RESEARCH ARTICLE

Improvement in acupoint selection for acupuncture of nerves surrounding the injury site: electro-acupuncture with Governor vessel with local meridian acupoints

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Abstract

Peripheral nerve injury not only affects the site of the injury, but can also induce neuronal apoptosis at the spinal cord. However, many acupuncture clinicians still focus only on the injury site, selecting acupoints entirely along the injured nerve trunk and neglecting other regions; this may delay onset of treatment efficacy and rehabilitation. Therefore, in the present study, we compared the clinical efficacy of acupuncture at Governor vessel and local meridian acupoints combined (GV/LM group) with acupuncture at local meridian acupoints alone (LM group) in the treatment of patients with peripheral nerve injury. In the GV/LM group (n = 15), in addition to meridian acupoints at the injury site, the following acupoints on the Governor vessel were stimulated: *Baihui* (GV20), *Fengfu* (GV16), *Dazhui* (GV14), and *Shenzhu* (GV12), selected to treat nerve injury of the upper limb, and *Jizhong* (GV6), *Mingmen* (GV4), *Yaoyangguan* (GV3), and *Yaoshu* (GV2) to treat nerve injury of the lower limb. In the LM group (n = 15), only meridian acupoints along the injured nerve were selected. Both groups had electroacupuncture treatment for 30 minutes, once a day, 5 times per week, for 6 weeks. Two cases dropped out of the LM group. A good or excellent clinical response was obtained in 80% of the patients in the GV/LM group and 38.5% of the LM group. In a second study, an additional 20 patients underwent acupuncture with the same prescription as the GV/LM group. Electomyographic nerve conduction tests were performed before and after acupuncture to explore the mechanism of action of the treatment. An effective response was observed in 80.0% of the patients, with greater motor nerve conduction velocity and amplitude after treatment, indicating that electroacupuncture on specific Governor vessel acupoints promotes functional motor nerve repair after peripheral nerve injury. In addition, electromyography was performed before, during and after electroacupuncture in one patient with radial nerve injury. After a single session, the patient's motor nerve conduction velocity increased by 23.2%, indicating that electroacupuncture at Governor vessel acupoints has an immediate therapeutic effect on peripheral nerve injury. Our results indicate that Governor vessel and local meridian acupoints used simultaneously promote functional repair after peripheral nerve injury. The mechanism of action may arise from an improvement of the local microenvironment in injured nervous tissue, as well as immediate effects of Governor vessel and local meridian acupoint stimulation to ensure the continuity between the peripheral and central nervous systems.

Key Words: *nerve regeneration; peripheral nerve injury; acupuncture; electroacupuncture; Governor vessel acupoints; local acupoints; electrophysiology; spinal cord; motor nerve conduction; functional repair; neural regeneration*

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Introduction

Functional recovery of peripheral nerve injury is a slow process. This may be because of the length of time needed for neural regeneration and functional reconstruction, but treatment methods may also contribute to the delay in recovery (Jin et al., 2013; Ma et al., 2013). Clinicians often consider peripheral nerve injury as isolated local damage, and focus on treating the problem only at the site of the injury, especially when using non-drug therapies. In acupuncture, the acupoints selected are almost entirely along the injured nerve trunk (Chan et al., 1999; Dong et al., 2008; Sheng et al., 2008). However, peripheral nerve injury does not simply cause local damage (Gu et al., 2004), but can also induce apoptosis of individual spinal cord neurons in corresponding segments of the spinal cord (Gong, 2002; Lv et al., 2005; Wu et al., 2006; Lu et al., 2007). Neuronal apoptosis has little impact on the surrounding tissue structure, and the morphology and function of adjacent neurons or parts of glial cells remain normal. However, ignoring the treatment of spinal cord segment lesions may hinder a patient's rehabilitation. Based on the above understanding, clinicians should not only focus on local injury, but should also pay attention to the treatment of secondary apoptosis of spinal cord neurons. Therefore, the traditional prescription for clinical acupuncture, which only selects the acupoints around the local injury (Li et al., 2013; Xia et al., 2013), must be adjusted accordingly. Few studies have addressed this to date. Therefore, in the present study, we determined the efficacy of a novel acupoint principle compared with the traditional method, and discussed its possible mechanism.

According to the meridian theory, the Governor vessel extends along the center of the spine, overlapping the spinal cord. Spinal cord injury is therefore often thought to be associated with Governor vessel injury, and Governor vessel acupoints are usually selected to treat spinal cord injuries or diseases. The vessel can also stimulate local segments of spinal cord tissues, causing the secretion of large amounts of neurotrophin-3 (Zhang et al., 2012), which can provide a suitable microenvironment for spinal cord injury repair. Here, we selected Governor vessel acupoints to treat spinal cord lesions arising from peripheral nerve injury.

