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Fracture site augmentation with calcium phosphate cement reduces screw penetration after open reduction—internal fixation of proximal humeral fractures

Kenneth A. Egol, MD*, Michelle T. Sugi, MD, Crispin C. Ong, MD, Nicole Montero, MD, Roy Davidovitch, MD, Joseph D. Zuckerman, MD

Department of Orthopaedic Surgery, NYU Hospital for Joint Diseases, New York, NY, USA

Background: We sought to examine fracture settling and screw penetration after open reduction—internal fixation of 2-, 3-, and 4-part proximal humeral fractures and determine whether the use of calcium phosphate cement reduced these unwanted complications.

Methods: We performed a retrospective study of prospective data. Inclusion criteria included patient age of 18 years or older and an acute traumatic fracture of the proximal humerus that was treated with open reduction—internal fixation with a locked plate. Metaphyseal defects were treated with 1 of 3 strategies: no augmentation, augmentation with cancellous chips, or augmentation with calcium phosphate cement. Various radiographic measurements were made at each follow-up visit to assess for humeral head settling or collapse. Overall, 92 patients (81%) met the inclusion criteria and form the basis of this study. Augmentation type included 29 patients (32%) with cancellous chips, 27 (29%) with calcium phosphate cement, and 36 (39%) with no augmentation.

Results: There were no statistical differences among the groups with respect to patient age, sex, and fracture type. At the 3, 6, and 12-month follow-up visits, there was less humeral head settling with calcium phosphate cement compared with repair with no augmentation or with cancellous chips. Findings of joint penetration were significant among patients treated with plates and screws alone versus those augmented with calcium phosphate ($P = .02$) and for those augmented with cancellous chips versus those augmented with calcium phosphate ($P = .009$).

Conclusion: Augmentation with calcium phosphate cement in the treatment of proximal humeral fractures with locked plates decreased fracture settling and significantly decreased intra-articular screw penetration.

Level of evidence: Level III, Retrospective Case-Control Design, Treatment Study.

Keywords: Proximal humeral fracture; calcium phosphate cement; screw penetration; locked plate

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*Reprint requests: Kenneth A. Egol, MD, 301 E 17th St, Ste 1402, New York, NY 10003, USA.
E-mail address: Kenneth.egol@nyumc.org (K.A. Egol).

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Fractures of the proximal humerus are quite common. They account for approximately 4% to 5% of all fractures and are the second most common fracture of the upper extremity, after distal radius fractures. The majority of proximal humeral fractures are minimally displaced or nondisplaced and may often be treated nonoperatively, whereas the remainder require surgical intervention.[6] Closed reduction and intramedullary fixation, percutaneous pins or screw fixation for 2-part fractures, and hemiarthroplasty for 4-part fractures have shown acceptable results; however, open reduction−internal fixation (ORIF) with locked plates and screws has become the standard method of operative treatment.

A number of studies have shown improved surgical results with the advent of locked plates for use in proximal humeral fractures.[1,3-5,11,12,15,16] The benefits of this method of stable internal fixation include early rehabilitation, decreased risk of implant-induced rotator cuff damage and potential implant removal, and lower rates of implant failure.[3,12] Despite such benefits, complications are still reported and include osteonecrosis of the humeral head, humeral head settling with loss of neck-shaft angle, nonunion or malunion, screw penetration into the glenohumeral joint, and implant failure. Intra-articular screw penetration has been a frequent complication with locked-plate technology, with reported rates in the literature ranging from 0% to 43%.[3,11,12] A recent study by Owsley and Gorczyca[11] found that the use of locked plates in the surgical treatment of proximal humeral fractures is associated with an unexpectedly high rate of screw penetration and revision surgery, especially in patients aged older than 60 years who have a 3- or 4-part fracture. Screw penetration, particularly in the young and active patient, is a significant postoperative complication because it may lead to pain, as well as damage to the glenoid cartilage, and mechanically obstruct sufficient range of shoulder motion needed for activities of daily living. In addition, intra-articular screw penetration often requires repeat surgery for screw removal or shoulder arthroplasty.

