2015–16
Trauma and Orthopaedic Research Unit
Mission Statement

The Trauma and Orthopaedic Research Unit (TORU) has capacity to undertake clinical and laboratory studies in the field of musculoskeletal disease.

This includes clinical aspects of arthroplasty, tissue reconstruction and trauma, fracture surveillance and management, medical imaging and joint kinematics.

TORU has established a laboratory facility at both Canberra Hospital and at the John Curtin School of Medical Research at the ANU. This enables us to conduct translational research within our own unit.

TORU’s mission is to conduct excellent research which meaningfully impacts on the clinical practice of orthopaedics and the well-being of patients.
The Trauma and Orthopaedic Research Unit (TORU) is now 16 years old. At its inception we had a borrowed office with a single student, a computer and no phones! Although TORU is still a modest size, it punches above its weight in productivity and innovation. We are now winning large grants for basic science projects and are contributing meaningfully to the ANU medical school research agenda.

Five years ago my vision was to build our capacity to supervise medical higher degree by research candidates in order to increase the research capacity within orthopaedics. We have yet to supervise our first medical PhD scholar, but we have laid the foundations with 5 surgical registrars achieving their MPhil degrees with TORU. The PhD program is still a difficult nut to crack since it requires dedicated time, which is currently at odds with the orthopaedic training program. However, this year Dr Tom Ward, who already has a PhD, took 12 months away from his set training to undertake a research project on image registration in the hip, thereby setting a precedent for research in orthopaedic set training. His work is featured on page 13.

Industry funding of research has become increasingly problematic in recent years. Where once companies were able to provide financial support to research units in order to build up investigator-led programs, the amalgamation of companies has led to an impoverished environment with reduced opportunities for support. There is a fundamental mismatch in the attitude of the corporate sector and the profession with respect to the value of research education. Fellowships are uniformly clinically focused and there is no research funding built into the support. It is surely time to revisit these relationships. We would welcome industry engagement in this space.

We have had a number of scholars who have completed their theses over the past year. It is important to acknowledge that achieving a higher degree by research (HDR) is a significant undertaking for a clinician. Unlike a taught degree, an HDR requires the candidate to manage a complex project while learning research skills, conducting experiments and mastering advanced writing skills. Dr Sumedha Amarasekara submitted his MPhil thesis on periprosthetic hip fractures in October this year. It represented the result of 5 years of work during which time Sumedha moved to Sri Lanka to commence practice as a consultant. Mitchell Kingston and Claire Bolton are other orthopaedic registrars who are currently undertaking an MPhils at ANUMS with TORU. We anticipate that they will both submit their theses in 2017.

Everyone on the TORU team deserve special mention but I have singled out three for 2016: Bryan Ashman, Ben Serpell and Jennie Scarvell. Dr Bryan Ashman who is the Director of Surgery at Canberra Hospital, has recently achieved his Masters degree in Surgical Education from Melbourne University. He has also been awarded the title of Clinical Associate Professor at the ANU Medical School. Ben Serpell, who is the strength and conditioning coach for the Brumbies Rugby club, is imminently poised to submit his PhD thesis which includes three published papers. Finally, I would also like to acknowledge the achievement of my friend and colleague Jennie Scarvell, who was made Professor of Physiotherapy at the University of Canberra this year. Jennie was the inaugural clinical research coordinator for TORU and has maintained close links continuing her oversight of the PICKLeS knee study. This is a fitting accolade for a gifted and effective academic.

Finally, none of the work reported in this newsletter could be achieved without our talented and dedicated team of whom I am very proud and grateful.

I hope you all enjoy this 2016 edition of the TORU newsletter.
Professor Paul Smith is an orthopaedic surgeon at the Canberra Hospital and at Calvary John James Hospital in Canberra. He is also Co-Director of the Trauma and Orthopaedic Research Unit at the Canberra Hospital. Prof Smith is also president of the Arthroplasty Society of Australia, and Clinical Director of Orthopaedic surgery at the Canberra Hospital.

Prof Smith received his medical and surgical training in Adelaide before specialising in hip and knee joint reconstructive and replacement surgery. He was a Royal Australasian College of Surgeons Travelling Fellow in 1996 and 1997 with Fellowships in joint replacement surgery at the University of Western Ontario in Canada and at The Princess Elizabeth Orthopaedic Hospital in England. He has been honoured by The Knee Society, receiving the inaugural John N Insall Travelling Fellowship in knee surgery and has been appointed as Professor of Orthopaedic Surgery at the ANU Medical School. Prof Smith’s particular clinical interests are in reconstruction and replacement surgery of the hip and knee, complex revision joint replacement surgery and management of pelvic and acetabular injuries.

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Dr Diana Perriman BAppSc (Physio), MSc., PhD
Clinical Research Coordinator

Dr Diana Perriman, BAppSc (USyd), MSc. (University of East London), PhD (ANU). Dr Perriman is currently the clinical research coordinator of TORU.

Dr Perriman is a physiotherapist who has completed her PhD at the ANU in 2011.

Her clinical career has spanned two decades in which she worked in hospitals, the community and private practice both in Australia and the UK. She has worked at the Trauma and Orthopaedic Research Unit since returning from the UK in 2003.

Her PhD research investigated the thoracic spine and kyphotic thoracic posture in aging, a suite of thoracic spine biomechanical and imaging studies culminating in a randomized controlled trial of the effect conservative treatment for thoracic kyphosis.

Dr Perriman has also been the recipient of an NHMRC Dora Lush scholarship for this research. As clinical research coordinator Dr Perriman’s research interests lie in arthroplasty and fracture outcomes in accordance with the main focus of the Trauma and Orthopaedic Research Unit.

Dr Perriman is a senior lecturer at the ANU Medical School and an adjunct Associate Professor at the University of Canberra.

Contact: diana.perriman@act.gov.au

Dr Rachel Li MD, PhD
Laboratory Research Coordinator

Dr Li is a molecular pharmacologist and osteoimmunologist with interests in understanding the processes that control a ‘foreign body reaction or response’ initiated by biomaterials implanted into bone or exposed to human cells.

Dr Li worked as a surgeon and senior liver diseases specialist at China Medical University. She led a number of clinical trials in anti-viral and anti-inflammatory drugs and successfully transferred an intellectual property to pharmaceutical industry. Dr Li completed her PhD at Southern Cross University and gained her postdoctoral experience in molecular pharmacology at John A Burns School of Medicine, University of Hawaii.

Dr Li established the TORU Laboratory which pioneered basic orthopaedic research at the ACT region. Her current research focus is to develop biocompatible, bioactive and biodegradable materials for future orthopaedic implants.

She has made some major research contributions to the fields of osteoimmunology and also great contribution to medical education as a senior lecturer in CMU, Associate Professor (pharmacology) in University of Canberra, and Professor (Orthopaedic Surgery) in Shandong University, China.

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**Laboratory Report**

TORU Laboratory team bridges basic and clinical sciences and facilitates communication among TORU’s collaborative institutes, universities and orthopaedic industries.

TORU team presently investigates chronic and complex bone diseases, some of which cause lifelong pain and disability. These chronic conditions can be rare, such as revision joint replacement and osteolysis or can be remarkably common, such as arthritis, trauma and osteoporotic fractures. Combined, they affict millions of Australians and cause tremendous human suffering, and cost millions of dollars in health care.

The team utilizes a mix of conventional molecular biology approaches as well as global methods such as next generation sequencing to study miRNA expression and its regulation by non-coding RNA e.g. microRNAs with an ultimate goal of identifying novel molecules that regulate bone resorption, formation, fracture repair and bone homeostasis.

**Key Research Areas**

The third generation of magnesium (Mg)-based biomaterial development

This project, supported by ARC-LP project grant, addresses a need for translational research to enhance treatment and improve management of bone diseases and disorders. To advance the understanding of interaction at the interface of biomaterials and biological systems, the TORU Laboratory is studying biocompatibility, biodegradability and bioactivity on a series of magnesium (Mg)-based biomaterials either on controlling biodegradation or osteointegration. Our recent results suggests that the SiPO4 conversion coating is a promising option for controlling the early rapid degradation rate, and hence hydrogen gas evolution, of Mg implants without adverse effects on surrounding cells and tissues.

