International Society for Prosthetics and Orthotics
United Kingdom Member Society

Trent International Prosthetic Symposium **2016**

ISPO UK MS Annual Scientific Meeting

28th September – 1st October 2016
Glasgow, UK

Golden Jubilee Conference Hotel

"Advances in our Understanding"

The Compendium

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WELCOME

We are delighted to welcome you to the first joint Trent International Prosthetics Symposium and ISPO UKMS Annual Scientific Meeting (TIPS/ISPO2016).

By way of background, the Trent Prosthetics Symposium (TPS) was the vision of three clinicians from the Nottingham area: Vivian Ibbotson, Janet Kingston and John Ronald. TPS focussed exclusively on Upper Limb Prosthetics and was also unashamedly clinical in its outlook, with a balance of research and clinical papers. It was held over three days and enjoyed a reputation for its lively social programme. When the three colleagues retired, the ISPO UK Member Society took responsibility for its continuance, and developed the event into an international conference: TIPS. This is the first year we have chosen to combine our local scientific meeting with TIPS, at the same venue.

The theme of TIPS/ISPO2016 is: ***Advances in our Understanding***. With advances in compact computers and medical sciences, it is now becoming possible to unlock how we control our limb and how people adapt to limb deficiency. We can use this knowledge to improve the control and comfort of the prosthetic limb. We aim to create a forum to allow colleagues to present this to you, the audience.

Delivering a scientific programme of the highest quality is a longstanding tradition at both TIPS and ISPO. We can achieve this thanks to the many nationally and internationally renowned guest speakers, from both technical, clinical and scientific backgrounds, who are willing to contribute.

Our multidisciplinary approach to amputee rehabilitation includes participation from Engineers, Physicians, Surgeons, Occupational Therapists, Physiotherapists, Prosthetists, Orthotists, Clinical Scientists and many other professions, and this is well reflected in the programme.

Keynote speakers at TIPS this year are Tamar Makin, from Oxford University, challenging current thinking on the link between phantom pain and brain plasticity; Rickard Branemark from Integrum Sweden on the latest developments in Osseointegration, and Raoul Bongers (The Netherlands) and Carol Garcia (Sheffield Hallam University, UK) who will discuss the applications of Virtual Reality in prosthetic rehabilitation.

The response to the call for free paper abstracts was phenomenal resulting in a programme of over 50 free paper presentations from speakers across the globe - from the USA to Australia; Holland to Japan. There is an interest in functional assessment and outcome measures, with a number of presentations on the development of new measurement tools as well as their use in gauging the impact of new prosthetic design or how people adapt and learn to use their prostheses.

Alongside the techniques and technology, case study presentations will cover different aspects of the process. One of the new factors currently impacting our field is 3D Printing, (also known as Rapid Manufacturing). Using this technique we can now produce items completely customised to the individual. The questions we all ask concern how effective or useful these solutions are? How long will they last? Papers will be presented which aim to answer these concerns.

The George Murdoch Prize Medal will be awarded at the ISPO UK Annual Scientific Meeting and we congratulate Dr David Moser for his winning paper and for his outstanding contribution to amputee rehabilitation. The prestigious Blatchford Lecture will be presented by Levi J Hargrove from the the Rehabilitation Institute of Chicago on work involving Targeted Muscle Reinnervation.

Neither TIPS nor the annual ISPO UK meeting could take place without the strong support and sponsorship of the commercial companies. Special thanks are extended to Platinum sponsors, ***Touch Bionics,*** Gold sponsors ***Steeper*** and ***Opcare,*** Silver Sponsors, ***Ottobock*** and ***Fillauer,*** Bronze Sponsors, ***Coapt***; and to ***Blatchfords, OETT*** and ***North Sea Plastics*** for their generous contributions. In tandem, and with the support of all our commercial exhibitors, this enables the organising committee to host a first class scientific meeting and commercial exhibition, along with a lively, entertaining social programme. Please ensure you take time to visit the commercial exhibition stands and engage with the exhibitors. Their contribution to the event is invaluable.

Glasgow is a vibrant city, rich in historical traditions. It is a place where there is enormous heritage, spectacular architecture, many museums, world class restaurants, art galleries, theatres and music venues. Its logo and branding ***"People make Glasgow"*** is well revered throughout the world, and as such, we feel it's the perfect backdrop for TIPS/ISPO2016. After all, it's ***you***, our delegates and presenters - ***"people"*** - who will make TIPS/ISPO2016 a resounding success by embracing the opportunity to inform and be informed, engage and be engaging, inspire and be inspired. We hope your experience is memorable. Welcome to Glasgow!

Dr T Lal Landham
Chairman
ISPO UK MS

David Gow
Chairman
TIPS2016

PROGRAMME

Wednesday 28 September 2016 TIPS2016 AUDITORIUM

0730 hrs Registration Opens

0815 hrs *Welcome – David Gow*

Chair: Corry van der Sluis

0830hrs **Effects of adding vibrotactile feedback to a myoelectric controlled hand on performance and visual attention with a disruption of visual feedback**
Eitan Raveh, Dept. of Occupational Therapy, Tev Aviv University, Israel

0845 hrs **Myoelectric prosthesis following total thumb amputation**
V G van Heijningen, Rijndam Rehabilitation Institute, Erasmus Medical Center, Rotterdam, The Netherlands

0900 hrs **Impact of Bilateral Upper Limb Prosthesis Simulators in Pre-Prosthetic Training: a Case Study**
Debra Latour, TRS Prosthetics, Boulder, CO, USA

0915 hrs **The use of 3D CADCAM system in the design and manufacture of forequarter prosthesis**
M Currie & L Powell, AR Clinic9, Addenbrookes Hospital, Cambridge, UK

0930 hrs **The impact of Partial Hand Amputation - a Case Presentation**
Lindsey Barker, Harold Wood Long Term Conditions Centre, Essex, UK

0940 hrs **Myoelectric arm prosthesis approach in children at the Japan Hyogo Rehabilitation Center**
Yaeko Shibata, Hyogo Rehabilitation Center, Kobe, Japan

1000 hrs **Refreshments/Exhibitor Showcase**

Chair: Peter Kyberd

1030 hrs **Latest developments in the use of Osseointegrated upper limb prostheses**
Rickard Branemark, Director of Centre of Orthopaedic Osseointegration, Sahlgrenska University Hospital, Gothenburg, Sweden

1130 hrs **PPP-Arm: the implementation of a national Prosthesis Prescription Protocol**
P A Wijdenes, Dept. of Rehabilitation Medicine, University Medical Center, Groningen, The Netherlands

1145 hrs **Forming an international consortium for sharing resources of upper limb absence worldwide - *the handsmart group***
Liselotte N Hermansson, Dept. of Prosthetics & Orthotics, Örebro University Hospital, Örebro , Sweden

1200 hrs **Lunch/Exhibitor Showcase**

Chair: Claudio Castellini

1300 hrs **Developing a test to determine quality of proportional control over a myoelectric prosthetic hand**
Anniek Heerschop, Centre for Human Movement Sciences, University of Groningen, The Netherlands

1315 hrs **Evolution of Refined Clothespin Relocation Test for Prosthesis Users for use as a Clinical Assessment**
Ali Hussaini, Institute of Biomedical Engineering, University of New Brunswick, Canada

1330 hrs **An Exploration of the correlation between an amended Box and Blocks Assessment, the standard Box and Blocks Assessment and the Assessment of Capacity of Myoelectric Control, with myoelectric prosthesis users**
Melissa Jacobs, Queen Mary's Hospital, London, UK

1340 hrs **Development and reliability testing of a qualitative score for rating compensatory movements in upper limb prosthesis wearers during execution of 4 FCE-tests**
T M J van der Laan, University Medical Centre Groningen, The Netherlands

1350 hrs **Development of a functional capacity evaluation measurement for individuals with upper limb reduction deficiency or amputation**
C K van der Sluis, University Medical Centre Groningen, The Netherlands

1405 hrs **A reflective case study of a quadrilateral amputee, over a 16 year period: exploring coping with the challenges of activities of daily living, prosthetic interventions and adjusting to the psychological impact of such a severe level of limb loss**
Charlie Hurd, West Midlands Rehabilitation Centre, Birmingham, UK

1420 hrs **A protocol to establish the relative importance of factors influencing ease of myoelectric prosthesis control**
Alix Chadwell, University of Salford, Salford, UK

1435 hrs **Choosing a multi-functional hand that suits the patient's requirements**
Judy Davidson, Eastern Sydney Occupational Therapy, Sydney, Australia

1445 hrs **POSTER PRESENTATIONS**

1500 hrs **Refreshments/Poster Exhibition/Exhibitor Showcase**

Chair: Raoul Bongers

1530 hrs **3D printed upper limb prosthetics are not backed by clinical evidence**
Laura E Diment, Institute of Biomedical Engineering, University of Oxford, UK

1545 hrs **Utilising 3D printing techniques when providing unique assistive devices: a Case Study**
Sarah Day, National Centre for Prosthetics & Orthotics, University of Strathclyde, Glasgow, UK

1600 hrs **Application of Finch, a 3D printed prosthetic hand, to a patient with bilateral upper-limb deficiency**
Satoko Noguchi, The University of Tokyo Hospital, Tokyo, Japan

1610 hrs **MANUFACTURERS' WORKSHOPS**
Touch Bionics; Steeper; Ottobock; TRS/Fillauer

1740 hrs **DAY END**

1900 hrs **Welcome Reception & Buffet**

Thursday 29 September 2016 TIPS2016 AUDITORIUM

0800 hrs Registration Opens

Chair: Max Ortiz

0830 hrs **Advances in prosthesis control - gesture control**
Alison Goodwin, Touch Bionics, Livingston, UK

0845 hrs **Structured training for advanced prosthesis control**
Sebastian Amsuss, Ottobock Healthcare Products GmbH, Vienna, Austria

0900 hrs **Upper limb osseointegration, prosthetic technology**
Stewe Jönsson, TeamOlmed, Kungsbacka, Sweden

0915 hrs **Clinical Pattern Recognition in the US: Experiences and Demographics**
Blair A Lock, Coapt LLC, Chicago, IL, USA

0930 hrs **Clinical experience of developing bespoke cycling prostheses**
Brian Bradbury & Paul Richardson, PACE Rehabilitation, Cheadle, UK

0945 hrs **Evolution of an Aesthetic Heavy-Duty Electric Terminal Device**
Harold H Sears, Motion Control div. of Fillauer, Utah, USA

1000 hrs **Refreshments/Exhibitor Showcase**

Chair: Liselotte Hermansson

1030 hrs **Phantom Pain Revisited**
Tamar Makin, Associate Professor, FMRIB Centre, Nuffield Department of Clinical Neuroscience, University of Oxford, UK

1130 hrs **Investigations of the uncanny valley for prosthetic hands**
Ellen Poliakoff, University of Manchester, Manchester, UK

1145 hrs **Exploring everyday materials and prosthetic hands**
Graham Pullin, DJCAD, University of Dundee, Dundee, UK

1200 hrs **Lunch/Exhibitor Showcase**

Chair: Ellen Poliakoff

1300 hrs **CASE STUDIES**

Chair: Melissa Jacobs

1400 hrs **Osseointegrated Prostheses for Transhumeral Amputees: Long-term follow up of patients using Patient-rated Outcome Measures**
Kerstin Caine-Winterberger, Sahlgrenska University Hospital, Gothenburg, Sweden

1415 hrs **Decreasing phantom limb pain by virtual reality - a Case Presentation**
Z Pihlar, University Rehabilitation Institute, Ljubljana, Slovenia

1430 hrs **Cutaneous Anchor Technology and Creative Solutions to Complex Problems**
Debra Latour, Single-Handed Solutions LLC, Springfield, MA, USA

1445 hrs **POSTER PRESENTATIONS**

1500 hrs **Refreshments/Poster Exhibition/Exhibitor Showcase**

Chair: Tamar Makin

1530 hrs **Factors influencing use and satisfaction with upper limb prosthesis**
H Burger, University Rehabilitation Institute, Ljubljana, Slovenia

1545 hrs **The influence of environment: experiences of users of myoelectric arm prosthesis: a Qualitative Study**
Cathrine Widehammar, Dept. of Pediatrics, ÖrebroUniversity Hospital, Örebro, Sweden

1600 hrs **The relationship between prosthetic control, wearing patterns and daily prosthesis use**
Liselotte N Hermansson, Dept. of Prosthetics & Orthotics, Örebro University, Örebro, Sweden

1615 hrs **Symptom severity and prosthesis use: exploring the pain experience using the Disabilities of the Arm Shoulder and Hand (DASH)**
Lewis Mackay, Touch Bionics, Livingston, UK

1630 hrs **Use of myoelectric prostheses and participation in everyday activities - environmental factors impact on assistive technology use**
Cathrine Widehammar, Dept. of Pediatrics, Örebro, University Hospital, Örebro, Sweden

1645 hrs **Web-based innovative care using Gemstracker AADA, introducing remote follow up (monitoring) of function**
L M Melis-Schrijver, Rijndam Rehabilitation Institute, Erasmus Medical Center, Rotterdam, The Netherlands

1700 hrs **Comparison of prosthetic terminal device grip force adjustability between myoelectric control and Bowden cable control**
Kengo Ohnishi, Tokyo Denki University, Tokyo, Japan

1715 hrs **Scottish Specialist Prosthetics Service: Advances in our understanding with fitting, training, providing and maintaining multi-articulating upper limb prosthetics for our patients**
Brian Garrett & Anne Sillitoe, SMART Centre, Edinburgh, UK

1725 hrs **Report of survey on situation and the use of unilateral TR myoelectric hand in Japan: Comparison between continuous user and suspended to use groups**
Jumpei Oba, Dept. of Occupational Therapy, Kobe Gakuin University, Kobe, Japan

1735 hrs **DAY END**

1900 hrs **TIPS DINNER**

0800 hrs Registration opens

Chair: Laurence Kenny

0830 hrs **Textile Electrodes for Acquisition of Myoelectric Signals**
Shannon Brown, Chalmers University of Technology, Goteborg, Sweden

0845 hrs **Digital Controller for Artificial Limbs fed by Neuromuscular Interfaces via Osseointegration**
Enzo Mastinu, Chalmers University of Technology, Goteborg, Sweden

0900 hrs **Impact of Upper Limb VC-VO Prosthesis Simulators in Prosthetic Rehabilitation**
Debra Latour, TRS Prosthetics, Boulder, CO, USA

0915 hrs **A preliminary study on characterisation of finger interface kinetics using a pressure and shear sensor system**
Nicholas Hale, University of Southampton, Southampton, UK

0930 hrs **Validation of AnyBody™ model kinematics for characterising prosthesis functional usage: a comparison with Vicon® Plug-in-Gait model**
Vikranth H Nagaraja, Institute of Biomedical Engineering, University of Oxford, UK

0945 hrs **Refreshments/Exhibitor Showcase**

Chair: Sarah Day

1030 hrs **Serious Gaming in learning to use a prosthetic device**
Raoul Bongers, Assistant Professor, Centre for Human Movement Sciences, University Medical Centre, Groningen, The Netherlands

Patient's perceptions of upper limb prosthetics and how virtual reality may be used in clinical practice
1115 hrs *Carol Garcia, Senior Physiotherapy Lecturer and Team Leader Physiotherapist,*
Faculty of Health & Wellbeing, Sheffield Hallam University, Sheffield, UK
To preview work visit https://m.youtube.com/watch?v=Hp_KKhPMXJE on Channel 4 news 270716

1200 hrs **Lunch/Exhibitor Showcase**

Chair: Kainoush Nazarpour

1300 hrs **Simulated gripping of an object with a real-time musculoskeletal model of the hand: application to prosthesis control**
Author: Edward K Chadwick, Guy Hilton Research Centre, Keele University, Stoke-on-Trent, UK
Presenter: Amartya Ganguly, ISTM – Keele University, Stoke-on-Trent, UK

1315 hrs **A multimodal immersive haptic virtual reality system for the rehabilitation of phantom limb pain in upper limb amputees**
Peter Snow, Royal National Orthopaedic Hospital, Stanmore, UK
To preview work visit https://m.youtube.com/watch?v=Hp_KKhPMXJE on Channel 4 news 270716

1330 hrs *Chair: Peter Kyberd/Saeed Zahedi*
MANUFACTURERS' PANEL DISCUSSION
Blair Lock, Coapt
Harold Sears, Motion Control
Martin Schoppl, Ottobock
Ted Varley, Steeper
Bob Radocy, TRS
Bill Hanson, LTi

1500 hrs **CLOSE - TIPS 2016**

1500 hrs **Refreshments/Exhibitor Showcase**

Chair: Lal Landham

1530 hrs **Assessing Variability in Lower Limb Prosthetic Socket Fabrication**
A S Dickinson, Faculty of Engineering and the Environment, University of Southampton, UK

1542 hrs **Comparison of subjects using purely mechanical hip disarticulation/hemipelvectomy limbs to those using hydraulic and microprocessor limbs**
Elena Harris, WESTMARC, Queen Elizabeth University Hospital, Glasgow, UK

1554 hrs **Gon(y)algia parasthetica/Saphenous neuralgia: masquerading as residual limb pain**
A Boppana, West Midlands Rehabilitation Centre, Birmingham, UK

1606 hrs **Characterisation of Low Cost CAD/CAM Scanners**
A S Dickinson, Faculty of Engineering & the Environment, University of Southampton, UK

1618 hrs **Patterns of bony deformity following transtibial amputation due to septicaemia**
M Geada, Royal National Orthopaedic Hospital, Stanmore, UK

1630 hrs **Equipping Therapists to rehabilitate amputees post sudden onset natural disaster – BACPAR's Collaboration with Handicap International UK**
M J Cole, School of Rehabilitation Sciences, St George's, University of London, London, UK

1642 hrs **George Murdoch Prize Lecture -** *Introduced by Professor Rajiv Hanspal, President, ISPO*
The development of biomimetic hydraulic self-aligning ankles for lower limb amputees
Dr David Moser, Head of Research, Blatchford Group, Basingstoke, UK

1715 hrs **ISPO UK MS ANNUAL GENERAL MEETING**

1745 hrs **DAY END**

1900 hrs **ISPO DINNER**

Saturday 1 October 2016 ISPO2016 - PROSTHETICS STREAM ARCOONA SUITE

0800 hrs Registration opens

Chair: Saeed Zahedi

0830 hrs **Targeted Muscle Reinnervation: UK experiences**
Invited Speaker: Norbert Kang, Consultant Plastic Surgeon, Royal Free Hospital, London, UK

0900 hrs **Outcomes and Challenges of fitting microprocessor controlled knees: a 6-month review**
Laura Brady, WestMARC, Queen Elizabeth University Hospital, Glasgow, UK

0912 hrs **Clinical evaluation of a measurement system for loading at the lower limb stump/socket interface**
Michael McGrath, Faculty of Engineering and the Environment, University of Southampton, UK

0924 hrs **The 3-layer silicone socket design for lower limb amputees**
Ian Talbot & Lynzy Holding, Aintree University Hospital, Liverpool, UK

0936 hrs **Towards a computationally efficient model of transtibial socket fitting**
J W Steer, Faculty of Engineering and the Environment, University of Southampton, UK

0948 hrs **Assessment of socket interface kinematics and kinetics based on a trans-femoral amputee case study**
Jinghua Tang, Faculty of Engineering and the Environment, University of Southampton, UK

1000 hrs **Refreshments/Exhibitor Showcase**

Chair: Peter Kyberd

The Blatchford Lecture: Targeted Muscle Reinnervation

1045 hrs *Guest Speaker: Levi J Hargrove, Associate Professor of Physical Medicine & Rehabilitation, Northwestern University, Chicago, IL, USA*

1200 hrs **Lunch/Exhibitor Showcase**

1300 hrs **The future funding of advanced prostheses**
Imad Sedki, The Royal National Orthopaedic Hospital, Stanmore, UK
John Colvin, WestMARC, NHS Greater Glasgow & Clyde, Glasgow, UK
Alan Mistlin, Frimley Park Hospital NHS Foundation Trust, UK Ministry of Defence, UK

1330 hrs **Direct Skeletal Fixation: An Overview**
S Sooriakumaran, Queen Mary's Hospital, Roehampton, London, UK

1400 hrs **Panel Discussion**: **Interface Technology**
Imad Sedki, The Royal National Orthopaedic Hospital, Stanmore, UK
John Colvin. WestMARC, NHS Greater Glasgow & Clyde, Glasgow, UK
Carolyn Young, Programme of Care Lead – Trauma, NHS England (Midlands & East), UK

1445 hrs **Prizegiving**

1515 hrs **CONFERENCE CLOSE**

Saturday 1 October 2016 ISPO2016 - ORTHOTICS STREAM CLYDE SUITE

0800 hrs Registration opens

Chair: Steve Seccombe

0915 hrs **The OETT LECTURE**
Orthotics in a Digital World
Guest Speaker: Chris Drake, Orthotics Experts Ltd., London, UK

1030 hrs **Effectiveness and cost effectiveness of prosthetics and orthotics services/interventions**
A Healy, Science Centre, Staffordshire University, Stoke-on Trent, UK

1045 hrs **Use of the Theory of Planned Behaviour to understand beliefs about use of Ankle-Foot Orthoses (AFOs) in people with stroke**
Christine McMonagle, NCPO, Dept of Biomedical Engineering, University of Strathclyde, Glasgow, UK

1100 hrs **Extending Practice: The role of an Orthotist within the Orthopaedic Clinic**
Laura Barr, Extended Scope Orthotist (Foot & Ankle Orthopaedics)
Greater Glasgow & Clyde NHS, Glasgow, UK

1130 hrs **Lower limb salvage a "double edge sword"**
Frank L Bowling MSc (Surg) DPM PhD, FFPM, RCPS
Podiatric Doctor (Surgery), University of Manchester, Manchester, UK

1200 hrs **Lunch/Exhibitor Showcase**

1300 hrs **Partial foot amputation: orthotic or prosthetic care pathway – which is better?**
Lindsey Webster, Orthotist, Queen Mary's Hospital, Roehampton, London, UK

1330 hrs **The use of CAD/CAM Technology in Clinic**
Francesca Makey& Nigel Birkett, Sheffield Mobility & Specialist Rehabilitation Centre, Sheffield, UK

1445 hrs **Prizegiving**

1500 hrs **CONFERENCE CLOSE**

POSTER EXHIBITION

A Content Analysis of factors associated with embodiment of upper limb prostheses
Andrew D Hodrien, University of Salford, Salford, UK

Orthotic equipment in comprehensive habilitation of child with bilateral congenital deficiency of upper limbs – case report
Darinka Brezovar, University Rehabilitation Institute, Ljubljana, Slovenia

Patient with bilateral trans-humeral amputation: what to suggest? (A case study)
Matej Burgar, University Rehabilitation Institute, Ljubljana, Slovenia

A Coordination Dynamics Approach to Test Multi-DOF Myoelectric Prostheses: Preliminary Results
Andreas Franzke, University of Groningen, The Netherlands

High definition silicone suction socket
Mike Pickering, Specialised Ability Centre, Manchester, UK

A holistic and reflective case study of a quadrilateral amputee over a 16 year period
Charlie Hurd, West Midlands Rehabilitation Centre, Birmingham, UK

Pre-Clinical Application of Abstract Muscle Synergies for Myoelectric Control
Matthew Dyson, University of Newcastle, UK

A brief analysis of a prosthetic hand performance evaluation tool in terms of a human interface theory
Isamu Kajitani, National Institute of Advanced Industrial Science & Technology, Ibaraki, Japan

User training for pattern-recognition based myoelectric prostheses using a serious game
Morten Bak Kristoffersen, University of Groningen, The Netherlands

How to ride a horse with unilateral congenital wrist disarticulation deficiency – a case presentation
Maja Mlakae, University Rehabilitation Institute, Ljubljana, Slovenia

Multimodal measurement and evaluation on the influence of donning myoelectric transradial prosthesis socket by measuring
Kengo Ohnishi, Tokyo Denki University, Saitama, Japan

Estimates of Classification Complexity for Myoelectric Patterns Recognition
Niclas Nilsson, Chalmers University of Technology, Goteborg, Sweden

Improved myoelectric classification via using inertial measurement units (IMUs)
Agamemnon Krasoulis, University of Edinburgh, Edinburgh, UK

GUEST SPEAKERS

Rickard Brånemark MD, Msc, PhD

Dr Brånemark is a senior consultant at the Centre for Advanced Reconstruction of Extremities (C.A.R.E) at Sahlgrenska University Hospital, associate professor at the Department of Orthopaedics, University of Gothenburg, visiting professor at the University of California, San Francisco, Department of Orthopaedic Surgery and co-director of the international Center for Osseointegration Research, Education and Surgery (*i*CORES). He has pioneered the use of osseointegration to anchor limb prostheses for more than 20 years. Dr Brånemark has been internationally acknowledged, and was rewarded with the Hanger Prize in 2007 for his contribution in amputation research. He was recently awarded the UCSF Presidential Chair Award 2016-2017.