The purpose of the present study is to improve the clinical efficacy of acupuncture by enhancing our understanding of acupoint selection. Using an approach that diverges from the traditional acupoints principle, we selected Governor vessel acupoints located on the segment of apoptotic spinal cord neurons that corresponded to the injury site, in combination with the local acupoints around the injured nerve. We used electrophysiological tests to determine the repair status of the injured peripheral nerve and to investigate the electrophysiological mechanism underlying acupuncture therapy of peripheral nerve injury.

Subjects and Methods

Subjects

This study was approved by the Ethics Committee of the First Affiliated Hospital, Sun Yat-sen University, China. The study was divided into two stages: in the first stage, we compared the clinical efficacy of electroacupuncture at local meridian acupoints alone with acupuncture at Governor vessel and local meridian acupoints combined; in the second stage, we investigated electromyographic responses to the combined method. A total of 50 patients with peripheral nerve injury were enrolled from the Acupuncture Department of the First Affiliated Hospital of Sun Yat-Sen University, China in accordance with the diagnostic and inclusion criteria listed below. Thirty patients were recruited for the first stage and divided randomly (using a random number table) and equally into two experimental groups: local meridian acupoints alone (LM) and Governor vessel with local meridian acupoints (GV/LM) (**Table 1**).

For the second stage, an additional 20 patients were recruited. The demographic data for these 20 patients is shown in **Table 2**.

Diagnostic criteria

With reference to *Surgery* (Wu et al., 2006): (1) patient has sensory nerve, motor nerve and autonomic nerve damage; (2) tendon reflex is reduced or absent; (3) electrophysiological test indicates single or multiple peripheral nerve damage, including axonal changes and demyelination.

Inclusion criteria

(1) Patient has a diagnosis of peripheral nerve injury; (2) is aged 18–75 years; (3) has electrophysiologically-confirmed peripheral nerve damage such as demyelination; (4) is willing to join this randomized controlled study and (5) has signed the informed consent form.

Exclusion criteria

Patients with mental disorders, liver or kidney dysfunction, circulatory system diseases, or transmissible infections were excluded.

Acupoint prescription

LM group

The following acupoints were selected at the injury site: radial nerve: *Jianyu* (LI15), *Binao* (LI14), *Quchi* (LI11), *Hegu* (LI4), and *Yangxi* (LI5); ulnar nerve: *Qingling* (HT2), *Xiaohai* (SI8), *Zhizheng* (SI7), *Wangu* (SI4), and *Houxi* (SI3); median nerve: *Quze* (PC3), *Daling* (PC7), *Neiguan* (PC6), and *Laogong* (PC8); peroneal nerve: *Yanglingquan* (GB34), *Guangming* (GB37), *Juegu* (GB39), and *Qiuxu* (GB40); tibial nerve: *Yinlingquan* (SP9), *Sanyinjiao* (SP6), *Diji* (SP8), and *Lougu* (SP7); sciatic nerve: *Huantiao* (GB30), *Ciliao* (BL32), *Zhibian* (BL54), *Yanglingquan* (GB34), *Weizhong* (BL40), and *Juegu* (GB39); brachial plexus: *Jianyu* (LI15), *Binao* (LI14), *Quchi* (LI11), *Waiguan* (SJ5), and *Baxie* (EX-UE8).

GV/LM group

The following acupoints were selected: (1) Acupoints on the Governor vessel: nerve injury in the arm: *Baihui* (GV20), *Fengfu* (GV16), *Dazhui* (GV14), and *Shenzhu* (GV12); nerve injury in the leg: *Jizhong* (GV6), *Mingmen* (GV4), *Yaoyang-*

guan (GV3), and *Yaoshu* (GV2). (2) Local acupoints at the injury site were as described in the previous group.

Acupuncture procedure

After routine disinfection of the acupuncture sites with 75% alcohol, we used stainless steel disposable acupuncture needles (0.35 mm diameter, 25 mm length; Suixin brand, Suzhou Hualun Medical Appliance Corporation, Suzhou, Jiangsu Province, China) for the treatment. The needles were placed approximately 1 cun deep into the selected acupoints. After manipulation by hand to achieve the desired sensation, the needles were connected to the electroacupuncture apparatus (Ying Di KWD-808-I Multi-Purpose Health Device; Changzhou Yindi Electronic Medical Device Corporation, Changzhou, Jiangsu Province, China). A sparse-dense wave with a frequency of approximately 2/100 Hz was selected and the magnitude of the stimulation was as great as each patient could tolerate. The needles were withdrawn after 30 minutes of treatment. The procedure was conducted for 6 weeks, once a day, five times per week (30 sessions in total).

