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.

Message from the Director

This has been another productive year in TORU with a few milestones to celebrate. Of note have been three successful collaborations yielding grant moneys totalling over 2 million dollars from the ARC and the NHMRC. Of course not all of this money will come to TORU but there is nothing like a successful grant to put a spring in one’s step. These projects include two laboratory collaborations with Monash and Griffith University and a clinical RCT which is being coordinated by Prof Ian Harris.

Research funding has become very challenging in recent years and we are most grateful for any philanthropic support that may come our way. To this end we are pleased to be associated with the Canberra Orthopaedic Research and Education foundation (CORE) which is a body established to help fund excellence in orthopaedic research and practice in the ACT. CORE will provide a nexus for philanthropic support of orthopaedic research and excellence in the Canberra community.

We have had the pleasure of hosting 3 fellows this year including two Deupuy Synthes Fellows: Mitchell Kingston who is an unaccredited registrar and MPhil candidate at ANU and Tom Ward who is an accredited registrar conducting Post doctorate work; and Sam Young who is a Stryker arthroplasty fellow. We very much appreciate the industry support offered for these fellowships which enable talented young orthopaedic surgeons the opportunity to conduct research in a research rich environment.

Finally, I need to acknowledge the amazing efforts of our laboratory and clinical teams who have worked tirelessly, as always, to create important new knowledge while nurturing young minds and navigating the minefield that is grant writing. The laboratory and clinical teams, although located on separate sites, support and encourage each other and, by so doing, make TORU a uniquely cohesive unit whose reputation continues to grow and of which I am inordinately proud.

Australia-China Collaboration in Orthopaedics

In September, Director of TORU, Professor Paul Smith and Dr Rachel Li, Head of TORU Laboratory, were invited by Professor Qunhua Jin, Director of General Hospital of Ningxia Medical University to visit the hospital. During this visiting, Paul and Rachel presented TORU's research outcomes and delivered lectures to Chinese orthopaedic professionals and postgraduate students. A memorandum of understanding on future collaboration in clinical and research was signed between the hospitals and TORU. Prof Smith delivered a presentation entitled “Is modularity a problem?” introducing orthopaedic implant devices for the use of exchangeable parts or options in the fabrication of an object. Dr Li’s invited lecture entitled “Orthopaedic Implants Materials: Past, Present and Future” highlighted urgent need in research on materials for orthopaedic implants and emphasized our research today is part of future. This visit was a great opportunity to discuss clinical and laboratory experiences face-to-face, new ideas and establishment of research relations with global partners for future collaboration.

Professor Smith and Dr Li also presented at The World Congress of Orthopaedics on a clinical investigation on “Massive Acetabular Reconstruction in Revision Total Hip Arthroplasty”, which caused a great interest and discussion among clinicians from the USA and Europe. Rachel presented TORU’s laboratory research entitled “Revision Joint Arthroplasty - A View from Nano Osteoimmunology and Genetics”, in which she suggested the aberrant expressed miRNA can be used as targets in development of prevention and treatment for control implant loosening. They also had a sightseeing of Xian’s historical museum - Terracotta Army.
TORU's People

**Prof Paul Smith, BMBS FRACS (Ortho). Director**

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.

Contact:
psmith.admin@orthoact.com.au

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**Dr Diana Perriman, PhD. Clinical Research Co-ordinator**

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 of 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

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**Dr Rachel W Li, MD, PhD. Laboratory Research Co-ordinator**

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 (CMU) from 1982 to 1996. She led a number of clinical trials in anti-viral and anti-inflammatory drugs and successfully transferred an intellectual property to pharmaceutical industry.

In 2003 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 returned to Australia in 2006 and established the TORU Laboratory which pioneered basic orthopaedic research at the ACT region. 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.

Contact: rachel.li@anu.edu.au
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.

Dr Mona Singhal, Research Officer

Dr Singhal studied medicine at Bangalore University, India. Dr Singhal has just completed the Australian Medical Council Registration Examination. She worked with us from 2013 to April 2015 as a Research Officer on the Whiplash study.

Mrs Christine Hanrahan, Database Manager

Christine Hanrahan is a qualified nurse and has worked with both the Red Cross and the Therapeutic Goods Administration. Christine helped to develop the Arthroplasty surveillance database and continues to manage the database which is based at Orthopaedics ACT.

Dr Ruidang Wang, Database Architect

Rui is a database architect who designed the Fracture Surveillance Database, iFracture. Rui has extensive IT experience specialising in applying database design, analytic informatics, business intelligence and online platform technologies to clinical context. Rui has just completed her PhD at ANU entitled A new generation system for scientific knowledge discovery.

Ms Amanda Phillips, Database Officer

Amanda works closely with Christine as part Joint Surveillance team at Orthopaedics ACT to help manage the arthroplasty database. Along with Christine she ensures joint replacement patients are followed up regularly and the data is accurate.
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.’

Assoc Prof Jennie Scarvell
B(App)Sc Physiotherapy, Grad Cert Higher Ed, Cert Health Economics, PhD, A/Prof Dept of Physiotherapy (University of Canberra).
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.

