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RESEARCH ARTICLE

EVOLUTIONARY TREND OF TIBIAL SSEP IN TRAUMATIC INCOMPLETE SPINAL CORD INJURY

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ABSTRACT

Background & Purpose: Neuro-rehabilitative and restorative therapies have emerged as a promising tool in recovery of spinal cord injuries. Comprehensive program can modulate the spinal excitability and help in yielding desired results. A handful of studies on humans has surged the interest in this field. Other than the expensive tools available for tapping plasticity changes in CNS some other tools like evoked potential have been found to be equally satisfactory. Evoked potentials could be useful prognostic, longitudinal monitoring and CNS remodelling tools.

Case description: This case study is an attempt to determine the progression of sensory evoked potential in traumatic SCI patient.

Intervention: Patient underwent a specifically designed protocol of 24 weeks (Activity Based Therapy & Surface Spinal Stimulation) for enhancing function and locomotion in patient with incomplete SCI.

Outcome measures: ASIA motor scores for lower extremity, light touch and pin prick as neurological, SSEP as tool for CNS plasticity changes and SCI-FAI as a tool for functional outcome measure were used.

Discussion: During the 24 weeks neuro-rehabilitative program the scores of ASIA, WISCI-II and SCI-FAI changed along with changes in t SSEP.

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INTRODUCTION

When the human spinal cord is damaged, surviving neural circuitry caudal to the lesion takes on functional characteristics that result from and represent the degree and distribution of their disconnection from supra spinal control (Dimitrijevic *et al*., 2016). The surviving neural circuitry can be tapped again for regaining functions. Once thought as an ailment not possible to be treated, Spinal cord injury is now prime area of research and concern amongst the clinicians, scientists and neuro-physiotherapists across the world. Centuries of research is being translated into clinical practice and it is building hopes for restoring functional abilities amongst the people with SCI. Walking /ambulation is one of the "most discussed" goal for a patient as well as treating physician and neuro-physiotherapist. Advancements and promising findings in neuro-rehabilitative and neuro regernative procedures for impaired spinal cord function has increased the demand for extensive neurophysiological evaluation. Electrophysiological recordings have been used in the management and care of SCI patients since 1970 but are routinely performed only in a few SCI centers (Jones *et al*., 2012). These techniques supplement clinical and neuro-radiological examinations and allow the differentiation between lesions of the spinal (ie ascending and descending fibres tracts) and the peripheral nervous system (eg: radicular lesions, plexus, and peripheral nerves). Besides being quantitative in nature measures of evoked potentials complement existing SCI recovery assessments, such as the ASIA sensory and motor scores. Both somatosensory and motor evoked potentials have been shown to generate new lateral axonal sprouts following SCI, which supports CNS plasticity and functional repair. To date, few investigations of somatosensory preservation following SCI have been presented, possibly due to a perceived lack of clinical applications. However, an eye over the preserved subclinical somatosensory function may shed light into the unexplained aspects in patients with SCI.

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Aim

The present research work determines the variation in somatosensory evoked potential in a person with incomplete SCI undergoing "specifically designed intervention".

MATERIALS AND METHODS

Participation of human subject was approved by an institutional review board before the initiation of the study.

The present work strictly compiled to the ICMR guidelines. Patient was explained in detail about the purpose and methods of this study. Informed consent was obtained from the participant. A 35 year old, male with incomplete spinal cord injury, ASIA D participated in 24 week duration protocol designed to improve the walking/ambulatory status. The participant underwent a thrice weekly sessions of activity based therapy (3 hours) and Surface Spinal Stimulation (45 minutes). Both of these interventions were delivered on the same day. Protocol also included loco motor training using Body weight support treadmill training (BWSTT) for 30 minutes in each ABT session.

ABT has following principles (Jones *et al*., 2012)

Phase I/II: Reactivation/Reorganisation and development/ stabilization Phase. Stimulates the nervous system with active assisted exercises and use developmental sequencing to develop joint stabilization

Phase III: Strength: Initiate eccentric and concentric muscle contractions through positional movement or stimulation.

Phase IV: Function and co-ordination-Improve co-ordinated movement through all planes of movement and motion. Most exercises are performed in load bearing position. Mainly free standing.

Phase V: Gait training- Focus on proper gait mechanics and the ability to move over ground in multiple planes of motion.

Surface Spinal Stimulation is non-invasive form of electrical stimulation delivered at the T 10 –L1 vertebral level with the adhesive electrodes placed para-vertebrally on each side of spine 5 cm apart. Electrodes are self-adhesive in nature rectangular 4.5 cm * 9 cm in size. The electrical stimulations had an amplitude modulated Alternating Current (AC), with a carrier frequency of 2500 Hz, modulated to “beat” frequency of 30Hz and stimulation amplitude was raised to elicit sensory stimulation (Wang *et al*., 2000). SSEP study was done by stimulating Posterior tibial nerve at the ankle on left side. The tibial nerve was stimulated dorsal of the malleolus medialis, and cortical potentials (P37/N45 complex) were recorded at Cz’ (2 cm behind the Cz position of the international 10/20 system) against the reference Fz. Impedance was maintained below 5 kΩ. Square wave electrical stimulus was delivered at 6Hz frequency. The electrical activity was averaged to 1000 responses at least and the test was repeated twice to ensure reproducibility.

