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Case Study

Effects of Electrical Stimulation in Foot Drop and Restoration of Normal Gait Pattern

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ABSTRACT

This presents a case study that observes the efficacy of the functional electrical stimulation method in promoting recovery by strengthening the muscles to correct foot drop. For example, stimulation of the tibialis anterior and extensor digits digitorum longus improved ankle dorsiflexion that led to balanced walking without causing the foot to get inverted or everted. Efficiency was assessed by measuring the range of motion before and after stimulations which showed wonderful effects. Without stimulation, the toe of the affected leg was dragging across the ground. The functional electrical stimulations of the tibialis anterior muscle and deep peroneal nerve elevated the foot such that the toe clears the ground. The normal range of motion of the affected foot after the application of stimulations was recovered. Dorsiflexion was improved up to 18° from 0° remarkably, plantar flexion form 35° to 38°, inversion from 25° to 30°, eversion form 15° to 20°. The range of motion was measured through a goniometer. Further muscle strengthening, stretching exercises, gait and balance training exercises helped in correcting the foot drop and restoring the normal gait pattern. The transition from a high steppage gait to a normal gait pattern improved the postural defect and thus enhanced the quality of life.

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INTRODUCTION

The term "foot drop" is frequently used to describe an individual's inability to move the front of the foot towards the shin because the muscles that lift the foot are weak or paralyzed. Numerous neuromuscular conditions can cause it. A "wait and see" strategy, physical therapy, orthotics, surgery, or medication therapy are possible interventions.[1] The posterior divisions of L4-5, S1-2 and the common peroneal nerve make up the sciatic nerve's smaller and terminal branch, the common peroneal nerve. The nerve can be felt behind the fibula's head and

it spirals around the bone's neck. Commonly, the important dorsiflexion of the foot will become weak when the common peroneal nerve is damaged.[2] The major causes of foot drop include brain or spinal disorders (stroke, cerebral palsy, multiple sclerosis, charcot - marie- tooth disease) muscle injuries(muscle dystrophy, amyotrophic lateral sclerosis, polio) sports injuries, diabetes, post-surgery and prolonged immobilization.[3] Due to peroneal nerve injury pain and numbness occurs from the shin up to the dorsal and ventral surface of the foot. All the ankle movements including the dorsiflexion, plantar flexion, inversion and eversion are affected. The most commonly affected movement is dorsiflexion of the foot involving the weakness of the tibialis anterior, extensor hallucis longus and extensor digitorum longus. These muscles help in clearing the foot during the swing phase of walking and control plantar flexion of the foot on heel strike.[4]

Foot drop can occur at any age to one or both feet due to which people who cannot lift their feet, elevate their knees higher than usual to prevent dragging their toes. To clear the floor more effectively, some patients may enhance the hip flexion on the affected side, while other patients may circumduct the hip and drag the forefoot along the floor.[5] The ability to clear the paretic lower limb is decreased by the foot drop during locomotion, prompting the development of compensatory motor methods during the swing phase of gait. These compensatory movements result in biomechanical alterations that may slow down gait speed, create asymmetries, increase instability and increase the danger of falling, as well as make a person more reliant on others for daily chores.[6] Liberson et al. first introduced functional electrical stimulation (FES), one of the techniques used in gait therapy to rectify food drops in 1961. In the FES system, a nerve or muscle is stimulated with an electric current to cause a muscular contraction that is employed for a functional activity. Surface electrodes that are attached to your skin are used by the electrical stimulation device to deliver impulses to the muscles. This technique aids in stimulating the brain, increasing muscular growth and stretching the back of the calf, which can occasionally get stiff.[7] This method has a therapeutic effect to promote recovery by strengthening muscles, improving voluntary control, increasing walking speed, joint range of motion, energy expenditure and slowing atrophy. Moreover, it provides an orthotic effect by addressing gait irregularities.[8]

METHODS

Electrodiagnostic studies that include electromyography testing (EMG) and nerve conduction studies (NCS) were carried out. Physical diagnostic tests were also performed including manual muscle testing (MMT), time up and go (TUG) test and 6 minute walk (6MW) test. The range of motion (ROM) of foot was assessed by goniometer before and after the application of FES. In order to check the tone, strength and balance modified Ashworth ccale, motricity index and Berg balance scale were used respectively. Manually muscle grading was done by assessing the foot movements.

