature termination of treatment. In two remaining cases (one axonotmesis and one neurotmesis), where EA treatment commenced more than one year post-injury, no improvement was noted even after several months of treatment [8].

Peripheral nerve injury causes the axon of a neuron to be divided into two segments, distal and proximal to the injury site. The distal portion starts to an anterograde degenerate called Wallerian degeneration. However, the proximal segment can sprout with the speed of 1-3 mm per day through a complicated process called staggered axonal regeneration [15]. Sometimes, under special circumstances, the proximal segment of the damaged axon not only does not regenerate, but also destructive changes occur in its cell body. In these circumstances, injuries of motor or sensory peripheral nerves cause apoptosis in spinal motor neurons (ventral horn) and sensory spinal ganglion neurons, respectively [16]. It is shown that neurotrophic factors such as Glial cell-derived neurotrophic factors (GDNF), Brain-derived neurotrophic factors (BDNF), and Nerve growth factor (NGF) could decrease apoptosis and alleviate PNI *in vitro* and in animal models [17-19]. ES stimulates Schwann cells (SCs) to secrete glutamate, which can increase intracellular $Ca^{2+}$ concentration, leading to the increased activity of BDNF, a $Ca^{2+}$-dependent protein. Glutamate can also increase SC-derived exosomes, including mRNA, miRNA, and protein cargoes, which can facilitate axonal regeneration, as confirmed by in vitro and in vivo studies [20, 21]. EA could significantly promote facial nerve regeneration by upregulating the expression of GDNF and N-cadherin (a calcium-dependent protein) in neurons, inhibiting neuronal apoptosis in rabbits [22]. Furthermore, EA enhances BDNF and tropomyosin receptor kinase B (TrkB) expression, which, through a $Ca^{2+}$-dependent mechanism, upregulates cyclic AMP (cAMP) expression. The activation of various neurotrophin signaling pathways by cAMP response element-binding protein (CREB) culminates in the nucleus, where CREB boosts the expression of regeneration-associated genes like growth-associated protein-43 (GAP-43), T$\alpha_1$ tubulin, and F-actin [23,24].

Precision treatment tailored to the patient's specific condition is crucial in managing peripheral nerve injuries. Among the myriad of interventions, acupuncture stands out for its significant anti-inflammatory properties and ability to expedite nerve repair.

The most important limitation of this study was the fact that NCS was performed before and after treatment by two different specialists, as well as the patient's refusal to perform NCS during the follow-up period. Conducting a three-arm controlled clinical trial (real acupuncture, sham acupuncture, and conventional treatment) in future research could better reveal the effect of acupuncture on the treatment of femoral nerve injury.

## Conclusions

After completing twelve EA sessions, the strength of the quadriceps and iliopsoas muscles and active range of motion in hip flexion and knee extension on the right side returned to normal limits, no sensory disturbances were noted on the medial side of her right leg. NCS did not show any major damage to the right femoral nerve. In conclusion, this case report provides clinical and NCS evidence that EA may be effective in treatment of a chronic severe femoral nerve injury.

## Conflict of Interests

The authors declare no conflict of interest.

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