

Characterisation of hip joint dynamics in juvenile patients with intertrochanteric osteotomy by means of musculoskeletal modeling

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INTRODUCTION: Excessive internal hip rotation during walking is common in children with cerebral palsy (CP) and involves more than 40% of the patients [1]. This can result in non-physiological gait patterns and increased joint loading, which ultimately lead to degenerative hip joint diseases [2]. One surgical treatment option is to correct the femoral misalignment by intertrochanteric osteotomy of the femur. This leads to improved gait pattern and reduced joint loading [3,4]. Experimental approaches of obtaining children's joint loads of lower extremities are invasive and complex. In this context, one possible solution is to derive biomechanical data of joint dynamics using musculoskeletal multibody simulation (MMBS) based on motion-captured 3D gait analysis [5]. Therefore, the aim of our study was to analyze juvenile CP patients before and after intertrochanteric osteotomy during gait by means of MMBS.

METHODS: An analysis of the pre-/postoperative gait of 11 children and adolescents with CP as well as 11 healthy infantile subjects was performed (Table 1). All subjects with CP were treated with femoral intertrochanteric derotation osteotomy (FDO). The motoric function was assessed using the Gross Motor Function Classification System (GMFCS) prior to surgery. The 3D motion-capturing system (Vicon Motion Systems) collecting data from 21 skin markers attached to the body and 3D force plates was used to obtain trajectories of the skin markers and ground reaction forces. Joint angles and loads were subsequently calculated using a generic musculoskeletal model of the lower limb implemented in AnyBody™ (AnyBody Technology™). This model comprised six degrees of freedom and more than 160 muscle structures per lower limb [6]. The multibody simulation was adapted to the individual patient by scaling according to each patient's body height and weight. Subsequently, it was used to perform inverse kinematic and inverse dynamic analyses to calculate joint angles and forces during gait.

RESULTS SECTION: The musculoskeletal model showed clear differences for the pediatric patients before and after osteotomy in the hip flexion angle by up to 6° (Figure 1A) and internal/external hip rotation up to 10° (Figure 1B). The resultant hip joint force was up to 2.5 times higher during the gait before surgery (Figure 1C). The postoperative kinematics and hip joint forces were generally closer to the healthy control group than to the preoperative situation.

DISCUSSION: We were able to calculate numerically joint angles and hip joint loading during gait in pediatric patients before and after intertrochanteric osteotomy. These data can be used as boundary conditions for finite element analyses of the femoral bone. A limitation of our present study is that the individual morphology of the femur could not be considered within the MMBS. Furthermore, data from more patients should be derived for statistical significance in future studies.

SIGNIFICANCE/CLINICAL RELEVANCE: During gait hip joint forces and torques are increased in juvenile CP patients with pathologically enhanced internal hip rotation. Intertrochanteric osteotomy of the femur seems to be a successful surgical technique to reduce hip joint loading in patients with CP.

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IMAGES AND TABLES:

