

Original Paper

# Hip-Knee-Ankle-Foot Orthosis Using a Medial Single Hip Joint: A Clinical Study of a Paraplegic Child

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*(Accepted May 20, 1998)*

Key words : orthosis, paraplegia, child, standing, ambulation

## Abstract

This study describes and discusses a clinical experience with a hip-knee-ankle-foot orthotic (HKAFO) system using a medial single hip joint (MSH-KAFO). The MSH-KAFO (Walkabout<sup>®</sup>) was invented by Stewart MacKay in 1992. It has many merits compared with other HKAFO systems because the hip joint is compact and removable. This system was clinically tested with a paraplegic child (female, 14 years old) whose condition was the result of a thoracic spinal cord injury. Her functional level was T-6. A few days after she began to use the MSH-KAFO, she was able to stand without any support and initiated parallel bar ambulation on the third day. On the seventh day, she was able to ambulate using two Lofstrand crutches with moderate assistance from the physical therapist. The functional level attained was lower than that of others, because she had severe scoliosis, spasticity in her hip flexor and triceps suare muscles, and flexion contractures in her knee joints. It was concluded that MSH-KAFO is most suitable for patients without deformities, contractures, or spasticity in the spine or lower extremities.

## Introduction

Ambulation has always been difficult for paraplegic patients, even if they have a strong desire to walk. The wheelchair is, at present, the most useful device for locomotion. However, the value of an upright posture, even for short periods, has been demonstrated in patients normally confined to a wheelchair [1]. According to Saitoh et al.[2], the lower eye-position when confronting other people gives the patient a feeling of inferiority. For other medical reasons, such

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as osteoporosis, contracture of the legs and cardiovascular deconditioning, standing and ambulation exercises are valuable in the rehabilitation of paraplegics. In orthotic trials for standing and ambulation by paraplegics, hip-knee-ankle-foot orthoses (HKAFO) have been adopted. The author previously reported the case of a congenitally paraplegic infant patient with a thoracic spinal cord injury, who was able to ambulate using two Lofstrand crutches and an HKAFO attached to a spinal brace[3]. Orthotic control required hip joint locks to prevent flexion and resulted in restriction of hip motion, forcing a swing gait. To achieve a reciprocal gait, a new HKAFO, which has a unique medial single hip joint (MSH-KAFO), was introduced. The author adopted this HKAFO for treating a congenitally paraplegic patient. The purpose of this study is to report on the clinical experience with the new HKAFO (MSH-KAFO, Walkabout®).

### Case

The patient was a 14-year-old female with congenital paraplegia due to a sixth thoracic spinal cord injury. She was a junior high school student in a regular school, who regularly used a wheelchair for locomotion. Her mother and friends helped her when she had problems at school. At the age of six, she was brought to our hospital by her mother. She hoped to receive outpatient treatment in the form of physical therapy, such as standing and ambulation exercises, in addition to regular medical examinations. In August 1990, she was fitted with an HKAFO attached to a spinal brace and physical therapy was begun. From 1990 to 1995, the patient received about 40 minutes of training once a week, as an outpatient. After six years, she could ambulate with the HKAFO using both Lofstrand crutches, ambulating independently for a distance of 300 meters at a speed of about 25m/min using a swing-gait pattern. An evaluation in January 1996 revealed the following. She was 136 cm tall and weighed 32.5kgs. A sensory and manual muscle test (MMT) showed complete sixth thoracic level paraplegia. The strength of both upper extremities was normal, whereas that of the abdominal area and both lower extremities was zero. The muscle tonus of the paralyzed part of her body was flaccid, but stimulation of the soles of the feet showed hypertonus of the triceps surae muscle, ankle clonus and hip flexor muscles. The range of motion test (ROM-T) showed an extension of -10 degrees for both knees while the ankles showed zero dorsiflexion. An X-ray disclosed S-curve scoliosis of the thoracic and lumbar spine (Cobb 55 degrees) and deformity of her left frontal thorax. There were no problems with her cranial nerves, intelligence or emotional states. With the support of her mother, she was motivated to achieve ambulation, even non-functional ambulation, with the aide of the new HKAFO. She was able to independently operate a wheelchair for locomotion and the activities of daily living. The goal of physical therapy was for the patient to attain non-functional ambulation using the new HKAFO (MSH-KAFO).