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.
Prior to working as a doctor, Tom lived in New York, and worked as a consultant for McKinsey and Company, which involved studies of the pharmaceutical industry in the United States and of health policy in the Middle East. Tom has also been involved in biomechanics training in Cambodia in the decade between 1999 and 2009, and hopes to continue this involvement when he completes his orthopaedic surgical training. He is currently conducting post-doctoral research through TORU, focusing on the kinematics of femoroacetabular impingement.

Dr Sam Young FRACS
Sam grew up on a farm in the south west of WA. He undertook his orthopaedic training in WA and completed his FRACS exam and training in 2014. Currently Sam is a Stryker Orthopaedic Fellow at Orthopaedics ACT and TORU with planned fellowships in Brisbane and London, Canada.
Sam’s interests lie in hip and knee joint reconstruction as well as trauma. He has a particular research interest in hip tribology and metallosis as well as taper disease. Currently he is a co-author in a retrieval study examining determinants of taper corrosion in hip implants.
Personally, Sam enjoys being outdoors, fishing, four-wheel driving, working on the farm with his family.

Dr Mitchell Kingston
Dr Kingston is an orthopaedic registrar at the Canberra Hospital and Deupy Synthes Clinical and Research Fellow. He is currently undertaking an MPhil at the ANU looking at the anatomy of the circumflex femoral arteries.
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Ben Serpell 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 and remains an affiliated of TORU while he completes his study for the last few years. 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. To do so Ben is upskilling in the use of technology including electromyography, force plates, and the novel CT-Fluoroscopy algorithm used for measuring knee joint kinematics originally developed by Mark Pickering and others at TORU. Ben is in the final stages of his PhD and will be submitting within the next few months.

Ben juggles his part-time studies with full time work as the rehabilitation coordinator for the ACT Brumbies. He has held similar roles with other football clubs including Port Adelaide Power and Gloucester Rugby in the United Kingdom.

Andrew Griffin has begun a PhD investigating injury in competitive kayak and ocean paddlers. This study will investigate injury type, injury rates and their contributing factors as well as biomechanical investigations.

The purpose of the PhD is investigating injuries in competitive Ocean, Ultra-Marathon and Sprint kayak and Ocean-ski paddlers. There is very little published data about injury in these groups, and none in relation to Ocean-ski paddlers. With ocean racing growing rapidly in popularity, and ocean skis being used more commonly in flat-water racing, the altered biomechanics and impact on injury is generally unknown.

Andrew is a medical intern at The Canberra Hospital and has a background in Sports Physiotherapy and Exercise Science with elite athletes including having worked at the English Institute of Sport.

Catherine Galvin is an engineer who started her PhD with TORU midway through 2014. 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 new non-invasive imaging process. She is combining the data from a fluoroscope and a CT scan to generate a new 3D image showing us the relative motion of the bones. Her plan is to develop a set of normative data for the kinematics of healthy ageing knees and knees with OA. This will be the first of its kind. This new data set will 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.

Catherine has been the lecturer and tutor in biomechanics at the University of Canberra. Catherine was the University of Canberra PhD winner of Three Minute Thesis Competition and participated in the Trans-Tasman finals in Brisbane in October. She was also very honoured to be nominated and made a Fellow of Engineers Australia and to be awarded the 2015 scholarship for Women in Biomedical Engineering.
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 electromagnetic 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.

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 minimisation of wear debris produced in the hip joint, thereby resulting in a longer prosthetic lifetime. This work is supported by Global Orthopaedics.

Weiqiang obtained his bachelor in biomedical sciences and completed his honours in Microbiology from UWA in collaboration with the Singapore Immunology Network (SIgN, A*STAR). His current research interests are in arthrogenic alphavirus pathogenesis and host’s immune response to the virus infection.

His PhD project investigated the bone remodelling pathways and musculoskeletal pathologies during Ross River virus and chikungunya virus infection using murine models. The findings from his PhD shed new insight on how alphaviruses cause bone loss in murine and human infections. His work also showed that primary human osteoblasts from osteoarthritis (OA) patients are more susceptible to alphavirus infection, suggesting the possibility of exacerbated alphavirus-induced bone pathology in individuals with pre-existing OA.

Weiqiang started his PhD with Professor Suresh Mahalingam in 2011 and graduated this year from the Institute for Glycomics, Griffith University.
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 life-long 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 afflict millions of Australians and cause tremendous human suffering, and cost million 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 mRNA 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**

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.

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

This area 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 team is studying biocompatibility, biodegradability and bioactivity on a series of magnesium (Mg)-based biomaterials either on controlling biodegradation or osteointegration.

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

Integrated molecular, genetic and mathematic 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.**

We are screening anabolic drug candidates for bone biological therapeutics that promote wound and fracture healing by directing the progenitor cells growth and differentiation. We are also exploring the use of natural extracellular matrix components as biomaterials that provide appropriate structural and stimulating properties for generating functional osteoblast and bone cells.

