Effect of flipped venous catheter combined with spinal cord electrical stimulation on functional recovery in patients with sciatic nerve injury

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Abstract. – OBJECTIVE: This study aimed to explore the effect of flipped venous catheters combined with spinal cord electrical stimulation on functional recovery in patients with sciatic nerve injury.

PATIENTS AND METHODS: 160 patients with hip dislocation and sciatic nerve injury were divided into conventional release and flipped catheter + electrical stimulation groups according to the treatment methods (n=80). Motor nerve conduction velocity (MCV) and lower limb motor function were compared. Serum neurotrophic factors brain-derived neurotrophic factor (BDNF) and nerve growth factor (NGF) were compared. The frequency of complications and quality of life were also compared.

RESULTS: The MCV levels of the common peroneal nerve and tibial nerve in the flipped catheter + electrical stimulation group were greater than the conventional lysis group (p<0.05). After treatment, the lower extremity motor score (LMEs) in the flipped catheter + electrical stimulation group was greater than the conventional lysis group (p<0.05). The serum levels of BDNF and NGF in the flip catheter + electrical stimulation group were higher than the conventional lysis group (p<0.05). The complication rate in the flipped catheter + electrical stimulation group was lower than in the conventional release group (6.25% *vs.* 16.25%, p<0.05). The quality-of-life score in the flip catheter + electrical stimulation group was greater than the conventional lysis group (p<0.05).

CONCLUSIONS: The flipped venous catheter combined with spinal cord electrical stimulation can improve nerve conduction velocity, lower limb motor function, serum BDNF and NGF levels, reduce complications, and help improve the quality of life of sufferers with sciatic nerve injury. Chictr.org.cn ID: ChiCTR2400080984.

Key Words:

Flipped venous catheter, Spinal cord electrical stimulation, Sciatic nerve injury, Functional recovery, Influence.

Introduction

The sciatic nerve is the thickest nerve in the human body. It starts from the lumbosacral spinal cord, passes through the pelvis, penetrates through the sciatic foramen, reaches the hip, and then descends along the back of the thigh to the foot[1]. The sciatic nerve can control the lower limb muscle sensory and motor function; acetabular fracture, hip dislocation, and other bone injuries can lead to sciatic nerve injury[2]. The sciatic nerve injury can affect the lower limb function, and in serious cases, it can also lead to the loss of lower limb function, causing serious prognosis for sufferers quality of life and prognosis[3,4]. Many sciatic nerve injuries occur at the proximal end of the nerve, that is, at the level of the sciatic notch, hip and thigh, and most cases are accompanied by fracture, local contusion, or impact injury[5]. Whether at the hip or thigh level, the sciatic nerve is generally divided into the tibial nerve and common peroneal nerve to facilitate the evaluation and repair, respectively, which is very important for repairing the nerve injury existing in nerve continuity[6]. If it is a sharp cutting injury, the nerve should be repaired as soon as possible, and its treatment effect is also ideal. At present, the clinical choice of epineural neurolysis or interfascicular neurolysis can reduce and improve sciatic nerve function, but the treatment effect of some patients is not ideal, and the prognosis is not satisfactory[7,8].

It has been reported that creating a suitable biomimetic microenvironment for nerve regeneration may help nerve injury regeneration and repair, thereby improving the efficacy of peripheral nerve repair[9].

Rotating the venous catheter can facilitate direct contact between the venous adventitia and

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regenerated nerve fibers, thereby increasing the availability of Schwann cells for nerve fiber regeneration, ultimately promoting the process of nerve regeneration[10]. Spinal cord electrical stimulation treatment is the most advanced minimally invasive treatment of spinal cord injury in modern medicine. By implanting electrode wires into the spinal epidural space, it transmits current to the spinal cord for low-voltage electrical stimulation, blocks the flow of peripheral nerve impulses to the central nervous system, inhibits abnormal sensory signals such as pain, and achieves the effect of relieving and eliminating pain[11,12]. Previous studies[13] have confirmed that spinal cord electrical stimulation could help increase the excitability of spinal cord circuits by activating transcutaneous spinal cord stimulation, helping motor neurons reach the threshold, and promoting the recovery of neuromotor activity. In this study, we selected 160 patients with hip dislocation + sciatic nerve injury admitted to our hospital from September 2020 to September 2023 as the observation subject, and we aimed to analyze the effect of flipped venous catheter combined with spinal cord electrical stimulation on the functional recovery of patients with sciatic nerve injury.

