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CASE REPORT

Rehabilitation of Left-Sided Hemiparesis Post-MCA Infarction Using Faradic Electrical Stimulation and Robotic Hand Rehabilitation: A Case Report

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ABSTRACT

A 60-year-old male with complete left-sided hemiparesis due to infarction in the MCA territory was the subject of this case study on rehabilitation. The intervention occurred three months and two weeks post-stroke and severe deficiency in motor coordination, muscle power, and motor activities of daily living on the affected side of the patient. Faradic electrical stimulation and Syrebo C-12 model robotic hand therapy was the rehabilitation methodology of choice during the entire period. The treatment programme was completed over a four weeks' time, and the therapy sessions were scheduled for five days a week. Here, Faradic electrical stimulation was used on the wrist extensors as well as the finger flexors in order to promote muscle contractions and, thereby, minimize muscle atrophy. At the same time, robotic hand rehabilitation gave movement repetitions to strengthen the muscles and supply functional use. In case of Syrebo C-12 model; the therapist was able to provide individualized guidance and cues to increase patient's activation and make perfect movements. Achievements conclusively showed a positive level of change in hand and fingers while performing activity. The combined therapy also positively influenced the patient's attitude and self-estimate in the possibility to utilize the involved limb during the daily activities. This case provides a good example of the benefits of using the combination of technologically assisted therapy with robotic control and selective neuromuscular electrical stimulator after stroke. . The effectiveness, longer-term consequences, and the best strategies for using these therapies together with others should be studied in further research.

Keywords: Poststroke rehabilitation; MCA Infarction; Hemiparesis; Faradic electrical stimulation; Robotic hand therapy; Syrebo C12; Neuroplasticity; Functional recovery

1 INTRODUCTION

Stroke is still an important source of subsequent long-term disability globally and MCA infarctions are among the major portion of ischemic brain strokes[1]. These infarctions often cause hemiparesis or even flaccid paralysis on the face and/or limbs on the side of the brain opposite the lesion which in turn makes activities of daily living nearly impossible for the patient. Rehabilitation of functional independence after extensive motor loss in MCA infarcted patients is demanding in most cases, and requires time and efforts to execute appropriate rehabilitative strategies[2].

The earlier and modern form of post-stroke rehabilitation comprises faradic electrical stimulation and some robotic-associated apparatuses which reveals reasonable effectiveness. Faradic stimulation which is a type of neuromuscular electrical stimulation involves the administration of short pulse electrical currents to paralyzed muscles in order to facilitate muscle contraction and reduce muscle disuse atrophy[3]. This approach may be effective in recruitment of motor units and possibly in rewiring of the prepared hemisphere. In parallel to this, robotic based rehabilitation provides a very accurate method of repeatedly performing goal directed movements which is essential for activation of neuroplasticity and improved motor function[4]. They offer welcomed, or even essential, robotic movement patterns which help the patient to adapt strength, coordination and functional outcome in due course.

This coaxial use of two therapeutic strategies may have an additive influence in paralyzed muscles reanimation and cortical remapping alongside repetitive motor practice.

Faradic stimulation improves the mechanisms through which robotic systems can facilitate functional movements, whereas robotics might offer the strength and stability required for neurorehabilitation [5].

This is a report on the application of faradic electrical stimulation and robotic hand therapy in the treatment of MCA territory infarction patient. And they underscore the possible synergistic effect of adding these combined interventions to reverse the impacts of hemiparesis and enhance activity and participation of clients in post-stroke rehabilitation.

2 PATIENT PROFILE

A 60-year-old male with no documented history of prior neurological illness presented with complete left-sided hemiparesis secondary to an ischemic stroke in the MCA territory which lead to complete left side paralysis. MRI revealed an acute infarct in the right middle cerebral artery territory, involving the frontal and parietal cortices, with associated loss of grey-white differentiation and mild surrounding edema. On first assessment when the patient was admitted to the unit, He was unable to move any part of the left hand and fingers. At baseline, spasticity was rated at 0 on the Modified Ashworth Scale without touching the limb during assessment. Likewise, assessment of motor function with the help of Motor Assessment Scale was harvested a score of 0, corroborating with marked motor dysfunction.