Osteoimmunology, microRNAs’ (miRNA) regulation and genetic risk factors in biomaterial related osteolysis in total joint replacement.

This research has in part supported by AOA Research Foundation. Building on the foundation laid by the dendritic cells involvement in osteolysis, the group is using off-cut tissues from the cohorts of healthy, primary and revision subjects of TJR for characterization of wear particles and identification of molecular and genetic risk factors that contribute to the osteolysis. The ultimate goals are to contribute to the development of better predictive markers, treatments, and prevention strategies.

**Silico model of interplay and mechanism of human bone remodelling**

Integrated molecular, genetic and mathematical approaches help to identify genes that play a key role in bone homeostasis and disease process. The team is developing a multi-scale, quantitative and predictive model, which will significantly contribute to a better understanding of the intersystem crosstalk in bone remodelling including cell-cell, pathway-pathway, molecule-molecule, and gene-gene. The silico model of osteo network will hopefully facilitate recognizing biomarkers for diagnosis of rheumatoid arthritis and osteoporosis.

**Molecular pharmacological research for osteoporosis, wound and fracture healing and arthritis**

We are screening anabolic drug candidates for bone tissue engineering that promote wound and fracture healing by directing the progenitor cells growth and differentiation. Our newly developed project in collaboration with Professor Suresh Mahalingam (Griffith University) investigates viral infected arthritis, which is supported by NHMRC project grant. Mosquito-borne viruses can cause severe inflammatory diseases, and there are limited therapeutic solutions targeted specifically at virus-induced inflammation. Chikungunya virus, a re-emerging alphavirus responsible for several outbreaks worldwide in the past decade, causes debilitating joint inflammation and severe pain. We have demonstrated that NLRP3 inhibition in vivo can reduce inflammatory disease symptoms using mouse models of mosquito-borne viral disease, and that specific targeting of inflammasome function is a viable strategy for development of virus-specific therapies.

**Novel manufacturing method for fabricating biocompatible metal orthopaedic implants**

Laser based metal 3D printing technology is applied to build orthopaedic implant within appropriate post processes. Core manufacturing process will be deeply analyzed by numerical simulation to investigate laser-material interaction and a model will be built to help find better composite material for implant manufacturing. Biocompatibility and mechanical property will be validated and analyzed after each manufacturing task.

**Laboratory Facilities**

**Advanced manufacturing facility:**

TORU member has full access to material and manufacturing research lab at C1.12 at Craig Building, which contains an recent purchased EP-M250 metal 3D printer – have the ability to print biocompatible metal parts, dual-extruders Makerbot Replicator 2X 3D printer – reliably print 2 different plastic materials onto a single item, and a Pursa DeltaBot 3D printer – able to print plastic item up to 530mm height.

**Surface Validation Assays:**

TORU member has full access to metallurgical microscope inverted that located at lab C1.12 at Craig Building, which belongs to material and manufacturing group in CECS. It allows the maximum magnification of 1000 times. We also have access to Wyko NT9100 Optical Profiler that belongs to Laser Physics Centre in RSPE, which has the ability to observe sub-nanometer vertical resolution on surface with excellent reliability.

**TORU Laboratory Report**

**TORU Annual Report 2015-16**

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**TORU Laboratory Report**

**TORU Annual Report 2015-16**
Novel Orthopaedic Surface Coatings

Management of fractures of bone frequently requires the implantation of prosthesis, internal fixation devices such as plates, rods and screws in order to stabilise the injury. However, due to the aging demographics of many populations, osteoporosis is becoming more prevalent. Osteoporotic bone is more prone to fracture than normal bone, and current orthopaedic implant materials are not ideal for the osteoporotic cases. Recently, Trauma and Orthopaedic Research Laboratory has reported that a surface coating of SrPO4 on a titanium alloy promotes the growth of osteoblasts and inhibits osteoclast activity, thus potentially enhancing bone growth. Furthermore, the use of biodegradable materials for temporary bone stabilisation such as biodegradable plates and screws could be more cost effective, less painful and more favorable for patients. The supervisors’ laboratory has demonstrated SrPO4 coated Magnesium alloys offered considerable promise for implants due to their inherent properties including biodegradability, biocompatibility and bioactivity.

This project aims to study cell-cell and cell-material interaction on the SrPO4 coated materials. Expected findings will provide useful information for exploration of the structure-property relationships of the SrPO4 coatings to maximise benefits whilst eliminate side effects, i.e. promoting bone cell growth and controlling the metal release rhythm.

Staff

Dr Donghai Zhang

Dr Zhang is a Chinese Anaesthetist from Shandong University who travelled to Canberra to join the TORU lab team working specifically on ‘Biocompatibility of novel sensing materials for assessment of fracture healing.’
Management of bone diseases such as arthritis, trauma and fractures frequently requires the implantation of prostheses, internal fixation devices including fixation plates, rods and screws. Issues raised from the medical implants which limit the long term success of orthopaedic surgery are inaccurate sizes of implants, non-personalized design of implants, weak adhesion strength of coating material on the surface of implant, and wear debris accumulation caused by imprecisely fitted device around the bone surface.

The 3D printing technology provides a promising way to solve these problems through personalized and procession medical devices. The advancement of additive manufacturing (AM) technique with laser power has been offering an ideal way for personalized and precision manufacturing, which caters the requirement of bone implant fabrication owing to its tailored made solution. Furthermore, powder based techniques of AM technology have the unique ability to build metal items with precise surface and inner structure. Therefore, we hypothesize that a 3D printable personalized medical implant model for precise orthopaedic device can be reverse modelled and improved via miro-CT reconstruction from clinical images, and multiple manufacturing processes will be applied on one implant using different manufacturing methods, which possess superior biocompatibility and biofunctions by different materials.

This research targets on better applying the powder based AM technology in orthopaedic industry based on following four main objectives:

1) Advance laser based AM technique with multiple manufacturing process compatibly achieve a single implant establishment process. Material limitation on a single 3D printer is one of the most significant barriers to 3D laser printing development. The proposed system will be designed and prototyped to be capable of applying different manufacturing processes into one to better utilize correspondent advantages. More than one material can be used to produce parts with specific requirements which cannot be met by a single material, such as graded composition, coating systems, and locally controlled properties.

2) Produce medical implement coating with high degree of adhesion. Current medical implement coating is a separated process to the fabrication of the implant substrate, by which the risk of coated layer detaching from the implant always exists. This research integrates the coating process to the implement fabrication process via the proposed AM technique, which enables the coating entangles to the substrate to form strong mechanical bond between two dissimilar materials.

3) New surface polishing technique for the improvement of wear resistant. Combining AM process with polishing process leads not only simpler and faster procedure but also the component with denser interior and smoother surface.

4) Standardizing the performance and biocompatibility testing of the AM implants for the guide of the development of medical implant industry.
Collaborators

Prof Dongsheng Zhou
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Prof Jiake Xu
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Prof Chris Parish
Department of Immunology, John Curtin School of Medical Research, ANU

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Prof Brett Kirk
Associate Deputy Vice-Chancellor, Research office of Research and Development, Supervisor of 3D imaging and bioengineering lab, Department of Mechanical Engineering, ANU

Dr Jian-Ping Wu
Deputy supervisor of 3D imaging and bioengineering lab, Department of Mechanical Engineering, ANU

Prof Xiaomin Wang,
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Professor Nicholas Birilis
Dean of the Dept of Materials Engineering, Monash University

Dr Xiaobo Chen
Dept of Materials Engineering, Monash University

Prof Qunhua Jin
Head of General Hospital, Ningxia Medical University, China
Clinical Report

Clinical Research involves questions about the treatment, prevention, diagnosis/screening, or prognosis of disease or enhancement and maintenance of health. The gold standard clinical research design is the double (or triple) blind randomised controlled trial (RCT). The inherent bias which the RCT aims to reduce, affects researchers and patients has been well demonstrated. But RCTs in surgery are rare because randomisation requires the surgeon to have sufficient doubt, or equipoise, about their treatment. Equipoise means that there is genuine uncertainty about what best to do with the patient. In our experience this is rare. Surgeons operate because they believe that they are helping the patient by so doing. Patients, on the other hand, often prefer a non-surgical option if equipoise is suggested (Harris 2016).

