AXIAL COMPRESSION TESTS OF PLATED BONE: A NUMERICAL STUDY TO INVESTIGATE THE EFFECT OF LOADING CONDITIONS ON THE MECHANICAL RESPONSE

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Introduction

The axial stiffness of fractured bone with fixation devices such as locking plates has been extensively investigated due to the importance of interfragmentary motion in fracture healing. A survey of literature shows that the estimated stiffness values differ by three orders of magnitude for locking plates (Bottlang, 2010; Hoffmeier, 2011; Kim, 2010; Stoffel, 2003). This study investigates the influence of loading conditions on the prediction of fracture gap motion using finite element (FE) analyses.

Methods

Four different commonly used loading scenarios (Fig. 1a-d), employed in simulations or for in vitro testing, are considered. The FE model used a sawbones tibial geometry with a Synthes 4.5 narrow LCP locking plate.

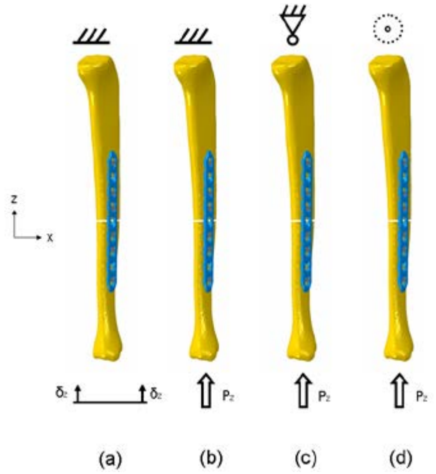

Figure 1: The four loading conditions examined

Results

The different loading conditions are found to have a profound effect on gap motion prediction. Loading in the form of prescribed displacements (bone ends are clamped and not permitted to rotate) produces the lowest predicted motions (Fig. 2a) whereas the largest value is for loading condition (c) in which the loading direction remains unchanged while the bone ends are permitted to rotate (Fig. 2c) . It is also found that the strain environment within the bone and the stresses within the plate are different for the different loading conditions.

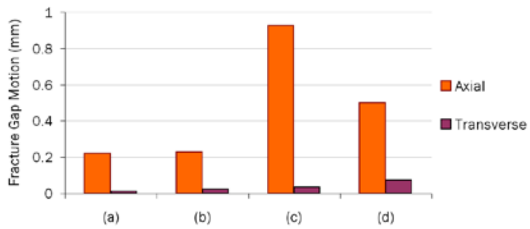

Figure 2: The fracture gap motion prediction due to the different loading conditions at a load of 1035N

Discussion

Many variables are known to influence fracture gap motion prediction such as the length of the bone, plate dimensions, bone-plate off-set and screw positioning. Changing the loading conditions alone can change prediction of gap motion by almost five times (Fig. 2), and this value can be much higher if the bone length is shorter such as in idealised bone cylinder tests. It is concluded that in order to correctly predict the fracture gap motion and strain environment within the bone the boundary conditions implemented need to be specific to the bone being tested. A recommendation is made for an alternative to the most commonly used experimental boundary conditions.

References

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