2016 – 17

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) has had a busy and productive year with successful publications and grants, and a graduation. This all takes place in an increasingly challenging research environment which requires commitment and resolve from all members of our remarkable team.

There are many significant achievements described within the pages of this newsletter. One which I would like to particularly mention is the achievement of a PhD by Dr Ben Serpell. Ben was awarded his PhD at the ANU in July. He completed his PhD by publication while working in a high profile coaching job with the Brumbies rugby club. This was a significant achievement and Ben is recognized as being an innovator in his field. We look forward to collaborating with Ben and UCRISE in future studies.

We are very pleased to have won a coveted AOA Research foundation grant this year. The grant was submitted by our laboratory titled “Surface modifications to prevent infection and promote osseointegration of orthopaedic implants”. The grant represents a recognition of the imperative to find new ways to solve the problem of infection in the midst of increasing antibiotic resistance.

Our publications this year are the result of many years of hard work. Song Chen has published some of his PhD work elucidating numerical solutions from biological data. This new and exciting work explains osteoblast behavior with respect to adhesion on metal surfaces. We have also published two randomized controlled trials. Corinne Coulter completed her MPhil with TORU in 2016 and her RCT comparing post-operative rehabilitation for total hip replacement delivered at home to supervised classes is an important addition to the literature. Our multicenter RCT comparing the performance of a Bicruciate-stabilized knee to a posterior-cruciate-stabilized implant was published this year after many years of effort. Credit must be given to the many centres involved and the team at Smith & Nephew for this achievement.

I particularly want to acknowledge a few people in our team by name this year. Assoc. Prof Rachel Li has led the laboratory to great success this year. She has won grants for innovative biomaterial research and advance 3D printing of orthopaedic implants. Professors Jennie Scarvell and Mark Pickering continue to drive our efforts in knee kinematic discovery. Catherine Galvin is nearing the end of her PhD journey and is busily crafting the final chapter of the tour de force that is her thesis. Alice Churchill has completed a brilliant honours year with our unit and has graduated from the University of Canberra as a physiotherapist. Joe Lynch, who has been such an excellent research assistant for TORU over the past three years has taken the hint and commenced a PhD with us. Bravo Joe.

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 2017 edition of the TORU newsletter.

Paul Smith, BMBS FRACS (Ortho)
Director, Trauma and Orthopaedic Research Unit

Ben Serpell with his parents at his PhD graduation
Prof Paul Smith BMBS, FRACS, FAOrthA

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.

Professor Smith is passionate about research and teaching and was involved in the establishment and ongoing management of the Trauma and Orthopaedic Research Unit at The Canberra Hospital; the ACT Bone Bank; and the ACT Musculoskeletal and Orthopaedic Research Foundation. His teaching affiliations include the ANU Medical School.

Contact:

p smith.admin@orthoact.com.au
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. Prior to research, Diana had an extensive clinical career in which she worked in acute hospitals, the community and private practice both in Australia and the UK. She has worked at the Trauma and Orthopaedic Research Unit both as a research officer, PhD candidate and as the coordinator 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 was a recipient of an NHMRC Dora Lush scholarship for this research. As clinical research coordinator Dr Perriman’s research interests lie in arthroplasty, knee kinematics and fracture outcomes in accordance with the main focus of the Trauma and Orthopaedic Research Unit. She also collaborates with other researchers investigating whiplash and hamstring injury in running sports.

Dr Perriman is a senior lecturer at the ANU Medical School and an adjunct Associate Professor at the University of Canberra. In this role she supervises medical students, Physiotherapy students and higher degrees students from both disciplines. She sits on the scientific committee of the ACT Health ethics committee and is also the President of the ACT branch of the Australian Physiotherapy Association

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.

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

The TORU clinical team is based at Canberra hospital but is also part of the ANU medical school. The clinical team partners with the laboratory team and many other institutions to create a rich environment of scholarly research endeavour in orthopaedics in Canberra.

The TORU clinical team has changed this year. Belinda Payne has moved to another position in ACT Health and our new office manager, Anna Davis has ably taken on the challenges of supporting TORU. We welcome Anna to our team and wish Belinda all the very best with her new challenges. Joe Lynch is now fully ensconced in his PhD studies but still gives TORU one day a week. We are therefore a slimmed down unit in terms of permanent staff but have had a steady stream of students, scholars, fellows and registrars occupying our seats and minds.

Our PhD scholars include Catherine Galvin (UC), Claire Kenneally-Dabrowski (ANU), Dr David Owen (ANU) and Joe Lynch (ANU). Our MPhil scholars include Dr Mitchell Kingston (ANU) and Dr Claire Bolton (ANU). Orthopaedic fellows have included Uli Schmidden (Stryker), Phil Markham (Stryker), Daniel Meyerkort (Stryker), Shamshuddin Mohamed Ali (Smith & Nephew). Registrars who have undertaken research with us include Luke Barr, Yi Deng, Ken Ye, Xuan Ye.

We have 6 medical students complete their research project with us this year: Kaitlyn, Jacobs, Henry Williams, Paul LeMeasurier, Martin Schutte, Laura Soffous and Tom Staniforth. Summaries for their projects can be found on pages 25-26. Our 2017 cohort includes: Alexander Cary, Harrison Slockee, Sally Gilbert, Tom Sizeland, Kyle McCabe and Ka Man

The clinical unit has been focussed on some significant ongoing projects this year. The most investment has gone into the Pickles knee project which is starting to provide rich and meaningful data about the kinematics of deep knee flexion and step up. Catherine Galvin is completing her PhD thesis investigating the effect of age on knee kinematics in health and osteoarthritis (OA). Alice Churchill completed her honours research (University of Canberra, Physiotherapy) with an investigation of the effect of morphology on knee kinematics. The results offer a clue as to how obesity might change the way the knee behaves. Kaitlyn Jacobs and Henry Williams completed ANU medical school research projects which examined whether knee kinematic parameters were associated with functional scores (Oxford Knee Score) in people with OA. The results of both of these projects suggested that the degree and rate of medial translation may be the most important factor differentiating good and poor scores (24). Our statistical modelling of this data has been an area of growth and discovery and Dr Teresa Neeman from the Statistical Consulting Unit has been crucial to our increased understanding in this area.

