

The effect of bridging span and fracture healing on the performance of high tibial osteotomy plates

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Introduction

High tibial osteotomy (HTO) is an established surgical procedure for the treatment of early-stage knee arthritis. Other than infection, the majority of common complications in opening wedge HTO are related to mechanical factors – in particular, the stimulation of healing at the osteotomy site. If healing is delayed, there is a significantly greater likelihood of other complications. The aim of this study was to investigate the effect of plate bridging span on the fracture site stimulation and the role that fracture healing has on plate stress.

Methods

A ten degree opening wedge HTO was created in a composite tibia. Imaging and strain gauge data were used to create and validate finite element models. Finite element representations of an intact tibia and a tibia implanted with a custom HTO plate using two different bridging spans (30mm and 55mm) were validated against the experiments. The validated model was then developed to include physiological muscle forces and different stages of callus healing corresponding to approximately 0, 2 and 4 post-operatively. The predictions of plate stress and interfragmentary movement (IFM) for the custom plate were compared against an industry standard plate (Tomofix).

Results

The finite element model predicted IFM values within 5% of the experimental measurements. Linear regression of the predicted and measured strains gave R^2 values of over 0.96 for all cases examined. The short span custom plate produced substantially lower peak von Mises stress than the Tomofix plate with similar levels of IFM. The long span custom plate increased axial and shear IFM values by 24% and 47% respectively. In all cases, with callus formation of 28MPa (typical for fibrocartilage), the plate stress reduced by at least 50% compared to the gap defect model.

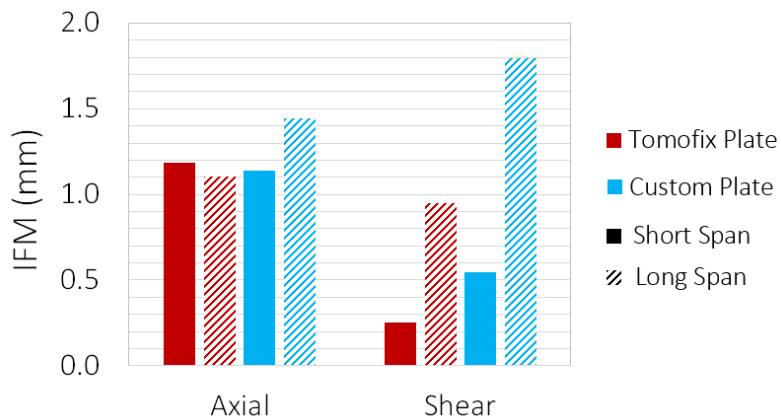


Fig. 1. ...

Discussion

Our analysis confirmed previous studies' findings that increasing the bridging span increased the axial and shear IFM [1-2]. We found that, for both plate types, the longer bridging spans did not necessarily increase plate stress. Indeed, when early callus formation was included in the models, the plate stress was similar or lower for the longer bridging spans. The location of peak plate stress predicted by our study was also found to be the most common location of plate breakage clinically.

Conclusions

This study demonstrates that the initial plate stress in both plate designs are much higher than the fatigue strength of titanium alloy and, therefore, callus healing is required to prevent fatigue failure. Positioning screws so that the bridging span is larger, increases the IFM. As callus healing progresses, the plate stress can become lower for larger bridging spans compared to shorter spans.

References

- [1] Stoffel et al., 2003, Injury, 34.
- [2] MacLeod et al., 2016, J. Orthop. Res.