Patients and Methods

General Information

This clinical trial was registered at the Chinese Clinical Trial Registry (https://www.chictr.org.cn/searchproj.html), with the number ChiCTR2400080984. A total of 160 patients with hip dislocation + sciatic nerve injury admitted to our hospital between September 2020 and September 2023 were included. Inclusion criteria: (1) all sufferers matched the clinical diagnostic criteria for sciatic nerve injury[14], and all underwent sciatic nerve release; (2) ages from 20 to 60 years old; (3) complete clinical data without loss. Exclusion criteria: (1) the presence of a malignant tumor; (2) patients unable to cooperate with the study therapists; (3) patients undergoing other treatments; (4) important organs' organic lesions. Based on the treatment ways, the patients were divided into the conventional neurolysis group (sciatic nerve neurolysis, n=80) and the flipped catheter + electrical stimulation group (the conventional neurolysis group was given the flipped venous catheter combined with spinal cord electrical stimulation, n=80).

In the conventional neurolysis group, there were a total of 80 patients, comprising 46 men and 34 women, with a mean age of (45.83±5.85) years and a mean BMI of (24.27±3.72) kg/m^2. Similarly, the flip catheter + electrical stimulation group consisted of 80 cases, with 50 men and 30 women, having a mean age of (46.01±4.04) years and a mean BMI of (24.38±3.16) kg/m^2. There were no significant differences in general characteristics between the groups (p>0.05).

Methods

The conventional neurolysis group was given sciatic nerve lysis: the patient was guided to take the contralateral decubitus position and was given epidural nerve block anesthesia. The gluteus maximus muscle was fully exposed through the posterior approach of the hip joint, and the sciatic nerve was passively isolated and exposed. The sciatic nerve was passively separated along the sciatic nerve to the greater trochanter of femur, iliotibial tract and bilateral branch nerve tissues, and the nerve adventitia was fully protected after surgery. The flipped catheter + electrical stimulation group was given the flipped venous catheter combined with spinal cord electrical stimulation based on the conventional lysis group: the sciatic nerve was observed, and the proximal and distal ends of the nerve were respectively placed into the venous catheter of 2 mm, and the 11-0 atraumatic suture was used for sleeve suture fixation of 4-6 needles respectively. A portable electro-treatment device was used for spinal cord electrical stimulation to guide the patient to take a sitting position. The stimulation electrode was placed at the level of the t11/t12 vertebral body, and the reference electrode was placed at the patient's umbilicus. Turn on the stimulator and adjust it. The patient found that the legs and feet were tingling so as to stimulate the activation of lower limb muscles. The stimulation lasted for 30 min.

Observation Indexes

(1) Nerve conduction velocity: electromyography was used to detect the motor nerve conduction velocity (MCV) of the common peroneal nerve and tibial nerve of patients before and after treatment.

(2) Lower extremity motor function: the lower extremity motor score (LMEs) was used before and after treatment. The total score of the unilateral lower extremity was 25. The motor function of the unilateral lower extremity of the affected limb was detected. The greater the point, the greater the motor function of lower extremity of the patient.

(3) Serum neurotrophic factors: the expression levels of BDNF and NGF were detected by ELISA before and after treatment in the two groups. It is possible to observe the result directly with the naked eye on a white background. The darker the color in the reaction hole, the stronger the positive degree. The negative reaction is colorless or very light. OD value could also be measured on the ELISA detector at 450 nm. The OD value of each well was measured after zeroing with the blank control well.

