Clinical Application of Functional Electrical Stimulation to The Hemiplegic Cerebral Palsy Children

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Abstract

We intend to apply functional electrical stimulation (FES) instead of orthoses to conditions such as hemiplegic cerebral palsy children. The purpose of this paper is to report on application of FES to the hemiplegic cerebral palsy children.

The subjects were two boys (both are 6 years-old) and a 7 year-old girl. They were diagnosed as spastic hemiplegic cerebral palsy. Heel contacts were not seen, and crouching and circumduction gait due to equinus foot were observed.

Calf muscle lengthening (Vulpius method) was performed initially, and percutaneous intramuscular electrodes were simultaneously implanted to the motor points of tibialis anterior muscle and soleus muscle. Custom made electrical stimulator was applied for gait restoration. Gait parameters were evaluated with 3-D motion analysis system and force plate.

The velocities and the strides were increased. Foot contact was changed to a heel-strike pattern instead of toe-strike pattern. Circumduction gait and knee recurvatum were improved. Combined method of muscle tendon lengthening and gait restoration by FES with percutaneous intramuscular electrodes is clinically useful for cerebral palsy children.

Key words: functional electrical stimulation, percutaneous intramuscular electrodes, cerebral palsy, child, hemiplegia

Introduction

Cerebral palsy (CP) is a diagnostic category in which the common underlying abnormality is an injury to the central nervous system occurring within the first 2 years of life. Several types of orthoses are applied for spastic cerebral palsy children to correct gait. Circumduction gait due to equinus foot was commonly seen in hemiplegic patient and ankle-foot orthoses are usually used to correct equinus foot. There are few reports on FES application to correct equinus foot for CP children [1]. We intend to apply FES instead of orthoses to conditions such as hemiplegic cerebral palsy child. The purpose of this paper is to report on application of FES to the hemiplegic cerebral palsy children.

Subject

The subjects were three children. They were two boys (both are 6 years-old) and a 7 years-old girl. They were diagnosed as spastic hemiplegic cerebral palsy. Equinus foot progressed year after year in spite of conventional therapy. Heel contact was not seen, and crouching and circumduction gait due to equinus foot were observed. The subjects and their parents gave informed consent to this FES program.
Methods

The operation was performed under general anesthesia. Calf muscle lengthening (Vulpius method) was performed initially, and percutaneous intramuscular electrodes were simultaneously implanted to the motor points of tibialis anterior muscle and soleus muscle. After casting for 3 weeks, therapeutic electrical stimulation for muscle strengthening was started. Custom made electrical stimulator Akita heel-toe sensor system (AHTSS, Biotec Ltd.) was applied to gait restoration. AHTSS consisted of 4 channel stimulator and two pressure sensors which were attached to the heel and the toe. Stimulation pattern was determined by the sensor switch on/off pattern. Anterior tibial muscle was stimulated during the swing phase, soleus muscle was stimulated from heel-off to toe-off (Fig. 1). Gait analyses were performed with 3-D motion analysis system (Vicon 140; Oxford metrics) and force plate (Kistler). Temporal-distance factors (gait velocity, stride length and cadence), sagittal plane stick figure of right lower extremity, horizontal locus of the foot and vertical ground reaction force (GRF) pattern were compared between preoperative and FES gait.

Results

The velocities and stride lengths increased about 10-30%. The cadences decreased about 5-15%.

Figure 1. Tibialis anterior muscle is stimulated during swing phase. Soleus muscle is stimulated from heel-off to toe-off.

Initial contact with toe and knee recurvatum in the late mid stance phase were observed before operation. In FES gait, initial contact with the heel was observed and knee recurvatum disappeared. (Fig.2).

Preoperative vertical GRF pattern of the right leg showed irregular curve and abnormal notch. Vertical GRF pattern of FES gait showed smooth double curve pattern.
Discussion

There are many clinical approaches to correct equinus foot in the CP patient, such as orthoses, tibial nerve block, muscle-tendon lengthening and so on [2]. We have applied FES to correct equinus foot for adult stroke patient [3]. Our FES system called Akita heel sensor system (AHSS) consists of the stimulator, heel sensor switch and the percutaneous intramuscular electrodes implanted in the peroneal nerve and anterior tibial muscle. The surface electrodes have been used in many reports to correct equinus foot for stroke patient [4]. But the surface electrodes give the patients irritable discomfort to the skin. Percutaneous intramuscular electrodes don’t give such discomfort. Irritable or painful treatment is difficult for children. Percutaneous intramuscular electrodes are adequate for children.

In our case, the combined method of muscle tendon lengthening and gait restoration by FES with percutaneous intramuscular electrodes is adopted. Initial foot contact with toe altered to a strike with heel by means of our methods. Altered initial foot contact may give a normal gait pattern and GRF pattern.

CP children have various types of disabilities in each case. Appropriate selection of the CP patient to apply FES leads to a good result.

Conclusion

The combined method of muscle tendon lengthening, muscle strengthening using TES and gait restoration by FES is clinically useful for cerebral palsy children.
References