2.1 Initial Assessment

The baseline assessments corroborated the lack of voluntry movements and minimal muscle tone of the limb at hand. The patient was recruited for the rehabilitation protocol at 1 months and 1 weeks post-stroke, corresponding to the acute stage of recovery, with an MMT of 0/5 indicating flaccid paralysis of the left upper limb . Grip strength and the usability of hand were measured by using the Manual Muscle Testing (MMT), which has finger flexor 0/5 and finger extensor 0/5 suggesting lack of discernible contractility of muscle fibers (Daniels & Worthingham, 2007). Specific functional impairments observed were apraxia of the hand, an inability to grip or pinch and impaired flexion-extension of the hand. Based on these results, there was a need to imply an extensive, comprehensive post-acute stroke rehabilitation to focus on motor function and the overall level of functioning.

2.2 Intervention Strategies

2.2.1 Faradic Electrical Stimulation

Faradic electrical stimulation was applied in an attempt to stimulate neuromuscular pathways to produce muscle contractions in the left hand. Of course, the patients received daily 20 minutes training sessions focusing separately on flexor and extensor digitorum muscles, employing currently accepted parameters that avoid discomfort. The volume was progressively increased every week according to the patients' status resolving on muscle reactivation and disuse atrophy prevention [6].

2.2.2 Syrebo C-12 Model of Robotic Hand Rehabilitation

The Syrebo C-12 model, a wearable robotic glove, for CPM and active assist in the hand was used throughout the entire treatment period. This device allowed for the practice of skills that involved pick up and release control while engaging intrinsic and extrinsic muscles of the hand. Motor relearning was encouraged through peripheral feedback in addition to regulation of neuroplasticity with the help of the robotic glove. The frequency of the applied protocol involved , co-activation, and co-ordination sessions in 30 minutes daily and five time in a week for four weeks with increased aerobic activities that require active involvement of the patient in order to increase cognitive and motor integration [7] .

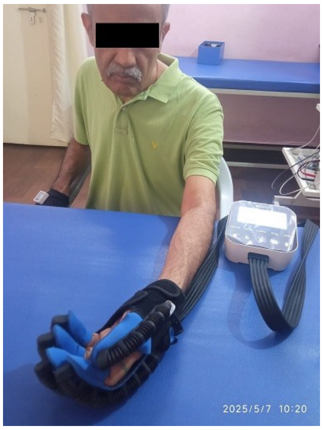

Fig. 1: Shows Syrebo C- 12 is used by the subject

2.3 Combination Strategy

The enhancement of robotic rehabilitation with faradic stimulation was helpful because it exploited the advantages of both approaches. Faradic stimulation helped to reopen neuromuscular connections that had previously been severed; the robotic glove supported voluntary control and repeated 'practice' in the form of guided motor movement. This was intended to bring about suspensory changes of the central nervous system and, hence, create motor and functional recovery.

2.3.1 Outcome and Progress

After the four weeks of combined therapy, the patient showed the effective recovery of hand function. Muscle tone grew enhanced with actual MMT score of 2/5 representing conscious contraction that only opposes the force of gravity. The patient's grip and release tasks also showed enhanced positive results hence recommending this combined rehabilitation method.

3 RESULTS

3.1 unctional Outcomes

At the end of the four-week intervention, the patient demonstrated significant improvements in hand mobility and strength. The MMT score improved from 0/5 to 2/5, indicating the development of slight muscle contraction and movement without gravity. Range of motion assessments showed increased flexibility in the wrist and finger joints, and the patient achieved partial grasping ability, suggesting functional recovery.

Grip strength showed improved ability to hold objects in gravity gravity-eliminated position and dexterity tests indicated enhanced control in finger movements. Throughout the intervention, significant improvements were observed in the range of motion of the wrist and fingers. Wrist flexion increased from 0° at baseline to 30° by the end of four weeks, while wrist extension improved from 0° to 25°. Finger flexion showed a notable recovery, progressing from no movement (0°) at baseline to 60°, allowing for a near-complete fist. Finger extension also improved significantly, increasing from 0° to 40°, demonstrating enhanced ability to open the hand. Additionally, thumb abduction increased from 0° to 25°, indicating restored functionality essential for grasping and precision tasks. These improvements in joint mobility reflect the effectiveness of the intervention in promoting motor recovery and functional independence.