Joe Lynch has taken on a PhD which seeks to investigate the shape of the knee and how that influences functional outcomes and kinematics. He will include the implant shape in his explorations and takes the Pickles project to a whole new level with this innovative work. This PhD marks a new collaboration with Prof Thor Besier from The University of Auckland.

Another area of investigation that has been of ongoing interest is femoroacetabular impingement (FAI). The political climate surrounding FAI has changed markedly over the past year or two with the MBS excluding arthroscopic treatment for FAI from the schedule due to lack of evidence for efficacy. Unfortunately we are still unsure about what characterises the patients who do benefit from this procedure. Sarah Ellis, our Reg Kitchin scholar and final year ANUMS medical student, has been investigating the effect that the degree and shape of the bony morphology has on outcomes after
surgery. We have prepared a paper for publication and Sarah will be presenting this data in our meeting in December. Tom Staniforth undertook a medical student project investigating whether the capsule might affect outcomes in FAI and he will be presenting this work as a poster at the December ACT AOA Annual Scientific Meeting. Of particular note is the Crossfire RCT which aims to examine the effect of fixation in elderly wrist fracture. This RCT is funded by an NHMRC grant on which Paul Smith is a CI. Luke Barr is the local coordinating registrar. The work of our students and scholars investigating hip morphology, the blood supply to the gluteal tendons, whiplash and hamstring in sport are all featured in the pages of this newsletter and so I won’t repeat here. However, the activity has been purposeful and productive. Research is difficult and ongoing. Seneca remarked “A single lifetime, even though entirely devoted to the sky, would not be enough for the investigation of so vast a subject”. So as we range over the vast realm of orthopaedics we do not expect to finish, merely to report to the world what we have done. This year we have presented our papers at meetings and published a number of papers (pgs 16-21). Two papers in particular have taken many years to come to fruition. Corinne Coulter published her RCT comparing the effect of Physiotherapy after total hip replacement finding no difference between monitored home programs and directly supervised models. Jennie Scarvell was first author on the multicentre Journey Knee RCT to which this unit contributed.

Diana Perriman

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**Clinical Team**

**TORU Staff**

Ms Belinda Payne  (until mid 2017) - Office Manager  
Ms Anna Davis (from mid 2017) - Office Manager

**Clinical Database**

Ms Amanda Phillips - Database Officer  
Mrs Jessica Little - Database Officer

**Clinical and Research Fellows**

Dr Uli Schmiddem - Clinical Orthopaedic Fellow  
Dr Phil Markham - Clinical Orthopaedic Fellow  
Dr Dan Meyerkort - Clinical Orthopaedic Fellow  
Dr Shamshuddin Mohammedali - Clinical Orthopaedic Fellow  
Professor Jennie Scarvell—Head of Health Science, University of Canberra - Research Fellow
Teaching Clinical Research Skills in Myanmar

In June I went on an unforgettable trip to Myanmar (previously known to the west as Burma). During my two week visit I visited the most breathtakingly beautiful places, but I also taught clinical research skills to Higher Degree students in the physiotherapy school in Yangon.

I had arranged to teach a couple of classes in the school but the head of school, Dr Myo Thuzar Khin, organized for an assembly of all the HDR students from Yangon and Mandalay, for a full day workshop on the Yangon campus. I also returned the following day to teach the final year undergraduates about proximal hip fractures and lower limb arthroplasty. Trauma is a major problem in Myanmar and arthroplasty is being performed in Thailand and the patients are returning to Myanmar for rehab.

The workshop and lectures went very well and the feedback was excellent. The participants also included some senior clinicians and university staff. I was concerned that my lessons would not be well be understood given that I don’t speak the Myanmar language. I therefore scaffolded the lessons very carefully and ensured that I regularly checked for understanding. The culture is not one of questioning teachers, which is something that the faculty is trying to change. My quick quizzes proved to be a really good device which the students loved and which the staff are now going to use in the future.

Myanmar has had some pretty bad press recently, for good reason, but the people of Myanmar are eager to join the world again. I found my experience teaching in Myanmar to be both refreshing, rewarding and mutually beneficial. I hope to visit again and encourage colleagues to do the same.

Dr Diana Perriman
Clinical Research Coordinator

Professor Jennie Scarvell in Europe

Prof Jennie Scarvell was supported by University of Canberra to spend 4 months on sabbatical from June 2017. Jennie had the pleasure of presenting TORU’s collaborative research at World Congress of Physiotherapy in Cape Town and European Orthopaedic Research Society in Munich.

Jennie was based in Cardiff University, one of UK’s top 10 universities, where she was hosted by Prof Robert Van Deursen. While there, Jennie spent time furthering her understanding of motion analysis and implementation science while also visiting the Arthritis UK Research Centre. Jennie also had the opportunity to visit KU Leuven for a week, and met some great researchers looking at load in joints, including Musculoskeletal modelling but also stress loads on chondrocytes in hydrogels, and real time motion CT.
Clinical Collaborators

Prof Jennie Scarvell  Head of School of Health Sciences, University of Canberra
Dr Phil Newman  Assistant Professor, Physiotherapy, University of Canberra
Prof Gordon Waddington  Physiotherapy and UCRISE, University of Canberra
A/Prof Mark Picking  School of Engineering and IT, UNSW@ADFA
A/Prof Heiko Timmers  School of Physical, Environmental and Mathematical Sciences, UNSW@ADFA
Dr Mitali Fadia  Pathology, ANU
Dr Jane Desborough  Department of Health Services Research and Policy, Research School of Population Health, ANU
Prof Jane Dahlstrom  Anatomical Pathology, ANU
Prof Kirsty Douglas  General Practice, Medical School ANU
Prof Ian Harris  UNSW South Western Sydney Clinical School, Whitlam Orthopaedic Research Centre
Dr Chris Roberts  Orthopaedic Surgeon, OrthoACT
Dr Nick Brown  Deputy Director - Research and Applied Science at AIS
Dr Karen Falk  Radiologist, Woden Specialist Medical Centre
A/Prof Bruce Shadbolt  Deputy Director of Research, ACT Health
Adrian Meijer, Asha Bott-Sharma, Bridie Player  ACT Healthy Radiology