(4) Complications: closely monitor the condition changes of the two groups, record and compare the complications of constipation, pressure sores, wound infection, urinary system infection, and so on.

(5) Life quality: the life quality of the sufferers was evaluated, including 4 items, with all points of one hundred. The point was proportional to the quality of life. The evaluation time was before and after treatment in the two groups.

Statistical Analysis

SPSS 20.0 software (IBM Corp., Armonk, NY, USA) was used to analyze the data of this research. The measurement data are expressed as means ± standard deviation (SD), and the *t*-test is used for comparison between the two groups. Count data are expressed as numbers (%), and a comparison between the two groups is carried out using χ^2 test. $p<0.05$ was statistically different.

Results

The Impact of Flipped Venous Catheter Combined with Spinal Cord Electrical Stimulation on Nerve Conduction Velocity

There was no distinction in nerve conduction velocity between the two groups at pre-treatment ($p>0.05$). After treatment, the MCV levels of the common peroneal nerve and tibial nerve in the two groups were improved, and the MCV levels of the usual peroneal nerve and tibial nerve in the flipped catheter + electrical stimulation group were greater than those of the conventional lysis group ($p<0.05$, Table I).

The Effect of Flipped Venous Catheter Combined with Spinal Cord Electrical Stimulation on Lower Limb Motor Function

There was no significant difference in LME scores between the two groups at pre-treatment ($p>0.05$). After treatment, the LMEs score in the flipped catheter + electrical stimulation group was greater than the conventional lysis group ($p<0.05$, Table II).

The Effect of Flipped Venous Catheter Combined with Spinal Cord Electrical Stimulation on Serum Neurotrophic Factor

There was no significant difference in the levels of BDNF and NGF between the two groups before treatment ($p>0.05$). After treatment, the serum levels of BDNF and NGF in the flip catheter + electrical stimulation group were higher than in the conventional lysis group ($p<0.05$, Table III).

The Effect of Flipped Venous Catheter Combined with Spinal Cord Electrical Stimulation on Complications

The complication rates in the conventional release group and the flipped catheter + electrical stimulation group were 16.25% and 6.25%, respectively. The complication rate in the flipped catheter + electrical stimulation group was less than the conventional release group ($p<0.05$, Table IV).

Table I. Effect of flipped venous catheter combined with spinal cord electrical stimulation on nerve conduction velocity

Groups	Cases	MCV of common peroneal nerve (m/s)		Tibial nerve MCV (m/s)	
		Before treatment	After treatment	Before treatment	After treatment
Conventional lysis	80	32.18±3.15	38.49±3.42[a]	36.27±2.25	39.86±3.08[a]
Flip catheter + electrical stimulation	80	31.98±4.16	46.75±2.19[a]	35.67±2.44	43.52±2.78[a]
t		0.343	18.192	1.617	7.890
p		0.732	<0.001	0.108	<0.001

Compared with the same group before treatment, [a]$p<0.05$. Motor nerve conduction velocity (MCV).

Table II. The lower limb motor function compared between the two groups before and after intervention.

Groups	Cases	LMEs score	
		Before treatment	After treatment
Conventional lysis	80	13.28±2.18	17.85±6.13[a]
Flip catheter + electrical stimulation	80	12.97±3.05	21.54±7.03[a]
t		0.740	3.539
p		0.461	0.001

Compared to the same group at pre-treatment, [a]$p<0.05$. Lower extremity motor score (LMEs).

Table III. Effect of flipped venous catheter combined with spinal cord electrical stimulation on serum neurotrophic factor.