Clinical testing

Stage 1: clinical response

The therapeutic efficacy of the two acupuncture methods was examined by evaluating the motor and sensory functions of the patients' affected limb before and after the course of treatment, using the method recommended by the British Medical Research Council (Zhu et al., 2007). Treatment response was ranked as follows: excellent (sensory and motor function recovered to ≥ $S3^+$ and ≥ M4, respectively); good (composite function recovered to S3 or M3, or pure sensory or motor function recovered to ≥ $S3^+$ or ≥ M4); average (composite function recovered to S2 or M2, or pure sensory or motor function recovered to ≥ S3 or ≥ M3); poor (function ≤ S1 and/or ≤ M1).

Stage 2: electromyography

Acupuncture was performed in 20 additional patients using the GV/LM method. Electromyography was carried out before and after the treatment to detect the motor and sensory nerve conduction velocity as well as the latency and amplitude of different nerve injuries in order to determine the nerve repair status. Keypoint 4-channel electromyography (Dantec, Alpine Biomed ApS, Skovlunde, Denmark) was used to measure motor and sensory nerve conduction velocity, latency, and amplitude in different nerve injuries. For motor nerve conduction, we used disposable skin electrodes and placed the cathode of the electrode over the distal nerve. The anode was placed over the proximal nerve. The recording electrodes were over the muscle belly, and the reference electrode was placed over the tendon. The ring electrode was placed between the stimulation and recording electrodes. We recorded the peak-to-peak amplitude and latency of compound muscle action potentials on the muscle controlled by the injured nerve. The nerve conduction velocity was calculated as the distance between the distal and proximal ends of the nerve divided by the difference between the distal and proximal latencies. Sensory conduction was measured orthodromically by the ring electrode. The stimulating electrode was placed at the tip of a finger or toe. The cathode was at the proximal end of the nerve to the anode. Recording electrodes were placed over the nerve trunk, close to the stimulation site. Reference electrodes were placed at the opposite end of the nerve trunk to the stimulation site. A ground wire was fixed between the stimulating and recording electrodes. The latency period was measured, and sensory conduction velocity was calculated as the distance between the stimulating and recording electrodes divided by the latency.

Electromyographic responses to treatment were ranked as follows: Complete (motor and sensory functions returned to normal; electrophysiology returned to normal); excellent (motor and sensory disorders notably improved; electrophysiology not returned to normal but motor and sensory conduction velocities increased by ≥ 5 m/s); moderate (motor and sensory function slightly improved; motor and/or sensory conduction velocity increased, but by < 5 m/s); ineffective (no improvement, or worsening, of motor or sensory function; no increase, or possible decrease, in motor and sensory conduction velocities relative to baseline).

Statistical analysis

All data were analyzed using SPSS 17.0 software (SPSS, Chicago, IL, USA) and conformed to a normal distribution. Counts were expressed as percentages and analyzed using the chi-square test; measurements were expressed as the mean ± SD. Independent sample *t*-tests were used to compare two groups, while a paired *t*-test was used for comparing data obtained before and after treatment. $P < 0.05$ was considered statistically significant.

Results

Quantitative analysis of participants

In the first stage, a total of 30 patients were enrolled and assigned equally and at random to the LM and GV/LM groups. Two patients dropped out from the LM group. There were marginally more male patients than female patients in both groups. The patients were aged 18–40 years and the duration of their illness was < 2.5 years. Before treatment, there were no statistically significant differences between the groups in terms of gender, age, or duration of illness ($P > 0.05$; **Table 1**). In the second stage, 20 patients were enrolled, with no drop-outs.

Comparison of good or excellent response rates between the GV/LM and LM groups

In the GV/LM group (n = 15), functional response was ranked excellent in four patients and good in eight patients, with a combined good and excellent rate of 80%. In the LM group (n = 13), treatment response was ranked excellent in three cases and good in two cases. The good or excellent response rate was 38.5%, significantly lower than that in the GV/LM group ($P < 0.05$; **Table 3**), indicating that the therapeutic effect of electroacupuncture at Governor vessel acupoints combined with local meridian acupoints is more clinically effective in the treatment of peripheral nerve injury than the use of local meridian acupoints alone.

