Abstract
In this presentation I aim to describe some of the practical issues presented and addressed in our clinic. The FES clinic has treated over 2600 patients with a range of clinical problems over the past 14 years. Approximately 150 new patients are treated each year and up to 2500 follow up sessions provider. The most frequently provided treatment provided is FES for correction of dropped foot with around 25% of patients also receiving stimulation of other muscle groups to improve knee or hip flexion or other functions. The service is approximately 40% CVA and 40% MS with CP, TBI, SCI, HSP and Parkinson's disease making up the remaining 20%. The majority of treatment use external FES but an implanted Dropped foot service is also provided. Upper limb treatment is provided for CVA, CP, TBI and SCI. This is predominantly restricted to simple exercise but more functional interventions are being introduced. FES is also used to treat postural hypotension in high level tetraplegia. Most treatment is funded by the UK's National Health Service. This paper describes the treatments offered with their referral criteria and clinical procedure.

1. FES for dropped foot and other gait problems. ODFS and O2CHSII

Referral criteria
Cause and functional deficit
- Neurological deficit due to an upper motor neurone lesion. An upper motor neurone lesion is defined as one that occurs in the brain or spinal cord at or above the level of T12. This is normally but not exclusively associated with spasticity.
- Upper motor neurone lesion resulting in dropped foot occur in conditions such as stroke, multiple sclerosis, incomplete spinal cord injury at T12 or above, cerebral palsy, familial / hereditary spastic paraparesis, head injury and Parkinson's disease.

Nature of functional deficit:
- Dropped foot defined as a deficit of dorsiflexion and / or eversion of the ankle. While this will be frequently associated with lack of heel strike, FES can be successfully used to correct inversion at first contact to significantly improve the stability of the ankle in the stance phase, improving the safety of gait.
- A dropped foot can be unilateral or bilateral
- In addition to drop foot, deficits in knee flexion or extension, hip extension and abduction and push off at terminal stance can be addressed. FES can be used to strengthen and / or control other muscles used in gait such as hamstrings, quadriceps, gluteal and calf muscles.

Functional ability
- Able to passively achieve a neutral angle of the ankle. A resistance due to spasticity of the calf muscles can be overcome but fixed contracture preventing plantagrade is a contraindication
- Able to obtain standing from sitting unaids. Use of aids such as sticks, frame or crutches is acceptable
- Able to walk a minimum distance of about 10m. Use of aids such as ankle foot orthosis (AFO), sticks, frame or crutches is acceptable
- A reasonable exercise tolerance is required for treatment sessions. However, FES often reduces the effort of walking therefore poor exercise tolerance is only an exclusion criteria in extreme cases
- There is no maximum walking distance limit. FES devices have been successfully used in cases where a dropped foot only becomes a significant problem when the device user is tired or when the deficit is relatively mild.

Motivation, understanding and independence
- Able to understand the aims of the treatment and be motivated to comply with treatment protocols. Where appropriate, carer support can assist in using the equipment
- Where patients live alone and do not have carer assistance, they must be able to place electrodes and operate the equipment independently. If family or carer support is present, less independence is required.

Precautions
- Poor skin condition is a contraindication as sores or irritation prevents the use of self adhesive electrodes
- Poorly controlled epilepsy. Where epilepsy is controlled by drugs or there has been no fits experienced for a reasonable period, FES can be used
- A history of significant autonomic dysreflexia in incomplete spinal cord injury above T6
- The effect of FES on the unborn child in pregnancy is not known
• Active medical implants such as cardiac pacemakers or other devices must be treated with caution and information sought from the device supplier about the use of electrical stimulation in their presence. Additional clinical test may be required to determine the safety of FES.

• Patients with a cancerous tumour in the area of the electrical stimulation should be excluded as increased local blood flow may increase tumour growth

• Patients with exposed orthopaedic metal work in the area of electrical stimulation should be avoided.

• While the majority of our patients fit the above criteria, patients outside these criteria can be considered in special circumstances

Clinical Procedure
All patients must be referred by their GP or Medical Consultant and referrals are made to the Head of Department, Prof. Ian Swain. The referral letter is reviewed by Prof. Swain or in his absence by experienced clinical staff at the National FES Centre. If it is judged that FES might be a suitable treatment an appointment is made for an initial assessment. Some times further details are requested from the referring clinician.

At the initial assessment clinic, the above referral criteria are checked. An additional acceptance criterion is the ability to tolerate the sensation of electrical stimulation. A FES device is tried and in most cases an improvement in gait is immediately apparent. Following discussion with the patient a decision whether to proceed with treatment is made. In some cases the clinician may judge that a period of electrical stimulation training is required in order to strengthen muscles, reduce spasticity / increase ROM or to accustom the patient to the sensation of electrical stimulation. Stimulation exercises may be started at this appointment if time permits. Otherwise exercises will be set up at another appointment.