Tamar Makin

Tamar Makin is an Associate Professor at the Nuffield Department of Clinical Neuroscience of Oxford University. Her group studies plasticity of body representation in healthy populations and in individuals with a hand-loss. Her main interest is in understanding how habitual behaviour, such as prosthetic limb usage, drives brain reorganisation. For this purpose, she integrates methods from the fields of neuroscience, experimental psychology and rehabilitation. Tamar graduated from the Brain and Behavioural Sciences programme at the Hebrew University of Jerusalem in 2009. She then joined the University of Oxford, first as a Newton International Royal Society Fellow and subsequently as a Marie Curie Intra-European Early Career Development Fellow to establish her research program on brain plasticity in amputees. She is currently holding a Wellcome Trust/Royal Society Sir Henry Dale Fellowship. In October 2016 she will be joining the faculty of University College London at the Institute of Cognitive Neuroscience.

Raoul Bongers

Dr Bongers is Assistant Professor in the Faculty of Medical Sciences Center for Human Movement at the University of Groningen, The Netherlands. His research focusses on action-perception learning and development from a combined perspective of Ecological Psychology and dynamical systems theory, using uncontrolled manifold analyses and multifractal analyses to assess stability, variability, and interaction dynamics of the action-perception system. His studies explore processes to determine how new behaviours emerge and are stabilized during development and and learning. Dr Bongers uses a task perspective to develop serious games to train upper limb prosthetic use.

Carol Garcia

Carol Garcia has been qualified as a physiotherapist since 1987 and worked clinically for nineteen years primarily in acute respiratory care and cardiac rehabilitation. She joined Sheffield Hallam University in 2005 and went on to complete her MA in Teaching and Learning (Post Compulsory Education and Training) in 2013. Carol teaches cardiorespiratory physiotherapy across the undergraduate and post graduate programs and since joining SHU she has developed her interest and understanding of the pedagogy that underpins teaching in higher education. Since 2013, Carol has been developing her research skills through working in a multidisciplinary, cross faculty, multi organisation team looking at the use of virtual reality in upper limb prosthetics. Presently this research is being used as a pilot project looking at the wider uses of virtual reality in health care.

Norbert Kang

Mr Norbert Kang graduated from Charing Cross & Westminster Medical School in 1989. he did his pre-fellowship surgical rotation in Leeds-Bradford 1992-1994 and his MD fellowship at RAFT Institute (1995-1997). He completed his plastic surgery training in pan-Thames in 2002 and was appointed as a consultant in 2002. He has special interests in hand surgery, hypospadias surgery, prosthetic reconstruction (upper limb) and prominent ear correction.

Levi J Hargrove

Dr Hargrove received his MScE and PhD in electrical engineering from the University of New Brunswick (2005, 2008). He is a Research Scientist at the Rehabilitation Institute of Chicago (RIC), and an Associate Professor in the Departments of Physical Medicine & Rehabilitation and McCormick School of Engineering at Northwestern University.

Dr Hargrove currently is Director of the Neural Engineering for Prosthetics and Orthotics Lab at RIC. His research interests include signal processing, pattern recognition, and myoelectric control of powered prostheses. A major goal of his research is to develop clinically realizable myoelectric control systems that can be made available to persons with limb loss in the near future. His research addresses all levels of amputation and includes individuals who have received targeted muscle reinnervation. Key projects include the development of advanced and adaptive control systems for prosthetic legs, improving control of robotic hand prostheses, and intramuscular EMG signal processing. His work has been funded by the United States National Institutes of Health, National Science Foundation, Space and Naval Warfare Systems Center, and the US Army.

Frank Bowling

Frank Bowling is a Doctor of Podiatry working in both a surgical and research capacity at the University of Manchester, Manchester Royal Infirmary. He holds an undergraduate degree in Podiatry, MSc in odiatric Surgery and a Doctorate in Podiatric Medicine and PhD Medicine. Since graduation he has authored and co-authored over 70 papers in a range of medical journals including 12 book chapters and two books in Pharmacology, Disease Management, Diabetic Neuropathy, Biomechanics, Pathomechanics and Charcot Foot.

Chris Drake

Chris Drake is Director/Owner, Consultant Orthotist and Orthotic Expert Witness at Orthotic Experts Ltd – a dedicated Orthotic Medical Legal and Immediate Needs Reporting Consultancy providing excellence in medical legal reporting. He has extensive experience and specialist skills in orthotic principals/practice, lower limb biomechanical dysfunction and posture defects that have been gained over 30 years of clinical practice. He qualified in 1983 and initially worked in the private sector until 1991. From late 1991 to 2005, he held the post of Principal Orthotist and Head of Orthotics at Queen Mary's Hospital NHS Trust, London SW15. In 2005, he formed a private clinical practice The London Orthotic Consultancy Ltd where he was Managing Director and Principal Consultant Orthotist until December 2012.

Title: **Effects of Adding Vibrotactile Feedback to a Myoelectric Controlled Hand on Performance and Visual Attention with a Disruption of Visual Feedback**

Presenter: **Eitan Raveh, BPT, MSc**
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Other Authors: Sigal Portnoy, PhD, Department of occupational therapy, TAU
Jason Friedman, PhD, Department of physical therapy, TAU

Aims and Objectives: Despite advancements in prosthetic technology, the lack of tactile feedback in upper limb prostheses is still a challenge for prosthetic users. Therefore, amputees have to constantly use their visual feedback resources during performance of simple functional tasks. When visual feedback is disrupted, or in a dual-task paradigm, performance levels and allocation of visual resources are affected. Adding vibrotactile feedback (VTF) to the residual limb has been shown to be a viable mechanism for prosthetic users. However, the effects of adding VTF to a myoelectric controlled hand on performance and visual attention during daily tasks, were not investigated yet. Our objective was to examine the effects of adding VTF to a myoelectric controlled hand, during performance of simple functional tasks, where visual feedback is disrupted or during a dual-task paradigm.

Methods: Twenty healthy subjects were instructed to control a virtual car on a road presented on screen with their left hand on the keyboard. During the game, instructions for simple functional tasks, e.g. mixing sugar in a glass with a spoon, appeared on the screen. These tasks were performed with a myoelectric controlled hand, attached to their right hand. Pressure sensors at the tips of the hand and vibrotactile actuators attached to the right arm provided the subjects with VTF during grasping. We used an eye-tracking system to record the visual attention of the subject during performance. The study design was a repeated measures design with counter-balanced order of two conditions, so the game was repeated twice - with and without the VTF. In addition, the subjects performed the Box and Blocks test, with a disruption of visual feedback. This was done using a motion capture laboratory, with a virtual presentation of the test. A misleading visual feedback was presented on a screen, so that the virtual block randomly fell while the actual block was still held by the subject. Thus, the subjects were compelled to rely on the VTF during grasping, despite the misleading visual feedback.

Results: This is an ongoing study, which its current results are detailed below. We are continuing these trials with transradial myoelectric prosthesis users. In the group of non- impaired subjects, adding VTF was found to affect visual attention or performance in the dual task paradigm only in some tasks. For example, the average time (± standard deviation) to complete the sugar-mixing task was 13.7±17.2s with the VTF versus 19.3±9.1s without the feedback. In addition, the number of time the subjects have shifted their gaze from the screen towards the hand were 15.5±23.7 with VTF versus 20.0±11.6 times without the feedback. When examining the subjects with the misleading visual feedback, no difference was found in performance between with and without VTF.

Conclusions: Our interim results suggest that the performance of certain functional tasks, and allocation of visual attention resources may be improved by adding VTF to a myoelectric hand. Further investigation is required to evaluate the effects of VTF in prosthesis users and in different situations where visual feedback is disrupted.

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Title: **Myoelectric prosthesis following total thumb amputation**

Presenter: **Vera G. van Heijningen, Occupational Therapist CHT-NL**

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Aim and objectives

A passive thumb prosthesis is an possible solution to restore pinch grip and grip to improve hand function, in thumb amputations. However in the clinical experience of the authors this is not routinely a satisfying solution to the patient with a total thumb loss.
With the developments of the i-limb digits, options for improvement of partial hand deficits has been widened.
The aim of this study was to investigate the potential benefit of applying a myoelectric controlled thumb, in other words, will a myoelectric controlled thumb improve hand function in comparison to a passive prosthetic thumb?
This case study presents the process and preliminary results of optimizing the function of the hand of a person with a total thumb loss.

Case description and methods

A 53-yaer old woman reported with a chief complaint of impairment in daily activities.
The thumb of her right hand was amputated at the level of the carpo-metacarpal joint, following a period of suffering severe symptoms of Complex Regional Pain Syndrome type II result from a cat bite. Her left arm showed severe signs of overuse as a result of the limited capacity of her right hand. This case report describes the process of designing and manufacturing a myoelectric thumb prosthesis

Findings and outcome

This case-report describes also the process of Rehabilitation of regaining balanced use and interaction between two hands in daily activities. Experiences of the advantages and disadvantages of the options, either no prosthesis, passive prosthesis or myoelectric prosthesis, will be shared and discussed.

Conclusion – recommendations- implications

The myoelectric thumb restored the hand function beyond expectations of the patient. The client has regained the ability to be fully active in her daily life, in the most practical, comfortable and secure way as possible, furthermore her self-esteem and self-image are strengthens
This successful prosthetic case is achieved by approaching the treatment access question with an open mind for the outcome, as well as maintaining a wide look and look beyond the scope of what seems to be possible during the whole process.

Clinical relevance

No case-report or any literature on with this topic was found by the authors. This case report has identified a potential improvement of hand function, by using a myoelectric thumb component solely in case of total thumb amputation.

Title: **Impact of Bilateral Upper Limb Prosthesis Simulators in Pre-Prosthetic Training: A Case Study**

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It appears that the concept of utilizing simulators is underutilized. The body-powered prosthesis simulators used in this case scenario accesses voluntary-opening and voluntary-closing terminal devices. As described in this reflective case study, the prosthesis simulator can be used in **multiple stages** of prosthetic training. During the initial evaluation, the simulator can be used to compare function and access of the technologies for successful prescription and actual client trial. This evidence can be video-taped and photographed to provide compelling evidence justifying medical necessity to the funding stakeholder(s). The caregiver can experience the diverse technologies in order to better understand the requirements of use and application to functional and bimanual manipulative tasks. During the preparatory phase, the user can adjust to the demands of suspension and practice pre-prosthetic skills-drills and activities. Upon delivery of the definitive prosthesis, the simulator can be utilized to educate family members and caregivers to various strategies in order to complete bimanual tasks. These opportunities with the simulator appear to enhance carry-over of strategies to facilitate skill acquisition and appropriation of prosthetic satisfaction.

Mr. A is a 45 year old male who presents with acquired loss of both feet and both hands due to illness at the age of 11 months. He wore bilateral upper limb prostheses as a child, abandoning use after three months. He has accomplished most tasks using both residual limbs (partial hand level, no digits) at midline. This adaptive strategy requires more time as well as posturing in the trunk to accommodate whatever task he is attempting. Approximately 1 year ago he expressed interest in activity-specific devices because he perceived that his current method was inefficient and the overt posturing has appeared to cause mid and low back pain. The VC-VO prosthesis simulators were used during an initial occupational therapy evaluation to accompany the prosthetist request for authorization. Following insurance approval, the prosthesis simulators were used weekly in pre-prosthetic training for a period of six weeks. During this period, the client met all of his goals. At the time of delivery of his definitive prostheses, the client was immediately able to complete many self-care tasks independently using his technology. He has since engaged in prosthetic rehabilitation to refine skills toward instrumental activities of daily living including care of his young children, management of his home and property and eventual return to work.

The VC/VO prosthesis simulator was during the pre-prosthetic delivery phase of intervention to address skills drills of grasp and release in diverse planes, functional splinter skills and bimanual functional tasks; accompanied by work with the mirror box to occlude vision and address position in space, surface/ object feature identification and object identification. It is thought that such emphasis may help to improve functional outcomes and consumer satisfaction with the definitive prosthesis, impact user acceptance and minimize rejection of the prosthesis. This case study of the client with bilateral UL limb loss will detail the interventions used, report functional outcomes, perception of ability/disability and client satisfaction of the prothetic technology provided to him.

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Title:	**A case study in the use of 3D CADCAM system use in the design and manufacture of forequarter prosthesis**
Presenter:	**Mr M. Currie**, Prosthetist & **Mrs L. Powell**, Clinic Lead Prosthetist
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Aims of case study:

This case study aimed to outline the use of an innovative technique of shape capture for manufacture of a shoulder cap prosthesis in two forequarter amputees. The traditional method used for this level of amputation is a plaster of paris (POP) cast of the amputated side and a comparative POP cast of the contralateral side. The case study set out to ascertain if the use of 3D scanning improved patient satisfaction (including cosmetic presentation and procedure) and was more efficient than the traditional methods.

Techniques:

Due to the rarity of forequarter amputation, opportunity sampling was used to select two patients, one male and one female. Both these patients were primary forequarter amputees as a result of cancer. The 3D scanner used for this study was an Omega by Ohio Willowood in conjunction with the Omega Tracer Software, also from Ohio Willowood. The patients were fully aware of each stage of the process and opportunities provided for questions and feedback.

The patients were scanned directly onto their skin with the use of reflective markers. Their entire torso was scanned including the unaffected contralateral side. The unaffected side was used as a model to construct the shoulder prosthesis for the amputated arm. The scans were rectified on the CADCAM system and models were produced from a foam block by sending the rectified computer files to a robotic carver. The prosthetic shoulder caps were manufactured using the models in the on-site workshop. A fitting was carried out with the patient prior to the caps being completed and delivered. Patients were required to fill out a Quality of Life measure post fitting.

Results summary:

The process of scanning and rectification on the computer software was a more efficient process for the clinician and this meant the patients initial scanning/casting appointment was of a shorter duration. The manufacturing process was simplified as only one model was used with both sides readily comparable during shaping. The faster scanning process also that the patients modesty could be preserved. The fact no plaster was used meant the process was far cleaner and no washing or mess post casting. During the first fitting patients immediately reported that when wearing the prosthesis they preferred the way they looked. The Quality of Life measure indicated a positive impact on the patient's body image. Some comfort issues were encountered during a review of one of the patients, but this was easily solved and was a result of nerve issues during the amputation surgery.

Conclusions/recommendations:

Despite the low subject numbers, the initial results were very positive. Firstly the scanning and manufacturing process was much simpler than previous POP techniques. Secondly, the overall cosmesis improved and fewer fittings were required than in previous techniques. Finally, the patients satisfaction was much improved and the computer visuals allowed simplified explanations of the process to the patients and families.

As a result of this, 3D CADCAM shape capture should be used for scanning and more accurate manufacture of shoulder cap prosthesis for forequarter amputees.

Title: **The Impact of Partial Hand Amputation – A Case Presentation**

Presenter: **Mrs Lindsey Barker, Clinical Specialist Occupational Therapist**

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Partial hand amputation can impact on all aspects of an individual's well-being, quality of life and occupation. The loss of a hand, because of its highly symbolic and multi-functional nature, is known to be more traumatic than the loss of a leg. (Rybarczyk B et al 2008).

This presentation will explore through a case study, the impact of traumatic partial hand amputation on an individual and explore the types of prosthesis provided. The presentation will include the individual's progress through their journey following injury and amputation, describing occupational therapy intervention, and a multi-disciplinary approach to treatment.
Occupational performance outcomes will be presented using the Canadian occupational performance measure (Law et al 2014).

The clinical reference group for complex disability, equipment – prosthetics (2013) refers to the impact that the appearance a prosthesis may have on the successful prosthetic rehabilitation of a patient. It is currently difficult for clinicians to obtain funding for high definition silicone prostheses, and it is anticipated that this presentation will highlight the effect of amputation on body image and the importance of providing a realistic and acceptable prosthesis to the individual. It will be discussed that this in turn may have a positive influence on an individual's occupational performance.

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Law M, Baptiste S et al (2014) Canadian Occupational Performance Measure 5th Edition Canadian Association of Occupational Therapy ACE Publications

NHS England Clinical Reference Group for Complex Disability, Equipment – Prosthetics (2013) Clinical Commissioning Policy: Provision of custom made high definition silicone covers for prosthetic limbs and partial hand prostheses Reference NHSCB/DO1/S/d NHS England

Title: **Myoelectric arm prosthesis approach in children at the Japan Hyogo Rehabilitation Center**

Presenter: **Yaeko Shibata, OT, Ms**

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Background

In the West, early aggressive training with myoelectric arm prosthesis has been reported to be effective for children that lost an arm due to accident and children with birth defects. This is to enable the children to personally decide whether they want to live using a prosthetic arm in the future. Although the approach in Japan has been inadequate, trials with myoelectric arm prosthesis from infancy were started from 2002 at the Hyogo Prefecture Rehabilitation Center and that approach is still in place.

Aim

To clarify the trend in 50 children who underwent training using myoelectric arm prosthesis at this institution in 2002-2014. To introduce the approach and progress of myoelectric arm prosthesis for children and report the usage features and effectiveness of using myoelectric arm prosthesis in real-life setting by age.

Method

Fifty children who had lost (amputation) an arm that were examined at the Hyogo Prefecture Central Rehabilitation Hospital and had started training with a myoelectric arm prosthesis in 2002-2014 were the subjects. There were 26 males and 24 females. Eighteen had lost the right arm and 32 the left arm. Cause of the loss was congenital loss of an arm in 49 children and amputation due to trauma in one child. All training was out-patient based and one session was approximately 60 min.

Results

Forty five children continued using myolectric arm prosthesis and 5 discontinued the use. Infants were started from the use of decorative prosthetic arms, then introduced to one-electrode controlled and 3-electrode controlled myoelectric arm prosthesis from 1 year of age and 3 years of age onwards, respectively. Methods of play according to age were introduced focusing on grip training such as opening and closing of the hand, and playing with the use of both hands. Moreover, not only use of the prosthesis at home, but motions of using it in social life such as in the nursery and kindergarten were actively conducted.

Discussion & Conclusion

By wearing a prosthetic arm and using it in daily life from early stages, children will want to use both hands to accomplish tasks, and will have many opportunities where they can experience enjoyment in playing. Increased desire to opt for a prosthetic arm leads to improvement in the quality of life of the person affected. As the role and methods of use of a prosthetic arm changes as a child grows, continued periodical follow up and approaches are indispensible with myoelectric arm prosthesis for children.

Title: **Latest developments in the use of Osseointegrated upper limb prostheses**

Presenter: **Rickard Brånemark, MD, MSc, PhD, FRSM**
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Directly bone anchored prostheses according to the osseointegration concept were originally developed by the late Professor P-I Brånemark in Gothenburg in the 1960. Osseointegration was initially used to treat edentulism.

In a multidisciplinary approach osseointegration has been implemented for direct skeletal anchorage of amputation prostheses since 1990. Initially, the focus was on individuals with transfemoral amputations. However, the osseointegration concept is not restricted for use to the lower extremity. The treatment offers unique opportunities on the upper extremity to combine anchorage with advanced prosthetic control using implanted electrodes.

This presentation will give an overview of past work and ongoing research and development.

Title: **PPP-Arm: the implementation of a national Prosthesis Prescription Protocol**

Presenter: **P.A.Wijdenes, Occupational Therapist, Mrs.**

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Introduction: Patients with an acquired or congenital upper limb defect need highly specialized care from multidisciplinary teams. In the Netherlands, various rehabilitation centers had their own method of treatment. Standardized care for these patients was necessary, especially when prescribing prostheses.

Aim: To create and implement a national digital protocol for prescribing upper limb prostheses.

Method: The Prosthesis Prescription Protocol of the upper limb (PPP-Arm) is a tool to structure, underpin and evaluate the prescription of upper limb prostheses. The protocol is based on WHO's criteria of the International Classification of Functioning (ICF) and consists of the following layers:

1.Establishing patient's demands; 2. Establishing device requirements; 3.Preparation of treatment requirements; 4. Selection, try-out and final decision; 5.Delivery of the device; 6.Instructions and training; 7.Evaluation

Results of implementation: The protocol has been created through the collaboration of patients, rehabilitation teams, orthopedic workshops and insurance companies, collaborating in the working group PPP-Arm. Implementation started in four rehabilitation teams in the Netherlands. After one year another six rehabilitation teams started using the protocol. In each team a knowledge broker was appointed, who was responsible for the implementation within his own center. A national project coordinator maintained contact with all parties involved, collected questions and problems when using the protocol, organized activities and meetings to develop the protocol further and to stimulate using the protocol. In the last year of the project we have developed the folder Information. In this folder links can be found to educational materials for clients about for example: amputation, phantom sensations, upper limb prostheses, personal care and peer contact.

The protocol also has been translated in English and it is possible to use this version in other countries. Advantages of the protocol are complete and structured; user-friendly; using the same ICF terminology and the same treatment guidelines by all users; applied nationally; digital reporting; workplace independent login possibilities for all team members; prescription reports for insurance companies; patients gain more insight in their own treatment process; building a national database for research.

Disadvantages of the protocol are time investment is needed to learn using the protocol

Evaluation: The use of PPP-Arm has been evaluated using a questionnaire:

- PPP-Arm is used by all participating centers
- The quality of the prosthesis applications has improved
- PPP-Arm has produced a several positive developments: better team cooperation, more structure and completeness, more uniformity in the country, trial period.