RESULTS

Before the beginning of intervention the participant underwent basic examination; ASIA grading. The main focus of this study was to analyze the evolution of tSSEP parameters. However, in order to be able to interpret the functional recovery and CNS plasticity changes in spinal cord, we further analyzed the course of ASIA motor scores for lower extremity, light touch and pin prick as neurological and SCI-FAI as a functional outcome measure. Spinal Cord Injury Functional Ambulation Inventory (SCI- FAI) (Field-Fote *et al*., 2000), an observational gait assessment that includes 3 key domains of walking functions. The subscales include; gait parameters, assistive devices and temporal parameters. Higher scores denote higher levels of function in each subscale. Somatosensory evoked potential was used for assessing the CNS plasticity and functional repair.

Table 1. Score of ASIA, SCI-FAI, WISCI-II and t SSEP at Day 1, Week 12 and Week 24

Time Frame	ASIA			SCI-FAI (39)					WISCI-II (20)	SSEP
	LEMS	Pin prick	Light touch	Gait Parameter	Assistive Device	Temporal Parameter	2 min WT	Total Score		
Week0/day 1	31	105	105	19	13	4	184	36	19	3
Week 12	32	108	108	19	14	5	209	38	20	4
Week 24	34	110	110	20	14	5	219	39	20	5

LEMS: Lower extremity motor score
2 min WT: 2 minute walk test, distance walked in two minutes, measured in feet

SSEP CATEGORY
[6](considering N45 complex)

0 =absent

1= pathological

2=delayed

3= delayed latency but normal amplitude

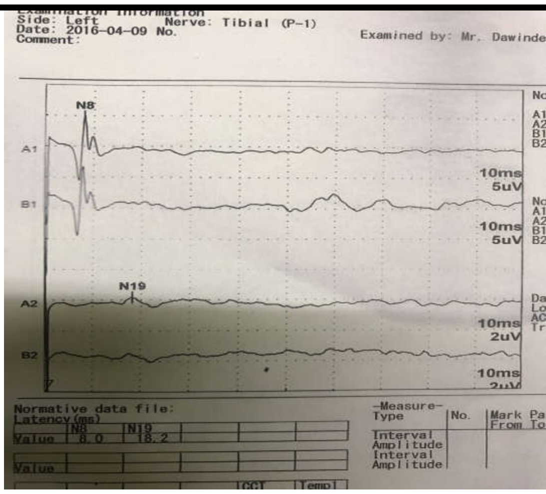
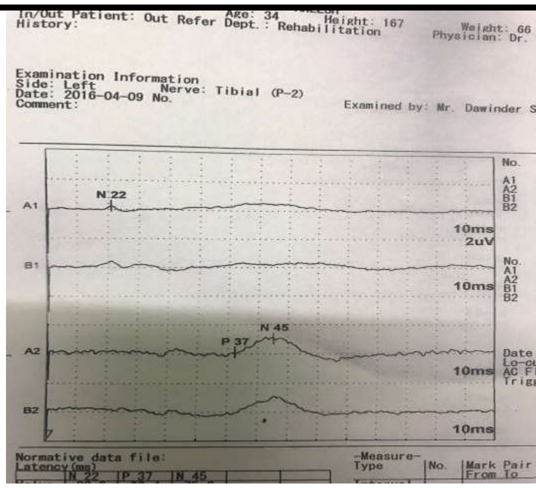
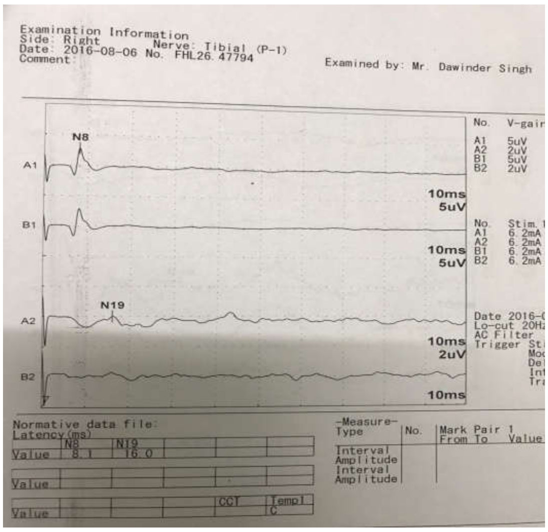
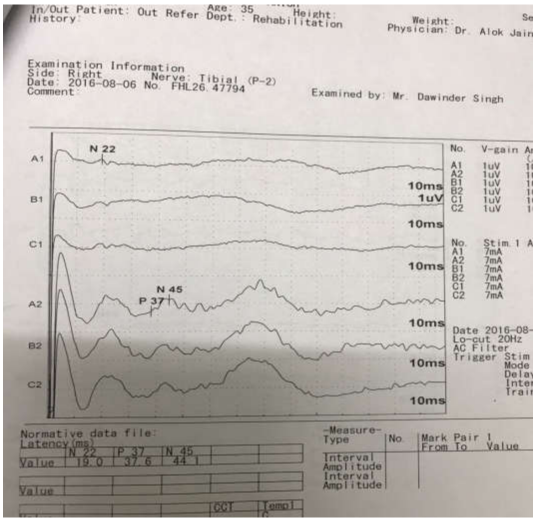
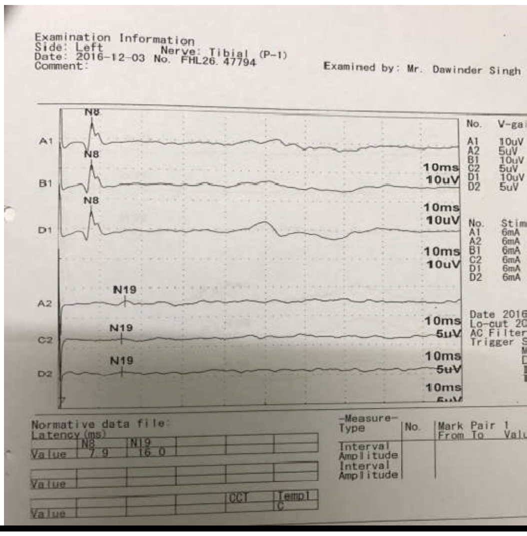
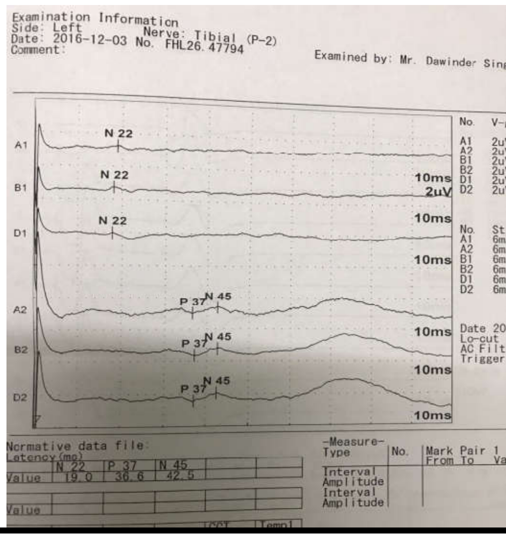
4=normal latency with delayed amplitude

