Computational measurement of hip migration percentage in pelvic x-ray

Brief description

Children with cerebral palsy are at risk of developing a hip problem where the ball of the joint moves slowly out of the socket. This can be detected by taking regular x-rays to measure hip migration percentage (MP) and to monitor if it is improving or becoming worse. The measurement of migration percentage is essential to decide how often children should have x-rays and when the condition is severe enough to require treatment. Currently, the measurement of migration percentage is often inaccurate or simply absent.

The aim of the PhD project is to develop and to validate computational machine learning algorithms to measure migration percentage automatically and accurately from pelvic x-rays.

Dr. Morgan Sangeux, senior biomedical engineer at The Royal Children’s Hospital, Melbourne and senior research fellow at The Murdoch Childrens Research Institute, will be the primary supervisor. The student will be co-supervised by clinicians and researchers involved in the management of children with cerebral palsy from The Royal Children’s Hospital and The Murdoch Childrens Research Institute.

The PhD project is suited to a biomedical, mechanical or computer science engineer providing existing experience in the treatment of images and machine learning.

The project will be funded by the NHMRC Centre of Excellence in Cerebral Palsy (CRE-CP). The CRE-CP will provide a scholarship of $25,000 per year plus $750 travel allowance. The scholarship is intended as seed funding and all students on a CRE-CP scholarship are required to provide proof of applications for external funding every year. Should the student be successful in receiving an external scholarship the CRE-CP will provide a top-up of $5,000 per annum. However, the CRE-CP will continue to fund the student if not successful.
BACKGROUND

Hip displacement is common among children with CP, with multiple population-based studies demonstrating that up to 35% of children will develop progressive hip displacement [1-3]. When not treated early or effectively, displacement can lead to painful dislocation of the hip, with a significant impact on function and health related quality of life [4-6]. Early management is vital for preventing the secondary consequences of hip dislocation.

Not all children with CP are at equal risk of developing hip displacement. Multiple population based studies have demonstrated a strong, linear correlation between the child’s level of gross motor function and their risk of developing hip displacement. This knowledge has led to the development of clinical guidelines for the systematic surveillance of hip displacement in children with CP [7,8]. ‘Hip Surveillance’ is a coordinated process of monitoring and recognizing the early indicators of progressive hip displacement in children with CP with the aim of ensuring early detection and timely referral for orthopaedic assessment and management. Clinical guidelines for hip surveillance recommend a frequency of radiographs relative to the child’s GMFCS level and the severity and rate of progression of their hip displacement [8]. Routine radiographs allow serial measurement of ‘migration percentage’ (MP) - a measure of the percentage of the femoral head (ball) which is not covered by the acetabulum (socket) and an indicator of the severity of hip displacement [9]. Knowing the MP is crucial to the interpretation and application of clinical guidelines for hip surveillance and an MP ≥30% is widely accepted as a trigger point for referral for orthopaedic assessment [8].

Formal, population-based hip surveillance programs implemented around the world have significantly reduced the incidence of hip dislocation in populations of children with CP [10,11]. In response to evidence of the effectiveness of these programs, the Consensus Statement on Hip Surveillance for Children with Cerebral Palsy: Australian Standards of Care [7] was developed by a national working party and subsequently published in 2008. The Consensus Statement was recently revised, updated and re-named the Australian Hip Surveillance Guidelines for Children with Cerebral Palsy: 2014 [8]. These clinical guidelines for hip surveillance have been implemented in Queensland through a coordinated and state-wide approach for over 5 years and have significantly reduced the incidence of hip dislocation in children with CP in that state [10].

Clinicians in other Australian states have also been screening and monitoring hip displacement in children with CP for many years now. However, without coordinated state-wide processes, children continue to present with severe displacement or hip dislocation that has been detected only once the hip became symptomatic. This results in late, invasive and difficult surgery that has less than ideal outcomes, including refractory pain. There are many steps in the process of hip surveillance and therefore many potential points of failure.

A knowledge translation project currently being conducted by the NHMRC funded Centre for Research Excellence in Cerebral Palsy is working to develop a framework and resources to support state-wide hip surveillance in Australian states that do not have a single, centralised health service for children with CP, using Victoria as a pilot state. A recent survey of Victorian health professionals supporting children with CP identified that a key barrier to successful hip surveillance was the content of radiology reports for radiographs taken for hip surveillance. Of the survey respondents who directly refer children for hip surveillance radiographs, 44% reported that MP was absent in more than 50% of the radiology reports they received. Without a measurement of MP, and the ability to compare change in MP between radiographs, it is impossible for clinicians to apply the clinical guidelines for hip surveillance. Another key theme to emerge from the survey was the importance of ‘ease of access’ for families to radiology facilities, and minimising the need for families to travel long distances in order to attend a tertiary centre where radiology staff are experienced in measuring and reporting radiographs for hip surveillance purposes.
PhD project proposal

METHOD
Calculation of the migration percentage requires the identification of specific landmarks on the femur and the pelvis on an x-ray image. Figure 1 presents the method of calculation of the migration percentage and the list of landmarks required to perform the calculation. Software will be developed to learn to detect the position of each landmark independently. Recently, algorithms were developed to delineate the contours of the adult pelvis and femur [12, 13]. These algorithms will be implemented as a starting point during the PhD project and adjusted to the features of more immature, child or adolescent pelvic x-ray.

RECRUITMENT STRATEGY
Anterior-posterior pelvis x-rays are performed for hundreds of children with CP annually at The Royal Children’s Hospital for the purposes of hip surveillance. The x-ray images are stored electronically in a PACS system which was implemented more than 10 years ago. The image training set of images (n=600) and test-set of images (n=50) will be accessed from this PACS system and anonymised prior to use in the study, following ethics approval through The RCH Research Ethics Committee low and negligible risk ethics application processes.

References

