Effect of Neuromodulation in Functional Recovery of Injured Sciatic Nerve

Ahmed Zaki Obaid[1]*, Mortada Abdulhussien Jubara[2], Mohammad Salem Yahya[3], Ghassan Faris Idan[4]
[1]M.B.Ch. B, CABA & IC, Arab Council of Interventional Pain Management, Baghdad Medical City Complex, Nursing Home Hospital, Baghdad, Iraq
[2]M. B. Ch. B, FICMS, Chairman of Iraqi Council of Regional Anesthesia and Interventional Pain Management, Medical City Complex, Nursing Home Hospital, Baghdad, Iraq
[3]M.B. Ch. B, CABA & IC, CJBA & IC, Arab Council of Interventional Pain Management Baghdad Medical City Complex, Nursing Home Hospital, Baghdad, Iraq
[4]Mbchb. caba & ic, pain and neuromodulation specialist /Iraq
Email: ahmzak.86@gmail.com

Abstract
Background: Neuromodulation is an expanding area of pain medicine that incorporates an array of non-invasive, minimally invasive, and surgical electrical therapies. **Aim of the study:** To evaluate the effectiveness of radiofrequency in the management of sciatic nerve injury. **Patients and method:** A clinical therapeutic trial study was conducted in Iraq, Baghdad, during the period from the 1st of April to the 1st of October 2022. Sampling method and inclusion criteria: A convenient sample of 25 patients aged ≥18 years and presented with sciatic nerve injury were enrolled in the current study. The intervention included pulse radiofrequency, motor stimulation, and sensory stimulation for two sessions at three months intervals. **Results:** There was a significant increase in the proportion of patients with mild nerve injury significant decrease in the proportion of patients with sensory impairment after the second session as revealed by electromyography assessment and clinical examination. In addition, the participants had a significantly lower level of pain as estimated by the visual analogue score after the first and second sessions. **Conclusion:** Pulsed radiofrequency and nerve stimulation can be used as coast effective and safe treatment of functional disability of pripheral nerve injury including sciatic nerve and management of pain associated with these injuries.
Keywords: Neuromodulation, Functional Recovery, Sciatic Nerve

1. Introduction

The sciatic nerve is the nerve of the posterior compartment of the thigh formed in the pelvis from the ventral rami of the L4 to S3 spinal nerves. It is about 2 cm wide, leaves the pelvis through the greater sciatic foramen below the piriformis and descends between the greater trochanter and ischial tuberosity in the gluteal region[1]. At the level of the upper angle of the popliteal fossa, the sciatic nerve divides into the common peroneal nerve and the tibial nerve[1, 2].

Sciatic nerve palsy may present with a wide range of clinical findings. Sensory manifestations include posterior thigh pain at the level of the sciatic notch, radicular pain along the sciatic nerve distribution with hip and knee range of motion, diminished sensation, and paresthesias. Motor manifestations include weakness or paralysis of muscles innervated by the sciatic nerve[3].

Peripheral nerve injuries are commonly encountered as a clinical problem and often result in chronic pain and severe functional deficit[4]. Stretch, compression, ischemia, and direct damage are the chief mechanisms[5]. Sciatic nerve injuries can result from a variety of trauma, autoimmune, musculoskeletal, and iatrogenic etiologies. Traumatic hip and hip fracture dislocations are frequent causes of such injuries at this level, occurring in approximately 10% of all cases of hip fractures[6].

Serious sciatic nerve injury can result from improperly performed injections into the buttocks. Older patients are more susceptible to injection-induced sciatic nerve injury because of their decreased muscle mass or the presence of debilitating disease[7]. In addition, it can occur in frog leg position in vertebral surgeries, and prolonged surgeries in the sitting position. Hyperflexion of the hip, and abduction and extension of the leg cause the stretching of the sciatic nerve. Hyperflexion of the lower limbs is commonly done in patients with sitting position craniotomy[8].

