The WalkAide® Functional Electrical Stimulation System – A Novel Therapeutic Approach For Foot Drop in Central Nervous System Disorders

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Abstract

Foot drop is the inability to voluntarily dorsiflex the ankle during the swing phase of gait. Foot drop decreases gait quality, limits mobility, increases fall risk, and greatly increases energy expenditure during walking. Traditionally, foot drop is treated with passive dorsiflexion support by an ankle foot orthosis (AFO) but today, functional electrical stimulation (FES) devices are available to promote comfortable, effective active dorsiflexion during gait for patients with central nervous system (CNS) causes of foot drop. The WalkAide® FES System's unique control system, with tilt sensors to trigger electrical stimulation during the swing phase, can help normalise gait and thus optimise safety, cosmesis and energy efficiency in people with stroke, multiple sclerosis, cerebral palsy and a wide range of other CNS disorders.

Keywords

Brain injuries, cerebral palsy, electric stimulation therapy, gait, multiple sclerosis, stroke, walking

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Foot drop is the inability to voluntarily dorsiflex the ankle and thereby lift the foot during the swing phase of gait. Foot drop is characterised by dragging the foot, which causes tripping or a steppage gait where the person raises their knee high during swing phase to avoid tripping over the hanging down foot and then, at the beginning of stance phase, the foot slaps the floor. Gait changes caused by foot drop decrease gait safety and efficiency, limit mobility, increase the risk for falls and greatly increase energy expenditure during walking.[1,2]

Causes of Foot Drop

Foot drop is usually caused by damage to areas of the nervous system that control ankle dorsiflexion. Foot drop may be caused by central or peripheral nerve dysfunction and is common in patients with a wide variety of neurological diagnoses including stroke, multiple sclerosis (MS), traumatic brain injury (TBI), spinal cord injury (SCI), cerebral palsy (CP) and peripheral neuropathy.

Treatment of Foot Drop

Traditionally, foot drop of all aetiologies is treated with bracing using an ankle foot orthosis (AFO) (see *Figure 1A*). An AFO is a device usually made of plastic, which wraps under the foot and behind the calf to passively assist ankle dorsiflexion. AFOs are simple devices that are widely available at relatively low cost, but they have a number of disadvantages and limitations. The passive dorsiflexion assistance they provide does not promote active use of remaining or recovering dorsiflexion function and also limits ankle range of motion. In addition, AFOs can be uncomfortable, bulky and, if poorly fitted, produce areas of pressure and tissue breakdown. Many patients find AFOs so uncomfortable or unsightly that they do not use them. Therefore, research has focused on developing alternative ways to treat foot drop. One of the most effective treatments for foot drop is functional electrical stimulation (FES, see *Figure 1B*).[2–5]

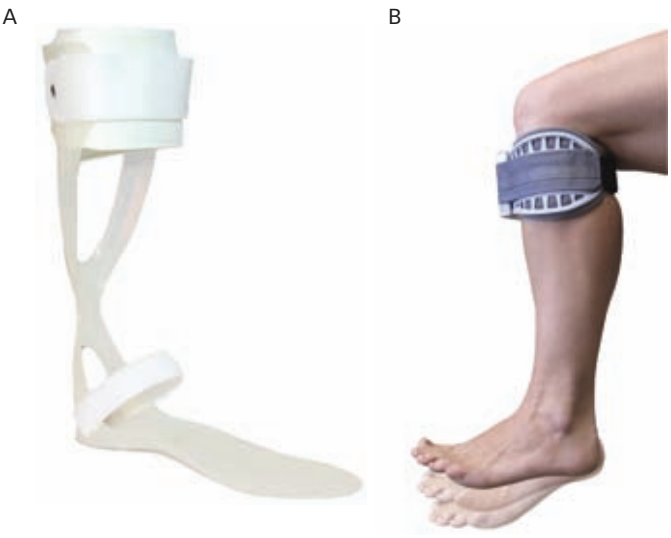
Who Can Use the WalkAide® Functional Electrical Stimulation System for Foot Drop?

FES is a new approach to treating foot drop. FES uses a low-level electrical current to stimulate peripheral motor nerves to produce active muscle contractions that promote functional movement. FES for foot drop involves stimulating the peroneal nerve to produce active dorsiflexion during the swing phase of gait. FES can be used to treat foot drop when the CNS is damaged and the peripheral nerves, neuromuscular junction and muscles are intact. Therefore, FES is particularly effective for treating foot drop caused by CNS disorders such as stroke,[6–8] MS,[3,9–11] TBI,[12] incomplete SCI[13–15] and CP[16,17] as well as other, less common CNS disorders.

How the WalkAide Functional Electrical Stimulation System Treats Foot Drop

The WalkAide® FES System is a non-invasive, self-contained device designed specifically to provide comfortable and effective transcutaneous stimulation to the peroneal nerve to improve dorsiflexion during the swing phase of gait. The WalkAide FES System is contained in a cuff worn around the proximal leg just below

Figure 1: Options for Treatment of Foot Drop



A: A traditional ankle foot orthosis; B: The WalkAide Functional Electrical Stimulation System.

