

Three dimensional fluoroscopy for detection of intra-articular hardware in a proximal humerus fracture model – a laboratory study

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Proximal humerus locking plates (PHLP) had significantly improved the treatment of displaced, osteoporotic proximal humerus fractures in recent years. Despite their relative success, they are not devoid of pitfalls and complications. One of the most commonly occurring adverse phenomenon is penetration of hardware into the gleno-humeral joint. The overall incidence of this adverse event is between 5 to 25 percent if cases(1, 2). Although many of these cases relate to varus collapse and therefore secondary settling of the humeral head and secondary hardware penetration, some screws are initially placed too long and screw penetration is missed by intraoperative fluoroscopy. Since the humeral head is a spherical structure, peripheral screws that are too long may be overlapped by the wider part of the humeral head and therefore missed in certain fluoroscopic views. The use of intraoperative three dimensional (3D) imaging has been described in the past recent years(3). Theoretically, 3D imaging of the humeral head during the procedure can offer a more detailed image quality for the surgeon enabling him/her better detection of intra-articular breaching of the humeral head. Most 3D fluoroscopic systems available today are still expensive, use a fair amount of radiation and are not available in many centers. Recently a computer system consisting of both hardware (calibration ring and phantom) as well as software components has emerged (C InSight, Mazor ST, Caesaria, Israel), allowing the use of a conventional C-arm fluoroscope to produce CT like intraoperative images with reduced cost and radiation dose. Our hypothesis was that use of intraoperative 3D imaging will improve the ability to detect penetrating hardware into the shoulder joint during internal fixation of proximal humerus fracture. The aim of this study was to compare the performance of standard, four-image view fluoroscopy with the CInSight in a proximal humerus fracture model.

Methods: A zinc-sprayed proximal humerus sawbone was affixed with a PHLP (PHILOS, Synthes Switzerland). Six different constructs were assembled using six cortical 3.5mm locking head screws. In each specimen, either one screw, two screws or none were inserted 2 mm proud of the articular surface as measured by a caliper. Each specimen was placed on a radiolucent table and imaged either with a standard 2D fluoroscope in a four view standardized image set consisting of an anteroposterior (AP), lateral and two oblique images or with the C inSight system. According to a power analysis, a set of six scans per each specimen was performed, producing overall 36 sets of images per each modality. Screws were designated alphabetically according to their position in the plate (A-I). The 36 sets of fluoroscopic scans as well as the C inSight scans were digitized and given to two blinded senior shoulder surgeons for evaluation. Eighteen duplicates of scans were also inserted in random order into the images given to the observers in order to assess intraobserver consistency and validity. Each observer was asked to identify whether one, two or none of the screws were protruding into the joint. The following correlations were examined: inter-observer agreement, intra-observer agreement (for the 18 repeat measurements), accuracy of each modality and accuracies of both modalities. Absolute agreement for each observation was defined as the accurate detection and designation of either one or two penetrating screws while partial agreement was the correct identification of one out of two penetrating screws penetrating the joint. The McNemar test was used for statistical analysis.

Results: Observer A had an absolute agreement of 69.4% (compared with the truth) and partial agreement of 19.4% with conventional fluoroscopy, with 11.1% absolute errors in detecting the penetrating screws. Using the C-InSight system, Observer A had an absolute detection of screws of 97.2% and partial agreement of 2.8% with no absolute errors ($p < 0.01$). Observer B had an absolute

agreement of 91.7% (compared with the truth) and partial agreement of 5.64% with conventional fluoroscopy, with a 2.8% of absolute errors in detecting the penetrating screws. Using the C InSight system, Observer A had an absolute detection of screws 100% with no errors ($p < 0.01$).