The International Neuromodulation Society (INS) defines neuromodulation as a "field of science, medicine, and bioengineering that encompasses implantable and non-implantable technologies, electrical or chemical, to improve the quality of life and functioning of humans". At present, neuromodulation implantable devices are either neural stimulators or micro-infusion pumps[9].

Neuromodulation is an expanding area of pain medicine that incorporates an array of non-invasive, minimally invasive, and surgical electrical therapies. These therapies include deep brain and motor cortex stimulation, peripheral nerve stimulation, and the non-invasive treatments of repetitive transcranial magnetic stimulation, transcranial direct current stimulation, and transcutaneous electrical nerve stimulation[10].

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Peripheral nerve stimulation is a neuromodulation technique in which an electrical current is applied to the peripheral nerves to ameliorate chronic pain through preferential activation of myelinated fibres, inducing long-term depression of synaptic efficacy[11].
To date, there has been Food and Drug Administration approval for temporary peripheral nerve stimulation for up to 60 days for the treatment of chronic pain, post- surgical pain, and post-traumatic pain of the back and/or extremities. In addition, it is approved for the treatment of peripheral mononeuropathy that is not responsive to the best medical management and for complex regional pain syndrome and phantomlimb pain[12].
Pulse radiofrequency is an interventional pain management technique that has been effective in the treatment of thoracic postherpetic neuralgia, trigeminal neuralgia, and radicular pain due to nerve injury. Pulse radiofrequency delivers a low-energy electrical field in rapid pulsations to target nerve tissue and associated microglia. Compared to high-temperature radiofrequency ablation, pulse radiofrequency is not ablative, but instead neuromodulating(13).
Aim of the study: To evaluate the effectiveness of sciatic nerve stimulation and pulse radiofrequency in the management of sciatic nerve injury.

2. Patients and Method

Study design and setting: A clinical therapeutic trial study was conducted in Baghdad, Iraq during the period from the 1st of April to the 1st of October 2022.
Sampling method and inclusion criteria: A convenient sample of 25 patients aged
≥18 years and presented with sciatic nerve injury were enrolled in the current study.

Exclusion criteria

1. Coagulopathy with INR > 1.5 and platelet counts < 50,000 per mm³ are absolute contraindications.
2. Patients with metastases involving more than one organ or tumour positionclose to essential structures, such as bowel, gallbladder, major bile duct, ureter, spinal cord, nerve or major blood vessels.

Intervention

A full medical history taking and physical examination including visual analoguescale to assess the severity of the pain were done for each patient. In addition, all patients had electromyography to evaluate the severity and extent of the sciatic nerveinjury.
Non-invasive monitoring including blood pressure cuff, pulse oximeter, was conducted on the patients with continuous monitoring of them during procedures.
The sciatic nerve was identified under ultrasonographic guidance with tracing of three points for application of the nerve stimulation and pulse radiofrequency (proximal to the site of injury, at the site of injury, and distal to the site of injury).

A sensory stimulation test was performed

Sensory stimulation was applied to the three sites with 10-20 pers of stimulation up to three volts or according to the patient's compliance. Motor stimulation was applied to the three sites for 10 minutes up to 3 volts or according to the patient's compliance. Pulsed radiofrequency was applied at a temperature of 42°C for 4 minutes for the three sites. These procedures were repeated 2-3 times per section fortwo sessions at three months intervals.
After the procedure, 2% Xylocaine (1 mL) was mixed with 40 mg Depo-Medrol Vial and diluted in normal saline to 8 mL and injected to prevent peri-neural inflammation. After the second section, another assessment was done for the patients by clinical examination, visual analogue scale, and electromyography.

Definition of vairables

The visual analogue scale (VAS) is a validated, subjective measure of acute and chronic pain. Scores are recorded by making a handwritten mark on a 10-cm line that represents a continuum between "no pain" and "worst pain"(14).