Conclusion: The nationwide implementation project PPP-Arm was successful, since all participating centers use the protocol. By developing PPP-Arm we have managed to create a national uniform and structured method to advise and evaluate the prescription of upper limb prostheses.

Title	**Forming an international consortium for sharing resources of upper limb absence worldwide - the *handsmart group***	
Presenter	**Liselotte N Hermansson[1,2,3], Associate Professor**	
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Introduction

An exciting and constantly changing environment in the upper limb prosthetics field challenges clinical teams on a daily basis. Prosthetic devices and control systems, as well as individual's requirements and expectations, have changed and developed over the past several years. To meet or exceed expectations, and to obtain the best outcomes in a coordinated clinical care continuum, therapists need to have foundational skills and knowledge. The aim of this work is to determine best clinical practice and to provide resources for therapists.

Methods

The prosthetic company Ottobock initiated a meeting in Berlin, Germany, in February 2016. Twelve independent international experts consisting of 11 therapists (4 physical and 7 occupational therapists) and 1 prosthetist, from different parts of the world, participated. The clinicians are all either independent practitioners or working with a company and specialized in upper limb loss/difference rehabilitation, either in clinical or research settings. Discussions were facilitated by an independent moderator. Decisions were made based on voting and consensus agreements.

Results

The international consortium of expert clinicians were united in the vision to provide the most holistic rehabilitation approach for every person with upper limb loss or upper limb difference, now and in the future. Based on this agreement the "*handsmart group*" was formed and further discussions took place.

The vision was operationalized by the mission to support and empower clinicians and patients worldwide by creating and updating an open access, easily understandable resource based on evidence, for those engaged in upper limb loss/difference rehabilitation. The consortium formed working groups to address the following objectives; 1) create an online platform for networking, sharing information, communicating and accessing resources for supporting clinical practice internationally; 2) search and apply for financial support for the future activities in the group; and, 3) search, compile and recommend interventions for different rehabilitation phases, in adults and children with upper limb absence.

Discussion

Some clinicians have difficulty accessing information or relevant findings in upper limb loss/difference rehabilitation. They usually receive their knowledge from peers, by trial and error over the years or reading materials in some special fields. The *handsmart* platform will provide evidence based resources that are easy to understand and accessible worldwide. Hopefully this will improve the quality of upper limb rehabilitation.

The *handsmart group* is a non-profit group, and the members are working on a voluntary basis. We invite external parties involved in upper limb loss/difference rehabilitation (e.g. patients organizations, commercial companies, professional organizations, other team members) to collaborate and support the group. This may enable successful work in promotion of our mission and vision.

Disclosure

Though Ottobock initiated and was in charge of organizing and supporting the first meeting, the *handsmart group* is independent and follows international needs and interests of all people. There are no financial interests of this group.

Acknowledgements

The authors thank Martin Schöppl for initiating this project, Christiane Jodl for organizing the first *handsmart group* meeting and Claudia Herczeg for facilitating the meeting. We thank Karen Roberts, Bambi Lombardi and Joyce Tyler for supporting the idea.

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Title: **Developing a test to determine quality of proportional control over a myoelectric prosthetic hand**

Presenter: **Anniek Heerschop[1], MSc., PhD-student**

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This study aimed to develop a test that can determine the quality of proportional control over a myoelectric prosthetic hand early in the rehabilitation process. Therefore, multiple tests with and without a prosthetic hand but all controlled using the sEMG of the flexor and extensor of the wrist, were compared in two experiments. In Experiment 1, 31 participants performed five tests in random order in one session, without training. The tests comprised two serious games in which objects had to be caught, two tests in which a prosthesis-simulator was used to either pick up rigid objects or to reach certain opening- and closing speeds, and one test matching the EMG with a pre-programmed line. Correlations between the performance of all tests showed only one weak correlation. In order to assess the effect of a short training period, in Experiment 2, 12 participants trained two tests for 12 minutes per day on five consecutive days. We compared performance in (1) a prosthesis task in which a prosthesis-simulator was used to pick up compressible objects and (2) a serious game in which objects had to be caught with a grabber while receiving ADL-relevant feedback. Earlier we showed skill-improvement in this game transfers to prosthesis use. Results showed no correlation between the tests for multiple outcome measures. Combined, the experiments show that performance in one test is not related to performance in another test. This indicates the quality of proportional control over a myoelectric prosthetic hand should be tested using a prosthesis task.

Title:	**Evolution of Refined Clothespin Relocation Test for Prosthesis Users for use as a Clinical Assessment**
Presenter:	**Ali Hussaini, Research Assistant, Mr**
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This study details the development phase of a new upper limb prosthetics outcome measure, the Refined Clothespin Relocation Test (RCRT) for clinical assessment. The primary focus was to develop a standardized outcome measure that could be performed in a prosthetics clinic within a 20 minute session. The test utilizes a modified Rolyan Graded Pinch Exerciser, a timer, and a single video camera. The user is asked to relocate 3 clothespins between horizontal and vertical rods, in a set order, while their compensatory motions are graded by a clinician and the time to complete is recorded. 5 trials in two directions (moving the clothespins upward from the horizontal rod onto the vertical and vice versa) are completed and the average times of upward and downward directions, as well as the average compensatory motion grade are calculated. A clinical assessment relies on these two metrics. Compensatory motion grade is based on the lateral tilt of the trunk and the over rotation of the shoulder (integer scale of 1-4, for each motion).

In this pilot study, 42 able-bodied subjects and 5 assessments from prostheses users (myoelectric and body-powered, transradial and transhumeral) have been performed. Paired sample t-tests (p=0.05) indicate that side-dominance is not a factor in terms of time to complete for able-bodied subjects, which will allow data to be pooled from left handed and right handed prosthesis users. The prosthesis users presented with larger compensation in their torso and shoulder movements (lower grade for compensations), and a longer mean time to complete (2.75 times longer). The mean time to complete (summation of upward and downward) for able-bodied and prosthesis users were 12.23 seconds and 33.57 seconds. Average grade across the able-bodied subjects for lateral tilt and shoulder rotation were 4 and 4, respectively (lowest possible compensation score). The average grade across the prosthesis assessments for lateral tilt and shoulder rotation were 3 and 3.

Utilizing the compensatory motions a prosthesis user makes when performing an assessment, in addition to time, provides greater insight into the quality of prosthesis usage. Improved control strategies and advanced prosthesis designs are expected to reduce the need for compensatory motions, as well as a lower times to complete. This will only result with improved intuitive control, reduced cognitive effort, and reduced compensations. For the subjects that have partaken in the

study, it was observed that faster attempts to complete the RCRT resulted in more compensatory motions (both groups).

Many subjects have commented that the time commitment required to complete all parts of the RCRT (instructions, test, patient-reported outcome survey) was reasonable or shorter than expected. Prosthesis users also had similar comments, and reported that the instructions were clear, the visual aids were helpful and the length of time to complete the test was more agreeable than other tests they had previously participated in.

The RCRT is a clinical measure which aims to determine whether a prosthesis user is likely to use their prosthesis with all available degrees of freedom and functionality to reduce compensations outside the clinic.

Title: **An Exploration of the Correlation between an amended Box and Blocks Assessment, the standard Box and Blocks Assessment and the Assessment of Capacity for Myoelectric Control, with myoelectric prosthesis users.**

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Background: Myoelectric prostheses are a popular choice for upper limb amputees as they combine function with cosmesis. However, costs and rejection rates associated with these prostheses are high. Furthermore, myoelectric prostheses are not available to all upper limb amputees on the NHS (Watve *et al.,* 2011). Additionally, NHS England recently concluded that there was insufficient evidence to justify the routine commissioning of newer multi-articulating models (2015). Widespread use of standardised outcome measures which have been validated for this population may enable more effective comparisons between different prostheses, thereby facilitating development of the evidence base and guiding prosthetic prescription. Yet, the evidence base relating to outcome measures for this population is limited. Furthermore, only one assessment has been designed and validated specifically for use with myoelectric prostheses – The Assessment of Capacity for Myoelectric Control (ACMC). Although a valid and reliable measure of myoelectric prosthetic ability, this assessment remains inaccessible to many clinicians' in the UK, due to high training costs and the level of previous myoelectric experience required. Therefore, alternative widely available and cost effective measures are needed. Previous studies have identified generic manual dexterity assessments, such as the Box and Blocks, as having potential for use with this client group. However, further research is indicated.

Aims and Objectives:

- To amend the Box and Blocks assessment for myoelectric prosthesis users with the creation of a wooden insert and standardised, graded positioning of blocks.
- To assess participants using the ACMC, standard and amended Box and Blocks assessments.
- To correlate scores from the amended and standard version, with the ACMC.

Methods: Relevant ethical and trust approvals were obtained prior to commencement of the study. Participants were recruited using convenience sampling. Participants completed the ACMC, standard and amended Box and Blocks assessments on two occasions, two months apart. Scores were correlated between the standard Box and Blocks and ACMC, amended Box and Blocks and ACMC and the standard and amended Box and Blocks.

Results: 14 Participants were recruited. Correlations were as follows: Amended Box and Blocks v's ACMC r=0.69, Standard Box and Blocks v's ACMC r=0.79, Standard v's Amended Box and Blocks r=0.93. The combined p–value for the correlations was =0.238. This study was underpowered.

Conclusion: The correlations observed were strong. The correlation observed between the ACMC and the standard Box and Blocks was higher than the amended Box and Blocks and the ACMC which was unexpected. However, the difference between the correlations was not statistically significant. The results support the existing literature regarding the potential of the Box and Blocks assessment with

This presentation will provide an overview of the research undertaken as part of a Masters of Research in Clinical Practice and provide an insight into the research process form the perspective of a novice researcher.

References:

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Watve, S., Dogg, G., MacDonald, R. and Stoppard, E. (2010) 'Upper limb prosthetic rehabilitation', *Orthopaedics and Trauma,* 25 (2), pp. 135-142.

Title:	**Development and reliability testing of a qualitative score for rating compensatory movements in upper limb prosthesis wearers during execution of 4 FCE-tests.**		
Presenter:	**T.M.J. van der Laan, MSc**		
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Background

Musculoskeletal complaints (MSC) are twice as prevalent in persons with an upper limb defect compared to the general population. Overuse of the sound limb or compensatory movements of the affected limb may explain this difference.

Objectives

To develop 1) a qualitative scoring system for rating compensatory movements in upper limb prosthesis wearers during the performance of functional capacity evaluation tests adjusted for one handed individuals (FCE-OH), and to determine 2) the inter- and interrater reliability and 3) the feasibility of the scoring system.

Methods

The scoring system was developed in three subsequent steps following an international guideline for instrument development. Twelve (inter-) national FCE-experts, 6 physiotherapists, 12 upper limb prosthesis wearers, and 20 healthy controls were involved in the development. During reliability testing the raters scored videotapes of participating upper limb prosthesis wearers and controls, performing 4 FCE-OH tests two times (two weeks apart), using the developed scoring system. Feasibility was determined by using a questionnaire.

Results

Kappa value for intrarater reliability was 0.77. Kappa values for interrater reliability in the first and second rating sessions were κ=0.54 and κ=0.64, respectively. Feasibility was rated as good to excellent.

Conclusions

A feasible scoring system was developed to assess compensatory movements in upper limb prosthesis wearers when executing FCE-OH tests. Intrarater reliability was good, interrater reliability was satisfactory in most instances. The standardized scoring system for assessing compensatory upper limb movements during performance of FCE-OH tests may provide clinicians with useful information for prevention and treatment of MSC in upper limb prosthesis wearers.

Title:	**Development of a functional capacity evaluation measurement for individuals with upper limb reduction deficiency or amputation.**		
Presenter:	**C.K. van der Sluis**		
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Background

Musculoskeletal complaints are a frequent problem in individuals with upper limb absence (ULA). An instrument that assesses physical force and repetition capacity in individuals with ULA is warranted.

Aims

Objectives of this study were to develop and pilot test a functional capacity evaluation (FCE) for individuals with ULA, due to an upper limb reduction deficiency or amputation, and to compare test results with matched controls.

Method

An existing FCE based on risk factors for work-related upper limb disorders was adapted for use in one-handed individuals, with or without a prosthesis. The adapted FCE was pilot tested by 20 individuals with ULA (of which 10 with a below elbow ULA and 10 with an above elbow ULA; 17 males, and a mean age of 46.3 (SD: 10.5)), and 20 matched controls.

Results

The adapted FCE was named FCE – one-handed (FCE-OH) and consists of the following tests: overhead lifting one-handed and two-handed, overhead working, repetitive reaching, fingertip dexterity and hand grip strength. Individuals with ULA lifted significantly less weight compared to their matched controls. No significant differences for the other tests were found.

Discussion & conclusion

The FCE-OH tests the functional capacity of the upper extremities of one-handed individuals, with or without a prosthesis, in a standardized environment. It will allow healthcare professionals to objectively assess the physical capacity of an individual with ULA and to give these individuals substantiated advice regarding suitable work.

Title: **A reflective case study of a quadrilateral amputee, over a sixteen year period. Exploring coping with the challenges of activities of daily living, prosthetic interventions and adjusting to the psychological impact of such a severe level of limb loss.**

Presenters: **P Davis Principle Prosthetist, Mr**
C Hurd Senior Occupational Therapist, Mrs

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Aims and Objectives:
To provide a holistic, informative and reflective case study of a young quadrilateral amputee who lost all four limbs as a result of meningococcal septicaemia, at bilateral transradial level and bilateral through knee, as well as suffering facial disfigurement. This gives you an overview of his sixteen year journey up to present day. Covering aspects such as maximising independence in activities of daily living, exploring what aids, adaptations and prosthetic devices and interventions were instrumental in helping this young man achieve his maximum rehab potential and limitations and obstacles encountered along the way.

Methods and Interventions used:
Through assessment and reviews focussed on patient goals over this sixteen year period, various prosthetic devices, both body- powered and myo- electric have been trialed by patient with varying degrees of success. Assessments used to guide treatment plans included the Canadian Occupational Performance Model COPM, Patient Goal Setting, ULPUG Upper Limb Prosthetic Usage Guide and UG timed up and go test for his lower limb prostheses. As well as prosthetic devices, various equipment aids, housing adaptations and car alterations have been assessed for and provided to enable the atient to achieve his goals and enhance his independence and quality of life.

Results and findings:
He is now an extremely adept prosthetic user of griefer electric hands with wrist rotation. He has found various equipment aids invaluable in providing him with independence in activities of daily living. Housing and car alterations have been carried out to maximise independence and achieve patient goals. He has his own workshop of adapted tools to make various appliances that he sells. Through patient assessment, feedback, reviews, photos, video footage of patient over the past sixteen years this presentation will show how a young man has gradually adapted to the daily challenges of being a quadrilateral amputee. This case study emphasises the importance of family support, patient motivation and determination, forming a good therapeutic relationship with our patients built on honesty, trial and error and the same end goal.

Conclusion summary:
In conclusion we hope that by sharing with you this extraordinary young mans journey we will inspire others about what can be achieved despite the loss of all four limbs, and provide an informative and interesting overview of working with patients with similar levels of disability. By
gaining a better understanding and valuable knowledge of what has been learnt from this case study and how we as health professionals can assist, guide and support our patients in maximising their independence and achieving their goals along the sometimes rocky, challenging journey of rehabilitation

Title: **A protocol to establish the relative importance of factors influencing ease of myoelectric prosthesis control**

Presenter: **Alix Chadwell, PhD student, Miss**

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A number of reports have suggested that myoelectric prostheses can be difficult to control. For many this has contributed to limited active use, or even total rejection of their prosthesis. Non-usage of the prosthesis can in turn lead to overuse of the intact limb and injuries. One of the major factors assumed to contribute to poor control is the absence of sensory feedback and this has led engineers to devote considerable effort to addressing this issue. However, as demonstrated by Saunders[1], a myoelectric hand whose response is both fast and highly predictable can be accurately controlled, even in the absence of sensory feedback, suggesting other issues may be equally or more important.

In this paper we have characterised the overall problem of control of current myoelectric prostheses as consisting of a series of inter-linked person-specific and prosthesis-specific elements. To understand the relative importance of each of these elements, we have developed a novel assessment protocol to characterise each of the subject and prosthesis specific elements in the prosthesis control chain, as well as prosthesis functionality and patterns of everyday use. Specifically, the following methods are presented for assessing:
1) User skill in generating the required myoelectric (EMG) signal. Using simple tracking tasks the ability of the user to control the signal amplitude will be assessed. Additionally, a novel reaction time test will provide a measure of how intuitive it is for users to activate the muscles controlling their prosthesis.

2) Unpredictability introduced at the electrode-skin interface. A series of reaction time tests will be undertaken with a 'perfect' electrode skin interface, acting as a control, and with socket-located electrodes (and mechanical loads applied to the socket) to establish the effect of socket fit and loading on variability in prosthesis response times.

3) Electromechanical delays within the prosthesis itself. The time taken for the prosthetic hand to respond to an electrical signal at the electrode will be measured.

Functionality will be assessed as follows. Firstly, using a simple functional upper-limb task the following aspects will be assessed: 1) Task success and duration, 2) Quality of movement (using accelerometry, and hand aperture analysis), and 3) Gaze behaviour. Finally, for the first time, the extent to which the participants use their prosthesis in everyday life will be assessed by inviting participants to wear an activity monitor (accelerometer-based device) on each wrist. Metrics will include total prosthesis wear time, as well as measures reflecting real world bilateral arm use[2].

The protocol is portable and, following piloting, will be used to collect data at a number of prosthetic centres across England. In order to establish the relative contribution of each input factors to the various measures of overall functionality multiple regression models will be used. Secondary, but equally novel, research questions will also be explored, including the relationship between performance on functional tasks and use of the prosthesis in everyday life. The results of this study will provide, for the first time, clear guidance to future researchers on the most productive areas to focus on.

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2. Bailey RR, Klaesner JW and Lang CE. Quantifying Real-World Upper-Limb Activity in Nondisabled Adults and Adults With Chronic Stroke. *Neurorehabilitation and Neural Repair*. 2015; 29: 969-78.

Title: **Choosing a multi- functional hand that suits the patient's requirements**

Presenter: **Judy Davidson, Occupational Therapist**

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Aim of the study: Enabling the amputee to choose his own multi-functional hand has been a project for the last 4 years.

Techniques used: In NSW, the insurers need justification of the functional benefits of the multifunctional hand prior to its approval. This is difficult to be specific without the individual amputee having the use of a trial prosthesis. Since 2013 the following unilateral upper limb amputees have had trials of one or more hands prior to prescription:

- DS (2013 and 2014) and BW (2014)– Ilimb and Michelangelo (Bebionic not available in Australia in 2013 and 2014)
- PT (2015) – Ilimb and Bebionic (did not want to trial a MichelangeloP
- RG (2013 and 2015) – the Ilimb and Bebionic
- AS (2015) – Trial of Bebionic and Ilimb briefly and Sensor speed. – the conclusion was AS had only a one site control.
- RH (2016) - Trial of Michelangelo

The questions that are asked by all funding bodies for a prosthetic request are:

- State the participant centred goal/s that relates to this/these items of prosthesis.
- Describe why the participant needs this prosthesis. How often is this prosthesis likely to be used?
- Describe why the features/specifications of the proposed prosthesis are reasonable and necessary. Why have these components been chosen?
- Can the participant donn and doff the prosthesis independently? If not what assistance is required?
- Other information relevant to the prescription.
- What other prosthetic options / components were considered or trialed? Why are they not appropriate?

Results: Each trial costs about $5,000 if an interim socket has to be fabricated but $1,000 if they already have a suitable socket. Every insurer has approved the interim socket and trial of the hand. They can see their way to approve $5,000 without high levels of justification but the cost of $100,000 requires oversite by the NSW governing body and is much more stringent).

As a result, the patients are able to determine their preference based on a variety of factors including cosmesis and function. Appropriate functional justifications dealing with specific tasks are able to be submitted for funding to easily answer the questions. To date all but AS have had the multifunctional hand approved. The conlusion after training was that AS had a single site and was having difficulty controlling a rigid grip hand and sufficient justification could be achieved at that time. It might be achieved in the future after use of the rigid grip hand.:

The method of prosthetic control was identified accurately, the postures that were identified, the outcome from other trials if another hand has been used. The amputee also takes responsibility for their own decisions. Manufacturers know that they have to be able to loan hand to make future sales. To date all of the requests have been approved. Specific tasks are identified. Not all results have been successful.

Title: **3D printed upper limb prosthetics are not backed by clinical evidence**

Presenter: **Laura E Diment[1], Engineering DPhil Candidate, Mrs**

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Additive manufacturing provides an exciting opportunity to create custom-made low-cost prosthetic arms. Many community projects, including the Open Hand Project, E-Nable and Open Bionics, provide open-source prosthetic designs for printing on consumer printers. However, despite the growing popularity of open-source 3D printed prosthetics, the clinical efficacy and effectiveness of using additive manufacturing to develop upper-limb prosthetics has not been assessed.

A systematic review of literature was performed using PubMed, Web of Science and OVID to find manuscripts that reported human trials of 3D printed upper-limb prosthetics. The title and abstract of each publication was reviewed to assess whether it met the inclusion criteria of:

I. **Relevance** - manuscripts were required to report on a trial with human participants that tested a 3D printed upper-limb prosthetic.
II. **Language** - only manuscripts written or translated into English were included.
III. **Peer-review** - manuscripts were required to have been through a peer-review process.

Only 6 manuscripts met the inclusion criteria, and these manuscripts did not cite any other studies that fitted the inclusion criteria. The manuscripts were rated according to their level of evidence, using the standard classification system of the Oxford Centre for Evidence Based Medicine (1).

All 6 studies evaluated below-elbow devices. One was a shoulder-controlled and externally powered hand that was tested with a 13-year-old transradial amputee, another tested a wrist-flexion-activated hand with 11 children who had upper-limb reductions. An electric prosthetic hand was tested by an adult amputee, and a forearm exoprosthesis was tested with an adult with early flaccid hemiplegia of the right arm. The final two studies only included healthy participants. One was a soft finger pneumatic actuator that was tested by 5 able-bodied adults by attaching it to the index finger of a hand orthosis, and the other was a myoelectric prosthesis that was validated through an able-bodied researcher using it to perform a set of daily-living tasks.

To analyse the quality of the studies under review, the Quality Index by Downs and Black (2) was used to assess the reporting, external validity, bias, confounding and power of each manuscript.

The results of this review show that very few studies assess the efficacy of using additive manufacturing for upper-limb prosthetics, and those that do are case studies or pilot studies that received a low quality score. No papers presented randomised or controlled trials, and there was not enough data to perform a meta-analysis to assess the efficacy of 3D printing for upper-limb prosthetics. However, all 6 studies showed promising results, suggesting that it is worth continuing research into the efficacy of additive manufacturing for upper-limb prosthetics. A large-scale clinical study of the effectiveness of using 3D printed devices compared to devices commonly prescribed by prosthetists is recommended before 3D printed products are widely promoted and distributed.

