UGME FALL RESEARCH FORUM

November 26, 2021 | 2:00 PM – 5:00 PM PST

FRIDAY, NOVEMBER 26, 2021

Chair: Dr. Lise Leveille
Review Panel: Dr. Helen Crofts, Dr. Bonita Sawatzky, D. Tim Bhatnagar

Note:
1. All presentations are strictly limited to **5 minutes**, followed by a **4 minute** discussion period with the review panel
2. All attendees are encouraged to submit questions using the Zoom "Chat" function. Presenters will respond to these questions using Zoom "Chat" after their presentation has been completed.

1400 – 1405:
Welcome and Opening remarks – Dr Kishore Mulpuri

Research Presentations (5 min. presentation + 4 min. discussion)

1405 – 1415:
Mona Behrouzian - *Muscle activation of adapted ergometry rowing and cycling for people with SCI* (Dr. Bonita Sawatzky)

1415 – 1425:
Genevieve Bonnor - *Development of an Omnidirectional Surrogate Neck* (Dr. Peter Cripton)

1425 – 1435:
Sara Bortolussi-Courval - *Muscle Activation in Spinal Muscles Assessed with Muscle Functional MRI in an Upright Open Scanner* (Dr. David Wilson, Dr. Thomas Oxland, Dr. Cornelia Laule, and Dr. John Street)

1435 – 1445:
Alexander Golab - *Applying Machine Learning Models to Automate Motor Assessment* (Dr. Dena Shahriari)

1445 – 1455:
Adan Moallemi, Nadine Truter - *Optogenetic stimulation in conjunction with biomaterials for axon growth and guidance after spinal cord injury* (Dr. Dena Shahriari)

1455 – 1505:
Shirromi Sarveswaran - *Mental Health in Adults with Arthrogryposis Multiplex Congenita (AMC)* (Dr. Bonita Sawatzky)

1505 – 1515:
Break

1515 – 1525:
Andrew Pauls - *Variability in Post-Operative Management of Developmental Dysplasia of the Hip: A Surgeon's Survey* (Dr. Kishore Mulpuri, Dr. Emily K Schaeffer)

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1525 – 1535:
Frances Scheepers - *Split Tendon Transfer of Posterior Tibialis for Spastic Equinovarus Foot Deformity: Does Tendon Routing Impact Post-Operative Ankle Kinematics?* (Dr. Lise Leveille)

1535 – 1545: Break

1545 – 1555:
Rosalind Groenewood - *Inter and intra-rater reliability of the Checketts grading system for pin site infections across all skin colours* (Dr. Anthony Cooper)

1555 – 1605
Caitlyn Siu - *Variation in operative and non-operative treatment rates for paediatric Gartland type II supracondylar humerus fractures across multiple Canadian centres* (Dr. Emily K Schaeffer, Dr. Christopher W Reilly)

1605 – 1615:
Emily Dunnion, Michael Frew - *3D-Printed foot prosthesis for children with fibular hemimelia* (Dr. Anthony Cooper)

1615 – 1625:
Renitha Reddi - *Prevalence of congenital limb reduction defects: A scoping review* (Dr. Anthony Cooper)

1625 – 1635:
Tara Gholamian - *Morquio B Disease: An Orthopaedic Case Report* (Dr. Anthony Cooper)

1635 – 1645:
Anjuli Chehil - *Quality of Referral Letters Sent to a Paediatric Orthopaedic Clinic* (Dr. Kishore Mulpuri)

1645 – 1655:
Phillip Yeung - *Risk factors for the development of heterotopic ossification following acetabular fractures: a systematic review* (Dr. Pierre Guy)

1655-1700:
Review Team Closing Comments

1700: Adjourn

UGME Fall Research Forum Abstracts

1405-1415 **Muscle activation of adapted ergometry rowing and cycling for people with SCI – Mona Behrouzian**

Authors: **Behrouzian**, Mona; Sawatzky, Bonita
Supervisor: Dr. Bonita Sawatzky

PURPOSE/HYPOTHESIS: The objective of this proof-of-concept study is to assess the muscle activation of our adaptive rowing machine (AROW) compared to traditional arm-crank ergometry (ACE) for people with spinal cord injury/disease (SCI/D). We hypothesize that the AROW will have similar muscle activation compared to ACE.

METHODS: Five participants were recruited from ICORD's Physical Activity Research Centre who regularly exercise. Electromyography (EMG) and accelerometry were collected with the Delsys Trigno Wireless EMG System. Participants were fit with surface electrodes on nine muscles on their dominant arm and trunk to record 60-seconds of using the ACE and AROW at their chosen cadence. For this case study, only one participant's data set was analysed. A root-mean-square (RMS) envelope was calculated to define magnitude, and the accelerometer data was used to define cycles after the pull phase.

