Paediatric Spine Research Group Newsletter

July 2011

The Paediatric Spine Research Group (PSRG) was formed in 2002 by agreement between the Qld University of Technology and Mater Health Services Brisbane to conduct high quality research into spinal deformity. This newsletter provides an update of the group's activities and achievements.

What's ahead for the PSRG?

The PSRG is in its 9th year and in this newsletter we have departed from the usual format to look into the future and identify our research directions in the field of spinal deformity and its surgical correction in the coming years. Due to the complexity of the spine and the 3D nature of spinal deformities, there is still much debate in the clinical community regarding how best to treat different types of deformity, how to predict which patients are most at risk of deformity progression, and how early intervention or preventative measures can be used to avoid the need for major surgery in patients of all ages.

Our work to date has fallen into three main areas; (i) the development of what we believe to be the largest single centre database of thoracoscopic (keyhole) scoliosis correction cases worldwide, now containing 190 consecutive cases, (ii) development of a unique biomechanical modelling capability for patient-specific computer simulation of adolescent idiopathic scoliosis surgery, and (iii) a growing body of work on tissue properties in spinal deformity at the microscopic scale, which is important for understanding the relationship between cell and tissue behaviour and overall spinal deformity. Building on this foundation, we see the direction of our research in the coming years falling into four main categories;

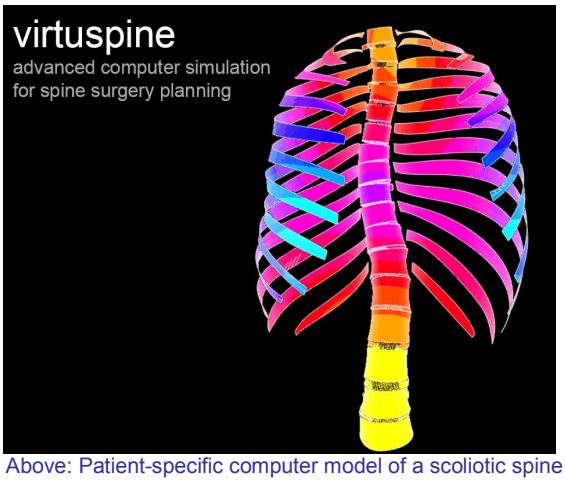
1. Ongoing research into clinical aspects of spinal deformity surgery, building on our strong existing collaborative links with the Mater Children's Hospital.
2. Biomechanical and medical imaging studies of spinal growth leading to the development of effective, minimally invasive techniques for spinal growth modulation, thus avoiding the need for major fusion surgery in adolescent patients.
3. Further development of advanced patient-specific biomechanical computer simulations to create clinically useful tools which can assist surgeons in planning optimal correction for spinal deformity patients (both paediatric and ageing spine).
4. Tissue level studies of spinal degeneration, deformity and repair, with an emphasis on how cells and tissues respond to both chemical and mechanical stimuli, with application to a range of problems including preventing and treating osteoporotic vertebral compression fractures, promoting spinal fusion, and preventative strategies for spinal degeneration in the ageing spine.

Research Capabilities

To support our research interests, the PSRG has access to a world class research environment for biomechanical testing, modelling and simulation, medical image processing, and clinical data collection and analysis through Queensland University of Technology's Institute of Health and Biomedical Innovation, Faculty of Built Environment and Engineering, and High Performance Computing facilities. Our clinical research is based at the Mater Hospitals in Brisbane, which provides us with close links to the Mater Medical Research Institute. In addition, research space at the new Queensland Children's Hospital (due for completion in 2014) will provide an ideal environment for patient-related research in close proximity to the spinal deformity clinic. Specifically, our future research directions will encompass;

1. Patient Specific Computer Modelling

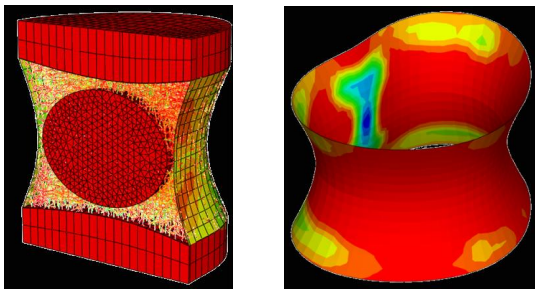
PSRG postdoctoral researcher Dr Paige Little is developing patient-specific biomechanical computer models of the spine and ribcage (see virtuspine image below) to assist surgeons to plan optimal deformity correction procedures in individual patients.



Above: Patient-specific computer model of a scoliotic spine

A low dose CT scan of the patient provides the individual's spinal anatomy to build an accurate model of the spine. Advanced biomechanical computer simulations calculate deformation, stress and strain in both the spinal tissues and the spinal implants for individual patients of all ages and various bone qualities. The ultimate goal of this technology is to allow the surgeon to input various surgical and instrumentation strategies and for the computer to predict the surgical outcome and the risk of any complications for each of the strategies provided.

