AN ADVANCED APPROACH TO DESIGN EXPERIMENTS TO INVESTIGATE THE BIOMECHANICS OF THE PELVIS

Pierre-Louis Ricci (1), Stefan Maas (1), Torsten Gerich (2), Jens Kelm (3,4)

1. Research Unit in Engineering Sciences, University of Luxembourg, 1359 Luxembourg, Luxembourg
2. Service de Traumatologie du Centre Hospitalier de Luxembourg, 1359 Luxembourg, Luxembourg
3. Chirurgisch-Orthopädisches Zentrum, 66557 Illingen/Saar, Germany
4. Klinik für Orthopädie und Orthopädische Chirurgie, Universitätsklinikum des Saarlandes, 66421 Homburg/Saar, Germany

Introduction

The pelvis is a complex circular structure of the human body ensuring vital load transfers. Fractures of the anterior or/and posterior alters this proper loading and may lead to further complications. Researchers conducted numerous studies to evaluate the mechanical stability provided by plates and devices on fractured pelvises. Simplistic boundary conditions were considered in numerical and experimental studies, but inclusion of muscular and ligamentous conditions provides closer *in vivo* results [1].

In the present study, muscles forces and joints reaction forces induced when walking were calculated by inverse dynamics. Those physiological loadings served as basis to define boundary conditions for Finite Element (FE) analysis and for experimental testing in order to get closer to realistic loadings such as walking, increasing the understanding of the pelvis's biomechanics.

Methods

An inverse dynamics analysis performed on the standard rigid-body walking model from AnyBody Technology [2] provided muscles forces and joint reactions forces according to the position of the gait. Forces were directly applied to the finite element model of a healthy pelvis, according to the anatomical attachments of the muscles.

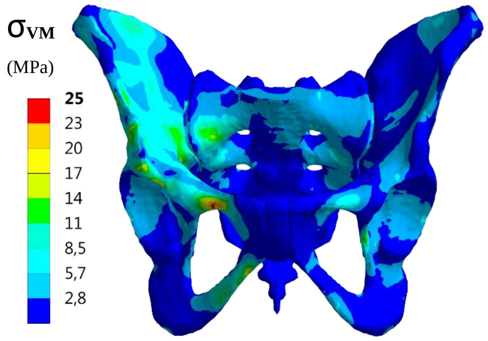

Figure 1: Example of Von Mises Stresses distribution during the left foot strike moment of the gait

The results obtained from this complex FE model allowed designing an experimental testing bench with only four forces and a fixed bearing reproducing closely the stress conditions of the gait. It was chosen to use four pneumatic cylinders to reproduce the main forces applied to the pelvis: two pushing to represent the hips and two pulling with wires to simulate the muscles. To be sure that the use of four actuators provides approximatively the results as *in vivo* conditions, the cylinders are adequately tilted and their controlled time varying pressure was defined by FE analysis. To do so, matching of Von Mises stresses distribution and principal stresses between the initial FE model of the gait and the numerical simulation of the testing bench was aimed.

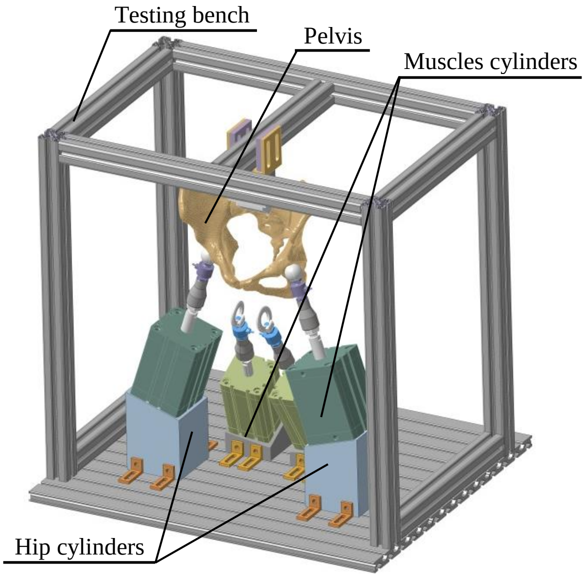

Figure 2: CAD model of the developed gait-testing bench

Results

The preliminary numerical study revealed that according to the position of the gait, left/right superior/inferior rami experience the highest stresses of the model. By analysis of different fractures patterns, it can be shown that the stability of the pelvis is directly linked to the integrity of the anterior structures. The experimental setup resulting from the simulations is currently built up to test artificial pelvises with cyclic loadings to compare different reconstruction implants in case of bone fracture of the rami.

Discussion

Boundary conditions directly influence both simulations and experiments, and therefore realistic physiological loadings are essential. Hence, the core idea of this study is to use a large number of muscle forces from AnyBody rigid body simulation, apply those in a FE simulation of the pelvis and analyse the stress distribution. The double-sided experimental testing bench is then designed by FE simulations, thus that it approximates best this stress distribution.

References

1. Phillips *et al*, Med Eng Phys, 29:739-748, 2007.
2. Manders *et al*, ANSYS Conference & 25th CADFEM Users' Meeting, 2007