RESULTS: For the participant analysed (male, high-thoracic complete SCI, 17-year injury duration, 60 W ergometry power output) the muscle activation patterns of the two exercises were similar for the brachioradialis (Br), triceps brachii (short head—TriS), posterior deltoid (PD), and trapezius medius (TraM). Activation varied for the biceps brachii (BB), triceps brachii (long head—TriL), latissimus dorsi (LD), and trapezius (medius—TraM) (lower—TraL). The BB and TriS were active for the longest periods for both ACE and AROW, respectively; the Br and PD were active for the shortest periods. All muscles were recruited for both the pull and recovery phases for rowing. For ACE, the TriL was not recruited in the pull phase, and neither were the LD and TriL in the recovery phase.

CONCLUSIONS: The AROW had similar muscle activation compared to ACE for some arm and trunk muscles. Compared to hand-cycling, more of the muscles tested were recruited in key phases in rowing and were active for longer. This case study explains our previous physiological findings that rowing increases energy expenditure for the same power output; however, more participants must be analysed to be more generalizable.

1415-1425 **Development of an Omnidirectional Surrogate Neck – Genevieve Bonnor**

Authors: **Bonnor**, Genevieve; Booth, Gabrielle; Manson, Dean; Cripton, Peter
Supervisor: Dr. Peter Cripton

INTRODUCTION: The ability of an anthropomorphic test device (ATD) to have a biofidelic response to impact is crucial for safety testing, but no ATD neck mimics the cervical spine's response to impact in multiple loading directions.

METHODS: We focused on four elements of the cervical spine: intervertebral discs, ligaments, musculature, and vertebral geometry. 3D printed vertebrae were modelled after a normal cervical spine CT scan, with muscle attachment points for the insertion of screw eyes. Muscle cables were fixed at the head-neck mounting plate and were tensioned and fixed at the lower-neck mounting plate. Ligament straps and discs were molded and attached to the vertebrae with screw eyes and adhesive, respectively.

RESULTS: High-speed video was taken of direct forehead impacts of a Hybrid-III headform with a 14 kg linear impacting ram at various speeds. Displacements of markers that had been placed on the head center of gravity (CG) and the left transverse process of each vertebra were tracked. Maximum head deflection was found for each impact speed, which were substantially higher than actual head deflection of sled test volunteers in similar tests.

CONCLUSIONS: Future designs must increase the neck stiffness to better replicate in-vivo neck kinematics.

1425-1435 **Muscle Activation in Spinal Muscles Assessed with Muscle Functional MRI in an Upright Open Scanner – Sara Bortolussi-Courval**

Authors: **Kupper,** Jessica; Bortolussi-Courval, Sara
Co-Supervisors: Dr. David Wilson, Dr. Thomas Oxland, Dr. Cornelia Laule, Dr. John Street

PURPOSE/HYPOTHESIS: Clinically, the role of muscles in compensation for adult spinal deformity and the effect of muscle damage during surgery on spine function are of considerable interest. Muscle functional magnetic resonance imaging (mfMRI) is an approach used to assess muscle activity relying on T2, a physical property of the tissue that changes due to metabolic change in the muscle [1].

The objective of this study is to determine the T2 mfMRI response of spine muscles during contraction, before and immediately after exercise, and during post-exercise recovery in healthy participants. Our specific aim is to determine ΔT2 (T2 at test condition – T2 at rest) for the erector spinae and multifidus muscles for both contracted and post-exercise scenarios. We hypothesize that ΔT2 will be highest for the post-exercise contraction and will drop with increasing time after exercise.

METHODS: Ten healthy volunteers will be imaged in the 0.5T MRO (upright open MR machine; Fig 1) six times with exercise. The six test conditions are: at rest, during contraction before exercise sets, during contraction after exercise sets, and at 10, 20, and 30 minutes of rest post-exercise. The muscle contractions and exercise sets will consist of isometric and isotonic torso extensions with resistance, respectively. To analyze the images, a region of interest at each MRI slice level will be segmented for each muscle, selecting muscle and excluding fat and blood vessels. Difference maps (ΔT2) will be created for each muscle. We will test the null hypothesis that muscle T2 is not affected by muscle activity condition at all six test conditions using a repeated- measures ANOVA.

RESULTS: N/A

CONCLUSIONS: If validated, this work will have the potential to improve our understanding of spinal disease and deformity, predict the effects of physiotherapy and surgery, and monitor the efficacy of exercise intervention in people with spinal deformity or post-surgically.

REFERENCES:
[1] B. Cagnie, 2011, Journal of Orthopaedic & Sports Physical Therapy, vol. 41, no. 11, pp. 896–903.

1435-1445 **Applying Machine Learning Models to Automate Motor Assessment – Alexander Golab**

Author: **Golab**, Alexander
Supervisors: Dr. Dena Shahriari

PURPOSE/HYPOTHESIS: There are many interventions being studied for different motor deficit conditions, and behavioural studies remain a critical and common methodology to assess the outcome. Nonetheless, the process is generally performed manually and is therefore time-consuming and prone to bias. The recent advances in machine learning have made it possible to create models autonomously capable of visual data processing at rates beyond human capability while significantly removing human errors and biases. One use of visual data processing is pose estimation, a process tracking movement from a predefined pose, which can measure range of movement. DeepLabCut is a deep learning neural network capable of animal pose estimation. CatWalk XT is a system able to automatically label visual gait analysis data by employing machine learning models. Through the data outputted by CatWalk XT and DeepLabCut, it is possible to produce programs able to semi-autonomously process data, which minimizes human involvement. The aim of this project is twofold – to remove bias through automation of behavioural analyses using machine learning models, and to determine the most relevant method to evaluate movement changes of the joints and limbs.