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Title: **Utilising 3D printing techniques when providing unique assistive devices: A case study**

Presenter: **Sarah Day, National Centre for Prosthetics & Orthotics, University of Strathclyde, Glasgow, UK**

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Partial hand amputations can cause limitations in some functional activities. This case study discusses how computer aided design (CAD) and 3D printing techniques were utilised in providing a suitable assistive device for a partial hand amputee, to meet his specific functional needs.

The patient was a 77 year old male with a passion for music, in particular the French horn, which he played socially with a group of friends. Since undergoing a left 5th finger amputation he had been unable to hold his musical instrument securely as the 5th digit of the left hand is fundamental in this action. This had caused him difficulty in playing and resulted in him giving up this recreational activity.

The aim of this project was to design and fit a device which would enable him to comfortably hold the musical instrument for prolonged periods, enabling him to play again. An alginate cast of the patient's hand was taken, and dimensions of the musical instrument were recorded. The cast was scanned using a photogrammetry technique with Autodesk 123D Catch software to finalise the scan, and 3 different assistive device designs were modelled using Autodesk Fusion 360 software. The designs were then printed using a Zmorph printer, and fitted to the patient. FEA was performed on the designs, taking into account the weight of the musical instrument and forces applied through it.

Fit and function were assessed within the clinic, and following the completion of an appropriate risk assessment the patient took the devices for home trial. The patient completed a simple questionnaire after using each device which covered topics such as fitting, comfort, function and cosmesis. The 3D printed devices were also compared with a low temperature thermoplastic device and a fabric device which he had previously been supplied with.

It took an average of 3 hours to design each device, although this would reduce as experience of using the software increases, and printing time averaged 5 hours. The average cost of printing each device was £13.37.

Benefits of using CAD and 3D printing techniques when fabricating one-off functional devices are that the low cost and low fabrication time, alongside ease of repeatability make it economical to remake devices after small design modifications, thus improving the quality of the device being provided.

Title: **Application of Finch, a 3D printed prosthetic hand, to a patient with bilateral upper-limb deficiency**

Presenter: **Satoko Noguchi, Occupational Therapist**

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The purpose of this study is to demonstrate fitting and effectiveness of a 3D printed prosthesis, Finch, for patients with bilateral congenital upper-limb deficiency. Finch was designed as a trans-radial prosthesis with simple mechanism, controlling three digits to contribute to its good workability, lightweight, and low-cost.

Here we report a 5-year-old boy with congenital deficiency of bilateral whole upper-limb, early-onset idiopathic scoliosis, and mild mental retardation. As he was wearing a spinal orthosis for his idiopathic scoliosis, the spinal orthosis was remodeled to connect the shoulder sockets for bilateral prosthetic arms. After his adaptation to the weight and body image with bilateral prosthetic work arms, Finch was connected to the right arm prosthesis. A distance sensor was placed at the inner side of the spinal orthosis to operate the Finch system. Through this process, he could press the sensor with his left shoulder voluntarily, and control Finch well to hold his favorite doll and play simple games by himself.

These findings suggest that Finch is a useful and practical electric prosthesis with low expense for patients with bilateral upper-limb deficiency. Finch connotes a potential to increase the possibility of children with upper-limb deficiency by providing the opportunity of challenging and participating in various activities. On the other hand, as 3D printed parts used in Finch are not strong enough for daily use, this trial may be confined to limited settings in occupational therapy and at home.

Manufacturers' Workshops

Four workshops will run concurrently, with contributions from Touch Bionics, Steeper, Ottobock and Fillauer. Places are limited and will be ticketed. Delegates who have not already registered for workshops, should visit the ISPO Registration Desk by 12 noon on Wednesday 28th September.

Introducing the *Supro Wrist* - Touch Bionics

the new electronic wrist rotator from Touch Bionics is the first hand and wrist prosthesis with synchronized wrist rotation and grip selection. Using *i-mo™* technology, when an i-limb™ quantum grip is activated using gesture control, the supro wrist will simultaneously choose the correct wrist orientation. Separately, a *rotational control* can be activated via digital electrodes using intuitive 'rotate-left' and 'rotate-right' proprioceptive signals. The workshop will introduce these functions and the benefits to the prosthetic user.

bebionic Prosthetic Development – Steeper

Steeper will discuss the developments in design, technologies, performance and control strategies behind the complete range of bebionic multi-articulating hands. This interactive workshop will provide delegates with the opportunity to ask detailed questions about the technology of the bebionic range, and the impact of these features upon bebionic users and their daily tasks. The workshop will be run by Ted Varley, Steeper Technical Director and Brian McLaughlin, Steeper Product Manager.

Fitting solutions for children – Ottobock (Session A)
Body Powered Education Concept:Try Body Powered Kit – Ottobock (Session B)

The Ottobock workshops will be presented by Erik Andres and Dieter Stork and will be interactive sessions using demonstration products and offering content including case studies, fitting solutions and a new therapy concept for parents of children with upper limb amputations/deficienci

Upper Limb Product Line: Rugged, Practical and Elegant - Fillauer

TRS New Products - presenter: Bob Radocy

TRS continues to pursue the development of body-powered and activity-specific UE prosthetic products that provide the profession with options. Options that provide the prosthetic professional with the tools they require to create more versatile and functional solutions for their patients/customers. We will be presenting some of our most innovative and new product concepts as well as discussing future product development. TRS PROCUFF prostheses and Prosthetic Simulators will be demonstrated along with new technology that simplifies and enhances the prosthetist's ability to create better products for individuals with a wrist disarticulation or partial hand absence. Our newest voluntary closing prehensor the GRIP 5 Evolution will be demonstrated. The GRIP 5 is our first step in enhancing prosthetic TD design with 21st Century graphics. Additionally we will present a review of the wide variety of activity specific prosthetic adapters that are now available providing high performance access to activities from swimming to weight lifting and how many products have "cross-over" vocational and domestic applications making it easier to justify their prescription and acquisition.

The Newest in Motion Control (MC) Electric Terminal Devices – presenters Scott Hosie and Harold Sears

Learn about the *ruggedness* and *convenience* in Motion Control devices. Featuring hands-on demonstration of the set-up and utilization for both the practitioner and the patient:

- Bluetooth adjustment, via the free App, MCUI, for iPhone and iPad.
- Auto-Cal, allowing the wearer to trigger an automatic re-calibration whenever they are fatigued.
- FLAG – (Force Limiting Auto-Grasp). Dependable patient-friendly force control. Hold a baby's hand, or hold a fine camera – you're in control.
- ProWrist – the finest wrist control, connect to Bluetooth for perfect adjustment.
- NEW – ETD2, the newest version of the highly rugged ETD, with higher aesthetics.
- Powered Flexion Wrist – coming soon. Compatible with modified MC systems, as well as other manufacturers' hands.

ABSTRACTS - Thursday 29 September (in order of presentation)

Title:	**Advances in prosthesis control – gesture control**
Presenter:	**Alison Goodwin, Prosthetist, Miss**
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Developments in the functions of multi articulating hands have advanced dramatically in the last decade. Allowing prosthetic hands to more closely mimic the functions of a human hand, and enabling the user to perform activities in a more precise, natural way. Although the functionality has increased the methods of control have remained unchanged.

The use of traditional myoelectric control has limited the direct access to these advanced functions, referred to as the bandwidth issue of prosthesis control.

Current methods of switching functions include specific muscle signals, hardware switches, mobile application control, and Bluetooth. These methods have offered a practical solution, however each has limitations. For example: increased requirement for advanced training, use of contralateral hand, necessity for additional accessories.

Acknowledgement of these limitations has led to the development of a more accessible control mechanism which aims to reduce this perceived complexity. Gesture control utilises physical movements of the prosthesis to instruct the hand on which grip pattern to adopt.

Benefits of gesture control include; no additional accessories, no use of the contralateral side, quicker and easier to learn, learning only one technique offers access to four functions of the hand.

As gesture control is easier and quicker to learn the clinician can focus more time on practical applications of the functions, rather than on advanced training on how to access the functions.

Gesture control helps to close the gap between the technical developments and the users' ability to access and use these functions practically in their daily lives.

Title: **Structured training for advanced prosthesis control**

Presenter: **Sebastian Amsüss, R&D Engineer, PhD**

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Aims and objectives

The aim of this study was to investigate the efficacy of structured training of naïve subjects, who for the first time experienced advanced control of a multi-articulated prosthesis of the upper extremity.

Methods

Ten subjects (9 male, 1 female) with acquired unilateral transradial amputation participated in this study. Each amputee had been wearing a myoelectric prosthesis for at least 1.5 years, 4 hours per day. A certified prosthetist manufactured experimental prosthetic systems with an active wrist flexion/extension joint, active rotation unit, eight surface EMG electrodes and a Michelangelo hand prosthesis (all from Ottobock Healthcare Products, Vienna, Austria) for each participant. Simultaneous, proportional activation of the wrist flexor and rotation units (linear regression) combined with sequential, proportional hand function (linear discriminant analysis classifier) was implemented[1].

Subjects were randomly divided in 2 groups and completed 3 sessions each, with a minimum of 3 weeks between sessions. Users did not have access to the advanced prosthesis between sessions. First, a reference SHAP[2] test with the prosthesis of daily use ("base line") was performed. In the second session, after sufficient familiarization, each subject completed a SHAP test with the advanced prosthesis without any specific user training ("naïve session"). In the third session ("follow up"), the first group again completed SHAP without user training and the second group received structured training to maximize control benefit from the advanced prosthesis before completing the test.

The structured training comprised the following stages:

1) Imitation stage: User follows experimenter's movements with phantom limb
2) Repetition stage: User repeats the movements on his own
3) Biofeedback stage: User is presented with visualization of exerted muscle signals and is instructed to make them more consistent using the shown biofeedback

4) Adaptation stage (only applied if necessary): Experimenter prompts user to slightly modify phantom movements for better differentiability while using biofeedback ("Use fingers 4 and 5 more when pinching", "Don't extend wrist while rotating"…)

The effect of this structured training on user performance was examined using clinical measures.

Results

All subjects completed the full experiment. Average baseline scores were 63.4±7.3 and 66.6±10.1 for subjects in non-training and training group, respectively. With the advanced prosthesis, average scores in the none-training group were 38.4±8.9 in the naïve and 41.2±10.2 in the follow up session (+2.8±8.6). Subjects that received training improved from 27.8±11.4 in the naïve session to 49.0±11.6 in follow-up session (+21.2±8.3).

Conclusions

Although the subjects in the training group performed considerably worse with the advanced prosthesis in the naïve session compared to the non-training group, they outperformed the non-training group notably in the follow-up session. The latter group showed only minor changes in SHAP scores. Subjects of both groups performed similarly with their own prosthesis and all subjects performed best with their clinical prosthesis of daily use.

We conclude that the structured training approach followed in this study has an important influence on the outcome of usability when using advanced prosthetic control strategies. Long term training appears to be warranted for profound familiarization.

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Title: **Upper limb osseointegration, prosthetic technology.**

Presenter: **Stewe Jönsson CPO**

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Orthopaedic osseointegration (OI) for fixation of extremity prosthesis has been ongoing for over 26 years and gains more and more ground. For us, who has been involved in this field over the years, the treatment is today a part of our daily activities. But for colleagues that are new in this field, there is a need of knowledge and training. Upper limb osseointegration from a prosthetic, rehabilitation and a prosthetist point of view has been described [1,2].
This presentation will focus on new techniques, give a guideline in to the component systems and lift up some FAQ about handling and constructions.

Improvement of the prosthetic fitting procedure, including quick and effective prosthetic fitting close to the S2 surgery is important. For TH level the patient can have a safe and controlled situation during the initial weight training phase by using a special full length prosthesis, with a built in weight system. Diagnostic/checkout prosthesis for direct temporary fitting and data collection can be used. With this prosthesis, EMG sites, functions, alignments and length can be tried out directly and before the final prosthesis is fabricated. Only one patient visit before delivery of the final prosthesis is needed. For all existing amputation levels the prosthetic production methods also makes it possible to replicate methods, facilitates for central/distance fabrication.

Component sets for OI prosthetics is available and cover most needed parts. Those are used in combinations with ordinary UL prosthetic components, however some recommendations exist. There is still a need of some custom made components, such as spacers, the attachment "puck" for TR level and electrode holders. For finger levels the component kit can be used in combination with several production methods of the silicone cosmetic cover and fillers.

OI prosthetics shall also meet up and take advantages of new platforms, for example, implanted electrodes for signal pickups and sensory feedback systems.

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Title: **Clinical Pattern Recognition in the US: Experiences and Demographics**

Presenter: **Blair A Lock, Managing Partner, Mr**

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Pattern recognition for improved control of powered upper limb prosthetics has been a focus of research and development for decades at many institutions around the world. Resulting from that effort, a robust pattern recognition solution was made commercially available in the US in 2014 and has been quickly gaining in popularity. To date, a significant number of these systems have been deployed to users of various amputation levels and applied to many different configurations of prosthetic components. Responses from users and clinicians have been highly favorable, with many users reporting that the new system allows them unprecedented control of their device.

In this paper, we present a comprehensive look into the breakdown of pattern recognition deployment by amputation level and clinical involvement. Also included is specific attention to the applications for unique subsets such as targeted muscle reinnervated, congenital, and bilateral amputee users. Collected qualitative assessment from patients, practitioners, therapists, and other stakeholders will also be shared. This clinical summary is a first-of-its-kind report of a large number of pattern recognition users and the only to date showcasing pattern recognition as a commercially available system.

Title: **Clinical experience of developing bespoke cycling prostheses**

Presenters: **Brian Bradbury, Prosthetic Technician**

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Since 2012 Pace Rehabilitation has increasingly been involved with the production of bespoke prosthesis for professional cyclists. We have now gained considerable experience in developing specialised upper limb prostheses for training and competitive use across several disciplines. We anticipate that several of these devices will be used in Rio during the 2016 Paralympic Games. We report here on our approach to these prostheses, much of which can be applied to the production of similar devices for recreational cyclists.

Key considerations in our approach:

- Multidisciplinary approach is critical. Our team typically includes the cyclist, prosthetist, technician, coach, bike tech and physiotherapist….
- Understanding individual requirements for the particular event, including:
    - Clinical: elbow and shoulder ROMs, posture on cycle
    - Technical: connection point to cycle, positions, transitions,
- Equipment required in clinic: Turbo trainer, rollers, full length mirror, camera
- Prosthetic hardware: “terminal devices” and handlebar modifications
- Trial devices, feedback form various sources, iterations of device
- Manufacturing techniques and materials, aerodynamic considerations
- Risk assessment and safety considerations
- Costs: large time investments required but generally low hardware expenditure

Title:	**Evolution of an Aesthetic Heavy-Duty Electric Terminal Device**
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Aims and objectives:

Over the last decade, the heavy-duty Electric Terminal Device (ETD) product has been successfully used by thousands of UE amputees. Its success is due to the combination of functional hooks with a motor driven 2-speed transmission in a water-resistant housing.

A new version was sought, with goals to, 1) shorten the overall length (for equivalent length between interchangeable hand and work TDs), 2) use earlier work with TD designs to improve grip security, and, 3) improve aesthetics so that wearers could use a heavy-duty TD in a wider range of environments and social situations.

Methods used:

The development process evolved a new device, the ETD2, which uses advanced integrated metal and plastic manufacturing methods. A more integrated aesthetic was sought, while retaining nearly all positive features of the earlier ETD, including high durability, water and dirt resistance, low comparative weight, quick speed, high pinch force, visibility and accessibility of slender fingers for fine work and reaching tight spaces.

The electronic features maintained from the ETD were: "plug and play" compatibility for interchangeability with almost all other terminal devices, Bluetooth wireless communication using Apple handheld devices, and the useful Force Limiting Auto Grasp (FLAG), an electronic method enabling the wearer to limit pinch force when handling fragile objects.

Summary of results

Figure 1 : ETD2 prototype

The main targets have been achieved in the ETD2 design: overall length of the ETD2 vs. ETD1 is 30 mm less, equivalent weight; strength and speed have been measured. The earlier standard for water and dirt resistance is met, and a method to allow replacement of the gripping surfaces in the field is successful as well – a major improvement.

A small-scale field trial (n=6) indicates equivalent function in most areas, while some grip modes are superior (flat and cylindrical objects), and subjective opinions show aesthetics have improved. Interestingly, for some the reduced length produces a slightly lighter perceived weight. Field-replaceable gripping surfaces generate positive feedback as well.

Ongoing survey of wearers with the FLAG feature, in both ETD and Hands (n=8), shows the Force Limiting feature highly rated: 7/8 responded positively to "increased number of tasks performed", and the same proportion to "a benefit is provided in the prosthesis that I did not have previously".

Conclusions or recommendations or implications arising out of this work

ETD2 retains the earlier features, such as rugged function, high speed and pinch force, and integration of the FLAG feature. In addition, field trials confirm the benefits of lower overall length, improved aesthetics, and strength achieved through advanced manufacturing processes.

More results from a larger population will be possible with release of the ETD2 device after mid-year 2016.

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Title: **Phantom Pain Revisited**

Presenter: **Tamar Makin, Associate Professor, FMRIB Centre, Nuffield Department of Clinical Neuroscience, University of Oxford, Oxford, UK**

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Following arm-amputation brain areas that previously operated the hand will be "recruited" to work for other body parts. This ability to dynamically reassign processing responsibilities to a certain brain area based on changing circumstances (termed 'plasticity') is key for our basic ability to adapt to new situations. In amputees, this process is widely held to result in the experience of phantom limb pain (pain that is perceived to be arising from the missing hand), and is therefore considered to be maladaptive.

Evidence will be presented to challenge the proposed link between phantom pain and brain plasticity, and instead demonstrate that plasticity in amputees can be adaptive. It will be demonstrated that despite amputation, representation of the missing hand is preserved in the human brain. This maintained representation of the phantom hand is linked with phantom pain, with potential implications on future treatment. It will further be shown that contrary to textbook wisdom, brain plasticity is not pre-determined, and is instead shaped by habitual strategies that individuals adopt to compensate for their disability; the "freed up" cortical resources of the missing hand can be used by a multitude of body parts, and even artificial limbs.

Based on this evidence, it is suggested that plasticity in amputees is experience-dependant, and is not inherently maladaptive.

Title: **Investigations of the uncanny valley for prosthetic hands**

Presenter: **Ellen Poliakoff, Cognitive Neuroscientist, Dr**

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In 1970, Mori hypothesised the existence of an 'uncanny valley', whereby stimuli falling short of being fully human are found to be creepy or eerie. Previously we demonstrated that more human-like artificial hands are rated as more eerie than clearly mechanical or real hands.[1] In the current series of experiments, we compared responses to photographs of prosthetic hands pre-selected as more or less human-like ('having human form or attributes'), as well as mechanical and real hands.

In experiment 1, participants (N=40) rated the hands for eeriness ('mysterious, strange, or unexpected as to send a chill up the spine') on a scale of 0-9, presented either in a first person or third person orientation. The less realistic prosthetic hands were rated as more eerie (mean = 6.59) than the more realistic prosthetic hands (4.90), the mechanical hands (4.49) and the real hands (1.23). In addition, the orientation of the hands (first vs. third person) did not significantly affect the ratings. Thus, the notion of an uncanny valley (or peak of eeriness) was supported for the less realistic prosthetic hands. However, the more realistic prosthetic hands were not uniformly found to be eerie; the ratings varied more between individuals than for the other categories.

In experiment 2, participants (N=40) performed a speeded classification (human/non-human) task for the same set of hands. Reaction times (ms) were significantly slower for the more realistic prosthetic hands (mean = 771) compared to the less realistic prosthetic hands (677) and the real hands (675). This shows that the more realistic prosthetic hands were hardest to characterise, which was also reflected in the high error rate (72%), i.e. mistaking them for human hands. Thus, the category of hands found to be most eerie (less realistic prosthetic hands) was not the same category that was most difficult to categorise (more realistic hands). A control experiment in which participants responded to the location (left/right) of the hand on the computer screen indicated that the results could not be attributed to slower responses in general to the more realistic prosthetic hands.

Overall, people do report prosthetic hands to be eerie. This effect was most consistent for less human-like prosthetic hands and does not seem to be driven solely by ambiguity about whether the prosthetic hand falls into a human or non-human category. In addition, the variability in ratings given to the more realistic prosthetic hands suggests that individual differences in responses to prosthetic hands, including familiarity, would be a fruitful avenue to investigate. The implications are that less realistic prosthetic hands which are more obviously artificial consistently generate a sense of eeriness, while more realistic prosthetic hands may avoid the uncanny valley, at least on initial viewing due to being mistaken for real hands.

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Title: **Exploring everyday materials and prosthetic hands**

Presenter: **Graham Pullin, Design Researcher, Dr**

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Aims

Hands of X is exploring the meaning of materials—and the meaning of being able to choose materials—with amputees, designers, makers and prosthetists. The *'X'* stands for of *what* a hand is made and also for *whom*.

The materials currently employed in prosthetics and the reasons for their selection are polarised: silicone, chosen for its mimicry of human skin; carbon fibre for its technical properties; custom fabrications for their outright individuality. *Hands of X* explores an overlooked middle ground: our vision is an understated common design offered with a nuanced personal choice of materials.

Methods

In this endeavour we are exploiting and pushing flexible digital fabrication. But whilst 3D printing is increasingly seen as an important technology in the future of prosthetics, we wish to challenge the assumption that this implies a future of plastic hands. In past centuries a much wider palette of materials was drawn on—leathers, woods, metals, fabrics. This use of materials found in other everyday objects tied the design of prosthetic hands to the design of other things, lending them a familiarity and approachability.

Our methods involve lots of making, since we believe that materiality must be seen and touched to be discussed. We are particularly interested in everyday materials, including different woods (beech; cedar; ash), plastics (cellulose actetate) and fabrics (felted wool) and in the first instance we are making hands—abstracted hands—out of single materials to understand how material alone might change people's perceptions of prosthetic hands.

Indication of results

TIPS 2016 comes 7 months into our 18 month study. We will present the results of participatory workshops with amputees, designers, makers and prosthetists. The project partners are DJCAD, the art college at the heart of the University of Dundee; the Institute of Making at University College, London; and MAKLab, public access digital fabrication centres across Scotland. Even more important is our collaboration with amputees, through Finding Your Feet and other groups; limb manufacturers Steepers; and the limb fitting centre at RNOH Stanmore.

We will have been collecting samples of materials that people would be interested to see employed in prosthetics *together with the reasons why*. One of the outputs of the workshops will be co-created concepts for hands that combine two materials, which we will prototype. We will also outline our ongoing work to prototype more representational prostheses based on these material combinations and also to prototype the experience of a service that could offer such variation and choice.

Implications

This project is being funded not as medical research but as part of 'Design the Future', an EPSRC initiative to explore and prototype new manufacturing practices.
So for once disability-related design is not (just) benefitting from a 'trickle down' effect—rather prosthetics being seen as a crucible for wider innovation across manufacturing as a whole. Which feels an exciting and appropriate relationship, given its profundity.

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Case Studies

Two case study sessions, organized by Sarah Day, will run concurrently, each for 30 minutes**.** Delegates will have the opportunity to attend **both** sessions.

