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Effect of Surgical Procedures for Crouch Gait

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Abstract

Crouch gait is a common gait deviation found in patients with cerebral palsy that is characterized by an excessive amount of flexion at the knee joint. This study aims to quantify the effect of corrective surgery on lower limb mechanics in order to determine the best procedure for a particular patient. Kinematic data were obtained from 11 patients who underwent surgical procedures to correct for crouch gait. A 3D finite element model of the lower extremity (including bone, cartilage, extensor mechanism, soft-tissue, and muscle) was developed in Abaqus/Explicit. The gait cycle of each patient was simulated both pre- and postoperatively.

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I. Introduction

Crouch gait is a common gait deviation found in patients with cerebral palsy [1]. Crouch gait is characterized by an excessive amount of flexion at the knee joint during gait. It is a progressively degrading gait deviation; in part because the crouched posture itself reduces the capacity for muscles to generate extension accelerations at the hip and knee joints [2].

Surgical procedures to correct for crouch gait commonly include a type of patellar advancement and/or distal femoral osteotomy [3-5]; however, there is no generally agreed upon standard for selecting the surgical procedure(s). The objective of the current study is to quantity the effect of corrective surgery on the lower limb mechanics of patients with crouch gait.

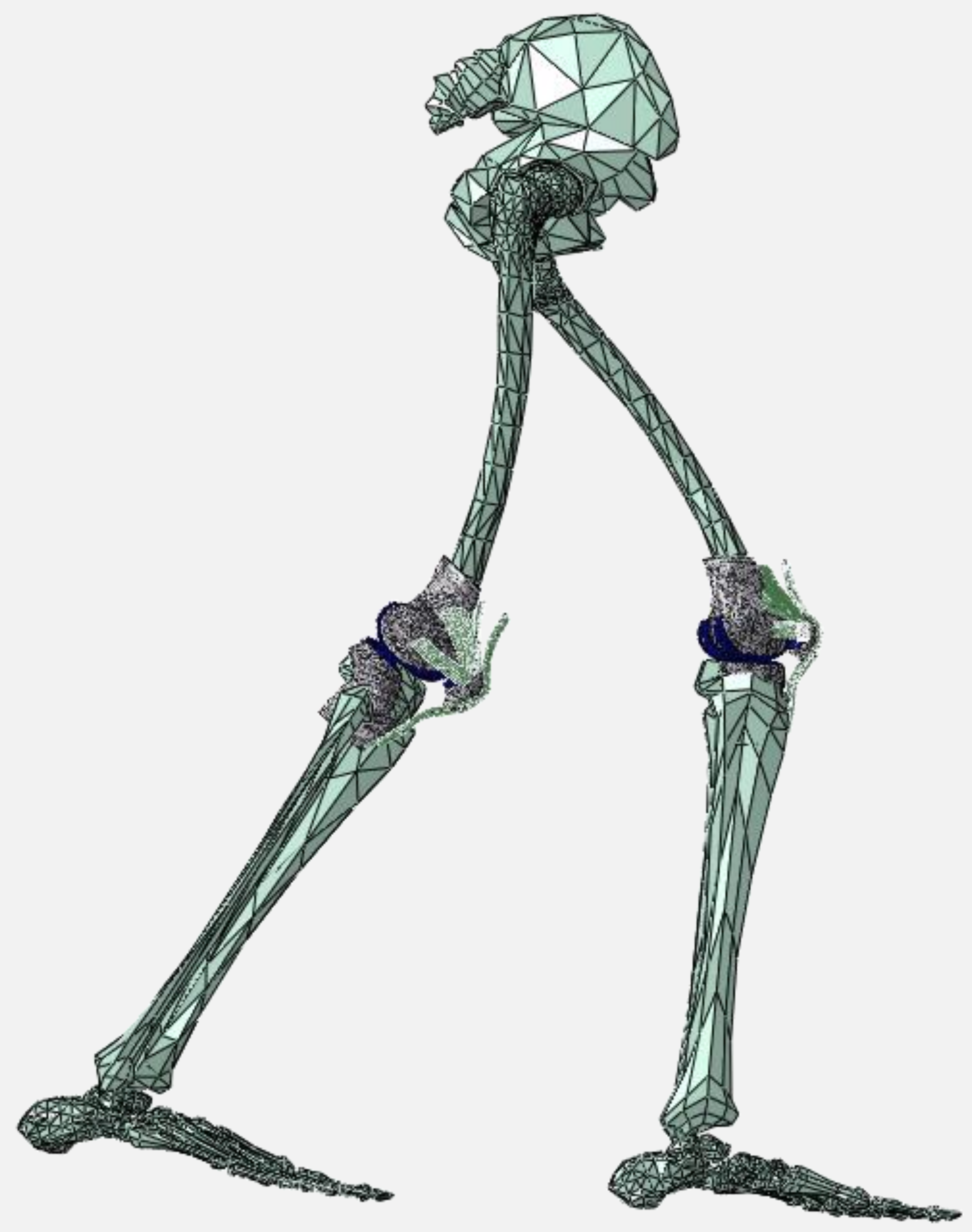

Figure 1: Patient Specific Model with Joint Kinematics and Muscle Forces Developed from Motion Capture and Force Plate Data

II. Methods