The difficulty faced when undertaking an RCT in surgery might be reduced by ‘preparing’ the site with observational studies which show that there is reason for uncertainty about an ‘established’ practice. Three years ago we undertook a retrospective study of outcomes after volar plating vs other surgical fixation in the over 65 population. We expected worse outcomes in this group, but actually found that they did significantly better. This paper, although not an RCT, challenged our view that these patients would be better treated with less ‘invasive’ treatments. Our original hypothesis is the same as that which underlies a new multicentre trial led by Prof Ian Harris. The ‘Crossfire’ study, which will come on line at Canberra Hospital in 2017, requires random allocation to the RCT OR allocation to the observational arm if the patient chooses not to be randomised. We suggest that the Canberra surgeons are much more likely to engage in the randomisation of wrist fractures because they have been exposed to the local observational data already.

The point of this discussion is to underline the importance of good clinical observational research. Although it does not ‘prove’ anything, it is important because it offers the opportunity for a long lens view at outcomes in a local context. The generation of ‘naturalistic’ data about the result of local interventions is essential and should be encouraged at all sites. Is this audit? No, because it does not just assess performance against an accepted standard. The data produced reflects the current state of practice – or a baseline against which any new interventions should be assessed in the long term. Therefore, the RCT should not be held up as the only research design of clinical importance. Observational data is essential to the work of any clinical research unit. Much of TORU’s research is observational partially because it is commonly performed by medical students. But we have presided over some remarkable pieces of observational research in the past few years and some of it is included in this newsletter.

The priorities for the clinical unit over the past year have been have been:

- The PiCKLeS knee RCT which is ongoing and is reported on page 14
- The Attune Knee study – a surveillance study of the Depuy Attune Knee
- The R3 Acetabular study which is now at the 5 year follow up stage.
- The FAI study which is an ongoing observational outcome study reported on the next page.
- Supervision of ANU medical student research projects. These are undertaken by students in their first and second years and are a mandatory requirement for the ANUMS MChD (Doctor of Medicine and Surgery). Many of the projects reported in the newsletter are conducted by the medical students attached to our unit. We undertake not only to supervise these projects, but to teach and nurture young clinical medical scientists. For this reason we are still in contact with many of our students some years after they have graduated. Two notable examples are John Au and Andrew Griffin. John has written and published a number of great papers this year (pages 18-19) and Andrew is finalising his paper describing the results of his Australian paddle sports injury survey which we hope to publish next year.

- Supervision of Higher Degree students - Ben Serpell has spent the past 5 years doing his PhD part time while working full time in a challenging sports career. He submitted his thesis on vertical stiffness and the ACL, with his three published papers contained within it, in November this year. This represents an enormous achievement and another milestone for TORU. Achieving a higher degree while practicing medicine is a significant challenge. This year we have three orthopaedic registrar MPhils being undertaken/completed. Dr Sumedha Amarasekara submitted his MPhil Thesis on Periprosthetic Hip fractures in October this year. This represented about 5 years of work and Sumedha is currently awaiting his examiners results. Dr Claire Bolton, who was accepted onto the training program while her MPhil, is currently trying to complete it while managing the training program and a young family. We hope that we can support her to complete in 2017. Dr Mitchell Kingston commenced his MPhil in 2015. He has just been accepted to the program also and is working very hard to complete his thesis by next year when he takes up
Femoroacetabular impingement (FAI) is characterised by abnormal morphology of the femoral neck and/or acetabulum which causes hip pain and dysfunction with decreased range of movement. This impingement between the articular edges can result in injury to the labrum and an increased risk of developing osteoarthritis. FAI is suspected of affecting 10-15% of the population and is thought to be the most common cause of hip pain in young adults. Surgery involves trimming the impinging bone to normalize the mechanics of the joint but outcomes are varied and we still know very little about how to predict who is going to have a the best result. Accurate patient selection is clearly critical for optimizing outcomes.

Previous research has reported that younger age, no sign of arthritic changes, shorter duration of symptoms, and lower preoperative pain/ functional scores are associated with better outcomes. However, these factors do not explain all of the variance in the outcome data. Although we don't yet have sufficient data to accurately identify more predictive factors, our research has enabled us to build some preliminary models of the effect of pre-operative imaging signs. This study was conducted by ANU Medical Student Sarah Ellis who presented the results at the last ACT AOA meeting. Her scholarship project has involved further investigation of both x-ray and CT imaging signs and metrics. She will be presenting some of this work at this year’s ACT AOA meeting.

Stephanie Baddock, another ANU Medical student compared outcomes in patient who had their pre-surgical planning based on the results of 3D planning software (Dyonics™) to those who did not. Her results suggested that planning software reduced complications related to under resection (not enough bone removed). She presented this work at the National AOA meeting this year in Cairns.

Our understanding of the kinematics of FAI is limited. The location and degree of the impingement is only inferred from a combination of history, physical exam, static imaging and image-based simulations which do not account for soft tissue factors. However, FAI is a dynamic phenomenon and the kinematics are complex. In a project conducted during his set 4 training year, Dr Tom Ward joined TORU in collaboration with Dr Al Burns and Assoc. Prof Mark Pickering to investigate the kinematics of the FAI hip. For this project Tom used image registration technology developed for the PiCKLeS knee study and validated in the hip. This method of fitting a 3D CT scan to 2D dynamic fluoroscopic images allowed Tom to develop accurate kinematic data which will be submitted for publication imminently.

Dr Diana Perriman
Clinical Research Coordinator
Osteoarthritis and Total Joint Replacement

Osteoarthritis and Total Joint Replacement is an area of special interest for TORU. We have continued to follow-up our patients for the R3 Acetabular System study, the Attune Knee Study and, of course the PICKLeS knee study.

R3 (Smith & Nephew) is now at the end of its surveillance period and we have commenced our final 5 year follow-ups. This study aims to evaluate the clinical outcomes of the R3 Acetabular System in patients with degenerative hip disease. We have started the 2 year follow-ups of participants in the “Examining the 15 year outcomes and survivorship of the Attune Total Knee System” study. Our large RCT entitled “Prospective Imaging study of Cruciate retaining and substituting knee replacement, in osteoarthritis and healthy aging (PICKLeS)” has finished recruitment and we are now following up our TKR group out to two years. This study aims to compare the kinematics of three designs of knee replacement and compare those to normal. This has been accomplished using a novel method of combining 3D CT with single plan fluoroscopy. Catherine Galvin has been working on PICKLeS for the past three years and is currently writing up her PhD thesis on the comparative kinematics of normal and osteoarthritic knees. Nicola Hribar recently completed her honours thesis using data from this study exploring the difference between healthy males and females during a deep knee bend. Both Catherine and Nicki are students of the University of Canberra where their primary supervisor is Prof Jennie Scarvell. Henry Williams and Kaitlin Jacobs who are both ANU medical students will be completing their research projects using PICKLeS data this year.

Finally, we have had 2 medical students working with us over the past 18 months and have completed systematic reviews, one looking at pelvic discontinuity (Jason Szepetanski) and the other examining multiple dislocations following THR (Al Watson). Both of these projects will be presented at the ACT AOA meeting this year and will be submitted for publication.

The results of these studies have been presented at the Canberra Health Area Research Meeting, the Australian Physiotherapy Association Research Symposium, and The Australian Biomedical Engineering Conference.

Whiplash

The whiplash study has become a collaboration between TORU, Dr Alex Webb (ANUMS Anatomy department) and Assoc. Prof. Mark Pickering (UNSW). The data has been analysed in a number of ways. First, we have examined the muscles of the cervical spine using a segmentation algorithm designed by Mark Pickering. From this work we have developed two papers for publication (pg 18). One, is the first MRI atlas of the cervical spine muscles and has received a lot of attention (Au et al 2016). The second is an anatomical description of the levator scapulae variants which are shown to be very common (Au et al 2016b). Four of our medical students completed projects using the data from the whiplash dataset; these are described on pages 24 and 25. The data from these studies will lead in two directions. First, the DRG volume changes detected in the chronic whiplash group is an intriguing result that will be further investigated and presented at the ANZACA meeting this year. Second, the muscle volume data from Corey Ta’s study will be used to build an atlas for the development of semi-automated segmentation which was the subject of Nikhil Jha’s study (not yet complete).