Electromyographical comparison of sensory conduction between before and after electroacupuncture along the Governor vessel and local meridian

The sensory conduction velocities of the radial and ulnar nerves were significantly greater after treatment than before treatment ($P < 0.05$, **Table 4**). The latencies for these nerves were also improved after treatment ($P < 0.05$).

However, no significant differences were found in the latency, potential amplitude, or sensory conduction velocity of the median, tibial or peroneal nerves ($P > 0.05$).

Electromyographical comparison of motor conduction between before and after electroacupuncture along the Governor vessel and local meridian

The motor conduction velocities of the radial and tibial nerves were significantly increased after treatment ($P < 0.05$, **Table 5**). Treatment also improved the potential amplitude for these nerves ($P < 0.05$). However, the difference in latency was not statistically significant before and after treatment ($P > 0.05$).

In the median nerve, treatment improved the latency, potential amplitude, and sensory conduction velocity ($P < 0.05$, **Table 5**). The latency and potential amplitude of the ulnar and peroneal nerves were also significantly improved after treatment ($P < 0.05$, **Table 5**), but motor conduction velocity was not significantly different ($P > 0.05$).

Clinical efficacy

The total effective therapeutic rate was 80.0% in the 20 patients (**Table 6**). Six patients had not received any prior treatment before entering the study, and in five of those (83.3%) the treatment was effective. There were 14 patients who had received other therapies before entering the study, and their efficacy rate was 78.6%. The difference between these efficacy rates was not significant ($P > 0.05$). Although this study had a relatively small sample size, these results suggest that electroacupuncture is clinically effective in peripheral nerve injury whether or not the patient underwent previous treatment attempts.

Typical case

Figure 1 shows radial nerve motor conduction electromyography before, during and after electroacupuncture in an 18-year-old female patient in the GV/LM group who suffered from radial nerve injury for 2 months. **Figure 2** shows electromyography traces of motor and sensory conduction in the radial nerve before and after treatment in the same patient.

Discussion

The peripheral nerve and the cell bodies of its corresponding spinal cord segments are physiologically and pathologically interdependent

A neuron consists of a cell body and cytoplasmic processes. The cell bodies are located in the brain or spinal cord, and the processes, which constitute the peripheral nerve, innervate the target tissue, which can be a long distance from the cell body. As two parts of the same neuron, the cell body and cytoplasmic processes are interdependent under physiological and pathological conditions. The peripheral nerve is mainly composed of long nerve fibers or axons and has no capacity to synthesize the proteins and lipids necessary for injury repair, but rather depends on the neuronal cell body. However, the survival of the cell body also relies on the functional integrity of the axon (Roy et al., 1999). To survive and maintain physiological function, the neuronal cell body communicates through its axon with peripheral target tissues and Schwann cells, which release neurotrophic factors. Thus, the cell body of a neuron and its axon are physiologically interdependent, which in turn determines their relationship with each other under pathological conditions. Peripheral nerve injury causes apoptosis of corresponding neuronal cell bodies (Wu et al., 2006). After peripheral nerve injury, nutrient transport is interrupted or obstructed, causing the cell bodies to lose target-derived neurotrophic factors, resulting in apoptosis (Himes et al., 1989). Because adult neurons cannot divide or proliferate, the decline in neuronal number will lead to a decreased number of peripheral nerve fibers. This pathophysiological relationship will affect the time and extent of functional recovery after peripheral nerve injury. Therefore, to ensure the injured peripheral nerve has renewable materials available, preventing neuronal apoptosis is an important strategy to improve the structural and functional recovery of peripheral nerves after injury. This is why we aim to improve acupuncture therapy in this field.

The apoptosis of spinal motor neurons and spinal ganglion sensory neurons induced by peripheral nerve injury is not widespread and does not involve the whole spinal cord, but is associated with neurons that are related to the damaged peripheral nerves. For example, after cutting the rat sciatic nerve on one side, the ipsilateral $L_{4–6}$ anterior horn motor neurons, sensory neurons and sciatic nerve all express p75, a low affinity nerve growth factor receptor, which induces neuronal apoptosis; however, no expression is found at the injury site (Yun et al., 2001). This suggests that selecting acupoints along the injured peripheral nerve in combination with those along the Governor vessel in the corresponding spinal segments will improve therapeutic outcome.

