A Computational Model of Clavicle Fracture Fixation

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Introduction

Recent randomized clinical trials (Canadian Orthopaedic Trauma Society, 2007) have demonstrated the benefits of fracture fixation in a far greater proportion of patients with midshaft clavicle fracture than traditionally were managed operatively. The ideal method of fixation however remains unclear with a proportion of patients suffering failure of fixation. The advent of fixed angle (locking) plates has added to the armamentarium of orthopaedic surgeons dealing with this condition. Biomechanical tests of fixation constructs to date have utilized relatively simple three-point bending models in the main which do not well simulate the in-vivo situation. In order to better evaluate the fixation methods, an estimation of the in-vivo forces that operate on the clavicle was necessary. There has been little published data on the topic to date and so the investigators used a 3-D computer model of the shoulder complex to assess the section forces and moments in the fracture.

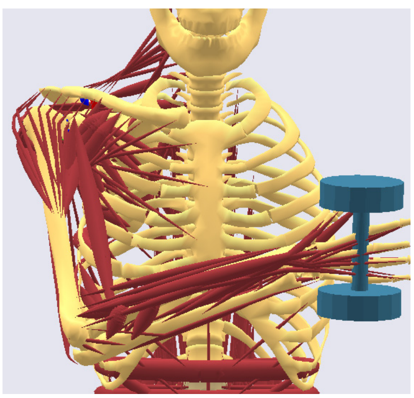

Figure 1. The computational shoulder model. The dumbbell has a mass of 1 kg.

Methods

A three-dimensional musculoskeletal model of the shoulder complex (Figure 1) was built using the Any-Body Modeling System (Damsgaard at al, 2006). The model is based on the data and modelling assumptions of the Dutch Shoulder Model (van der Helm et al, 1992). The model simulates the lifting of a 1 kg load representing a coffee mug or similar from a table to the mouth and computes resulting muscle and joint forces in the system. The clavicle is equipped with a midshaft fracture (Figure 2) and the necessary section forces and moments for stabilization of the fracture are computed.

Results and discussion

The movement of the hand from table to mouth results in a variation of section moments. The bending moments are rather constant until the final stages where the *y* component tapers off. In the majority of the movement this gives rise to a bending of the clavicle that opens the fracture in an inferior and frontal direction. The analysis also reveals that the clavicular part of the m. pectoralis is the principal contributor to the loading. This indicates that a superior placement of the fixation is non-optimal.

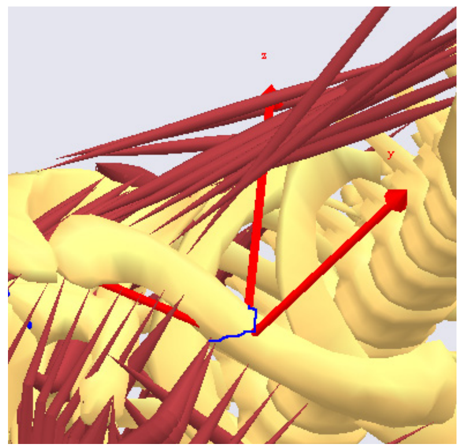

Figure 2. Placement and orientation of the fracture. Coordinates are: *x* lateral, *y* superior, and *z* posterior.

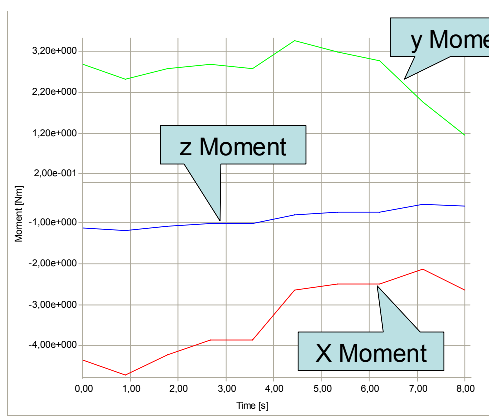

Figure 3. Fraction bending (*y* and *z*) and twisting (*x*) moments.

References

Damsgaard M, et al. Simulation Modelling Practice and Theory, 14, 1100-1111, 2006.

Canadian Orthopaedic Trauma Society. J Bone Joint Surg Am., 89, 1-10, 2007

Van der Helm FC, et al. J Biomech. 25, 129-144, 1992.