Figures depict the 3D models generated for the MRI atlas of the cervical muscles
Trauma

Our trauma research has taken three forms this year.

1. The fracture Database, which we have renamed FractureNet, is still being developed. Some preliminary data from the database are being presented at our scientific meeting this year by Dr Tau Loseli.

2. The Open fracture treatment Study. A 2012 Canadian study, reported an 11 fold increase in risk of infection in open fracture wounds with delayed primary closure compared to immediate primary closure in propensity matched cohorts (Jenkinson et al. 2012). At Canberra hospital wounds are managed with delayed closure, early administration of intravenous broad-spectrum antibiotics, early and repeated irrigation and thorough surgical debridement, and VAC dressings. In the Canadian study conventional dressings were used rather vacuum dressings. The procedure used in Canberra is believed to minimize the risk of deep infection and optimize healing. However, in the light of Jenkinson et al.’s findings we believe that we should evaluate and compare our infection rates with their cohort of patients treated with primary closure. In this study we aim to compare the risk of developing a deep wound infection following an open fracture at Canberra Hospital with the rate reported by Jenkinson et al. (2012) using primary closure. This study is being led by Dr Jobe Shatov.

3. Minimal Trauma Pelvic fracture. The MT pelvic fracture project is a pipeline of studies aimed at assessing the effectiveness of our current treatment of minimal trauma pelvic fracture and determining whether surgical options should be considered in this cohort. The initial retrospective notes review has been undertaken by Dr Nushin Ahmed, Dr Dani Piper and Dr Luke Barr.

Research Fellowships

TORU sets a precedent for a Research Fellowship embedded in the Orthopaedic Training Program.

Traditionally, fellowships are undertaken by surgeons between completing their training and commencing as a consultant surgeon. These fellowships are often sponsored by device companies and are primarily clinical. However, this year Dr Tom Ward took the courageous decision to undertake research with TORU in year four of his training program without the guarantee that it would be counted in his training.

Tom is a remarkable scholar having undertaken a PhD in biomechanical engineering at Oxford University as a Rhodes Scholar. His research this year was an exploration of the kinematics of the hip in femoroacetabular impingement. Tom spent six incredibly efficient (and busy) months completing a validation study for single plane fluoroscopic image registration compared to radiosterometric analysis. He then conducted a study which quantified the kinematics of the hip in patients with FAI compared to the other side. After 12 months back in the clinical environment Tom has prepared three papers for publication and won the best registrar paper at this years AORA conference.

We believe that ‘in training’ research fellowship experiences such as this are a fantastic opportunity to train surgeons in research. Currently, device companies conceptualize fellowships as being post training. Although these are of course important, the opportunity to do research and generate valuable knowledge during training fits in perfectly with the current requirements for Australian Orthopaedic set registrars. Perhaps, with encouragement, the device companies might start considering more creating ways of supporting emerging surgeons in this way.

It should be acknowledged that Tom was supported by an AVANT scholarship which paid for materials and conference support. Latterly we have also received support from Depuy Synthes which we have appreciated very much.

So in conclusion, this novel experiment worked. Should it pave the way of the future for orthopaedic registrars? We think so but is it for everyone or should it just be for those whose research proposal has particular merit?
Clinical Team

Ms Belinda Payne
Belinda is TORU’s Office Manager, Belinda has been with TORU since 2013 and can be contacted at any time for queries regarding the unit. Belinda comes from a clinical background in nursing which gives her great insight into the many different aspects of orthopaedic research. Her role is diverse and comprehensive including conference and meeting organisation, financial management and administrative duties.

Mr Joe Lynch, Research Officer
Joe joined the team in mid 2014. He completed his Bachelor of Science in Exercise Science, and a Master of Science in Biomechanics at the University of Ottawa. At present Joe is involved in the running of various trials within the unit with his main interest being in functional and imaging analysis following injury and surgery. Joe is planning on starting his PhD in 2017 examining the kinematics of knee replacements.

Dr Ruidang Wang, Database Architect
Rui is a database architect who designed the Fracture Surveillance Database, FractureNet. Rui has extensive IT experience specialising in applying database design, analytic informatics, business intelligence and online platform technologies to clinical context. Rui has completed her PhD at ANU entitled A new generation system for scientific knowledge discovery. Rui has recently left TORU to take up a senior IT position with ACT Health.

Ms Amanda Phillips, Database Officer
Amanda works with Joint Surveillance team at Orthopaedics ACT to help manage the arthroplasty database and is the main link between the surgeons and patients regarding their outcomes. Amanda ensures joint replacement patients are followed up regularly and the data is accurate.

Prof Jennie Scarvell
A career as clinical physiotherapist lead Jennie to a PhD on knee kinematics and the role of aberrant motion in degenerative change using a model of ACL injury. Jennie is Head of Discipline (Physiotherapy) and the University of Canberra and is leading our PICKLeS study. She is the primary supervisor for one of our PhD students, Catherine Galvin.

Dr David Wheatley FRACS
David was the Orthopaedics ACT fellow for 2016. David completed his training in Queensland prior to coming to Canberra. During his time here, David has been looking into quantifying the curvature of the anterior pelvic ring using CT. Following this fellowship, he plans on setting up a practice in both the public and private sectors specialising in trauma and lower limb reconstruction.

Dr Tom Ward
Tom is an accredited orthopaedic registrar in the third year of his training. He holds a university medal in engineering, an honours degree in medicine, and a doctorate in orthopaedic biomechanics, obtained at Oxford in 2005, where he studied as a Rhodes Scholar. Tom worked with during the first half of 2016 focusing on the kinematics of femoroacetabular impingement. He is currently up in Sydney completing his orthopaedic training.

Dr Mitchell Kingston
Dr Kingston is an orthopaedic registrar at the Canberra Hospital and Depuy Synthes Clinical and Research Fellow. He is currently undertaking an MPhil at the ANU looking at the anatomy of the circumflex femoral arteries.
Clinical Collaborators

Prof Jennie Scarvell
Head of Physiotherapy, University of Canberra

Dr Nick Ball
Head of Sport Science, University of Canberra

A/Prof Mark Pickering
School of Engineering and Information Technology, UNSW@ADFA

Dr Sean O’Byrne
School of Engineering and Information Technology, UNSW@ADFA

Dr Krishna Shankar
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Dr Alexander Burns
Consultant Orthopaedic Surgeon, OrthoACT

Dr Chris Roberts
Consultant Orthopaedic Surgeon, Ortho ACT

Mitali Fadia
Pathology, ANU

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Statistical Consulting Unit, ANU

Prof Jane Dahlstrom
Sub Dean Canberra Hospital Campus; Anatomical Pathology, ANU

Dr Ashley Watson
Infectious Diseases, ANU

Dr Alexandra Webb
School of Anatomy, ANU

Prof Jan Provis
Director, School of Anatomy, ANU

A/Prof Alex Fisher
Geriatric Medicine, ANU

Dr Bryan Ashman
Director of Surgery and Orthopaedic Surgeon, Canberra Hospital

A/Prof Bruce Shadbolt
Centre for Clinical Epidemiology, Canberra Hospital

Melanie Egan, Amy Krause Adrian Meijer and Asha Bott-Sarma
Medical Imaging, Radiography, Canberra Hospital

Prof Ian Harris
UNSW South Western Sydney Clinical School, Whitlam Orthopaedic Research Centre
Research Output

Publications

The anatomy of the cervical spine musculature visible on magnetic resonance (MR) images is poorly described in the literature. However, the correct identification of individual muscles is clinically important because certain conditions of the cervical spine, for example whiplash associated disorders, idiopathic neck pain, cervical nerve root avulsion and cervical spondylotic myelopathy, are associated with different morphological changes in specific muscles visible on MR images. Knowledge of the precise structure of different cervical spine muscles is crucial when comparisons with the contralateral side or with normal are required for accurate description of imaging pathology, management and assessment of treatment efficacy. However, learning the intricate arrangement of 27 muscles is challenging. A multi-level cross-sectional depiction combined with three-dimensional reconstructions could facilitate the understanding of this anatomically complex area. This paper presents a comprehensive series of labeled axial MR images from one individual and serves as a reference atlas of the cervical spine musculature to guide clinicians, researchers, and anatomists in the accurate identification of these muscles on MR imaging.

