



ELSEVIER

ORIGINAL ARTICLE

Defining optimal calcar screw positioning in proximal humerus fracture fixation

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Background: Anatomic reduction and placement of an inferior calcar screw are strategies to prevent fixation failure in proximal humerus fractures. Optimal position of the calcar screw remains unknown.

Methods: There were 168 shoulders (68.5% female; average age, 63.6 ± 11.5 years) that underwent open reduction and internal fixation of a displaced proximal humerus fracture involving the surgical or anatomic neck. Univariate and multivariate analyses were performed on preoperative clinical, preoperative radiographic, and postoperative radiographic variables to determine association with fixation failure. A receiver operating characteristic curve was performed to determine a maximum distance from the inferior screw to the calcar (“calcar distance”) as well as a maximum ratio of this distance and the head diameter (“calcar ratio”).

Results: There were 26 of 168 (15.5%) patients with radiographic failures (19 related to fixation failure). Univariate analysis and multivariate analyses found quality of reduction ($P < .001$), calcar distance ($P < .001$), and calcar ratio ($P < .001$) to be significantly associated with radiographic success. In all patients, receiver operating characteristic analysis found quantifiable thresholds of 12 mm or within the bottom 25% of the humeral head as measures to prevent fixation failure.

Conclusions: Quality of reduction, calcar distance, and calcar ratio independently correlated with fixation failure. This study provides optimal distances and ratios for calcar screw placement that can be used clinically.

Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

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Proximal humerus fractures account for approximately 10% of fractures in patients older than 65 years.^{2,9,10} Whereas nonoperative management is the most common management option, open reduction–internal fixation (ORIF) is the most common surgical intervention.⁶ The incidence of proximal humerus fracture fixation is increasing in the United States.³ As the incidence of surgical treatment of proximal

humerus fractures increases, the burden of complications, including fixation failure, will become increasingly significant.

A recent analysis of proximal humerus fracture ORIF found an 18.4% rate of fixation failure and a reoperation rate of 27.6%.¹³ Interestingly, the quality of reduction at the time of surgery was predictive of both radiographic and clinical outcomes. Earlier analyses found age, local cortical density, quality of reduction, and restoration of the medial cortical support to be predictive of radiographic failure.⁸ Retrospective analysis of patients undergoing proximal humerus ORIF found that placement of a medial support (calcar) screw was associated with a decreased risk of loss of reduction.^{12,13}

The inter-relatedness of fracture reduction quality and the position of the medial support (calcar) screw has not been quantified. The purpose of this study was to identify radiographic variables that were independently associated with failure of proximal humerus fracture ORIF and to generate thresholds for optimal calcar screw placement based on the quality of the reduction.

Methods

Study population

All operatively treated proximal humerus fractures were identified by querying an institutional database by *International Classification of Diseases, Ninth Revision* and *Tenth Revision, Clinical Modification* and *Current Procedural Terminology* codes. This database included patients from January 2008 through March 2016. The codes used were 79.31 (open reduction of fracture with internal fixation, humerus), S42.2__ (all codes for fracture of upper end of humerus), and 23615 (open reduction with internal fixation of proximal humerus). Exclusion criteria were revision surgery, associated diaphyseal fracture, fixation with an intramedullary device, no anatomic or surgical neck component of the fracture (eg, isolated greater tuberosity fractures were excluded), inadequate preoperative or postoperative films, incomplete clinical variables, previous shoulder fracture or nonunion, and <12-week postoperative

films. Direct chart review of all patients and radiographs was performed to determine if they had in fact sustained a proximal humerus fracture that underwent ORIF, if the fixation was with a locking plate and screws construct, and if the patient did not meet any exclusion criteria.

Independent variables

Preoperative clinical variables were identified for all patients. These variables included age, gender, race, individual medical comorbidities, and age-adjusted Charlson Comorbidity Index.^{4,14} Preoperative radiographic variables were identified for all patients on true anterior-posterior and Y-view radiographs. These variables were cortical density measurement,¹⁵ Neer classification,¹¹ medial hinge displacement,⁷ medial comminution,⁷ and presence of varus or valgus angulation (Fig. 1). A neck-shaft angle of <120° was considered varus (Fig. 1, A), whereas a neck-shaft angle >150° was considered valgus (Fig. 1, B).¹³

Early postoperative radiographs (true anterior-posterior and Y-view radiographs) taken at 2 weeks postoperatively were reviewed for a number of variables. All preoperative and postoperative radiographs are standardized at our institution. Based on the parameters for reduction quality described by Schnetzke et al, medial head-shaft displacement of <5 mm, greater tuberosity cranialization of <5 mm, and varus or valgus angulation of 120°-150° were considered.¹³ If all 3 criteria were met, the fracture was considered adequately reduced. If 2 of the 3 criteria were met, the fracture was considered partially reduced. If only 1 or 0 of the 3 criteria was met, the fracture was considered malreduced. In addition to the reduction quality, the integrity of the calcar, distance of inferior screw to the calcar (referred to as calcar distance), ratio of calcar distance and the head diameter (referred to as calcar ratio), distance of the inferior screw to the humeral head articular surface (referred to as tip distance), number of diaphyseal screws, number of proximal screws, and number of proximal screws in the inferior half of the head were also considered.^{1,17} The calcar distance was measured as the perpendicular from the threads of the calcar screw to the apex of the arch of the calcar. A well-reduced and well-fixed proximal humerus fracture that went on to successful radiographic healing is shown in Figure 2 (all measurements shown).

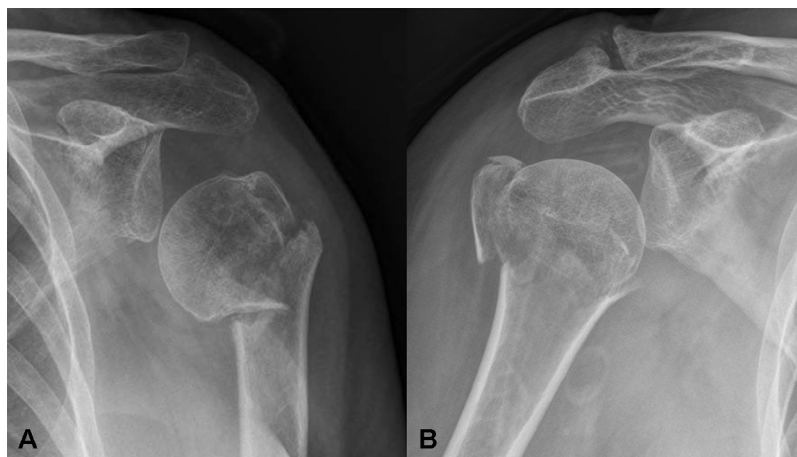


Figure 1 (A) Representative anterior-posterior radiograph of a Neer 2-part¹¹ proximal humerus fracture in varus (neck-shaft angle of <120°). (B) Representative anterior-posterior radiograph of a Neer 4-part¹¹ proximal humerus fracture in valgus (neck-shaft angle of >150°).

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