TORU received the Departmental CHARM award this year. Professor Paul Smith received the award from the Director General of ACT health at the CHARM dinner held at the lobby restaurant in Canberra this year. CHARM is an acronym for Canberra Health Annual Research Meeting. It attracts papers from all over the ACT and TORU is a major supporter and contributor. The award included $2000 for research support.

TORU Clinical research Report

The clinical arm of TORU is located in Building 6 at the Canberra Hospital. Our principal objective, with the laboratory, is to support Professor Smith to undertake clinically based research and to act as a resource for both medical staff and students undertaking research in orthopaedic related research. As such, the Trauma and Orthopaedic Unit functions as the Academic Unit of Orthopaedics at the Canberra Hospital with close links with all of the Canberra Orthopaedic Surgeons. The staff at TORU has changed in recent times. Diana Perriman is still the Clinical Research Coordinator but Kylie McKay, our treasured office manager has moved to a new job in the organisation. She continues to offer help and advice for which we are grateful. Our new office manager is Belinda Payne. Belinda has a background in nursing and is fast adapting to the many new skills needed to keep us all organised. John Warnhemoven is now undertaking a PhD in Rowing Biomechanics at USyd but continues to work part time for TORU. Rui Wang is our database architect and continues to work on the Fracture Database design and implementation. Dr Mona Singhal is involved with the Whiplash project and Dr Phuong Ghi who is an imaging physicist has joined us on a casual basis to assist with various projects but we hope to collaborate on future projects to develop new imaging protocols. Dr Claire Bolton is working at TORU as a research Fellow investigating the anatomy of the acetabulum in health and disease. Dr Shyam Rajagopalan is a visiting fellow from the UK who is involved in a number of studies investigating arthroplasty imaging and wear. Finally Angela Yu is a law student who is helping us build our image library at TORU.

成功 and we are very pleased with all of these metrics over the past year. Descriptions of many of these studies are provided in the pages of this newsletter in the form of abstracts but noteworthy are two publications which form the basis for considerable ongoing work for TORU in the future. First Andrew Griffin’s paper An In Vivo Comparison of the Orientation of the Transverse Acetabular Ligament and the Acetabulum which was published in the Journal of Arthroplasty this year and cited at the AOA Conference in October this year. The study showed that the transverse acetabular ligament does indeed represent a reliable anatomical reference for acetabular version in the normal population. Dr Claire Bolton is continuing this work investigating pathologically. Second, Jennie Scarvell’s paper titled Prevalence of Undisclosed osteoporosis in patients with minimal trauma fractures: A prospective cohort study which was published in The Physician and Sports Medicine this year. This work has resulted in the establishment of a position to confront this problem of ‘preventing the second fracture’ at Canberra Hospital. We are setting up systems for collecting data from this initiative. A major strength of the unit is our continued collaborations with the ANU, University of Canberra and University of NSW. Projects such as the Pickles knee project, the Carbon-Nanotube Smart film Project and the trunnion wear projects are all examples of this.

To conclude, we continue to enjoy very productive relationships with a number of companies who have sponsored meetings, studies and research fellows at TORU. Without this support we would not be able to do the work we do and for their support we are most thankful. We are looking forward to another busy year in 2014.

Dr Diana Perriman, Clinical Research coordinator

STOP PRESS

MPhil Graduation

TORU congratulates Dr Siva Chandrasekaran who will be awarded an MPhil by the ANU on December 19th this year. His thesis is entitled “Magnetic Resonance Imaging Kinematics of the Posterior Cruciate Deficient Knee”. His supervisors were Prof Paul Smith and A/Prof Jennie Scarvell.
Introduction

To improve the quality of life of all our patients affected by diseases of the bones, joints and muscles, the mission of the TORU Laboratory is to research into the causes, treatment, and prevention of musculoskeletal diseases, to provide the training of basic and clinical scientists to carry out this research, and to facilitate communication among TORU’s collaborating institutes, universities and companies about needs and opportunities related to the TORU’s mission.

Most of these diseases related our mission are chronic and many cause life-long pain and disability. Some are rare, such as revision joint replacement and osteolysis while others are remarkably common, such as arthritis, trauma, osteoporosis and its related fractures. Combined, they afflict millions of Australians and cause tremendous human suffering, costing millions of health care. Dollars.

Fortunately, modern science has brought to light the importance of acknowledging trans-disciplinary areas and approaches. The complex diseases and conditions can be seen through a new lens using genome-wide analyses, microRNA sequencing, cell behavioral-physical-mathematical model, new imaging modalities, immunomodulation, mesenchymal stem cells (MSCs), and tissue engineering.

In keeping with the rapid evolution of science, collaborations of researchers and disciplines are increasingly important for addressing diseases and co-morbidities relevant to the mission of the TORU Laboratory.

Collaborative Research

TORU Laboratory has developed research collaborations multi- and cross-disciplinary research teams:

ANU Research School of Chemistry

ANU College of Engineering and Computer Science

University of Western Australia

The Westmead Hospital, University of Western Sydney

A full list of TORU collaborators is included on page 14.

TORU Laboratory Research Activities

The TORU Laboratory conducts research aimed at improving the diagnosis, treatment, and prevention of diseases and injuries of the musculoskeletal system and its component tissues. Key public health problems addressed by this research include failure of total joint replacement (TJR), osteoporosis and its related fracture, and rheumatoid arthritis and osteoarthritis. Research is conducted at every level, from fundamental bone biology, genetic research, to drug intervention. Research is managed under three main areas:

Nanoscale wear particle related osteolysis in TJR and genetic/genomic variations in individuals with failure of TJR. The Laboratory led TORU’s contribution to the wear particle related osteolysis project supported by AOA Research Foundation.

Building on the foundation laid by the dendritic cells involvement in osteolysis, TORU Laboratory’s work now includes a broad range of research aimed at expanding understanding of interaction between biosynthesized materials and biological systems. The projects in these areas focus on understanding of the osteoimmunology, human tissue’s responses to implants, microRNAs’ (miRNA) variant expression and miRNA sequencing in the wear particle related osteolysis, and on translating and applying this knowledge to a variety of diseases and conditions related to TJR. The TORU Laboratory uses cohorts of healthy, primary and revision subjects of TJR for the characterization of the size and shape of wear particles and for the identification of genetic and environmental risk factors that contribute to the osteolysis. The ultimate goals are to contribute to the development of better predictive markers, treatments, and prevention strategies.