PURPOSE: Accessory attachments of the levator scapulae (LS) muscle have been described in the literature in previous cadaveric studies, but there is little knowledge about the incidence and distribution. Knowledge of LS accessory attachments is relevant to clinicians working in the fields of radiology, surgery, neurology, and musculoskeletal medicine. The purpose of this study was to explore the incidence and spectrum of LS caudal accessory attachments in vivo using magnetic resonance (MR) imaging in a young cohort.
METHODS: MR images of the cervical spine were obtained from 37 subjects (13 males and 24 females) aged 18-36 years using an axial T1-weighted spin echo sequence acquired from a 3-Tesla MR scanner. The LS muscle was identified, and the presence of caudal accessory attachments was recorded and described.
RESULTS: LS caudal accessory attachments were identified in 16 subjects (4 right, 6 left, and 6 bilateral; 12 female). Ten had unilateral accessory attachments to the serratus anterior, serratus posterior superior or the first/second rib. Four had bilateral accessory attachments to serratus anterior. One had bilateral accessory attachments to serratus posterior superior and unilateral accessory attachment to serratus anterior. One had bilateral attachments to both muscles.
CONCLUSIONS: Both unilateral and bilateral LS caudal accessory attachments were present in nearly half of the subjects examined. They were relatively more frequent in females than males. The findings indicate that these accessory attachments are common, and in some cases, those accessory attachments can occur bilaterally and to more than one site.

Ding, Y., Li, R.W., Nakai, M., Majumdar, M., Zhang, D., Niinomi, M., Birbilis, N., Smith, P.N., Chen, C.
Osteoporosis is becoming more prevalent due to the aging demographics of many populations. Osteoporotic bone is more prone to fracture than normal bone, and current orthopedic implant materials are not ideal for the osteoporotic cases. A newly developed strontium phosphate (SrPO4 ) coating is reported herein, and applied to Ti-29Nb-13Ta-4.6Zr (wt%), TNTZ, an implant material with a comparative Young’s modulus to that of natural bone. The SrPO4 coating is anticipated to modulate the activity of osteoblast (OB) and osteoclast (OC) cells, in order to promote bone formation. TNTZ, a material with excellent biocompatibility and high bioinertness is pretreated in a concentrated alkaline solution under hydrothermal conditions, followed by a hydrothermal coating growth process to achieve complete SrPO4 surface coverage with high bonding strength. Owing to the release of Sr ions from the SrPO4 coating and its unique surface topography, OB cells demonstrate increased proliferation and differentiation, while the cellular responses of OC are suppressed, compared to the control case, i.e., bare TNTZ. This TNTZ implant with a near physiologic Young's modulus and a functional SrPO4 coating provides a new direction in the design and manufacture of implantable devices used in the management of orthopedic conditions in osteoporotic individuals.
Contrast agent comparison for three-dimensional micro-CT angiography: A cadaveric study. Contrast Media & Molecular Imaging.


Barium sulfate and lead oxide contrast media are frequently used for cadaver-based angiography studies. These contrast media have not previously been compared to determine which is optimal for the visualisation and measurement of blood vessels. In this study, the lower limb vessels of 16 embalmed Wistar rats, and four sets of cannulae of known diameter, were injected with one of three different contrast agents (barium sulfate and resin, barium sulfate and gelatin, and lead oxide combined with milk powder). All were then scanned using micro-computed tomography (CT) angiography and 3-D reconstructions generated. The number of branching generations of the rat lower limb vessels were counted and compared between the contrast agents using ANOVA. The diameter of the contrast-filled cannulae, were measured and used to calculate the accuracy of the measurements by comparing the bias and variance of the estimates. Intra- and inter-observer reliability were calculated using intra-class correlation coefficients. There was no significant difference (mean difference [MD] 0.05; MD 95% confidence interval [CI] -0.83 to 0.93) between the number of branching generations for barium sulfate-resin and lead oxide-milk powder. Barium sulfate-resin demonstrated less bias and less variance of the estimates (MD 0.03; standard deviation [SD] 1.96 mm) compared to lead oxide-milk powder (MD 0.11; SD 1.96 mm) for measurements of contrast-filled cannulae scanned at high resolution. Barium sulfate-resin proved to be more accurate than lead oxide-milk powder for high resolution micro-CT scans and is preferred due to its non-toxicity. This technique could be applied to any embalmed specimen model.


AIMS: Total wrist arthrodesis (TWA) produces a spectrum of outcomes. We investigated this by reviewing 77 consecutive TWA performed for inflammatory and post-traumatic arthropathies, wrist instability and as a salvage procedure.

PATIENTS AND METHODS: All operations were performed by a single surgeon using a specifically designed pre-contoured dorsally applied non-locking wrist arthrodesis plate at a single centre.

RESULTS: Median post-operative Buck-Gramcko Lohman (BGL), Disabilities of the Arm, Shoulder and Hand and Patient Rated Wrist Evaluation scores at six years (interquartile range (IQR) 3 to 11) were 9 (IQR = 6 to 10), 19 (IQR = 7 to 45) and 13 (IQR = 1 to 31) respectively. Polyarticular inflammatory arthritis and female gender were associated with poorer patient-reported outcomes, although the effect of gender was partly explained by higher rates of inflammatory disease among women. Return to work was negatively influenced by workers’ compensation and non-inflammatory wrist pathology. There was no difference in complication rates for inflammatory and non-inflammatory indications.

TAKE HOME MESSAGE: Polyarticular inflammatory arthritis is a risk factor for adverse patient-reported outcomes in TWA. Furthermore, when compared with patients without inflammatory arthritis, dorsally applied pre-contoured plates can be used for wrist arthrodesis in patients with inflammatory arthritis without an increased risk of complications.
Conference Presentations

ACT Branch Australian Orthopaedic Association Annual Scientific Meeting

- Anatomical variations of the levator scapulae muscle - an MR Imaging Study
  
  Au, J., Webb, A., Buirski, G., Smith, P.N., Pickering, M., Perriman, D.

- Physiotherapy after total hip replacement: what does the evidence support?
  
  Coulter, C., Neeman, J., Scarrvell, J., Smith, P.N.

- The ischial spine sign predicts patients who improve most after FAI surgery
  
  Ellis, S., Perriman, D., Burns, A.W., Neeman, T., Lynch, J., Smith, P.N.

- There is no difference in walking speed and standing duration between people with gluteal tendinopathy and hip osteoarthritis: an observational study
  
  Fearon, A., Scarrvell, J., Cook, J., Neeman, T., Smith, P.N.

- Novel technique for visualising intra-tendinous arterial supply
  
  Kingston, M., Webb, A., Perriman, D., Smith, P.N.

- A promising orthopaedic material SrP-TNTZ for osteoporotic bone
  
  Li, R., Chen, X., Zhang, D., Birbilis, N., Smith, P.N.

- Does hip impingement planning software improve outcomes at 1 year for patients who have had surgery for femoracetabular impingement?
  
  Lynch, J., Baddock, S., Perriman, D., Burns, A., Neeman, T., Smith, P.N.

- A comparison of femoral head allograft preparation methods
  
  Marshall, T., Chow, J., Ahmed, N., Jones, A., Smith, P.N.

- Patient reported outcomes following displaced mid-clavicular fractures: operative vs non-operative management
  
  Van Alphen, M., Perriman, D., Vrancic, S., Smith, P.N.

- An in vivo three dimensional method for investigating the kinematics of femoroacetabular impingement: early results.
  

- Supercable Fatigue Testing for Simulating Femoral Fracture
  

- Life after arthroplasty
  
  Shadbolt, B., Meresfield, S., Perriman, D., Smith, P.N.

- E-POSTER: The development of an MR atlas of the cervical spine musculature
  
  Au, J., Perriman, D., Pickering, M., Buirski, G., Smith, P.N., Webb, A.

- E-POSTER: Lifestyle restrictions following total hip arthroplasty: do we need them?
  