Ethical consideration

The research was approved by the Scientific Council of Anaesthesia and Intensive Care of the Arabic Board of Medical Specializations. Written consent wasobtained from each patient before the recruitment.

3. Statistical Analysis

The collected data were analyzed using Microsoft Excel software. The descriptive analysis focused on frequencies and percentages. Categorical data were presented as
proportions and the chi-square test and t-test were used for the difference between the two proportions. A P-value of less than 0.05 was considered statistically significant.

4. Results

A total of 25 patients were enrolled in the current study, males constituted the largest percentage of the sample (64%), as shown in table 1.

Table 1: Age and gender distribution of the participants

		Mean	SD
Gender	Male	16	64.0
	Female	9	36.0
Age group	18-30	2	8.0
	31-40	5	20.0
	41-50	8	32.0
	>50	10	40.0

There was a significant decrease in the proportion of patients with sensory impairment after the first session and a significant decrease in this proportion after the second session compared to the first session, as shown in figure 3.

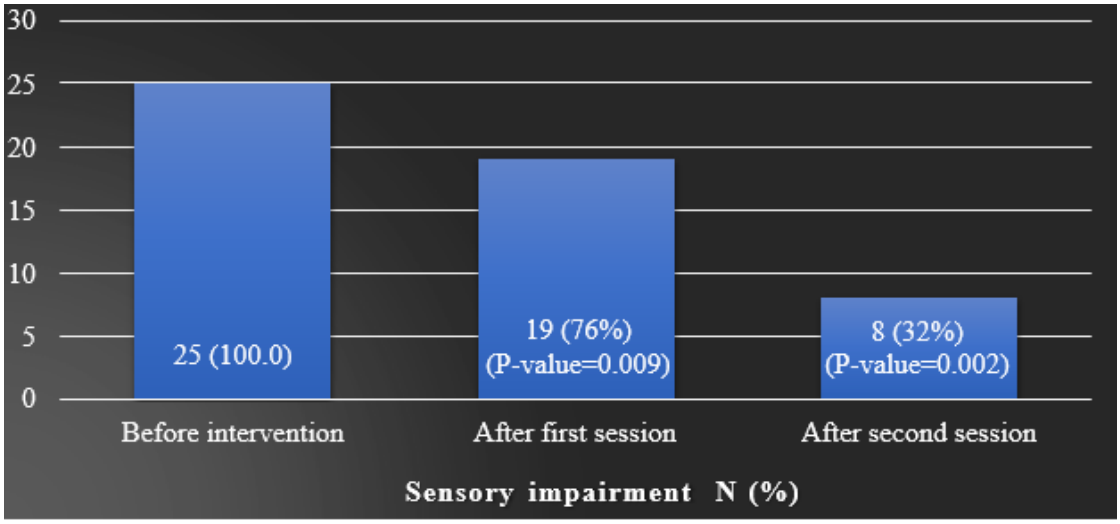

Figure 3: Sensory improvement after intervention

There was a significant decrease in the proportion of patients with severe injury after the first session as revealed by electromyography assessment and clinical examination. After the second session, there was a significant increase in the proportion of patients with mild motor injury compared to the first session (P- value=0.019) (Table 2).

Table 2: Motor improvement after the intervention			
Motor injury	Before intervention N (%)	After first session N (%)	P-value
Severe injury	13 (52.0)	4 (16.0)	0.007
Moderate injury	10 (40.0)	16 (64.0)	0.092
Mild injury	2 (8.0)	5 (20.0)	0.226
	After first session N (%)	After second session N (%)	
Severe injury	4 (16.0)	1 (4.0)	0.161
Moderate injury	16 (64.0)	11 (44.0)	0.160
Mild injury	5 (20.0)	13 (52.0)	0.019

An improvement was obtained in the pain as estimated by the VAS score after the first session and after the second session compared to the first session (Table 3 and figure 2)