Bone biology and diseases. The projects in these areas cover a broad spectrum of research to better understanding of genetic and cellular mechanisms involved in the build-up and breakdown of bone. Research areas include: mechanisms of bone formation and bone desorption; regulation of bone remodelling; and effects of hormones, angiogenesis factors, growth factors and cytokines on bone forming and resorbing cells; biomarkers for diagnosis of rheumatoid arthritis and osteoporosis. The projects are establishing a silico model of interplay and mechanism of the human bone remodelling- osteo network. The osteo network, a multi-scale, quantitative and predictive model, will significantly contribute to the better understanding of the intersystem crosstalk in bone remodelling including cell-cell, pathway-pathway, molecule-molecule, and gene-gene. The projects emphasize the application of fundamental knowledge of bone remodelling to the development of pharmaceutical intervention for bone diseases, especially osteoporosis and fractures.

Novel and biocompatible scaffolds for bone regeneration. The projects address a need for translational research to develop discoveries that enhance treatment and improve management of bone diseases and disorders. The ultimate objective is to advance the understanding of interaction at the interface of biomaterials and biological systems and develop novel and biocompatible scaffolds for bone regeneration. We are developing biomaterials and scaffolds that mimic or result in functionally superior extracellular matrix. Research projects include the study of differentiation of mesenchymal stem cells and bone forming cells on a variety of novel materials, such as biodegradable and sensor materials, synthesized through TORU’s collaborations.

Molecular pharmacological research for wound and fracture healing. The projects investigate novel biological therapeutics and biomaterials 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. Therapeutic approaches of interest in these projects include anabolic drugs for bone formation, nutritional interventions, and joint replacement (including biomaterials and implant science).

Laboratory Facilities

The 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.
TORU Laboratory Research Report

**Molecular Biology Assays:** TORU Lab has, or has same floor access to, thermocyclers (PCR and RT-PCR machine), film processor/developer, Bio-rad gel doc system, a complete Affymetrix GeneChip DNA array system, Sequence analysis pipeline, such as SOLiDTM Small RNA Pipeline and HiSeq2000.

**Biochemistry and Immunohistology Assays:** TORU Lab has, or has same floor access to, UV-VIS spectrophotometer, Infinite 200Pro (Luminescence, fluorescent and isotope spectrometer), Beckman ultracentrifuge, Packard liquid scintillation counter, Victor X3, Flow cytometer (BD’s FACSCalibur with 9 colors, FACScan), fluorescent microscopy, confocal microscopy, and electron microscopy.

**Cell Culture:** TORU Lab has a dedicated tissue culture room equipped with Class II biosafety hoods, CO2 incubators, phase contrast inverted microscope with digital photography capabilities, water bath, and temperature controlled centrifuge, bench-top microcentrifuge, freezers and fridges.

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**Paul Smith honoured for work establishing and supporting Bone Bank in the ACT**

On the 6th of November the ACT Chief Minister Katy Gallagher recognised a special group of individuals for their outstanding contributions to organ and tissue donation awareness in a ceremony at the National Arboretum in Canberra. Among them was Professor Paul Smith. Prof Smith was presented with the **Ben Wise-man Award for Healthcare for his role in creating and directing the ACT Bone Bank**.

Gift of Life President David O’Leary thanked recipients for their dedication in raising awareness for organ and tissue donation. “Community advocates such as those we’re recognising today play an important role in encouraging discussions within families and friends about organ and tissue donation. By thereby increasing family consent, we can take comfort in knowing that many more Australian lives can now be saved,” he said.

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Paul and Claire Smith at the ACT Chief Ministers Awards in November 2013
Dislocation following total hip replacement (THR) is a complication that causes significant morbidity and increased deployment of health resources. This retrospective study aimed to identify and describe patient and surgical factors, as well as mechanism and treatment of dislocation in a cohort of 272 patients presenting to Canberra Hospital Emergency Department between August 1997 and November 2012.

Grossly, the dislocation rate over the whole study period in terms of dislocations per replacement done was found to be 4.3% but this rate does not take into account the fact that dislocations often occur multiple times and some do not occur in the peri-operative period. Female patients were primarily affected and the proportion of female patients presenting for dislocation has steadily increased. It was found that multiple dislocations were not uncommon but 50.7% of patients presented only once. The most common activity causing dislocation was hyper-flexion typically a sit to stand manoeuvre which lead to a disproportionate number of older female patients presenting for dislocation following THR.

The results of this study indicated that the dislocation rate for all patients reduced during the study period and the majority of patients achieved stability. However, more research is required to determine why a disproportionate number of older female patients presented for dislocation following THR.

After controlling for depression and anxiety scores, quality of life measures and number of systemic and neurological symptoms were not significantly different between the groups. However, the BHR group was less depressed and more anxious than their THR counterparts which suggests that the media attention surrounding this implant may be a source for patient anxiety.

An association between serum cobalt and chromium ion levels and self-reported bladder and bowel symptoms was found and the possible reasons were discussed. The BHR surgery in this cohort was found to be at least as effective as THR surgery in restoring quality of life to patients.

Medical Student Projects

Michael Ardern
Dislocation following total hip replacement, a descriptive study of common factors and treatment in Canberra

Sean Barret
Neurological Status in THR vs Resurfacing Patients

Samuel Harkin
Outcomes after compartment syndrome in lower limb fracture patients

Acute compartment syndrome (CS) is a surgical emergency occurring in up to 10% of lower leg fractures, and requires urgent fasciotomy to avoid potentially devastating sequelae. Lower leg CS managed with fasciotomy has been associated with negative long-term functional outcomes; however there is limited data available on the impact of CS on long-term quality of life. The aim of this study was to assess to whether CS after lower leg fracture affects long-term patient outcomes including quality of life, lower extremity function, pain, employment status, and duration of hospital stay.

This involved a prospective questionnaire survey of two distinct cohorts: 24 patients (20M:4F, Age 34 ±12) with tibial alone or tibial and fibular fracture with CS; and 24 patients (18M:6F, Age 32 ±13) with tibial alone and tibial and fibular fracture without CS. Mean time to follow-up was 6 years ±1.2 (4-8). Age, sex, fracture type, mechanism of injury, length of hospital stay, and time to fasciotomy were identified from hospital records. The AQoL -8D was used to assess quality of life, the Lower Extremity Functional Scale to assess lower limb function, the Visual Analogue Scale for Pain to determine pain levels, and additional questions to determine employment status.