  Robertson, T., Perriman, D., Smith, P.N., Fearon, A

AOA and NZOA combined Annual Scientific Meeting, Cairns, QLD

- A promising modulus appropriate implantable material SrP-TNTZ
  
  Li, R., Chen, X., Zhang, D., Birbilis, N., Smith, P.N.

- In-vivo kinematics of femoroacetabular impingement
  

- Does hip impingement planning software improve patient outcomes in patients who have had surgery for femoroacetabular impingement?
  
  Baddock, S., Perriman, D., Neeman, T., Lynch, J., Burns, A., Smith, P.N

10th World Biomaterials Congress, Montreal, Canada

- POSTER: Addressing the challenge in osteoporotic fracture fixation through strontium-releasing surface
  
  Ding, Y., Li, R., Majumdar, T., Birbilis, N., Smith, P.N., Chen, X.

Australian Biomedical Engineering Conference, Brisbane, QLD

- A New Optimization Technique for Fast Multi-Modal 2D-3D Registration
  
  Galvin, C., Pickering, M., Perriman, D., Scarrvell, J.
Canberra Health Annual Research Meeting

- Does hip impingement planning software improve patient outcomes in patients who have had surgery for femoroacetabular impingement?
  Baddock, S., Perriman, D., Neeman, T., Lynch, J., Burns, A., Smith, P.N.
- The ischial spine sign predicts patients who improve most after FAI surgery.
  Ellis, S., Perriman, D., Burns, A., Neeman, T., Lynch, J., Smith, P.N.
- Pain, rather than impairment, may drive walking, standing and strength dysfunction in women with hip pain
  Fearon, A., Neeman, T., Cook, J., Scarvell, J., Smith, P.N.
- What is the most effective strategy for treating pelvic discontinuity? A systematic review.
  Szczepanski, J., Perriman, D., Smith, P.N.
- Surgical management of displaced midshaft clavicular fractures results in better 5+ year patient reported outcomes.
  Van Alphen, M., Perriman, D., Neeman, T., Vrancic, S., Smith, P.N.
- POSTER: The influence of variable gearing on hamstring injuries; a conceptual model.
  Kenneally-Dabrowski, C., Perriman, D., Spratford, W., Serpell, B.
- POSTER: Life after arthroplasty – factors affecting risk of subsequent arthroplasty
  Merefield, S., Perriman, D., Smith, P.N., Shadbolt, B.

17th International Conference on Biomedical Engineering Systems and Technologies, Rome, Italy

- Investigation of wear in orthopaedic hip prosthetic devices
  Ihesiulor, O.K., Shankar, K., Smith, P.N., Fien, A.

ACT Australian Physiotherapy Association Research Symposium

- Why do some people have multiple dislocations after a total hip arthroplasty? **WINNER BEST PAPER**
  Perriman, D., Watson, L.A., Neeman, T., Young, S., Smith P.N.
- Deep knee flexion in 6 degrees-of-freedom, comparing older males and females
  Hribar, N.

Australian and New Zealand Orthopaedic Research Society, Melbourne, Vic

- Osteoanabolic Implant Materials for Orthopaedic Treatment
  Li, R., Chen, X., Zhang, D., Birbilis, N., Smith, P.N.

Tissue Engineering and Regenerative Medicine International Society – Asia Pacific Meeting, Taiwan

- Osteoanabolic Implant Materials for Orthopaedic Treatment.
  Chen, X., Li R., Smith, P.N., Birbilis, N.

Australian Orthopaedic Registrar Association Scientific Meeting, Cairns, QLD

- In-vivo kinematics of femoroacetabular impingement **WINNER BEST PAPER***

Educating the Next Generation

Doctor of Philosophy

Ben Serpell - ANU

Is there a relationship between hamstring and quadriceps co-contraction and ACL elongation?

Ben began working at TORU as a research assistant after completing his studies in Occupational Therapy and Human Movement in Victoria on projects related to knee kinematics following knee arthroplasty. He has been a part-time PhD candidate at the Australian National University while working full-time as Athletic Performance Director for the ACT Brumbies rugby club. Ben’s research remains concerned with knee joint kinematics and kinetics as he tries to establish if there is a relationship between musculotendinous stiffness and traumatic lower limb injury with special reference to anterior cruciate ligament injury. Ben recently submitted his PhD and will graduate in the upcoming months!

Claire Kennelly-Dabroski - ANU

The dynamic architecture of the hamstring complex: An investigation into its influence on injury and performance.

Claire’s started her PhD with us this year after working as a post-graduate scholar at the AIS. Prior to working at the AIS She completed her undergraduate degree in Sport and Exercise Science at Federation University. Her PhD is a collaborative effort encompassing the ANU, AIS, and ACT Brumbies focussing on hamstring injuries. Hamstring injuries are common in running based sports and rates of initial injury and recurrence are high. Injuries usually affect the biceps femoris long head (BFllh) muscle during sprinting and the personal and financial consequences are significant. This project aims to examine how the architecture of the BFllh muscle influences high speed running. More specifically, the main research question to be addressed is: ‘Does the architecture of the BFllh muscle affect its performance and potential for injury?’ In addition, there are three sub-questions to be addressed through the three main studies.

1. What is the morphology and architecture of the BFllh muscle in elite athletes?
2. How does the architecture of the BFllh muscle function during high speed running in elite athletes?
3. Can a training intervention change the architecture of the BFllh muscle?

Song Chen - ANU

A Bioinformatics approach to establish an osteo-network: Osteomics

Song is a PhD student of ANU. Song gained his bachelor of applied physics from Shanghai JiaoTong University in China and master of engineering from ANU. He has a background in theoretical physics and computational analysis of engineering materials.

Song’s PhD project is to investigate interactions at the interfaces among pathways of multiple systems in bone remodelling. His work is currently focusing on re-building signalling pathways in osteoblasts and osteoclasts by mathematical description and proving this description by designing the experiment to treat osteoblasts, osteoclasts and co-culture of osteoblasts and osteoclasts under physical stimulus from low frequency electro-magnetic field. Song’s PhD project is supervised from both TORU and the college of engineering and computer science in ANU. This project is partially supported by MAWA research grant."
Yuan Chai - ANU

Novel orthopaedic metal implant manufacturing method that centered with 3D printing technology

Yuan is a PhD student of ANU. Yuan gained his bachelor of engineering from China University of Mining and Technology. He has a background in mineral powder processing and 3D printing technology. Yuan’s PhD project is to establish an effective way of manufacturing orthopadic metal implant by investigating the interaction between laser energy and metal powder during selective laser melting process, and researching the biomedical respond to the manufactured item within different fabrication conditions and post processes. His work is currently focusing on modeling of the energy distribution of laser beam scanning on material surface, trying to build a universal optimized model of laser-material interaction for our current equipment. This work includes numerical simulation of laser sintering process, experimental manufacture validation, and mechanical property/ biocompatibility test. Yuan’s PhD project is supervised from both TORU and the college of engineering and computer science in ANU.

Catherine Galvin - University of Canberra

Age-associated variation in both healthy and ostearthritic knee kinematics

Catherine is an engineer who is entering her final year of her PhD at TORU. Catherine’s area of interest is the biomechanics of the knee, specifically, how the biomechanics of the tibiofemoral joint changes due to ageing and knee osteoarthritis. Her research looks at the movement of the femur and tibia while a knee is straightening and deeply bending. Using a non-invasive imaging process, she is combining the data from fluoroscopy and CT scan to generate 4D images of the knee. She is developing a set of normative data for the kinematics of healthy ageing knees and knees with OA. This data set will help inform the improved design of knee replacement prosthesis and the development of healthy knee programs that can delay the symptoms of knee OA and keep healthy knees healthy.

Obinna Ihulsior - UNSW @ ADFA

Simulation of wear in total knee replacement using finite element analysis

Obinna is a PhD student at UNSW Canberra. He obtained his Masters degree in 2012 at the same university. His current research interest is in the area of prosthetic devices for joint replacements. His PhD research work is on the investigation of wear of total hip replacement at the taper-trunnion junction. Recently, it’s been identified that excessive fretting wear at the taper-trunnion (head-neck) junction potentially contributes to premature failure of some total hip replacement procedures. The project aims to develop novel methods for investigating, evaluating and quantifying wear of total hip prostheses at the taper-trunnion junction by employing numerical methods via finite element modelling. In a broader sense, the principal goal is to work toward the minimization of wear debris produced in the hip joint, thereby resulting in a longer prosthetic lifetime. This work is supported by Global Orthopaedics.
**ANU Medical Students Completed Research Projects**

**Laurance Watson**

Why do some people have multiple dislocations after a total hip arthroplasty?

