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REPORT ABOUT THE DESIGN OF EXTERNAL FIXATOR FOR TREATMENT OF PELVIS AND ACETABULUM FRACTURES

INFORMOVÁNÍ O KONSTRUKCI EXTERNÍHO FIXÁTORU PRO LÉČENÍ ZLOMENIN PÁNVE A ACETABULA

Abstract

Main point in this contribution is the design of external fixators applied in traumatology and orthopaedics. These fixators can be used in the treatment of open and unstable (i.e. complicated) fractures of pelvis and its acetabulum. Numerical modelling (i.e. Finite Element Method), together with CAD modelling, experiments, material engineering, and nanotechnology are presented as a support for developing of a new design of external fixators.

Abstrakt

Hlavním bodem článku je návrh externích fixátorů aplikovaných v traumatologii a ortopedii. Tyto fixátory mohou být používány pro léčení otevřených a nestabilních (komplikovaných) zlomenin pánve a acetabula. Obory numerické modelování (Metoda konečných prvků), společně s modelováním v CAD, experimenty, materiálové inženýrství a nanotechnologie vytváří v dnešní době podporu pro vývoj nových směrů v konstrukci externích fixátorů.

1 INTRODUCTION

This paper reports about the designing of external fixators applied in traumatology and orthopaedics. These fixators can be applied in the treatment of open and unstable (i.e. complicated) fractures of pelvis and its acetabulum, for example see an radiograph in Fig. 1.

Acetabular fractures either occur with high-energy trauma (e.g. auto collisions, falls, etc.) or as an insufficiency fracture. In younger patients, there is almost always significant trauma, and commonly associated injuries, when an acetabular fracture occurs. In elderly patients, acetabular fractures can occur due to bone weakened from osteoporosis.

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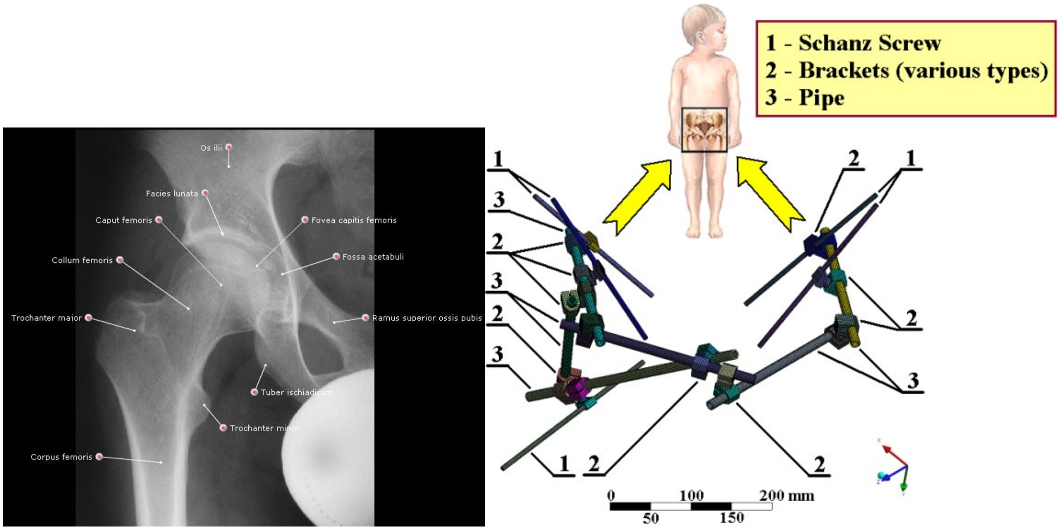

Fig. 1 Fracture of pelvis and acetabulum and its treatment (radiograph, external fixator - way of treatment).

External fixation, see Fig. 1 and 2, is a surgical treatment usually used to set bone fractures in which a cast (plaster) would not allow proper alignment of the fracture. In this kind of treatment, holes are drilled into uninjured areas of bones around the fracture and special bolts or wires are screwed into the holes. Outside the body, rods and curved pieces of metal with special joints (bracket) connect the bolts to make a stiff support. The complicated fracture can be set in the proper anatomical configuration.

