Institution: Keele University

Unit of Assessment: B15 General Engineering

Title of case study: Technological solutions to facilitate independence in the community for people with long term conditions affecting their mobility

1. Summary of the impact

The Orthotic Research & Locomotor Assessment Unit (ORLAU) (http://www.rjah.nhs.uk/ORLAU) has run multidisciplinary services to improve the function and lifestyle of severely disabled patients since 1975. New specialist clinical services have been established, based on research and development activity. The effectiveness of these services has been the subject of further investigations. Work has focused on the development of novel technology (in gait analysis and orthotics) and increasing understanding of human movement. Conditions treated include cerebral palsy, spinal cord injury, neuromuscular disorders, arthritis and stroke. Technological developments have led to licencing within the commercial sector. ORLAU has also contributed to the development of national and international clinical education and guidelines.

2. Underpinning research

ORLAU is based at The Robert Jones & Agnes Hunt Orthopaedic Hospital NHS Foundation Trust in Oswestry, a specialist tertiary hospital providing a comprehensive range of musculoskeletal (bone, joint and tissue) surgical, medical and rehabilitation services; locally, regionally and nationally. ORLAU's specialist staff, facilities and clinical services mean that it is very well placed to deliver translational research. Research and development projects have focused on improving the function and welfare of patients. Research has covered 4 key areas, as listed below.

- ***Development of movement analysis technology***

The analysis of movement, particularly gait, was fundamental to ORLAU's original vision. In 1975 commercial movement analysis systems were not available, so ORLAU engineers developed ways of presenting forces and muscle activities in combination with sequential video images. The Video Vector technology, available to ORLAU in the 1970s, has only been commercially available in the last ten years. The system continues to be used for new research projects[1].

- ***Human gait assessment***

ORLAU has continued to be an internationally recognised centre of excellence in gait-related research and has extended the portfolio of research to include the use of computer modelling techniques. These techniques have been used to inform surgical decision making in cerebral palsy[2]. The role of muscles during gait has been further elucidated using the novel approach of random electrical stimulus application to a muscle during walking[3].

In recent years a new programme of research has looked at gait patterns before and after total knee replacement. The novelty of this work is in its focus on the loading on both hip and knee joints in single joint disease. The risk to the other joints of continued muscular co-contraction and overloading has been highlighted.

- ***Novel clinical services***

ORLAU/RJAH hospital was the first organisation in the UK to offer Selective Dorsal Rhizotomy (SDR), a surgical procedure for children with cerebral palsy. Research from ORLAU has impacted significantly to the development of selection criteria, using gait analysis to select suitable patients for SDR procedures. The focus on rigorous selection criteria in patients has resulted in significant improvements in spasticity reduction[4].

- ***New orthotic devices***

ORLAU researchers have also developed novel orthotic devices for the management of contractures[5], standing frames to support the training of motor control (supporting the research of the Movement Centre) and a unique range of walking devices, such as the ORLAU Parawalker and Swivel walker[6]. ORLAU's rehabilitation engineering team have secured funding from a number of NHS/NIHR/EU/NIH funding streams.

ORLAU's expertise in orthotic design and manufacture enabled the development of a device for measuring muscle strength, which was subsequently used for research in an acute stroke unit, following funding from Action Medical Research (AP1131). Two postgraduate projects followed on from this work, extending ORLAU's interests into the prevention and reversal of muscle atrophy.

- ***Grant Funding includes:***

Title	Funder	Award
Technical support to produce a performance specification for lower limb orthotic devices	EU Craft	£74,200
A comparative study of the effectiveness of treatment of contractures with mechanically applied stretch and heat	Action Medical Research	£82,870
Feasibility study for a free knee reciprocal walking orthosis	Dept of Health HTD	£70,218
Prosthesis control by forward dynamic simulation of the intact biomedical system (with University of Chicago and US National Institute of Biomedical Imaging & Bioengineering)	National Institutes of Health (USA)	$13,860
Development of an integrated service model incorporating innovative technology for the rehabilitation of the upper limb following stroke.	NIHR	£137,849
Strength training with electrical stimulation - Is this is a viable method of facilitating independence and improving muscle function following a severe stroke?	Action Medical Research	£78,002
Can sNMES of the wrist and hand, in conjunction with routine therapy, facilitate recovery of arm function in people with poor prognostic indicators of functional recovery?	Action Medical Research & UHNS R&D	£124,300

3. References to the research (three key quality references are highlighted: 3, 4 & 6)

1. Butler PB et al. The effect of fixed ankle foot orthoses in children with cerebral palsy. *Disabil Rehab Assist Technol.* 2007 **2**(1):51-8
2. Stewart C et al. Estimation of hamstring length at initial contact based on kinematic gait data. *Gait Posture.* 2004 **20**(1):61-6.
3. Stewart C et al. An exploration of the function of the triceps surae during normal gait using functional electrical stimulation. *Gait Posture.* 2007 **26**(4):482-8.
4. Cole GF et al. Selective dorsal rhizotomy for children with cerebral palsy: The Oswestry experience. *Arch Dis Child.* 2007 **92**(2):781-5.
5. Farmer SE et al. Dynamic Orthoses in the Management of Joint Contracture. *J Bone and Joint Surg Br.* 2005 **87**(3) 291-5.
6. Stallard J. Walking for the Severely Disabled: Research and Development, Experience and Clinical Outcomes. *J Bone Joint Surg Br.* 2005: **87**(5):604-607.