Figure 2: The WalkAide System Delivering Electrical Stimulation to the Common Peroneal Nerve and Produces Timed Contraction of the Dorsiflexor Muscles

Figure 3: The WalkAide System Has the Unit and Cuff in a Single Component and Can Be Used Without Shoes

the knee (see *Figure 1B*). The device includes tilt sensors, with accelerometers and inclinometers to measure the speed and position of the lower leg to trigger stimulation, and a pulse generator and self-adhesive electrodes to deliver the electrical current. The entire device is powered by a single AA battery. With the WalkAide, low intensity pulses of electrical current, of sufficient duration and amplitude to produce action potentials in peripheral nerves, are delivered from the generator to transcutaneous self-adhesive electrodes placed over the common peroneal nerve near the fibular head (see *Figure 2*). The stimulated action potentials are transmitted orthodromically to the superficial and deep peroneal nerves, and thence to the neuromuscular junctions of the muscles of the lateral and anterior compartment of the leg. This causes acetylcholine release at the neuromuscular junctions and muscle contractions to produce active ankle dorsiflexion. The tilt sensors trigger the electrical current pulses to start just as the patient enters the swing phase of gait and to end when swing ends. This produces dorsiflexion throughout swing phase, minimising or entirely eliminating foot drop and normalising the gait pattern.

Features and Advantages of the WalkAide Functional Electrical Stimulation System

FES has a number of advantages over an AFO for treatment of foot drop (see *Table 1*). The active contraction produced by FES can help to prevent the muscle atrophy and range of motion loss associated with passive support offered by an AFO. In addition, the active muscle contractions and joint motion stimulate muscle spindles, Golgi tendon organs and joint proprioceptors, increasing sensory awareness and input to the CNS. This sensory input improves motor output, including the quality and control of movement patterns, the degree of reflex activity and the balance of muscle tone. The repetitive active movement stimulated by FES-facilitated gait also contributes to motor learning and neuroplastic changes in the CNS.[18] By establishing and promoting active motion in patients with foot drop, FES fosters long-term improvements in motor control, balance of muscle activation and quality and efficiency of gait. Unique features of the WalkAide FES System make it particularly well suited to the treatment of foot drop. The WalkAide is the only device on the market that uses tilt sensors to detect the angular velocity of the leg during gait and to use this information to determine when to trigger stimulation, and thus muscle contraction, during the gait cycle.[19] Most other devices use a heel-sensor-triggered switch to detect the beginning and end of swing phase. Since heel switch devices stimulate whenever the heel is off the ground, stimulation may occur when the heel, but not the toes, are raised. This can promote inefficient walking

Table 1: Comparison of Benefits of Funtional Electrical Stimulation and Ankle Foot Orthosis for Foot Drop

	FES	AFO
Reduces foot drop	Yes	Yes
Improves gait mechanics	Yes	Yes
Prevents loss of passive ROM	Yes	Yes
Prevents loss of active ROM	Yes	No
Active muscle contraction	Yes	No
Slows muscle atrophy	Yes	No
Increases input to muscle spindles, GTOs, proprioceptors	Yes	No
Promotes motor learning	Yes	No
Promotes neuroplastic changes	Yes	No

AFO = ankle foot orthosis; FES = functional electrical stimulation; GTO = Golgi tendon organ; ROM = range of motion.

patterns including steppage gait and stiff legged walking with hip circumduction and vaulting. By triggering stimulation specifically in response to leg movement in the sagittal plane, the WalkAide stimulates dorsiflexion when the patient swings their leg straight through in the sagittal plane. This unique tilt sensor triggered stimulation promotes normal gait not only by stimulating optimal timing of ankle dorsiflexion during gait but also by helping the patient decrease compensatory motions and improve voluntary motor control at the hip and knee. All of these features contribute to the WalkAide allowing the person with foot drop to walk faster, more safely and with reduced energy consumption.[1,15,18–21]

The WalkAide FES System can also be precisely tailored to each individual's gait pattern and can adapt to a range of patient-initiated changes in gait. It alters the timing of the stimulation if walking speed direction or step length, change. It also adapts to changes produced by different gait tasks, such as walking up or down stairs or inclines or walking on rough terrain. Having a tilt sensor on the leg rather than a heel switch also allows the patient to use the WalkAide with a wide variety of footwear, or even to walk barefoot (see *Figure 3*). All of these features give the patient improved function during a wide range of activities of daily living and improve quality of life. The unique design and construction of the WalkAide System further contribute to its utility. The entire device is essentially contained in one component. The unit attaches to a lightweight cuff strapped around the leg that can be accurately placed and fully operated with one hand. The cuff is fully washable and the device is powered by a single AA battery that lasts for up to one month of use. The WalkAide System offers you and your patients the latest advance in the treatment of foot drop. It is the most physiologic and effective approach for optimising gait mechanics and efficiency in patients with foot drop, allowing them to walk quickly, efficiently, and safely in the widest range of conditions. ■

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