Subject: A 32 years old female visited our clinic. She complained that she is feeling difficulty in walking. She was dragging her foot and was leaning to the opposite side. She was

Table 1: ROM of Affected Foot Before Application of Treatment Protocols

Ankle ROM	Active ROM	Passive ROM
Dorsiflexion	Unable to perform	20°
Plantar Flexion	35°	40°
Inversion	25°	30°
Eversion	15°	20°

experiencing numbness, heaviness, loss of sensation and swelling in her right leg and foot. All these symptoms appeared after spinal anesthesia given to her for C-section. She informed us that as she was given anesthesia, her right leg and foot got numbed and symptoms did not resolve even after a few days. She visited us after three weeks of her operation as her symptoms persisted and worsened with time. We suspected it might be a foot drop. Upon physical examination, her muscle power, strength and ROM of her foot were assessed by diagnostic tests using different scales and tools. We did her NCS and EMG tests which confirmed the injury of the peroneal nerve.

Table 2: Grades of Affected Foot Before Application of Treatment Protocols

Movements	Grading
Dorsiflexion	0
Plantar Flexion	2+
Inversion	3
Eversion	3

Treatment Protocols: Firstly, we used the FES on the motor points of the leg for 15 minutes. Stimulating the peroneal nerve improves foot drop. The procedure aimed to improve walking ability. Then TENS and EMS were used to increase the strength and power for 10 minutes simultaneously. Strengthening exercises were done to increase the range of dorsiflexion. Gait training education was given to her so that she could walk efficiently.[9]

Assessment: Movements of the foot in the sagittal plane were assessed based on the gravitational acceleration and measured using a goniometer. Similarly, grades were also checked manually first after two weeks of therapy then after four weeks to interpret the difference in muscle power.[10]

Table 3: ROM of Affected Foot After Application of Treatment Protocols

Ankle ROM	Active ROM	Passive ROM
Dorsiflexion	18°	20°
Plantar Flexion	38°	40°
Inversion	30°	30°
Eversion	20°	20°

DISCUSSION

The most intriguing finding of the study was that the use of electrical stimulation leads to an increase in motor potential and muscle voluntary contraction by stimulating the motor points of the leg and foot region. Therefore, the improvements in voluntary control most likely contributed to the gains in walking speed.[11]. The objectives of our conservative management include gait stabilization, fall avoidance, and contracture prevention. It is noteworthy that positive changes took place in a short period. However, the time duration required for the recovery may vary from patient to patient depending upon the ongoing medical condition of the patient. The earlier the patient is recommended for physiotherapy after proper diagnosis, the quicker recovery will be achieved. Delayed cases would show slow results as compared to others. To prevent contracture and maintain the range of motion of muscle groups, the home exercise program should be an integral part of therapy and must be followed properly.[12]

CONCLUSION

As the number of cases of foot drop has been increasing nowadays, its treatment must be customized. The muscle reeducation as well as muscle strength of the tibialis anterior, extensor hallucis longus, and peroneus longus muscles were significantly improved by electrical

Table 4: Grades of Affected Foot After Application of Treatment Protocols After 2 and 4 Weeks

Ankle Movements	Grading after 2 weeks	Grading after 4 weeks
Dorsiflexion	2+	3+
Plantar Flexion	3+	4+
Inversion	4	5
Eversion	4	5

stimulation after four weeks of a rehabilitation program. Electrical stimulation techniques of the weekend dorsi flexors prove the wonderful effect. Improvements in walking ability, independence, confidence and social engagement were the results of our treatment protocols. The combination of electrical stimulation, muscle strengthening exercises, stretching and gait training may have a positive impact on a patient that enables her to perform her daily activities efficiently. Her performance was overall assessed by various tests at the end of the session like 6MW test and balance test which confirmed her improvement.[13]

DECLARATIONS

Consent to participate: Written consent had been taken from patient. All methods were performed following the relevant guidelines and regulations.

Availability of data and materials: Data will be available on request. The corresponding author will submit all dataset files.

Competing interests: None

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