Electroacupuncture on specific Governor vessel acupoints promotes functional repair after peripheral nerve injury

In the first stage of this study, a higher rate of good and excellent clinical responses was observed in the GV/LM group than in the LM group, indicating that the therapeutic effect of electroacupuncture on Governor vessel and local acupoints combined was better for the successful treatment of peripheral nerve injury than restricting treatment to local meridian acupoints. In the second stage, the total effective rate was 80.0%, with the greatest effect on motor nerve conduction. Electroacupuncture on specific Governor vessel acupoints appears to promote functional repair after peripheral nerve injury, particularly in terms of motor conduction. We also calculated the total effective rate after 30 days of acupuncture in 14 patients who had received other treatments before entering this study. Acupuncture efficacy was

Table 1 Baseline data of the 30 patients in stage 1

Item	GV/LM group	LM group	*P*
Gender (male/female, *n*)	8/7	9/6	0.713
Age (year)	28.3±9.6	28.6±10.3	0.118
Duration of illness (year)	1.4±1.0	1.4±1.1	0.220

GV/LM: Electroacupuncture performed on Governor vessel and local meridian acupoints; LM: electroacupuncture performed on local meridian acupoints alone. Data are expressed as the mean ± SD ($n = 15$ per group). Comparison of age and duration of illness was conducted using independent samples *t*-tests; differences in gender were compared using the chi-square test.

Table 3 Clinical efficacy of electroacupuncture in the Governor vessel with local meridian acupoints (GV/LM) group and the local meridian acupoints (LM) group

Item	GV/LM group ($n = 15$)	LM group ($n = 13$)
Excellent (*n*)	4	3
Good (*n*)	8	2
Average (*n*)	2	2
Poor (*n*)	1	6
Good and excellent rate (%)	80.0	38.5*

*$P < 0.05$, *vs.* GV/LM group (chi-square test); $\chi^2 = 6.343$, $P = 0.042$. Therapeutic efficacy ranking (Zhu et al., 2007): Excellent, motor and sensory score recovered to ≥ M4 and ≥ S3$^+$; good, composite score of M3, S3, or pure motor or sensory score of ≥ M4 or ≥ S3$^+$; average, composite score of M2, S2, or pure motor or sensory score of ≥ M3 or ≥ S3; poor, scores of ≤ M1 or ≤ S1.

Table 2 Demographic data for the 20 patients in stage 2

General information	*n*
Gender condition	
Male	11
Female	9
Total	20
Age distribution (year)	
18–40	15
41–60	4
> 61	1
Total	20
Duration of illness	
Within 2 weeks	2
2 weeks to 1 month	3
1 month to 1 year	1
Over 1 year	14
Total	20
Cause of injury	
Trauma (due to traffic accidents, heavy lifting or birth trauma)	9
Wedge pressure (improper posture causes limbs suffering from long-term compression)	4
Infection (caused by inflammation)	1
Chronic strain (no apparent reason, but has physical strain history due to long-term work)	6
Total	20
Nerve injury type	
Single nerve injury	
Radial nerve	2
Median nerve	3
Ulnar nerve	3
Multiple nerve injury	
Brachial plexus	9
Sciatic nerve	3
Total	20
History of treatment before acupuncture	
Received rehabilitation therapy or neurotrophic agent before attended in this study	14
Accept no prior treatment	6
Total	20

not significantly different between patients with or without previous treatment attempts, indicating that acupuncture at both sites is effective regardless of treatment history. The sample size was small, so a larger sample size should be used in future studies.

Possible mechanisms of electroacupuncture on specific Governor vessel acupoints for peripheral nerve injury

(1) *Electroacupuncture on the Governor vessel improves the microenvironment of the nervous tissue and stimulates neurotrophic factor release*

After sciatic nerve injury, the metabolic microenvironment of the lumbar spinal cord shows reduced acetylcholinesterase activity and increased acid phosphatase activity, the main causes of apoptosis in the affected neurons (Zhang et al., 2002; Yan et al., 2013; Chen et al., 2014). Therefore, reducing the toxicity of the microenvironment is one of the important ways to prevent neuronal apoptosis. Furthermore, electroacupuncture stimulation increase acetylcholinesterase expression in spinal cord tissue after peripheral nerve injury (Wang et al., 2009). It can be presumed that electroacupuncture on Governor vessel acupoints combined with local acupoints can also increases acetylcholinesterase expression in spinal cord tissue, which helps to adjust the toxic environment and prevent secondary impairment of neurons. This may be the primary mechanism for peripheral nerve injury treatment. In addition, electroacupuncture on the Governor vessel can also stimulate local spinal cord tissue to secrete large amounts of neurotrophic factor 3 (Li et al., 2012; Zhang et al., 2012), effectively preventing or delaying neuronal apoptosis. Therefore, an important mechanism underlying the treatment of peripheral nerve injury by electroacupuncture on the Governor vessel is a reduction in tissue toxicity and stimulation of neurotrophin release, which provides a microenvironment conducive to nerve repair.