The sessions will provide an opportunity for group discussion about a small selection of patients with upper limb amputation, the difficulties they encounter, challenges they have overcome, treatment options and future developments. The sessions will be informal and interprofessional in nature.

We will focus on two patient groups: multiple limb absence and high level amputation, and will be joined by three volunteers who hope to share their stories, challenges and achievements with us.

Our volunteers

Marie underwent lifesaving bilateral transradial amputations in 2013 following a violent infection. She maintains an active lifestyle despite having extensive scarring to her residual limbs.

Corrine is a mother and businesswoman who, in June 2013, had her hands and feet amputated after contracting septicaemia. Since her amputations Corrine has undertaken a range of physical challenges including climbing Ben Nevis, the UK's highest mountain. She works tirelessly for her charity 'Finding Your Feet' – http://findingyourfeet.net which provides practical, emotional and financial support for those who have suffered limb loss. Corrine is currently awaiting a hand transplant.

Neil is a businessman who underwent a forequarter amputation in 2014. He suffers with phantom limb pain and has explored the numerous treatment options available hoping to find some relief.

Sarah Day is a Prosthetist Orthotist and an educator, currently working at the University of Strathclyde, Glasgow. She has held clinical, academic and managerial posts in a variety of international settings including the UK, Ireland, Australia, South-East Asia and the Middle East. Sarah's teaching and research interests are focused around upper limb prosthetics, and she has a particular interest in investigating the burden of disability, treatment pathways and appropriate technology. You can contact Sarah at sarah.day@strath.ac.uk

Title: **Osseointegrated Prostheses for Transhumeral Amputees; Long-term Follow-up of patients using Patient-rated Outcome Measures.**

Presenter: **Kerstin Caine-Winterberger, Occupational therapist**

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Background: This is a retrospective study from 1994 until 2013 with 18 adults with transhumeral amputation treated with osseointegrated (OI) implants in Gothenburg, Sweden. Two patients were excluded from the study, due to removal of the implant. The treatment involves two surgical procedures, where a titanium fixture is operated into the skeleton and after six months a skin penetrating abutment is connected to the fixture, to enable a prosthetic attachment. Training, prosthetic application and rehabilitation starts shortly after surgery following a strict protocol (Jönsson et al, 2011).

Aims of study: The aim of this study is to investigate the outcome in terms of prosthetic use, body function, daily activities and health between persons using osseointegrated prostheses and socket prostheses**.** Are there any differences concerning: Prosthetic use, perceived pain/discomfort, the ability to perform daily activities and health status.

Material: Sixteen prosthetic users with osseointegration have been examined regarding patient reported outcome measures (PROM) and compared with upper limb amputees supplied with traditional socket prostheses (SP) (22 patients). Reasons for amputation in the OI-group was trauma in 14 cases and tumor in 2 cases. Thirteen were men and 3 were women and the mean age at amputation was 33 years. The cause of amputation in the socket group was trauma in 19 cases, 1 tumor, 1 infection and 1 nerve injury. Eighteen were men and 4 women, born 1934-1984 and mean age at amputation was 34.7 years.

Method: All patients answered 3 questionnaires. A short questionnaire was used for obtaining data concerning amputation, prosthetic history and prosthetic use. Two outcome measures were used: the Disability of Arm Shoulder Hand (DASH) and EuroQol EQ5D. DASH is a well-known instrument for upper limbs with activities of daily living and disabilities perceived after injury, consisting of 30 questions (Hudak et al 1996). EQ5D and EQ VAS health score was used as a standardized health measure consisting of 5 items plus the health score (EuroQol Group, 1990).

Results: All 16 in the OI group were prosthetic users. Eleven used myoelectric prosthesis, 3 cosmetic-, 3 work- and 1 hook/cosmetic prostheses. In the socket group 16 were prosthetic users and 6 were non-users. Six used myoelectric prosthesis, 6 cosmetic, 3 work- and 1 body-powered prosthesis. There was a statistical significant difference in prosthetic use (p=0,023) for the OI group.

The OI-group vs the SP showed better PROMs. There was a statistical significance for the following items: “wash your back”, “carry”, “use knife to cut food”, “tingling”, “sleeping problems” and the total DASH score (p=0.04). Using EQ5D, there was a statistical significance in “anxiety/depression” (p=0.03) and “total health state” for the OI group (p=0.04).

Conclusion: The OI treatment for Transhumeral amputees can lead to better functionality of the upper limb, higher prosthetic use, better health state and less problems with anxiety/depression.

References:

Jönsson S, Caine-Winterberger K, Brånemark R : Osseointegration amputation prostheses on the upper limbs: methods, prosthetics and rehabilitation. Prosthet Orthot Int 2011, 32(2), 190-200.

Title: **Decreasing phantom limb pain by virtual reality – case presentation**

Presenter: **Z Pihlar, OT, Mrs**

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Aims and objective

Between 50 – 80% of patients after amputation had phantom limb pain (PLP) (1), and many of them reported that it interferes with their activities and participation. In spite of several treatment options, treatment of PLP is still problematic (1). The aim of our study is to present a case in which Neuromotus (2) was successfully used. This system is based on the open source platform BioPatRec (3), where algorithms for the prediction of individual and simultaneous movements are implemented together with virtual and augmented reality, as well as gaming control (4).

Patient and methods

In 2011 the patient fell from an elevator 20m deep. His right upper limb was torn away, he was also one hour unconscious, Glasgow Coma Scale score is not known. He was fitted with body-powered prosthesis that he wears 4 – 5 hours per day. Since the beginning he had severe PLP (6 or stronger on numeric rating scale) which interferes with his activities and participation. He was quite depressed and had no will to return to any work. Most of his time he spent at home. He was treated with Pregabalin 150 mg in the morning and 300 mg in the evening. He agreed to participate in the study that was approved by Ethic committee of our Institute.

Treatment consisted of 12 up to two hours long sessions by Neuromotus. After assessing pain and placement of electrodes, patient practice motor execution in virtual reality (VR), play game by racing a car using phantom movements, and match random target postures of a virtual arm in VR. The difficulty was increased when previous level was successfully completed. We did follow up one, three and six months after the last session. All sessions were led by the same specially trained occupational therapist.

Results

PLP intensity decreased (figure 1). At the end of the treatment we decreased Pregabalin to 75mg twice per day and one month after treatment to 75mg once per day. He was less depressed and wanted to return to work, so he started with vocational rehabilitation program.

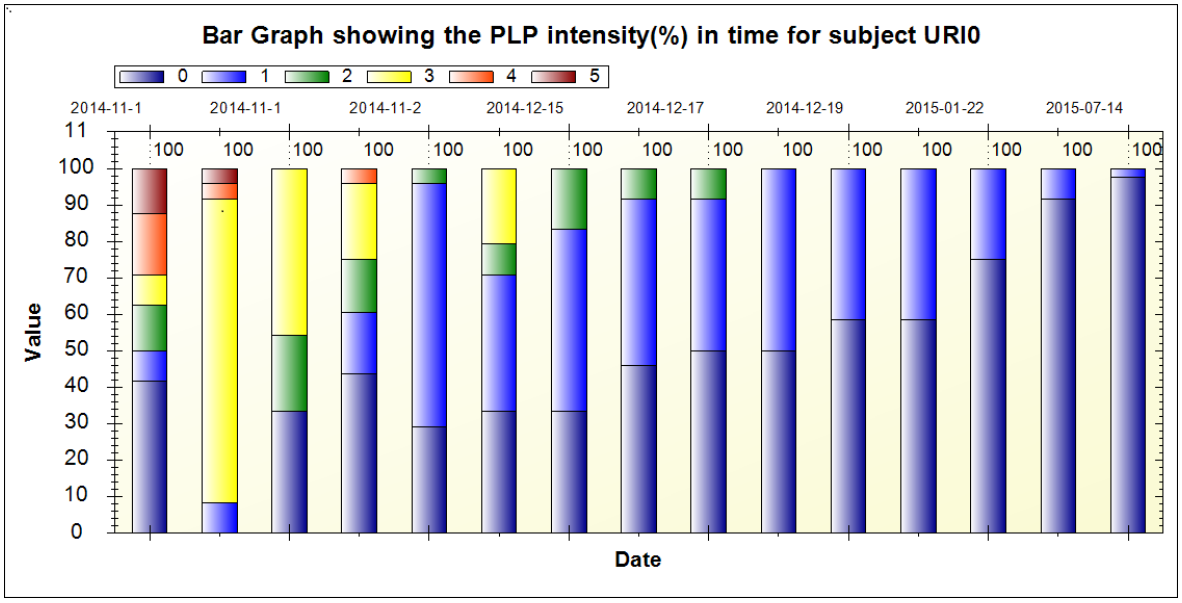

Figure 1: Pain distribution during training days (12 sessions) and at follow-ups (last three bars)

Conclusion

This novel method exploiting brain plasticity was successful in reducing persistent PLP. Study on a greater number of subjects is needed for definite conclusions.

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Title: **Cutaneous Anchor Technology and Creative Solutions to Complex Problems**

Presenter: **Debra Latour, M.Ed., OTR/L**

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Individuals with upper limb deficiency choose to wear and use prosthesis technology for many reasons. Evidence suggests that these reasons include personal, social and functional preferences. With age, these individuals often experience difficulties with prosthetic fitting and use due to anatomical presentations that may affect both of their upper limbs. This problem is magnified in the person who has acquired limb loss due to trauma. The non-amputated side may be affected by different debilitating issues which may impact the user's ability to access power from available body movements or to access myo-signals. The end-result is that the prosthesis-user experiences challenges to use the non-amputated 'involved' upper extremity and the prosthetic extremity to complete bilateral activities necessary for independent function.

The Cutaneous Anchor technology (CAT) derives its primary source of control from the scapula on the same side of the limb deficiency. Because the harness is eliminated, the benefits have the technology have been reported to include more symmetrical bilateral upper extremity development, increased function, greater comfort and improved cosmesis. Although it was originally developed for use for individuals with involvement at the trans-radial level, derivatives of the technology have been used to suspend and control prosthetic technology at all levels including trans-humeral and partial hand.

This paper addresses case solutions for problems associated with accessing power and/or control of the prosthesis using simple technology advances to complement the more complex technology used in the design of the prosthesis. Reflective case studies are discussed which include initial presentation with consumer-stated problems and concerns, solutions offered and training provided to the user. Occupational therapists are concerned with the abilities of clients to attain the skills vital for maximal functional independence. Proficiency in these areas fosters an enjoyable and positive perception of quality of life.

Four subjects are identified for the purpose of this reflection: A: 70 year-old male with acquired trans-humeral loss h/o fracture of residual humerus and insertion of a pacemaker in his chest wall (Figure 1); B: 31 year-old male with recent acquired loss of dominant index finger at PIP joint due to an industrial accident (Figure 2); C: 45 year old male with L congenital trans-radial deficiency and severe R epicondylitis with shoulder and wrist pain; D: 61year old male with acquired L trans-radial deficiency and R rotator cuff injury. Each client utilized a diverse form of CAT to meet individual needs, given the varying anatomical presentations and demands of their prosthetic technology with instruction to use in guided trials and home programs.

Outcome measures included DASH video-graphed UNB and prosthetic satisfaction survey. Preliminary data reflects overall satisfaction with the cutaneous anchor technology as an alternative to traditional harnessing. The CAT is simplistic in design, is durable, affordable and easily available. The potential benefits of this device appear to include increased satisfaction, increased prosthesis wear and use (related to tolerance, frequency and spontaneity) as it allows improved comfort, cosmesis and intuitive access to movement during functional activity.

Figure 1

Figure 2

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Title: **Factors influencing use and satisfaction with upper limb prosthesis**

Presenter: **H Burger, MD, PRM specialist, PhD, Mrs**

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Objectives and aim - To use a prosthesis, the person has to be satisfied with it. Satisfaction may cover several domains. We found two instruments for measuring satisfaction with prosthesis in the literature, the Client Satisfaction with Device module of the Orthotics and Prosthetics Users' Survey (OPUS -CSD) (1) and the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) (2). OPUS-CSD has been validated on the upper limb prosthesis users in Sweden (3); QUEST has not been validated on this population. The aim of our study was to the users' satisfaction with their upper limb prosthesis at our outpatient clinic.

Methods and subjects - All (51) unilateral upper limb prosthesis users who visited our outpatient clinic in 2014, were older than 17 years, use their prosthesis for at least one year and were willing to participate were asked to fill in the OPUS-CDS questionnaire (3). Descriptive statistics and t-test were used for data analysis. The study was approved by the Ethic Committee of our Institute.

Results - Thirty-three men and 18 women, 19 to 82 years old, amputated one to 62 years ago filled in the questionnaire. Most of them (41, 80%) had trans-radial amputation, and use passive prostheses (32, 63%). They used their prostheses from a few hours per week to 16 hours per day (mean 9.5 hrs/day, SD 0.74). In general, the participants who used their prosthesis more hours per day were more satisfied with it ($p=0.033$) and rated higher that it fits well ($p=0.031$), is comfortable throughout the day ($p=0.009$), looks good ($p<0.001$), and is pain free to wear ($p=0.025$). The amputation level and the type of prosthesis were not associated with how much time the participants wore their prostheses daily.

Conclusion - For upper limb prosthesis users in Slovenia it is important that the prosthesis looks nice, fits well, is comfortable and pain free.

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Title: **The influence of environment - experiences of users of myoelectric arm prosthesis, a qualitative study**

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Aims and objectives: Myoelectric prostheses can be prescribed to people born with upper limb reduction deficiency or with acquired amputation in order to improve their function and quality of life. Despite this, prostheses are used in varying degrees. An environment with barriers, or without facilitators, will restrict the individual's occupational performance and can also result in limitations of Quality of Life. According to the International Classification of Functioning, disability and health (ICF) the environment includes the physical, social and attitudinal environment in which people live and conduct their lives. Few studies have been made to see the impact of environmental factors on prosthesis use. In this study the ICF- model is the framework to understand the complexity of environmental factors influence on prostheses use. The aim of this study was to describe users' experience of how environmental factors influence their use of a myoelectric prosthesis in both congenital and acquired absence of a hand.

Method: Qualitative descriptive approach. Semi-structured interviews were audiotaped, transcribed by the first author and analyzed through inductive content analysis according to Graneheim & Lundman. Investigator triangulation was used to ensure the credibility.

Subjects: Strategic selection was used to get a varied sample in terms of sex, age, deficiency level, etiology, current prosthesis use, and length of experience. Interviews were conducted with 13 adult patients, previously provided with a myoelectric prosthetic hand at the Prosthetics and Orthotics Outpatient Clinic in Örebro, Sweden. The participants were 9 males and 4 females with age ranging from 20-74 years; they had acquired (n=5) or congenital (n=8) cause of absence at trans-humeral (n=3) or trans-radial (n=10) level. Their experience from prosthesis use was ranging from 2- 30 years. At the time of data collection the participants reported different patterns of prosthesis use: daily (n= 6) or non-daily (n=7), ranging from use only at work to never.

Results: The overarching theme "*Different degree of embodiment provides various experiences of influence from environment*" illustrates the participants' adaptation to prosthesis, which in turn influences the ability to manage environmental barriers. Four categories emerged from the data, "*The prosthesis function", "Other peoples' attitudes", "Support from family and healthcare*" and "*Personal approach to the environment*". Environmental facilitators such as, support from family and healthcare, and, good function and fit of the prosthesis, helped to make the prosthesis an embodied experience, leading to daily use. This embodiment reduces the influence of environmental barriers, e.g. climate, attitudes, and technical shortcomings. Myoelectric prosthesis use facilitates activity and participation among daily users.

Conclusions: The embodiment of the prosthesis may reduce influence of environmental barriers and promote myoelectric prosthesis use in both congenital and acquired upper limb deficiency. The users' experience in this study indicates that support and training can facilitate the embodiment of myoelectric prosthesis. Thus, as prescribers of prostheses it is our responsibility to give support and information to the patient and also to family, pre-school and school teachers, and local healthcare, in order to motivate and encourage prosthesis use in everyday life.

Title	**The relationship between prosthetic control, wearing pattern and daily prosthesis use**

Presenter	**Liselotte Norling Hermansson**[1,2,3], **Associate Professor**		
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Aim and objectives

Myoelectric prostheses are often prescribed to children with arm deficiency and prosthetic training is given regularly by the prosthetic clinics. One goal of prosthesis fitting is to give the child an assistive tool to perform their daily activities. Our clinical experience told us that prosthetic fitting should be initiated at a young age but less is known whether the prostheses can ease the performance of the children's daily activities. Thus, the study aim was to evaluate the relationship between prosthetic control and the ease of performance in using the prosthesis to perform daily activities.

Method

During their clinic visits, pediatric prosthesis users (n=60, age 3 to 17) were asked to fill in a questionnaire, '*Prosthetic Upper Extremity Functional Index',* where the child (or the parent if the child is under 6) rated the ease of performance in using the prosthesis to perform 26-38 daily activities. Then the child performed a bimanual activity and an occupational therapist from the clinic (n=6) assessed the child's prosthetic control with an assessment tool '*Assessment of Capacity for Myoelectric Control'.* Pearson r was used to calculate the correlation between prosthetic control and ease of performance.

Multiple regression analysis was used to assess the capacity for control, wearing pattern and age to predict the ease of performance in PUFI activities.

Results

A strong correlation (Pearson 0.68) was found between the level of prosthetic control (ACMC score) and the ease of performance in using the prosthesis to perform daily activities (PUFI score). The multiple regression model showed that the percentage of variance increased by 26.7% when ACMC scores and wearing pattern were added into the model. When comparing

ACMC scores and wearing pattern, the ACMC scores have a higher beta value (0.48) than wearing pattern.

Conclusion

The correlation between ease of performance and prosthetic control suggests that a myoelectric prosthesis can ease the performance of their daily activities if the child has a good prosthetic control.

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Title: **Symptom severity and prosthesis use; exploring the pain experience using the Disabilities of the Arm Shoulder and Hand (DASH)**

Presenter: **Lewis Mackay,** Occupational Therapist (Touch bionics), Mr

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Aims and objectives:
The pain experience of amputees has been identified as an important factor in relation to prosthesis use (1), and as an outcome that can change as a result of prosthesis use. The authors have previously reported on functional outcomes recorded using the Disabilities of the Arm Shoulder and Hand (DASH) outcome measure (2), however the aim of the study was to explore the effect on specifically the self reported symptom severity score of the DASH as a result of prosthesis use. The authors aimed to establish if the use of a prosthesis had an impact on the levels of pain reported and if this varied across levels of absence or origin of limb absence.

Method:
The cohort consisted of 25 Individuals reporting on outcomes via an online platform comprised of the DASH questionnaire in addition to questions requesting level of absence, cause of limb absence, and various other questions to establish if the population was representative. The entire cohort were current prosthesis users. The demographic information allowed the effect of prosthesis use on the symptom severity score to be analysed across sub groups.

A Wilcoxon signed rank test was used in addition to the descriptive data to ensure that change in the responses was not dispersed, and to provide more detail about the nature of change across the group. Presented below are the results for the partial hand subgroup. These data will be compared for the overall pain rating across subgroups including partial hand, trans-radial, above elbow, and congenital. The congenital subgroup will act as a control.

Results:

Pain rating	Pre fitting		3 months	
	Patients	%	Patients	%
None	9	36.0%	13	52.0%
Mild	8	32.0%	8	32.0%
Moderate	6	24.0%	3	12.0%
Severe	2	8.0%	1	4.00%
Total	25	100%	25	100%

Pre fitting and 3 months Wilcoxon signed Ranks test – Overall pain rating

Wilcoxon signed Ranks Test Full cohort (n = 25 patients)			
3 months – Pre fitting	**N**	**Mean Rank**	**Sum of Ranks**
Negative Ranks	**8a**	**5.13**	**41.00**
Positive Ranks	**1b**	**4.00**	**4.00**
Ties	**16c**		
Total	**25**		

a. 3 months rating < Pre fitting rating
b. 3 months rating > Pre fitting rating
c. 3 months rating = Pre fitting rating

Test (statistic Z):	
Z	-2.31
Asymp. Sig. (2-tailed)	**.021**

Conclusions:
The self reported measure of pain recorded by question 24 of the DASH showed a statistically significant reduction in pain symptoms from pre to post prosthesis use over the cohort. This positive effect was also observed for questions relating to pain when performing a specific activity and stiffness. These results indicate that powered partial hand prostheses can provide benefits to the pain experience of partial hand amputees.

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Title: **Use of myoelectric prostheses and participation in everyday activities – environmental factors impact on assistive technology use**

Presenter: **Cathrine Widehammar, MSc[1,2,3], Occupational Therapist**

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Introduction: In rehabilitation, assistive technology (AT) such as myoelectric prostheses (MEP) can be prescribed in order to improve the functional capability of individuals with disability. Well-functioning AT can be crucial for activity and participation in society. Sadly, the devices prescribed are not always used. In a recent qualitative study with persons who use MEP we found that different aspects of the environment have a big impact on use of the prosthesis but further studies based on quantitative methodology were needed. Hence, the aim of this study was to investigate the prevalence, frequency and magnitude of environmental barriers and facilitators that may have an impact on MEP use and in comparison with users of powered mobility devices (PMD) and assistive technology for cognition (ATC).

Method: A cross-sectional survey with group comparisons. The survey contained the Swedish version of Craig Hospital Inventory of Environmental Factors (CHIEF-S) and a study-specific questionnaire focusing on facilitating factors. In CHIEF-S respondents rate the occurrence of 25 environmental barriers based both on frequency and magnitude of the barrier. The total CHIEF-S score is calculated based on the mean of the product of magnitude and frequency, ranging from 0 to 8. Higher score indicate greater experience of environmental barriers. The study-specific questions asked about 7 environmental factors that facilitate use of AT, these were scored on a five-point rating scale ranging from 0= not at all, to 5= very much. The frequencies of environmental factors are presented as barriers or facilitators and analyzed both for differences within and between the three AT groups. Since the scores were not normally distributed Kruskal Wallis test for significance ($p<0.05$) and 2-tailed Mann-Whitney U test for differences between the groups were used for analyses. 156 participants were randomly identified and answered the survey. Of these, 51 (33%) were MEP users, 58 (37%) PMD users, and, 47 (31%) ATC users. The experience of using AT varied between 1-41 years, mean=11.6, (MEP mean= 22.9, PMD mean=7.1, and, ATC mean=3.7). More than 2/3 of the participants used their AT daily (MEP= 80%, PMD=64%, and, ATC=87%).

Results: The environmental facilitator *support and encouragement from related persons* was scored high for users of MEP and PMD, while *support from rules and regulations* was lowest for users of MEP and ATC. Environmental barriers were significant lower for MEP than for the entire group of AT (except sub-score *work/school*). Median CHIEF-S total score were MEP=0.120, PMD=0.619, ATC=1.560. Persons with MEP who used their AT daily scored the least barriers (median=0.080) whereas persons with ATC scored the most barriers (median=1.560).

Conclusions: Prosthesis users experience less barriers from the environment and have a higher level of participation in society compared to people using PMD or ATC. The facilitating factor *Support from rules and regulations* was rated lowest for MEP, which may reflect the system for prescribing advanced technology in Sweden.