METHODS: In this project, we conducted behavioural studies using Catwalk XT and DeepLabCut to record and label data. This method measures murine recovery from paralysis following intervention to improve mobility. Literature review and data visualization concur the best measures of recovering mobility are regularity, luminance, rage of movement, and average speed. A custom written program was developed to automatically process the data output by CatWalk XT and DeepLabCut. The combination of these assays and the program streamlined the rate and accuracy in data analysis.

RESULTS: Currently our automated data collection and labelling of behavioural analysis minimizes human interference. Processed data on murine models before and after spinal cord injury show an immediate drop in motor movement across all tests after the injury.

1445-1455 **Optogenetic stimulation in conjunction with biomaterials for axon growth and guidance after spinal cord injury – Adan Moallemi, Nadine Truter**

Authors: **Moallemi**, Adan; Truter, Nadine; Shalileh, Shahriar; Shahriari, Dena
Supervisor: Dr. Dena Shahriari

PURPOSE: A challenge in improving function after spinal cord injury (SCI) is that damaged axons do not spontaneously regenerate. Axons intrinsically lack a sense of direction and, upon inducing regeneration, grow in random directions. Optogenetics, a technique used to sensitize cells to light via a light-sensitive cation channel, channelrhodopsin2 (ChR2), has shown promise in inducing growth both in vitro and acutely following SCI in vivo. However, the effects of chronic optical stimulation have not been studied in vivo primarily due to the lack of a device capable of chronically delivering light to sensitive spinal cord tissue. In addition, for decades, multi-channeled implants have been developed to guide growing axons across the SCI. Their implantation, however, requires invasive surgery, risking further damage to intact axons. Thus, a minimally-invasive alternative is desired.

METHODS: To understand the impact of optical stimulation on axon regeneration, an AAV vector was injected into the rodent spinal cord to transfect neurons with ChR2. Harvested tissues were analyzed to assess its expression. Our lab has developed a wirelessly

rechargeable, fully-implantable device containing a flexible probe for months-long light stimulation. This device enables optogenetic stimulation of transfected neurons and is being used in on-going in vivo studies to assess axonal growth. To guide this growth across the SCI, we have engineered injectable and magnetically-alignable singular channels. These are developed by dip-coating a wire in a polymer/salt solution containing magnetic nanoparticles. The centimeter-long channels with 300 µm inner diameters were injected in vitro and oriented under a magnetic field. Next steps are to sequentially inject and magnetically align the channels with the aim of forming a self-assembled multi-channeled scaffold.

RESULTS: We have verified the expression of virally-delivered ChR2 in over 30 mm along the rodent spinal cord and have aligned injected channels in-vitro in under 10 seconds with an applied magnetic field. This paves the way in the search for potentially assembling an array of channels into a multichannel scaffold after sequential injection in vivo.

CONCLUSIONS: With the use of optogenetics and our light-delivery device, we can assess promoting axonal growth following SCI under light stimulation. Additionally, the channels are expected to be sequentially injected and aligned in a spinal cord lesion via a minimally invasive approach.

1455-1505 **Mental Health in Adults with Arthrogryposis Multiplex Congenita (AMC) – Shirromi Sarveswaran**

Authors: **Sarveswaran**, Shirromi
Supervisor: Dr. Bonita Sawatzky

PURPOSE/HYPOTHESIS: In previous work we found adults living with Arthrogryposis Multiplex Congenita (AMC), an umbrella term for having at least two joint contractures at birth in different areas of the body, achieve high levels of education, normal levels of work and good independence. However, no specific study has explored their mental health status. Therefore, the purpose of this study is to assess the mental wellbeing of adults living with AMC by determining possible correlates of anxiety and depression in this population.

METHODS: This study is part of a larger participant-oriented project involving an international data registry of adults living with AMC aiming to address knowledge gaps on the impact and long-term functional outcomes of AMC in adulthood. The participants' completed registry questionnaires online. Mental health was measured using the Hospital Anxiety and Depression Scale. Other measures included the Oswestry Disability Index, Brief Pain Inventory, Fatigue Severity Scale, Barthel ADL Index, the Physical Independence subsection of the Craig Handicap Assessment, Craig Hospital Inventory of Environmental Factors—Short Form, Workplace Activity Limitations Scale, and demographic variables. Pearson correlations (r) were reported.

RESULTS: The sample included 60 participants (85% female) with a mean age of 40 years. 70% were from the United States, 12% from Canada, and 18% from other countries. The majority had the Amyoplasia subtype of AMC, an anterior horn cell deficit. Cut off scores for anxiety and depression were exceeded by 43% and 36% of participants respectively. Fatigue was most highly correlated to anxiety (.465) and depression (.542). In addition, age (.267), workplace limitations (.347), environmental factors (.317), and pain (.273) were significantly correlated with anxiety, while environmental factors (.401) was significantly correlated with depression.

