Accuracy of the Axillary Projection to Determine Fracture Angulation of the Proximal Humerus

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Abstract

The accuracy of measuring angulation of stable proximal humerus fractures using the axillary lateral projection was investigated. A closing wedge osteotomy with apex anterior angulation was performed on two cadaveric humeri to simulate a stable surgical neck fracture. One specimen was fixed at 30° angulation and the other at 55°. Axillary radiographs were taken with each specimen articulating with the glenoid of a cadaveric scapula. The humerus was held in neutral rotation. Abduction was set at 30°, 60°, and 90°. In each position of abduction, an axillary lateral radiograph was taken in 30° forward flexion, neutral, and 30° extension to simulate various arm positions. A total of nine radiographs were taken for each specimen.

The axillary view is not accurate for measurement of proximal humerus angulation at the arm positions commonly encountered in the trauma setting.

The axillary projection of the gleno-humeral joint has been shown to be useful in assessing glenohumeral joint dislocation as well as glenoid rim pathology, acromial abnormalities, and acromioclavicular joint pathology. It has also been used as part of the standard trauma series to assess proximal humerus fractures. It has been suggested, however, that the axillary projection itself may cause distortion of angulation at the surgical neck, leading to errors in fracture classification and treatment.

This study investigated the accuracy of measuring angulation with the axillary projection in stable surgical neck fractures using a cadaveric laboratory model.

Materials and Methods

Two right-sided cadaveric humeri similar in size were selected for this study. All soft tissue was dissected from the bone. An apex anterior, uniplanar, closing wedge osteotomy was performed on each specimen.

A 30° wedge was removed from one specimen and a 55° wedge from the other. The head fragment was fixed to the shaft fragment using nylon suture through multiple drill holes in addition to radiolucent epoxy at the osteotomy site. The possibility of rotational deformity was eliminated by aligning the bicipital groove regions of each fragment.

Radiographs of each specimen were obtained in the scapular-anteroposterior (AP) and axillary lateral projections to verify measurement of the uniplanar deformity.

A cadaveric scapula was mounted to a block of wood. Axillary radiographs were obtained with each specimen held in a bone clamp such that the humeral head articulated with the glenoid. The radiographic beam was uniformly aimed parallel to the floor, tangential to the glenoid articular surface with the radiograph plate located superior to the glenohumeral joint. The distance from the beam to the glenohumeral joint to the radiograph was kept constant for all positions. The humerus was held in neutral rotation by aligning the distal humerus parallel to the floor. A radiograph was obtained with glenohumeral abduction of 30°, 60°, and 90°. In each position of abduction, a radiograph was taken in 30° forward flexion, neutral, and 30° extension to simulate the various arm positions in a clinical setting. A total of nine radiographs were taken for each specimen and labeled for blinded interpretation.

Angulation at the osteotomy was...
measured for each radiograph by two attending orthopedic traumatologists, one fellowship-trained shoulder surgeon, two senior orthopedic residents, and one orthopedic surgeon completing a shoulder fellowship. All reviewers were blinded to the study design, and the radiographs were presented in a random order. A goniometer and grease pencil were provided and the surgeons were instructed to measure angulation using the technique they would use in a clinical setting. Any marks made on the radiographs were removed before the next individual performed measurements.

Statistical analysis was performed to determine the accuracy for angulation measurements. Mean, standard deviation, percentage agreement within 5°, and average measurement error were calculated for each specimen at the various glenohumeral positions. Percentage agreement was calculated as the percentage of observers who recorded the head-shaft angulation within 5° of the actual wedge removed. Average measurement error was calculated as the mean difference between measured and actual head-shaft angulation at each glenohumeral position.

RESULTS

The apparent radiographic angle between the humeral head and shaft was dependent on the position of the humerus in relation to the glenoid (Figure 1). Measurements of angulation varied from the actual angle of each osteotomy depending on arm position (Figure 2). The 30° osteotomy was measured to be as small as 12.7° (30° abduction, 30° flexion) and as large as 57.7° (30° abduction, 30° extension). The 55° osteotomy was measured to be as small as 6.7° (30° abduction, 30° flexion) and as large as 75.5° (30° abduction, 30° extension).