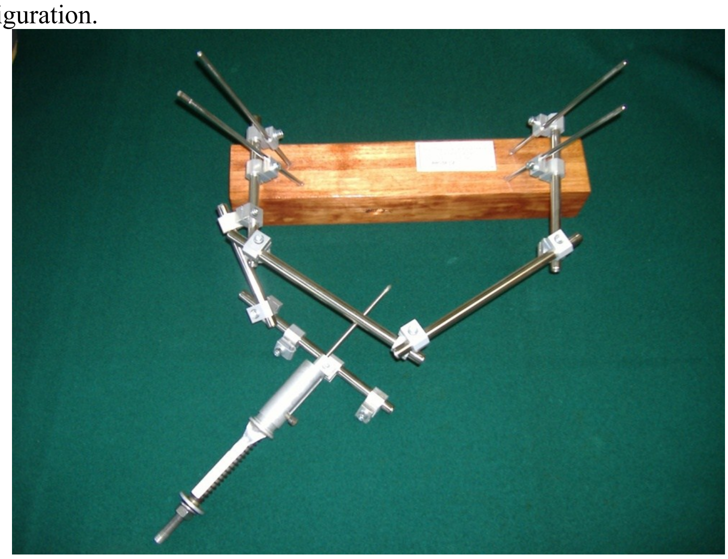

Fig. 2 Application of external fixator for pelvis and its acetabulum (experiments in our laboratory).

2 CAD AND FE MODEL

The new types of external fixators for treatment of fractures of pelvis and acetabulum were designed in the CAD system (Inventor software), see Fig. 3 and reference [4].

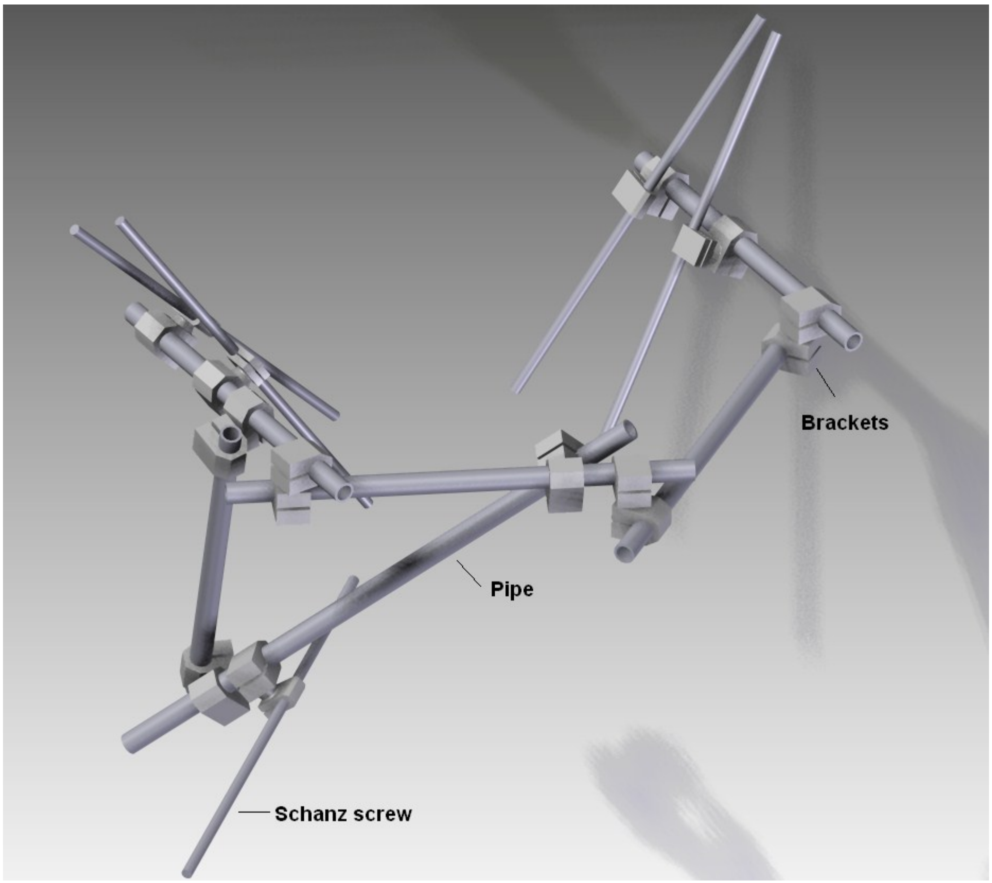

Fig. 3 CAD model of external fixator for pelvis and its acetabulum.

The CAD model, see Fig. 3, was imported into the Finite Element (FE) software Ansys Workbench in which the FE mesh was created, see Fig. 4 and 5.

