THE INFLUENCE OF USING ONE OR TWO LAG SCREWS ON THE MECHANICAL ENVIRONMENT OF A FEMORAL NECK FRACTURE.

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INTRODUCTION

Fracture healing requires two major pre-requisites; sufficient blood supply and mechanical stability [1-2]. Optimum mechanical conditions for fracture healing remain unknown, but micro-movements of the fracture fragments are significant to a developing healing callus [2-3]. This study uses Finite Element analysis to evaluate an idealized neck fracture callus, for single, and two lag screw intramedullary nails, with two load conditions.

METHODS

A validated Finite Element model of a fractured femur, stabilized with an intramedullary nail was used to investigate the effects of loading and the mechanical environment on an idealized fracture callus, as the callus stiffness increased.

Load sharing between the device and bone was assessed for different fixation techniques, nail material properties, and callus size and stiffness. Titanium and Stainless steel constructs were investigated with a callus thickness of 0.5mm and 1.5mm. Strain energy and strain energy density were examined in the fracture callus on a comparative basis to evaluate the use of four different lag screw configurations. The four configurations are:

- Single lag screw of 12mm in diameter (12).
- Two lag screws of 7mm and 9mm diameter with the 7mm lag screw placed more proximally to the 9mm lag screw (7-9).
- Two lag screws of 7mm and 9mm diameter with the 9mm lag screw placed proximally to the 7mm lag screw (9-7).
- Two lag screws of 8mm diameter each (8-8).

Femur geometry was based on computerized tomography data. Bending and torsion loads were applied to the femur [4]. These load conditions use a joint reaction force and an abductor load.

A Coulomb frictional contact model was used to model the interface surfaces between the implant and bone. Sliding friction was permitted at the lag screw interface with the implant. Material properties were assigned in regions as linear elastic and isotropic.

RESULTS AND DISCUSSION

Strain energy varies significantly in the early developing callus (Figure 1). For a two-screw construct, the load sharing in each component changes as the callus stiffens. Two-screw configurations demonstrate smaller strain energy in the fracture callus at the early stages of healing, and more into the healed (stiff) fracture callus (Figure 2). The use of two screws may therefore be beneficial to a healing facture callus, by reducing the load carried into the callus at the early stages and countering stress shielding in the repaired bone.

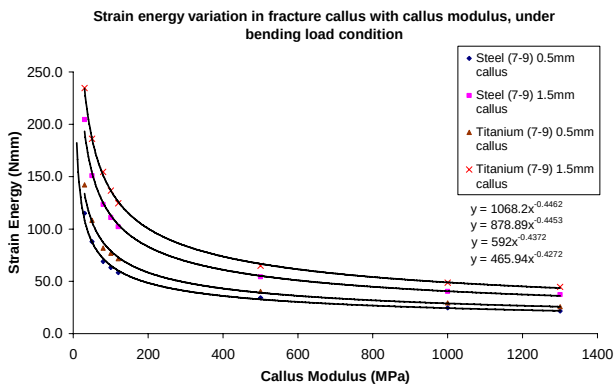

Figure 1 – Strain energy in the fracture callus as the callus stiffens for a bend load case.

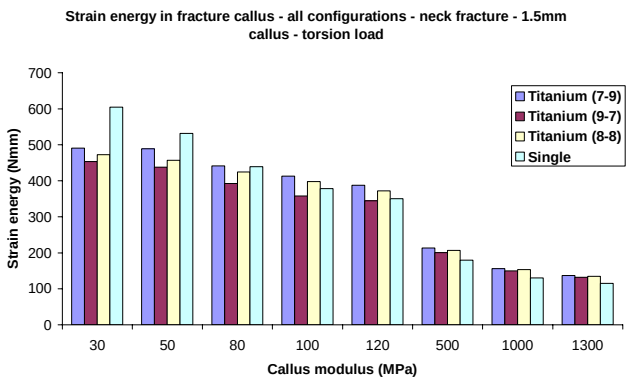

Figure 2 – Strain energy in the fracture callus for all configurations under a torsion load case.

The strain energy in the callus decreases as the fracture callus stiffens and the trend is an inverse power relationship.

Titanium lag screws share the load more evenly between them, particularly at low callus moduli, and the use of titanium significantly reduces the peak stress in the lag screw insertion hole.

Two lag screws are a more stable configuration with respect to a stiffening callus.

REFERENCES

1. Goodship AE, et al. *J.Bone & Jt Surg*, **67-B**:650-655, 1985.
2. Claes LE, et al. *J Orthop. Res*, **38**, 1099-1105, 2002.
3. Claes LE, et al. *Clin. Biomechanics*, **10**, 227-234, 199
4. Simpson DJ, et al. PhD Thesis, Brunel University, 2005.