**Laboratory Facilities**

TORU Laboratory is located at the John Curtin School of Medical Research in the Australian National University and has established collaborations with Professor Chris Parish at the Department of Immunology and Genetics. TORU Lab has access to all the necessary high-end equipment.

Dr Rachel Li
Laboratory Research Coordinator
**Functional Strontium Phosphate Coated Magnesium Alloys for Orthopaedic Use**

Fractures are common in Australia and of particular concern with the aging demographic with fractures associated with osteoporosis. The incidence of hip fractures has been projected to increase by 15% every 5 years and an estimated 150,000 fractures by 2026 and over 200,000 by 2050. Fracture management frequently requires the implantation of internal fixation devices such as plates, rods and screws in order to stabilise the injury. Traditionally, such implants are made of materials such as stainless steel, titanium or cobalt-chromium alloys. These materials differ substantially to mechanical properties of bone. In particular, these materials have a significantly higher tensile properties than bone, producing stress shielding around implants. In addition, concerns have arisen over the release of toxic elements of the existing internal fixation devices and the low bone-tissue-growth rate over their surface. As such, addressing these issues in implant design should consider the development of techniques and materials to promote bone growth for more assured recovery.

This project aims to: (1) Develop a functional strontium (Sr)-release surface upon magnesium-based orthopaedic implants to suppress the rapid degradation rate of Mg; (2) Facilitate new bone formation and ultimately shorten healing process. The project will increase our understanding of the formation mechanisms in Sr-releasing coatings, and determine the critical release rate of Sr to activate bone cell responses (Figure 1). This project addresses two key issues: (1) The inherent high degradation rate of magnesium-based biomaterials for orthopaedic uses; and (2) The low bone growth rate at bone-implant interface.

The knowledge will form a scientific basis to engineer more advanced biomedical materials from the “bottom up”, provide the necessary demonstrations, and establish a commercial product protocol. The project is significant for the development of practical, bone-favourable and degradation-inhibiting surfaces for magnesium implants, which are in demand and can bring significant patient benefits.

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**Can bone cells be “programmed” by electromagnetic fields?**

In 1979, FDA approved the usage of pulsed electromagnetic fields for the treatment of delayed or non-healing fractures. However, the underlying mechanisms at a cellular level are still not completely understood. Both in vitro and vivo, research findings have revealed that certain electromagnetic fields, can enhance bone fracture healing and bone formation by bone marrow derived osteoblasts. Researchers also found that electromagnetic fields can either accelerate apoptosis, enhance cell proliferation or suppress cell proliferation of osteoclasts depending on the strength and frequency of the field. This indicates that electromagnetic fields could be a function generator which manipulates bone cells by different combinations of its physical parameters. If so, can we program bone cells by electromagnetic fields, such as switching the mode of osteoblasts from proliferation to apoptosis and then back to proliferation?

We developed a system to generate electromagnetic fields within an incubator. This system is capable of switching from static electromagnetic fields to pulsed electromagnetic fields and monitoring the induced magnetic field’s intensity and frequency. We studied osteoblasts and osteoclasts separately under different combinations of induced magnetic field intensity and frequency, as well as osteoblasts and osteoclasts co-culture. Based on the experiment data, we built several mathematical models trying to explain the underlying mechanism of bone cells at cellular level in an explicit formulation.

We found that exposure time of electromagnetic fields on bone cells showed no statistically significant differences. The influence of induced magnetic strength on osteoblast proliferation can be formulated with two postulated parameters of osteoblasts: (1) Adhesive coefficient and; (2) Diffusion coefficient. Alteration of these two parameters by changing induced magnetic intensity, direction and frequency can switch the mode of osteoblasts between proliferation and apoptosis. The osteoclasts have a more complicated mechanism than osteoblasts in electromagnetic fields and future research will attempt to find a targeted parameter to control.
**TORU Clinical Research Report**

**TORU laboratory and clinical interface:** Although TORU is one unit we are operationally organised as clinical and a laboratory unit. However, where possible we work together in order to optimize our effectiveness. To this end we have worked to support Dr Li in her biological work by recruiting patients and retrieving tissue for analysis in the laboratory. We hope one day to be able to translate her exciting discoveries to the clinical space in Australia.

**Pickles Knee Study:** Our largest clinical study continues to be the Pickles Knee study (below). This is a collaboration with CI Assoc. Professor Jennie Scarvell from the University of Canberra (UC) and Assoc. Prof Mark Pickering from UNSW at ADFA. Catherine Galvin, who is a jointly funded PhD candidate at UC, has spent the year recruiting and collecting the data for this project. As described below this RCT is primarily trying to examine whether the knee kinematics of the knee are reproduced in the prosthetic knee in vivo. We are also capturing valuable kinematic data for a large cohort of native knees which we will be able to examine for the effect of age and sex. Nicki Hribar, a UC honours student is also working on this project. We envisage that data collection for this study will be completed by early 2016. Sincerely thanks to Adrian Meijer, Amy Krause, Linda Crawford and Mel Egan from radiology for their continued support with this project. We also gratefully acknowledge support from Canberra Hospital Private Practice Fund and Zimmer Biomet (originally BioMet) for this study.