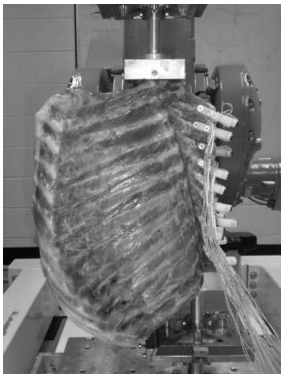
The surgeon would then choose the strategy which results in the optimal spinal deformity correction with minimal complications for an individual patient as part of the preoperative planning process.



(Left) Computer model of an osteoporotic vertebra augmented with bone cement and (Right) Computer model predicting bone strains in the outer shell of an osteoporotic vertebra under body weight loading.

2. Biomedical Engineering Laboratories

The strong association of the PSRG with QUT's Medical Engineering research focus ensures that any research performed is rigorously designed to be of the highest scientific standard to produce results that can be trusted and relied upon and therefore incorporated into patient care. The "Bench to Bedside" philosophy is especially relevant for our research group where "Real World" clinical problems feed the research projects undertaken by the undergraduate and postgraduate engineers. The research projects may involve medical imaging (CT, MRI, micro-CT, intra-operative fluoroscopy), microscopy, histology, in vitro animal and cadaveric biomechanical testing, animal surgical studies at QUT's Medical Engineering Research Facility or use of QUT's laboratories and equipment at their various campuses.



Right: Six degree of freedom spine testing robot used to test calf spine & ribcage with an Optotrak Certus motion tracking system.

3. Clinical Specialists & Databases

The PSRG has access to large clinical databases to draw from for clinical research projects. Thanks to the expertise of specialist spinal deformity clinicians, the clinical data available for analysis includes data collected on general spinal deformity management, innovative surgical techniques such as thoracoscopic scoliosis correction, the minimally invasive insertion of dual growing rods, thoracoscopic spinal stapling for juvenile scoliosis, and degenerative scoliosis correction procedures in the ageing spine. These databases have produced numerous publications and conference papers and will continue to do so into the future. The close involvement of our spinal orthopaedic specialists ensures that the clinical research of the PSRG addresses relevant and much needed clinical aspects of deformity care and treatment, and most importantly that the findings of our clinical research can be translated for use in the care of spinal deformity patients of all ages.

International Collaborators

The PSRG has formed a number of international collaborations in order to complement our research capacity, including;

- Professor Peter Fratzl, Director of the Max Planck Institute of Colloids and Interfaces, Potsdam, Germany
- Professor Deepak Vashishth, Head of Department of Biomedical Engineering at Rensselaer Polytechnic Institute, New York State, USA
- Professor Mike Swain, University of Sydney, Australia
- Profesor Paul Roschger, Ludwig Boltzmann Institute of Osteology, Vienna, Austria
- Professor Richard Hall, Professor of Spine Biomechanics, University of Leeds, UK
- Jun. Professor Oliver Rohrle, Simtech, University of Stuttgart, Germany

Thanks to those who have supported us so far and we look forward to working with our partners and research collaborators well into the future.

Latest PSRG Publications

We are pleased to announce that for 2011 we have 6 journal papers and one book chapter published or accepted with another three currently under peer review.

1. Little JP, Adam CJ, 2011. Patient-specific computational biomechanics for simulating adolescent scoliosis surgery. *Int Journal for Numerical Methods in Biomed Engineering 27:347-56.*

2. De Visser H, Adam CJ, et al, 2011. Interactive image manipulation for surgical planning. *Med J Australia* 194(4): S41.

3. Hellier D, Albermani F, Adam CJ, et al, 2011. Flexural and torsional rigidity testing of the heated colonoscope. *Proc Institute of Mechanical Engineers, Part H: Journal of Engineering in Medicine*.

4. Shillington MP, Labrom RD, Askin GN, Adam CJ, 2011. A biomechanical investigation of vertebral staples for fusion-less scoliosis correction. *Clinical Biomechanics* 26(5): 445-51.

5. Adam CJ, Swain MV, 2011. The Effect of Friction on Indenter Force and Pile-Up in Numerical Simulations of Bone Nano-indentation. *Journal of Mech Behavior Biomed Materials* (In Press)

6. Little JP, Adam CJ, 2011. Effects of surgical joint de-stabilisation on load sharing between ligamentous structures in the thoracic spine; an FE investigation. *Clinical Biomechanics* (In Press)

7. Adam CJ, Dougherty G, 2011. Applications of medical image processing in the diagnosis and treatment of spinal deformity. Book chapter in *Medical Image Processing, Springer,* Dougherty (ed).

Any questions or want to know more?

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