No significant differences were found between the CS and non-CS groups in terms of quality of life, function, or pain. Length of hospital stay was significantly longer (p<0.01) in the CS group, with a mean stay of 13 days ±5.5 (5-28), compared with 5 days ±6.2 (1-28) in the non-CS group. In this cohort, who were 4-8 years post lower leg fracture with CS there were no significant differences in terms of self-reported quality of life, pain, or function compared to an age, gender, and time since injury matched cohort with lower leg fracture. Duration of hospital stay was significantly longer in the CS group.
The quality of life of BHR patients remains uncertain. This study was designed to investigate the relationship, if any, between elevation of serum cobalt and chromium metal ions in BHR patients and functional and quality of life outcomes.

A prospective survey of 118 BHR patients was conducted using two functional and quality of life measures: the Oxford Hip Score (OHS) and the Assessment of Quality of Life (AQoL-8D). Average follow-up was 6.5 years. The cohort included 79 males and 39 females who were an average age of 57 (29-74) years. The strength of the relationship between outcome and serum cobalt and chromium ion concentrations was tested with correlation coefficients.

The average serum cobalt and chromium concentrations for the BHR cohort were 38.3 (10 – 120) nmol/L and 27.2 (5 – 139) nmol/L respectively. The mean OHS for this cohort was 42 demonstrating that the BHR prostheses were performing well. The AQoL-8D scores were similar to age-matched Australian normative data however, the pain and physical superdimensions were 7.0% and 7.4% respectively lower than the normative mean value. There was no association detected between elevated serum cobalt or chromium metal ion levels in BHR patients and either patient functional or quality-of-life outcomes.

Unicompartmental knee replacements (UKR) have many benefits over total knee replacements; however they remain controversial with variable outcomes and higher revision rates. This study aimed to evaluate outcomes in UKR and TKR patients in a Canberra cohort.

Participants completed the Assessment of Quality of Life (AQoL-8D), Oxford Knee Score (OKS) and Visual analogue scales (VAS) for pain satisfaction and performance satisfaction. 68 UKR (68.0 ± 10.6 years, 65% males) and 88 TKR (68.7 ± 35 8.7 years, 59% males) patients participated (64% response rate). Prosthesis type had no effect on outcomes regardless of age or time since operation, however female gender predicted significantly lower AQoL-8D and OKS scores despite equivalent satisfaction scores.

The study indicated that there was no long term advantage of UKR over TKR in this cohort.

Distal radius fracture is the most commonly sustained skeletal injury (2-4 per 1,000 residents per year). Although locking plates have become a very common treatment there is some doubt as to whether they actually deliver better functional outcomes in elderly patients with compromised bone quality. Bearing in mind that this technology is expensive, in this study we aim to investigate the outcomes of plate fixation in these patients in terms of functional scores, complication rate and quality of life scores compared to conservative treatment.

Measuring pelvic tilt with x-ray involves conservable radiation because accurate measurement requires shoot through views. A previous study conducted at TORU by John AU revealed that the orientation of the acetabulum is significantly affected by pelvic tilt and that many patients whose acetabulum is orientated in the safe zone in supine are outside the safezone in standing due to large alterations in pelvic tilt. We are interested in developing accurate non-invasive and non-irradiating ways of measuring pelvic tilt during functional activities in order to characterise which movements endanger the patency of a hip replacement and render it more vulnerable to wear. With this technology we can potentially better instruct and rehabilitate patients and also identify and mitigate risk in vulnerable patients. The aim of this study is to investigate and validate triaxial accelerometry for this purpose.
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 is now a part-time PhD candidate at the Australian National University and remains an affiliated of TORU while he completes his study. 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 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.

Dr Claire Bolton is an orthopaedic registrar who has enrolled in an M. Phil through the ANU and TORU.

Her masters is primarily looking at acetabular morphology and its relationship to the transverse acetabular ligament (TAL) on CT scans in 3 cohorts of people.

The 1st is a normal population, looking at whether there is an effect of gender, age or hip side on acetabular morphology and the TAL.

The second phase of the study is to look at the disease state of osteoarthritis and whether this changes the TAL/acetabulum relationship.

The final phase of the study is to look at CT scans of people with developmental hip dysplasia and once again assess the TAL/acetabular relationship. The results of the 1st phase of the study have been presented at the AOA Annual Scientific Meeting in Darwin, as well as in poster format at the CHARM meeting in Canberra.

Dr Shyam Rajagopalan, Arthroplasty Fellow

Shyam hails from Chennai, one of the cricketing meccas of South India. After his initial education in Chennai, he moved to Hyderabad where he did his Medicine and Masters in Orthopaedics which he completed in 1995. Shyam moved to the UK in 1997 and completed his FRCS (Gen Surg) in 1999 during his Basic Surgical Training. He took up the post as a Staff Orthopaedic Surgeon at Grantham Hospital, Lincolnshire in the year 2000 and was promoted to an Associate Specialist in 2009. He successfully cleared the FRCS Tr & Orth exam two years ago and is currently a lower limb Arthroplasty Fellow under the supervision of Professor Paul Smith. During his time in Australia he has completed a study titled “Arthroplasty Surveillance: Are radiology reports useful?” which is included in the abstracts on page 11. He is currently examining the long term wear profiles of hip prostheses with crossfire polyethylene bearings.

**Current project: Crossfire Study**

**Title: Wear Analysis of First-Generation Highly Cross-Linked Polyethylene (HXLPE) in Primary Total Hip Arthroplasty against a 32mm metal head: A 4 to 11 year follow up study.**

Recent reports indicate that highly cross-linked polyethylene (HXLPE) bearings are more resistant to wear in patients up to 10 years post arthroplasty. We have 11 years’ experience with first generation HXLPE bearings (Crossfire; Stryker, Mahwah, NJ) articulating with a 32mm metal (stainless steel) heads. This bearing technology has been superseded but it has yet to be shown that newer bearing materials are superior in the long term. The purpose of this study therefore was to measure and report linear, volumetric wear and osteolysis rates of first-generation HXLPE bearings after 4 to 11 years articulation with 32 mm heads. The linear wear was measured using Roman software V1.70. We are currently using PolyWare 3D V7.01 software to measure the volumetric wear.

