# Research Progress on Neuromodulation Technology for Treating Post-stroke Movement disorder

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**Abstract:** Neuromodulation technologies have shown great potential in treating post-stroke movement disorder. The current research progress of neuromodulation technology in stroke rehabilitation includes methods such as transcranial magnetic stimulation, transcranial direct current stimulation, functional electrical stimulation, and botulinum toxin injection. These methods promote the recovery of motor function in stroke patients through various mechanisms, such as neural regeneration and remodeling, synaptic plasticity, and the balance between neuronal activation and inhibition. These technologies can not only improve patients' exercise ability, but also enhance their quality of life.
***Keywords*:** neuromodulation technology, post-stroke,movement disorder

## 1. Introduction

Stroke is one of the main causes of adult disability, seriously affecting patients' quality of life. Although traditional rehabilitation treatment methods have certain effects, they have limitations. In recent years, neuromodulation technology has received widespread attention due to its characteristics of non-invasive and potential high therapeutic efficacy. Based on this, this article explores the research progress of neuromodulation technology in the treatment of post-stroke movement disorder, aiming to lay a solid foundation for future development.

## 2. Pathophysiological mechanism of stroke

The pathophysiological mechanism of stroke is very complex, mainly involving the interruption of local blood supply to the brain caused by vascular obstruction or rupture. When the blood flow in a certain area of the brain is blocked, the nerve cells will gradually die due to hypoxia and insufficient nutrients, leading to a series of neurological dysfunction. In the long run, inflammation and glial cell proliferation may occur around the damaged area, further affecting the function of the neural network. In addition, stroke may trigger a systemic inflammatory response, causing damage to other organs[1]. These complex pathological processes work together to cause various functional disorders such as motor, sensory, and cognitive impairment in stroke patients.

## 3. Manifestations of movement disorder

Movement disorder is a common post-stroke symptom, which manifests in various forms. Patients may experience limb weakness or complete paralysis, especially when stroke affects the motor cortex of the cerebral hepIMC[2]. Decreased ability in fine motor control is also very common, such as decreased finger dexterity. In addition, the patient's abilities of coordination and balance may be impaired, and their gaits may be abnormal during walking. Some patients may also experience involuntary movements, such as muscle spasms[2]. These symptoms not only affect the patient's ability to engage in daily activities, but may also lead to psychological stress and a decrease in social participation. Therefore, rehabilitation treatment for movement disorder is particularly important.

## 4. Application of neuromodulation technology in stroke rehabilitation

### 4.1 Brain stimulation technology

#### 4.1.1 Transcranial magnetic stimulation

Transcranial magnetic stimulation is a non-invasive brain stimulation technology that involves placing a magnetic field coil on the scalp to generate a time-varying magnetic field[1], which induces electrical currents in the cerebral cortex and regulates neuronal activity. TMS is commonly used for stimulating the motor cortex of the brain, typically located in the anterior part of the skull, roughly corresponding to the upper part of the forehead. During use, the operator determines the stimulation point and then sets the appropriate stimulation intensity and frequency. TMS can effectively improve post-stroke movement disorder by promoting neural plasticity and enhancing neural activity in damaged areas[3].

#### 4.1.2 Transcranial direct current stimulation

Transcranial direct current stimulation is a non-invasive brain stimulation technology that uses weak constant current to regulate cortical excitability. Usually, the anode (positive electrode) is placed in the target brain area, and the cathode (negative electrode) is placed on the opposite side to guide current flow to a specific area. For the treatment of post-stroke movement disorder, transcranial direct current stimulation is often applied to the motor cortex, located approximately in the anterior part of the head. During the process of operation, there is a need to clean the scalp and apply conductive paste, then fix the electrode in the corresponding position on the scalp[4]. It has been found that transcranial direct current stimulation can enhance or inhibit neural activity by altering neuronal membrane potential, thereby promoting neural plasticity. Multiple transcranial direct current stimulation can help improve the motor function of stroke patients and enhance their quality of life.

### 4.2 Muscle or nerve stimulation technology

#### 4.2.1 Functional electrical stimulation

Functional electrical stimulation is a technology that uses external electrical currents to stimulate nerves or muscles in order to restore or improve motor function. Generally speaking, electrodes are placed on specific nerves or muscles to stimulate corresponding motor responses. For the treatment of post-stroke movement disorder, functional electrical stimulation is often applied to the muscles of the lower limbs to help patients recover their walking ability, especially the thighs and calves. During operation process, the electrode was precisely placed on the target muscle or nerve, then it would be connected to a functional electrical stimulation device and appropriate current intensity and pulse frequency would be set. Functional electrical stimulation can induce muscle contractions, enhance neural connections, and promote neural plasticity. Moreover, functional electrical stimulation can prevent muscle atrophy, improve blood circulation, and significantly enhance the exercise ability and quality of life of stroke patients.

