# CAN WIDENING OF A STRESS FRACTURE DECREASE LOCAL STRAINS SUFFICIENTLY TO ENABLE HEALING?

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## Introduction

Stress fractures at the anterior border of the tibial mid-diaphysis are often problematic to heal, possibly because strains in the fracture gap are too large. Therefore, surgical intervention may be inevitable. Today, the surgical methods focus on achieving complete stability of the crack gap. In this study, a potential method that is less invasive is hypothesized and evaluated from a biomechanical point of view. The concept is to widen the fracture gap by drilling a hole with a large diameter from the anterior border, through the crack and into the medullary cavity. The aim of the present study was to evaluate the differences in the mechanical response of the intact, fractured and drilled tibia, using a finite element (FE) model.

## Methods

The geometry of the tibia was acquired from clinical CT images via semi-automatic segmentation. FE models were established for an intact tibia and a tibia with a stress fracture before and after drilling. Orthotropic material properties were used for the cortical bone, whereas in the trabecular bone isotropic material properties were mapped over each element based on CT density [Linde, 1992]. Granulation tissue was modeled in the fracture gap and drilled hole. The stiffness of the intact tibia was validated against *in vitro* experimental data [Cristofolini, 2010]. The load magnitude was set equal to the highest tibio-femoral contact force during gait [Taylor, 2005]. The force was applied at the tibial condyles of the FE models, while the distal end was fixed to prevent rigid body motion.

## Results

The stiffness of the intact tibia model was within the range of the experimental data. However, some differences were noted for bending in the coronal plane (29 %). In the crack region, high strains (> 20 %) and pressures (> 2 MPa) were predicted in a large portion of the granulation tissue (Fig 1). After drilling, the magnitude decreased significantly: strains < 3 %, hydrostatic pressure < 0.1 MPa in the granulation tissue. When investigating the overall tibia stiffness, the drilling was found to have a minor effect. The largest differences were observed for bending in the sagittal plane, in which the drilled tibia were 11.6 % less stiff than the intact tibia, whereas the tibia with a stress fracture was 3.1 % less stiff than the intact tibia.

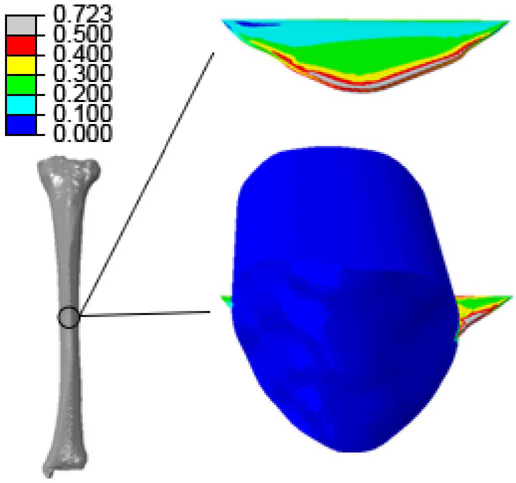


*Figure 1: Tibia model (left) with max principal strain of the granulation tissue in the crack before and after drilling (right).*

## Discussion

The high strains and hydrostatic pressures predicted in the stress fracture before drilling, together with existing tissue differentiation theories may explain the low healing capacity of the stress fracture. The dramatic decrease of the predicted strains in the drilled tibia suggests that the healing capacity may increase. This is also supported by the favourable outcome of a similar surgical procedure [Miyamoto, 2009]. Only a small decrease of the tibia stiffness is predicted after drilling. Therefore, drilling is not believed to affect the mechanical function of the tibia significantly.

## References

Cristofolini *et al*, J Biomech, 2010; Linde *et al*, J Biomech, 1992; Miyamoto *et al*, Am J Sports Med, 2009; Taylor *et al*, JOR, 2005.

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