**How to Use Fluoroscopic Imaging to Prevent Intra-Articular Screw Perforation During Locked Plating of Proximal Humerus Fractures: A Cadaveric Study**

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**Purpose:** Intra-articular screw perforation is a common complication after open reduction and internal fixation (ORIF) of proximal humerus fractures. The purpose of this study was to determine the sensitivity and specificity of intraoperative fluoroscopic images used to evaluate if the tip of a screw is completely located within the bone of the proximal humerus or if it is intra-articular. The authors hypothesized that: (1) a screw that is completely contained within bone would always image as if it is within bone, (2) intra-articular screws can falsely appear on imaging as if they are completely located within bone, and (3) specific fluoroscopic views can be used to reliably evaluate specific locations of the humeral head.

**Methods:** 22 proximal humeri in fresh-frozen cadavers were instrumented. The articular surface was divided into equal-sized three rows (superior, central, inferior) and three columns (anterior, middle, posterior) so screws could be placed in reproducible locations at the intersections of the rows and columns. The screws in the first 10 specimens were inserted so their tips were located 2mm beneath the articular surface. The next 12 specimens had screws placed so their tips protruded 2 mm past the articular surface into the glenohumeral joint. 27 different C-arm views were obtained of each specimen/screw configuration for a total of 1242 images.

**Results:** A screw that is located completely within bone always imaged as if it was completely within bone. There were 0 false positives and therefore specificity was 100%. The average sensitivity of the images of the intra-articular screws was 55%, and varied greatly depending on the specific image and the screw tip exit location (range, 0%-100%) (Table 1). The sensitivity for the inferior row of screws was the lowest (39.1%) and was particularly low for the posterior inferior screw exit location (20.7%).

**Conclusion:** Screws that are completely contained within bone will never image as if they are intra-articular. Unfortunately, screws that are intra-articular, particularly the posterior inferior screw, can image incorrectly and appear as if they are completely located within bone. We recommend the use of seven specific C-arm images (black highlighted boxes in Table 1) since these views had a sensitivity of 100% for 8 of the 9 screws positions and 97% for the posterior inferior screw and required the least C-arm manipulation. This specific fluoroscopic imaging technique could be used to decrease the chances of placing intra-articular screws during ORIF of proximal humerus fractures.

See pages 99 - 147 for financial disclosure information.

**Table 1.** Sensitivity of Each Screw Exit Location for Each of the 27 C-Arm Views

| | Cephalic Cant | | | | | | | | | Neutral Cant | | | | | | | | | Caudal Cant | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Position | Roll Back | | | Neutral | | | Roll Over | | | Roll Back | | | Neutral | | | Roll Over | | | Roll Back | | | Neutral | | | Roll Over | | | |
| Screw Exit Point | Arm IR | Arm NR | Arm ER | Arm IR | Arm NR | Arm ER | Arm IR | Arm NR | Arm ER | Arm IR | Arm NR | Arm ER | Arm IR | Arm NR | Arm ER | Arm IR | Arm NR | Arm ER | Arm IR | Arm NR | Arm ER | Arm IR | Arm NR | Arm ER | Arm IR | Arm NR | Arm ER | Average |
| **Anterior Superior** | 83 | 92 | 75 | 92 | 50 | 17 | 58 | 25 | 8 | 58 | **100** | 92 | **100** | 92 | 42 | 92 | 42 | 25 | 25 | 92 | **100** | 75 | **100** | 92 | 92 | 58 | 42 | 67.3 |
| **Anterior Central** | 25 | 67 | **100** | 75 | **100** | 67 | **100** | 42 | 0 | 0 | 58 | **100** | 50 | **100** | 83 | **100** | 67 | 8 | 0 | 50 | 83 | 58 | **100** | 67 | **100** | 67 | 33 | 63.0 |
| **Anterior Inferior** | 0 | 8 | 58 | 0 | 67 | **100** | 75 | **100** | 83 | 0 | 33 | 83 | 0 | 75 | **100** | 50 | **100** | 42 | 0 | 58 | **100** | 25 | **100** | **100** | 67 | 92 | 42 | 57.7 |
| **Middle Superior** | 75 | 92 | 92 | 75 | 67 | 58 | 50 | 42 | 25 | **100** | **100** | **100** | **100** | **100** | **100** | **100** | 92 | 50 | 42 | 42 | 67 | 42 | 75 | 92 | 67 | **100** | **100** | 75.6 |
| **Middle Central** | 67 | 42 | 83 | 92 | **100** | 92 | **100** | 92 | 42 | 8 | 8 | 75 | 17 | 92 | **100** | 75 | **100** | 67 | 0 | 0 | 50 | 0 | 33 | 92 | 33 | 92 | 83 | 60.5 |
| **Middle Inferior** | 0 | 0 | 17 | 0 | 25 | 75 | 33 | 92 | 92 | 0 | 0 | 17 | 0 | 25 | 92 | 17 | 83 | **100** | 0 | 8 | 50 | 0 | 42 | **100** | 8 | 83 | 92 | 38.9 |
| **Posterior Superior** | 83 | 92 | 92 | 83 | 92 | 92 | 83 | **100** | 92 | **100** | 50 | 50 | 92 | 75 | 75 | 75 | 83 | 92 | 50 | 17 | 0 | 42 | 17 | 33 | 33 | 58 | 83 | 67.9 |
| **Posterior Central** | **100** | 42 | 25 | 92 | 67 | 92 | 92 | 92 | **100** | 50 | 8 | 0 | 33 | 8 | 58 | 33 | 58 | **100** | 8 | 0 | 8 | 8 | 0 | 25 | 0 | 17 | 75 | 44.1 |
| **Posterior Inferior** | 75 | 0 | 0 | 17 | 0 | 25 | 0 | 58 | 83 | 17 | 0 | 8 | 0 | 0 | 25 | 8 | 25 | 75 | 25 | 0 | 8 | 0 | 0 | 8 | 0 | 17 | 83 | 20.7 |
| **Average** | 56 | 48 | 60 | 58 | 63 | 69 | 66 | 71 | 58 | 37 | 40 | 58 | 44 | 63 | 75 | 61 | 72 | 62 | 17 | 30 | 52 | 28 | 52 | 68 | 44 | 65 | 70 | 55.1 |

IR = internal rotation, NR = neutral rotation, ER = external rotation. All sensitivities are in percentage, views with 100% sensitivity are bolded, and recommended views are highlighted in black.

• The FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an "off label" use). For full information, refer to page 600.