**Additional Authors:** Diana Perriman, Teresa Neeman, Sam Young, Paul N. Smith

**Introduction:** Dislocation after THA has been relatively well studied but the risk factors for multiple dislocation are poorly understood. The aim of this study was to examine the factors which discriminated between patients who dislocated three or more times compared to those who dislocated fewer than three times.

**Methods:** THA patients who dislocated between 1997 and 2015 were identified, of which 78/338 were multiple-recurrent dislocators (≥3 dislocations). These patients were age/sex-matched with patients from 260 finite dislocation controls (≤ 2 dislocations). 36/78 multiple-recurrent dislocators were further identified as revised-recalcitrant dislocators (dislocated in spite of revision/s) and compared with matched controls. Chi-square tests were performed to identify the most predictive risk factors. The relative effect of these factors was then estimated using multivariate logistic regression and odds ratios.

**Results:** Polypharmacy (≥6 medications) was the dominant risk factor for multiple-recurrent dislocation (≥2 surgeries) [OR: 9.37 (95% CI: 4.01 – 21.9; \( p < 0.001 \)] followed by revision surgery [OR: 5.85 (95% CI: 1.82 – 18.8; \( p < 0.003 \)]. For revised-recalcitrant dislocators, revision history and polypharmacy were most predictive [OR: 26.2 (95% CI: 4.74 – 145; \( p < 0.001 \)] and 13.9 (95% CI: 3.10 – 62.2; \( p < 0.001 \)], respectively. Only 5% of recurrent-multiple dislocators had a successful revision halting further dislocation.

**Conclusion:** Multiple-recurrent dislocators are distinguished by polypharmacy and an increased incidence of revision surgery. Early recognition of these patients may facilitate more effective revision surgery.

**Maxine Rees**

**Title:** Dorsal root ganglia volume changes using 3 Tesla-magnetic resonance imaging in acute and chronic whiplash patients

**Additional Authors:** Alexandra Webb, Diana Perriman, Christian Lueck

**Study design:** A prospective cohort study

**Objective:** To assess whether cervical dorsal root ganglia (DRGs) volume is altered after whiplash.

**Summary of background data:** There is currently a lack of understanding of the symptoms experienced by whiplash patients. In vivo morphological changes in the cervical spine have been inconsistent. Biomechanical and autopsy studies suggest that DRG damage may lead to pain after whiplash due to neural hyperexcitability.

**Method:** 3T magnetic resonance imaging (MRI) scans of subjects from control, acute and chronic whiplash groups were selected from the larger ‘Characterising whiplash with MRI’ study. MRI scans were analysed using Mimics software. Cervical DRG (C2-C7) were defined on sagittal slices and reconstructed to render 3-dimensional volumes. DRG volumes were compared by vertebral level, side of the body at corresponding levels, sex, and whiplash group using a linear mixed model.

**Results:** The model revealed a significant group by level effect with apparent reduction in chronic group DRG volume between C2 and C4. However, there was no significant difference between the groups when analysed by level. In control patients DRG volumes were smallest at C3 and C4, slightly larger at C2 and C5 and largest at C6 and C7. Their shape was most spherical at C2 becoming progressively more elongated by C7. There was no difference in DRG volume by side of the body and males had larger DRG than females at C6 and C7 only. Chronic whiplash patients had relatively smaller ganglia at C2-C5 and both acute and chronic whiplash patients had larger ganglia at C6 and C7.
Mitchell Connelly
Post-thrombotic syndrome following lower limb arthroplasty: A systematic review
Additional Authors: Diana Perriman, Paul Smith

Background: Post-thrombotic syndrome (PTS) is a known long-term complication of deep vein thrombosis (DVT). Given that DVT is relatively common after arthroplasty, the risk of PTS is advanced as the reason for routine anti-thrombotic therapy post-discharge. This therapy is both expensive and uncomfortable and there is clinical suspicion with respect to the routine need. This study aimed to examine the strength of the evidence for an association between PTS and asymptomatic DVT post arthroplasty.

Methods: Of 1286 papers screened ten papers were included in the review following a systematic electronic literature search. Studies were included if participants had undergone total hip arthroplasty (THA) or total knee arthroplasty (TKA), screened post-surgery for asymptomatic DVT and then reassessed for PTS a minimum of six months post-surgery. Data from each separate paper was analysed using the Cochrane software package.

Results: The meta-analysis identified a relative risk of 2.56 (CI 1.55 to 4.25; I² 61%) in THA or TKA patients who developed an asymptomatic DVT compared to those who did not (p = 0.006).

Conclusions: This review identified that there is a substantially increased risk of PTS with asymptomatic DVT after lower limb arthroplasty. However, the absence of a standardised diagnostic criteria for PTS resulted in decreased precision between studies and therefore the results should be viewed in the light of this limitation.

Corey Ta
Title: Normative Volume of Cervical Spine Muscle Established Using 3D Magnetic Resonance Imaging

Introduction: Two-dimensional measurements of cervical muscles have been extensively reported in the literature, especially in relation to whiplash associated disorders. However, these measurements may have been affected by measurement errors due to inconsistent slice angles and the partial volume effect. This study aimed to provide three-dimensional measurement of volume for all cervical muscles in healthy adults. Furthermore, the correlation between cervical muscle volume and neck morphometry will be investigated.

Materials and Methods: T1-weighted axial magnetic resonance (MR) images of five healthy adults were obtained using a 3 Tesla MR scanner. All xx cervical muscles were individually segmented on the MR images from the level of the occiput to the first thoracic vertebra. The volume of each muscle, on the left and the right, was calculated. Add in here the rest of the methods including the statistical analysis to investigate correlation

Results: 3D volumes were determined for 26 of the 27 cervical muscles. There was a moderate relationship between neck morphology and cervical muscle volume (r = 0.7) and a weak negative relationship between muscle volume and neck length.

Conclusions: The data from this study will be used to inform a semi-automated segmentation method. This will streamline the process of calculating individual muscle volume to facilitate investigation of changes in muscle size and muscle fat infiltrate in individual muscles following whiplash injury.

Andy Daniluk
Volumetric Studies of the Cervical Disc: the normal and whiplash case
Additional Authors: Diana Perriman, Alexandra Webb, Bryan Ashman

Objective: The goal of this study was to measure intervertebral disc volumes in the cervical spine. These volumes are then established in a normal group of subjects and compared to a chronic whiplash group.

Background: Currently there are a significant number of patients who present with the clinical features of the whiplash syndrome with minimal evidence of injury on MR imaging. The cervical intervertebral discs are hypothesised to be injured in whiplash; however they also undergo physiological degeneration from an early age. Studies thus far have focussed on their signal intensity and regions of interest, and to date have found no significant differences. To our knowledge no-one has studied cervical discs in a quantitative, volumetric manner in a normal or whiplash setting.

Methods: Here we undergo a protocol designed to threshold the MRI signal values to distinguish the disc region from surrounding structures. Then an observer systematically, though manually, edits the threshold masks to eliminate material outside the disc or fill in gaps. This creates 3D models that are representations of the cervical intervertebral discs from which volume can be quantified.

Results: We found no difference in disc volume between the normal and chronic whiplash groups. However, we determined that disc volume is associated with gender and vertebral level. Intra-observer reliability (Intraclass Correlation Coefficient (ICC)2,1) was 0.98

Conclusion: These preliminary results provide a method for the quantification of cervical disc volume. Disc volume does not appear to change as a result of chronic whiplash injury.
**Masters**

**Completed**
Corryn Coulter, a musculoskeletal physiotherapist at the Canberra Hospital, finished her Masters this past year. The title of her thesis was: “Rehabilitation after Total Hip Replacement—an RCT”. Congrats Corrin!