**Whiplash Studies:** For the past three years we have undertaken a fascinating investigation of MRI morphometry after whiplash with Dr Alex Webb from ANU. We are currently analysing the data for muscle, discs, dorsal root ganglion ligaments and synovial folds. Dr Dan Owers has completed his systematic review and submitted it for publication and Dr John Au has prepared two manuscripts based on the muscle findings including the development of a 3D cervical atlas using a graphical user interface designed by Assoc Prof Mark Pickering. We gratefully acknowledge support from Canberra Hospital Private Practice Fund for this project.

**Femoracetabular Impingement (FAI):** We are very interested in evaluating outcomes after arthroscopy for femoracetabular impingement. With the considerable assistance from Dr Al Burns and his team at OrthoACT, we have been collecting hip outcome scores (iHOT) for FAI patients over the past three years. This data has been used for two student projects (page 15) completed this year. We are hoping to streamline this process in the near future by adding FAI as a module to the web-enabled arthroplasty database discussed below.

**Surveillance:** Funding continues to be a major impediment to our efforts to interrogate important clinical questions and conduct large important trials but, as Prof Smith has outlined, we are actively involved with large collaborative projects which have gained institutional funding this year. In terms of corporate funding we are conducting a number of device surveillance studies including the Attune study (DeupSyneht) and the R3 study (Smith&Nephew) which will be in its final year is 2016. Joe Lynch has done a magnificent job of running these studies for TORU over the last two years.

**Whiplash Studies:** We are investigating heavily in terms of time and money into web-enabled data capture. To this end over the past 5-10 years we have been developing an arthroplasty ‘database’ and a fracture ‘database’ – iFracture which is described on the facing page. These systems leverage the power of the Discoverquick platform designed by Dr Victoria Wang and Associate Professor Bruce Shadbolt. Dr Wang is the architect of iFracture and Assoc. Prof Shadbolt has been instrumental in developing the Arthroplasty database.

**Student Research:** This newsletter contains descriptions of the medical student projects conducted under our auspices last year. We had a strong student cohort who undertook their work with application and rigor. We are currently preparing four of these manuscripts for publication in the coming year and submission to the AOA ASM scientific committee for presentation at next year’s ASM. MPhil and PhD research is detailed elsewhere.

**Finally TORU could not function without the considerable talents of our office manager Belinda Payne to whom we are always indebted for her hard work and application.**

Dr Diana Perriman
Clinical Research Coordinator

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**Pickles Knee Study—A prospective imaging study of cruciate retaining and substituting knee replacement, in osteoarthritis and healthy aging**

This study aims to examine knee kinematics before and after knee arthroplasty and compare these to the kinematics of knees in a non-arthritic age-matched cohort. In the past the only way of measuring knee kinematics accurately in three planes was to implant RSA beads or use of bone pins. These methods are both highly invasive. In this study we aim to overcome this problem by using an image registration technology developed at TORU by Prof Smith, Assoc Prof Jennie Scarvell and Assoc Prof Mark Pickering by combining 3D CT and 2D video fluoroscopy. This study is unique because, for the first time, knee replacement patients will have their knee kinematics accurately measured both before and after surgery. Recruitment is nearly finished for both the total knee replacement patients and healthy controls. Volunteers participating range from 20 to 90.

Participants have their knee is scanned while they perform a number of loaded end-of-range activities which will us to see how the knee kinematics change following surgery compared to normal. OA patients are randomised to receive one of three different design of implant. Postoperative testing is being done by the TORU staff in combination with the medical imaging department at The Canberra Hospital. This will make up the bulk of Catherine Galvin’s PhD work.

This study has been funded by the Canberra hospital Private Practice Fund, the University of Canberra and Biomet.
Femoroacetabular Impingement (FAI) is characterised by abnormal morphology of the femur and/or acetabulum causing abutment up against each other during hip movements causing injury. 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 and predisposes to osteoarthritis of the hip. Surgery involves trimming the bone that prevents normal movement. Although the aim of the surgery is to change the mechanics of the joint we still know very little about what it actually achieves, and if we can better predict who is going to have a positive result. Correct patient selection is critical for good outcomes. While we know younger patients, no sign of arthritic changes, shorter duration of symptoms, and lower preoperative pain and functional scores are associated with better outcomes, there is still a group of patients who do not have a good outcome. We are using preoperative imaging in an attempt to predict 1 year iHOT-33 outcomes. Results of this could help improve our ability to select patients who will have a good surgical outcome.

A novel image registration technique is being used to investigate 3D hip kinematics which involves fitting a 3D CT scan to 2D dynamic fluoroscopic images. This study will implement this novel method for investigating hip kinematics in FAI. In conjunction with this project, we are looking at the effect of a 3D planning software on outcomes and complications of FAI. Initial results indicate that the planning software can help reduce complications related to under resection.

