# Functional Electrical Stimulation for Upper Extremity Therapy in Chronic Stroke: A Case Study


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## Introduction

50,000 Canadians and 795,000 Americans will experience a new or recurrent stroke each year. Despite receiving weeks of rehabilitative therapy, the majority of stroke survivors are unable to incorporate the affected upper extremity into daily activities at 6 months post-stroke.

Functional electrical stimulation therapy integrates electrical stimulation to peripheral sensor and motor nerves with repetitive functional movement. Randomized controlled trials have shown that FES therapy can restore voluntary upper limb movement in sub-acute stroke and spinal cord injury patients [Ref 1,2]. The neural mechanisms underlying the improvements are not fully understood and it remains uncertain whether FES therapy is effective in chronic stroke with severe hemiparesis.

## Objective

To investigate the impact of intensive Functional Electrical Stimulation (FES) therapy on neuromuscular changes in the upper limb (UL) of stroke patients with severe hemiparesis. [Ref 3]

## Methods

**Design:** Open label case study. To eliminate contributions from spontaneous recovery, a chronic patient (>2 yrs post-stroke) was recruited.

**Participant:** 22-year-old female with severe upper limb paresis 2 years after a hemorrhagic stroke in the right frontal parietal area, secondary to an anteriovenous malformation bleed.

**Intervention:** FES Therapy administered for 1 hour, twice daily for 12 weeks for a total of 108 treatment sessions.

**Clinical Assessments:** Chedoke McMaster Stages of Motor Recovery (CMSMR), Motricity Index, Maximum Voluntary Contraction (MVC), and Modified Ashworth Scale (MAS)

**Electrophysiological Assessment:** H-reflex and Maximum motor response ($M_{max}$)

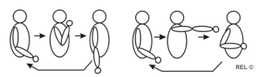
**Upper Arm Joint Kinematic Assessment:** Dynamic Range of Motion (ROM) test and Drawing Test (at 6 and 12 weeks). (**NOTE:** These assessments were added to the study as a result of remarkable improvements observed after 6 weeks of therapy, no baseline captured)

### FES Therapy Program

FES Therapy consisted of two components:

1) Pre-programmed, coordinated surface electrical stimulation of multiple muscle groups to coincide with the phase and type of arm or hand motion a patient is striving to achieve.
2) Manual assisted (externally generated) passive motion in order to establish physiologically correct movement.

The FES system offers a full range of reaching and grasping movements to facilitate shoulder, elbow, wrist and hand function.



As the patient recovers voluntary function, neuroprosthesis assistance is reduced and eventually removed.

## Results

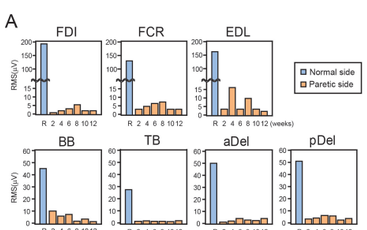
### Clinical Assessments

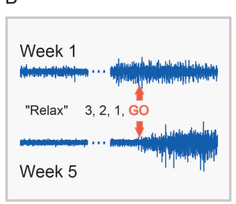
The patient completed all training sessions and assessments. The CMSMR scores remained unchanged over the course of the study. Likewise, the Motricity Index did not change during the 12 week treatment period.

Modified Ashworth Scale scores decreased from 3 to 2 for the hand and from 4 to 3 for the arm during the 12 week study period.

### Maximal Voluntary Contraction (MVC)

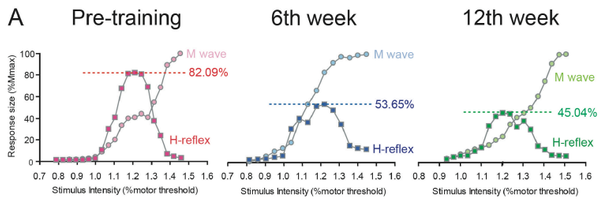
MVC of the affected arm was remarkably smaller than that of the less affected arm and showed no significant changes over the course of therapy (Figure A below). Some muscle groups (i.e., TB and FDI) showed improved EMG activity as a result of the FES Therapy (Figure B)



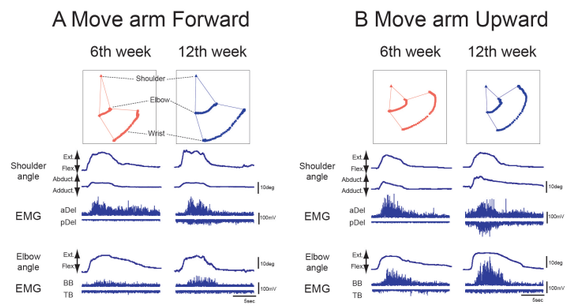

### H-reflex and $M_{max}$

H-reflex, which reflects spinal motoneuron excitability, decreased considerably over the treatment period.




### Range of Motion (ROM)

As a result of dramatic improvements observed in the first 6 weeks, voluntary arm ROM was captured using a three-dimensional tracking device (FASTRAK). For the shoulder and elbow joints, ROM tended to be larger at week 12 relative to week 6.



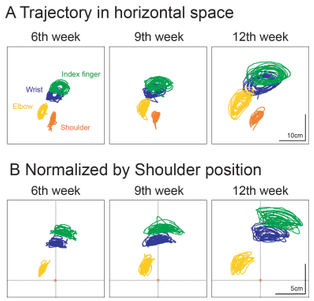

On enrollment the patient rarely used her paretic arm for functional activities.

On discharge from the study, the patient could relax her arm and hand voluntarily, allowing the arm to hang by her side when she is not using it.

Following 12 weeks of the FES Therapy, she was able to pick up a thin object and to touch her nose, movements she had been unable to perform before the therapy.

### Drawing Test

At baseline, the patient was unable to draw a circle. Over the course of FES Therapy, the patient was able to proficiently draw increasingly larger circles. The following figure shows the trajectory of the shoulder, elbow, wrist and index finger as the patient performed the circle-drawing test: (a) absolute positions of individual joints; and (b) positions normalized with respect to the shoulder joint.




## Conclusion

While motor function assessments such as CMSMR and MVC did not show remarkable changes, the chronic stroke patient showed significant improvement in upper extremity functional motion following FES Therapy.

Improvements in upper-limb function observed following intensive FES Therapy can be attributed to a) regained ability to voluntarily contract muscles of the affected arm; b) reduced spasticity and improved muscle tone in the same muscles; and c) increased range of motion of all joints.

## References and Declaration of Interest


[1] Thrasher et al. Neurorehabilitation and Neural Repair. 2008; 22(6): 706-714.
[2] Popovic et al. Neurorehabilitation and Neural Repair, 2011; 25(5): 433-442.
[3] Kawashima et al. Physiotherapy Canada 2013; 65(1): 20-28


*Declaration of Interest - Dr. Popovic is a founder, a shareholder and the Chief Technology Officer of MyndTec Inc, a healthcare company created to commercialize technologies described in this presentation.

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