Title: **Webbased innovative care using Gemstracker AADA, introducing remote follow up (monitoring) of functioning.**

Presenter: **Lisette M. Melis-Schrijver, Occupational Therapist.**

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Aims and objectives: The introduction of Patient Related Outcome Measures (PROM's) results from "empowerment" of patients, it is increasingly used to evaluate the effectiveness of treatment. Moreover, it enables shared decision making and therefore higher compliance to treatment. However, paper and pencil registration is time-consuming for both patients and health care specialists. Therefore, the aim of this study was to develop a custom-built webbased registration, which also allows comparison between patients and treatments.

Methods: We built a registration system using LimeSurvey software, an open source system. Reliable and valid questionnaires that are widely used in Rehabilitation Medicine were incorporated. They give information on functioning on all domains of human functioning as described in the World Health Organization's Classification of functioning (ICF and ICF-CY). The Gemstracker registration system enables patients, physicians and / or therapists to enter information in a secure web application, named Gemstracker AADA. We use a monitoring protocol for both children and adults, specified in age groups with emphasis on Health Related Quality of life.

Results: Gemstracker AADA makes this information available both in care registration protocols, in individual questionnaires and measurement forms. Each questionnaire is associated with a unique token which makes PROM's and therapist-reported outcome measures digitally traceable. We already enrolled 122 patients in the Gemstracker AADA registration. The online care registration procedure is described as a protocol, starting with the first patient contact. We use Gemstracker AADA as a structured online long-term follow-up care registration within the rehabilitation process, thereby making outcome measures transparent for clients and professionals within the AADA group. Gemstracker is able to show PROM's both in ICF and ICF-CY domains, in age groups, and in average assigned Gemstracker registration protocols.

Discussion: Gemstracker AADA is a secure webbased application, which is to the advantage of time management. By automatically sending planned questionnaires and being less time consuming than paper and pencil registration it will lead to higher compliance and an increase of client centered practice. Gemstracker AADA uses open source software so therefore, future projects can benefit from additional functions such as developed for this project, for instance linking to electronic health records and constructing databases for research data etc. Moreover, it enables multiple care givers to view the data. The application can be used as a tracking system and it can also easily be used for long term follow up.

Title: **Comparison of prosthetic terminal device grip force adjustability between myoelectric control & Bowden cable control**

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Number of upper limb prosthetic hands have been developed and evaluated with engineering instruments and occupational therapy protocols. The assessment methods of moving certain object and measuring the operation time, as in SHAP test, are simple and effective for comparing the terminal devices and users' ability. However, the results of these test are effected by the mechanical property of the device and object, and therefore, the result does not simply present the difference between the control method. In this report, we target to compare the operability of the two-site two-function proportional myoelectric control system and the elbow operated Bowden cable control system by measuring the settling time to adjust to the target pinch force.

Ten non-amputated subjects in their 20's year-of-age were tested. The subjects with no initial experience of controlling a prosthetic device and myoelectric signal control were recruited. The target grip force of the device were set from 5 to 25 N at 5N interval and the target force were set randomly. The terminal device were fixed to a frame and the arm with the sensor or control cable were place on the table. The digits were adjusted to have minimal excursion between the digit and force sensor. The Bowden cable were assembled with 2 setups: first was with standard cable and housing and the second was with low friction liner installed in the housing. The trials were measured and recorded, and the performances of the sound hand grip were also measured as reference.

Results show that the settling time for operating the Bowden cable controlled terminal device was equivalent to that of sound hand, and better when the target force was over 20 N. Furthermore, the dispersion among the individual were smaller for the Bowden cable controlled when comparing the result of the myoelectric controlled. The settling time of the myoelectric control had the worst performance at 5N and the standard deviations were also larger for all target force. However the performance of the myoelectric controlled improved as the target force became larger.

The result of this experiment should be read with knowledge that the all subject were at the entry level of controlling the terminal device. They were provided with time to adjust to opening and closing the hand but not fully to control the pinch force before starting the experiment.

Title: **Scottish Specialist Prosthetics Service: Advances in our understanding with fitting, training, providing and maintaining multi-articulating upper limb prosthetics for our patients**

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Since its inception the Scottish Specialist Prosthetics Service (SSPS) has enabled our multi-disciplinary teams to fit and train multiple patients with upper limb multi-articulating prostheses. Fourteen patients with trans-radial upper limb deficiency have progressed through the program and been fitted with bebionic or i-limb hands. They have participated in fitting, training and have utilized their prostheses for longer than six months. Our knowledge base and clinical skills have increased from problem solving difficulties and learning from the successes incurred in program development and providing service for our patients. The program has given us an opportunity to go through the process with multiple patients and more fully understand the similarities and differences in provision of multi-articulating prostheses with more traditional prostheses. We will review our experiences with staff training, patient education, outcome measures completed, fitting, product selection, repairs and our ongoing struggles.

Key recommendations and conclusions: The provision of multi-articulating prostheses has been effective with patients who are appropriately educated and selected. With the transition from more traditional prostheses to a multi-articulating prosthesis, it has to be expected that increased patient education, contact, training and maintenance will be required. The provision of this type of equipment has offered increased selection and opportunities for our patients. We hope to continue to have access to the Scottish Specialist Prosthetics Service and using the extra skills and knowledge we have acquired, successfully prescribe the correct prescription to future patients.

Title: **Report of survey on situation and the use of unilateral TR myoelectric hand in Japan: Comparison between continuous user and suspended to use groups**

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Introduction

We had a survey of unilateral upper extremity amputees who had prescribed the arm prostheses in Japan. The purpose of the survey was to know the situation of the myoelectric hand and how they use the hand in their ADLs. The aim of this report is to make clear the current situation and the problems related to the myoelectric hand use and then reconsider the rehabilitation.

Method

A questionnaire was sent to them through mail. The contents of the questionnaire included sex, age, age at injury, side and level of amputation, type of prosthesis, how many hours to use the hand in a day, had received the occupational therapy or not, and the scale of satisfaction in VAS.

Result

49 cases had an experience to use the myoelectric hand. They were 35 males and 14 females, 31 right and 18 left amputees, 36 were continuous users and 13 suspended to use. The continuous group used the hand for 10.3±1.96 hours a day but the suspended group used for 14.08±2.27 hours. 91.6% of the continuous group received the rehabilitation training by the occupational therapists but 53.8% of the suspended group received it.

Discussion

The continuous group is considered to use the myoelectric hand effectively in their activities of daily living. The result also shows that the rehabilitation training by OT is essential for the amputees to use their myoelectric hands continuously. We will report the usability and problems into the detail at TIPS 2016.

Title: **Textile Electrodes for Acquisition of Myoelectric Signals**

Presenter: **Shannon Brown**

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Objective

Traditionally Ag-AgCl electrodes are used to acquire surface Electromyography (sEMG) signals because the conductive adhesive in the electrodes limit motion artifacts and its gel conductive layer ensures a good enough skin-electrode interface for voltage sensing, most often, guaranteeing high quality signal acquisition. However, these electrodes when used for extended periods of time cause skin irritation[1]. This study attempts to evaluate a fully integrated smart textile band for sEMG acquisition for pattern recognition of upper arm movements. The textile band contains electrical connecting tracks knitted with intarsia techniques and knitted textile electrodes (textrodes). This development aims to simplify the user interface for everyday muscle training and decrease overall skin irritation when compared to traditional gel electrodes for applications such as phantom limb pain treatment.

Methods

Myoelectric pattern recognition for motor volition and signal-to-noise ratio (SNR) were used to compare the textrode's sensing performance versus the conventional Ag-AgCl electrodes in offline and real-time evaluations. In the recording session three repetitions of each movement were performed and the EMG superficial biopotential was acquired with a sampling frequency of 2000 Hz for a measurement time of 10 seconds and a duty cycle of 50%. *i.e. 5 second movement time with a 5 second rest between movements*. The textrodes were wet with 2 ml of undistilled water to improve skin electrode interface [2].Five healthy subjects between the ages of 22-30 as well as a transradial amputee were tested using a motion test of six upper arm movements to compare the performance of the two electrodes.

Results and Discussion

No significant differences were found between the textrodes and the Ag-AgCl electrodes in SNR and prediction accuracy obtained from pattern recognition classifiers. Figure 1 below shows the range of classification accuracy for the 5 subjects and transradial subject in real-time. In all movements the textrode performed in the same range of accuracy as the Ag-AgCl electrode. The median difference on average in accuracy of the two electrode types is approximately 1.0 %. This suggests that the textrodes could serve as a replacement for traditional Ag-AgCl electrodes for sEMG acquisition.

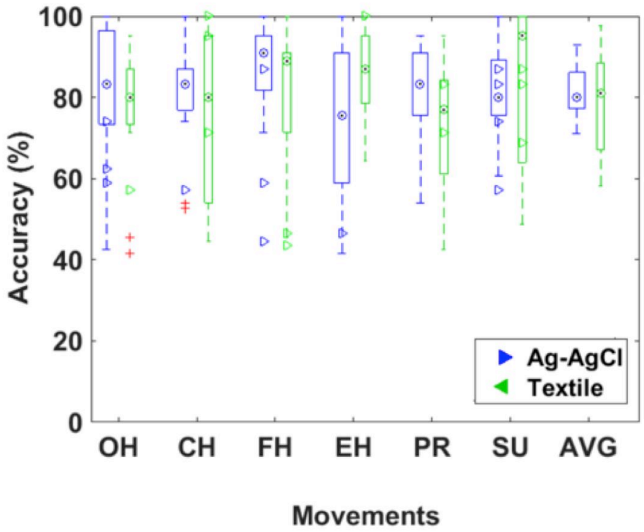

Figure 1. Movement Specific Pattern Recognition Accuracy of completed movements for Six Core Movements across 5 subjects ,and transradial subject represented by the triangle ,in real time (Open Hand, Close Hand, Flex Hand, Extend Hand, Pronate, Supinate and Average). Targets represent median while the + represents outliers in the data set

Conclusion

Further research is ongoing regarding movement classification of a greater number of transradial amputees and the influence of washing and wearing on the sensorized band's performance. If the results continue to support this fully textile sensorized garment as suitable sensing interface for acquisition of sEMG, this might be the cornerstone enabling the use of conductive smart textiles for novel applications in muscular therapies for amputees.

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DIGITAL CONTROLLER FOR ARTIFICIAL LIMBS FED BY NEUROMUSCOLAR INTERFACES VIA OSSEOINTEGRATION

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Although the development of bioelectrically controlled upper limb prosthesis started in the 1970's, the majority of amputees do not use this technology due to its poor functionality, reliability and comfort.

This study is based on the previous work conducted by Ortiz-Catalan, Håkansson, and Brånemark, who developed a permanent bidirectional interface into the human body, namely the Osseointegrated Human-Machine Gateway (OHMG)[1, 2] (Fig.1).

Figure 1. Osseointegrated Human-Machine Gateway (OHMG).

The aim of this study was to develop an Artificial Limb Controller (ALC) that decodes motor volition and provides sensory feedback using the OHMG (Fig. 2).
The system is composed by 3 stacked modules (Fig. 3):

- Neurostimulator (NS)
- Mixed signals processing unit (MSPU)
- Prosthetic control unit (PCU)

The MSPU is responsible for managing all the modules, bioelectric and artificial signal processing, and motor volition decoding. In the MSPU bioelectric signals are digitalized at 24 bits with a variable sampling rate. Band-pass and power line notch filters are implemented via firmware. Pattern recognition and direct control algorithms are implemented and were evaluated in real-time. The data from the force sensors in the artificial limb is then used to mediate the stimulation pulses that are generated by the NS to elicit the perception of touch. In its simplest stimulation mode, amplitude and

pulse-width are constant while the frequency varies proportionally with the grasping force.

A communication dongle can be plugged into the system providing wireless communication with a PC for fitting, monitoring and data management. The system includes a SD card to continuously keep track of all relevant processes in order to better understand prosthetic use and the potential sources of errors. Inertial sensors are also included in the system not only to complement information on prosthetic use, but also to potentially improve the controllability of the system by incorporating such information in the motor volition decoding task. This system has passed bench tests and is currently under clinical implementation.

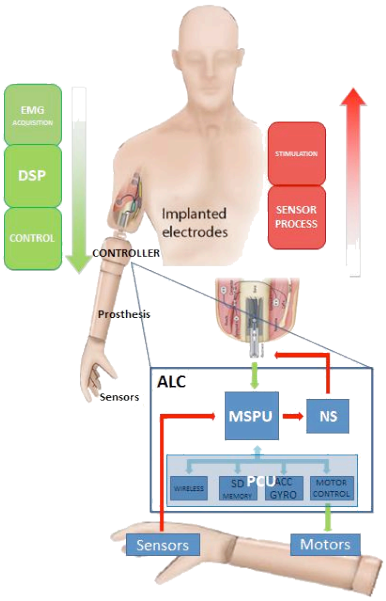

Figure 2. System overview

Figure 3. PCBs.

References:

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Title: **Impact of Upper Limb VC-VO Prosthesis Simulators in Prosthetic Rehabilitation**

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Evidence has been published regarding the beneficial impact of prosthesis-simulators. Bittermann (1968) cites use of such simulators with the non-amputee. This concept has been utilized for decades to impart empathy and to facilitate understanding operation of the body-powered technology. Companies such as Otto Bock and Touch Bionics use simulators to assess myo-sites and to develop controls skills during pre-prosthetic training. Weeks et al (2003) discusses the use of a simulator with uninvolved upper limb to successfully transfer skill of prosthesis use to the involved upper limb. Teaching individuals with upper limb deficiency to become adept with the prosthesis, its use and integration of it into acquisition of skills related to activities of daily living, work, recreation and social interactions can be challenging. As any practitioner of occupational therapy services knows, it is integral for beneficial outcomes that caregivers and other family members be involved in the process. Carry-over of recommendations for all aspects of wear schedule of the prosthesis, skills-drills activities and adaptive strategies and techniques is essential for the successful outcomes of functional independence and positive perceived quality of life. Although family members and other caregivers may be present during the prescriptive and therapeutic phases of the prosthetic program, they often lack first-hand experience of wearing and utilizing an actual prosthesis. Simulators of limited technology, such as a voluntary-opening device may be available to provide this experience on a limited basis, but not readily accessible on an ongoing basis. This technology is typically used to provide a forecast to the consumer relative to expectations. Such simulators have also been used with clinicians and peer groups to advocate empathy and respect for individuals with upper limb differences and to enhance understanding of what is involved to strategically utilize body-powered prosthetic technology.

It appears that the concept of utilizing simulators is underutilized. The body-powered prosthesis simulator described accesses both voluntary-opening and voluntary-closing terminal devices. As described in this presentation of reflective case studies, the prosthesis simulator can be used in multiple stages of prosthetic training. During the initial evaluation, the simulator can be used to compare function and access of the technologies for successful prescription and actual client trial. This evidence can be video-taped and photographed to provide compelling evidence justifying medical necessity to the funding stakeholder(s). In addition, the caregiver can experience the diverse technologies in order to better understand the requirements of use and application to functional and bimanual manipulative tasks. During the preparatory phase, the user can adjust to the demands of suspension and practice pre-prosthetic skills-drills and activities. Upon delivery of the definitive prosthesis, the simulator can be utilized to educate the family members and caregivers to various strategies in order to complete bimanual tasks. These opportunities with the simulator appear to enhance carry-over of strategies to facilitate skill acquisition and appropriation of prosthetic satisfaction. Case presentations of diverse groups mentioned will be described during this presentation.

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Title: **A preliminary study on characterisation of finger interface kinetics using a pressure and shear sensor system**

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Introduction: Active prosthetic hands could benefit from tactile feedback at the fingers when performing a variety of daily activities, such as grasping and manipulating objects. This requires real-time monitoring of pressure and shear at the interface between the fingers and objects. Although some pressure sensors are available, little work has been reported on sensor systems capable of simultaneous measurement of pressure and shear, despite the fact that shear monitoring is crucial in detecting object slip and movement[1]. A novel tri-axial pressure and shear sensor system (TRIPS) has recently been reported to be applicable at the critical residuum/socket interface for lower limb prosthetics[2]. This preliminary study aims to expand the potential applications of the TRIPS sensor system to upper limbs, in particular, by monitoring dynamic loads at finger/object interface during typical object handling tasks.

Method: Baseline calibrations for the TRIPS sensor system were conducted in research lab settings using specifically designed test protocols. Synchronous function of five sensors was studied in detail. Subsequently, up to five sensors were attached to the finger phalanges of a healthy participant's hand. The participant performed typical daily interactive tasks, such as grasping, holding and manipulating objects. Real-time pressure and shear values at various phalanx locations and finger digits were obtained and analysed as a function of these activities.

Result: Peak values of pressure and shear were reported and compared with results in literature. These pressure and shear values as a function of time provide characteristic kinetic information associated with manipulation of objects. Sensor outputs at different anatomical locations, i.e. the proximal, intermediate and distal phalanges respectively, also give some indications of natural hand movement characteristics, including flexion and extension of the tendons. The initial results suggest that the developed TRIPS sensor system could be used at hand/finger interface for dynamic load feedback. As such, the system could be potentially exploited in various areas, for example, to assess rehabilitation outcomes for stroke patients, to assist design and provide load feedback for prosthetic hands, and to provide input for real time simulation of upper limb dynamic functions.

Conclusion: This study provides preliminary evidence that the TRIPS sensor system could be used at the interface between finger and object to monitor dynamic changes in pressure and shear. The potential applications could be further expanded to areas in studies of upper limb functions, advanced prosthetic development, and assistive technologies for rehabilitation.

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Title: **Validation of AnyBody™ model kinematics for characterising prosthesis functional usage: a comparison with Vicon® Plug-in-Gait model**

Presenter: **Mr Vikranth H. Nagaraja, D.Phil. Student, Mr**

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There has been an increased interest to objectively and scientifically assess compensatory movement patterns. Compensatory movements adopted during functional usage of upper limb (UL) prosthesis have been linked to the poor outcomes widely reported in literature [1]. Most studies characterising these movements are limited to kinematic analyses and few studies have focused on musculoskeletal modelling and understanding these movement patterns at a dynamics level. The kinematics that drive the musculoskeletal model need to be correct before such a model can be applied to estimate motion dynamics.

In this preliminary study, we seek to validate outputs calculated by the commercially available software AnyBody Modelling System™ (AMS) [2]. The joint angles calculated by the standard AMS model available in the AnyBody Managed Model Repository (AMMR) are compared with the outputs from the commonly used Vicon® Plug-in-Gait (PIG) model. We have applied wrist bracing to simulate lack of a controllable distal joint during prosthetic limb usage on UL kinematics, especially at the proximal joints, shoulder and elbow.

This study was approved by the local Research Ethics Committee. One right-handed able-bodied participant (Age: 25 years, Height: 1.75 m, Weight: 75.4 kg) provided informed consent and participated in the study. Prosthesis usage was simulated by use of a wrist brace that mimics lack of a controllable wrist in a typical prosthetic device. The participant performed three trials of range of motion (RoM) tasks (wrist flexion/extension (WFE) and wrist abduction/adduction (WAA) tasks) and 'reach and grasp' task along two directions (anteroposterior (RGF) and mediolateral (RGR) axes) in a gait laboratory setting. In order to standardise the protocol, the reach and grasp tasks were performed in a seated position on a height-adjustable chair and using a custom-built apparatus that was adjusted to the participant's reaching dimensions at elbow level. The PIG and the AMS models were customised to match participant's anthropometric dimensions. Raw marker trajectories from the motion capture system were used to drive the AMS model.

The outputs from the two models are compared by comparing the difference in maximum RoM angles and the root mean square (RMS) errors. Both AMS and PIG models have showed an increase in joint RoM angles at shoulder and elbow for wrist braced condition. Initial results seem to indicate that the outputs from both the PIG and AMS models are comparable. Further investigations will be undertaken that involve inverse dynamics-based musculoskeletal analysis of the compensatory movements, and assess joint and muscle loading.

Keywords: Prosthetic device, Compensatory movements, Simulated prosthesis usage, Musculoskeletal modelling, Validation, Motion analysis, Plug-in-Gait model

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Title: **Serious gaming in learning to use a prosthetic device**

Presenter: **Raoul M Bongers, University Medical Centre, Centre for Human Movement Sciences, Groningen, The Netherlands**

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The use of computer environments or computer games has gained popularity in rehabilitation lately. Also in the rehabilitation of prosthesis use the employment of computer games has increased; companies provide with their prosthesis simple training games for the myosignals and several games for learning to control the myosignal have been investigated in the literature. The current paper concentrates on serious games that are games of which the main goal is not simply entertainment but to provide a situation in which a user can learn certain skills. The current paper focuses on applying such games to improve action-perception skills to control the prosthesis. The papers' goal is to give a brief overview of the games proposed for those purposes. This overview will be taken as a starting point to think about how to investigate the effect of serious games for prosthetic rehabilitation. Using our own research we will show the difficulty in developing appropriate serious games for prosthetic rehabilitation. These difficulties will be put in a broader perspective on rehabilitation. That is, it will be shown that the problems finding a serious game for which the developed skills transfer to prosthesis use provide general insight into how to develop rehabilitation training. The paper will finish with a proposal of how to proceed with developing rehabilitation training for prosthesis use and especially for using serious games for that. It will be argued that the primary focus should be on the action-perception couplings characterizing the prosthetic use, and, second, it will be argued that to develop a training it is required to focus on the processes that represent the evolving of a skill over learning.

Title: **Patient's perceptions of upper limb prosthetics and how virtual reality may be used in clinical practice**

Presenter: **Carol Garcia, Senior Physiotherapy Lecturer & Team Leader Physiotherapist, Faculty of Health & Wellbeing, Sheffield Hallam University, Sheffield, UK**

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Upper limb prosthesis non-use rates are quite high and this non-use has been attributed to a range of factors, including user acceptance of limb loss, a mismatch between the prosthesis and expectations, gender, age at fitting, and lifestyle. Thus in order to facilitate user satisfaction there needs to be a good match between the specific needs and expectations of the individual and the type of prosthetic chosen. However, establishing this match is a challenge, since until a user tries out a prosthesis it is difficult for them to fully understand what it might look like and how it might function.

Virtual reality offers an opportunity for users to try out prostheses as part of the process of matching the prosthetic to their individual needs using a 'try before you buy' approach with the ultimate aim of being able to better involve users in the design of new prosthetics.

The presentation will look at patient's perceptions of their experience of prosthetic use and prescription and then how virtual reality may be used in order to potentially facilitate a match between user expectations and prescription and the future use of VR in the field of upper limb prosthetics.

Title: **Simulated gripping of an object with a real-time musculoskeletal model of the hand: application to prosthesis control**

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Object manipulation is an important goal for upper limb prosthesis users. Increasingly sophisticated prosthetic devices have become available over the last few years, but the difficulty in providing sophisticated control limits full exploitation. The long-term goal of our work is to enable simultaneous, continuous control of multiple degrees of freedom (DOF) to facilitate natural performance of complex tasks. We have proposed the use of a real-time musculoskeletal model as a controller for a prosthetic device[1] whereby control signals from the user can be recorded from residual muscles to drive a dynamic simulation of hand motion. The resulting modelled finger actions can be replicated by the prosthesis, giving natural movements. In this paper we demonstrate how such a model could be used to control grip force in a simulated prosthetic hand.