Kinematic data were obtained from 11 patients who underwent patellar advancement and/or distal femoral osteotomy procedures to correct for crouch gait. Pre- and postoperative gait analysis data were collected from these patients using a Vicon lower extremity marker-based motion capture system and in-ground force plates. Patient-specific muscle forces were predicted using the rigid-body musculoskeletal platform OpenSim [6].

A 3D finite element model of the lower extremity was developed in Abaqus/Explicit (Fig. 1). Detailed, deformable representations were included at the knee joint (Fig. 2). 2D membranes with fiber-reinforced springs were used to represent medial and lateral patellofemoral ligaments, patellar tendon and quadriceps tendons. The gait cycle of each patient was simulated both pre- and postoperatively.

Figure 2: Detailed Knee Scaled and Fitted to Patient Specific Model with Surgery Specific Modifications

III. Results & Conclusions

Surgical procedures were shown to reduce the minimum flexion angle of the knee equating to an increase in leg extension. Mean stress, strain, and contact pressure experienced by the patella were also found to be reduced in postoperative models. Preliminary results show that higher pressure concentrations exist in pre-surgery models putting patients at higher risk of osteoarthritis (Fig. 3).

This study develops a pipeline from clinical gait analysis to finite element prediction of lower limb and joint mechanics. Patients with crouch gait are at greater risk than the general population for anterior knee pain, patellar stress fractures and early onset patellofemoral osteoarthritis. The framework established in this work will be applied to investigate differences as a result of different corrective procedures in order to assist in determining the best procedure for a particular patient.