Groups	Cases	BDNF (μg/L)		NGF (μg/L)	
		Before treatment	After treatment	Before treatment	After treatment
Conventional lysis	80	27.24±4.31	35.34±3.80[a]	53.10±18.52	67.73±14.39[a]
Flip catheter + electrical stimulation	80	27.15±2.35	40.64±4.60[a]	49.35±14.29	72.23±10.80[a]
t		0.164	7.945	1.434	2.291
p		0.870	<0.001	0.154	0.023

Compared to the same group at pre-treatment, [a]$p<0.05$. Brain-derived neurotrophic factor (BDNF), nerve growth factor (NGF).

Table IV. Effect of flipped venous catheter combined with spinal cord electrical stimulation on complications (cases, %).

Groups	Cases	Constipation	Pressure sores	Wound infection	Urinary tract infection	Total occurrence
Conventional lysis	80	3 (3.75)	3 (3.75)	4 (5.00)	3 (3.75)	13 (16.25)
Flip catheter + electrical stimulation	80	1 (1.25)	1 (1.25)	2 (2.50)	1 (1.25)	5 (6.25)
χ^2						4.006
p						0.045

The Effect of Flipped Venous Catheter Combined with Spinal Cord Electrical Stimulation on Life Quality

The life quality score in the flip catheter + electrical stimulation group after treatment was greater than the conventional lysis group ($p<0.05$, Table V).

Discussion

Sciatic nerve injury is one of the common complications of hip injury. It not only damages the motor and sensory functions of the lower limbs but also may lead to atrophy of the surrounding muscles. Long-term sciatic nerve injury may also

Table V. Effect of flipped venous catheter combined with spinal cord electrical stimulation on quality of life.

Groups	Cases	Social life	Sleep emotion	Physical activity	Energy
Conventional lysis	80	76.08±4.51	75.43±5.16	72.18±5.43 a	74.51±4.19[a]
Flip catheter + electrical stimulation	80	91.33±5.28	92.05±6.33	88.57±4.27 a	92.38±5.04[a]
t		19.643	18.203	21.222	24.387
p		<0.001	<0.001	<0.001	<0.001

Compared to the same group at pre-treatment, [a]$p<0.05$.

be complicated by nerve and secondary ischemia, scar adhesion, etc., which can also lead to the loss of lower limb motor function and affect the life quality of sufferers[15-17]. The etiology of sciatic nerve injury is clear and diverse. Common pathogenic factors include physical factors such as traffic accidents, hip knife injuries or hip surgery that damage the sciatic nerve, and chemical factors such as hip drug injection that cause sciatic nerve injury[18-20]. The disease tends to occur in those who encounter traffic accidents, hip knife injuries, hip surgeries, hip drug injection injuries, and can be induced by mental factors.

Sciatic nerve release can relieve sciatic nerve compression, help nerve cell regeneration, and help restore sciatic nerve function, but the effect is not ideal when applied alone, and some patients have a poor prognosis. Finding ways to help patients with sciatic nerve function recovery has become the focus of medical staff in bone surgery[21,22]. Spinal cord electrical stimulation can stimulate Schwann cells by giving the body a weak current, promoting the growth of neuronal axons, and helping nerve regeneration and recovery so as to play the effect of nerve rehabilitation. Moreover, spinal cord electrical stimulation has the advantages of simple operation, safety, and effectiveness and it is currently widely used in spinal cord injury, neuralgia, and other aspects[23,24]. Some studies[25] believe that spinal cord electrical stimulation can effectively relieve pain in patients with postherpetic neuralgia, and the medium and long-term curative effect is better. Flipping the venous catheter can adjust the direct contact between nerve fibers and venous adventitia. Parasympathetic and sympathetic nerve fibers, which are widely distributed in the venous adventitia, provide a large number of Schwann cells, which can help regenerate injured nerve fibers and provide a good environment for nerve repair[26,27]. In this research, after treatment, the MCV levels of the common peroneal nerve and tibial nerve in the flipped catheter + electrical stimulation group were greater than the conventional lysis group, and the LMEs score level of the affected side in the flipped catheter + electrical stimulation group was greater than the conventional lysis group. It shows that a flipped venous catheter combined with spinal cord electrical stimulation can improve nerve conduction velocity and lower limb motor function in patients with sciatic nerve injury. The reason is that a flipped venous catheter can provide Schwann cells, Schwann cell basement membrane, and a large number of collagen and laminin substances, providing a good environment for sciatic nerve repair, while spinal cord electrical stimulation can stimulate Schwann cell activation and accelerate neuronal growth. The two methods work together synergistically to promote rehabilitation of the sciatic nerve.

