Computer-Aided Image-Guided Bone Fracture Surgery: System Integration and Prototype

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We are developing FRACAS (FRActure Computer-Aided Surgery), a computer-integrated orthopaedic system for assisting surgeons in closed long bone fracture reduction. The goals are to reduce the surgeon's cumulative exposure to radiation and improve the positioning accuracy by replacing uncorrelated static fluoroscopic images with a virtual reality display of 3D distal and proximal bone fragment models created from preoperative CT and tracked intraoperatively in real-time. Fluoroscopic images are used to register the bone models to the intraoperative situation and for verification. Last year's paper[1] describes the system concept and prototypes of the modeling, preoperative planning, visualization, and fluoroscopic image processing modules.

We have integrated the software modules and integrated a Northern Digital Polaris optical tracking unit for real time tracking of bone fragment models and drill. We use Traxtal active infrared instruments attached to bone fragments and to the drill.

We have developed a custom adjustable drill guide device for distal locking The guide attaches to the nail's head like the proximal targeting fixture. It has four adjustable degrees of freedom which are locked once the desired position and orientation have been found. To determine the relative position of the distal nail holes with respect to the 3D distal bone fragment contour, we acquire AP and lateral distal images of the bone and nail, extract the hole axes and 2D bone contours, and match them with the registered 3D distal bone fragment model. By registering the tip of the positioning device with the bone contour, we establish a common reference frame between the target holes and the drill guides. The goal of the surgeon is then to align the nail holes and the drill guide hole axes following their spatial view on the computer screen.

We have also developed a bone fragment holder for in-vitro simulation. We will use it to conduct accuracy tests, perform ergonomy evaluation, and conduct training sessions. The device consists of two adjustable bone fragment holders mounted on a radio-lucent basis. Each bone fragment holder is a lockable spherical joint to which bone fragment holders are attached to. The spherical joints are spring loaded so as to simulate the effect of muscle action. We have started conducing accuracy tests and feasibility studies.

[1] "Computer-Aided Image-Guided Bone Fracture Surgery – Concept and Implementation" L. Joskowicz, L. Tockus, Z. Yaniv, A. Simkin, C. Milgrom, *Proc. 12th Int. Symposium on Computer Assisted Radiology and Surgery*, H.U. Lemke *et. al.* eds, 1998.