Dr Wayne Spratford  Assistant Professor, Sport and Exercise Science, University of Canberra
Dr Angie Fearon  Assistant Professor, Physiotherapy, University of Canberra
Prof Christian Cook  UCRISE, University of Canberra
Dr Sean O’Byrne  School of Engineering and IT, UNSW@ADFA
Dr Teresa Neeman  Statistical Consulting Unit, ANU
Dr Anne Parkinson  Health Services Research & Policy, Research School of Population Health, ANU
Dr Alexandra Webb  Medical School, ANU
A/Prof Alex Fisher  Geriatric Medicine, ANU
A/Prof Thor Besier  Auckland Bioengineering Institute, University of Auckland
Dr Alexander Burns  Orthopaedic Surgeon, OrthoACT
Dr Maurizio Damiani  Orthopaedic Surgeon
Dr Ben Serpell  Athletic Performance Director, ACT Brumbies
Dr Ashley Watson, Prof Peter Collignon, Prof Frank Bowden, Dr Sanjaya Senanayake, Dr Karina Kennedy, Dr Kathryn Daveson, Dr Ashwin Swaminathan  Infectious Disease Unit, ACT Health
Dr Joe Lau  Orthopaedic Surgeon, ACT Health
Laboratory Report

The TORU Laboratory, based at the John Curtin School of Medical Research, ridges 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 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

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 suggest that SrP04 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 rhematoid arthritis and osteoporosis.

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

We are screening anabolic drug candidates for bone biological therapeutics that promote wound and fracture healing by directing the progenitor cells growth and differentiation. Our newly developed project in collaborating 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...
The Evolution of Osteoporosis

It has been suggested that osteoporosis was less prevalent in the past, or that despite comparably low BMD osteoporotic fractures were relatively rare, possibly implicating lifestyle or adaptive protections of bone quality. However, others have argued that osteoporosis was similarly prevalent in past populations, and question the impact of lifestyle factors. Kate’s project will explore the evolution of osteoporosis using bone samples of archaeological and modern population, with a view to identifying adaptive or lifestyle mechanisms affecting disease risk and prevalence today. This research may also provide a framework for exploring the differences in osteoporosis prevalence observed between different modern population groups.

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 favourable 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 eliminating side effects, i.e. promoting bone cell growth and controlling the metal release rhythm.

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.

Laboratory Facilities

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Surface Validation Assays

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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.
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.’

Collaborators

Prof Dongsheng Zhou
Department of Trauma and Orthopaedics, Shandong University, Jinan, China

Prof Jiake Xu
School of Pathology and Laboratory Medicine and Head of molecular laboratory, UWA

Prof Chris Parish
Department of Immunology, John Curtin School of Medical Research, ANU

Prof Qinghua Qin
College of Engineering and Computer Science, ANU

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 Tim Senden
Director, Department of Applied Mathematics, Research School of Physics & Engineering, ANU

Prof Mark Knackstedt
Department of Applied Mathematics, ANU

Prof Xiaomin Wang
Capital Medical University, Beijing, China

Prof Suresh Mahalingam
Principal Research Leader & ARC Future Fellow, Institute for Glycomics, Griffith University

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

Australian National University

Griffith University
Research Output


A double-layered model is proposed for numerically simulating osteoblast adhesion on surface-engineered biomaterials. The proposed model consists of molecular and cellular motions based on theoretical and experimental evidence and creates predictive simulations from sparse experimental data. The comparison of numerical solutions and experimental data reveals that the proposed model can explain the nonlinear behaviour of osteoblast adhesion on material surfaces in respect to nanophase grain size (0-100 nm). The model further provides insight into the optimisation of nanophase grain size on the surface of the biomaterial.


OBJECTIVE: To determine whether patients do better with unsupervised (home-based) physiotherapy or in an outpatient setting.
SETTING: Acute care public hospital in the region, supporting a population of >540,000.
DESIGN: Single-blind randomized controlled trial.
PARTICIPANTS: Adult patients (N=98) after unilateral elective total hip replacement (THR) were randomly assigned to a supervised (center-based) exercise (n=56) or a unsupervised (home-based) exercise (n=42) program and followed for 6 months post-surgery.
INTERVENTIONS: The supervised group attended a 4-week outpatient rehabilitation program supervised by a physiotherapist. The unsupervised group was given written and pictorial instructions to perform rehabilitation independently at home.
MAIN OUTCOME MEASURES: Western Ontario and McMaster Universities Osteoarthritis Index; Short-Form 36-item Health Questionnaire (SF-36) mental and physical component summary measures; University of California, Los Angeles activity scale; and timed Up and Go test.
RESULTS: There were no differences between the groups for any measure. The overall differences between the adjusted means were as follows: Western Ontario and McMaster Universities Osteoarthritis Index, 0.50 (95% confidence interval [CI], -6.8 to 5.7); SF-36 physical component summary, 0.8 (95% CI, -6.5 to 8.1); SF-36 mental component summary, 1.7 (95% CI, -4.1 to 7.4); University of California, Los Angeles activity scale, 0.3 (95% CI, 5.2 to 6.1); and timed Up and Go test, 0 seconds (95% CI, -1.4 to 1.3s).
CONCLUSIONS: The results demonstrated that outcomes in response to rehabilitation after THR are clinically and statistically similar whether the program was supervised or not. The results suggest that early rehabilitation programs can be effectively delivered unsupervised in the home to low-risk patients discharged home after THR. However, the relative effect of late-stage rehabilitation was not tested.


Background: The bicruciate-stabilized (BCS) knee arthroplasty was developed to replicate normal knee kinematics. We examined the hypothesis that patients with osteoarthritis requiring total knee arthroplasty (TKA) will have better functional outcome and satisfaction with the BCS implant compared with an established posterior cruciate-stabilized implant.
Methods: This multicenter, randomized, controlled trial compared the clinical outcomes of a BCS implant against an established posterior cruciate-stabilized implant with 2-year follow-up. Of the patients awaiting primary knee arthroplasty for osteoarthritis, 228 were randomized to receive either a posterior-stabilized or BCS implant. Primary outcomes were knee flexion and Oxford Knee Score. Secondary outcomes were rate of complications and adverse events (AEs). Tertiary outcomes included Knee Society Score, University of California, Los Angeles, activity score, Patella scores, EQ-5D, 6-minute walk time, and patient satisfaction.
Results: Complete data were recorded for 98 posterior-stabilized implants and 97 BCS implants. Twelve patients had bilateral knee implants. There was no difference among the groups for any of the measures at either 1 or 2 years. At 2 years, knee flexion was 119 ± 0.16 and 120 ± 1.21 degrees for the posterior-stabilized and BCS implants, respectively, (mean, standard error, P = .538) and Oxford Knee Scores were 40.4 ± 0.69 and 40.0 ± 0.67 (P = .828), respectively. There were similar devicerelated AEs and revisions in each group (AEs 18 vs 22; P = .732; revisions 3 vs 4; P = .618).
Conclusion: There was no evidence of clinical superiority of one implant over the other at 2 years.

