Simultaneous Use of 2 C-Arm Devices Facilitates Percutaneous Treatment of Proximal Humerus Fractures

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Abstract

Percutaneous treatment of proximal humerus fractures is a technically challenging procedure because percutaneous implants must be placed in a specific configuration to obtain optimal fixation while avoiding joint penetration. Using 2 C-arm devices can expedite this procedure by providing simultaneous visualization of the fracture and implants in 2 planes. Simultaneous orthogonal imaging during pin insertion decreases the number of passes needed to obtain optimal pin placement. Dual fluoroscopy also avoids excess exposures and inadvertent sterile field contamination, which can occur with repeated C-arm repositioning.

In appropriately selected patients, percutaneous treatment of proximal humerus fractures compared to open reduction-internal fixation offers the potential advantages of less soft tissue trauma, shorter operative time, better preservation of vascularity to the humeral head, and improved cosmesis.[1-3] However, percutaneous treatment is technically demanding because the surgeon must reduce the fracture by closed or percutaneous techniques, then place percutaneous implants in a specific configuration to obtain optimal fixation while avoiding joint penetration. Assessment of the fracture reduction and implant position almost entirely relies on intraoperative imaging.

Biplanar C-arm imaging, compared to a single C-arm,[4,5] offers the ability to see 2 orthogonal views of the proximal humerus simultaneously, allowing the surgeon to correctly fine-tune pin trajectory without having to stop and adjust the C-arm position. The percutaneous pins can be placed with greater efficiency, fewer adjustments, in less time, and with potentially less radiation exposure to the patient and surgeon. Less repositioning of the C-arm avoids the excess exposures used to find the area of interest, and also avoids inadvertent contamination of the sterile field that can occur with repeated C-arm manipulations.

To our knowledge, use of biplanar fluoroscopy in treatment of proximal humerus fractures has never been described in the literature. However, a similar technique has been used in the modern treatment of slipped capital femoral epiphysis (SFCE), where a single cannulated screw must be placed accurately through the center of the femoral epiphysis in the coronal and sagittal planes.[6,7] Deviation from this central position may lead to intra-articular implant penetration or damage to the intraosseous blood supply of the weight-bearing portion of the femoral head.[8] Similarly, during the percutaneous treatment of proximal humerus fractures, correct pin positioning relative to the fracture lines and to the joint space is paramount for a successful outcome. Biplanar imaging may be even more advantageous in the case of proximal humerus fractures since a closed reduction must be maintained during pin placement, whereas most cases of SCFE are fixed in-situ.

Surgical Technique

Patients are placed in a modified beach chair position with the head of the bed at approximately 45°. After gently securing the head and adequately padding all bony prominences, the large C-arm is brought in from a cephalad direction parallel to the operating table (Figure 1) and adjusted so that it can obtain an axillary view of the shoulder. While keeping the large C-arm in position, a mini

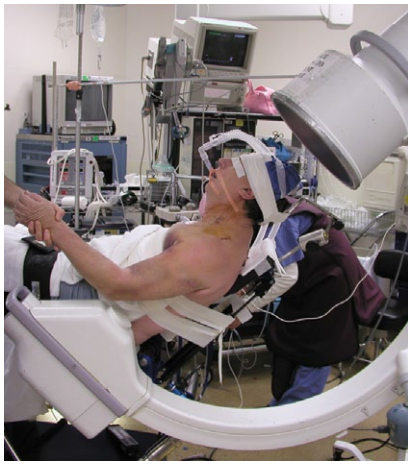

Figure 1. The large C-arm is brought in from a cephalad direction to obtain the axillary view.

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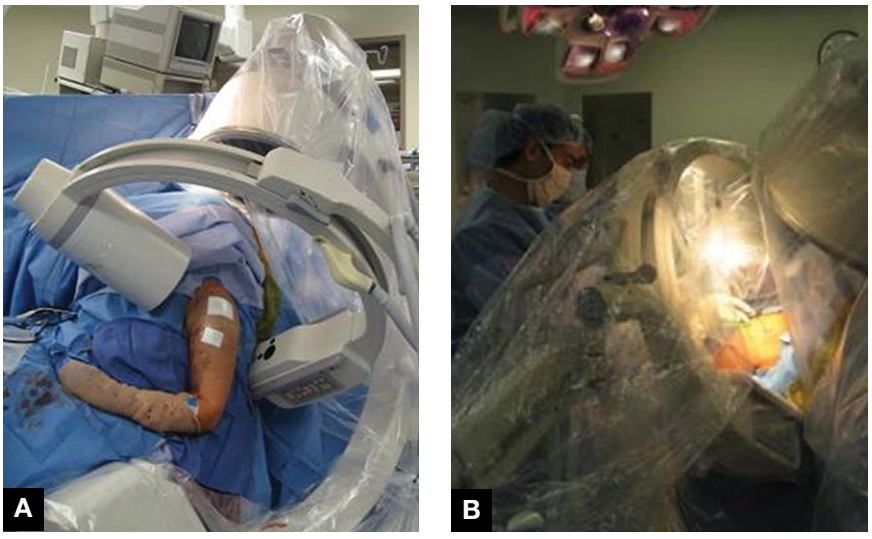

Figure 2. The mini C-arm is used to obtain the true anteroposterior view (A) and allows adequate working space for the surgeon to obtain a reduction and place the percutaneous implants (B).

Figure 3. An image is taken with the pin against the skin to localize the skin incision needed to reach the ideal starting point on the lateral humeral shaft.

Figure 4. The drill guide is placed onto the starting point and acts to direct pin trajectory and to protect the soft tissues during pin insertion.