### Program and course of physical therapy

Her program of physical therapy included the following:

1. Muscle strengthening exercises for the upper extremities
2. Range of motion exercises for the lower extremities
3. Exercises to correct scoliosis
4. Standing balance exercises
5. Ambulation exercises

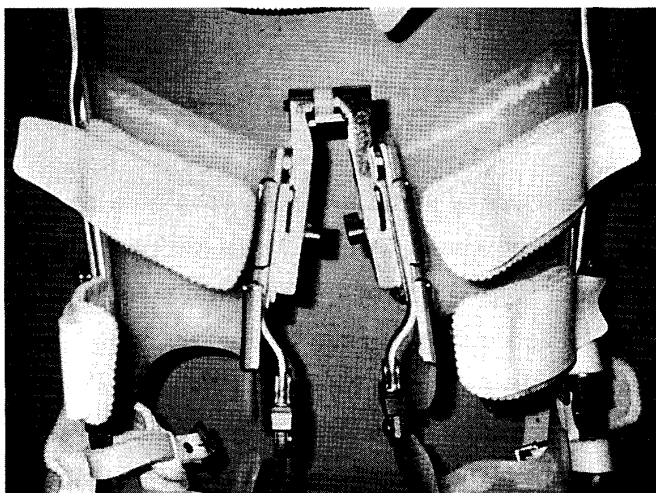
The course of physical therapy was as follows. The KAFO and the spinal brace to stabilize her scoliotic spine were customized for the patient by our orthotists in December 1995. Two weeks was needed for fabrication, after which the patient was admitted in January 1996 for a week of intensive training by her physical therapist in standing and ambulating using the MSH-KAFO. She was not able to stand using the system on the first day. In a few days, however, she was able to stand without any support for about one minute, but tended to lean forward because the hip joints were flexed by the spasticity of the hip flexor muscles. The angles of extension of the hip joints were zero. Parallel bar ambulation was initiated on the third day and she was able to ambulate with close supervision. However, the patient required a great deal of assistance with both upper extremities while ambulating. On the fifth day, she began to ambulate using two Lofstrand crutches with moderate assistance from her physical therapist. The therapist had to help her extend the hip joints while ambulating. The patient was able to ambulate for 120 meters on the last day of her stay in the hospital using two Lofstrand crutches and with moderate assistance. Thereafter, she followed an exercise program once a week. The angle of extension of the hip joint was changed from zero to -10 degrees on January 30, resulting in an increase in stability while standing and ambulating. Thereafter, she was able to ambulate with minimal assistance (Fig.1).

### Discussion

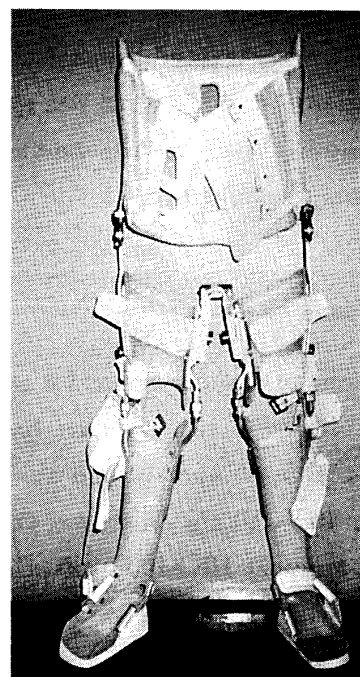
Several orthotic systems for assisting paraplegics to stand and walk have been designed and tried. HKAFO systems have been most commonly used. Among these, reciprocating gait orthoses (RGOs) and the hip guidance orthosis (HGO) are well known and seem to succeed in promoting walking. However, they are bulky and difficult to use with wheelchairs. Recently, a more compact HKAFO system with a unique medial single hip joint (Walkabout<sup>®</sup> unit, Poly-med, Gold Coast, Queensland, Australia), has been introduced (Fig.2). This new HKAFO system was adopted for clinical use on a paraplegic child. The new system (MSH-KAFO) is a unique orthotic system invented by Stewart MacKay in 1992. The KAFO part, which is fabricated by an orthotist for each patient, has a quadrilateral shaped plastic thigh cuff, a Swiss knee lock joint, and a rigid plastic ankle-foot orthosis. A single axis hip joint unit, which is located between the thighs under the perineum, has detachable portions so that the KAFOs can



Fig. 1 The patient was able to ambulate with minimal assistance from the physical therapist using the MSH-KAFO and two Lofstrand crutches.



