18th International Conference
ENGINEERING MECHANICS 2012
Svratka, Czech Republic, May 14 – 17, 2012

pp. 198–199
Paper #98

NUMERICAL ANALYSIS OF FRACTURED FEMUR WITH INTERNAL OSTEOSYNTHESIS

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Abstract: *The internal osteosynthesis method of the thighbone diaphysis allows use of some different types of devices in dependence on complexity and a type of the diaphysis fracture. The aim of this project is a numerical stress analysis in case of two types osteosynthesis plates applied to two different thighbone diaphysis fractures. We simulated incidents, when a pacient's broken leg was too early however fully treated and his thighbone did not begin to recovery yet. In these extreme incidents the whole stresses are carried by the plates. The modeling and calculations was done using FEM software ANSYS Workbench.*

Keywords: ***Biomechanics, Internal osteosynthesis, Femur, Finite element method, ANSYS Workbench***

1. Introduction

This paper disserts about numerical analyses of two internal osteosynthesis methods used in fractured human thighbone therapy. The aim is a comparison of stress distribution in two types of osteosynthesis plates applied to two types of the thighbone diaphysis fractures, oblique and wedge, ones which represent the most common fractures of the thighbone diaphysis caused by light traffic accidents.

2. Virtual models

The virtual models used in our analyses were made up by the fractured thighbone, two types of plate (wave and straight plate) with cortical screws and cortical filler in case of the wave plate. All models were imported or created in ANSYS Workbench. The homogeneous linear isotropic mechanical properties were used in all parts of models.

The original `*.x_t` format of 470 mm tall left thighbone virtual model is provided by author (Dr. Marcello Papini, University Ryerson, Toronto, Canada) for noncomercial use. This model was imported to ANSYS Workbench DesignModeler where we modified a volume of the cancellous bone and made diaphysis fractures.

Our virtual wave plate model represented a simplified version of the original ©Litos wave plate, which `*.stl` model was provided for this project purposes. Especially we used the cylindrical screws and screw holes in our model. The cortical filler was siplified too. We used a cuboid design of the filler. The straight plate virtual model is based on our wave plate model and has not any real template. This plate was made up by straightening wave plate middle part because of the objective stress distribution comparison between the plate with wave and the same plate without wave.

A finite element model was created from tetrahedron (femur, plates, screws) and cuboid (cortical filler) elements. We compromised mesh quality in dependence on sophistication of parts of our model systems between hardware requirements to numerical analysis and precision of results. Our models consisted of 28 000 to 37 000 elements.

2.1. Initial conditions and loads

The thighbone was loaded by force of 2500N that occurred on a proximal side of the thighbone head. A vector of the force occurred in axis intersected the center of the femur head on the proximal side

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and the center of distal epiphysis. We used the support of distal parts of both condyluses that allowed free displacement in ortoghonal plane to the force vector. Similar to the real experiment, we allowed a rotation around Z axis in our analyses.

3. Validation of virtual thighbone

There was required to validate our virtual model of the thighbone before the main numerical analyses of fractured thighbones with internal osteosynthesis. This task proceeded per experiments (Jírová et al.,1989) which contained stress values at medial and lateral side of a loaded real human thighbone. We used identic initial conditions and loads for this publication for unbroken thighbone validation and for next other analyses.

4. Results

This project's aim was focused on numerical comparison of marked tensile stress values at screws and the wave plate contrary to the straight plate implemented to the fractured thighbone. We observed the stress results at plates, screws and contact faces of fragmented thighbones, safety factor of the cortical bone and relative deformations of both fragmented parts of the fractured thighbone.

The stress results in the case of the wedge fractured thighbone diaphysis showed almost equal stress distribution along all screws and screw holes in both cases of the used plates. On the other hand, the results of stress distribution in the case of the oblique fractured thighbone were influenced by the specific type and form of the fracture which caused the lower stress values in the case of the wave plate than with the straight plate.

A high value of the loading force caused mutual contacts of the proximal to distal parts of the fractured thighbones and mutual contacts of the fractured thighbones to plates. Therefore we analysed the compression stress on these faces. In all analyses, we registered the higher compression stress values on the contact faces of the proximal parts of the fractured thighbone.

The last analysed magnitude was the safety factor of the cortical bone. We registered the vaules of safety factor less than a limit value in cases of all analysed samples mainly at the contact faces of proximal parts of the fractured thighbones and on the lateral sides of proximal parts of the thighbone under central parts of the plates. These presented areas of the cortical bone had been probably more destructed.

5. Conclusions

The aim of this project was to compare the stress results at loaded virtual models of fractured thighbones with internal osteosyntheses. We focused mostly on the tensile stress on plates and screws, compressive stress on contact faces of fractured parts of the thighbones (proximal and distal part) and finally on the safety factor of the cortical bone. We registered better ability of the wave plate to tensile and compressive stress distribution in all our analyses and probably lower range of cortical bone destruction with the wave plate implementation.

Acknowledgments

The project has been supported by the research plan of the Ministry of Education, Youth and Sports MSM6840770043.

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