(2) *Immediate effect of electroacupuncture on Governor vessel acupoints ensures continuity between the peripheral and central nerve*

From **Figure 1**, electromyography revealed considerable changes in radial nerve motor conduction before, during and after electroacupuncture. The immediate therapeutic effects of electroacupuncture on the Governor vessel are evident. Electroacupuncture on both the Governor vessel and local acupoints can provide temporary continuity between the damaged peripheral nerve and the central nerve, thereby ensuring the supply of nutrients between neuronal cell bodies and maintaining neurotrophic factors, a lack of which

Table 4 Sensory nerve conduction before and after 30 sessions of electroacupuncture on Governor vessel and local meridian acupoints

Nerve	Before treatment	After treatment	*P*
Radial nerve			
Latency (ms)	2.17±0.86	1.65±0.64*	0.007
Potential amplitude (μV)	8.65±8.11	9.43±7.16	0.759
Sensory conduction velocity (m/s)	33.63±17.92	41.25±17.59*	0.035
Median nerve			
Latency (ms)	3.06±1.38	3.01±1.76	0.854
Potential amplitude (μV)	8.59±10.27	10.50±9.85	0.228
Sensory conduction velocity (m/s)	33.51±15.00	35.95±16.81	0.452
Ulnar nerve			
Latency (ms)	1.81±1.35	1.45±1.09*	0.038
Potential amplitude (μV)	9.96±7.04	7.83±6.19	0.059
Sensory conduction velocity (m/s)	31.83±23.35	36.27±25.79*	0.029
Tibial nerve			
Latency (ms)	3.85±2.30	3.74±1.77	0.882
Potential amplitude (μV)	1.96±1.98	3.24±1.70	0.069
Sensory conduction velocity (m/s)	35.57±13.80	31.37±2.90	0.579
Peroneal nerve			
Latency (ms)	3.43±1.32	3.3±0.86	0.746
Potential amplitude (μV)	1.28±1.08	1.8±2.01	0.420
Sensory conduction velocity (m/s)	33.48±6.19	33.00±4.08	0.730

*$P < 0.05$, *vs*. before treatment (paired *t*-test). Data are expressed as the mean ± SD ($n = 20$).

Table 5 Comparison of motor nerve conduction between before and after 30 sessions of electroacupuncture on Governor vessel and local meridian acupoints

Nerve	Before treatment	After treatment	*P*
Radial nerve			
Latency (ms)	6.96±9.16	4.20±1.88	0.171
Potential amplitude (μV)	5.05±5.43	9.06±6.13*	0.002
Sensory conduction velocity (m/s)	39.17±30.15	56.03±20.67*	0.038
Median nerve			
Latency (ms)	5.40±3.12	4.41±2.33*	0.033
Potential amplitude (μV)	8.97±6.63	11.01±5.68*	0.006
Sensory conduction velocity (m/s)	45.50±18.20	52.68±17.58*	0.037
Ulnar nerve			
Latency (ms)	6.77±4.20	4.57±3.28*	0.005
Potential amplitude (μV)	5.98±5.38	8.30±6.65*	0.044
Sensory conduction velocity (m/s)	48.43±22.49	66.64±53.88	0.329
Tibial nerve			
Latency (ms)	5.47±6.20	5.38±5.37	0.862
Potential amplitude (μV)	0.98±1.46	4.40±3.47*	0.009
Sensory conduction velocity (m/s)	27.5±9.96	32.4±8.15*	0.048
Peroneal nerve			
Latency (ms)	11.89±12.63	4.10±4.19*	0.042
Potential amplitude (μV)	3.50±4.57	4.85±4.83*	0.007
Sensory conduction velocity (m/s)	36.54±20.68	38.96±19.30	0.871

*$P < 0.05$, *vs*. before treatment (paired *t*-test). Data are expressed as the mean ± SD ($n = 20$).

Table 6 Therapeutic efficacy of electroacupuncture on Governor vessel and local meridian acupoints in 20 patients in stage 2

Item	Cases which received no other treatment before entering the group ($n = 6$)	Cases which had received other therapies before entering the group ($n = 14$)	Total treatment cases
Complete (*n*)	1	2	3
Excellent (*n*)	0	2	2
Moderate (*n*)	4	7	11
Ineffective (*n*)	1	3	4
Effective rate (%)	83.3	78.6*	80.0

*$P = 0.8073$, $\chi^2 = 0.0595$ (chi-square test).

would cause neuronal apoptosis. Providing this assistance may shorten the repair process for damaged nerves, and can also provide a basis for nerve regeneration.