CONCLUSIONS: This initial study showed that many adults with AMC likely experience depression and anxiety. The most significant factor is fatigue, although the causal nature of this relationship cannot be determined. Pain, workplace, and environmental factors also play a role. Physicians treating those with AMC need to explore ways to reduce pain and fatigue

issues, including directing patients to resources strategizing ways to minimize workplace and environmental barriers.

1505-1515 **Quadriceps realignment with rectus femoris re-routing: case series and description of a novel procedure for habitual patella instability – Kathryn Reilly**

Author: **Reilly**, Kathryn
Supervisor: Dr. Lise Leveille

BACKGROUND: Habitual patella dislocation is a rare condition in children in which the patella dislocates with each flexion and extension cycle of the knee. Surgical treatment is controversial, challenging, and frequently complicated by the presence of open growth plates.

PURPOSE: This study describes a novel surgical technique involving realignment of the extensor mechanism for the treatment of habitual patella dislocation and reviews the outcome of this procedure in our series of patients.

METHODS: We retrospectively reviewed records of patients who underwent quadriceps realignment with rectus femoris rerouting procedure for patella dislocation at a tertiary care pediatric hospital between 2004 and 2020. The procedure involves a lateral retinacular release, proximal mobilization and release of the rectus femoris tendon, release of the remainder of the quadriceps mechanism from the patella, rerouting of the rectus femoris tendon under and through the vastus medialis (VMO), followed by VMO advancement, and vastus intermedius and lateralis imbrication and repair. The primary outcome measure was revision surgical intervention for recurrence of patellar maltracking. Other measures collected include knee contracture, extensor lag, activity level, pain history, and need for revision surgical procedures.

RESULTS: The total number of patients was 23 (16 female). Thirteen patients had unilateral and 10 had bilateral habitual dislocations. The average age at surgery was 10 years (range five to 15 years). Average follow up was three years (range two months to 11 years). Twenty-eight knees were included (five bilateral). One patient with Kabuki Syndrome had continued patella maltracking and required a tibial tubercle osteotomy as a subsequent surgical procedure. Five other knees experienced mild residual maltracking but all were high functioning and none had subsequent surgical procedures at the time of final follow up. At final follow up two patients experienced mild pain with intense activity. Two knees in one patient with Kabuki syndrome developed a post-operative contracture (5-15 degrees). Five knees had mild extensor lag (< 10 degrees), two of which were less than one year post-operative. No patient had significant ongoing activity limitations related to their knees at final follow up.

CONCLUSION: As we continue to refine the surgical technique and indications, initial results show that quadriceps realignment with rectus femoris rerouting is a safe and successful surgical option in the treatment of habitual patella dislocation in the skeletally immature. This procedure does require significant post-operative rehabilitation to regain full motion, strength and function.

1515-1525 **Variability in Post-Operative Management of Developmental Dysplasia of the Hip: A Surgeon's Survey – Andrew Pauls**

Authors: **Pauls**, Andrew D; Sandhu, Akshdeep; Banting, Nicole; Mulpuri, Kishore; IHD Study Group; Schaeffer, Emily K
Supervisor: Dr. Kishore Mulpuri, Dr. Emily K Schaeffer

PURPOSE/HYPOTHESIS: Developmental Dysplasia of the Hip (DDH) is the most common pediatric hip condition with 1-3% of all newborns diagnosed at birth. There are no standardized treatment and management protocols for DDH, which can lead to variability in management choices. The main objectives of this project were to investigate the variation in post-operative management of DDH between surgeons, and to develop a consensus treatment protocol for post-operative management of patients with DDH

METHODS: A REDCap survey was developed and sent to pediatric orthopaedic surgeons who treat patients with DDH practicing worldwide. The survey included sections of quantitative questions regarding surgeon's imaging choice and procedural decisions.

RESULTS: A total of 48 surgeons responded to the survey. Respondents were from the United States, Canada, Australia, India, Egypt and the United Kingdom. There was general agreement on age ranges for closed (CR) and open reduction (OR) procedures. There was variability in spica cast flexion and abduction angle across unilateral and bilateral CR and OR procedures (Flexion 0-105°, Abduction 0-100°). Similarly, there was a wide range for recommended weeks of post-operative immobilization (2-26 weeks). Respondents were split on use of double leg (57.1%, n=24) or one-and-one half leg spica casts (42.9%, n=18) for unilateral CR. There was disagreement on whether bilateral OR should be single-staged (40.0%, n=10) or a staged procedure (60.0%, n=15). Preference of pelvic osteotomy procedure was varied, with Dega and Pemberton the most frequently chosen. Femoral shortening was the most frequently chosen femoral osteotomy procedure for unilateral (78.1%, n=25) and bilateral OR (65.6%, n=21).

CONCLUSIONS: This survey displayed variability amongst pediatric orthopaedic surgeons in their treatment of DDH. Understanding the variability amongst surgeons will encourage discussion and promote development of a treatment algorithm for patients with DDH.