**Ongoing**

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<tr>
<th>Dr Sumedha Amarasekara</th>
<th>Dr Mitchell Kingston</th>
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<td>Supercable Fatigue Testing for Simulated Femoral Fracture</td>
<td>Arterial Anatomy of the Gluteus Medius and Minimus tendons</td>
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<td>Biomechanical factors predisposing injury in Sprint kayaking, marathon kayaking and ocean paddling</td>
<td>The antibacterial provision of orthopaedic implants with silver nanoparticles</td>
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<td>Supervisors: Prof Paul Smith, Dr Diana Perriman</td>
<td>Supervisors: A/Prof Rachel Li, Prof Paul Smith</td>
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University of Canberra Physiotherapy

Nicky is currently completing her Honours in Physiotherapy at the University of Canberra in the area of knee kinematics. Her project belongs to the PICKLeS knee study and answers the question "Do older male and female knees move differently?". Using a 2D-3D registration process the study will be the first to examine tibiofemoral kinematics with six degrees of freedom in an older population. After graduation Nicola will enter the Australian Defence Force as a uniformed Physiotherapist.

Current ANU Medical Students

Tom Staniforth is a physiotherapist who has decided to change careers and move into medicine. The title of his project is: The effect of capsule-synovial thickness on pre-operative functional status and 12 month outcomes in patients with femoroacetabular impingement.

Henry Williams entered medicine after a number of years working as a plumber. Henry will answer the question: Does Oxford Knee score predict deviation from normal step-up kinematics in patients with osteoarthritis.

Laura Soffoulis comes from a science background. For her medical school project Laura want to examine the functional outcomes after MUA for arthrofibrosis.

Martin Schutte comes from a chiropractic background. For his project, Martin wants to investigate whether a complete bony restoration is required for good outcomes after a Laterjet procedure.

Kaitlyn Jacobs is a Science graduate who previously worked as a Research Assistant. The title of her project is “Kinematic parameters predict OKS during deep knee bend kinematics in patients with osteoarthritis”.

Kitiphume Thammasiraphop has completed a Bachelor of Medical Science at UNSW. He is working with Rachel Li on his project entitled: Novel Strontium Phosphate Coated Materials Enhance Osteogenesis of Orthopaedic Implants.
Trauma and Orthopaedic Research Events

AOA ACT ASM

The Australian Orthopaedic Association’s ACT branch, in collaboration with TORU, held it’s annual scientific meeting on December 5th 2015 at the ANU medical school. There were a record number of presentations and posters at the meeting with topics ranging from arthroplasty to trauma to sports medicine. The guest speaker this year was Professor Michael Solomon from Sydney whose interest in hip surgery includes the adult, teenager and paediatric age group with his recognized expertise in the treatment of hip disorders. Prof Solomon gave two presentations entitled: “Hip Dysplasia: Current concepts, management and osteotomies” and “Total Hip Replacement in the very young patient”. Following the meeting, a dinner was once again held at the Commonwealth Club to celebrate the achievements of the presenters and organisers plus look back at the year that was. See below for all of the award winners from the meeting.

AWARD WINNERS

Best Lab Paper - Rachel Li: A promising orthopedic material SrP-TNTZ for osteoporotic bone
Best Paper – Jim Pierrepont: Pelvic tilt in the standing, supine and seated positions
Best Poster - Stefan Paret: High-resolution imaging in tendinopathy, added value or just a niche?
Best Registrar - Tom Ward: An in vivo three dimensional method for investigating the kinematics of femoroacetabular impingement: early results
Best Student – Mike Van Alpen: Patient reported outcomes following displaced mid-clavicular fractures: Operative vs Non-Operative Management

AOA Student Week

Each year the Australian Orthopaedic Association hosts a week-long undergraduate workshop designed to showcase orthopaedic surgery, through a combination of lectures and practical exercises, to final year medical students. It is held in a different state every year with Canberra hosting this past year’s workshop from 30 November to 5 December. The AOA invited Universities from across the country to nominate one student, who was interested in pursuing orthopaedics as a career, to attend this exciting initiative. The ANU selected Aleria Selkert to attend this event. The next student week, to be held in Adelaide, will be attended by Matthew Lim.

Each day the students took part in various activities that included:

- Orthopaedic Research Morning which included presentations from Prof Paul Smith and Dr Rachel Li
- Orthopaedic research tools workshop
- Time in theatre with consultants of various specialties
- Plastering workshop
- Saw bone workshop
- War Memorial Tour with Dr Brendan Nelson

The final day had the students attend the ACT’s Annual Scientific Meeting followed by the annual dinner.
Research Breakfasts

3D Printing and Beyond: Orthopaedics for the 21st Century

In April, TORU brought in Mike D’Souza, the CEO of Australian 3D Manufacturing Association (3DMA) to talk about 3D printing in Orthopaedics. A3DMA is the not-for-profit body that develops, promotes, builds, networks and informs Australians about 3D Manufacturing, 3D printing, additive and advanced manufacturing techniques. Mike’s presentation started by highlighting the history of 3D printing both in general and in orthopaedics. Following this, Mike touched on what is currently happening in orthopaedics, giving examples of custom titanium implants used for patients with bone defects from cancer. Lastly, Mike spoke about how he thinks the continued development of implants and printing tissues for damaged structures is the future 3D printing. Mike’s talk was very informative and all attended were grateful for his insights to this ever developing industry.

Complex Regional Pain Syndrome

During CHARM week, TORU were lucky enough to have hosted Professor Lorimer Mosely for a research breakfast at the ANU Medical School. Lorimer is Professor of Clinical Neurosciences at the University of South Australia and Senior Principal Research Fellow at Neuroscience Research Australia. He leads the Body in Mind research group, which investigates the role of the brain and mind in chronic pain, undertaking both fundamental behavioural and neurophysiological experiments, and randomized controlled trials and prognostic studies. Lorimer sought to explain the brain’s role in explaining and treating complex regional pain syndrome. As always, Lorimer’s enthusiastic presentation style, combined with his passion and knowledge of neuroscience captivated the audience and left a lasting impression on everybody in attendance.
This past year, TORU was able to purchase a Mac Pro computer for our office thanks to a generous donation from The Canberra Hospital Foundation. The purchase of this computer, and its associated software, allows both researchers and clinicians to investigate clinical problems that might not have been possible before. Specifically, we are able to visualise patient anatomy in higher resolution, reconstruct diagnostic scans into three and four dimensional images, and process large amounts of data quickly. This enables better knowledge of patient anatomy and mechanics, and could allow for the development of treatment plans and surgical options before operating on patients thereby potentially improving patient outcomes. We would again like to thank the gratitude of the Canberra Hospital Foundation for funding the important piece of equipment.
TORU Prizes

ACT Branch Australian Orthopaedic Association Annual Scientific Meeting

**BEST STUDENT PAPER**
Patient reported outcomes following displaced mid-clavicular fractures: operative vs non-operative management
Van Alphen, M., Perriman, D., Vrancic, S., Smith, P.N.

**BEST REGISTRAR PAPER**
An in vivo three dimensional method for investigating the kinematics of femoroacetabular impingement: early results.

**BEST LAB PAPER**
A promising orthopaedic material SrP-TNTZ for osteoporotic bone
Li, R., Chen, X., Zhang, D., Birbilis, N., Smith, P.N.

University of Canberra Three Minute Thesis

**PHD COMPETITION WINNER; SECOND PLACE OVERALL**
A Moving Tale of the Femur and Tibia
McMaster, C

ACT Australian Physiotherapy Association Research Symposium

**BEST PAPER**
Why do some people have multiple dislocations after a total hip arthroplasty? **WINNER BEST PAPER**
Perriman, D., Watson, L.A., Neeman, T., Young, S., Smith P.N.

Australian Orthopaedic Registrar Association Scientific Meeting, Cairns, QLD

**BEST PAPER**
In-vivo kinematics of femoroacetabular impingement

Interested in Studying with TORU in 2017?
TORU is affiliated with the Australian National University and works closely with UNSW@ADFA and University of Canberra as well. Prospective higher degree students are encouraged to consider possible research opportunities at TORU in 2016. Contact TORU or prepare a 1-2 page research proposal for TORU to consider. TORU is committed to progressing research in trauma and orthopaedics, and to developing young researchers.