Interestingly, electroacupuncture had little effect on sensory nerve conduction (**Figure 2**), consistent with our findings that after 30 days of treatment, motor nerve conduction recovered well, whereas sensory nerve conduction recovery was poor.

Together, our results indicate that the current treatment options have little effect on sensory nerve recovery over a 30 day observation period. Sensory nerves may require a longer treatment time to achieve the desired effect, or perhaps a larger sample size would have revealed an effect on sensory nerve conduction. This delayed recovery of sensory function compared to motor function is related to the regeneration of motor neuron axons after peripheral nerve injury, which dominates muscular branches, known as prioritization of muscle branch reinnervation (Richard et al., 2005; Zheng et al., 2010; Maeda et al., 2013). Moreover, it is also associated with axons retreating to the cell body after peripheral nerve injury (Witzel et al., 2005). Synapses around neuronal axons also withdraw from the surface and, after nerve regeneration, barriers to axonal morphology restoration remain, which is also one of the important reasons why recovering sensory function is difficult (Watson et al., 1974). Therefore, in reconstructive surgery on denervated tissue, neuron dendrite growth must be guided towards its original target tissue; this will be our key scientific research question in the future.

In conclusion, electroacupuncture on specific Governor vessel acupoints appears to effectively promote functional repair after peripheral nerve injury. The mechanism may relate to the Governor vessel improving the local microenvironment and ensuring continuity between the peripheral and central nerve. Therefore, the preferred acupoint prescription for peripheral nerve injury should focus on two sites, the injury site and the spinal cord, *i.e.* simultaneous electroacupuncture on the Governor vessel and local meridian acupoints. A limitation of the present study is the small number of subjects; however, a trend is evident and more in-depth studies with larger sample sizes should be performed to confirm our results.

