FE ANALYSIS OF AN EXTERNAL STABILIZER APPLIED IN TREATMENT OF THE PROXIMAL PHALANX FRACTURE IN HORSES

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Introduction

Fractures of the proximal phalanx (P1) in horses belong to a wide group of fractures in those animals. Most of them are treated by means of surgical methods which give good results. However, treatment of multi-fragmental fractures of P1 is difficult and often gives unsatisfactory clinical outcome. In many cases, especially when the fracture is open and infected, they can be life-threatening problems.

We propose treatment of such complex fractures with application of an orthopaedic external stabilizer designed in Warsaw University of Life Sciences. The device is fixed into the third metacarpal bone (MC III) by five Apex screws. Its role is to unload the treated bone during getting up and standing after surgery. The aim of the present study is to verify strength of the stabilizer and influence of the device fixation on bone tissue behaviour.

Methods

The external stabilizer consists of two semi-circular arms oriented horizontally with respect to the third metacarpal bone axis and connected with each other by means of three vertical rods. In addition, two circular rods are fixed to the stabilizer to prevent the patient from standing on the hoof (Fig. 1).

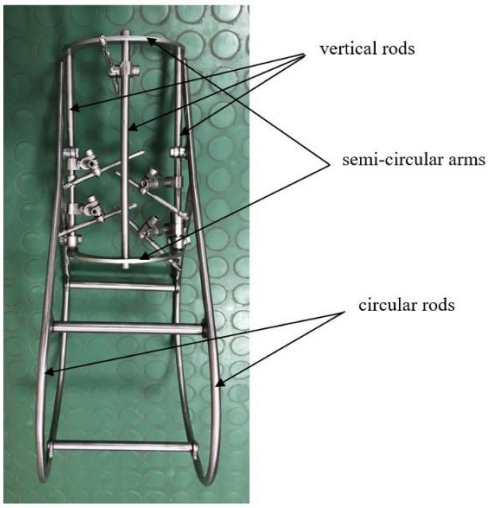

Figure 1: External stabilizer for treatment of proximal phalanx fracture.

We performed finite element (FE) analyses using Ansys 2021 package. The stabilizer was modelled as an isotropic elastic material (Young's modulus 220 GPa, Poisson's ratio 0.3) and bone as non-linear viscoelastic material by means of a constitutive equation formulated according to the method described in [1]. All degrees of freedom were fixed at the lower part of the circular rods. It is estimated that the force acting on the cannon bone during getting up is approx. 2743 N [2] for a horse weighing 500 kg. Therefore, we decided to apply force 3000 N on the upper surface of the MC III bone along its long axis.

Results

In Fig. 2 von Mises stress distribution in the stabilizer is presented. Also, the boundary conditions are shown. We can identify the most loaded regions of the stabilizer. The maximal value of stress in the orthopaedical device equals 1334 MPa.

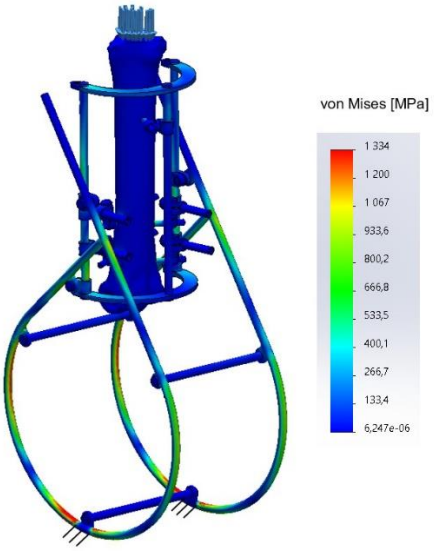

Figure 2: Stress distribution in the external stabilizer and the MC III bone.

Discussion

The numerical results indicate that the construction of the external stabilizer is correct. However, closer analysis of bone behaviour in the vicinity of the screws is required. We observed stress and strain concentrations in those regions, which might lead to bone necrosis. This also suggests that strong bone remodelling might take place there. The phenomena can be minimised by optimising the angular orientation of the screws, which is also in the field of our interest.

References

1. M. Pawlikowski et al, J Mech Beh Biomed Mat, 85:162-169, 2018.
2. B. Turek et al, Pol J Vet Sci, 18:323-332, 2015.