Altered Biomechanics of a Perthes' Hip Investigated by Contact Modeling

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A. Gopalakrishnan, E. Hampp; Stryker Corporation, Parsippany, NJ.

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B. A. Slavens1, A. J. Schnorenberg1, A. Graf2, J. Krzak2, P. A. Smith3, G. F. Harris3; 1Univ of Wisconsin Milwaukee, WI, 2Shriners Hospitals for Children - Chicago, IL, 3Marquette Univ, Milwaukee, WI.

M316 A Method for Assessing Accuracy in Tracking Foot Bones with Biplainar Videoradiography
M. J. Rainbow2, J. B. Schwartz2, I. S. Davis1, D. C. Moore3; 1Harvard Medical School, Cambridge, MA, 2Rhode Island Hospital, Providence, RI, 3Rhode Island Hospital / Brown University, Providence, RI.

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Presentation Abstract

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Presentation: Altered Biomechanics of a Perthes' Hip Investigated by Contact Modeling
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Abstract:

Introduction

Perthes’ disease is one of the most common hip disorders in young children characterized by malformation of the femoral head. Several studies have investigated the biomechanical alterations of Perthes’ disease using Finite Element Analysis (FEA), however, most of them were 2D models and lack patient-specific details of the cartilage and necrotic bone. Thus, the objective of this study was to investigate the altered biomechanics of a Perthes’ hip joint by finite element contact modeling using MRI to develop the patient-specific model of the cartilages and bones.

Methods

The MRI data of both hips of a unilateral Perthes’ case was obtained to segment the bones and cartilages using Simpleware. A 3D point cloud data of the segmented parts were exported to SolidWorks to build the 3D models. FEA was performed using Comsol 4.3b. The same Poisson’s ratio 0.30 was set for the femoral, pelvic and necrotic bones. The Poisson’s ratio 0.35 was set for the femoral and acetabular cartilages. The elastic modulus for the pelvis, femur, cartilages and necrotic bone were, 5 GPa, 500 MPa, 50 MPa and 20 MPa, respectively. For the loading conditions, the distal part of the femur was fixed while the pelvis was displaced 1.5 mm downwards in the axial direction (Fig. 1).

Results

The results show that the contact pressure in the femoral cartilage of normal hip (left) is more distributed than the Perthes’ hip (right) (Fig. 1). Since the elastic modulus of the femur is higher than the necrotic bone in the affected hip, the maximum contact pressure 5.01 MPa was found in the normal hip (4.70 MPa for Perthes’ hip). The von Mises stress distribution of the femoral cartilage was more localized in the Perthes’ hip (3.45 MPa max.), i.e. where the junction of the necrotic and normal bone is located below the femoral cartilage.

Conclusion

In this study, we have found out that the increase and localization of stress significantly altered the biomechanics of the hip joint. This knowledge will help orthopaedic surgeons decide where to redistribute the localized stresses and thus important in the treatment planning of Perthes’ disease.

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