During the operative repair of displaced proximal humeral fractures, surgeons often encounter a metaphyseal void after head-shaft reduction. The void may be attributed to a number of reasons, including slight malreductions resulting in cortical gaps, cortex bone comminution in an anatomically reduced fracture, or more likely, metaphyseal cancellous bone impaction. Several strategies for void filling are available to the treating physician, which concomitantly may serve to minimize fracture collapse and screw loosening and enhance healing. Calcium phosphate cement has become more commonplace in orthopedic surgery as a void filling material because of its strong resistance to compressive forces. Its osteoconductive properties along with resistance to compression may make it the ideal graft substitute for many fractures.[2,13,18]

The purpose of our study was to examine the incidence of fracture settling and screw penetration after ORIF of 2-, 3-, and 4-part proximal humeral fractures and determine whether the use of calcium phosphate cement reduced this complication. We hypothesized that fracture site augmentation with calcium phosphate cement would be associated with decreased fracture settling and screw penetration compared with ORIF alone or ORIF with fracture site augmentation by use of cancellous chips.

Methods

Between February 2003 and October 2009, 114 patients who presented to our affiliated institutions with a displaced proximal humeral fracture and underwent surgery were included in an institutional review board−approved registry and followed up prospectively. Seven fellowship-trained orthopedic trauma and shoulder surgeons were involved in the surgical management of all patients. No algorithmic protocol was established, and all surgeons treated their patients according to their own custom and practice. However, a similar surgical approach and identical implants were used in all cases. Inclusion criteria for this study included patient age of 18 years or older, an acute traumatic fracture of the proximal humerus that was treated with ORIF with a locked plate with 1 of 3 strategies (no augmentation, augmentation with cancellous chips, or augmentation with calcium phosphate cement) for the metaphyseal void, and sufficient clinical and radiographic follow-up (3-, 6-, and 12-month visits). Fractures resulting from a primary or metastatic tumor, open fractures, nonunions, and malunions were excluded from this study. Overall, 92 patients (81%) met the inclusion criteria and form the basis of this study. The mean age was 61 years (range, 22-84 years; median, 61 years), and there were 68 women and 24 men, with a mean age of 62 years for women and 56 years for men.

At the time of enrollment, a series of standard radiographs were obtained, including anteroposterior (AP) scapular, axillary, and trans-scapular lateral (Y) views of the affected proximal humerus (Fig. 1, *A*). A computed tomography (CT) scan was obtained to assess for fracture dislocations and/or intra-articular fractures when standard imaging was insufficient. A complete history was obtained, physical examination was performed, and open wounds and neurovascular status were assessed. Informed consent was obtained, and trained researchers obtained baseline demographic data (eg, age, sex, and fracture type [Neer and Orthopaedic Trauma Association (OTA)]), and injury information.[7] Operative data—including the number of screws used; type of fracture augmentation, if used; and intraoperative complications, if any—were extracted from the hospital record. Fractures were classified according to the Neer criteria and OTA classification based on initial radiographs and CT scans and were confirmed or corrected intraoperatively.[9]

Operative technique and type of plate and screws were standardized for all surgeons. Patients were operated on in the beach-chair position through a deltopectoral approach. Tuberosity mobilization and fixation were achieved directly with the use of nonabsorbable sutures placed through the rotator cuff tendons adjacent to the displaced fragments. In all cases, the humeral head was elevated (if valgus impacted) and reduced (if in varus) through a lateral cortical window, followed by provisional fixation. The tuberosities were then reduced and stabilized with K-wires, and the void that remained in the metaphyseal region after reduction was addressed in 1 of 3 ways: no augmentation, grafting of the defect with allograft cancellous chips, or filling of the void with