The Canberra Hospital is a Level 1 Trauma Centre which treats approximately 4000 fracture trauma cases per year. The cost of this service exceeds $55 million per annum with a staff compliment of 12 VMOs, 13 registrars and 6 interns. The treatment data for these patients is curated within the medical record in a way which is difficult/time consuming to retrieve and often inaccurately coded. Further there is no facility to evaluate patient outcomes except in cases of complaint. Therefore the utility of this record for evaluation and research is minimal. Canberra Hospital is not alone in this. It is well recognized that there is an urgent need for precise, intuitive and clinically meaningful data collection instruments which engage the clinician and inform the administration. It is on this background that iFracture was built.

The longitudinal measurement of patient-reported outcomes is a common currency by which treatment efficacy can be measured across a number of clinical disciplines. By separating the clinician from the outcome assessment there is less bias and more signal accuracy. Administrative instruments are primarily concerned with activity and expenditure-related outcomes which are of secondary interest to the clinicians. The clinicians do not engage comfortably in this process and therefore information is often poorly characterized. However, by collecting clinically meaningful outcomes with the precision that the clinical environment can confer (i.e. complete and accurate coding), there is the added opportunity for administrative records to be optimized for greater precision and accuracy. The data management teams in our organization are very interested in this.

iFracture leverages the internet to allow clinicians and patients to populate the data fields thereby minimising the costs of data management staff and potentially leads to much higher response rates, though this needs to be tested. iFracture has been developed in the ACT over 10 years and offers a powerful solution to many of the data resource issues that are being faced around the world. iFracture is currently being used by the orthopaedic team at Canberra Hospital. In a nutshell iFracture puts the clinician in the driving seat while supplying data deliverables which are of intense interest to the administrative sector.

The Joint Replacement Outcomes database has undergone a major upgrade over the past year. Not only has the layout been redesigned to make its appearance more modern and intuitive, the upgrade allows for remote online follow-up. Patients receive an email at their allocated follow-up time directing them to an online portal to complete their questionnaires. This new feature will save patients time and allow easier and faster clinical decision making.

The data provided by database serves to provide clinical surveillance reports and longitudinal outcome collection. The data collected also has the potential to facilitate waiting list categorization and follow-up frequency management thereby improving efficiency while remaining responsive.
Medial and lateral hamstrings and quadriceps co-activation affects knee joint kinematics and ACL elongation: a pilot study


BMC Musculoskeletal Disorders

Background: Many injury prevention and rehabilitation programs aim to train hamstring and quadriceps co-activation to constrain excessive anterior tibial translation and protect the anterior cruciate ligament (ACL) from injury. However, despite strong clinical belief in its efficacy, primary evidence supporting training co-activation of the hamstrings and quadriceps muscles for ACL injury prevention and rehabilitation is quite limited. Therefore, the purpose of the study presented in this paper was to determine if hamstring-quadriceps co-activation alters knee joint kinematics, and also establish if it affects ACL elongation.

Methods: A computed tomography (CT) scan from each participant’s dominant leg was acquired prior to performing two step-ups under fluoroscopy: one with ‘natural’ hamstring-quadriceps co-activation, one with deliberate co-activation. Electromyography was used to confirm increased motor unit recruitment. The CT scan was registered to fluoroscopy for 4-D modeling, and knee joint kinematics subsequently measured. Anterior cruciate ligament attachments were mapped to the 4-D models and its length was assumed from the distance between attachments. Anterior cruciate ligament elongation was derived from the change in distance between those points as they moved relative to each other.

Results: Reduced ACL elongation as well as knee joint rotation, abduction, translation, and distraction was observed for the step up with increased co-activation. A relationship was shown to exist for change in ACL length with knee abduction ($r = 0.91; p \leq 0.001$), with distraction ($r = -0.70; p = 0.02$ for relationship with compression), and with anterior tibial translation ($r = 0.52; p = 0.01$). However, ACL elongation was not associated with internal rotation or medial translation. Medial hamstring-quadriceps co-activation was associated with a shorter ACL ($r = -0.71; p = 0.01$), and lateral hamstring-quadriceps co-activation was related to ACL elongation ($r = 0.46; p = 0.05$).

Conclusion: Net co-activation of the hamstrings and quadriceps muscles will likely reduce ACL elongation provided that the proportion of medial hamstring-quadriceps co-activation exceeds lateral.

Development and validation of a VISA tendinopathy questionnaire for greater trochanteric pain syndrome, the VISA-G.

Fearon A.M., Ganderton C., Scarvell J.M., Smith P.N., Neeman T., Nash C., & Cook J.L.

Manual Therapy

Background: Greater trochanteric pain syndrome (GTPS) is common, resulting in significant pain and disability. There is no condition specific outcome score to evaluate the degree of severity of disability associated with GTPS in patients with this condition.

Objective: To develop a reliable and valid outcome measurement capable of evaluating the severity of disability associated with GTPS.

