Title: Biomechanics of Developmental Dysplasia of the Hip - an engineering study of closed reduction utilizing the Pavlik Harness for a range of subtle to severe dislocations in infants

Developmental Dysplasia of the Hip (DDH) is an abnormal condition where hip joint dislocation, misalignment, or instability is present in infants. Rates of incidence of DDH in newborn infants have been reported to vary between 1 and 20 per 1000 births, making it the most common congenital malformation. DDH early detection and treatment is critical to avoid the use of surgical treatment in infants and to prevent future complications in adult life. To this day several non-surgical treatments involving the use of harnesses have been proposed to treat DDH in infants, with the Pavlik harness (PH) being the current non-surgical standard used to treat DDH at early stages. Although the PH has been proven to be successful treating subtle dislocations, severe dislocations do not always reduce. Until now the use of the harness remains an empirical method and its effectiveness often depends on physician expertise or trial-error procedures; thus a clear guideline has not been established to determine the best optimal harness configuration to treat both subtle and severe dislocations. The goal of this dissertation is to understand the connection between reductions for subtle and severe dislocations and passive muscle forces and moments generated while the harness is used during treatment.

While the understanding of DDH biomechanics will provide a valuable clinically applicable approach to optimize and increase harness success rate, it is not without its difficulties. In this dissertation, a three-dimensional model of the pelvis-femur-lower limb assembly of a representative 10 week-old female was generated based on CT scans of a 6-month and 14-year old female, as well as the visible human project with the aid of anthropomorphic scaling of anatomical landmarks. The medical segmentation software Mimics was used to process the CT scans. The kinematics and dynamics of the lower limb were defined, five (5) adductor muscles namely, the Adductor Brevis, Adductor Longus, Adductor Magnus, Pectineus, and Gracilis, were identified as mediators of reduction using the Pavlik Harness were identified as mediators of closed reduction with the PH. Clinical observation indicates that reduction with the PH occurs in a passive mode in deep sleep under the action of gravity, and consequently a Fung-type model was used to characterize the passive hyperelastic stress-strain response of the muscles in the model. Four grades (1-4) of dislocation as defined in terms of increasing severity by the International Hip Dysplasia Institute (IHDII) were considered in the study. The infant model was computationally manipulated to represent physiological dislocations, and the dynamic response under passive muscle action and under the effect of gravity was resolved using the ADAMS solver.

Major: Mechanical Engineering

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2008, University of Central Florida
Master's of Mechanical Engineering, MS, 2010, University of Central Florida

Committee in Charge:
Alain Kassab, Chair, Mechanical and Aerospace Engineering
Eduardo Divo, Mechanical Engineering at Embry-Riddle Aeronautical University
Faissal Moslehy, Mechanical and Aerospace Engineering at the University of Central Florida
Seetha Raghavan, Mechanical and Aerospace Engineering at the University of Central Florida

Approved for distribution by Alain Kassab, Committee Chair, on March 18, 2015.

The public is welcome to attend.