We are hoping to present our study in the next EFORT(European Orthopaedic Congress) in London in June 2014.
Characterising whiplash injury using magnetic resonance imaging - Alex Webb

This study brings together musculoskeletal experts in trauma and orthopaedics research, radiology and anatomy. The results of this research could lead to internationally important findings in the field of whiplash identification and management. If this pilot is successful we will be seeking NHMRC and/or corporate support for a larger longitudinal study.

Whiplash is a term describing a range of injuries caused by or related to sudden distortion of the neck. It is commonly associated with motor vehicle accidents, usually when the vehicle has been hit in the rear.

Injuries to the cervical spine following motor vehicle accidents (whiplash injury) are one of the most common causes of neck pain and disability in the developed world with significant numbers likely to develop long lasting symptoms. In the 2007/2008 financial year, the annual financial costs associated with whiplash injuries were approximated to be $AUD 700 million in New South Wales alone. To date there are no reliable physical markers with which to unequivocally diagnose whiplash injury or the degree of severity.

Dr Alex Webb has recently developed methods for quantifying the morphometry of the synovial folds in the cervical spine using MR imaging. These structures may represent structures of interest with respect to whiplash diagnosis and prognostication.

The purpose of this study is to investigate the use of 3T magnetic resonance imaging (MRI) to detect structural damage to synovial folds and surrounding structures in whiplash patients with neck pain caused by motor vehicle accident.

In this study, participants who have both acute and chronic neck pain following a motor vehicle accident will be compared with participants who do not have neck pain using MRI as well as clinical tools which have previously been used to determine the severity and prognosis of whiplash injury. This is a pilot study involving 60 participants aged between 18 and 29 years. We are recruiting:

- **Acute whiplash patients** - n=20 - Less than 2 weeks following motor vehicle accident; identified from the Canberra Hospital Emergency Department.
- **Chronic whiplash patients** - n=20 - Greater than 12 weeks but less than 3 years following motor vehicle accident; identified in the same way as the acute patients.
- **Control subjects** - n=20 - No neck pain; recruited from the community. Flyers have been sent to GPs, physiotherapy departments and placed on community notice boards in universities and other tertiary institutions.

THR Physiotherapy Rehabilitation Study—Corinne Coulter

This study is being undertaken as part of my Masters of Philosophy (Research) supported through the ANU and TORU. The aim is to determine the value of physiotherapy rehabilitation after total hip replacement. There is current uncertainty in practice and throughout the literature regarding physiotherapy for patients after discharge from hospital after total hip replacement, and this study’s aim is to determine the benefit of physiotherapy post total hip replacement by looking at two rehabilitation interventions; a supervised or unsupervised program.

This randomised control trial continues in the participant recruitment phase; this was commenced in June 2010 and is planned for recruitment completion at the end of 2013 with ideal participant numbers aimed at 120. Outcomes to be evaluated during this study are the WOMAC (Western Ontario & McMasters University Osteoarthritis Index) and SF36 (Short form 36) questionnaires; standardised quality of life measures and a functional timed walking measurement. As part of this study we have recently completed a systematic review titled ‘Physiotherapist-directed rehabilitation exercises in the outpatient or home setting improve strength, gait speed and cadence after elective total hip replacement: a systematic review’. The conclusion made from this review was that physiotherapy rehabilitation improves hip abductor strength, gait speed and cadence in people who have been discharged from hospital after total hip replacement. Physiotherapist-directed rehabilitation exercises appear to be similarly effective whether they are performed unsupervised at home or supervised by a physiotherapist in an outpatient setting. This systematic review is awaiting publication in the Journal of Physiotherapy.

Femoro-Acetabular Impingement—Outcomes of Surgery—Nicholas Baxfield

Femoroacetabular impingement is a condition affecting the femoral head and acetabulum, leading to damage of the articular or labral cartilage. It is suspected of affecting 10-15% of the population and is the most common cause of hip pain in young adults, as well as very likely a cause of early osteoarthritis. The FAI study is a retrospective outcome review of patients who have been diagnosed in the last 5 years and had arthroscopic surgery to repair FAI lesions. Using a newly developed survey (International Hip Outcome Tool 33), the study aims to evaluate patient satisfaction after the procedure. Additionally, the study involves evaluating pelvic X-rays and correlating patient post-operative satisfaction with the degree of pathology visible on X-ray pre-operatively. The study is progressing well and data will be collated for presentation in 2014. As there is little research in this area and some doubt over the prognostic value of the different diagnostic tests used for FAI we expect the results to be of significant value.
R3 Study
John Warmenhoven


This multicentre study aims to determine the safety and efficacy of the R3 Acetabular System prosthesis in primary total hip replacement compared to an established control. The device is currently being assessed using RSA, the Harris Hip Score self-assessment questionnaire and the occurrence of revision surgery and adverse events. Information is currently being obtained over a five year follow-up period, conducted at 6 months, 12 months and 2, 3 and 5 year intervals post-surgery. Harris Hip Score information and standard x-rays have also been obtained pre-operatively and TORU has completed all participant recruitment for the project. We have currently performed seventeen two-year reviews of the 5-year study.

Modelling Trunnion wear in hip replacement - Obinna Ihesiulor

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.

Studies have shown that despite contributing less to the total material loss than the bearing surfaces (head-cup), the head-neck interface remains a critical source of implant induced wear debris and subsequent release of metallic ions, a process known as metallosis. In order to quantify the amount of material loss to ultimate locations in the surrounding joint space, the taper-trunnion project for wear investigation is conceptualized and motivated.

The project aims to develop novel methods for investigating, evaluating and quantifying wear of total hip prostheses at the taper-trunnion junction by employing numerical methods via finite element modelling. In a broader sense, the principal goal is to work toward the minimization of wear debris produced in the hip joint, thereby resulting in a longer prosthetic lifetime. This work is supported by Global Orthopaedics.