Methods: A phenomenological framework using in-depth semi-structured interviews of patients and medical experts, and focus groups of physiotherapists was used in the item generation. Item and format clarification was undertaken via piloting. Multivariate analysis provided the basis for item reduction. The resultant VISA-G was tested for reliability with the inter class coefficient (ICC), internal consistency (Cronbach’s Alpha), and construct validity (correlation coefficient) on 52 naive participants with GTPS and 31 asymptomatic participants.

Results: The resultant outcome measurement tool is consistent in style with existing tendinopathy outcome measurement tools, namely the suite of VISA scores. The VISA-G was found to be have a test-retest reliability of ICC$_{2,1}$ (95% CI) of 0.827 (0.638–0.923). Internal consistency was high with a Cronbach’s Alpha of 0.809. Construct validity was demonstrated: the VISA-G measures different constructs than tools previously used in assessing GTPS, the Harris Hip Score and the Oswestry Disability Index (Spearman Rho:0.020 and 0.0205 respectively). The VISA-G did not demonstrate any floor or ceiling effect in symptomatic participants.

Conclusion: The VISA-G is a reliable and valid score for measuring the severity of disability associated GTPS.

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Trauma and Orthopaedic Research Unit Newsletter

Journal Articles 2015
Liver function parameters in hip fracture patients: relations to age, adipokines, comorbidities and outcomes

Fisher L, Srikusalanukul W, Fisher A, & Smith P.

International Journal of Medical Science

AIM: To assess liver markers in older patients with hip fracture (HF) in relation to age, comorbidities, metabolic characteristics and short-term outcomes.

METHODS: In 294 patients with HF (mean age 82.0±7.9 years, 72.1% women) serum alanine aminotransferase (ALT), gamaglutamyltransferase (GGT), alkaline phosphatase (ALP), albumin, bilirubin, 25(OH)vitaminD, PTH, calcium, phosphate, magnesium, adiponectin, leptin, resistin, thyroid function and cardiac troponin I were measured.

RESULTS: Elevated ALT, GGT, ALP or bilirubin levels on admission were observed in 1.7%-9.9% of patients. With age GGT, ALT and leptin decrease, while PTH and adiponectin concentrations increase. Higher GGT (>30 U/L, median level) was associated with coronary artery disease (CAD), diabetes mellitus (DM), and alcohol overuse; lower ALT (≤20 U/L, median level) with dementia; total bilirubin=20 μmol/L with CAD and alcohol overuse; and albumin>33 g/L with CAD. Multivariate adjusted regression analyses revealed ALT, ALP, adiponectin, alcohol overuse and DM as independent and significant determinants of GGT (as continuous or categorical variable); GGT for each other liver marker; and PTH for adiponectin. The risk of prolonged hospital stay (>20 days) was about two times higher in patients with GGT>30 U/L or adiponectin>17.14 ng/L (median level) and 4.7 times higher if both conditions coexisted. The risk of in-hospital death was 3 times higher if albumin was <33 g/L.

CONCLUSIONS: In older HF patients liver markers even within the normal range are associated with age-related disorders and outcomes. Adiponectin (but not 25(OH)vitaminD, PTH, leptin or resistin) is an independent contributor to higher GGT. Serum GGT and albumin...
Background: Recent studies report that operative fixation of displaced mid-clavicular fractures results in fewer complications in the short-term. The aim of this study was to assess whether operative management also results in superior long term (>5 years) patient-reported outcomes. A further aim was to assess which measurements technique for clavicular displacement best predicts outcome in non-operatively managed patients.

Methods: 76 patients who presented to Canberra hospital with displaced mid-clavicular fractures between July 2008 and December 2009 were surveyed retrospectively. The survey included the Disability of the Shoulder, Arm and Hand (DASH), hand dominance, and two visual analogue scales (VAS) for pain and satisfaction with cosmesis and post-injury complications. Initial x-rays were used to measure the displacement of the fragments. Statistical modelling was used to compare the groups.

Results: Of the 76 patients, 43 responded (29 operative and 14 nonoperative, 57%). The non-operative group was older (30 yrs vs 40 yrs, p=0.022). Overall 81% were male and the average follow-up time was 77 months. DASH scores were significantly better in the operative group (3.1 vs 17.5; p=0.001). Pain scores were lower in the operative group, but were not significant after adjusting for age and sex (1.3 vs 2.5, p=0.084). Only the ‘displacement’ technique for measuring clavicular displacement proved to be predictive of long-term DASH scores (p=0.039).

Conclusion: Operative fixation resulted in significantly better patient-reported outcomes when compared to non-operative management at more than 5 years follow-up. The non-normalised ‘displacement’ method was a better predictor of outcome than other normalised and non-normalised methods. Operative management of displaced mid-clavicular fractures should be considered more often in older, less active patients who are not typically managed surgically.