4. Details of the impact

- ***Development of movement analysis technology***

The availability of video vector technology enabled ORLAU to be a pioneer in the field. This resulted in the establishment of the first comprehensive gait analysis service in the UK. The technology allowed existing interventions, such as plastic Ankle Foot Orthoses (AFOs) to be biomechanically aligned, or 'tuned'. Video vector technology has only been introduced to the market in the last decade or so (e.g. Templo system, Contemplas (www.contemplas.com/motion_analysis_templo.aspx)). A major pressure to develop these technologies has come from an understanding of the need to tune AFOs, an insight, whilst not originating in ORLAU, was significantly developed by ORLAU clinical teams[1] (*source a*).

ORLAU has been a leading contributor to the development of both national and international practice and education in movement analysis. ORLAU hosted the first meeting of the ESMAC Society (European Society of Movement Analysis for Adults and Children) (*source b*) and was a founder member of CMAS (Clinical Movement Analysis Society, UK) (*source c*) and will host its 13th (2014) Annual Scientific Meeting. ORLAU has continued to significantly contribute to the

movement analysis community with ORLAU staff chairing both the committee and the standards groups of CMAS. ORLAU staff played a significant role in the development of standards with Dr Caroline Stewart overseeing the introduction of the UK's first accreditation programme for gait laboratories (*source c*).

- ***Human gait analysis***

Movement analysis research has had an impact on both clinical services and the establishment of significant international collaborations[2,3]. One key area has been the construction of computer models of the human musculoskeletal system. These models are used at every clinical review of patients going through the ORLAU gait laboratory in order to understand the length of their hamstring muscles and consequent need for surgery. The research has led to an overall reduction in the need for certain muscle lengthening procedures in children with cerebral palsy (*source d*).

- ***Novel clinical services***

The development of a specialist movement analysis service has allowed ORLAU to be innovative in the introduction of new clinical procedures, in particular the orthopaedic management of children with cerebral palsy (*source e*) and other severely disabled neurological patients (*source f*).

ORLAU/RJAH was responsible for the introduction of Selective Dorsal Rhizotomy (SDR) to the UK. The selection criteria for SDR developed by Cole et al 2007[4] has since been embedded in service provision within ORLAU and been presented internationally. In recognition of the work carried out by ORLAU the Director has been invited as an External Adviser to the NICE Clinical Guideline 145 (*source g*). ORLAU staff have also provided input to the development of NICE guidance (Interventional Procedures 195 (2006) and 373 (2010), *source h*) and are currently participating in the planning of national commissioning planning for SDR services.

- ***New orthotic devices***

ORLAU continues to deliver clinical services supplying novel devices developed by the rehabilitation engineering team. Commercialisation has occurred through licensing to Otto Bock (*source i*). The Swivel Walker and the Parawalker allow patients with little or no active lower limb muscle power to mobilise in a normal upright posture. The Standing Frame also allows patients to be supported in weight bearing. ORLAU records show around 90 standing frames are being produced for patients every year. An upright posture has many functional, social and physiological benefits. The Swivel walker won a Design Council Award in 1981. The only commercially available swivel walkers are based on the designs originating from the original research from ORLAU.

Joint deformities (contractures) are common secondary complications in patients with severe levels of disability. Research has demonstrated that the treatment has the ability to give significant clinical benefit and this is reflected in the number of devices sold (1760).

- ***General impacts of the work described***

ORLAU's specialist work has led to a number of requests to run training courses. Over the years courses have been run in specialist orthotic devices and in gait analysis. ORLAU staff support the training of specialist registrar training in orthopaedics and participating in FRCS preparation courses. Caroline Stewart, Neil Postans and Andrew Roberts have all been involved in teaching on ESMAC's European Gait Analysis course (*source j*), an annual event associated with the European conference.

5. Sources to corroborate the impact

a) Morris C et al. Orthotic management of cerebral palsy: recommendations from a consensus conference. *NeuroRehabilitation.* 2011 **28**(1):37-46
b) ESMAC: http://www.esmac.org/index.php/about-esmac
c) CMAS: http://www.cmasuki.org
d) Laracca et al. The effects of surgical lengthening of dynamically long hamstring muscles in children with cerebral palsy. *Gait Posture* 2009 **30**(S2):s75-s76
e) Patrick JH. Techniques of psoas tenotomy and rectus femoris transfer: "new" operations for cerebral palsy diplegia – a description. *J Pediatr Orthop B*. 1996 **5**(4):242-6

f) Patrick JH, Keenan MA. Gait Analysis to Assist Walking After Stroke. Lancet 2007 369(9558):256-7
g) NICE Clinical Guidelines, No 145 "Spasticity in Children and Young People with Non-Progressive Brain Disorders" July 2012. http://www.ncbi.nlm.nih.gov/books/NBK116587/
h) NICE Interventional Procedure No 373 "Selective dorsal rhizotomy for spasticity in cerebral palsy", December 2010. http://www.nice.org.uk/nicemedia/live/11220/52083/52083.pdf
i) Managing Director, Otto Bock Healthcare Plc, 32 Parsonage Road, Englefield Green, Egham, Surrey, TW20 0LD
j) European Gait Analysis course: http://www.ior.it/en/didattica-e-formazione/esmac-gait-analysis-course