Pressure Sensitive Carbon-Nanotube Film Study

This major study aims to examine knee kinematics before and after knee arthroplasty and compare those 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. Although this can easily be done at surgery this technique precluded pre-operative measurement thereby making pre and post-operative comparison impossible. In this study we aim to overcome this problem by using the image registration technology developed at TORU by Prof Smith, Assoc Prof Jennie Scarvell and Assoc Prof Mark Pickering. This study is unique because, for the first time, knee replacement patients will have their knee kinematics accurately measured both before and after surgery. At this stage we are recruiting normal participants and imaging their knee using both CT scanning and video-fluoroscopy while they perform a number of loaded end-of-range activities. So far we have recruited over forty participants with healthy knees and will soon be seeking to recruit three cohorts of knee replacement patients. This study has been funded by the Canberra hospital Private Practice Fund and the University of Canberra.

The specific aims of this research are to:
1. Develop pressure-sensitive plastic films doped with carbon nanotubes.
2. Test the potential for these films to be used with embedded microcomputers as sensors in knee replacements.
3. Test the applicability as shoe inserts for mapping of load patterns in running and jumping sports and in the military.
4. Prepare for an NHMRC or ARC application with a view to commercialisation of the product all possible applications.

The project was just one of a small number which were funded by ACT health in 2013. Dr Sean O’Byrne at UNSW has commenced the preliminary work involved in fabrication and validation, TORU will be involved in testing the sensor in its knee simulator.

Obinna Ihesiulor

A prospective Imaging study of cruciate retaining and substituting knee replacement, in osteoarthritis and healthy aging.

This project is the first stage in the development of an innovative new pressure sensing technology which will seamlessly interface with ‘smart’ wireless data acquisition.
**Video Analysis of Hamstring Injuries—Vignesh Vetrival**

Hamstring muscle tears are painful and costly to both the athlete concerned and the sporting clubs for whom they play. A mountain of research has been devoted to hamstring injury over the past 20 years because it affects 6 players in every club in every season in all the running and kicking sports such as soccer, rugby and AFL. These injuries can vary in severity and resultant time spent off the field but the most common predisposing factors are age and previous injury. In other words, if you have had a hamstring injury you are at a high risk of having another and the older you become the risk increases.

The mechanism of injury has been described as being a combination of factors such as contraction force and external stressors, along with the degree and velocity of muscle stretch (Orchard, 2002). So it is assumed that undue stress on the muscle when it is on full stretch results in tearing of the fibres, particularly adjacent to the central tendon. However, no study has been conducted which aims to examine the mechanisms preceding hamstring injury in order to test this theory.

A previous study of ACL injuries in footballers used video footage of the injured player just before injury to systematically describe the injury mechanism (Cochrane et al. 2007). This methodology is relatively easy for ACL injury because it stops play and the television stations tend to replay the causal incident time. However, hamstring injury is rarely a cause for play to stop since the player generally is seen to grab his posterior thigh but stumble on.

During his time at Port Adelaide Ben Serpell managed to obtain video footage of 13 hamstring injuries being sustained. From these we analysed the mechanism of injury and derived four potential manoeuvres which preceded the injuries (see abstract page 12). The main finding however was that the hamstring muscle was not always on full stretch. On the contrary the knee was rarely fully extended but the muscle was changing function or ‘gear’ from a speed to power—typically decelerating. We postulate that the mechanism of hamstring tear may be fundamentally related to its pinnate nature.

Pennate muscles are designed to be able to produce a lot of power at low speed or a lost of speed at low power depending on the angle of pennation. We hypothesize that the propensity for injury is potentially governed by the individuals ability to adjust to these demands in time for there not to be a conflict resulting in the wrong insertional fibre angle for the function required. This theory would fit with the increasing risk with age and decreasing neuromuscular acuity. We hope to investigate this theory further.

**Fractures Database—Rui Wang**

The fracture database is a unique tool with the capacity to make every patient admitted to the Canberra Hospital for fracture management a study participant. This smart tool uses the power of the internet to enable remote surveillance and evaluation of longitudinal outcomes in our whole patient population. Of course complete capture will not be possible but this tool puts in place the capacity to track outcomes using current technology while providing the perfect test bed for new technology surveillance. Although this tool has taken longer to go online than we had hoped we expect to launch the tool in 2014. After embedded testing and editing we will investigate the possibilities of making this tool available to other jurisdictions. This exciting initiative is a leap forward in data collection and patient evaluation.

**Arthroplasty Database—Chris Hanrahan**

The arthroplasty database is also an online tool which introduced in the private sector in 2009 and we hope will be taken up by ACT health in the future. The data provided by this tool serves to provide clinical surveillance reports and longitudinal outcome collection but also has some unique functions for management. The data collected has the potential to facilitate waiting list categorization and follow-up frequency management thereby improving efficiency while remaining responsive. The database is currently being streamlined.
Conferences Report—2013

**CHARM 2013**
Canberra Health Annual Research Meeting. This meeting is held annually and is designed to showcase health research being undertaken in the Canberra region. This year TORU submitted 12 abstracts and won the departmental award for the most active unit in the region.

**AOA National Scientific Meeting Darwin 2013**
TORU was successful in achieving 5 podium presentations at the National AOA meeting this year in Darwin.

**CORS Venice Italy 2013**
Combined Orthopaedic Research Society Rachel Li presented on behalf of TORU at this important international meeting.

**ANZORS Sydney 2013**
Australian and New Zealand orthopaedic Research Society. Both Paul Smith and Rachel Li attended ANZORS this year.

**Australian Physiotherapy Association Research Symposium Canberra 2013**
Diana Perriman presented at this meeting on behalf of TORU and was awarded a prize for “A systematic video analysis of hamstring injuries in Australian Rules Football – a pilot study”

**Australian Physiotherapy Association National Conference Melbourne 2013**
Diana Perriman presented at this important national meeting.

**Results after one year of experience using tranexamic acid for total knee arthroplasty.**
Canberra Hospital, Trauma and Orthopaedic Research Unit, OrthoACT

**Introduction**
Knee replacement improves quality of life for patients with osteoarthritis but has associated morbidity with pain and blood loss. We report preliminary outcomes for intra-articular tranexamic acid (TXA) during knee replacement surgery.

**Method**
We performed a retrospective study comparing a cohort of patients who had received intra-articular TXA and a cohort who had not. All patients were treated by a single surgeon. Transfusion rates, pre- and post-operative operative haemoglobin levels, serum protein and serum albumin, range of motion, opiate and length of stay were extracted and analysed using linear regression models.

