Effect of Dermatomal Electrical stimulation on Hemiplegic Drop foot During Gait in Patients with Stroke

Ji Yong Lee [1], Young-Hee Lee[1] , Sa Yub Kim[2] , Yong Jin Kim[1], Kyoubom Auh[1]
Young Ho Kim[2]
[1]Department of Rehabilitation medicine, Yonsei University, Wonju College of Medicine, Won ju, Korea
[2]Department of Biomedical Engineering, Research Institute for Medical Instrumentation & Rehabilitation Engineering, Yonsei University, Won ju, Korea

E-mail : jylee103@wonju.yonsei.ac.kr

Abstract

The purpose of this study was in hemiplegia patients, to examine the effect of the inhibitory effect of spasticity appeared in response to dermatomal electrostimulation applied to the ankle plantar flexor on the spastic foot drop during gaits. The study population was 9 patients. They walked for 5 times before electrical stimulation and during electrical stimulation. In the gait performed under dermatomal electrical stimulation, in the affected side, the ankle dorsiflexion angle during the initial heel contact was significantly increased and during the midstance, the maximal dorsiflexion angle of ankle joint was found to be significantly increased ($p < 0.05$).
In addition, prior to electrical stimulation and during the stimulation, between the non-affected side and the affected side, the time difference of swing time was decreased, however, a statistically significant difference was not detected ($p > 0.05$). The experiment results show that in spastic foot drop patients caused by the spacticity of the ankle plantar flexor muscles, dermatomal electrical simulation increased the active range of motion of the ankle joint and affected the gait cycle and the gait pattern

1. INTRODUCTION

An estimated 20% of survivors have a spastic drop foot. Spastic drop foot is condition that frequently complication stroke.[1]This deformit y is mainly caused by spastic of the soleous, gastrocnemius, and tibialis posterior muscles. This spasticity is sometimes associated with p eroneus and tibialis anterior muscle weakness, motor control loss, and Achilles tendon shorte ning. Treatment of spastic drop foot is phama cologic therapy, multimodal and includes phys ical therapy, an orthsis, chemical neurolysis w ith phenol and alcohol, botoliuim toxin injecti ons, peripheral selective neurotomy, tendontra nsfer, and Achilles tendon lengthening. It has been shown that the therapeutic electrical sti mulation is effective at reducing spasticity an d improving the functions for patients with an injury of the central nervous system. .[2]
Electrical stimulation of the cutaneous afferent nerve ending has been reported to reduce spasticity effectively without any pain or discomfort, since the stimulation intensity required is lower than that required by the other methods.[3] Kim et al have reported that dermatomal electrical stimulation decreased the spasticity in lower extremities of patients with brain injury.[4] However, previous studies showing the effect of dermatomal electrical stimulation on the functional movement of lower extremities are not available. The purpose of this study was to determine the immediate effect of dermatomal stimulation applied to the sensory lesion of gastrocnemous and soleus during the gait cycle on the ankle kinematics and temporospatial data of adult with hemiplegic sroke.

2. METHODS

2.1 Selection Criteria

Nine patients were recruited to the study.Patients were referred to the investigators from physiotherapy department in the Wonju area. These patients were assessed for their suitability for study against following criteria:

1) Hemiplegia as a result of a cerebrovascular accident(CVA). 2) Modified Ashworth Scale(MAS) score 1 over on ankle plantar flexors. 3) Manual Muscle Testing on ankle dorsiflexors,plantar flexors score 2+ over 4) Ability to walk independently without assistive devices for at least 10m 5) no severe joint contracture on ankle, knee, hip joint 6) Sufficient communication skills to understand the processing of this study 7) Greater than three month post CVA.

9subjects, 5male and 4 female, aged 44 to 62 years(mean = 48.1), they were on average 31.2 months post CVA. 6 right hemiplegia and 3 left hemiplegia (Table 1)

2.2 Gait Evaluation

Patients were instructed to walk at their comfortable speeds on a 10m walkway for 5 repetitions. A Vicon motion analysis system with 6 cameras was used to record gait kinematics at 120Hz. Reflective markers were placed on the bilateral second metatarsal head, lateral malleolus, heel cord, midshank, knee joint center, midthigh, anterior superior iliac spine, posterior superior iliac spine. Data was calibrated by static data. The study subjects walked 5 times under the condition without electrical stimulation and during electrical stimulation. In each trial, to prevent the muscle fatigue of the subjects, they were rested sufficiently. Based on the temporal and spatial information of these gait events, the Vicon Clinical Manager Software calculated velocity, stride length, single-leg stance time, swing time, and double-leg stance time. Also ankle sagittal kinematic data was collected.

Table 1. *Clinical characteristics of subjects* (n=9)

Subjects	Age	Sex	Dx	Lesion	Time since injury (month)	MAS	MMT	Hight (cm)
1	44	F	CVA	Lt	21	G2	P-	158
2	54	F	CVA	Rt	22	G1+	P-	162
3	59	M	CVA	Rt	72	G2	F-	170.7
4	44	M	CVA	Lt	41	G1+	F-	164.5
5	38	M	CVA	Lt	56	G1	P+	165.5
6	50	M	CVA	Rt	24	G1	P+	172.5
7	62	M	CVA	Rt	13	G3	F	168
8	34	F	CVA	Rt	3	G1	F-	162
9	48	M	CVA	Rt	6	G1	F	158
Mean±SD	48.1±8.7				31.2±22			164.1±4.8

2.3 Electrical Stimulation

Electrical stimulation was applied using a potable neuromuscular stimulator. The electrodes were placed over the S2 dermatome.(Fig 1). The stimulation parameters used were biphasic rectangular pulses of 35Hz frequency, with a 250 μs pulses width. Electrical stimulation was delivered through a 5 x 5cm surface electrode surface electrodes. The intensity of the stimulation was adjusted to a level just below the threshold of visible muscle contraction.