Sarah-Jane Meresfield
Life After Arthroplasty – factors affecting risk of subsequent arthroplasty

The aim of this study was to create prognostic models for lower-limb arthroplasty based on the type of primary prosthesis implanted, the joint replaced, age, gender and Oxford Hip or Knee Score (OHS/OKS data). This study involved a retrospective review of prospectively collected data and included 3034 patients who had undergone a primary total hip arthroplasty, hip resurfacing, total knee arthroplasty or unicompartmental knee arthroplasty, with a mean age of 65.7 (range: 15-99 years). The mean follow-up time was 37.6 months (range: 1 to 183 months). We found that the surgical trajectory for patients after their first lower limb arthroplasty was significantly dependent on the joint (hip or knee), patient’s age, one year post-operative Oxford Hip Score and the preoperative Oxford Knee Score. This study has identified an important marker for knee arthroplasty failure which will potentially inform surgeons and patient about the likelihood of future joint failure and the need for enhanced surveillance in ‘at risk’ patients.

Jason Szczepanski
What is the most effective strategy for treating pelvic discontinuity in revision THA – a systematic review.

Background: Pelvic discontinuity is a rare condition for which a range of implant constructs have been developed with varied results. Failure rates are high but recent advances in surgical constructs offer promise. Surgical outcome data for pelvic discontinuity is sparse and primarily presented in case-series. It is therefore difficult to gain a clear picture of which constructs provide the best outcomes in the short- to long-terms. Questions/purposes: (1) Which construct is superior by providing low failure rates, high bone healing rates and low complication rates over the short-, medium- and long-terms? (2) Is there evidence to support better outcomes with the use of constructs supplemented with porous metal technology?

Methods: A systematic review of studies reporting pelvic discontinuity in revision total hip arthroplasty since 2005 was conducted. Data retrieved included the intervention performed, length of follow-up, failure, healing and complication rates. Study quality was assessed with the Methodological Index for Non-Randomised Studies (MINORS) instrument.

Results: None of the 21 papers included were of good quality. Custom triflange components provided the lowest failure and highest healing rates compared with the commonly used cup-cage construct and anti-protrusio cage (APC). However, complication rates were higher than cup-cage. Overall porous metal technology appears to be effective in reducing failure rates. Long-term evidence investigating both interventions and porous metal technology is limited.

Conclusions: The review found some evidence in support of custom triflange constructs and porous metal technology but the study quality was universally poor. This indicates the need for better studies and/or a registry.
**Background:** Femoroacetabular impingement (FAI) is characterised by abnormal morphology of the femur and/or acetabulum causing significant hip pain. The diagnosis of FAI has traditionally been made on clinical and radiographic signs. However, diagnosis of FAI does not guarantee a good post-surgical outcome. Therefore the aim of this study was to determine which radiographic signs or measurements predict improved outcomes at 12 months following arthroscopic surgery.

**Methods:** Radiographs of 42 hips in 40 patients who had undergone arthroscopic surgery for FAI were reviewed. The difference between pre-surgical and 1 year International Hip Outcome Scores (iHOT-33 change) for these patients were used as an indicator of post-surgical outcome. Eleven diagnostic radiographic signs and measurements were ascertainment. A generalised linear model was used to determine whether there was an association between any or all of these signs and measurements and iHOT-33 change.

**Results:** Of the 11 signs and measurements examined, the ischial spine sign was the only FAI diagnostic sign or measurement that predicted a significant improvement in iHOT-33 score following surgery for FAI (p = 0.019).

**Discussion:** The findings of this study indicate that the presence of the ischial spine sign predicts good post-surgical outcomes suggesting that 1) patients with a retroverted acetabulum are good candidates for surgery and 2) the ischial spine sign is a robust radiological marker in the clinical environment. The ischial spine sign should be included in clinical decision making related to arthroscopic surgical intervention for FAI.

**Background:** Three-dimensional modelling software is emerging as a potentially effective tool for improving patient outcomes following arthroscopic surgery for femoroacetabular FAI. The use of data acquired from the Dynonics hip impingement planning software (Smith and Nephew) could result in improved patient-reported outcomes and lower post-op complication rates, in patients who have had surgery for FAI.

**Methods:** All patients undergoing hip arthroscopy for FAI were prospectively assessed with the iHOT-33 preoperatively and at, 6 weeks post-op. Femoral and/or acetabular osteoplasty were undertaken to address the cause of impingement, with labral and capsular repair as required. Two groups were identified: One included all patients who had preop Dynonics planning and, the other included all those who did not. Statistical analysis was used to compare the two groups regarding the change in iHOT-33 scores (iHOT change) from pre-op to 6 weeks post-op, and complication rates in the first 12 months post-op.

**Results:** 151 patients were entered into this study. Of these, 78 had pre-op Dynonics planning and 73 did not. There were no differences between the groups in terms of demographics or iHOT change scores (P=0.41). However, there was a difference between the groups in terms of complications, with fewer under-resections in the Dynonics planning group (P=0.005).

**Discussion:** Our results indicate that Dynonics planning significantly reduced the rate of under-resection in patients undergoing arthroscopy for FAI. However, 6-week outcomes were not improved by using the pre-op Dynonics planning. Reducing the risk of under-resection is of significant value because incomplete reshaping from under-resection is the most frequent indication for revision of arthroscopic treatment of FAI.

