

Table-mounted vs. Bone-mounted Reference Frame Attachment in Navigation-Assisted Orthopedic Surgery

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Introduction:

Fluoroscopy-based navigation systems enable surgeons to simultaneously correct parameters while placing implants in multiple two-dimensional views. This facilitates implant placement in all planes with less radiation and provides maximal accuracy. To enable a navigated procedure, a rigid bony tracker named reference frame is rigidly fixed to a stable bony structure. This may create technical obstacles such as interference with surgical instruments and the fluoroscope and create an additional albeit small operative site. Subsequently local wound complications may occur. As an alternative, we propose to attach the reference frame to the fracture table instead of the iliac crest, under the assumption that no motion between the table-mounted reference frame and the target organ will occur. We validate this assumption by comparing the navigation accuracy while fixing the reference frame to the patient's bony anatomy and to the operating table.

Methods:

The study population consisted of 7 patients with femoral neck fracture (AO/OTA 31B1, 31B2.1) who underwent fixation of the fracture with three cannulated 6.5mm cancellous screws, using fluoroscopy-based navigation. In order to measure accuracy during the navigated procedure, the following steps were performed: Step 1 - The patient was positioned on a fracture table and the reference frame was attached to the iliac crest with two 3mm Shanz screws. Three guide wires used for cannulated screw fixation were inserted under fluoroscopy-based navigation. Step 2 - New fluoroscopic images were acquired with the

guide wires in place. Step 3 - The navigated drill guide was placed over each guide wire to record final navigated drill guide position. The resulting images include the actual guide wire positions (in lieu of the real implant) and the virtual trajectories of the navigated drill guide as computed by the navigation system. Ideally, when no relative motion occurs, these two positions should completely match; in practice, a small error appears. Validation of the navigation accuracy was performed by measuring the translational and angular deviations of the virtual trajectory image from the real image of the implant on the same fluoroscopic image in anteroposterior and lateral views. Step 4 – The reference frame was removed from the iliac crest and attached to the fracture table with bars and clamps of an external fixator. Step 3 was then repeated. Finally, the recorded images were downloaded and analyzed, with all measurements reported in-plane. Two tailed T-test was used for statistical analysis.

Results:

The data for 20/21 screws is presented. For the anteroposterior view, when the reference frame was attached to the iliac crest, the average translational deviation of the trajectory from the inserted guide wire was 0.91 ± 0.80 mm at the entry site and 0.98 ± 0.92 mm at the trajectory tip. When the reference frame was attached to the fracture table, the average deviation was 1.25 ± 0.87 mm and 1.70 ± 1.32 mm, respectively. The differences were not statistically significant. The angular differences were $0.86\pm 0.72^\circ$ in the iliac crest mounted reference frame group and $1.07\pm 0.81^\circ$ in the table mounted reference frame group, which is also not statistically significant. For the lateral view, when the reference frame was attached to the iliac crest, the average translational deviation of the trajectory from the inserted guide wire was 1.79 ± 0.74 mm at the entry site and 1.77 ± 1.25 mm at the trajectory tip. When the reference frame was attached to the fracture table, the average deviation was 1.20 ± 0.74 mm and 1.60 ± 0.73 mm, respectively. The difference between those two groups is significant at the entry point in favor of the table mounted reference frame ($p=0.015$). Angular differences were $0.94\pm 0.75^\circ$ in the iliac crest mounted reference frame group and $1.15\pm 0.74^\circ$ in the table mounted reference frame group, not statistically significant.

Conclusion:

In navigation-assisted cannulated screw fixation for femoral neck fractures, attaching the reference frame to the fracture table instead of to the iliac crest allows for similar accuracy of the navigation process with the possible benefit of reducing patient morbidity. This may have further application for table mounted devices and navigated surgical instruments.

References:

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