A MECHANICAL MODEL FOR HIP REDUCTION VIA PAVLIK HARNESS IN NEWBORNS

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INTRODUCTION

- Developmental dysplasia of the hip (DDH) is an abnormal condition in infants and commonly treated by the use of the Pavlik Harness.
- 1 out of every 20 babies has some hip instability.
- The effectiveness of the Pavlik Harness depends on physician's expertise, experience, and trial- and error procedures.
- A multi-physics computational approach was used for a better understanding of how to use the Pavlik Harness in the most effective way possible.
- To prove the results of the computational approach, a mechanical model is needed to provide physicians with a better understanding of the mechanics of DDH when using the Pavlik Harness.

OBJECTIVES

- Replicate an infant's hip with DDH and the 7 muscles that play a role in the hip reduction.
- The mechanical model will be scaled proportionally to the size of an infant and passive muscle forces will be simulated.
- Trial and error experiments will calibrate the pneumatic muscles to obtain the desired pressure for replicating each individual curve.
- The data for the path of reduction of the femoral head will be acquired by IMUs, and processed using MATLAB.

METHOD

- Clinical reports and previous research show very low success rates for the Pavlik Harness for severe grades of hip dislocation. Statistically, it has been shown that for reduction rate for the International Hip Dysplasia Institute (IHDI) Grades I-III is 92% while only 2% for grade IV.
- DDH is found responsible for 29% of primary hip replacements in people up to 60 years of age. The primary goal of this project is to assist in the improvement of the success rate on non-surgical interventions for patients with DDH, as well as the ensuing consequences in adulthood.
- In order to experimentally verify the computational model of the hip reduction and abduction in severe cases of DDH, a mechanical bench-top model is to be designed, built, and tested for the four grades of dislocation.
- This approach will be repeated for three patient-specific infant's musculoskeletal models, as to corroborate the use of this experimental bench-top design in the validation of the patient-specific computational model.

RESULTS

- A scale of 4:1 was selected for the model to ensure an adequate size and weight practical for teaching and testing purposes.
- The team successfully created a 3D printed model of the right half of the lower extremities that will be used to visualize the desired points of origin and insertion.
- The 3D model will also help to visually understand what is happening during the hip reduction process in order to implement this procedure on a patient-specific case.

REFERENCES


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ABSTRACT

Developmental Dysplasia of the Hip (DDH) refers to an abnormal hip condition in infants characterized by anomalous development of the hip joint, in which hip joint dislocation, misalignment, and musculoskeletal instability are present.

This study describes a multi-physics computational approach to simulate the hip joint reduction process and to evaluate the effectiveness of the Pavlik Harness.

In this work, a computational model of the hip joint was developed, and the mechanical behavior of the hip joint was investigated. The model was validated by comparing the predicted and experimental results, including the hip joint reduction process and the forces acting on the musculoskeletal system. The results showed that the Pavlik Harness can significantly reduce the hip joint dislocation and misalignment, and provide a better understanding of the mechanics of DDH when using the Pavlik Harness.

BUDGET

- The 3D printer, MakerBot 2nd Generation has been the most expensive purchase.
- The visual representation of budget divided in 3D prototyping and air muscle pneumatics. Total Budget is $3840.20