**Results**
69 TXA patients (53 TKR, 11 UKR) and 24 non-TXA (19 TKR, 5 UKR) were identified. Controlling for pre-operative haemoglobin, gender and type of operation we found significant differences in post-operative haemoglobin and transfusion rates. In patients who received TXA post-operative haemoglobin was 9.79 mmol/L higher (95% CI 6.00-13.59, p<0.001) and transfusion units were decreased by 0.48 units (95% CI 0.17-0.79, p=0.003). There were no significant differences detected between post-operative serum protein or albumin, range of motion, opiate use or length of stay.

**Conclusions**
The results suggest that intra-articular TXA results in decreased transfusion rates as well as higher post-operative haemoglobin but serum protein was not affected.

**Comparison of unicompartmental vs total knee joint replacement: patient reported satisfaction, performance and quality of life**
Selkirk A, Perriman D, Smith P
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**Introduction**
Unicompartmental knee replacement (UKR) as opposed to total knee replacement (TKR) is performed for isolated medial compartment damage. UKR is less invasive and anecdotally results in a more natural feeling knee. However, revision rates are higher. This study aims to evaluate the outcome of UKR vs TKR in a Canberra cohort.

**Methods**
101 UKR patients and a further 164 TKR patients with similar characteristics for age, gender and years since surgery were identified. These patients were sent the Assessment of Quality of Life (AQoL), Oxford Knee Score (OKS) and Visual Analogue Scales (VAS) for satisfaction with performance and pain.

**Results**
68 UKR (68±11yrs; 44M) and 86 (68±8yrs; 50M) TKR patients responded (58%). There were no significant differences between UKR and TKR for any of the outcome measures. However, regression analysis showed that gender was a significant predictor of AQoL (p < 0.000) and OKS (p = 0.007) but not satisfaction.

**Conclusion**
There is no evidence from this cohort that UKR offers a long term advantage to patients in terms of perceived pain, function and quality of life but males in both cohorts reported higher scores than females for the AQoL and OKS. Patient comments indicated a potential difference in expectations for UKR.
Pelvic fracture classification: can an educational tool improve orthopaedic registrar performance?

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Introduction Pelvic fracture has been described as the “killing fracture” because of the risk of significant vascular compromise. The ability to correctly classify pelvic fractures is crucial to patient survival and outcome. Pelvic fracture classification is difficult and previous research has indicated that ability is suboptimal in registrars. Our study aimed to examine the use of a self-administered electronic-format educational package to improve registrars’ ability to classify pelvic fractures.

Methods 20 orthopaedic registrars were prospectively recruited. A testing package was used to assess their classification ability before and after using a self-administered educational package. A third test was performed two weeks after the second to assess the stability of learning.

Results There was a significant improvement in registrars’ ability to classify pelvic fractures after the education package (p < 0.05). There was no significant difference in performance between the second and third test (p > 0.05) suggesting good stability of learning. Participants were very positive about the package format and design.

Conclusion The reliability with which orthopaedic registrars classify pelvic fractures was improved by using this self-administered education package and there was good stability of learning. The e-format allows web upload so that all orthopaedic registrars can be educated and tested prior to commencing.

MicroRNA Profile in wear particle associated osteolysis

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Introduction MicroRNAs (miRNAs) act as negative regulators of gene expression by slicing transcripts and inhibiting the translation or promoting the degradation of target mRNAs. We investigated miRNA expression profiles in wear particle associated osteolytic bone from revision surgery of total hip replacement (THR).

Methods Total RNAs were prepared from the trabecular bone specimens of the patients undergoing primary and revision THR surgery. The TruSeq Small RNA Sample Preparation kit was used to construct libraries that were further sequenced on an Illumina HiSeq2000 sequencer. The miRBase v19 was used for identifying start positions of all mature miRNA and edgeR package for differential expression analysis.

Results We demonstrated significantly and differentially expressed miRNAs between revision and primary THR surgery. The target mRNA including upexpressed miR127, miR-409, miR-574 and miR-146a (in revision surgery group). The target mRNA of these miRNAs, such as TGFβ1, SMAD4, RUNX2, COL1a1 and WNT4, play important role in osteogenesis pathway. These miRNA were further confirmed downregulated by RT-qPCR assay.

Conclusion Aberrant miRNA expressions identified in revision group may suggest the existence of genetic risk factors favouring osteolysis development in certain specific subgroups of patients. An in-depth understanding of the roles of these regulatory miRNAs in the skeleton warrants further investigation.

Arthroplasty Surveillance: Are radiology reports useful?

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Introduction Routine post-operative surveillance of lower-limb arthroplasty is widely recommended to identify asymptomatic failure. Inclusion of x-ray review is believed to be important but our experience is that review by the surgeon is overly time consuming. This study aimed to investigate the accuracy of radiology reports and other methods of screening.

Methods Patients with surgeon-reported x-ray abnormalities requiring orthopaedic review were identified (N= 47 patients; 49 joints). A further 91 patients (109 joints) with unreported abnormalities were randomly selected. Radiology reports, Oxford Hip and Knee Scores (OHS and OKS) were retrieved. The sensitivity and specificity of the radiology reports were assessed. The OHS and OKS scores were assessed for their predictive power.

Results 43 patients (45 joints) with surgeon-reported x-ray abnormalities were included. The radiologist’s sensitivity for detecting abnormalities was 16.3% and specificity 97.2%. Logistic-regression modelling suggested that the OHS question 5 was predictive of hips with abnormal radiology (p=0.007) but there were no significant predictive factors for knees.

Conclusion The results suggest that radiologists are not able to offer an adequately sensitive screening service post arthroplasty. We are currently using model ensemble methods to develop a classification model to screen patients in order to reduce the number of x-rays requiring surgeon review. This model will
A systematic video analysis of hamstring injuries in Australian Rules Football – a pilot study

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Introduction Hamstring injuries are the most common injury in Australian Rules football, as well as other sporting disciplines. While there is growing evidence relating to injury prevention, little is known about what actually causes the on-field injuries. This study aimed to investigate the value of video review in the analysis of hamstring injuries in AFL.

Methods Thirteen videos of hamstring injury being sustained were systematically analysed by 3 independent observers. Biomechanical data and player activity were classified according to a pre-defined system and emerging patterns and trends were identified.

