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DIFFERENT SCREW FIXATION PLACEMENTS IN TREATING OF PAUWELS TYPE III FEMORAL NECK FRACTURES: A FINITE ELEMENT STUDY

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1. Introduction

Intracapsular hip fractures in the young patients are typically a high energy injury fractures [1] which are commonly known as Pauwels type III femoral neck fractures [2]. Artificial head replacement surgery is usually not considered for treating femoral neck fractures in such patients [3]. The commonly used devices for fixation of vertical femoral neck fractures are multiple screws or a sliding hip screw with or without an anti-rotation screw [4]. Size, location and length of the screws are the most effective parameters in terms of structural performance of internal fixation implants [5], hence the optimal configuration of the screws is necessary to be investigated to guide the clinical practice [6]. The aim of this study was comparing an inverted triangle screw configuration with different screw fixation placements.

2. Materials and methodology

Left, 4th generation composite femur (Sawbones®, USA) was scanned using computed tomography and its geometry was obtained using Mimics software (Materialise, Belgium). A 3D assembly model of the femur with screws was created using SolidWorks software (Dassault Systèmes, USA). The screws' material was set to be titanium and the body radius of the screws was 5 mm. Assembly was then imported in Abaqus software (Dassault Systèmes, France) for further analysis. Femur's condyles were fixed and a vertical force of 600 N was applied to the acetabular region of the femoral head. The friction coefficient on the fraction site was set to 0.2 [3]. Four finite element analyses were made, one with an inverted triangle configuration and the other one with the "*x*-crossed" configuration. In the latter configuration, the first screw was positioned close to the inferior cortex of the femoral neck along the axis of the femoral head and the other two screws were positioned close to the anterior and posterior cortex in an "*x*-cross" shape. The two remaining configurations consisted of two screws, with one of them having the lowermost screw and only the right screw (*x-crossed-right*) and the other one having the lowermost screw and the left screw (*x-crossed-left*).

3. Results

The peak von Mises stress in the inverted triangle configuration was 58.03 MPa, located on the middle of the upper right screw (Fig. 1.). In the *x*-crossed configuration, peak von Mises stress was 53.62 MPa, located in the middle of the lowermost screw (Fig. 2.). The maximum displacement in the inverted triangle configuration was 4.183 mm (Fig. 3.), while the maximum displacement in the *x*-crossed configuration was 4.029 mm (Fig. 4.) both occurring on the topmost point of the femoral head. Maximum von Mises screw stresses and maximum femoral head displacements of both configurations along with *x-crossed-left* and *x-crossed-right* screw configurations are shown in Table 1.

Table 1. Maximum von Mises stress on the screw and displacement on the femoral head

Assembly	Stress [MPa]	Displacement [mm]
Inverted triangle	58.03	4.183
x-crossed	53.62	4.029
x-crossed-left	66.58	4.040
x-crossed-right	143.7	4.144

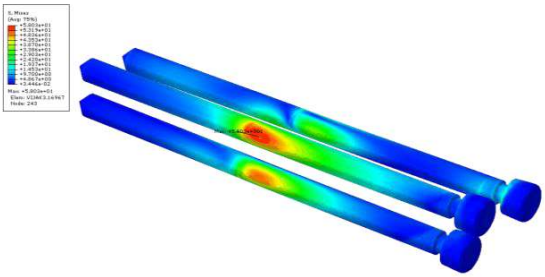

Fig. 1. Maximum von Mises stress on the inverted triangle configuration screw

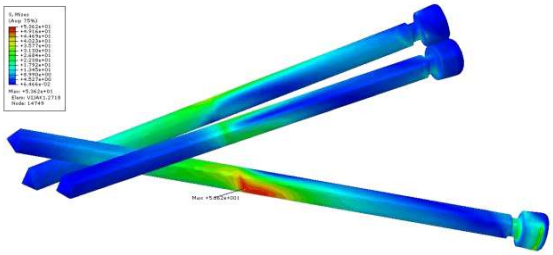

Fig. 2. Maximum von Mises stress on the *x*-crossed configuration screw

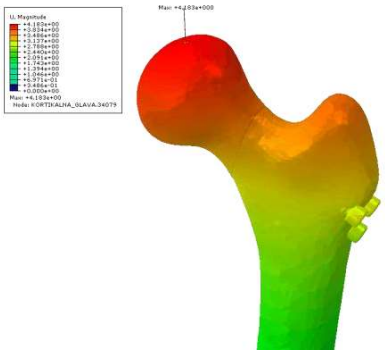

Fig. 3. Maximum displacement on the femoral head in the inverted triangle configuration

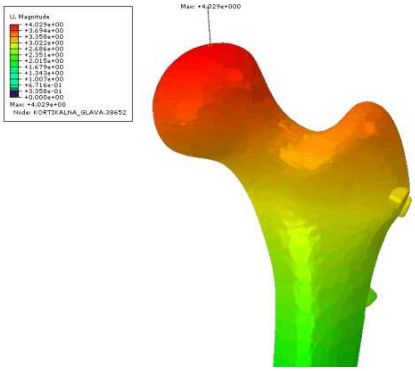

Fig. 4. Maximum displacement on the femoral head in the *x*-crossed configuration

4. Conclusions

Finite element analysis showed that the *x*-crossed configuration withstands higher von Mises stress while preserving less shear displacement on the fracture site in regard to the inverted triangle configuration which withstands smaller von Mises stress and consequently greater shear fracture displacement.

It is also shown that the *x*-crossed-left configuration has lower biomechanical stability than the *x*-crossed-right configuration. The analyses have further shown that among all of the configurations, the *x*-crossed-left configuration has significantly higher von Mises stresses, while maximum displacement is located in the inverted triangle configuration. This indicates that two instead of three screws could be used in the treatments of Pauwels type III femoral neck fractures at the expense of higher stresses on the titanium screws.

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