The musculoskeletal model of the hand is based on Holzbaur et al.[2] and comprises 24 DOF and 26 muscles, each modelled with activation dynamics and a 3-element Hill model. The muscle dynamics and equations of motion were combined into a set of implicit first-order differential equations with 100 state variables and 26 control inputs in the form of neural excitations to the muscles. The forward-dynamic model was used in simulated closed-loop control of gripping, where the object was simulated by a force applied to the tips of the fingers in the model. Fingertip forces were fed back to the model and the grip force (just preventing slip) modulated by controlling muscle excitations of the deep flexor muscles. The elbow, wrist and thumb were locked, with 50% of the weight being evenly shared between the four fingers. Muscle excitations were continually updated by a PD controller with proportional gain $KP=0.01N^{-1}$ and derivative gain $KD=0.0005N^{-1}$. The controller was tuned to give a short rise time and minimal oscillation.

The forward-dynamics simulation was able to run in real time on normal desktop hardware, with a 5s movement being simulated in 4.3s. The initial placement of the cup in the hand created a step-input for the system, and the grip force increased to prevent slip within 35ms, reflecting the time-delays in muscle activation. A brief oscillatory response in the muscle activations is seen, but diminishes after ~0.4s. From then on the controller maintains the muscle activations at the required level to ensure that the cup does not slip.

The dynamics of the hand model, including muscle activation dynamics, tendon compliance and parallel elastic force components, naturally lead to a human-like compliant grip when used as part of a controller. Human grip, however, is characterized by a significant anticipatory component as the delays in feedback are significant (~100ms). In this example, we have assumed an autonomous controller embedded within the prosthesis and so have not included the feedforward component or the feedback delays. However, a model-based approach, when combined with improvements in peripheral nerve interfacing, will allow the delivery of feedback signals representing muscle force and length to the user to give rich haptic and proprioceptive information on prosthetic hand function.

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Title: **A multimodal immersive haptic virtual reality system for the rehabilitation of phantom limb pain in upper limb amputees**

Presenter: **Peter Snow, PhD Student, Mr**

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Phantom Limb Pain (PLP) is a well known effect post amputation within the amputee population. The acute and chronic pain suffered from amputees with PLP has a detrimental effect on their daily lives made worse by the various treatment options and the various success rates of these treatment options.

One treatment option available is mirror box therapy which has been shown to have an effect in some amputees in reducing PLP, however this tends to be more short term relive. This is due to the amputee embodying the visual mirror image of their intact limb where their amputated limb is located. Employing tactile feedback has been shown to reinforce embodiment of a visual image within the non amputated population. Which has lead to research in using TMS to provide targeted feedback back to the CNS to allow amputees to feel objects they are holding onto with their prosthetic limb.

We have developed a multimodal immersive sensorimotor system that facilitates retraining of simple manipulation tasks. Users are able to perform motor tasks using our immersive haptic sensorimotor training system that provides, direct physical contact to the haptic device, mapping of the information from the device to the virtual representation of the physical limb, and an application that maintains challenge and interest to the individual. Based on these elements, the haptic system acquires EMG commands, residual limb kinematics and displays the combined residual limb movements in a virtual reality environment that includes force-based interactions with virtual objects. Visualisation is provided via a Head Mounted Display so as to facilitate first-person view of the virtual environment and embodiment of the residual limb with the virtual representation.

Our ongoing clinical pilot study taking place at the Royal National Orthopaedic Hospital, Stanmore, will establish a more solid scientific framework for advancing the knowledge of haptic interaction in the treatment of Phantom Limb Pain and its outcome will be used to inform a future phase II trial to quantify the new approach in terms of cost benefit and therapeutic practice. The proposed paper presents the design of the system and initial results from our clinical trial.

Title: **Assessing Variability in Lower Limb Prosthetic Socket Fabrication**

Presenter: **Dr A.S. Dickinson, RAEng Research Fellow**

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Background and Objective: In assessment of prosthetic socket fit, it is important to consider all sources of variability from residuum shape capture through to prosthetic limb assembly, adjustment, and donning. The range of overall accuracy in central fabrication facilities has been investigated for transtibial sockets [1], with the individual error contributions of carving and forming processes [2], but there has been less research into the sensitivity of process variables. This study presents an updated protocol to quantify fabrication process variability incorporating external and internal surface scanning. We then illustrate how sensitivity to fabrication process parameters may be tested, using an example of oven temperature.

Methods: Nine nominally identical transfemoral socket male moulds were carved in 80kg/m^3 polyurethane foam on an ORTIS carver (Roboticom, Italy). These were used to produce nine socket drapes. Three vacuum drapes were produced using 12mm polypropylene sheets (North Sea Plastics, UK) pre-heated in a thermoplastic convection oven (North Sea Plastics, UK) at each of three temperatures: 210°C (mid-range manufacturer-recommended temperature, 200-220°C), 195°C (low) and 225°C (high). Before draping, the foam mould was digitised using an Omega scanner (Ohio WillowWood Company, USA). The internal surface of the draped sockets was scanned after mould break-out, following 12hr cooling.
The pairs of surface scans were then processed by a previously presented computational technique. The .stl files were imported into the MATLAB modelling environment (Mathworks, USA) and aligned to a standard coordinate system. Each drape and mould scan pair was registered so that the location of corresponding points could be compared. Finally, the surface height deviation between drapes and moulds was quantified and presented using colour maps, with the volume and width profiles.

Results and Discussion: All nine dataset pairs showed the same trends of drape-mould deviations, notably spring-back around the concave ischial brim features, interference on the medial wall, and a slight reduction in convex distal tip radius.
Quantitatively, over the surface area of the final shape, the average surface height difference between drape and mould pairs was between 0.18mm and 0.38mm interference. As a measure of variability, the standard deviation of surface height difference was between 0.73mm and 1.17mm, approximately two- to four-times the range of scanner accuracy. No clear differences were observed between the results obtained across the tested temperature range, although there was a small reduction in surface variability for the highest temperature (S.D. of 0.82mm at 225°C vs. 0.91mm and 0.95mm at 210°C and 195°C, respectively). Overall deviations in width and volume were small.
Gross measures showed high consistency, but it was observed that the obtained surface deviation map results were highly sensitive to the alignment of the shape datasets, and markedly different deviation patterns resulted from different alignment strategies.

Conclusions and Implications: This study presents an updated method whereby the main sources of variability in CAD/CAM socket fabrication can be measured, and key process parameters identified. To illustrate this, an example of drape oven temperature was used, and was shown across the manufacturer-advised range to have little effect. A convention for alignment should be agreed, and additional work should investigate further process variables and the clinically-required level of socket accuracy.

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Title:	**Comparison of Subjects Using Purely Mechanical Hip Disarticulation/Hemipelvectomy Limbs to Those Using Hydraulic and Microprocessor Limbs.**	
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Aims and Objectives: Historically the hip disarticulation/hemipelvectomy amputee has been a challenge to fit in relation to comfort, successful gait outcomes and longevity of use. The introduction of hydraulic hip joints working in conjunction with micro possessor knee units has created a new possibility that the user and prosthetist could be more successful in these areas. The evidence supporting the use of this state of the art technology is limited. Therefore, the purpose of this study was to fit existing users with a helix hip joint and C-leg micro-processor knee unit and compare the results with their previous mechanical limb.

Subjects: 1 female and 2 male hip disarticulation amputees were recruited. The female subject previously used a 7E7 hip joint and 3R36 knee with a 1D35 foot, and now uses a helix hip, c-leg and triton foot. Each male subject previously used a 7E7 hip joint with one using an OFM2 knee and the other using a 3R36 knee and 1D10 feet. Both were given helix hip joints – one male uses a c-leg 3 and the other a c-leg 4 – both have triton feet.

Methods: Three subjects were asked to complete various tasks and questionnaires using their previous prescription and new state of the art limb. Three objective measures were recorded: the amputee mobility predictor (AMP); the 2 minute walk test (TWT); and the L-test. Three subjective measures were also taken: the EQ-5d, the TAPES-revised and the Activities Balance confidence scale(ABC). Measures were recorded at 3 and 6 months after new prescription was given and compared to previous limb.

Results: All subjects' objective scores improved. The AMP increased for all by 3 points with a maximum K-level of 4 and minimum of 3. The 2 TWT showed a mean increase of 30 metres and the mean increase in the L-test was 2.5 seconds.

The subjective results also showed improvements. The EQ-5D, and TAPES-R results, improved for all but one subject who remained the same with her state of the art limb. All subjects ABC confidence scales improved with a maximum increase of 50%.

Conclusions and recommendations: Preliminary results show that the hydraulic hip and micro-processor knee do have the potential to provide added benefits to users compared to mechanical joints. Further investigation into the separate effects of the micro-processor knee and hip would be of interest with a longer time frame and greater number of subjects.

Title: **Gon(y)algia parasthetica / Saphenous neuralgia : Masquerading as Residual limb pain**

Presenter: **Dr A.Boppana,** ST6 Rehabilitation Medicine Trainee & Trainee Representative
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Background: Saphenous neuralgia/gon(y)algia parasthetica is an uncommon painful conditionis caused by irritation or compression at the adductor canal or elsewhere along the course of the saphenous nerve.

It is an important differential diagnosis of anterior knee pain.It can simulate other pathology in kneelike for e.g. meniscal tears, Osteoarthritis, patellar tendinopathy etc.

Clinical details: A 50 yr old lady with spina bifida underwent bilateral below knee amputation at the age of 11 yrs, and since then has been a bilateral prosthetic user (PTB with silicone liner). she presented to clinic with burning pain in left residual limb all along the anteromedial aspect of knee and the shin,(scoring 9-10/10 on numerical pain scale) for the last 6 months, and unable to wear the prosthesis for not more than 45 mins. She has no other significant medical or surgical history.

Diagnosis & Management: On examination, Skin over the area was normal.She had Tenderness/ Tinel's sign positive along the saphenous nerve in the middle third of adductor canal, and has responded positively(Pain score 0/10) to Local anaesthetic nerve block (2.5% Chirocaine).Patient is now awaiting a steroid injection as a first stage of treatment. With regards to managing the condition, we looked in to medical literature; where in the case reports do mention about the benefit of steroid injection and phenol nerve ablation.
Similarly our recent study, a case series of 17 patients (all cases from July 2011 – June 2014 & non-amputees) diagnosed with the condition who have had either steroid injection or phenol nerve ablation, have demonstrated the benefits not only in terms of improved pain scores, but also improved function of the knee and quality of life.

In our study we looked in to the outcome/ efficacy of saphenous nerve block secondary to saphenous neuralgia/Gon(y)algia parasthetica

Our study Results were as follows(in brief) : Total of 18 cases were identified in 17 patients who met the criteria, the mean age 56.52yr's, mean time since they had the intervention was 17months, and the Comorbidities include Multiple sclerosis in 2 patients and knee problems in 9 patients. Four different methods were used for carrying out the perineural injection/ nerve ablation procedure (blind, Ultrasound guided, Nerve stimulator/locater guidance, USS+ Nerve stimulator/locater guided). Post injection we noticed improvement in pain scores (Numerical pain scale) in 76.6 %, function of knee (Oxford knee Score) improved in 53% of cases, and there was also an improvement in Quality of life (SF36). We found no statistically significant difference between the methods on pain (P value = 0.57) or knee function (P value =0.59).

Implications/recommendations: Saphenous neuralgia is uncommonly seen in amputees but nonetheless it is an important differential diagnosis for residual limb pain and as Amputee rehabilitation specialist's we need to be aware of the condition.

We recommend, Palpation of the saphenous nerve should be part of routine examination of every patient presenting with residual limb pain.

Title: **Characterisation of Low Cost CAD/CAM Scanners**

Presenter: **A.S. Dickinson, RAEng Research Fellow, Dr**

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Background and Objective: CAD/CAM technology may provide benefits in prosthetic socket design and fabrication by enabling a quantitative process, improved consistency of shape capture and fabrication, and increased patient-facing time for clinicians. Lower cost alternative scanning technology has been proposed for use in prosthesis and orthosis (P&O) production, and this study set out to evaluate the accuracy and repeatability of low cost scanners in comparison to clinical state-of-the-art systems.

Methods: Two analogue objects were scanned, representing prosthetics and orthotics scenarios: a 3D-printed model representing a transtibial amputation residual limb, and a foot cosmesis. Five repeat scans of each object were taken using a Creaform Go!SCAN (Scanner A, equivalent to clinically-used OMEGA Scanner), a 3DSystems Sense (Scanner B) and an iPad-mounted Structure Sensor (Scanner C).
The surface scans were then processed by a previously presented computational technique [1]. The .stl files were imported into the MATLAB modelling environment (Mathworks, USA), aligned, and registered to a 'baseline' shape: the 3D printer file for the residuum analogue, and the first Go!SCAN file, for the foot cosmesis. The variation in surface height between groups of 5 scans was calculated, and the deviation between 3D print file and scan files was calculated for the residuum analogue.

Results and Discussion: Indicating accuracy, scanners A, B and C showed a 95th percentile surface height error vs. the 3D print file below 0.31mm±0.17, 2.44±0.78 and 4.07mm±1.32, respectively (average of 5 scans ± S.D.). Indicating variability, the three scanners showed a 95th percentile surface height error vs. the mean of 5 scans below 0.14mm±0.10, 0.69mm±0.36 and 1.16mm±0.76. For context, the variability of rectification in plaster casting has been reported as 1-2mm on average, and up to 4.3mm maximum, in a two prosthetist study [2].
Compared to previous results [1], Scanner A performed consistently. Using a more powerful computer, Scanner B processed the scan data faster and thus acquired a shape more practically reliably (i.e. without loss of tracking) but showed somewhat higher surface height error and variability.
Inspection of colour maps of the distribution of error indicated where surface errors may be corrected. Scanner C produced relatively uniformly over-sized shapes which could potentially be re-scaled using a physical measurement. The study's main limitations are use of non-living, static analogue scanning targets rather than direct scanning of patients. Furthermore, Scanners B and C were used with non-P&O-specific software. For P&O use, an OMEGA Scan app (Ohio Willow Wood Company) has been developed for Scanner C, and this will be assessed in future work alongside additional low cost devices.

Conclusions and Implications: This study presents preliminary data for evaluating and selecting optimal scanning hardware for CAD/CAM P&O device production. The superior accuracy and consistency of the Go!SCAN/OMEGA scanner over lower cost devices is clear. Additional work should monitor the fast development of new systems and investigate the clinically-required level of scanner accuracy.

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Title: **Patterns of bony deformity following transtibial amputation due to septicaemia.**

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Introduction: It is recognised that, following meningococcal septicaemia, there is epiphyseal growth plate disturbance. Bradish et al. (2011) have described the deformities and their management. However, in people who have had an amputation, these deformities are likely to affect prosthetic rehabilitation.

Methods: This study is a retrospective review of 6 transtibial amputees (9 amputations) before the age of skeletal maturity, who had an amputation following life threatening septicaemia. There were 3 boys and 3 girls with ages ranging from 4 to 14years. All children were under regular review and follow up for their prosthetic maintenance and required X-rays because of obvious physical deformities and associated symptoms. All X-rays were reviewed.

Results: Only one child with bilateral trans-tibial amputations showed no significant epiphyseal growth plate disturbance but had bony overgrowth requiring revision surgery in both his residual limbs. He also showed fusion of the distal end of the tibia with the fibula. All other children showed significant growth plate disturbance with premature closure of the tibial epiphyseal growth plate associated with overgrowth of the fibula. Notably 4 children showed that the premature closure of the physis was on the medial side leading to a varus deformity. One child had fused epiphysis in the antero-medial aspect leading to a varus deformity associated with genu recurvatum. All had partial arrest of tibial growth on the *medial* side and associated overgrowth of the fibula.

Discussion: There seems to be a remarkable consistency in the pattern of the deformity that develops in these patients and this has not been recognised in previously published literature. We suggest two possible reasons for this:

- Since the epiphyseal growth plate damage seems to occur on the medial side, this may suggest that the anatomy of the vascular supply may make the medial side of the growth plate more susceptible to damage.
- Another hypotheses would be the consequence of the 'Wolff's Law' that states that bone adapts to the load that it is subjected to and the 'Hueter-Volkmann Law' that proposes that growth is retarded by increased mechanical compression (Stokes I.A.F., 2002) and accelerated by reduced loading in comparison with normal values. All X-rays showed a varus deformity to some degree and that would have subjected the medial side of the epiphyses to greater load leading to premature closure of the medial side of the physis. This may also explain why one patient did not show epiphyseal growth disturbance as he was largely dependant on his wheelchair for his mobility and did not load his knees. One would of course need to monitor his bony development as his mobility with prostheses progresses.

Conclusion: The importance of recognising the growth plate disturbance and the subsequent pattern of deformity as described above is to assist in prosthetic socket fit and maintenance. This will help identify the need for regular assessments and for planning any surgical intervention, if and when required to assist prosthetic mobility.

References:

1. Bradish CF, Park DH, The management of the orthopaedic sequelae of meningococcal septicaemia: patients treated to skeletal maturity. J Bone Joint Surf Br. 2011

Title:	**Equipping therapists to rehabilitate amputees post sudden onset natural disaster – BACPAR's (British Association of Chartered Society of Physiotherapists in Amputee Rehabilitation) collaboration with Handicap International UK**
Presenter:	**M J Cole, Physiotherapist, Mrs**
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Other Authors:	Peter Skelton MSc, MSCP

Background - Since 2013 BACPAR has been working with Handicap International (HI) to train rehabilitation professionals as part of the UK Emergency Medical Team. Following training, rehabilitation professionals with appropriate skills are selected to join the UK Trauma Register and train as part of a small multi-disciplinary team to deploy post disaster. The UK Trauma Register was established to facilitate the deployment of surgical teams from the UK to sudden onset disasters overseas and traditionally therapists had not been included in medical humanitarian response teams. Recent research and best practice guidance has placed rehabilitation professionals at the forefront of the emergency response. HI UK was awarded funding for 2 years for training purposes; funding has been extended for a further 5. HI continues to work with several UK Physiotherapy professional networks – including BACPAR – to train and deliver training to therapists on the register appropriate for the humanitarian context.

Aim - The development and delivery of theoretical, practical and e-learning modules aims to equip therapists with relevant specialist knowledge and skills to manage people acquiring amputation following sudden onset disaster.

Method - Under the guidance of HI, BACPAR was tasked with developing and delivering 3 amputee specific modules to therapists. The core amputee rehabilitation training module focuses on acute management including pre-amputation, perioperative and pre-prosthetic phases. Participants complete a post core training selfassessment and attend a top-up workshop (practical training module) to develop confidence and competence with practical skills as required. An e-learning module support and complements prior learning, advancing theory in key areas in an emergency context.

Results - There has been a encouraging response with approximately 150 UK therapists joining the register by June 2016 of which approximately 10 are specialised in amputee rehabilitation. 8 core training modules and 6 amputee rehabilitation workshops have been delivered up to now. Feedback has been positive to module content and delivery. The e-learning module is accessible to all registrants. To date there have been 4 short-term deployments involving approximately 30 therapists who have received training.

Discussion & Conclusion - "Early rehabilitation can greatly increase survival and enhance the quality of life for injured survivors.1. The collaboration between HI and BACPAR is preparing therapists for deployment in the situation of a sudden disaster and reflects the movement towards increasing professional standards in humanitarian response. The uptake of therapists on the UK Trauma Register is encouraging and feedback on training is positive. The experience of therapists who have been deployed post sudden onset disaster is to be researched and the appropriateness of the training modules will be explored.

References: 1. The Sphere Project. Humanitarian Charter and Minimum Standards in Humanitarian Response. Third Edition 2011. www.sphereproject.org

George Murdoch Prize Lecture

Title: **The development of biomimetic hydraulic self-aligning ankles for lower limb amputees**

Presenter: **Dr David Moser, Head of Research, Blatchford Group, Basingstoke, UK**

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The role of research is to ask and seek answers to questions and to continuously re-evaluate the answers (i.e. question what we think we know). In the case of amputees this means continuously evaluating and understanding how effectively technology meets the demands of daily activities. In the O&P field there is no shortage of questions to ask and many answers have been proposed which with re-examination may no longer be deemed valid.

Bioengineers over many years have come up with many varied design solutions for prosthetic feet based on a scientific understanding of the natural foot structure and behaviour. These solutions have inevitably evolved over the years as understanding has changed and as new technologies have emerged. Understanding user needs is not only at the forefront of both the research and design activity, it is fundamentally integrated within the process which makes technology development in the field exceptional. Still today the issue of socket fit and limb alignment can cause issues which profoundly affects limb performance and capability, particularly on uneven ground impacting the user's comfort and confidence.

This lecture reports the observations of over a decade of R&D and clinical studies which led to a new generation of biomimetic prosthesis which have a self-aligning capability, culminating in the commercialisation of the first hydraulic ankles for lower limb amputees. Measurement of outcomes must be the guiding principle to any research work, informing progress but also stimulating new avenues of investigation. Future challenges include issues around accessibility to more advanced technology, education, keeping pace with science and building up and reporting the scientific and outcomes evidence base as it continues to grow.

ABSTRACTS - Saturday 1 October – Prosthetics Stream (in order of presentation)

Title: **Targeted Muscle Reinnervation: UK experiences**

Presenter: **Mr Norbert Kang, Consultant Plastic Surgeon, Royal Free Hospital, London, UK**

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Targeted Muscle Reinnervation (TMR) provides a powerful new tool for improving the control of a prosthetic limb. However, it can also have an un-intended but powerful beneficial side-effect of improving pain symptoms due to neuromas and phantom limb in a large proportion of amputees. There is no formal TMR program in the UK because (so far) it has proved difficult to justify performing the procedure when the NHS is unable to fund either the rehabilitation or prosthesis that should naturally follow after the surgery. Nevertheless, we believe that the procedure can be justified on the basis of symptom improvement alone and hope to present the evidence to support this view.

Title: **Outcomes and Challenges of Fitting Microprocessor Controlled Knees: A 6 Month Review**

Presenter: **Laura Brady, Prosthetist, Miss**

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Background -Since the introduction of the Scottish Specialist Prosthetic Service (SSPS) in 2014 there has been the opportunity to fit state of the art prosthetic limbs to a large number of amputee patients. The prosthetic teams based in Glasgow and Edinburgh have had vast and varied experiences fitting most commercially available microprocessor controlled knees.

Microprocessor controlled knees (MPKs) have gained increasing popularity over the last decade with current evidence supporting their provision. Research has shown specific improvements in safety and energy expenditure.

Objectives - This presentation will discuss the improvements noted in the transfemoral amputee population who have been fitted with a microprocessor controlled knee as well as the challenges faced. Case studies will be used to highlight changes in gait profile, falls and quality of life.

Method - A range of both patient self-reported and objective clinical outcome measures were collected on 56 transfemoral patients who have been fitted with a microprocessor controlled knee. This data was collected at baseline, 3 months and 6 months.

Results - 6 patients abandoned use of the microprocessor controlled knee due to various reasons including increased weight, poor cosmetic integration and lack of commitment to rehabilitation.

