NOVEL CLAMPING SYSTEM DESIGN FOR THE ILIZAROV FIXATOR – FINITE ELEMENT ANALYSIS

Chryssoula Bairaktari[1], Nikolaos Perogamvros[2], George Labeas[2], Despina Deligianni[1]
[1]Laboratory of Biomechanics and Biomedical Engineering; [2]Laboratory of Technology & Strength of Materials
Department of Mechanical Engineering and Aeronautics, University of Patras, Greece

Intoduction

There is a general agreement on the crucial determinant of the wire tensioning in the Ilizarov apparatus, which specifies the success of the method. Proper wire tensioning that would be maintained throughout the whole healing period brings about a suitable balance in the stability and flexibility of the frame. Many scientists point the loss of the initial pretension of the wires as a main component of complications such us pin tract infection that can decrease the stability of the wire-bone interface. This loss is attributed to the slippage of the wires through the clamps, since the existing clamping system of the frame is based on the fastening of the wires by frictional forces.

According the above, our research focuses on the development of a novel wire tensioning and clamping system that will minimize or even diminish the loss of pretension, sharing at the same time the possibility of retensioning the slack wires. In this study, a computational method was applied for predicting the mechanical response of a configuration of the Ilizarov external fixator, and was compared with its experimental response.

Methods

The standard Ilizarov frame is symmetrical with respect to the fracture site. Thus, we concentrated our measurements and modeling only on the upper 2 rings (4 wires) of the system with d=160 mm.

The experimental set-up consisted of a polyethylene bar with d=33mm, representing the bone fragment, suspended on an Ilizarov frame that consisted of 2 stainless steel rings and 4 pretensioned fine wires. Apart from that, the research included Finite Element Analysis of the Ilizarov fixator, by way of comparing and validating the mechanical testing results. For this purpose, a full parametric 3D FE model was developed in Ansys FE code. The model consists of 8-node solid 45 elements and shares 600k DOFs (Figure 1). The material properties were imported in the analysis after mechanical testing of each independent Ilizarov component. The wire-bone interface was simulated using surface to surface contact algorithm in order to represent the capability of the wires to slide through the bone.

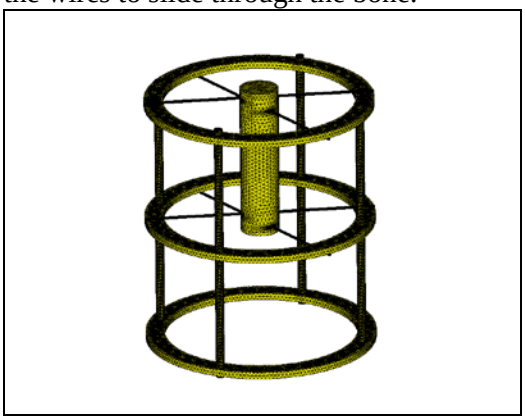

Figure 1: Ilizarov experimental frame FEA model.

Results

The outcomes from the nonlinear FE analysis were in good agreement with the experimental results and with other studies findings. There was observed a high stress concentration at the clamping site, after 1000N static load application. These results permit an optimum and more detailed design of the novel wire clamping system. In general the response of the FE model is in full unity with the research's prospective.

Discussion

The FEA analysis provided our research with valuable information about our attempt of novel clamping system design. The FE modeling system will be used to predict the characteristic response of the fixator configurations and clearly shows the relative changes in that response for variations in the number of components used. The analysis is still in progress sharing results comparable with our mechanical tests and literature.