QUESTION: What are the functional differences between people with greater trochanteric pain syndrome (GT), hip osteoarthritis (OA) or an asymptomatic population as measured by walking, Time Up and Go, single leg standing and strength?

DESIGN: Cross sectional study with blinded measurers.

PARTICIPANTS: 38 participants with GT, 20 with end stage hip OA and 21 asymptomatic healthy control (AS) participants. All participants were women.

OUTCOME MEASURES: Pain (numeric rating scale), Walking speed (m/s), cadence (steps/min) and step length (m) measured via the 10m walk test and the Timed Up and Go; balance via single leg stance (s) duration; and hip abduction, adduction, medial and lateral rotation strength, standardized to body mass (BM) via the body mass average index (BMavg), measured via a wall mounted dynamometer.

RESULTS: The two symptomatic groups reported similar pain levels (p=0.226), more pain then the AS group (p<0.000). Compared to the AS participants, participants with GT or hip OA demonstrated lower walking speed (10mwt and TUG, p<0.001), lower cadence and shorter duration single leg stance on the affected leg (p<0.05). Participants with GT or hip OA also demonstrated bilaterally weaker hip abduction than the AS group (p≤0.005). Compared to AS and GT participants, participants with hip OA demonstrated adduction weakness on the affected side (p=0.008 and p=0.002 respectively).

CONCLUSION: There is a significant level of dysfunction and impairments associated with GT and hip OA. As activity limitations do not appear to be differentiated by structural impairments, we suggest that pain, rather than the underlying pathology may be the driving impairment that leads to walking and single leg standing dysfunction.


PURPOSE: The purpose of the study was to compare the yield and compressed volume of femoral head allograft prepared by either hand morselization or a bone mill.

METHODS: Twenty human femoral head allografts were donated from a bone bank and morselized by two different methods. The heads were divided in half and split into two sample groups. One group underwent hand morselization with large bone nibblers, while the other was prepared using a bone mill. The volume of graft produced was measured. Ten-gram aliquots of each sample then underwent 30 impactions in a contained cavity, with the volume of graft compression measured.

RESULTS: Bone milling yielded approximately 31% more usable graft than hand morselization (81% to 50%; p = 0.0001). There was no difference between the compressed volume of graft prepared by either method ( p = 0.14).

CONCLUSION: This study demonstrates the efficacy of preparation of allograft with a bone mill and assists the clinician in determining the yield of graft by the weight of femoral head, thereby potentially minimizing excessive ordering and wastage.


Through blocking the cardiac persistent sodium current, riluzole has the potential to prevent myocardial damage post cardiac bypass surgery. A sensitive UHPLC-MS/MS method was developed and validated for quantitation of riluzole and 5-methoxypsoralen in human plasma and myocardial tissue homogenate using a liquid-liquid extraction with dichloromethane. The chromatographic separation was achieved using Shimadzu Shim-pack XR-ODS III, 2.0 x 50 mm, 1.6 μm column with a gradient mobile phase comprising methanol and ammonium acetate buffer pH 3.6 in purified water. The analyte and internal standard were separated within 3.5 min. Riluzole quantitation was achieved using the mass transitions of 235-138 for riluzole and 217-156 for 5-methoxypsoralen. The method was linear for riluzole plasma concentrations from 0.2 to 500 ng/mL and myocardial tissue homogenate concentrations from 0.2 to 100 ng/mL. The method developed was successfully applied to a clinical study for patients receiving riluzole while undergoing cardiac bypass surgery.
Mosquito-borne viruses can cause severe inflammatory diseases and there are limited therapeutic solutions targeted specifically at virus-induced inflammation. Chikungunya virus (CHIKV), a re-emerging alphavirus responsible for several outbreaks worldwide in the past decade, causes debilitating joint inflammation and severe pain. Here, we show that CHIKV infection activates the NLRP3 inflammasome in humans and mice. Peripheral blood mononuclear cells isolated from CHIKV-infected patients showed elevated NLRP3, caspase-1 and interleukin-18 messenger RNA expression and, using a mouse model of CHIKV infection, we found that high NLRP3 expression was associated with peak inflammatory symptoms. Inhibition of NLRP3 activation using the small-molecule inhibitor MCC950 resulted in reduced CHIKV-induced inflammation and abrogated osteoclastogenic bone loss and myositis, but did not affect in vivo viral replication. Mice treated with MCC950 displayed lower expression levels of the cytokines interleukin-6, chemokine ligand 2 and tumour necrosis factor in joint tissue. Interestingly, MCC950 treatment abrogated disease signs in mice infected with a related arthritogenic alphavirus, Ross River virus, but not in mice infected with West Nile virus—a flavivirus. Here, using mouse models of alphavirus-induced musculoskeletal disease, we demonstrate that NLRP3 inhibition in vivo can reduce inflammatory pathology and that further development of therapeutic solutions targeting inflammasome function could help treat arboviral diseases.


Antidepressants are among the most prescribed class of drugs in USA and though weight gain is a common outcome of antidepressant treatment, that effect is not well understood. We employed an animal model comprised of two weeks of chronic restraint stress with antidepressant treatment, followed by diet-induced obesity. We show that short-term antidepressant treatment had long-lasting effects, enhancing trabecular and cortical bone features in rats; therefore, weight gain in this model is different from that of the classic dietinduced obesity. Late in the post-restraint recovery period, antidepressant-treated animals were significantly heavier and had better bone features than saline treated controls, when assessed in the distal femoral metaphysis. The propensity to gain weight influenced the rate of catch-up growth and bone allometry, as heavier animals treated with fluoxetine also had enhanced bone features when compared to non-stressed animals. Therefore, short-term antidepressant treatment ameliorated the long-term effects of stress on body growth and bone. Growth and bone structural features were associated with leptin levels, and the interaction between leptin levels with antidepressant was significant for bone mineral content suggesting that short-term antidepressants in the context of long-term diet-induced obesity modified the role of leptin in bone formation. To our knowledge this is the first study reporting that short-term antidepressant treatment has long-lasting effects in restoring the effects of chronic stress in body weight and bone formation. Our findings may be relevant to the understanding and treatment of osteoporosis, a condition of increasing prevalence due to the aging population.