#### 4.2.2 Botulinum toxin injection

Botulinum toxin injection is a treat method that uses local injection of botulinum toxin to alleviate muscle spasms and improve motor function. Botulinum toxin is usually injected into overactive muscles to reduce muscle tension, such as the biceps in the upper limbs or the gastrocnemius in the lower limbs[3]. During the process of operation, the doctor need to identify the target muscle at first, perform local anesthesia, and use a fine needle to precisely inject a small amount of botulinum toxin into the muscle. By preventing the release of neurotransmitters, botulinum toxin can relax muscles and reduces spasms. Botulinum toxin injection can significantly improve the motor function of post-stroke patients, reduce muscle stiffness and pain, and improve daily activity ability.

### 4.3 Neuroplasticity and brain-machine interface technology

#### 4.3.1 The importance of neuroplasticity in stroke rehabilitation

Neuroplasticity refers to the ability of the nervous system to adapt to environmental changes in structure and function, which plays a key role in stroke rehabilitation. By promoting the formation of new connections between neurons, neuroplasticity helps to restore damaged motor function. In stroke rehabilitation, neuroplasticity can be achieved in various ways, such as brain-machine interface technology. Brain-machine interface technology typically implants electrodes in specific areas of the cerebral cortex, such as the motor cortex, to record neural activity. During operation process, doctors need to implant electrodes on the patient's scalp or brain surface and connect them to interface devices[5]. This kind of device is capable of decoding neural signals and converting them into instructions for controlling external devices such as prosthetics or rehabilitation robots. Through repeated practice, patients can relearn to control the affected limbs and promote the development of neural plasticity. Brain-machine interface technology can significantly improve the motor function and enhance the self-care ability of stroke patients.

#### 4.3.2 Brain-machine interface technology

Brain-machine interface technology is a treat method that directly connects the brain to external devices to restore or enhance neural function. Brain-machine interface technology typically implants electrodes in specific areas of the cerebral cortex to record neural activity, such as the motor cortex. During operation process, doctors implant electrodes on the patient's scalp or brain surface and connect them to interface technology devices. This device is capable of detecting and decoding neural signals, and converting them into instructions for controlling external devices such as prosthetics or rehabilitation robots. Through repeated practice, patients can learn to control these devices with their minds, thereby restoring or improving their motor function. BCI technology can significantly promote neuroplasticity and help stroke patients regain control over affected limbs.

# 5. The mechanism of neuromodulation technology in treating post-stroke movement disorder

## 5.1 Neural regeneration and remodeling

Neuroregulation technology promotes the recovery of post-stroke motor function through various mechanisms, among which nerve regeneration and remodeling play a core role. These technologies can activate nerve cells around the damaged area and promote the formation of new neural connections. By increasing the expression of nerve growth factors, it helps to regenerate damaged nerve fibers and rebuild neural pathways. In addition, they can activate astrocytes and oligodendrocytes and support the survival of neurons and the growth of axons[4]. These processes collectively promote brain remodeling, enhance the function of neural networks, thus significantly improving patients' motor abilities.

## 5.2 Synaptic plasticity

Neuromodulation technologies promote the recovery of post-stroke motor function by enhancing synaptic plasticity. These technologies can regulate the strength of connections between neurons and promote the formation of new synapses. Specifically, by increasing the release of neurotransmitters and the sensitivity of receptors, these technologies can enhance communications among neurons. In addition, neuromodulation technology can activate related genes, promote protein synthesis, and further strengthen synaptic connections[5]. These changes can help the brain restructure and optimize neural networks, thereby improving patients' motor coordination and control abilities

## 5.3 Balance between neuronal activation and inhibition

Neuromodulation technologies improve post-stroke motor function by promoting a balance between neuronal activation and inhibition. These technologies can regulate the activity of excitatory and inhibitory neurons in the brain, restoring normal neural signal transmission. Specifically, they optimize the function of neural networks by altering the activity of ion channels and adjusting the balance of neurotransmitters. In addition, neuromodulation technologies can promote the activation of inhibitory interneurons, reduce the activity of over excited areas, and enhance the recovery of damaged areas.

# 6. Conclusion

In conclusion, neuromodulation technology have shown great potential in the treatment of post-stroke movement disorder. Through the comprehensive operation of different mechanisms, these technologies can significantly improve patients' exercise ability and quality of life. The continuous development of neuromodulation technology has brought new prospect for stroke rehabilitation and is expected to become an important component of future stroke treatment.

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