Effects on Percutaneous Intramuscular Therapeutic Electrical Stimulus in Activities of Daily Living in Patients with Incomplete Paraplegia.

H. Ito*, Y. Shimada**, T. Matsunaga**, Y. Tsutsumi***, S. Ando*, T. Minato*, M. Sato**, S. Chida**, K. Hatakeyama**, K. Iizuka****
*Department of Orthopedic Surgery, Akita University School of Medicine, 1-1-1 Hondo, Akita City, Akita University Hospital, Akita, Japan
**Rehabilitation Division, Akita University Hospital, Akita, Japan
***Imamura Memorial Hospital, Akita, Japan
****BIOTEC, LTD

Abstract

Eleven spinal cord injured patients participated in this study. They were classified into two groups: (a) stimulated by percutaneous intramuscular electrodes, and (b) stimulated by surface electrodes.

In this study, we mainly evaluated the effect of stimulation using percutaneous intramuscular electrodes, in reducing spasticity and thus improving the activities of daily living (ADL) in patients with incomplete paraplegia. Next, we compared the results of percutaneous intramuscular stimulation versus surface stimulation in the incomplete paraplegic patients.

In the percutaneous intramuscular electrodes group, 5 of 7 patients were improved in ADL. On the other hand, in the surface electrodes group, none of the patients had any decrease in their level of spasticity.

Introduction

Incomplete injury to the spinal cord causes disability of gait due to spasticity and muscle weakness [1]. There are various approaches currently in the treatment of spasticity: physical rehabilitation, nerve block, drugs for muscle relaxation (antispasticity medication), orthosis, and electrical stimulation. Recently there have been many reports on spasticity reduction owing to therapeutic electrical stimulation (TES). Several forms of electrical stimulus like epidural and peripheral nerve implantation [5], mostly using surface electrodes, have been described.

We think that surface electrodes have some problems. They are due to requiring troublesome daily placement and removal, discomfort when excessive stimulation is given by surface electrodes. We have been using percutaneous intramuscular functional electrical stimulation (FES) since 1990 and have resolved the surface electrodes' problems.

The purpose of this paper is to show the effectiveness of electrical stimulation, using percutaneous intramuscular electrodes, in reducing spasticity and thus improving the daily activities in patients with incomplete paraplegia. The second purpose of this study was to compare the results of percutaneous intramuscular stimulation versus surface stimulation in the incomplete paraplegic patients.

Patients

Eleven SCI individuals, 8 men and 3 women, participated in this study. The patients were classified into two groups: (a) stimulated by percutaneous intramuscular electrodes, and (b) stimulated by surface electrodes. There were 7 patients in the percutaneous intramuscular electrodes group and 4 in the surface electrodes group.

The average age of the patients in the percutaneous intramuscular electrodes group was 39 years (range, 22-62 yeas). Injuries were classified as cervical in 2 patients, and thoracic in 5, with the interval between injury and therapeutic stimulus ranged from 13 to 103 months. The cause of the injury was traumatic in 5, infectious in 1 and spinal infarction in 1. The average follow-up time was 42.3months (range, 3 to 66 months). Table 1 is a summary of percutaneous intramuscular electrodes group.

In the surface electrodes group, the average patient age was 54 years (range, 40-73 yeas). Injuries were classified as cervical in 1 patient, and thoracic in 3. All patients were injured by traumatic episodes. The average follow-up time was 4months (range, 2 months to 5 months). Table 2 is a summary of the surface electrodes group.

All patients had retained some voluntary movement or walking ability (Frankel C or D). None of the patients received another treatment to control their spasticity.

Methods

In the percutaneous intramuscular electrodes group, the FESMATE developed by Nippon Electric Company was used for TES in this study (Fig. 1). A stimulation frequency of 20Hz was used. The pulse amplitude was modulated from 0 to –15V up to sensory tolerance. Rectangular pulse trains were used with 200 microseconds pulse width. Percutaneous intramuscular electrodes (Nippon Seisen Co. Ltd.) were implanted into the motor points of the muscles (Fig. 2). Electrical stimulation started two weeks after implantation. Table 3 shows the protocol of TES. At the beginning, the stimulation was applied for 5 minutes, three times daily. For the following two weeks, TES was conducted five times daily for 5 minutes each. After 4 weeks from the beginning, the

Table.1: Patient Characteristics in the percutaneous intramuscular electrodes group

Patient	Age/Sex	Injured Level	Cause of The Injury	Time Since The Injury	Time Since Starting TES	Frankel Classification
1.	25 / M	C5	fracture-dislocation	22m	20m	D
2.	22 / M	C6	fracture-dislocation	16m	57m	D
3.	44 / M	T6	tuberculous spondylitis	15m	14m	D
4.	49 / M	T10	fracture-dislocation	13m	45m	D
5.	69 / M	T11	spinal infarction	23m	3m	C
6.	62 / F	T12	burst fracture	103m	66m	D
7.	32 / M	T12	burst fracture	19m	52m	C

Table.2: Patient Characteristics in the surface electrodes group

Patient	Age/Sex	Injured Level	Cause of the Injury	Time Since Starting TES
1.	46 / M	T6	OPLL	5m
2.	40 / M	C6	cervical disc herniation	4m
3.	57 / F	T10	OYL	5m
4.	73 / F	T8	tuberculous spondylitis	2m