Purpose: To estimate the discriminative value of serum P1NP/βCTX ratio and albumin levels in hospitalized orthogeriatric patients with and without nonvertebral fractures.

Methods: In 1,239 orthogeriatric patients (mean age 78.1±9.52 years, 69.1% women) including 854 (68.9%) with osteoporotic nonvertebral fractures (455 [36.7%] with hip fracture [HF]) and 385 (31.1%) without fractures, markers of bone formation (procollagen type 1 N-terminal propeptide [P1NP], osteocalcin [OC], and bone resorption (beta-C-terminal cross-linking telopeptide of type 1 collagen [betaCTX]), indices of mineral metabolism, and parameters of liver and renal functions were assessed; data on clinical and laboratory characteristics were collected prospectively.
Results: Both lower serum P1NP/ßCTX ratio and albumin concentration (as continuous or categorical variables) were independently associated with fracture presence in multivariate logistic regressions. Compared with the highest P1NP/ßCTX tertile, the prevalence of HF, after adjustment for multiple covariates, was 3-fold higher in the lowest tertile and 1.5 times higher in the middle tertile; presence of any fracture was 2.3- and 1.6-fold higher, respectively; patients with albumin levels in the lowest tertile had multivariate odds ratio (OR) of 4.6 for HF and 2.8 for any fracture, in the middle tertile the ORs were 2.2 and 1.3, respectively. The P1NP/ßCTX <100.0 (median) and hypoalbuminemia (<33 g/L) demonstrated area under the curve values for HF of 0.802 and 0.806, respectively, and for any fractures of 0.711 and 0.706, respectively. When both characteristics were combined, the ORs for HF or any fracture, compared with the nonfractured group, were 7.8 and 3.2, respectively, with an accuracy of 79.6% and 71.6%, respectively.

Conclusions: In orthogeriatric patients, both serum P1NP/ßCTX ratio and albumin levels demonstrated an inverse dose–effect relationship with the prevalence of nonvertebral fractures and independently indicated fracture presence with acceptable discriminatory power. Lower P1NP/ßCTX (<100) and hypoalbuminemia could be useful simple additive prognostic tools for fracture risk stratification in the elderly.


Structural changes in the cervical muscles are the cause of most injurious and non-injurious neck pain for which surgery and therapy are used as medical interventions. In clinical practice, the correct diagnosis of disorders and the planning of treatments in the cervical region require high-precision 3-dimensional (3D) visualisation of the anatomy of patients’ muscles, which necessitates the highly accurate delineation of neck muscles. However, segmenting cervical muscles is an extremely difficult task due to their identical complexions and the compactness in clinical imaging data. As far as we know, past endeavours did not focus on neck muscle segmentation. Therefore, this paper presents a novel and complete automatic delineation and 3D reformation from tomographic data of some of the specific neck muscles responsible for injurious neck pain. Our method uses linear and non-linear registration frameworks to amend inequalities between the training and testing tomographic data. It can handle posture variabilities among patients using an alignment plan and also exploits a cognition-based grouping adjustment to enhance segmentation accuracy. Our algorithm obtains promising results for real clinical data and offers an average dice similarity coefficient of .085 ± 0.02.


Introduction: Kayak racing has been an Olympic sport since 1936. The sport is evolving with the introduction of ocean-ski and stand-up paddle boards (SUP). Musculoskeletal injury incidence surveys have been conducted for ultra-marathon events but no data has been published for other racing formats.

Objective: To identify and compare the rates and types of injuries sustained by paddling athletes as a function of discipline and training parameters in Sprint, Marathon, Ultra Marathon and Ocean events.

Methods: Competitors from six kayak and/or ocean surf-ski races in Australia were surveyed. Prior to each race, competitors were asked to complete a questionnaire. The questionnaire investigated paddling-related injuries over the previous five years, athlete morphology, flexibility, equipment and its set up, training volume and environment.

Results: 583 competitors were surveyed. Disciplines included 173 racing-kayak (K1), 202 touring-kayak, 146 ocean-skis, 42 stand-up paddle-boards (SUPs) and 20 other. The top 5 paddling-related injuries were shoulder (31%), low back (23.5%), wrist (16.5%), neck (13.7%) and elbow (11.0%). The highest percentage of injury was found in K1 paddlers for shoulder (40.5%), SUP for low back (33.3%) and ocean-ski for wrist (22.6%). After controlling for on-water training hours, the relative risk (RR) of wrist injury was significantly increased in ocean-ski paddlers (1.86) and in paddlers with decreased flexibility (1.53-1.83). RR of shoulder and low-back injury was significantly increased in athletes with lower training volumes (1.82-2.07). Younger athletes had lower RR of wrist and shoulder injury (0.58-0.62).

Conclusion: Injury risk was increased in athletes with reduced training volumes, poor flexibility and older age. Ocean ski paddlers were at greater risk of wrist injury than other disciplines.
**Conference Presentations**

**AOA ACT Branch Scientific Meeting, Canberra 2016**

- Thinking outside the box: customised orthopaedic implants for specific indications. Smith P.
- Imaging Nanoparticle Translocation in Cells. Thammasiraphop K.
- In vivo biocompatibility of SrPO4-Mg alloy using a rat model. Li R, Chen X, Zhang D, Birbilis N, Smith P.
- Image intensifier distortion influences a surgeon’s ability to aim guidewires during orthopaedic procedures. Schwarz B, Ward T, Le B, Smith G, Smith P.
- Volar locking plates result in better long-term outcomes in the elderly; an Australian cohort study. Deng Y, Pickup H, Perriman D, Neeman T, Smith P, Ashman B.
- Does being a local make you a better skier? Kingston M.
- The fracture database of Canberra Hospital: a one-year snapshot. Loseli M, Lynch J, Perriman D, Smith P.
- Are we preventing the second fracture in minimal trauma pelvic fracture patients at TCH? Barr L, Ahmed N, Piper D, O'Rourke L, Perriman D, Smith P.
- The burden of minimal trauma pelvic fractures in the elderly at TCH. Ahmed N, Barr L, Piper D, O’Rourke L, Perriman D, Smith P.
- Post-thrombotic syndrome following lower limb arthroplasty: A systematic review and meta-analysis Connolly M, Perriman D, Smith P.
- Manipulation Under Anaesthesia After Total Knee Arthroplasty: A Narrative Review. Soo M, Perriman D.
- Surgical treatment of Pelvic Discontinuity: A systematic review Szczepanski J, Perriman D, Smith P.
- Risk Factors Driving Multiple Hip Joint Dislocation Post Total Hip Arthroplasty. Watson L, Perriman D, Neeman T, Young S, Smith P.
- An Evidence Based Algorithmic Approach to Total Hip Replacements Reduces Dislocations. Wardle B, Perriman D, Smith P.
- **POSTER:** Reverse Total Shoulder Arthroplasty for the Treatment of Proximal Humerus Fractures in the Elderly (ReShAPE) – a multicenter randomized controlled trial Soo M, Vrancic S, Damiani M, Perriman D.