5= normal

Table 2. Trend in values of various waveforms of t SSEP at Day 1, Week 12 and Week 24

Time Frame/ Latencies (ms) →	N8	N19	N22	P37	N45
Day1/ Month 1	8.0	18.2	20.9	59.70	75.2
Month 3	8.1	16.0	19.2	37.4	43.5
Month 6	7.9	16.0	19.0	36.6	42.5

Table 3. Wave forms of t SSEP oat Day 1, Week 12 and Week 24

Time Frame	Wave forms	Wave forms
01 Week		
12 weeks		
24 weeks		

DISCUSSION

The major advantage of sensory evoked potentials lies in evaluating the relatively long sensory pathway from peripheral nerve to spinal cord and central cortex. Somatosensory Evoked Potential (SEPs) are elicited with stimulation of large periphery sensory nerves in the arms or legs (Pratt *et al*., 1998; Starr *et al*., 1981; Cohen *et al*., 1985). SEPs can be reproducibly recorded over the spine and scalp, reflect conduction of the afferent volley primarily along the heavily myelinated dorsal column, through lemniscal pathway to the primary somatosensory cortex. The present study tried to utilise the sensory evoked potentials in determining the effectiveness of activity based therapy and surface spinal stimulation in regenerating the lumbar locomotor pattern generator. After PTN stimulation, a sequence of waveforms occurs in the following order of increased latency: (a) popliteal fossa response (N8) (b) the lumbarN19- N22 (c) the scalp recorded P37 and cortical potential N45 complex. Each waveform has a putative generator; travelling wave evoked after PTN stimulation, dorsal gray matter of spinal cord and the primary sensory cortex. These potential produced by PTN stimulation arise from the activity in muscle afferents (Burke *et al*., 1981; Burke *et al*., 1982). It is believed by the authors that the presence of various waveforms and change in latencies of tibial SEP is an indicator of neural activity in spinal cord circuitry. Also it was observed that during the six months training program the scores of ASIA, WISCI-II and SCI-FAI changed along with changes in t SSEP. Thus, peripheral nerve stimulation in man results in scalp recorded SSEP, which represents a volume conducted potential reflecting a variety of brain and spinal cord generators including the activation of spinal cord generator for locomotion and proprioceptive pathways.

Conflict of Interest: None

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