Fig. 1 FESMATE (NEC, Japan)

Fig. 2 Percutaneous intramuscular electrode (Nippon Seisen, Japan)

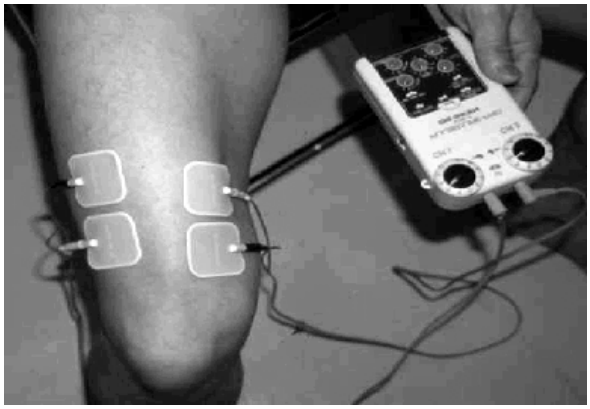

Fig. 3 PULSECURE-PRO (OG GIKEN, Japan)

Table. 3: TES protocol

Time Since Starting TES	Duration of stimulation	Times of stimulation a day
1week	5min	3
2weeks	5min	5
3weeks	10min	5
4weeks	15min	5

stimulation was extended to 15 minutes, five times per day. In the surface electrodes group, PULSECURE-PURO (OG GIKEN Co. Ltd.) was used for stimulation (Fig. 3). A stimulation frequency of 20-30Hz, a pulse duration of 300microseconds, and a stimulation amplitude of up to 90mA was used. The surface electrodes were placed over motor points of the quadriceps and hamstrings.

Spasticity in the lower limbs was assessed using the modified Ash worth scale. All patients were evaluated preoperatively and postoperatively by the senior author. To further evaluate the effects of TES, the following parameters were also studied; activities of daily living, gait analysis, muscular strength in the lower limbs and patient's assessment. The results were subjectively graded as excellent, good, fair, and poor.

Results

In the percutaneous intramuscular electrodes group, in patients 1, 2, and 3, the spasticity significantly decreased after stimulation for a period of about 1 week. These 3 patients regained muscle strength and smooth flexion-extension movement in their lower limbs so they felt that they had less difficulty during walking. As a result, these patients abandoned their wheel chair and walked with crutches. Patient 3 claimed that he could sleep through the night uninterrupted by spasms,which routinely woke him up

Table. 4: Results in the percutaneous intramuscular electrodes group

Patient	Spasticity Reduction	Increase of muscular strength	Improvement of ADL	Outcome
1.	marked reduction	moderate increase	wheel chair→crutch gait	excellent
2.	marked reduction	moderate increase	wheel chair→crutch gait	excellent
3.	marked reduction	moderate increase	wheel chair→crutch gait	excellent
4.	moderate reduction	no change	gait velocity, faster	good
5.	no change	no change	no change	poor
6.	no change	no change	gait velocity, faster	good
7.	no change	no change	no change	poor

Table. 5: Results in the surface electrodes group

Patient	Reduction of Spasticity	Increase of muscular strength	Improvement of ADL	Outcome
1.	moderate reduction	moderately increased	no change	fair
2.	no change	no change	no change	poor
3.	no change	no change	no change	poor
4.	no change	no change	no change	poor

before stimulation and that urinary dysfunction was improved. In patient 6, TES had little effect in treating spasticity but she felt that the ability of gait was improved after stimulation. The overall results were excellent in 3, good in 2, and fair in 2. On the other hand, in the surface electrodes group, none of the patients had any decrease in their level of spasticity.

Discussion

There have been many reports on spasticity due to secondary to electrical stimulation [2], [3], [4]. Surface electrical stimulation in the treatment of spasticity has been more widely investigated than other forms of stimulation. In these studies, authors mentioned that the effectiveness of stimulation on spasticity was objectively evaluated a using variety of methods. Few reports had described of the influence to daily activities.

In this report, we assessed the effectiveness of stimulation in evaluating improvements of the activity of daily living and in other parameters. Spasticity reduction was obtained remarkably in 3 of a total of 11 patients, all were in the percutaneous intramuscular electrodes group, and they abandoned their wheel chair and maintained the same daily activities. In another 2 cases, in spite of no or moderate reduction of spasticity, they had improved their walking ability and felt releived by stimulation.

In the percutaneous intramuscular group, 2 of 7 had no change in reduction of spasticity, increase of muscular strength, and improvement of ADL. They had poor reaction to stimulation. We supposed that these patients' injured level was a low level (termination of the spinal cord) so injury of peripheral nerves were combined. In the surface electrodes group, only 1 patient retained mild effects of stimulation and another 3 had no effect.

In this study, this group's average time since starting TES was 4months (range, 2 to 5 months). Owing to this short duration of stimulation and few patients, these two groups were not comparable, but in the percutaneous intramuscular group, spasticity decreased after stimulation for a period of about 1 week.

Viewed from this point, stimulation using percutaneous intramuscular electrodes was an effective treatment on reducing spasticity.

References

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