**Introduction:** Distal femur fracture is a rare but severe fracture. Traditional methods of fixation include intramedullary nailing (IM), or locking plates using the LISS technique. Current research gives no definitive answer to which method is superior, but some studies have found LISS to be problematic. In this study, we aim to assess the long-term outcomes of both IM and LISS plates.

**Methods:** An ICD-10 code for distal 1/3 fracture of femur (S72.4) was used to search the Canberra Hospital Electronic Medical Records for years 2008-2011. Patients with IM and LISS fixations were included in the study. Exclusion criteria included: under 18 years of age at time of study, non-LISS/IM surgeries, and non-retrograde IM nails. Patients completed Knee and Osteoarthritis Outcome Score (KOOS), Visual Analogue Scales (VAS) for pain and satisfaction, as well as a list of check-list questionnaires. Patients who could not be contacted by telephone after three attempts were considered lost to follow-up.

**Results:** Thirteen out of 46 eligible participants responded to the survey. This represented a final response rate of 37.1 percent. There were insufficient participants in the IM group for comparison between IM and LISS. Falls were responsible for the majority of fractures. There was no significant difference between respondents and non-respondents in terms of age, sex, and surgery type. Participants scored significantly lower on all subcategories of the KOOS compared to age matched reference population. Mean VAS scores were 3.7, 6.7, 6.4, and 5.7 for pain, satisfaction of surgery, recovery, and function, respectively.

**Conclusion:** The large number of misclassified distal femoral fractures is a concern for the Canberra Hospital and needs improvement. Our study showed that patients with distal femur fracture have poor long-term outcomes, suggesting that optimal clinical intervention is not yet established.
AOA ACT Branch Scientific Meeting, Canberra 2014

- Richardson A, Perriman D, Ashman B. How when and why do we revise volar plates at TCH?
- Moaaz A, Perriman D. Does Tranexamic Acid Help Reduce Transfusion Rates In Hip Fracture Surgery.

AOA National Scientific Meeting 2015

- Smith P.N., Wang, V., Perriman D. Establishing a web-bases fracture trauma outcome database in Canberra: triumphs and pitfalls

Australian Orthopaedic Association Annual Scientific Meeting - South Australia Branch. Adelaide 2015

- Smith P.N. Greater Trochanteric Pain Syndrome the scope of the problem and options for treatment
- Smith P.N. Management of severe bone loss in revision hip surgery - the acetabular side

Australian Physiotherapy Association 2015

- Perriman D., Ellis S., Lynch J., Burns A., Neeman T., Smith P. Femoroacetabular impingement: what radiographic signs determine who benefits most?

NZOA Hip Society COE Meeting, Auckland 2015

- Smith PN. Controversies in Hip Surgery 2015


- Do Q, O'Byrne S, Perriman D, Smith PN. Piezoresistive Nanocomposite as An Embedded Stress Sensor in Instrumented Knee Prosthesis

British Orthopaedic Association Congress, Liverpool UK 2015

- Rajagopalan S, Perriman D, Neeman T, Smith P. How reliable is computer assisted THA polyethylene wear measurement with current radiography practices?

Trauma Society

- Perriman D, Smith PN, Wang V. iFracture: An Intelligent Fracture Database


Conference Papers from 2014-2015

- Ihesuitor OK, Shankar K, Smith PN, Fien A. Investigation of wear in orthopaedic hip prosthetic devices

The 2nd Annual World Congress of Orthopaedics 2015 (WCORT-2015). Xi'an, China, 2015
- Smith PN. Management of Pelvic Discontinuity in Revision Total Hip Arthroplasty
- Li R, Patel HR, Perriman D, Lynch J, Quah B, Smith PN. Wear Particles Related Revision Hip Arthroplasty - A View from Nano Osteoimmunology and Genetics

- Li R. Workshop discussion – Drug development for Alzheimer’s and Osteoporosis.

Orthopaedic Forum, Beijing, September 24, Beijing, 2015
- Li RW, Patel HR, Zhang D, Perriman D, Lynch J, Quah B, Smith PN. Nano Osteoimmunology and Genetics in Revision Hip Arthroplasty

Canberra Health Annual Research Meeting, 2015
- Li RW, Xiaobo C, Zhang D, Chen S, Smith PN, Birbilis N. Innovative SrP Conversion Coated Magnesium for Future Osteogenic Implants
- Coulter C, Neeman T, Scarvell J, Smith PN. Rehabilitation after Elective Total Hip replacement - A Randomised Controlled Trial.
- Perriman D, Smith PN, Wang V. iFracture: An Intelligent Fracture Database
- Lim M, Perriman D, Smith PN. Dynamic Pelvic Tilt: Can it be Measured with Accelerometry?
- Pickup H, Perriman D, Neeman T, Smith PN. POSTER: Do Volar Plates Lead to the Best Outcome in Elderly Patients with Distal Radius Fractures?
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