However of the remaining subjects the mean outdoor walking distance reported by patients increased from 1.27km to 2.12km within the 6 month period following provision of a microprocessor controlled knee.

2 minute timed walking test and 10m timed walking test results highlight that transfemoral patients were able to walk further and at an increased speed at the 6 month follow up.

The percentage of patients having reported falls before being fitted with a microprocessor controlled knee reduced dramatically. This was highlighted further with a reported increase in balance confidence using a prosthesis.

The Vicon gait analysis system has shown improvement in all key gait related outcomes measures: walking velocity, average step length, step length symmetry, weight distribution and lower limb kinematic patterns.

Conclusion - Through local data collection including the use of outcome measures, patient feedback and Vicon gait analysis an improvement has been noted in our transfemoral amputee population following the provision of microprocessor controlled knees.

Outcomes have shown that the provision of a microprocessor controlled knee can improve a patient's functional ability while reducing the risk of falling. Further work is required however to determine which outcome measures are most effective at detecting change.

There have been challenges regarding weight of the microprocessor controlled knee, cosmetic integration and rehabilitation.

Title: **Clinical evaluation of a measurement system for loading at the lower limb stump/socket interface**

Presenter: **Michael McGrath, Research Fellow, Dr**

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Saeed Zahedi PhD, Technical Director, Chas A. Blatchford & Sons Ltd.

Introduction

The effects of dynamic loading at the lower limb stump/socket interface are widely agreed to influence the viability of the amputee's stump tissues. Excess pressure can not only cause ulcers, but also reduce the threshold for tolerable shear, leading to further tissue damage. In order for clinicians to monitor these interfacial loading conditions, a reliable measurement system is required. Using the Tri-axial Pressure and Shear (TRIPS) measurement system, recently described by the authors[1], its clinical performance was assessed in the present study, by examining its inter-test and inter-subject variability.

Method

Three trans-tibial male amputees participated in the study. Wearing his preferred socket and prosthetic, each subject was asked to walk along a 10m level walkway at a self-selected speed. TRIPS sensors were placed at the patella tendon (PT) and the sub-popliteal fossa (SPF). In addition, for one amputee, a reproducibility study protocol was performed. This involved the measurement of a number of gait cycles, after which the prosthetic was removed, then replaced and the walking protocol was replicated. This process was repeated to produce a total of three data sets.

Results

Both pressure and shear values were assessed against comparable values previously published, where available, with a maximum difference of 13% in peak values[2]. The system revealed a high degree of repeatability across gait cycles for each amputee (Pearson's correlation coefficient (PCC) = 0.9, $p<0.05$), as well as reproducibility when the prosthetic was doffed and replaced (PCC = 0.8-0.9, $p<0.05$). The inter-subject comparison was shown to provide reproducible results for pressure (PCC = 0.8-0.9, $p<0.05$), although a wider variation in shear measurements was obtained (PCC = 0.0-0.8, $p<0.05$).

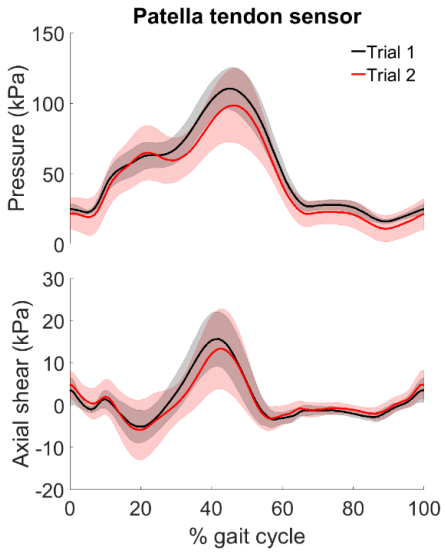

Figure 1: Reproducibility of pressure (top) and shear (bottom) measurements for same amputee between doffing/donning. Solid lines show means, shaded areas show ± one standard deviation.

Discussion

The TRIPS interface measurement system was shown to perform well in a clinical environment with high inter-test repeatability for each amputee. The inter-subject comparison showed that although similar levels of pressure may be measured, the shear measurements could be quite different. These findings might be attributed to the large variation in stump volume, position of bony prominences and quality of socket fit for the different amputees. Any potential monitoring system would need a trained prosthetist to work in conjunction with the individual amputee to determine their acceptable levels of loading.

Acknowledgements

This work was supported by the MRC and the EPSRC, for which the authors are extremely grateful.

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Title: **The 3-layer silicone socket design for lower limb amputees**

Presenters: **Ian Talbot, Senior Prosthetist, Steeper Group, Aintree University Hospital**

Lynzy Holding, Senior Prosthetist, Steeper Group, Aintree University Hospital

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Aims/objectives - Traditional materials such as polypropylene, laminate, pelite, and blocked leather have been used to manufacture prosthetic lower limb sockets for the past few decades. More recent designs have seen the use of a two-part socket with a semi flexible inner manufactured out of Northvane or polythene, and a laminate outer normally stuck in place with some double sided sticking tape or rivets.

Recent advances in the 'silicone bikini hip' manufactured at Aintree prosthetic and wheelchair centre have offered a new design concept which can be applied to lower limb prosthetic sockets. Giving the prosthetist more opportunity to offer a comfortable silicone interface, specific pressure relief areas within the socket, and comfortable flexible brim shapes all in a one-piece socket design.

The presentation is a series of case studies of lower limb amputees with different levels of amputation who access the Aintree prosthetic and wheelchair centre, each case study has a unique problem or justification for the use of the silicone socket design.

Method - A full assessment was carried out and the goals for the socket design were identified. Each patient was cast accordingly for their level of amputation and the casts were rectified as clinically indicated.

The silicone sockets were manufactured using a new 3-layer technique developed at the Aintree prosthetic centre. An internal cushioning silicone interface layer. A carbon frame for support and component attachment, and an outer silicone layer for flexibility at the proximal socket margins.

Results - Socket comfort scores were obtained retrospectively for pre and post definitive silicone sockets. The objectives of the socket design were recorded and scored against. Timed up and go, 3-minute and 6-minute walk tests were carried out on suitable patients.

Results show an improvement in socket comfort scores, objectives were met by the new sockets, and improvements were observed in the get up & go & timed walk tests.

Conclusion - The initial evidence observed in these case studies indicate that the silicone 3-layer socket design can be a useful option when designing sockets for lower limb amputees. They can be specifically designed to help the amputee achieve a variety goals including pressure relief, proximal brim comfort, improved suspension, & waterproof/swimming goals.

Title: **Towards a computationally efficient model of transtibial socket fitting**

Presenter: **J W Steer, PhD Student, Mr**

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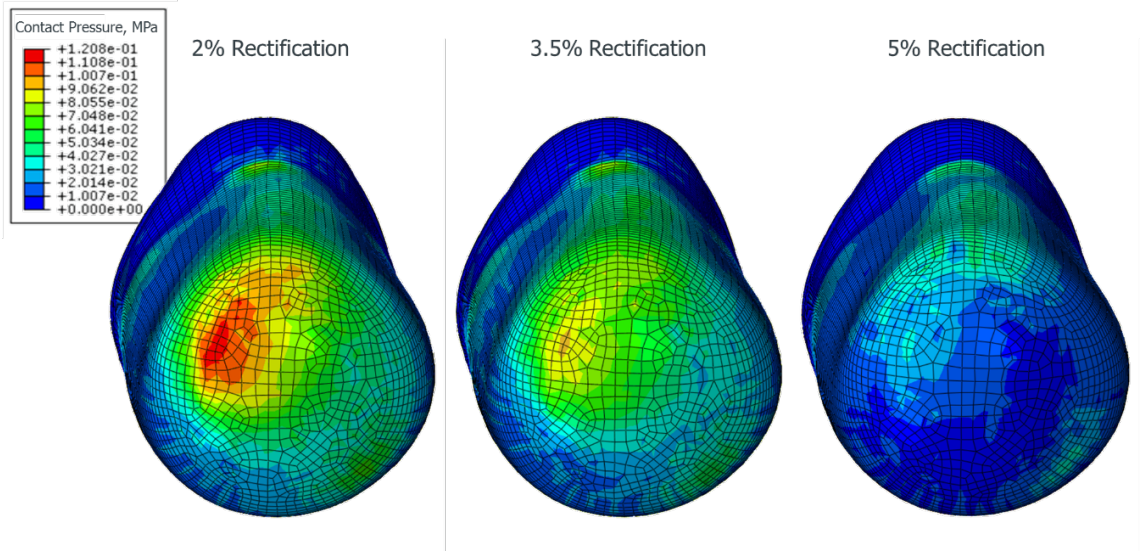
Other Authors: Dr AS Dickinson, Lecturer, University of Southampton

Aims:
The design of a transtibial amputee's socket is still a largely skill-based process, with little information available to the prosthetists past their own judgement and experience[1]. Finite element based computational models are used to predict the stresses and strains within structures, and have had considerable success within other areas bioengineering, such as structural analysis and pre-operative planning of total joint replacements. Computational models have long been identified as a possible technique to assist the prosthetist in socket fitting. Several academic studies have demonstrated their potential[2], however it is still not used within a clinical setting.

This study aims to demonstrate an initial, computational-based methodology for trailing different socket designs on a patient.

Methods:
The residuum external geometry was generated from digital scanning of an unrectified cast of a transtibial amputee. Statistical shape models were used to create the skeletal structures of the patient and the ligamentous structures were modelled manually. Three simplified Total Surface Bearing sockets were generated with distal volume reductions of 2.0%, 3.5% and 5.0%, respectively. A two stage loading procedure of the socket onto the residuum was performed. The socket was donned from a position of no contact and then loaded to simulate single-leg stance. The finite element model was used to predict soft tissue strains and skin-socket contact pressure for each of the socket designs.

Results and Discussion:
Simulation of the donning procedure enabled prediction of pre-stresses from the interference fit between the socket and residuum. When the socket was loaded, peak skin contact pressure was predicted to reduce with the reduction in socket volume (120kPa for 2.0%, 99kPa for 3.5% and 67kPa for 5.0% rectifications). This effect was most apparent at the tip of the residuum in keeping with socket fitting theory. Peak soft tissue strains were predicted in the region of the patella tendon and around the distal end of the tibia for all sockets.



This study's main limitation is that the initial model is generalised. The geometry was digitally generated in order to represent a typical, but non-patient-specific case, and material properties and load cases were taken from literature sources. However, the presented methods would be applicable to generating patient-specific models from imaging and biomechanical analysis data.

Conclusions:

This study has demonstrated a methodology for using computational techniques to trial different socket rectifications on a transtibial amputee. While experimental validation has not yet been conducted, the reduction in skin contact pressure with a reduction in socket volume was corroborated by socket fitting theory. Future studies will focus upon applying similar methods to real patients and collecting experimental data for model validation. Additionally, dynamic loading and different socket rectification techniques will be considered. Through future studies, the aim is to develop a clinically translatable computational model.

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Title: **Assessment of socket interface kinematics and kinetics based on a trans-femoral amputee case study**

Presenter: **Jinghua Tang, PhD Student, Mr**

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Introduction - Functional prosthesis, such as microprocessor-controlled ankle, has been developed to optimise the walking stability on different terrains. Understanding the mechanical coupling at the residuum/socket interface in relation to adaptations at the prosthetic ankle could potentially aid the optimization of the prosthetic components. This approach exploits a previously reported novel 3D motion capture method[1] and a tri-axial pressure and shear (TRIPS) interface sensor system[2] to provide real time kinematic and kinetic information, respectively, during ambulation of a knee-disarticulation amputee.

Method - The case study involved a knee-disarticulation amputee fitted with an Elan™ foot, KX06 knee and supra-condylar suspension socket. 3 TRIPS sensors were located at the anterior-proximal (AP), posterior-proximal (PP) and anterior-distal (AD) regions of the residuum. The subject was then asked to walk on both a level surface and a 5° descending and ascending surfaces, respectively. The socket interface coupling kinematics was assessed by analysing angular and axial couplings at the interface based on outputs from a CODA 3D motion capture system. Amputee walking tests were also conducted after adapting different ankle plantar/dorsi-flexion resistance settings of the prosthetic foot during ramp descent. Signal outputs from the gait lab and TRIPS sensors were synchronized during each test.

Results & Discussion - During level walking, the kinematics shows up to 9° angular coupling in the sagittal plane and up to 30mm axial coupling at the interface. Double peak pressure profiles were obtained from the TRIPS sensors at PP, AP and AD regions of the residuum with peak values of approximately 56kPa, 31kPa and 67kPa, respectively. Higher PP than AP peak pressures suggests residuum engagement at the PP region of the socket, aligns with the observed kinematic profile. The longitudinal shear stresses at the PP, AP and AD regions attained values of 36kPa, 2kPa and 5kPa, respectively. The profile of the resultant stresses at three locations matches well with the change in axial coupling.

During ramp descent, for both PP and AP regions, pressure increases of up to 20%, were observed in early stance phase compared to values in the terminal stance phase. Furthermore, the residuum was exposed to up to 20%

greater braking force needed for limb safety and stability. Indeed, when braking mode was activated on the Elan™ foot, up to 14% additional braking impulse was achieved. This led to a 17% reduction at AD region of the residuum. No significant changes were found with the shear stresses.

By contrast, during ramp ascent for both PP and AP regions, higher pressure (up to 16%) were observed in terminal stance phase compared with early stance phase. With assist mode activated on the Elan™ foot during ramp ascent, an increase of approximately 6% of propulsion impulse was evident. This also results in a reduction of approximately 40% for pressure and up to 35% for circumferential shear stresses on AD region of the residuum. No significant changes were found with the longitudinal shear stresses.

Conclusion - In this study, techniques of assessing socket interface biomechanics were demonstrated in relation to different terrains. The approach could potentially be used to access effect of different clinical interventions on the residuum/socket interface biomechanics. Further work is required to quantify theses effects in larger groups of amputees.

Acknowledgements - This work was supported by the MRC and the EPSRC for which the authors are extremely grateful.

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The Blatchford Lecture

Title: **Targeted Muscle Reinnervation**

Presenter: **Levi J Hargrove,**
Associate Professor, Departments of Physical Medicine & Rehabilitation and McCormick School of Engineering, Northwestern University, Chicago, IL, USA and
Director, Neural Engineering for Prosthetics and Orthotics Laboratory, Rehabilitation Institute of Chicago, IL, USA

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Amputation is a major cause of disability across the globe and is treated most effectively with a prosthetic limb. Recent advances in robotics have allowed for the creation of strong, lightweight and energy-efficient prosthetics. We, at the Center for Bionic Medicine, part of the Rehabilitation Institute of Chicago, have developed a technique called targeted muscle reinnervation, which restores myoelectric signals of amputee patients and provides a rich source of neural information that can be used to control prosthetic limbs. Originally developed for controlling upper-limb prostheses, we have now been working to extend this neural interface for powered legs, an emerging class of prosthetic limbs that are now reaching the market.

This presentation will briefly provide an overview of our targeted muscle reinnervation work as it relates to controlling upper and lower limb prostheses. It will also describe clinical application of new control algorithms, and provide quantitative data supporting the use of EMG signals to improve ambulation with powered leg prostheses.

ABSTRACTS - Saturday 1 October – Orthotics Stream (in order of presentation)

The OETT Lecture

Title: **Orthotics in a Digital World**

Presenter: **Chris Drake, Dip OTC, BAPO, CUEW, MEWI, Consultant Orthotist**
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A large number of people are now digitally connected all over the world and it was reported by The Independent in 2014 that there are now more mobile devices on the planet than people.

Now that digital technology has become fused into our daily lives, how is it currently being used in clinical orthotics today?

As digital technologies evolve and become more widely used in healthcare pathways, orthoses production and delivery, what are the possible consequences for the Orthotic industry?

This presentation intends to provide an overview of current trends and to open and stimulate discussion with the audience about how they see the use of digital technology in the future. Should we embrace or fear what lies ahead in the ever growing digital world?

Title: **Effectiveness and cost effectiveness of prosthetics and orthotics services/interventions**

Presenter: **A Healy, Senior Research Officer, Dr.**

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Aim: The aim of this systematic review was to establish what is known from the existing literature about the effectiveness and cost effectiveness of prosthetics and orthotics services/interventions.

Methods: This systematic review searched 14 databases (Web of Science, Medline, PubMed, CINAHL Plus, EMBASE, SCOPUS, Rehabdata, PsycInfo, ERIC, Education Research Complete, Business Source Complete, IEEE, NIHR and CEA Registry) using MeSH headings and free text terms for orthotics and prosthetics to capture all research in the area of orthotics and prosthetics (restricted to the last 20 years; 1995 – 2015). Metadata including the corresponding author's country affiliation, year of publication, and publication language were extracted from the search results. Data (study participants, prosthetic/orthotic intervention(s), outcome measure) relating to the characteristics of the included randomised controlled trials (RCTs) were extracted.

Results: A total of 28,958 articles were identified from the database searches. This total was reduced to 2,639 by concentrating on RCTs and those studies which examined cost-effectiveness. Research in this area have predominantly been conducted in a small number of countries (Australia, Canada, Germany, Netherlands, UK and USA). 321 randomised controlled trials examining the effectiveness/cost-effectiveness of orthotics services/interventions were identified and only 4 RCTs examining prosthetics were identified. The majority of this research examined the adult population and lower limb orthotics.

Conclusions: Results of this systematic review demonstrate the growth of research in the area of prosthetics and orthotics over the last 20 years. The majority of research in this area has focused on orthotics with scare RCTs on lower limb prosthetics and none on upper limb prosthetics. A large variety of outcomes measures examining aspects of function, activity and participation are used in these studies which complicates the synthesis of data to form conclusions on effectiveness/cost effectiveness of prosthetics and orthotics services/interventions.

Funding source: This work was supported by the International Society for Prosthetics and Orthotics (ISPO) (Sub-grant from ISPO's Collaborative Agreement with USAID Rehabilitation of physically disabled people in developing countries – USAID cooperative agreement DFD-A-00-08-00309-00.).

Title: **Use of the Theory of Planned Behaviour to understand beliefs about use of Ankle-Foot Orthoses (AFOs) in people with stroke**

Presenter: **Christine McMonagle, Teaching Fellow**

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Other Authors: Dr. Susan Rasmussen, Dr. Mark Elliott, School of Psychological Sciences and Health, University of Strathclyde; Mr Robbie Rooney, Orthotics Lead, NHS Lanarkshire

Introduction: Ankle-foot Orthoses (AFOs) are prescribed to people after stroke to improve mobility. However little is known about use of AFOs after delivery and reasons for non-adherence following stroke. Many people who have been prescribed AFOs may use them differently to recommended, or may not even know recommendations for use. Use of AFOs can be considered a health behaviour. Consequently, psychological theories of behaviour can be used to understand AFO use.

Aim of Study: The aim of this study was to identify beliefs affecting use of AFOs in people with stroke, using the Theory of Planned Behaviour (TPB)[1] as a guiding framework.

Method: Participants were 13 people living with stroke who had been prescribed an AFO by NHS Lanarkshire. A 10+3 model was used [2]. Ten participants were interviewed initially, with no new themes emerging for an additional 3 participants. Therefore data saturation was achieved. Participants were interviewed to elicit beliefs about using AFOs, using a structured questionnaire. Content analysis was used to group the responses into themes.

Results: Participants were 6 males and 7 females with a mean age of 67.2 yrs. Four participants reported using the AFO as recommended, two participants did not use at all; 6 used less than recommended and one reported using more than recommended. This group is considered a reasonably representative group of all people with stroke who have been prescribed AFOs in Lanarkshire.

A range of beliefs were elicited, both positive and negative in line with the TPB. Positive and negative attitudes towards using the AFO included: 'supports the position of the foot' and 'poor style of footwear'. Normative beliefs were influenced by 3 main groups: family, friends and health professionals. Participants reported factors that made the AFO easier to use such as 'being motivated' and factors that made the AFO more difficult to use such as 'challenges in putting the AFO on/ off'.

Discussion & Conclusion: The TPB provided a useful framework to investigate beliefs relating to AFO use in people with stroke. A range of beliefs were elicited, relating to attitudes, subjective norms and perceived behavioural control. A few participants related their disappointment when they realised they required to use an AFO in the longer term. This suggests the importance of managing user expectations when first prescribing an AFO. An understanding of beliefs of people with stroke about using orthoses may help allied health professionals to comprehend reasons for non-adherence.

This study used the TPB to identify beliefs about AFO use in people with stroke. The beliefs elicited will be used in a questionnaire to test the efficacy of the TPB in predicting AFO use. This knowledge may allow development of theory based interventions to increase mobility by use of AFOs.

References

1. Ajzen I. The theory of planned behaviour. *Organisational Behaviour and Decision processes*. 1991; 50: 179-211.
2. Francis JJ, Johnston M, Robertson C, et al. What is an adequate sample size? Operationalising data saturation for theory-based interview studies. *Psychology & health*. 2010; 25: 1229-45.

Title: **Extending Practice: The Role of an Orthotist within the Orthopaedic Clinic**

Presenter: **Laura Barr, Extended Scope Orthotist (Foot & Ankle Orthopaedics),**
Greater Glasgow & Clyde NHS, Glasgow, UK

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Role extension in the HNS is an increasingly popular means of improving patient care and wait times, by utilising the skills of highly trained non-medical practitioners within traditionally medical settings.

This presentation will provide an overview of the clinical responsibilities and case load of an Extended Scope Orthotist within an Orthopaedic Foot and Ankle clinic.

The additional training undertaken as part of this role will be discussed, as well as consideration to the transferable nature of such skills in complimenting general orthotic practice.

Title: **Lower limb salvage: "a double edge sword"**

Presenter: **Frank L Bowling, MSc (Surg) DPM, PhD, FFPM, RCPS**
Podiatric Doctor (Surgery), University of Manchester, Manchester, UK

E-mail: Frank.Bowling@manchester.ac.uk

Long standing lesions under the metatarsal heads commonly lead to infection of the bone or soft tissue, amputation are the eventual sequelae between 14% to 28% of patients with diabetes. Long-term rehabilitation is rarely successful in patients who receive a major amputation (above or below knee), only 5% of these patients can use a prosthesis to ambulate and most patients remain wheelchair-bound after five years.

For neuropathic patients with transfer lesions after a partial/complete ray or metatarsal head resection, salvage procedures that provide a plantigrade platform of the foot stump may offer a greater possibility for long-term function.

Title: **The use of CAD/CAM Technology in clinic**

Presenter: **Francesca Makey, Orthotist & Nigel Birkett, Production Manager, Plastics**
Chas A Blatchford & Sons Ltd, 11 Atlas Way, Sheffield, S4 7QQ

E-mail: Francesca.makey@blatchford.co.uk nigel.birkett@blatchford.co.uk

This presentation will provide a general update on how CAD/CAM technology can be used to develop new products. The benefits of using scanners in clinic at the manufacturing facility will be discussed along with information on type of scanners, software and carvers currently used. This technology has been used in partnership with a German scoliosis specialist, Dr Hans-Rudolf Weiss in order to provide the Gensingen spinal brace in our Sheffield facility. The results are inspiring!

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