BDNF and NGF are members of the neurotrophin family and are essential brain signaling molecules in synapse maturation, axon targeting, synaptic plasticity, and neuronal growth. BDNF, a neuroprotective agent widely present in the central nervous system, can repair damaged neurons. BDNF plays a role in the nervous system's functions, learning and memory, emotion regulation, reproductive system, and diabetes control[28,29]. BDNF is involved in the plasticity and development of the peripheral nervous system (PNS) and central nervous system (CNS) because it affects not only differentiation and proliferation but also synaptic activity and neurotransmission. NGF is important for neuronal sensation in adult injured tissues, and gene expression changes caused by NGF may have an impact on phenotypic changes[30]. Studies[31,32] have shown that NGF is famous for affecting the phenotype of mature sleep receptor receptors and the normal development of the embryonic nervous system[31], and the change of NGF level is related to the pathophysiology of chronic pain, for example, neuropathic pain[32]. The outcomes of this research show that the serum levels of BDNF and NGF in the flipped catheter + electrical stimulation group after treatment were greater than in the conventional lysis group, suggesting that the flipped venous catheter combined with spinal cord electrical stimulation could have improved the neurological function of patients with sciatic nerve injury. Injury to the sciatic nerve causes severe pain and impairs motor function in patients. This limits their ability to perform daily activities and work normally. Moreover, prolonged lower limb sports injury can lead to complications such as pressure sores and urinary system infections, which can negatively affect the patient's quality of life and overall prognosis[33]. In this research, the complication rates of sufferers in the conventional release one and the flipped catheter + electrical stimulation group were 16.05% and 7.21%, respectively. The complication rate of the flipped catheter + electrical stimulation group was less than the conventional release one, and the life quality score of patients in the flipped catheter + electrical stimulation group was greater than the conventional release one after treatment. It shows that a flipped venous catheter combined with spinal cord electrical stimulation can accelerate the recovery of lower limb sensory and motor functions, reduce the occurrence of complications caused by lower limb movement disorders, improve muscle atrophy, and improve the quality of life of sufferers, which is similar to the outcomes of relevant studies[34]. This research believes that low-frequency electrical stimulation combined with rehabilitation training in the treatment of neurogenic bladder induced by spinal cord injury could have an effective improvement in the life quality of sufferers, reduce the incidence of complications, and have certain clinical application value.

Conclusions

In conclusion, a flipped venous catheter combined with spinal cord electrical stimulation can improve nerve conduction velocity and lower limb motor function, significantly increase serum BDNF and NGF levels, reduce complications, and help improve the quality of life of sufferers with sciatic nerve injury. Nevertheless, because of the short duration of this study, the impact of flipped venous catheters combined with spinal cord electrical stimulation on the long-term prognosis of sufferers with sciatic nerve injury has not been analyzed. In the future, experimental subjects will be expanded, and experimental time will be increased for further exploration.

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Authors' Contributions
Shaoyan Shi conceived the structure of the manuscript. Ke Jiang did the experiments and made the figures. Xuehai Ou reviewed and edited the manuscript. All authors read and approved the final manuscript.

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Availability of Data and Materials
The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics Approval
This study was conducted in accordance with the ethical regulations of the Declaration of Helsinki. The study was approved by the Ethics Committee of the Honghui Hospital, Xi'an Jiaotong University (No. 2021097523).

Conflict of Interest
The authors declare that they have no competing interests.

Informed Consent
All patients signed the informed consent form.

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