Figure 5. After the surgical neck fracture is reduced and stabilized by 2 lateral pins, a greater tuberosity fragment may be reduced percutaneously using a skin hook.

C-arm is brought in from the side and adjusted so that it can obtain a true anteroposterior (AP) view, providing good visualization of the fracture lines and the glenohumeral joint space (Figure 2A). We found that this combination of large and small C-arms provides an adequate working space to place the pins, holds the reduction, and is also accommodated by the size of our operating rooms (Figure 2B). Once adequate orthogonal views are obtained, the location of the machines are marked on the operating room floor and are moved away to make room for prepping and draping.

The first step in the technique is obtaining an anatomic closed reduction. Surgical neck fractures are generally reduced as the shoulder is brought into adduction, internal rotation, and flexion with a posterior force directed on the humeral shaft. The fracture is held reduced while the lateral pins are inserted across the fracture site in a retrograde fashion under fluoroscopic guidance. We prefer using 2.8 mm terminally threaded Schanz pins. The first pin is placed from a starting point on the lateral humeral shaft just proximal to the deltoid insertion, in a safe zone between the axillary and radial nerves,[9] and inserted in a posteromedial direction to account for humeral retroversion. A fluoroscopic image is taken with the pin placed against the arm to determine the proper starting point (Figure 3). After making a small skin incision and dissecting down to the bone using a fine clamp, a soft tissue protector is inserted onto the starting point (Figure 4). The exact pin trajectory is adjusted based on the simultaneous AP and axillary views. It is helpful to advance the pin up to, but not through, the fracture site, so the surgeon can verify that the reduction is acceptable before committing to that position. Once the ana-

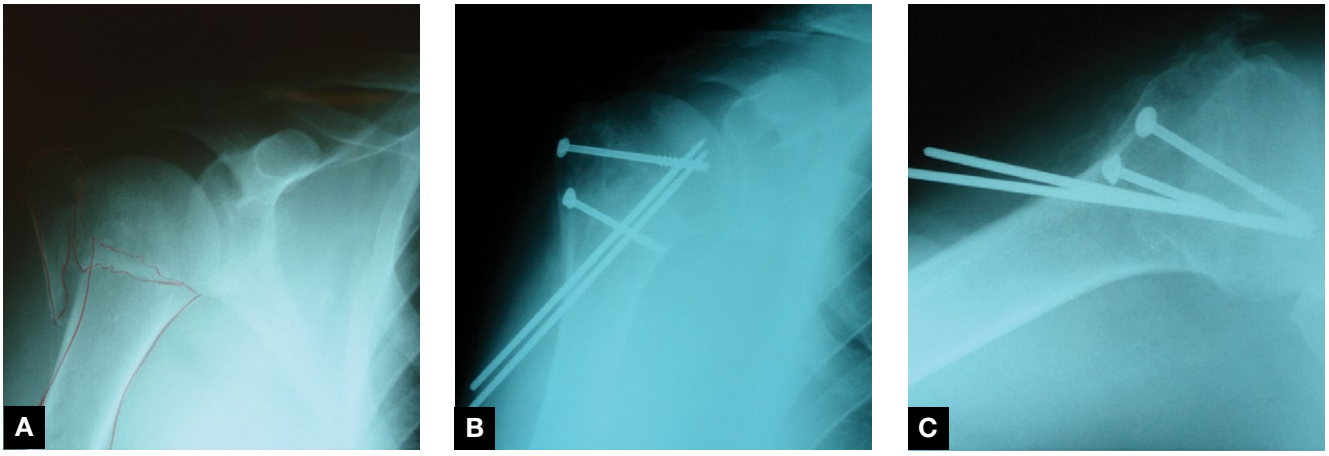

Figure 6. (A) Anteroposterior radiograph demonstrating a 3-part proximal humerus fracture (surgical neck and greater tuberosity) in the dominant shoulder of a 48-year-old active male patient with minimal comminution and an intact medical calcar. Six-week postoperative anteroposterior (B) and axillary (C) views of the fracture following closed reduction and percutaneous fixation with 2 pins across the surgical neck fracture and 2 cannulated screws across the greater tuberosity fracture.

tomic reduction is confirmed, the pin is advanced past the fracture into the subchondral bone of the humeral head. Two pins are generally needed to obtain translational and rotational stability. For more unstable fractures, additional pins may be inserted in a retrograde fashion from the anterior humeral cortex, or antegrade through the greater tuberosity directed medially and ending in the dense medial humeral calcar. Displaced greater tuberosity fractures are reduced percutaneously with a skin hook and fixed with 4.0 mm cannulated screws (Figure 5). The clinical radiographs of a 48-year-old active male patient with a 3-part proximal humerus fracture, with surgical neck and greater tuberosity, of the dominant shoulder is shown in Figures 6A-C.

Conclusion

Percutaneous treatment of proximal humerus fractures is technically challenging because exact pin positioning is required to obtain optimal fixation without joint penetration. Adequate fluoroscopic visualization intraoperatively is crucial to success. We believe that having 2 C-arms available to obtain simultaneous orthogonal images will expedite pin insertion and can greatly decrease the number of passes needed to obtain optimal pin placement. This means there is less disruption of the limited bone stock near the starting points of the pins and across the fracture line. Recently, there has been more concern regarding radiation exposure during orthopedic procedures as the prevalence of minimally invasive procedures relying on fluoroscopic imaging is on the rise.[10] Biplanar imaging can reduce the amount of radiation exposure to the patient and operating room team.

Authors' Disclosure Statement

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Quick Poll

What approach do you prefer in the treatment of proximal humerus fractures?

☐ **A.** Percutaneous treatment ☐ **B.** Open reduction-internal fixation ☐ **C.** It depends on the case ☐ **D.** Other