THE EFFECT OF FRACTURE ANGLE ON PLATE FAILURE FOR PERIPROSTHETIC FRACTURE FIXATION USING LOCKING PLATES

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Introduction

Periprosthetic femoral fractures (PFF) can occur as a complication of total hip arthroplasty and are often challenging to treat as the mechanical scenario is influenced by the presence of the metal prosthesis within the bone[Moazen,2011]. Failure of locking plate fixation following fractures around the tip of a stable prosthesis (Vancouver type B1) have been reported clinically [Buttaro,2007], suggesting that current plate and screw combinations used to stabilise these fractures may not be adequate. The aim of this study was to investigate the effect of fracture angle on the potential for locking plate failure, in PFF cases where a stable hip prosthesis will remain in situ and the bone stock is good.

Methods

A computational model was developed and validated against laboratory test data [Mak,2012]. A 3-D solid model of the synthetic femur (4thgen, Sawbones, Pacific Research Laboratories Inc. Sweden) was obtained Biomed Town (BEL repository). A cemented primary stem prosthesis (Exeter cemented hip stem V40, Stryker SA, Switzerland) was positioned in the femur. Five different fracture angles were investigated and were created 10mm distal to the tip of the stem, figure 1. The plate and screws, from CAD files provided by Stryker, were positioned to bridge the fracture. The model was loaded to 500N, at an angle of 10°. Strain was assessed at 8 sites on the plate and bone. Following mesh convergence tests, over 750000 quadratic, tetrahedral elements (C3D10M) were used to mesh the model.

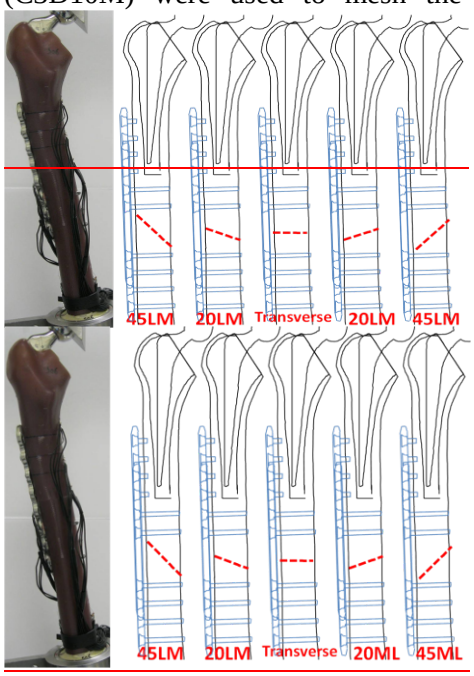

Figure1: Investigated fracture angles

Results

The bone strain patterns along the medial length of the femur were very similar between the transverse case and both the 20° LM and 20° ML fracture angle cases. The 45° fracture angles had a much larger effect on bone strain with increased strains located directly proximal to the fracture site, with strain doubling to over 300 με in the 45LM case. There were large changes in plate strain between the transverse case and the 45° fracture angles. The largest strains were observed in the 45° ML case where there was a strain peak of over 500 με.

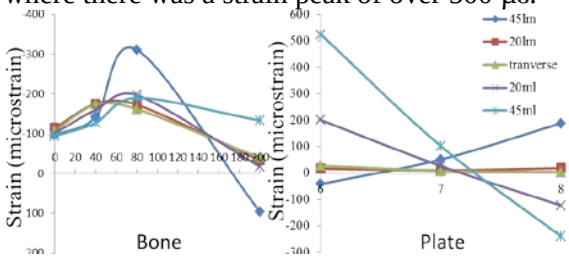

Figure 2: Bone and Plate stain (με) along the femur and locking plate

Discussion

The Vancouver classification system for periprosthetic fractures does not account for the angle of the fracture. Previous studies investigating the biomechanical performance of PFF fixation have focused on construct type and fixation methods, while the fracture has been simplified to an assumed worst case scenario, such as a transverse fracture. Fracture angle was found to have large effect on both bone strain around the fracture and on the plate. Fractures in the LM direction had a larger effect on bone strain while fractures in the ML direction had larger effect on plate strain. The strains observed at the 45ML fracture angle were very high and would likely cause the plate to fail. These results demonstrate that, in addition to the Vancouver classification, the orientation of the fracture should be also taken into account by surgeons when deciding on B1 PPF management.

References

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