1525-1535 **Split Tendon Transfer of Posterior Tibialis for Spastic Equinovarus Foot Deformity: Does Tendon Routing Impact Post-Operative Ankle Kinematics? – Frances Scheepers**

Authors: **Scheepers**, Frances; Bhatnagar, Tim; Leveille, Lise
Supervisor: Dr. Lise Leveille

PURPOSE: Equinovarus foot deformity is commonly seen in children with cerebral palsy (CP). The split tendon transfer of the posterior tibialis (SPOTT) is a surgical procedure where the split tendon is transferred posterior to the fibula with insertion on the peroneus brevis tendon to rebalance the forces across the hindfoot. Routing of the split tendon through the interosseous membrane has also been described. This variation has the potential benefit of augmenting ankle dorsiflexion in swing. The purpose of this study is to 1) report instrumented gait analysis outcomes for ambulatory patients with CP who underwent a SPOTT procedure; 2) determine if routing of the split tendon transfer through the interosseous membrane (IO group) improves ankle dorsiflexion in swing compared to routing posterior to the fibula (Post group).

METHODS: Patients with a diagnosis of CP and history of a SPOTT procedure for equinovarus foot deformity were identified from surgeon procedure logs. Patients with pre- and post-operative computerized gait analysis were included for review. A retrospective

chart review was completed to determine surgical technique used and concurrent surgical interventions performed at the foot or ankle. A randomly selected single side was included for patients with bilateral procedures. Pre-and post-operative max ankle dorsiflexion in swing was analyzed and compared between the IO and Post groups using a mixed effects model.

RESULTS: 38 patients met the inclusion criteria, 11 of which were in the IO group and 27 in the Post group. In the IO group 63% had either a gastroc recession or tendoachillies lengthening concurrently and the median surgery age was 13. In the Post group 88% had a concurrent procedure and the median surgery age was 8. Patients in the Post group were significantly younger than patients in the IO group (p: 0.01) and there were significantly more tendoachilles lengthening's in the Post group (p: 0.03). Both the interosseous and posterior routing significantly improved dorsiflexion in swing with a p value of 0.0098 and 0.0001 respectively. Equinus was corrected to a more neutral position in swing for both groups but there was no significant difference in the post-operative data between the two groups (p: 0.2036).

CONCLUSION: The SPOTT procedure utilized to correct spastic equinovarus foot deformity can improve max ankle dorsiflexion in swing with routing of the tendon through the interosseous membrane or posterior to the fibula if performed concurrently with appropriate tendon lengthening to address equinus contracture. However, more clinical studies and evidence are needed to better understand potential confounding factors before any clinical recommendations can be made.

1535 – 1545 BREAK

1545-1555 **Inter and intra-rater reliability of the Checketts grading system for pin site infections across all skin colours – Rosalind Groenewood**

Authors: **Groenewoud**, Rosalind; Lim, Brittany; Chhina, Harpreet; Sabharwal, Sanjeev; Iobst, Christopher; Bafor, Anirejuoritse; Cooper, Anthony
Supervisor: Dr. Anthony Cooper

PURPOSE: Despite the high incidence of pin site infections associated with external fixation devices (EFDs), there remains controversy over their definition and grading, which hinders the ability to research incidence, prevention and treatment. The purpose of this study was to evaluate the reliability of the one of the most commonly used grading systems, the Checketts grading system (CGS). As the CGS focuses on redness for minor infections, which is less apparent on dark skin, a sub-analysis comparing light and dark skin was included to evaluate the reliability of the scale in all skin colours.

METHODS: De-identified photographs of minor pin site infections were sent to pediatric limb reconstruction surgeons, and a group of patients, and their parents, that have had EFDs in the past. Each study participant was asked to grade the pin site infections and choose a treatment for each pin site. After a four-week period, the same survey was sent to the participants again for grading.

Reliability was calculated using the intraclass correlation coefficient for CGS and Fleiss' Kappa coefficients for treatment decisions. A sub-group analysis was performed for the reliability of CGS in dark skin compared to light skin. Skin colour was assessed using the Fitzpatrick Scale.

RESULTS: Overall, the inter-rater reliability of the CGS between surgeons (n=9) is moderate (ICC=0.56) with good intra-rater reliability (ICC=0.85). The sub-analysis for skin colour

showed a reduction in inter-rater reliability between surgeons when grading light skin (ICC=0.56) or dark skin (ICC=0.46).

The patient/parent group (n=8) showed moderate inter-rater reliability (ICC=0.50) and high intra-rater reliability (kappa=0.90), with no discrepancy between skin colour.

The inter-rater (kappa= 0.46) and intra-rater (kappa=0.45) reliability of treatment decisions between the surgeons was poor with a lower reliability for dark (kappa=0.38) compared to light skin (kappa=0.46).

CONCLUSION: The study demonstrated moderate to poor inter-rater reliability of the CGS which makes interpretation pin site infection research challenging. The intra and inter-reliability of treatment decisions for surgeons was also poor. Reliability was further reduced when evaluating darker skin. When designing such grading systems, skin colour should be considered in order to reduce a potential area of racial inequity.