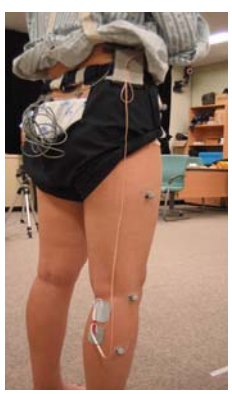

Fig 1. *Electrodes , reflective markers placed and test settings*

2.4 Statistical Analysis

The results of the change of gait parameter before and during electrical stimulation were analyzed by repeated one-way ANOVA. The statistical analysis of data were performed by using a commercial statistical program, SPSS 12.0, and the significant level α was 0.05.

3. RESULTS

In regard to the gait during dermatomal electrical stimulation, in the affected side, a significantly decreased plantarflexion angle at the initial heel contact was detected, and thus relatively, the dorsiflexion angle was increased significantly ($p < 0.05$), and during the midstance, the maximal dorsiflexion angle of ankle joint was found to be increased significantly ($p < 0.05$).

Table 2. *Gait parameter*

Parameters	EST Off	EST On	p
Initial contact Ankle Dorsiflexion	- 7.88±2.44	-5.82±1.98	0.02
Midstance Maximal Dorsiflexion	7.95±1.97	10.04±1.74	0.01
Step time/Stride time ratio	0.59±0.13	0.57±0.18	0.42
Swing time ratio(symmetry)	0.84±0.89	0.96±0.01	0.17

In the gait cycle, the swing time of the affected side was decreased, and the single-leg stance time of the non affected side was decreased, however, a statistically significant difference was not detected ($p > 0.05$). In addition, in the gait prior to electrical stimulation as well as during the stimulation, the time ratio of the swing time between the non affected side and affected side was decreased, but a statistically significant difference was not detected ($p > 0.05$). The gait velocity between the cases without electrical stimulation and during electrical stimulation was not different significantly.

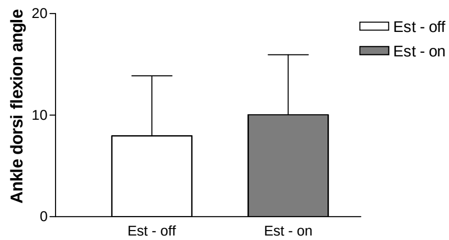

Fig 2. *comparison of ankle plantar flexion during initial heel contact (a) without EST and(b) with EST.*

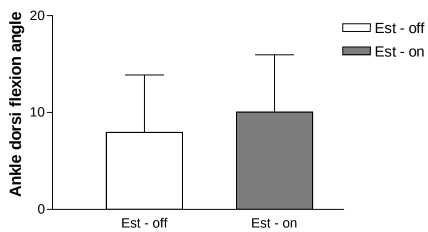

Fig 3. *Comparison of ankle maximal dorsiflexion during midstance (a) without EST and (b) with EST.*

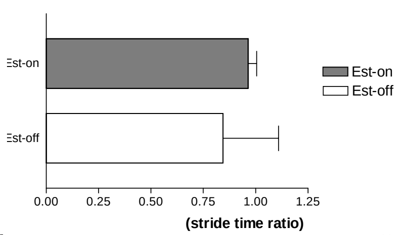

Fig 4. *Swing time symmetric ratio(non affected side swing time/affected side swing time=1)*

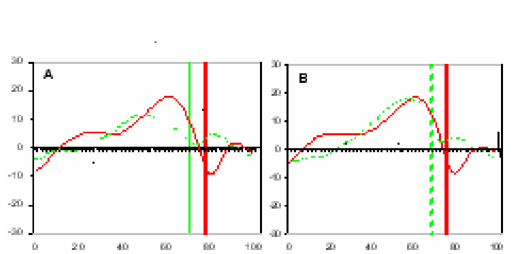

Fig 5. *Variation of ankle gait cycle: affected side and non affected side (a) sagittal ankle kinematic data without EST,(B) with EST(a dotted green line indicates affected side, a solid red line indicates non affected side).*

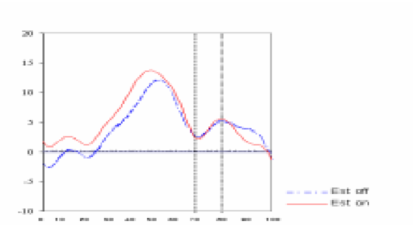

Fig 6. *Variation of affected side ankle range of motion during gait(a dotted blue line indicates without EST, a solid red line indicates with EST)*

4.DISCUSSIONAND CONCLUSIONS

In regard to the spastic foot drop phenomenon appeared in the spastic gait of hemiplegic patients, through dermatomal electrical stimulation, the ankle dorsiflexion at the initial heel contact and the maximal dorsiflexion during the midstance were increased significantly. This may be due to the increased of the activation of ankle dorsiflexors caused by the inhibition of the spascity of gastrocnemius and soleus through electrical stimulation. In a gait cycle, the reduction of the time of the affected side swing phase, and the stride time of non affected side and affected side and the symmetry of swing time were increased significantly. Although dermatomal electrical stimulation does not induce the contraction of muscles directly, during the period of spontaneous movement, the functional movement of lower extremities was performed, and thus it was able to improve the ability to recruit the muscles required for a gait and it induced the improvement of movement pattern obtained by the repeated use during electrical stimulation.

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