NUMERICAL ANALYSIS OF FRACTURE MECHANISM OF PELVIC RING DURING SIDE IMPACT LOAD

T. Klekiel[1], K. Arkusz[1] and R. Będziński[1]

[1]*Biomedical Engineering Division, Faculty of Mechanical Engineering, University of Zielona Gora, Licealna 9 Street, 65-547 Zielona Gora, Poland*

e-mail: t.klekiel@ibem.uz.zgora.pl

1. Introduction

Authors present the problem of a safety of a occupants in the car during a side impact. The mechanism of these fractures remains unclear and this makes the development of effective crash protection more difficult. The mechanism of a side-impact crash results in the energy transfer through the elements of a vehicle's construction onto the side of a passenger's [1] and causes pelvic fractures and injuries within the hip joint due to pressure of the femur head on the acetabulum. According to the contemporary knowledge, the influence of impulse loads on the passenger's body during a traffic accident depends on the velocity of a vehicle during the collision [2] distribution of passengers in the vehicle [3] type of the vehicle, as well as age, height, and weight of the passengers [4-5].

The objective of this work was to analyze the mechanism of multiple pelvis fractures in side-impact car crashes. The elaborated numerical model of the lumbo-pelvic complex includes the most important details responsible for its rigidity and strength including pelvic, hip, and the sacral bones and also soft tissues such as ligaments and cartilages.

2. Material and Methods

A geometric model of the lumbo-pelvic complex (LPC) including elements of skeletal, muscular and ligament structure stabilizing the pelvis was elaborated on the computed tomography images of 25-year-old patient. The fractures threshold were established by applying the impactor simulating the mass, velocity and energy similar to situation during side impact of the car with tree.

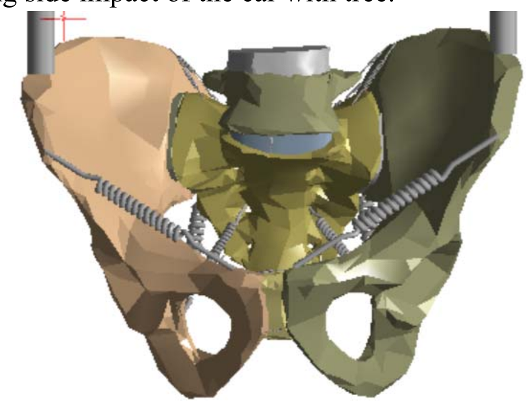

Fig.1. The model of Pelvic ring

LPC model included the following bones: hip, public, sacral with the coccygeal, femoral and the adjacent ligaments. Bone structures were meshed with 8-node tetrahedral finite elements. Cancellous and cortical bones were considered as isotropic material and its mechanical properties were defined using the literature data and original studies by Bedzinski et al. [6-7].

The ligaments were integrated into the model: ligaments responsible for supporting the weight of the torso and upper limbs preventing herniation of the sacrum with the coccygeal bone in-between pelvic bones thus reducing the vibrations transferred from pelvis to the spine: the anterior sacroiliac ligament and the posterior sacroiliac. Additional ligaments responsible for: preventing backwards tilting of the sacrum's tip: sacrotuberous and sacrospinous ligaments were also studied.

3. Results

The obtained results were compared with the clinical data concerning a 25-year-old patient injured in a road accident (side collision), diagnosed with the fractures of the stem of the left pubic bone, the left superior pubic ramus, the left ischium ramus, and the left lateral mass of the sacrum.
Additionally, it was assumed that the fracture occurs within the layer of cortical bone. This assumption was applied since the analysis of parameters of cortical and cancellous bone revealed that stress concentrates on the surface on which the fractures has been diagnosed by clinical test.

4. Conclusions

The results suggested the mechanism of creating fractures during impact load. In result of the high impact the damages getting in calculations were formulated similar to clinical case as the multi-fractures concentrated around the lateral part of the sacrum and around the ischium. The obtained results explained the relation between the level of the fracture and stiffness of the all ring. The strength of the pelvic ring has influence on the safety of the internal organs and the breaking of the ring continuity is very important and dangerous.
Apart of them the proposed model gave the opportunity to predicted behaviour of the pelvis in some different boundary conditions among which the most likely were selected.

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