1555-1605 **Variation in operative and non-operative treatment rates for paediatric Gartland type II supracondylar humerus fractures across multiple Canadian centres – Caitlyn Siu**

Authors: **Siu**, Caitlyn; Schaeffer, Emily K; Mulpuri, Kishore; Carsen, Sasha; Reilly, Christopher W
Supervisor: Dr. Emily K Schaeffer, Dr. Christopher W Reilly

PURPOSE: The treatment of paediatric Gartland type II extension supracondylar humerus (SCH) fractures remains a topic of controversy, as both operative and non-operative treatment are considered within standard of care. There exists significant institutional and surgeon treatment variation, but little comparative evidence. A prospective multi-centre study was undertaken to better understand treatment decisions and outcomes in type II SCH fractures. This first investigation examines operative and non-operative treatment rates across Canadian tertiary care paediatric hospitals, and reports on variation in preferred treatment.

METHODS: This prospective, multi-centre cohort study was designed to investigate functional and radiographic outcomes following operative and non-operative treatment of pediatric type II extension SCH fractures. Patients between the ages of 2 and 12 years who presented within eight weeks of injury at one of five tertiary pediatric centres across Canada were enrolled. Demographic data, including age, sex, and side of injury, as well as treatment data, including treatment methods, revision operations, and the use of reduction, were collected and are reported here for preliminary analysis.

RESULTS: A total of 309 paediatric patients (161 male, 147 female, 1 not reported) with type II SCH fractures were enrolled, and 294 (93.9%) had available treatment data. The average age of injury across all sites was 6.1 years (SD = 1.96), with individual site averages within 0.7 years from this mean. Overall, 102/294 (34.7%) patients received operative treatment and 192/294 (65.3%) were managed non-operatively. In total, 23/102 (7.4%) operative patients were initially treated non-operatively before conversion to operative treatment, with initial treatment including splinting (8/23), casting (12/23), back-slab application (1/23), and two not reported. Of the 192 patients who received non-operative treatment only, 113 (58.9%) were casted, 39 (20.3%) splinted, 40 (20.8%) taped, and 1 (0.5%) received another non-operative treatment. All operative patients were treated with closed reduction and percutaneous pinning. Across five centres, three had higher frequencies of conservative management as the initial treatment, with frequencies of 95.0% (18/20), 96.1% (125/130), and 68.2% (15/22). Conversion to operative management was required in 1/18 (5.6%), 7/125 (5.6%), and 8/15 (53.3%) patients, respectively. The remaining two centres had a majority of patients receiving operative management as their initial treatment (52.6% [60/114], 66.7%

[6/9]). An additional 6/114 (5.3%) and 1/9 (11.1%) patients were converted from non-operative to operative treatment, respectively. A reduction was performed in 165 (53.4%) patients, not performed in 102 (33.0%) patients, and not reported in 41 (13.3%) patients. Within-centre variation was noted. Individual surgeons at the center with the greatest variation in treatment chose non-operative treatment in 0.0% (0/1), 34.6% (9/26), 35.0% (7/20), 45.2% (14/31), 60.0% (9/15), 69.2% (9/13), and 100.0% (6/6) of cases.

CONCLUSION: The standard of care for type II SCH fractures varies considerably across Canadian paediatric centres, with both operative and non-operative treatments being used for similar fracture patterns. There is a clear need for further evidence regarding clinical and radiographic outcomes, as well as relative risks associated with treatments. Future research will address specific radiographic findings and outcomes, as well as long-term functional, radiographic, and patient-reported outcomes.

1605-1615: **3D-Printed foot prosthesis for children with fibular hemimelia – Emily Dunnion, Michael Frew**

Authors: **Dunnion**, Emily**;** Frew, Michael; Zakani, Sima; O'Connor, Keith; Jacob, John; Bhatnagar, Tim; Chhina, Harpreet; Cooper, Anthony
Supervisor: Dr. Anthony Cooper

PURPOSE: Reconstruction surgeries mitigate leg length discrepancies, angular deformities and ankle instability, improving the child's overall mobility and independence (reference). However, children with fibular hemimelia (FH) still struggle to find suitable footwear to accommodate foot size and shape differences and suffer from decreased stability, increased risk of tripping, and teasing from their peers. This can impact their self-esteem and can discourage participation in physical and social activities. Here, we aimed to design and manufacture a patient-specific prosthesis to help improve function of the affected foot and reduce the economic burden of buying different sized shoes.

METHODS: Twenty-five children with FH from the Limb Reconstruction Clinic were invited to complete an in-house needs assessment survey, providing an understanding of their satisfaction (functional and comfort) with their current shoe and their footwear needs. Five children with a foot size discrepancy were invited to participate in the pilot study. Children's baseline needs and functional status were captured in four steps: (i) the needs assessment survey; (ii) Pediatric outcomes data collection instrument (PODCI); (iii) baseline gait; (iv) The Bruininks-Oseretsky Test of Motor Proficiency (Second Edition).