**10th Australasian Biomechanics Conference, Melbourne 2016**


**Australia and New Zealand Orthopaedic Research Society, Adelaide 2017**

- Instrumented Knee Prosthesis with MWCNT/UHMWPE Piezoresistive Sensor Do O, O’Byrne D, Perriman D, Smith P.

**COE Meeting - Optimising Outcomes in Primary and Revision Hip and Knee Arthroplasty, Perth, 2017**

- Hip instability; a new take on an old problem. Smith, P
- When to operate? Smith, P.
AOA National Scientific Meeting, Adelaide 2017

- Deep Knee Flexion Captured Using A 2D-3D Image Registration Process Displays Different Arthrokinematics in Older Men And Women
- Post-thrombotic syndrome following lower limb arthroplasty: A systematic review and meta-analysis
  Connolly M, Perriman D, Smith P.
- Does Radiographic Analysis of FAI Hips Predict Patient Outcome Following Arthroscopic Repair?
  Ellis S, Perriman D, Burns A, Neeman T, Lynch J, Smith P.

Australian Physiotherapy Association Research Symposium, Canberra 2017

- The relationship between BMI and knee kinematics during step-up and deep knee bend.
  Churchill A, Pickering M, Perriman, D, Scarvell J
- Does Radiographic Analysis of FAI Hips Predict Patient Outcome Following Arthroscopic Repair?
  Ellis S, Perriman D, Burns A, Neeman T, Lynch J, Smith P.

Canberra Health Annual Research Meeting, 2017

- Knee kinematics of deep flexion
  Galvin C, Scarvell J, Pickering M, Perriman D, Smith P.
- Personalized Surgical Guide with Fused Deposition Modelling Manufactured Polylactic Acid
  Chai Y, Smith P, Li R
- Measuring pelvic tilt in femoroacetabular impingement using an accelerometer.
- Does Radiographic Analysis of FAI Hips Predict Patient Outcome Following Arthroscopic Repair?
  Ellis S, Perriman D, Burns A, Neeman T, Lynch J, Smith P.
- Risk Factors Driving Multiple Hip Joint Dislocation Post Total Hip Arthroplasty.
  Watson L, Perriman D, Neeman T, Young S, Smith P.
- Surface modified biodegradable magnesium (Mg) for orthopaedic application - in vivo biocompatibility study
  Li, R., Chen, X., Zhang, D., Birbilis, N., Smith, P.N.
- Instrumented Knee Prosthesis with MWCNT/UHMWPE Piezoresistive Sensor (Poster)
  Do Q, O’Byrne D, Perriman D, Smith P

26th Congress of the International Society of Biomechanics, Brisbane 2017

- Are you mad? You want me to kneel? Comparison of osteoarthritic and healthy knee kinematics while kneeling.
  Galvin C, Scarvell J, Pickering M, Perriman D, Smith P.

European Orthopaedic Research Society Conference, Munich 2017

- 4-dimensional kinematics of kneeling in older people.
  Scarvell JM, Galvin CM, Hribar NF, Lynch J, Perriman MR, Smith PN, Pickering MR.

World Congress of Physical Therapy, Capetown 2017

- If you could see inside the knee, what would you see in kneeling? Visualisation of 4-dimensional arthrokinematics in deep flexion.
  Scarvell JM, Galvin CM, Hribar NF, Lynch J, Perriman MR, Smith PN, Pickering MR

Arthroplasty Society of Australia Scientific Meeting, NSW, Australia 2017

- Utility of Serum metal ion testing in hip resurfacing arthroplasty patients.
  Smith, P.

International Union of Microbiological Societies (IUMS), 2017, Singapore

- Dengue virus infection can lead to cartilage loss and an osteoarthritis-like disease

The 9th Orthopaedics Expo and Surgeons Meeting, 2017, Chicago, USA

- Heparanase regulates inflammatory mediators in rheumatoid arthritis. Invited Keynote Speaker
  Li R, Smith P
Educating the Next Generation

Doctor of Philosophy

Ben Serpell - ANU

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

Ben is TORU’s most recent PhD graduate! Ben graduated this past year following completion of his thesis. Ben’s work focused on 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 continues to work as Director of Performance for the ACT Brumbies in Super Rugby while supervising PhD students through the ANU and UC. Congratulation Ben!

Claire Kenneally-Dabrowski - ANU

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

Claire is in her second year of her PhD. Claire is a past 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 (BFlh) muscle during sprinting and the personal and financial consequences are significant. This project aims to examine how the architecture of the BFlh muscle influences high speed running. More specifically, the main research question to be addressed is: ‘Does the architecture of the BFlh muscle affect its performance and potential for injury?’

Catherine Galvin - University of Canberra

Age-associated variation in both healthy and osteoarthritic 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.
Joe Lynch - ANU

Influence of knee shape on kinematics before and following total knee replacement

Joe is in the first year of his PhD at the ANU. Prior to this, Joe worked as a Senior Research Officer at TORU. He completed his Bachelor of Science in Exercise Science, and a Master of Science in Biomechanics at the University of Ottawa. Joe’s main interest are understanding of clinical and functional outcomes of patients suffering from osteoarthritis or following total joint replacement using novel measurement techniques. Joe’s thesis will examine what role the shape of the knee plays in influencing how the knee moves before and after joint replacement.