Figure 1: Severity of injury of the participants before and after intervention			
	Before intervention	After first session	P-value
	Mean (SD)	Mean (SD)	
VAS score	4.8 (1.4)	3.2 (1.2)	0.001
	After first session	After second session	
	Mean (SD)	Mean (SD)	
VAS score	3.2 (1.2)	1.9 (0.9)	0.001

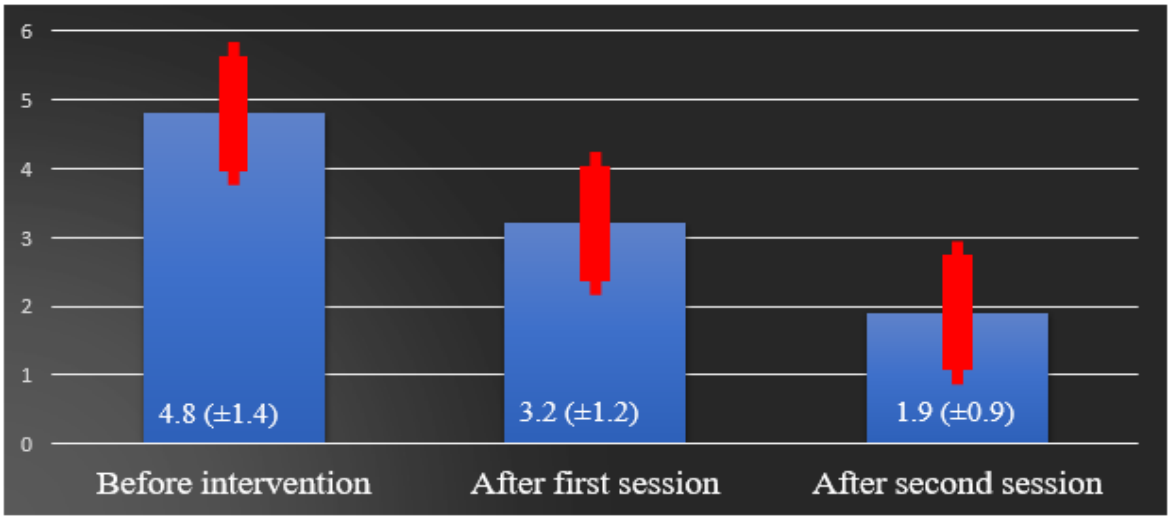

Figure 2: Pain improvement according to VAS score

5. Discussion

Many previous reports already demonstrated the usefulness of pulse radiofrequency in the management of peripheral neuropathies. Best to our knowledge[15, 16], this was the first study in Iraq to assess the effectiveness of pulse radiofrequency in the management of sciatic nerve injury.

In the current study, a significant improvement in functional disability was obtained after one session of pulsed radiofrequency. In comparison, the same results were obtained by another study that was done by Yi et al. in Korea[17]. Vallejo et al. indicate that the electromagnetic energy applied via PRF therapy influences the reversal of behavioural and molecular effects of hypersensitivity developed from a peripheral nerve injury[18].

After the intervention, there was a significant decrease in the pain sensation of the patients as recorded by the VAS score. In agreement, pulse radiofrequency is a minimally invasive and simple to perform procedure with compelling evidence in the management of cervical radicular pain. At the same time, the application of pulse radiofrequency for the treatment of lumbar radicular pain is a safe intervention that has shown good results in providing intermediate-term relief of pain with no complications[19]. It was found that pulsed radiofrequency impacts many different biological pathways involved in the modulation of chronic neuropathic pain (neuralgia)[13]. In agreement, Ren et al. pulse radiofrequency temporarily attenuates neuropathic and inflammatory pain[20].

In conclusion, pulsed radiofrequency and nerve stimulation can be used as coast effective and safe treatment of functional disability of prereferral nerve injury including sciatic nerve and management of pain associated with these injuries.

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