An anatomically accurate three-dimensional (3D) model of the participants' feet was created using a 3D surface scanner in different load-bearing scenarios. Each prosthesis was designed by complementing the surface anatomy of the affected foot with that of the unaffected foot, following guidelines available in the literature and in consultation with an occupational therapist and an orthopedic surgeon. Each prosthesis was 3D-printed using a combination of materials with shore hardness 70. The participants will be asked to complete a follow-up satisfaction survey, The Bruininks-Oseretsky Test of Motor Proficiency and a detailed gait analysis within a three-month window of when they received the devices.

RESULTS: We found the foot shape in a semi-weight-bearing position most accommodative for orienting the FH foot in the shoe. Preliminary results show that the children report a comfortable fit in their footwear with the new custom prosthesis.

CONCLUSION: Subjective results suggest the children are satisfied with the prosthesis. Objective results show the devices fits and conformed to the child's foot. A gait assessment and evaluation of baseline needs will be completed within the 3-month mark.

SIGNIFICANCE: This shoe prosthesis will increase the comfort and confidence of children with FH, promoting further participation and integration in daily activities.

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1615-1625 **Prevalence of congenital limb reduction defects: A scoping review – Reddi, Renitha**

Authors: L**evesque**, Gabrielle; Reddi, Renitha; Chhina, Harpreet; Lim, B; Elliot, Alison; Cooper, Anthony
Supervisor: Dr. Anthony Cooper

PURPOSE: Congenital limb reduction defects (CLRD) occur most commonly secondary to teratogens, amniotic bands or vascular disruption. CLRD can have significant physical, psychological, and financial impacts on patients and their families. The aim of this study is to describe the prevalence of CLRDs published in the literature to date.

METHODS: A scoping review was performed using Ovid Medline, Ovid Embase, Web of Science (WoS), and Google Scholar in April 2021. Inclusion criteria included: papers that described the incidence or prevalence of specified congenital limb reduction deficits of the upper or lower extremities for a population-based group of post-natal fetuses >500g and/or >20 weeks and/or stillbirths. Exclusion criteria included: acquired, traumatic or post-infective reduction deficits, deficits of the face or trunk, overgrowth, polydactyly, supernumary anomalies, syndactyly, clubfoot, animal studies, case reports, editorials, letters and newborns of in vitro fertilization, or twin studies.

RESULTS: The search resulted in 2076 articles which were then imported into Covidence for screening. 1857 (duplicates removed) studies were screened by title and abstract using the inclusion and exclusion criteria described above by 2 reviewers, with a third reviewer to resolve any conflicts. 355 studies underwent full text review again by 2 reviewers with a third reviewer to resolve conflicts. Google translate was used for non-English paper translation.

Data extraction will be performed using MS Excel for: study location (country), study period, data source, inclusion and exclusion criteria, number of births, prevalence of specified limb deficits. Prevalence will be recalculated using total number of births as denominator and number of specific limb deficiency cases as numerator. Prevalence rates will then be reported as cases per 10,000.

CONCLUSIONS: This scoping review will summarize the prevalence rates of CLRDs across the world, allowing for comparisons to be made between countries. This data may help identify areas with statistically significant higher rates of CLRDs, which may lead to the identification of teratogens specific to these areas. These results may also help identify areas where CLRDs are not being reported, and therefore help initiate establishment of a reporting system/registry.

1625-1635 **Morquio B Disease: An Orthopaedic Case Report – Tara Gholamian**

Authors: **Gholamian,** Tara; Chhina, Harpreet; Stockler, Sylvia; Cooper, Anthony
Supervisor: Dr. Anthony Cooper

BACKGROUND: Morquio B Disease (MBD or mucopolysaccharidosis IV type B) is an autosomal recessive condition caused by a genetic mutation in the GLB 1 gene coding for β-galactosidase on chromosome 3p22.33. β-galactosidases are a family of glycoside hydrolase enzymes that catalyze the breakdown of various β-galactosides such as keratan sulfate, that can accumulate in the retina and cartilage if not processed correctly. β-galactosidase deficiency can result in two different conditions, GM1 gangliosidosis and MBD, of which MBD has a milder phenotype and presents later.

AIMS: As MBD is extremely rare with a worldwide prevalence of less than 70 patients, we hope to outline all aspects of care that a patient with MBD received to offer clinical guidance for the treatment of such patients. Additionally, we hope to improve the care received by MBD patients as there are currently no case reports outlining the in-depth orthopaedic treatment a patient with MBD has undergone throughout their childhood and adolescence.

REPORT: In this case report we discuss a patient with MBD that was diagnosed at the age of 5 after initially presenting with the Morquio dysostosis multiplex. This included a bell-shaped chest, pectus carinatum, long and hyperextensible limbs, and a short neck. Radiographic characteristics at diagnosis included flat vertebrae, a hypoplastic odontoid with a stable relationship between C1 and C2, platyspondyly and hip dysplasia. Genetic testing showed the patient to have a β-galactosidase deficiency with mutation W273L/N484K on the GLB1 gene with polymorphisms on the gene. At diagnosis, the patient did not have issues with gait and ambulation, but his ability to walk has progressively deteriorated in his adolescence as a result of ankle, knee, and hip joint instability and pain. The patient underwent ankle epiphysiodesis for their ankle valgus and a guided growth procedure for their knee valgus using bilateral eight-plate application. This case report provides an in-depth exploration of the orthopaedic follow-up and treatment this patient received for symptom relief and improved walking ability.