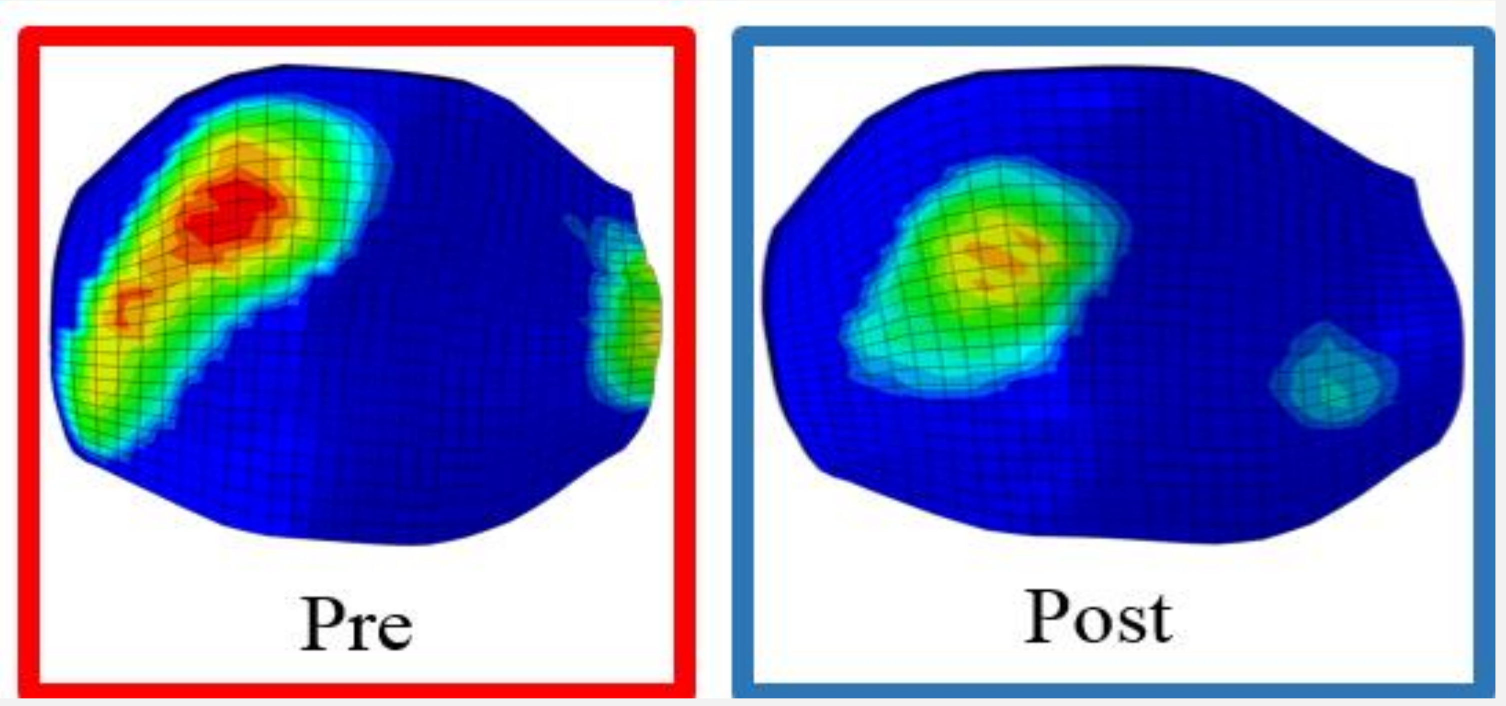

Figure 3: Patella Cartilage showing Contact Pressure

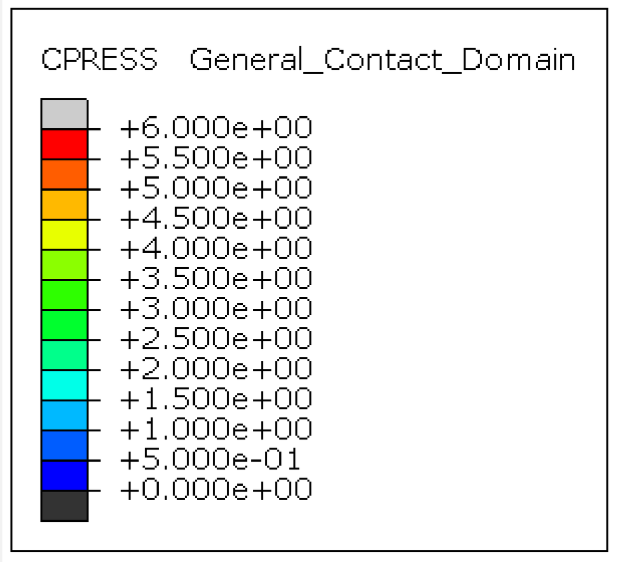

Figure 4: Scale for Contact Pressure in MPa

Acknowledgments

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