Table 1: Range of motion of wrist and finger

Assessment	Baseline	After 2 Weeks	After 4 Weeks
Wrist Flexion (Degrees)	0°	15°	30°
Wrist Extension (Degrees)	0°	10°	25°
Finger Flexion (Degrees)	0°	30°	60°
Finger Extension (Degrees)	0°	20°	40°
Thumb Abduction (Degrees)	0°	10°	25°

3.2 Subjective Outcomes

The patient reported increased confidence in using the left hand for basic tasks, such as grasping lightweight objects. He noted improved ability to perform self-care tasks with minimal assistance.

4 DISCUSSION

The outcomes of this case study reveal that the synergy of faradic electrical stimulation (FES) and robotic hand rehabilitation greatly improves the functional improvement in patients who have experienced severe paralysis due to stroke. Enhancements in arm and hand movements show that the combined therapy is very effective in relation to motor changes that are demonstrated in this study. Faradic electrical stimulation directly stimulates motor nerves to cause contraction of muscles, whereas robotic therapy encourages repetitive task specific skills necessary for motor learning and functional recovery.

The applied model uses both direct engagement and indirect support to engage with both neurological and musculature impairment. The use of Robotics devices to deliver consistent and precise movement pattern can enhance the ability of the therapist as well as the quality of therapy which are crucial for patient's recovery[5]. These findings are in concordance with findings highlighting the importance of repetitiveness in the stimulation of neuroplasticity important in stroke rehabilitation.

4.1 Comparison with Literature

Specific advantages of the robotic -assisted therapy and neuromuscular stimulation have been established. Kwakkel et al. have submitted that the high-repetition therapy administered through a robot provides the desired motor improvement and Manganotti and Amelio have proved that direct electrical stimulation helps muscle strength and saves it from atrophy. Though, relatively little has been written about their functionality when used together for stroke rehabilitation[4].

The present case study lends support to the contention that an amalgamation of these modalities may further improve results of the two therapies. Recent reviews by and Hatem et al. on the issue describe new trends in the simultaneous application of neurostimulation and task-specific training to address the various motor deficits seen in patients with hemiparetic stroke[8]. The current case shows that FES improves muscle existing mode, and robotic therapy increases complex movement and rewiring, both of which enable faster progression.

4.2 Mechanisms of Recovery

The observed recovery likely involves two key mechanisms:

- Neural Adaptation by Control of Movement with Robots

Robotic therapy involves patients in repeated goal-oriented activities that lead to changes in brain architecture. Training of functional movements enhances the development of other neural connections which assist in replacing the destroyed motor cortex as a result of the stroke. Lee et al. explain that among the major benefits of using robotic devices for training, the more important aspect of motor learning is created by sensory feedback and proprioceptive input. Such feedback enhances control of movement and increases the extent of volitional movements in the patient[9].

- Muscle Re-Education using Faradic Stimulation

Faradic electrical stimulation reproduces motor units recruiting impaired muscles and improves the neuromuscular function for the targeted joint. It helps avoiding muscle wastage and muscles contractions, which in turn helps in coming up with functional motor output. A study conducted by Hara Y, Ogawa S showed that electrical stimulation enhances transport for relearning motor excluding poor connectivity of motor cortex and peripheral nerves. When coordinated with robotic-assisted therapy it plays an important task of converting passive contraction of muscles into functionally useful movement when required [10].

These mechanisms are incorporated to form closed chain rehabilitation protocol in which both the neuroplasticity and the muscle activation are enhanced. As a result of possible stimulating both the nervous system and musculature at the same time, this dual therapy enhances the rehabilitation outcomes of patients with serious post-stroke motor deficits.

5 CONCLUSION

This c ase r eport o pens u p t he p ossibility o f t he u se of faradic electrical stimulation and use of robot assisted hand rehabilitation in patients with MCA territory infarction and severe hemiparesis. The gains in motor function noted in this study raise the argument of neuro-motor and mechanical based rehabilitation strategies. These d iscoveries s eem to support the idea of a parallel managing strategy, which may be most appropriate for patients presenting with major motor troubles after a stroke.

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