Song Chen - ANU

Bioinformatics approach to establish an osteo-network: Osteomics

Song is a final year 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

Personalized polymer surgical guide and orthopaedic metal implant manufacturing method that centred with 3D printing

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 additively manufacturing personalized surgical guide and functional implant, and researching the biomedical respond to the manufactured item within different fabrication conditions and post processes. His work is currently focusing on post processing of polymer object fabricated by fused deposition modelling, trying to build an experimental support for the current personalized surgical guidance. Future work includes fabricating a functional customized titanium orthopaedic implant and testing its mechanical and biocompatibility properties. Yuan’s PhD project is supervised from both TORU and the college of engineering and computer science in ANU.
Henry Williams

*Knee kinematics predict pain and function score during stair ascent*

**Aim:** To determine if one or more of six kinematic parameters, measured during a step-up movement, predicts Oxford Knee Scores (OKS) in patients with severe knee osteoarthritis (OA).

**Patients and Methods:** Five males and 5 females aged 63 – 84 with medial knee OA awaiting total knee replacement surgery from a larger study were included. CT scans for each patient were registered to fluoroscopy images of a step-up activity. The resultant kinematic data were described in terms of range, maxima in each direction, and rate of change as a function of flexion. The OKS surveys were administered when the images were taken. Linear regression models were used to investigate which kinematic parameters predicted OKS.

**Results:** Each 1° increase in internal/external rotation (Int/Ext) and abduction/adduction (Ab/Add) range increased OKS by 0.7 (p = 0.046) and 1.3 (p = 0.003) respectively. In addition, each 1 mm increase in maximum lateral translation and 1 mm decrease in maximum medial translation increased OKS by 0.48 (p = 0.035) and 0.94 (0.002).

**Conclusion:** OKS is influenced by knee kinematics, particularly excessive medial translation.

**Clinical Relevance:** Medial/Lateral translation, Int/External rotation, and Ab/Adduction may be important kinematic targets for improving performance on stairs.

Kaitlyn Jacobs

*Kinematics During Deep Knee Flexion Is Related To Oxford Knee Score In Patients With Medial Osteoarthritic Knees.*

**Aim:** To examine the relationship between knee kinematics during Deep Knee Flexion (DKF) in six degrees of freedom, and knee function in patients with knee osteoarthritis (OA).

**Patients and Methods:** Nine males and 7 females with medial-knee OA awaiting total knee replacement, aged 47 – 88 were included. CT scans for each patient were registered to fluoroscopy images of DKF. Oxford Knee Scores (OKS) for each participant were used to estimate patient reported knee function. Each of the kinematic parameters were visualised as a function of flexion OKS category (poor and good). Significant associations were tested using linear regression models with OKS as the dependent variable, and derived kinematic variables including range, maxima in each direction, and rate of change, as the independent variable. Each model was controlled for age, sex and flexion range.

**Results:** During deep flexion the knee internally rotated 7.4 ± 3.7 degrees, adducted 6.0 ± 2.9 degrees, posteriorly translated (femur relative to tibia) 19.3 ± 8.6 mm, medially translated 16.5 ± 9.3 mm, and distracted 5.8 ± 2.4 mm. The mean flexion achieved during DKF was 28.9 ± 13.4 degrees (range 98.06 to 127). There were visual differences in the trajectories for OKS ‘poor’ and OKS ‘good groups but the only significant kinematic parameter was the rate of lateral to medial translation (p = 0.01).

**Conclusion:** There were differences in knee kinematics during deep knee flexion but only the rate of lateral to medial translation was significant.

**Clinical Relevance:** Knowledge of factors which restrict knee flexion in kneeling will inform surgical and non-surgical therapeutic interventions.
Martin Shutte

The effect of glenoid restoration on functional outcomes following Latarjet procedure.—A Grant Proposal

The Latarjet procedure is a surgical technique for treating anterior shoulder instability. The procedure involves replacing bone that has been lost from the shoulder joint and reinforcing the anterior shoulder with a musculotendinous sling. It is not clear whether full bony restoration is needed, as well as the stabilising soft-tissue sling. This study will investigate the relationship between the restoration of bone loss and post-surgical outcomes as measured by the Western Ontario Shoulder Instability Index (WOSI).

Thomas Staniforth

Effect of anterosuperior capsule thickness on pre-operative functional status and 12 month outcomes in patients with femoroacetabular impingement

Purpose: To investigate the relationship between anterosuperior capsular thickness, and pre and post-operative function, in patients with symptomatic femoroacetabular impingement (FAI).

Methods: In this retrospective observational study, patients were included if they completed a 33-item International Hip Outcome Tool (iHOT33) prior to having hip arthroscopic surgery for FAI between 2013 and 2016, were 18 years or over, and underwent arthroscopic surgery for symptomatic FAI. Patients were excluded if they did not have a twelve-month post operative iHOT33, pre-operative Magnetic Resonance Arthrogram (MRA) within three years of their operation, and if the surgery was a revision. Linear regression models, adjusted for age, sex and baseline scores, were used to assess the effect of capsule thickness on iHOT33 score.

Results: 17 participants (6 males; 39 (11.5) years) were included. The participants were divided into those with thin (1.4mm to 1.7mm; n = 6), medium (1.8mm to 2.2mm; n = 6) and thick (≥ 2.3mm; n = 5) capsules. The adjusted means (SE) for preoperative iHOT33 score by capsular group were not significantly different (thin 39.7 (6.3) p = 0.69; medium 36.1 (5.2) p = 0.39; and thick 46.5 (5.4) p = 0.17). The adjusted means (SE) for the iHOT33 difference (twelve months minus baseline) by capsular group, were not significantly different (thin 18.4 (10.5) p = 0.3, medium 33.5 (8.8) p = 0.5 and thick 9.4 (9.5) p = 0.07). However, there were more patients in the thick capsule group who failed to improve in terms of minimally clinically significant iHOT33 score.

Conclusion: The results indicate that, although capsular thickness was not a significant predictor of functional outcome overall, thicker capsules may be a factor for non-improvement after surgery.

Laura Sofoulis

Use of patient-reported outcome measures as predictors of manipulation under anaesthetic following total knee arthroplasty

Background: Arthrofibrosis is a common complication of total knee arthroplasty, causing severe stiffness in 2-10% of patients. Manipulation under anaesthetic (MUA) is generally successful in restoring function to arthrofibrotic knees, but places patients under additional trauma immediately following arthroplasty. The identification of reliable risk factors for arthrofibrosis would potentially provide important prognostic data. This study explored the utility of patient-reported outcome measures as predictors of manipulation under anaesthetic.