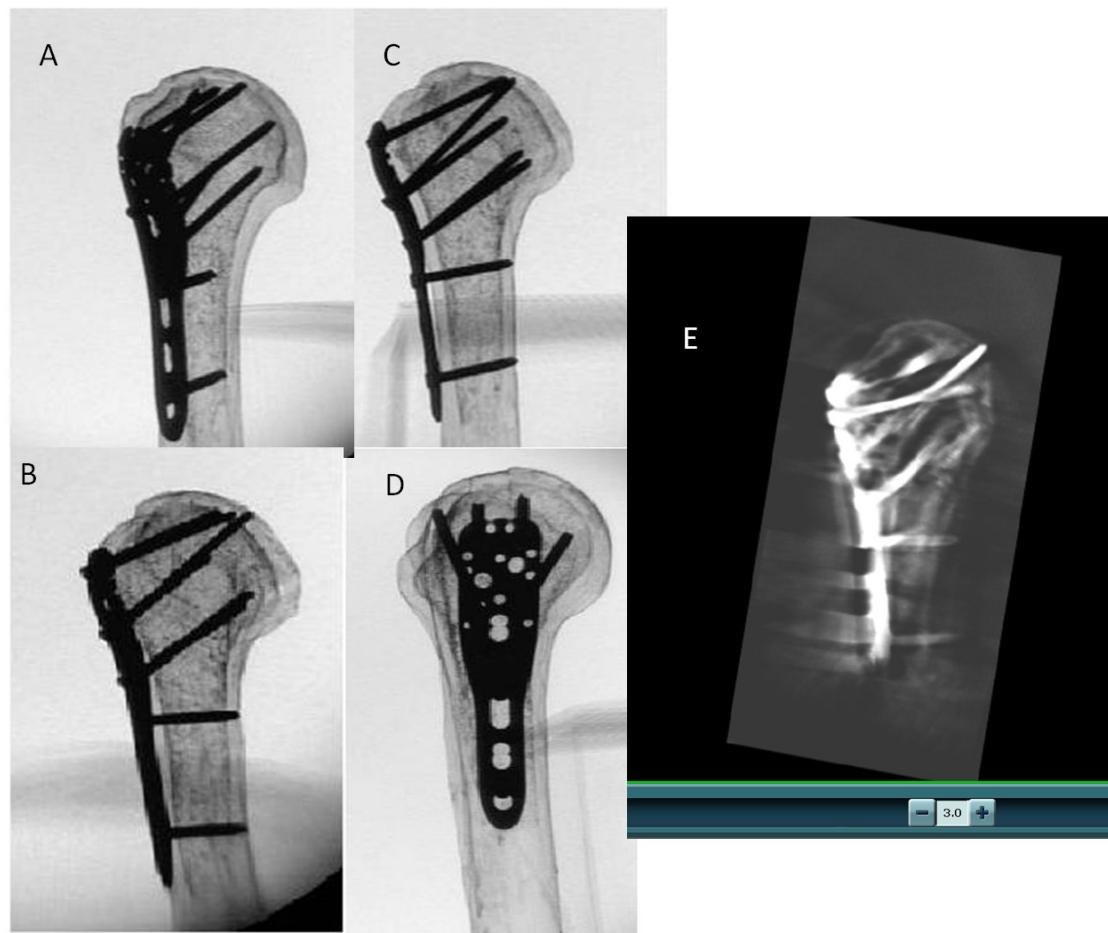


Figure 1: A-D – fluoroscopic views of a specimen without obvious findings of penetrating screws into the joint. On a coronal C-InSight reformat, however (E) – the penetrating screw can be readily seen

The inter-observer validity using conventional fluoroscopy yielded an interclass coefficient (kappa value) 0.806 and for the C-InSight a kappa value of 0.931.

The intra-observer validity of the conventional fluoroscopy yielded a kappa value 0.933 for observer A and a kappa value of 0.738 for observer B while the CinSight yielded a kappa value of 1.00 for both observers.

Conclusions: In a proximal humerus fracture model both good quality conventional fluoroscopy taken in four standardized views can detect most but not all instances of screw penetration into the humeral head. However, 3D fluoroscopy can maximize these detection capability. No errors and absolute correct intra and inter observer validity were achieved using the 3D fluoroscopy in detecting penetrating screws into the humeral head. Therefore, the use of the 3D fluoroscopy may help reducing the complication of placing penetrating intra-articular screws in proximal humerus fracture fixation.

Reference

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