CONCLUSION: There is a wide range of skeletal and non-skeletal manifestations that patients with MBD present with. This case report illustrates the complex orthopaedic challenges and treatments that a patient with MBD underwent from their diagnosis to late adolescence. An increasing number of case reports are needed to better understand the natural history of MBD and the various orthopaedic treatment options available.

1635-1645 **Quality of Referral Letters Sent to a Paediatric Orthopaedic Clinic – Anjuli Chehil**

Authors: **Chehil**, Anjuli; Sidhu, Bernita Vanessa; Mulpuri, Kishore; Schaeffer, Emily K
Supervisor: Dr. Kishore Mulpuri

PURPOSE/HYPOTHESIS: The referral process is a gateway to allowing patients the specific care they need. However, referral letters with incomplete information may cause delays in the referral process. The objective of this study is to assess the quality of referral letters sent to a paediatric orthopaedic clinic. We aim to identify parts of referral letters that leave room for improvement and recognize areas of letters that have been completed sufficiently. Our ultimate goal is to improve the quality of referral letters received to expedite and optimize the referral process.

METHODS: An evaluation of randomly selected referral letters from the years 2016 and 2020 was conducted. Letters were sent in to the Orthopaedic Department of a pediatric tertiary care centre. Two independent reviewers evaluated letters using a previously

published tool. Referral letters were given a general appreciation score (out of five) and a total score (out of 23) comprising all categories in the previously published tool. Referrals were also classified based on the type of referring physician. Type of referring physician was determined based on whether that information was explicitly contained in the referral letter. If the information was unclear, the referring physician was classified as "other."

RESULTS: General appreciation of referral letters was 2.55/5 for all letters from 2016 and 2020. The total score of all letters was 12.2/23. Categories displaying notable change between 2016 and 2020 included statement expected from the referral. Categories included more commonly in letters included description of chief complaint. Categories included less commonly in letters included allergies. The majority of all referrals came from physicians classified as "other", with 62.8% of referrals.

CONCLUSIONS: Improvement is needed in the quality of referral letters sent to a paediatric orthopaedic clinic. Poor quality and incomplete referral letters can impact the prioritization of serious cases, and overall patient management. Further steps must be implemented to ensure the inclusion of all relevant patient information in referral letters, achieving a more streamlined referral process.

I would like to thank Dr. Mulpuri and the Mulpuri Research Lab for their help with this project.

1645-1655 **Risk factors for the development of heterotopic ossification following acetabular fractures: a systematic review – Phillip Yeung**

Authors: **Yeung**, Phillip; Zarnett, Oren; Lefaivre, Kelly; Guy, Pierre
Supervisor: Dr. Pierre Guy

PURPOSE: Heterotopic ossification (HO) following acetabular fractures is a common complication that may affect clinical outcomes. However, the effects of prophylactic treatment with nonsteroidal anti-inflammatory drugs or radiotherapy remain controversial. While the literature reports various risk factors related to HO development, there remains uncertainty regarding their significance or effect size in the setting of acetabular surgery. Therefore, this systematic review aims to summarize the risk factors for HO following the operative fixation of acetabular fractures.

METHODS: In accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, PubMed, MEDLINE, EMBASE, and CINHAL databases were searched from inception to February 2021. This yielded 4585 articles, of which 2935 were unique. Studies that assessed factors related to HO development among patients with operatively repaired acetabular fractures were included. Risk factors and their effect sizes were analyzed.

RESULTS: Twenty-five studies and one conference abstract were included. The following risk factors for HO were identified:

Category	**Risk factors**
Patient factors	Male sex
	Age
	Body mass index ≥30

Injury factors	Traumatic brain injury
	Number and type of associated fractures
	Chest/abdomen injuries
	T-type acetabular fractures
	Hip dislocation
	Pelvic ring injuries
	ICU[1] admission
	Non-ICU[1] hospitalization >10 days
	Mechanical ventilation ≥2 days
Care factors	Delay to surgery
	Delay to prophylaxis
	Extensile and posterior surgical exposures
	Trochanteric osteotomy
	Postoperative step-off >3 mm

[1]ICU: intensive care unit

The following risk factors were not associated with HO:

Category	**Risk factors**
Patient factor	Ethnicity
Injury factors	Injury severity score >17
	Cause of fracture
	Femoral head injuries
	Degloving injuries
	Comminution
	Intra-articular debris
Care factor	Type of bone void filler

CONCLUSIONS: HO following acetabular fixation is not uncommon and can be associated with significant disability. Careful consideration of the effect size of risk factors may aid

physicians in guiding prophylactic management by identifying patients at risk for HO development. This study may establish a framework for future studies to further define the causal role of the identified risk factors.

1655 – 1700	**Review Team Closing Comments**
1700	**ADJOURN**