Results Twelve videos were included in the final analysis. There was no significant correlation between injury incidence and game quarter. The majority of injuries occurred to players while sprinting in non-contact situation. Four main categories of manoeuvres were identified as contributing to injury. In 10 cases the player was weight bearing through the injured leg at the point of injury. Players’ body positions were often found to be mechanically disadvantageous, placing increased strain on the hamstrings.

Conclusion Four common manoeuvres likely to be implicated in hamstring strain were revealed which may prove to be a useful tool for coaches and health care professionals. We speculate that the pennate structure of the hamstring muscles may contribute to the injury mechanism.

Are intramedullary nails superior to plates for fixing distal third extra-articular tibial fractures?

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Introduction Both intramedullary nails (IM nails) and plates are used to treat distal third extra-articular tibial fractures but plates are more expensive. Although the literature to date suggests that there is no difference in terms of performance between these two constructs this study aimed to examine outcomes in terms of resource implications.

Methods A retrospective review of patients treated between 2008 and 2012 for distal third extra-articular tibial fractures was conducted. X-rays of 344 patients were reviewed and 76 patients were included (67 IM nails and 9 plates). Clinical records were reviewed for complications, return to theatre for removal of hardware, time to union and length of hospital stay.

Results Thirty IM nail and 3 plated patients were lost to follow up. The time to union for nails was 10 weeks (6 - 46) compared with 28 weeks (8 - 44) for plates. Complications were only present in 6 of the IM nail group and 5 IM nail patients underwent removal of hardware.

Conclusion This preliminary data suggests that although the complication rate was higher for nails than plates the time to union may be longer for plates making the outcomes less favourable. However, data from the patients who were lost to follow-up is being sought to confirm these findings.

The Fracture Surveillance Database

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Introduction Canberra Hospital is a level 1 trauma centre treating over 3,500 fractures per year of which a significant proportion are treated surgically resulting in considerable resource implications. Current outcomes analysis of fracture management is anecdotal supplemented by retrospective reviews. Many patients are lost to follow-up because they return to their home states or towns. This paper aims to provide a description of the architecture and capacities of Canberra Hospital Fracture Outcome Surveillance Database which aims to overcome some of these difficulties.

Methods A web-based mechanism for identifying, classifying and surveying all fractures treated by the Canberra Orthopaedic team has been developed. The unique features of this system include web-based data capture and capacity for patient populated longitudinal data making it sustainable in the long term unlike other comparable data collection projects. Data is collected at the bedside using a tablet or smartphone.

Results The trial phase of this instrument is underway. A significant barrier yet to overcome is the requirement to gain informed consent.

Conclusion The information collected in this system has the capacity to provide individual patient surveillance but arguably more powerful is the potential to generate predictive models for effective and efficient fracture management into the future.

This project is supported by Synthes.
Pelvic Tilt Differences in Sitting and Standing in Total Hip Replacement Patients: Implications for Physiotherapists

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Question: Is pelvic tilt different in supine X-rays compared to standing X-rays in Total Hip Replacement (THR) patients? Do intra-subject differences in pelvic tilt affect the risk of dislocation in these patients?

Method: Participants: Thirty (18 F) adults 6 weeks post total hip replacement surgery who received a standardized antero-posterior and lateral X-ray set. Outcome measures: All the angles were measured from lateral digital x-ray images using AutoCAD software. Pelvic tilt and acetabular anteversion angles were measured relative to the coronal plane (superior rim, 10mm and 20mm below and inferior rim). Linear regression modelling was used to compare the age groups.

Results: The mean TAL anteversion angle was 17.7 ± 7.9 for males and 21.4 ± 8.7 for females. The acetabulum was comparatively more retroverted at the superior rim and became increasingly more antverted inferiorly. This torsion of the acetabular rim was consistent across sexes, right and left sides and age groups 30-89. The 20-29 year age group showed greater torsion of the acetabulum when compared to the older age groups (p<0.005). There was a significant difference (p<0.05) between male and female measurements at each acetabular level, with females being more antverted by approximately 3°. The TAL anteversion angle was most comparable to that measured at the mid-section of the acetabulum, independent of age, sex or side. 20.3% of all hips measured were retroverted at the level of the superior acetabulum.

Conclusion: The torsion of the acetabulum was greater in the youngest patient group and females were more antverted, however the TAL remained consistent in its relationship to the mid-acetabulum regardless of age or gender. The TAL therefore appears to represent a reliable landmark for THR independent of age, torsion or gender.

Ceramic On Ceramic Total Hip Arthroplasty Squeak: An Estimation Of The Incidence Of Squeak And Revision Surgery For Squeak

Owen, D. Smith, P

Introduction: Ceramic-on-ceramic (CoC) total hip arthroplasty (THA) squeak has attracted the interest of the orthopaedic community. However, the true incidence of CoC THA squeak and revision surgery for squeak is not known. We performed a meta-analysis to answer these questions.

Methods: Online database searches were performed with combinations of the terms: hip, squeak, squeaking, noise, arthroplasty and ceramic. 1403 reports were identified and examined by title and abstract. 116 of these were considered for assessment. Studies were included if either or both the incidence of squeak or incidence of revision for squeak could be determined. Forty-three studies met these criteria. The Australian National Joint Registry (ANJRR) was also consulted. The incidence of squeak and revision for squeak were calculated using maximum likelihood estimation from a beta-binomial distribution.

Results: We estimated the incidence of CoC THA squeak to be 4.2% (2.7-6.4%, 95% CI, n=15,131). Studies specifically questioning patients about THA squeak recorded an incidence of 4.5% (3.5-5.8%, 95% CI compared to 1.2% (0.6–2.6 95%, CI) in self-reported series. The frequency of revision surgery for squeak was 0.2% (0.08-0.57%, 95% CI, n = 16,794). The Stryker Accolade femoral stem had a significantly higher incidence of squeak 8.3% (5.9-11.5%, 95% CI, n=2,924 and frequency of revision for squeak 1.3%, (0.6-2.6, 95%CI, p <0.001) than other femoral components. The ANJRR reports a revision rate of 0.03% for all CoC THA (n=55,417) and 0.17% (n=2,955) for CoC THA with the Accolade femoral stem.