The most accurate measurements for the 30° osteotomy were obtained at 60° abduction and neutral flexion/extension, 90° abduction and neutral flexion/extension, and 90° abduction with 30° flexion. The most accurate measurements were obtained at 30° abduction and 30° extension and 30° abduction and 30° flexion. The least accurate measurements for the 55° osteotomy were at 90° abduction and 30° extension, 90° abduction and neutral flexion/extension, and 90° abduction and 30° extension. The least accurate measurements for the 55° osteotomy were at 30° abduction and 30° flexion, 30° abduction and neutral flexion/extension, and 30° abduction and 30° extension.

DISCUSSION

Proximal humerus fractures are common and increasing as the population ages. Several epidemiological studies have identified the age-adjusted incidence of proximal humerus fractures to be approximately 1/1000 person-years. This incidence increases with advancing age and often involves only minor trauma. The incidence pattern of proximal humerus fractures is similar to those of proximal femur and pelvis fractures. Proximal humerus fractures are a major cause of morbidity in the elderly, particularly in women.

The Neer classification is the most commonly used system for classifying proximal humerus fractures. In this system, a fracture fragment is considered displaced if it is angulated >45° or displaced >1 cm. Neer's statement that surgical neck fracture angulation "usually is directed anteriorly, occasionally in some other plane, but rarely in the coronal or scapular planes." Neer's classification was developed using primarily AP and scapular-lateral views with additional views including transthoracic and axillary views obtained when necessary.

Several studies have shown poor intra-/interobserver reliability in the use of the Neer classification system. Sidor et al showed that simplifying the Neer system from 16 to 6 categories did not improve interobserver reliability or intraobserver reproducibility. Bernstein et al and Sjoden et al failed to show an improvement in intraobserver reproducibility with the addition of computed tomography.

The standard series of radiographs for shoulder trauma includes a scapular-AP, scapular-lateral, and axillary views. De Smet reported in a series of 239 consecutive shoulder radiographs that a scapular-AP in external rotation and an axillary view together identified 99.3% of abnormalities. Other studies found the scapular-lateral view to be equal to or better than the axillary view in diagnosing shoulder dislocation and associated pathology.

In addition to differences in the standard shoulder series, no consensus exists on how best to obtain the axillary view in a trauma setting. The technique most often described has the patient lie
supine with the radiographic tube positioned near the hip. The radiographic cassette is positioned proximal to the shoulder and held against the patient’s neck. The head is moved away from the side of the cassette and the arm abducted to 90° and held in neutral rotation and neutral flexion/extension. Ebraheim et al.12 reported that the projection of the cortical bone of the posterolateral coracoid surface was continuous with the glenoid articular surface when a true tangential view was obtained. This view was obtained with the arm in 50° abduction rather than full abduction.12 It may be difficult to obtain full abduction in a shoulder injury because of patient discomfort.

As the results of this study indicate, even when the fragments of a two-part proximal humerus fracture are stabilized, the apparent angulation at the osteotomy or fracture site depends on the arm position relative to the scapula. With the arm abducted to 90° and neutral rotation, the axillary projection of the proximal humerus is true lateral. However, at limited abduction with the addition of forward flexion or extension, the axillary projection is no longer a true lateral of the proximal humerus.

Closing wedge osteotomies of 30° and 55° were chosen to simulate an acceptable and an unacceptable reduction, respectively. Rotational effects about the humeral shaft axis were eliminated by keeping the distal humeral elements parallel to the floor. Bias in measurement was eliminated by binding the interpreters to the experimental design. No formal instruction for angulation measurement was given because no uniform method of measurement has been described.

Although the classic description of the axillary view requires 90° of glenohumeral abduction, a trauma axillary view is commonly obtained with as little as 30° abduction to minimize patient pain and fracture displacement. The results of this study indicate that the most inaccurate measurements occur at 30° abduction. Measurement error decreased as abduction was increased towards 90°. Shoulder extension led to measurement error that exaggerated the true angulation whereas shoulder flexion led to measurement values that were lower than the true angulation. The effect of shoulder flexion and extension was amplified by decreasing abduction.

Only a true axillary view with the arm held at 90° abstraction and neutral flexion/extension can be used to determine fracture angulation. Therefore, it is crucial that the treating physician be aware of the arm position on axillary view before basing treatment decisions on the measured angulation.

REFERENCES