The basic information about the boundary conditions is presented in Fig. 4.

There are defined mechanical contacts with friction between the brackets and pipes and between brackets and Schanz screws, see also Fig. 4.

Schanz screws are embed in pelvis and its acetabulum in drilled holes. Their attachments are modelled by elastic supports (i.e. by Winkler's foundation, see point “A” and “B” in the legend of Fig. 6 and 7). The elastic support is applied in the radial and axial direction on a parts of Schanz screws. This is quite good and popular simplification of the real complicated interaction between screw and bone. For more information about the elastic foundation and its applications, see references [6], [7], [8] and [9]. Tensile force is explained in the chapter 4 too.

Material behaviour of the external fixator is isotropic and elastic. However, the model is nonlinear because of mechanical contacts between the brackets and pipes and between brackets and Schanz screws.

According to the previous text, the numerical model of external fixator with pelvis interaction was solved via FEM, for example see Fig. 5 (total displacement).

In the future, the Simulation-Based Reliability Assessment (SBRA) Method will be applied (i.e. probabilistic approach) in design, see references [5] and [6].

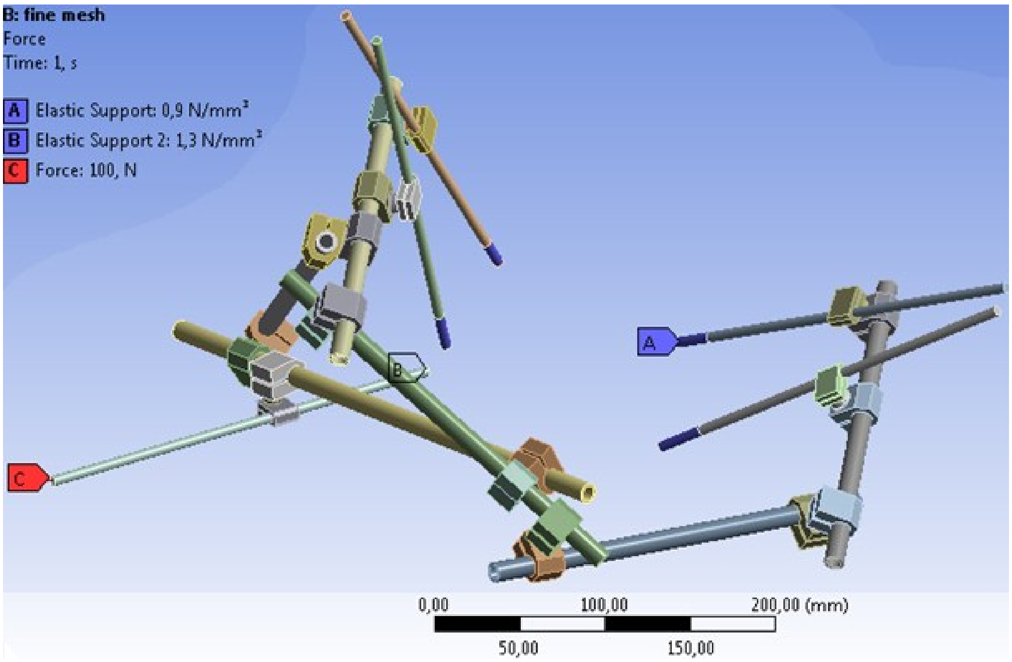

Fig. 4 FE model (boundary conditions) of external fixator for pelvis and its acetabulum.

