FRACTURE ANGLES INFLUENCE HEALING IN FULLY REDUCED DISTAL FEMUR FRACTURES TREATED WITH LOCKING PLATES

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Introduction

There has been considerable research on the healing environment for fractures with inter-fragmentary gaps in which secondary healing (with callus) occurs due to inter-fragmentary strain. Fully reduced fractures treated with locking plates (device commonly selected for distal femur fractures) are considered to be stable permitting primary (osteonal) fracture healing. The possible subtle inter-fragmentary motions, which could inhibit osteonal repair at the early stage of healing in these reduced fractures due to weight bearing are not well understood. This study used finite element models to analyse the normal and shear inter-fragmentary motions between the bone fragments. The effect of fracture angles between bone fragments was compared.

Methods

Reduced fractures at the distal end of the femur fixed with a stainless steel locking plate were simulated in ABAQUS. The plate was placed on the lateral side of the femur. Both transverse fractures and oblique fractures with varying fracture angles were considered. The same screw configurations were applied to all the fractures. The coefficient of friction between the bone fragments was assumed to be 0.46 [1]. Cortical bone and the trabecular bone were assumed to be linear elastic. At the distal femur, condyles were supported by a layer of soft material, whose Young's modulus was the same as meniscus [2]. Based on a previous study [3] the femoral head was partially restrained using a lateral spring. Load was applied from the centre of the femoral head to the centre of the condyles.

Results

Figure 1 shows the deformed position of the fractured fragments under 700N load (i.e fully weight bearing for a 71kg person) from the femoral head for three fracture angles. Normal and shear displacements were evaluated at the near and far cortices (close to and furthest from the plate). For the three fracture angles shown in Fig. 1 the results are shown in Fig. 2. It can be seen that fracture angles influence inter-fragmentary motion which has implications on healing.

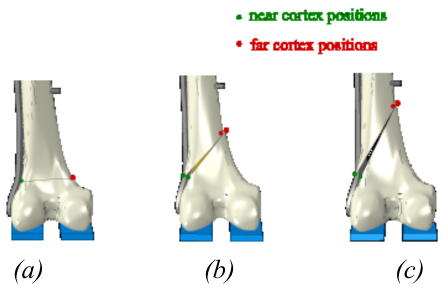

Figure 1: Deformed shapes of the fractured fragments on weight bearing: (a) Transverse fracture (b) 45°oblique fracture (c) 60°oblique fracture

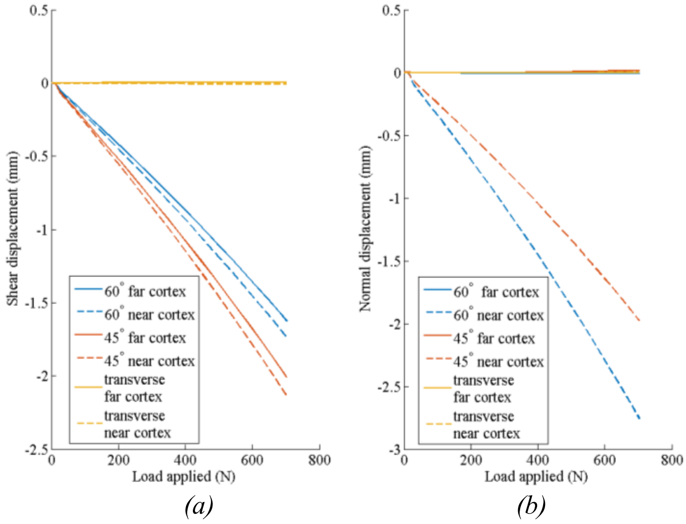

Figure 2: Relative normal (a) and shear (b) motions at the fracture site

Discussion

Inter-fragmentary motions are negligible for the transverse fracture. For oblique fractures, there are significant shear motions at both far and near cortex locations. At the far cortex position, the normal motion is restrained due to the compression between bone fragments. It is interesting to note that an increase in fracture angle does not always result in increased inter-fragmentary shear.

The stability of the fully reduced fixation is related to the fracture angles. Inter-fragmentary motions are more likely to occur for oblique fractures. Such motions would have a major influence on the healing process and may prevent primary osteonal healing occurring. Alteration of the screw configuration or degree of weight bearing of the patient may be needed to facilitate primary healing.

References

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