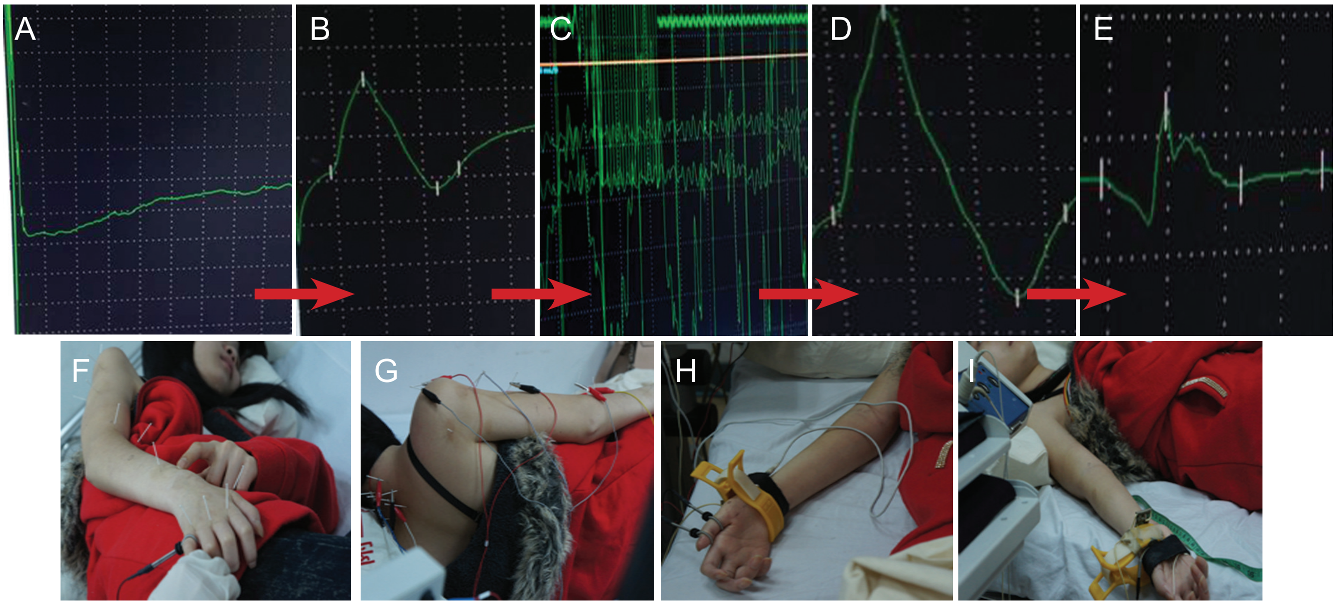

Figure 1 Electromyograms of radial nerve motor conduction before, during and after electroacupuncture in an 18-year-old female patient with radial nerve injury for 2 months.
(A) Prior to acupuncture treatment. Nerve conduction electromyogram is a straight line and motor conduction velocity difficult to measure. (B, F) After inserting the needle and bringing about the desired sensation, a change in the electromyogram was noted and motor nerve conduction velocity reached 18.5 m/s. (C, G) Electroacupuncture was performed, but the interference between electromyography and electroacupuncture was too great to obtain valid electromyography data during the treatment. (D, H) The electroacupuncture needle was withdrawn after 30 minutes and electromyography was performed immediately afterwards; motor nerve conduction velocity had risen to 22.8 m/s (a 23.2% increase from before treatment). (E, I) After a total of 30 electroacupuncture sessions, the motor nerve conduction electromyogram showed an obvious waveform; motor conduction velocity was 19.9 m/s (increased by 7.6% from before treatment).

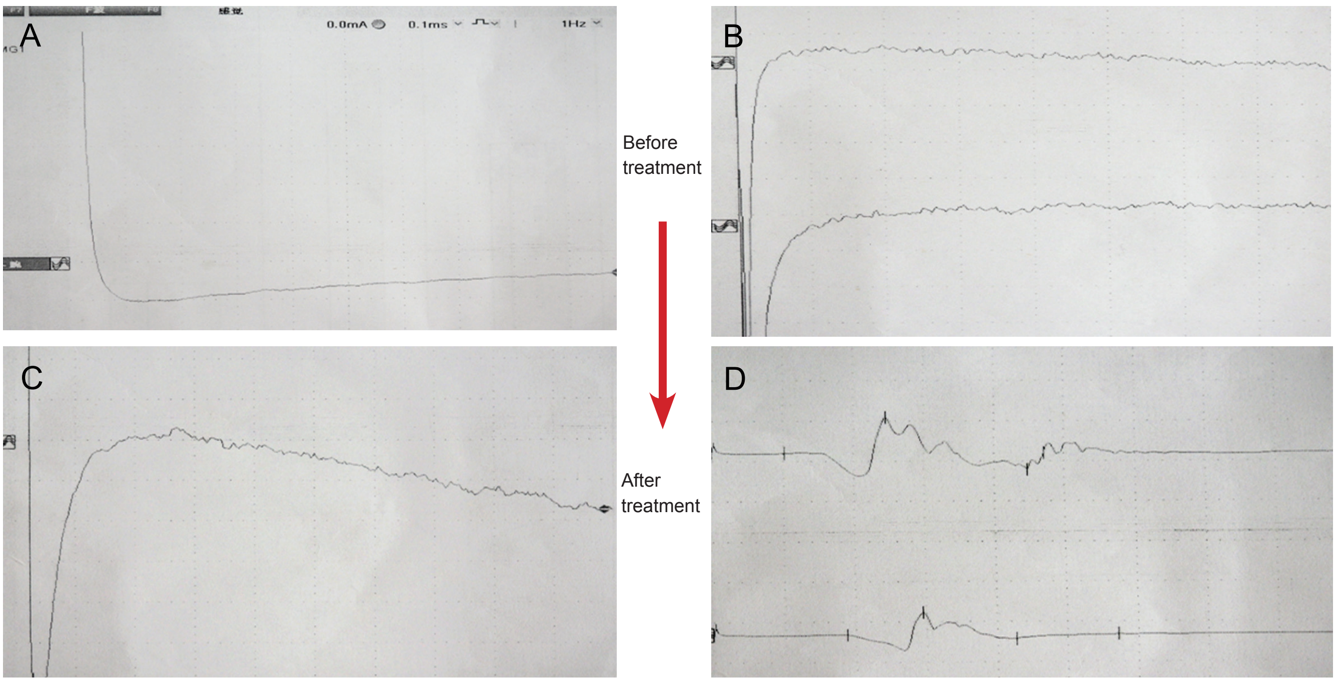

Figure 2 Electromyography of radial nerve motor and sensory conduction before and after electroacupuncture.
(A) Sensory nerve conduction before treatment. (B) Motor nerve conduction before treatment. (C) After 30 acupuncture sessions, no sensory nerve conduction could be detected. (D) In contrast, motor nerve responses were notably improved: latency, 5.06 ms; amplitude, 2.6 mV; conduction velocity, 19.9 m/s; overall 7.6% increase compared with baseline.

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