(A)



(B)

Fig. 2 The new HKAFO system: (A) The medial single hip joint part of the Walkabout® unit is located between the thighs of the KAFO under the perineum and is attached to the KAFO. The patient needed a spinal brace for her scoliosis: (B)

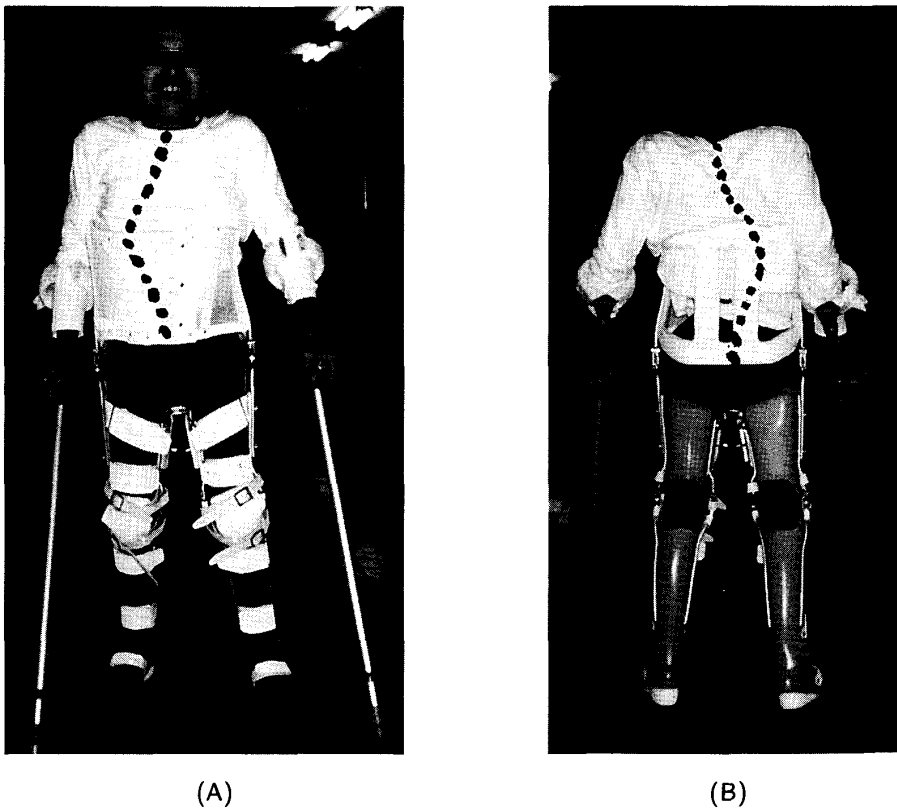


Fig. 3 The patient had severe scoliosis that resulted in instability of the trunk while ambulating: (A)(B)



Fig. 4 Spasticity in her hip flexor muscles and flexion contracture of her knee joints resulted in instability while standing and ambulating.

be easily removed. A thoracolumbar or lumbar corset is used with the system to stabilize the trunk. This corset has cross-straps to the hip joint that help the legs to swing. The paraplegic patient is able to swing from one leg to the other by shifting the body weight to the opposite side mechanically and automatically using the hip joint unit. Saitoh et al[2] performed clinical tests on the MSH-KAFO in five paraplegic patients with spinal cord injuries. They reported that all the patients were able to stand immediately after putting the system on, to initiate parallel bar ambulation on the first day, and to independently ambulate using Lofstrand crutches in a few days. The author would like to make clear the restrictive factors of the MSH-KAFO by comparing the patient in this study with those in Saitoh's study. The patient in this study had a severe spinal deformity (scoliosis), that resulted in an instability of the trunk in walking because she had to shift her body weight to one leg. She had spasticity in the hip flexor muscles, which disturbed her C-curve posture and full extension while standing and ambulating (Fig. 3). She also had flexion contracture of her knee joints that resulted in an instability of the sagittal alignment of the lower extremities (Fig.4). The patient had a severe thoracic spinal cord injury, weakness in her upper extremities, and needed a heavy spinal brace to stabilize the trunk. The new system seems to have many advantages for paraplegic patients, but its use may be restricted. The patients must be able to stand without assistance immediately after putting the system on, initiate parallel bar ambulation on the first day of exercise, and ambulate with Lofstrand crutches independently in a few days. Further restrictions are that they must be without any spinal deformity, spasticity in the hip flexor muscles, or flexion contracture of the knee joints. In addition, they must have strength in the upper extremities to stabilize themselves.

#### References

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