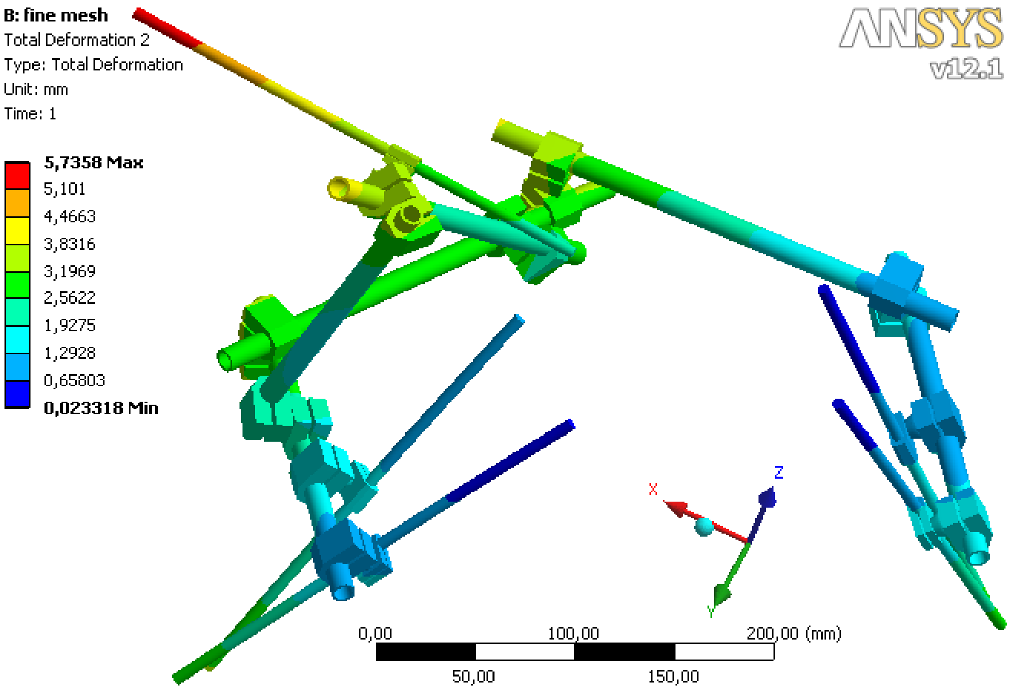

Fig. 5 FE modelling of external fixator for pelvis and acetabulum
(total displacement for tensile loading 100 N).

3 EXPERIMENT IN THE LABORATORY

The new types of external fixators for treatment of fractures of pelvis and its acetabulum were tested in the Laboratory of Biomechanics at the VŠB – Technical University of Ostrava (Ostrava, Czech Republic), see reference [4] and for example Fig. 6, 7.

Fig. 6 Prototype of the external fixator for pelvis and acetabulum and its measurement.

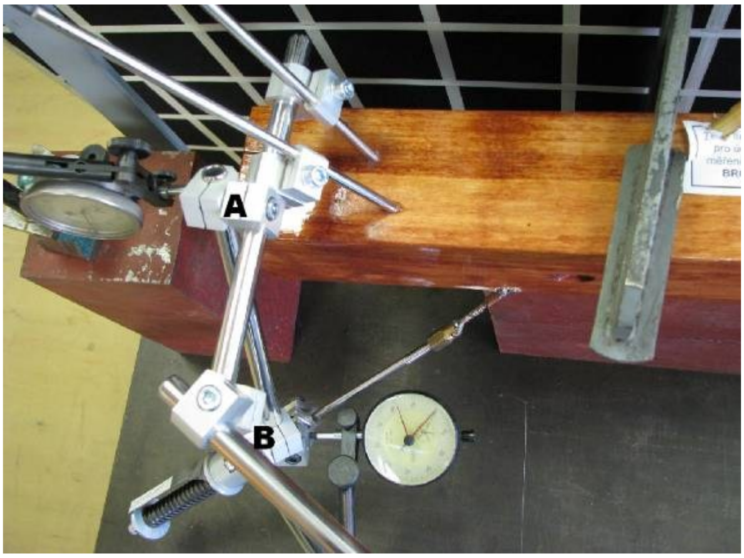

Fig. 7 Measuring in the laboratory.

The experiments were focused mainly on the stiffness and reliability for the whole system of the fixator and pelvis interaction (i.e. measuring at the place "A" and "B" – pulling the hip bone outwards from acetabulum after the reposition of pelvis fragments), see Fig. 7. The maximum value of force 100 N denotes the overloading (i.e. the tests were performed for excessive loading which is not usual during the treatment of patients).

4 CONCLUSION

Report about the new ways to design of external fixator for the treatment of fractures of pelvis and its acetabulum, based on the results of previous research, was presented. Hence, the new designs and materials of fixators will satisfy the ambitious demands of modern traumatology, surgery and economics.

VŠB - Technical University of Ostrava together with University Hospital of Ostrava and Trauma Hospital of Brno are now in the middle of a process creating a new design for external fixators. Hence, they are in cooperation with the Czech producers MEDIN Nové Město na Moravě (Czech Republic) and ProSpon Kladno (Czech Republic).

For more information about external fixators for pelvis and its acetabulum, see references [1], [2], [3], [4] and [10].

Therefore, all results could not be published in this paper due to confidentiality reasons.

Acknowledgements

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