Developmental dysplasia of the hip (DDH) is a common newborn condition where the femoral head is not located in its natural position in the acetabulum (hip socket). Several treatment methods are being implemented worldwide to treat this abnormal condition. One of the most effective methods of treatment is the use of Pavlik Harness, which directs the femoral head toward the natural position inside the acetabulum.

This dissertation presents a developed method for identifying the least energy path that the femoral head would follow during reduction. This is achieved by utilizing a validated computational biomechanical model that allows the determination of the potential energy, and then implementing the principle of stationary potential energy. The potential energy stems from strain energy stored in the muscles and gravitational potential energy of four rigid-body components of lower limb bones. Five muscles are identified and modeled because of their effect on DDH reduction. Clinical observations indicate that reduction with the Pavlik Harness occurs passively in deep sleep under the combined effects of gravity and the constraints of the Pavlik Harness.

A non-linear constitutive equation, describing the passive muscle response, is used in the potential energy computation. Different DDH abnormalities with various flexion, abduction, and hip rotation angles are considered, and least energy paths are identified. Several constraints, such as geometry and harness configuration, are considered to closely simulate real cases of DDH.

Results confirm the clinical observations of two different pathways for closed reduction. The path of least energy closely approximated the modified Hoffman-Daimler method. Release of the Pectineus muscle favored a more direct pathway over the posterior rim of the acetabulum. The direct path over the posterior rim of the acetabulum requires more energy.

This model supports the observation that Grade IV dislocations may require manual reduction by the direct path. However, the indirect path requires less energy and may be an alternative to direct manual reduction of Grade IV infantile hip dislocations. Of great importance, as a result of this work, identifying the minimum energy path that the femoral head would travel would provide a non-surgical tool that effectively aids the surgeon in treating DDH.

Major: Mechanical Engineering

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2005, King Abdulaziz University
Master's of Mechanical Engineering, MS, 2012, University of Central Florida

Committee in Charge:
Faissal Moslehy, Chair, Mechanical and Aerospace Engineering
Hansen Mansy, Mechanical and Aerospace Engineering
Alain Kassab , Mechanical and Aerospace Engineering
Eduardo Divo, Mechanical Engineering

Approved for distribution by Faissal Moslehy, Committee Chair, on October 14, 2015.

The public is welcome to attend.