

Intraoperative Fluoroscopy Underestimates Malreduction of Displaced Femoral Neck Fractures

Garin Hecht, MD; Patrick Michelier, BS; Blythe Durbin-Johnson, PhD; Jonathan Eastman, MD; UC Davis Medical Center, Sacramento, California, USA

Purpose: Clinical outcomes after internal fixation of displaced femoral neck fractures are affected by reduction quality. The reduction quality is traditionally measured by tangential radiographic views to detect displacement and angulation. This concept is routinely applied intraoperatively using fluoroscopy to assess reductions; however, its accuracy has never been investigated. We hypothesize that intraoperative fluoroscopy underestimates the displacement following reduction and internal fixation of displaced femoral neck fractures.

Methods: After IRB approval, a retrospective review at our institution revealed 119 patients treated for displaced femoral neck fractures (AO/OTA 31B2 or B3) with internal fixation between 2004 and 2014. 15 patients were found to have high-quality postoperative CT scans that allowed accurate comparison measurements. Displacement was measured on fluoroscopy using the known core diameter of the implant as a reference. Displacement on CT was measured using our institutional PACS (picture archiving and communication system) measuring tools. Fracture displacement was defined as the maximal measured displacement on any view. Absolute differences in CT and fluoroscopy measurements were compared using Student t test (significance $P=0.05$) and Pearson correlation coefficient (r). Blinded reviewers, consisting of three fellowship-trained attending traumatologists and two current trauma fellows, graded the fluoroscopic reductions as excellent (<2 mm displacement), good (2-5 mm), fair (>5 -10 mm), or poor (>10 mm). This evaluation method simulated the operating room experience in that no formal measurement tools were provided. Interclass correlation coefficients (ICCs) for reliability were calculated and a linear model with a random effect for reviewer was used to quantify the difference between these categorical assessments of fluoroscopy images and corresponding CT measurements.

Results: 73% of patients were treated with open reductions. The mean absolute difference of displacement measured by fluoroscopy versus CT was statistically significant at 1.4 mm ($P = 0.001$). The correlation between the two measurements was only moderately good ($r = 0.51$, Figure 1). There was no difference in the correlation of fluoroscopy to CT measurements when subgrouping by implant ($P = 0.96$) or reduction method (1.1 mm open, 2.0 mm closed, $P = 0.325$). The ICCs of intraobserver (0.57) and interobserver (0.49) qualitative assessments were fair. Reviewer grading of fluoroscopic imaging was significantly biased to underestimate maximal displacement measured on CT ($P = 0.01$). Patients with postoperative CT scans measuring 5-10 mm of displacement were graded appropriately as "fair" only 22% of the time (58% "good" and 20% "excellent").

Conclusion: Our study shows that fluoroscopic measurements of reduced femoral neck fractures underestimate the actual displacement detected on postoperative CT scans. We found a trend towards improved correlation of measurements with open reductions. Furthermore, qualitative grading of reductions based on intraoperative fluoroscopy significantly minimizes displacement. Our study indicates that more accurate measurement of displacement may better define what constitutes a clinically significant malreduction of a femoral neck fracture.

See pages 47 - 108 for financial disclosure information.

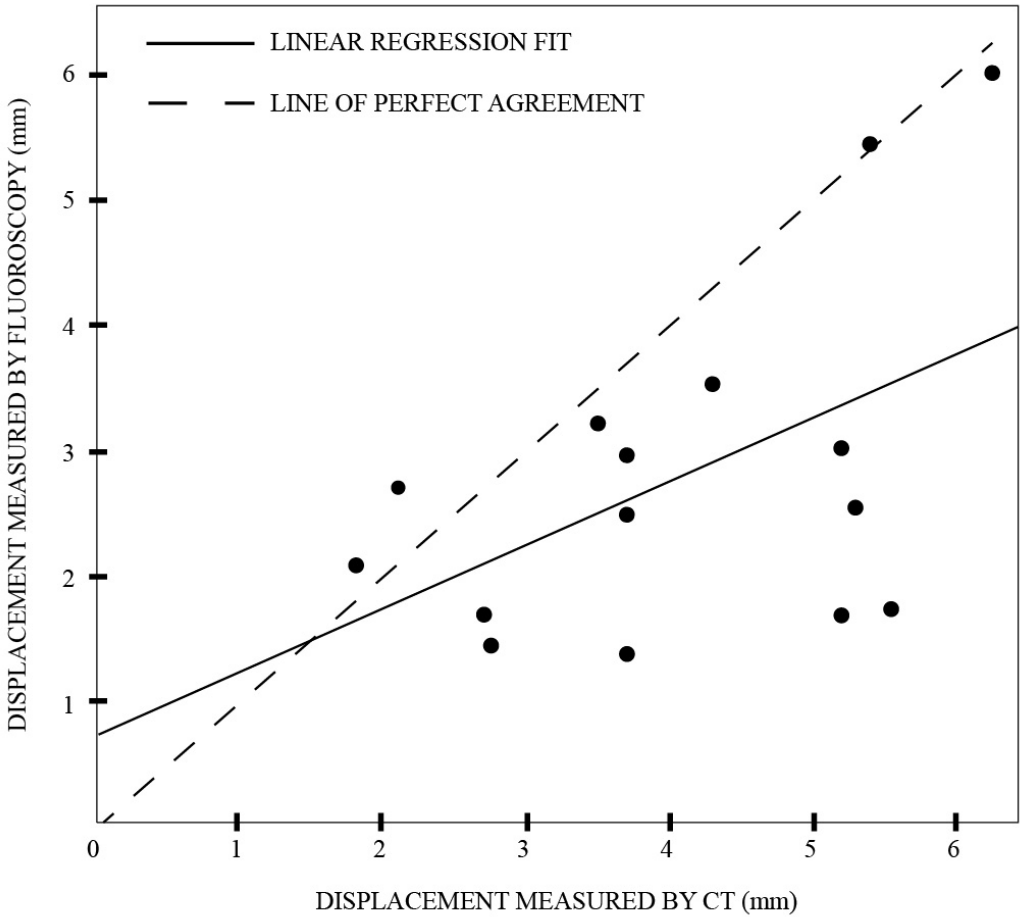


Figure 1. Scatterplot of measured displacement by postoperative CT scans and final intraoperative fluoroscopy images, showing only moderately good correlation ($r = 0.51$) between the modalities. As compared to the line of perfect agreement, fluoroscopic measurement underestimate the maximal displacement seen on CT scans ($p = 0.001$).

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.