Methods: We conducted a retrospective case-control study of 50 patients requiring manipulation between 2009 and 2016. These patients were matched by age, knee, and sex to a cohort of patients who did not require manipulation. Pre-operative and 1-year follow-up Oxford knee, WOMAC, and SF-12 scores were obtained from the Canberra Arthroplasty database and compared between groups using multivariate generalised linear models.

Results: We detected no difference in outcome scores between the patients who had undergone manipulation and those who had not. Extensive overlap was observed between groups, and mean scores were similar both pre-operatively and at 1-year post-arthroplasty. No pre-operative score was predictive of manipulation, but pre-operative scores were highly correlated with post-operative scores.

Conclusions: Pre-operative patient-reported outcome measures have no utility in predicting manipulation following arthroplasty. The similarity of scores at 1-year provides evidence that function and quality of life after arthrofibrosis are not significantly diminished at 1-year compared to a non-arthrofibrotic group.
**Kitiphume Thammasiraphop**

*Novel Magnesium Alloys Enhance Osteogenesis, showing potential for Orthopaedic Implants*

Issues associated with orthopaedic implant instability and toxicity have led to the development of ‘third generation’ materials with intrinsic bioactivity and biodegradability. One proposed material with such potential properties is magnesium, which is able to degrade *in vivo*. By testing the effect of magnesium based alloy extracts on osteoblast (bone forming cells) and osteoclast (bone resorbing cells) single- and co-cultures via various imaging modalities, we show that magnesium based alloy extracts suppressed osteoclast differentiation while enhancing the proliferation and maturation of osteoblasts. The results from the study encourages further investigation and progress in the development of magnesium based alloys as superior orthopaedic implantation devices.

**Paul Lemeasurier**

*What is the microarchitectural arrangement of the annulus fibrosus and nucleus pulposus with respect to the transverse fissures and unco-vertebral clefts at each of the cervical spine levels?*

**Aim:** The aim of this study was to view the microarchitectural morphology of the cervical intervertebral disc using micro-computed tomography imaging.

**Methods:** An isolated human cadaveric cervical spine was stained using an ethanol-iodine protocol. Following staining the imaging was conducted using micro-computed tomography. The micro-computed tomography was visualised using the Drishti Volume Exploration and Presentation Tool.

**Results:** All cervical intervertebral discs were visible following the scan. Features of the intervertebral disc including the uncovertebral clefts could be identified bilaterally at all cervical levels. However, transverse fissures were only evident at the cervical intervertebral disc level 3-4 and 4-5. The contrast resolution was not sufficient to view the fibre direction of the ligamentous tissue including the annulus fibrosus and anterior and posterior longitudinal ligaments. The nucleus pulposus of the disc was not able to be distinctively separated from the annulus fibrosus which is as expected in the aged cadaveric sample used in this study.

**Discussion:** There is an opportunity to improve the methods to enhance the contrast resolution and view ligament fibre direction by reducing the sample volume, using a more suitable stain, and optimising the micro-computed tomography parameters. By so doing microcomputed tomography has the potential of vastly improving our knowledge of anatomical relationships between tissues which have previously not been possible using methods which require specimen destruction.
### ANU Medical Student Research 2017-2018

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<td>Gait analysis after gluteal tendon repair: A comparison with symptomatic controls</td>
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<td>Clinical Outcomes after Gluteal Tendon Repair</td>
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<td>Robert Simic</td>
<td>Optimising the Design and Workflow of 3D Printed Orthopaedic Implants</td>
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### University of Canberra Physiotherapy

Alice 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 "**The relationship between BMI and knee kinematics during step-up and deep knee bend.**". Using a 2D-3D registration process the study will be the first to examine tibiofemoral kinematics with six degrees of freedom how and knee size influences the kinematics. After graduate, Alice plans to start her career as a practicing physiotherapist here in Canberra.

### Masters

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<tr>
<td>Dr Claire Bolton</td>
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<td>Dr David Owen</td>
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<td>Dr Andrew Griffin</td>
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<td>Dr Tom Cheng</td>
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<td>Miss Kate Phillips</td>
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Funding and Awards

Grants/Funding

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<tbody>
<tr>
<td>Australian Government Research Training Program (AGRTP) Stipend Scholarship</td>
<td>Influence of shape on kinematics before and after total joint replacement</td>
<td>Joe Lynch</td>
<td>$26,682/year</td>
</tr>
<tr>
<td>AO Spine</td>
<td>Could the Dorsal Root Ganglia be Associated with Chronic Whiplash symptoms?</td>
<td>Alex Webb, Diana Perriman</td>
<td>$6,530</td>
</tr>
<tr>
<td>ANZORS Travelling Grants</td>
<td>Various Conference Abstracts</td>
<td>Nicola Hribar, Quyen Do</td>
<td></td>
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<tr>
<td>ANU Major Equipment Committee Award</td>
<td>Refined processing of 3D printer for medical and orthopaedic implants</td>
<td>Rachel Li, Paul N. Smith, Qinghua Qin, Yuan Chai and Krisztina Valter-Kocs</td>
<td>$63,870</td>
</tr>
<tr>
<td>Australian Orthopaedic Association Research Foundation</td>
<td>Surface modifications to prevent infection and promote osseointegration of orthopaedic implants</td>
<td>Paul Smith and Rachel Li</td>
<td>$45,240</td>
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</tbody>
</table>

Publication Awards

One of our papers was awarded best paper in 2016 by the journal Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization. The paper is entitled “Robust initialisation for single-plane 3D CT to 2D fluoroscopy image registration”. The results of this paper have helped in analysing data from the PICKLeS study. Congrats to all of the authors: Masuma Akter, Andrew J. Lambert, Mark R. Pickering, Jennie M. Scarvell & Paul N. Smith.

We would like to congratulate Harrison Slockee, a 1st year medical student working with us, on receiving the Peter Sharp Scholarship. This scholarship supports Aboriginal and Torres Strait Islander medical students at the ANU.

Conference Awards

AOA ACT Meeting
- Best Paper: Rachel Li - In vivo biocompatibility of SrP04-Mg alloy using a rat model
- Best Lab: Yuan Chai - 3D printing: Pilot study for precision orthopaedic implants
- Best Student: Sarah Ellis - Does Radiographic Analysis of FAI Hips predict Patient Outcomes Following Arthroscopic Repair?