Conclusion / Clinical significance: The incidence of CoC THA squeak and revision for squeak is 4.2% and 0.2% respectively. Although the majority CoC THA perform well, a small proportion squeak with some requiring revision surgery. This is particularly related to certain prosthesis designs. It is important that patients are counselled about this complication and further research is focused on mitigating this problem. Caution with regard to squeak is advised when using the Accolade femoral prosthesis with ceramic bearings.
2013 – 2014 Collaborative Associates

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Professor Nicholas Birilis, Dean of the Dept of Materials Engineering, Monash University, Victoria.

Dr Xiaobo Chen, Dept of Materials Engineering, Monash University, Victoria.
Conference Papers (2013)

5. Li R, Smith P. MicroRNA Profiling in Wear Particle Associated Osteolysis. 8th Combined Orthopaedic Research Society (CORS); October; Venice, Italy 2013.
Journal Articles (2013)

TORU’s People

Prof Paul Smith, BMBS FRACS (Ortho). Director

Professor Smith is an orthopaedic surgeon at the Canberra Hospital and at Calvary John James Hospital in Canberra. He is also Co-Director of the Trauma and Orthopaedic Research Unit at the Canberra Hospital. Prof Smith is also president of the Arthroplasty Society of Australia, and Clinical Director of Orthopaedic surgery at the Canberra Hospital.

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

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A/Prof Rachel Wei Li, MD, PhD. Laboratory Research Co-ordinator

Dr Li obtained a Bachelor of Medicine from China Medical University in 1982 and worked as a surgeon and senior infectious diseases specialist at China Medical University from 1982-1996. Her Master project was on immune responses to viral infection. She led a number of clinical trials in antiviral and anti-inflammatory drugs and successfully transferred an intellectual property to pharmaceutical industry. In 2002 Dr Li completed her PhD in pharmacology at Southern Cross University and gained her postdoctoral research experience in molecular pharmacology in the University of Hawaii School of Medicine.

Dr Li returned to Australia in 2006 joining TORU and has established TORU laboratory with a focus on osteoimmunology. She has developed a range of laboratory capabilities to determine the effects of therapeutic, surgical and physiotherapeutic treatments on biomedical markers using human primary cell culture and large animal models.

In addition to her research work, she is an Adjunct Associate Professor at the University of Canberra teaching and supervising the students in Master of Pharmacy Program.

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Dr Diana Perriman, PhD. Clinical Research Co-ordinator

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.

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 randomised 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.

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**TORU Staff and Students**

**John Warmenhoven**
B Coaching Sci. John is a graduate of University of Canberra and is currently working on his honours thesis for his Bachelor of Sports Studies (hons) in biomechanics at the Australian Institute of Sport. John is studying the kinematics of rowers. He is a recipient of the AIS prize, and has a keen interest in swimming. John manages the TORU pelvic fractures database and assists with data management of the total knee and hip replacement study. Contact: john.warmenhoven@act.gov.au

**Ben Serpell**
BHSc, B(App)Sc OT (hons), B(App)Sc Human Movement (hons). Ben’s PhD asks “Is there a relationship between hamstring and quadriceps strength, and the knee joint kinematics which predict anterior cruciate ligament injury?” We look forward to collaboration with the AIS and UC

**Corinne Coulter**
B(App)Sc, Physiotherapy. Corinne is a senior orthopaedic physiotherapist working at the Canberra Hospital. She is currently undertaking an MPhil through TORU under the supervision of Prof Paul Smith and A/Prof Jennie Scarvell with an RCT exploring efficient and effective rehabilitation post total hip replacements. Contact: corinne.coulter@act.gov.au

**Sumedha S. Amarasekara**
MBBS (Syd), MS (Colombo), FRCEd
Dr Sumedha Amarasekara graduated from the University of Sydney and is a Board Certified Orthopaedic Surgeon from Sri Lanka. He is currently doing an MPhil with both a clinical component (outcomes of periprosthetic fractures) and a laboratory component (the efficacy of methods in fracture fixation).
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**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.” He has now returned to China.

**Song Chen**
Song Chen is studying as a 1st year PhD student in College of Engineering and Computer Science (CECS) in ANU, sponsored by a prestigious Chinese government scholarship.
Song Chen’s works, supervised by Prof. Paul Smith, Prof. Rachel Li from TORU and Prof. Qinghua Qin from CECS, focus on building a multi-scale computational model to predict the networks in bone cells.

**Dr Maoyuan Xin**
Dr Maoyuan Xin is a visiting 3rd year PhD student from the medical school of Shandong University, located in Jinan city of China. Xin’s work is supervised by Prof Paul Smith and A/Prof Rachel Li and focusses on novel sensor materials for use in medicine particularly in the field of orthopedics.

**Rui Wang**
Rui is a database architect who is designing the Fracture Surveillance Database. She has extensive IT and clinical experience and is currently completing her PhD at ANU.

**Belinda Payne**
Is the Office Manager for TORU. Contact: 02—6244 3858 belinda.payne@act.gov.au

**Dr Mona Singhal**
Mona is a medical Doctor trained in India. She is currently working on the Whiplash Study. Contact: mona.singhal@act.gov.au

**Dr Phuong Ghi**
Dr Ghi has a PhD in Medical Physics and is currently working on the Pickles Knee Project. Contact: phuong.ghi@act.gov.au

**Dr Nick Baxfield**
Nick is an intern in orthopaedics at Canberra Hospital. He commenced his research into FAI with Dr Al Burns and TORU while a final year medical student at ANU.

**Jennifer Truong**
Jennifer has just completed her final year as a medical student at ANU. She is doing a study which aims to accurately evaluate the cost of a 2 stage revision for infected arthroplasty.

**Dr Ritesh Darwa**
Dr Ritesh Darwa commenced his evaluation of the Eshelon implant while he was a registrar at TCH and is completing the study while working as an orthopaedic registrar in Queensland.

**Dr Ali Moaaz**
Dr Ali Moaaz is an orthopaedic registrar at Canberra Hospital. He is conducting a retrospective study evaluating the effectiveness of plates vs pins in distal tibial fractures.
Interested in Studying with TORU in 2014?

TORU is affiliated with the Australian National University and works closely with UNSW@ADFA and University of Canberra as well. Prospective higher degree students are encouraged to consider possible research opportunities at TORU in 2012. Contact TORU or prepare a 1-2 page research proposal for TORU to consider. TORU is committed to progressing research in trauma and orthopaedics, and to developing young researchers.