The ODFS is fitted over two clinic sessions on consecutive days. On the first day the user is taught how to apply the device while on the second day their ability to do so is assessed and further training given if necessary. Use of the stimulator is increased gradually over 2 to 3 weeks until it can be used all day. Follow up is made at 6 weeks, 18 weeks, 45 weeks and 72 weeks from first use and then every 6 months or yearly depending on the patient’s condition, for as long as the device is used. If users experience problems they are encouraged to contact the clinic so advice can be given, equipment repaired or extra clinic sessions arranged if necessary.

In the case of more complex movement problems where more than one muscle group are stimulated, treatment is often started with a single channel device and the second channel introduced at the 6 or 18 week follow up assessment once the user has become accustomed to FES.

2. Implanted FES for Dropped foot. STIMuSTEP
The indications for treatment and selection criteria are the same as external FES with the following additions:

• Demonstration of the successful correction of dropped foot by at least 6 months use of external FES.

• Contraindications are diabetes and use of immune system suppressive drugs.

• Patients with progressive conditions such as MS must be stable, demonstrated by no significant decline in walking function over the previous three of four years.

Most patients progress to implanted FES due to issues that prevent consistent use of external FES. This may be skin reaction to electrodes or difficulty in reliably locating electrodes. Improved convenience and quality of life has also been used as reason for patients likely to be long term uses of FES.

Clinical Procedure
The device is delivered in a 1 hour day case procedure under a general anaesthetic. 3 weeks is allowed for healing after which the external controller for the implant is set up and walking begun. Follow up is provided at 5, 9, 20 and 49 weeks post implant and then annually.

3. Functional Electrical Stimulation (FES) for the upper limb
FES treatment is provided for upper limb neurological problems resulting from stroke, brain injury, spinal cord injury or cerebral palsy. The treatment consists of cyclical electrical stimulation exercises using the Microstim 2V2 device. Referrals are accepted for three main categories of upper limb treatment

Subluxation of the shoulder

• The main aim is to reduce pain associated with shoulder subluxation

• The three compartments of the deltoid muscle plus the supraspinatus muscle are stimulated causing the humerus to elevate into the glenoid - humeral socket

• The treatment may be need to be continued long term to maintain reduction of pain unless functional movement improves

Functional group
FES Exercise to improve hand and arm function
Stroke and Cerebral Palsy

• Patients should have some functional ability, typically being able to produce a grip but may
not be able to release, or reduced ability to extend the elbow
• Main treatment aim is to increase the strength of the extensor muscles while reducing the spasticity in the flexor muscles
• Repetition of exercises may lead to neuroplastic changes resulting in improved function

Spinal cord injury
• Patients should have some functional ability, typically a weak tenodesis grasp in C6 tetraplegia or general weakness in incomplete C5/6/7 tetraplegia
• The main treatment aim is to increase the strength and therefore function of the effected muscles

Non functional group
• FES can be used to relieve spasticity with the aim of loosening an over tight grip or elbow flexion
• The main treatment aim is to reduce pain associated with spasticity, assist with hygiene by enabling better washing or assist other activities of daily living such as dressing

Motivation, understanding, independence and precautions
• Same requirements as for the lower limb applications of FES.

4. REAcH (Re-Education of Arm and Hand)
The Odstock REAcH is a new device, designed to re-train active movement following stroke. The device activates the muscles that open the hand and straighten the arm. These muscles are activated by a movement sensor inside the device that detects when the user reaches forward to grasp an object. The Odstock REAcH can be used to assist every day tasks and also to help re-educate the voluntary movements. Research shows that practising functional tasks with FES can lead relearning.

The referral criteria
• Stroke, Cerebral Palsy or Brain Injury
• Patients should have some functional ability, typically being able to produce a grip but may not be able to release or reduced ability to extend the elbow
• The ability to produce 40 degrees of shoulder flexion is required
• Main treatment aim is to retrain functional reach and grasp
• The treatment will also increase the strength of the extensor muscles while reducing the spasticity in the flexor muscles
• Repetition of exercises may lead to neuroplastic changes resulting in long term improved function

Clinical Procedure for Upper limb FES
The referral and assessment process is the same as for lower limb applications.

In most cases upper limb treatment is limited to a 6-month period. In that time the patient will be seen for five, 1 hour appointments. At the first appointment an electrical stimulation exercise programme for the patient to perform at home will be devised. Where appropriate, additional physiotherapy exercises may also be given. Follow up is provided at 2, 8, 16 and 24 weeks. At each session, the exercises are reviewed and progressed. Where appropriate, functional measures will be made to record progress.

In some cases it is beneficial to continue treatment over a longer period. This reviewed at the week 24 appointment and a recommendation made to the referring clinician.

References

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Suppliers: All external FES equipment is supplied by Odstock Medical Ltd. The STIMuSTEP implant is supplied by Finetech Medical Ltd.